ABENAKI CARBONATE PLATFORM IN RELATION TO THE JURASSIC-CRETACEOUS SABLE ISLAND DELTA, OFFSHORE NOVA SCOTIA, CANADA

by

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Dedicated to

My beloved wife and long suffering first editor, Velvet Elaine Eliuk

And in memory of my parents,
Nettie and Victor Eliuk

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Based on prior Eliuk work: (for reference only, no enclosures for these with thesis)

Eliuk, L.S. 1978. Abenaki Formation, Nova Scotia shelf, Canada - depositional and diagenetic model for a Mesozoic carbonate platform. Bulletin of Canadian Petroleum Geology, v. 26, p. 424-514. 1. KEY to symbols of Shell Canada MELISA plotting, 2. Mohawk B-93,

- 3. Mohican I-100, 4. Oneida O-25, 5. Demascota G-32, 6. Cohasset D-42,
- 7. Abenaki J-56, 8. Sauk A-57, 9. Heron H-73 (South Whale Subbasin),
- 10. Dauntless D-35

Offshore Energy Research Associates (OERA 2011). Play Fairway

Analysis, Chapter 9 – Late Jurassic Carbonate Play Fairway Analysis

- Addendum to Play Fairway Analysis by Beicip-FranLab
- (S. Doublet and co-workers), 104 p. http://www.oera,ca/Offshore-energyresearch/geoscience/play-fairway-analysis/PFA-atlas

Listed alphabetically *=based on Eliuk's log data except Glooscap
(others only PFA sequence logs likely based in part on Eliuk 1978
lithologs; their enclosures are part of their report):
Acadia K62-Encl_9-02, *Albatross B13 g - Encl_9-01,
*Bonnet P23 g - Encl_9-03, *Cohasset L97 g - Encl_9-04,
Como P21-Encl_9-05, Demascota G32 - Encl_9-06,
*Dominion J14 g - Encl_9-07,
Glooscap C-63 BF - Encl_9-08 (Beicip-Franlab logging),
*Kegeshook G67 g - Encl_9-09, Marcoh D41-Encl_9-10,
*Margaree F70 g - Encl_9-11,
*Marquis L35 g - Encl_9-12, Moheida P-15 - Encl_9-13,
Mohican I100 - Encl_9-14, Oneida O25-Encl_9-15,
Panuke B90-Encl 9-16, *Panuke F09 g - Encl 9-17,
Panuke H08-Encl 9-18, *Panuke M79 g - Encl 9-21,
*Panuke M79A g - Encl 9-22, Panuke PI1A-Encl 9-19,
Panuke PP3C-Encl 9-20, Penobscot L30 - Encl 9-23,
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ABSTRACT

The offshore Nova Scotia Late Jurassic to earliest Cretaceous continental scale shelf-margin Sable Delta succession is juxtaposed with the extensive kilometre-thick Abenaki carbonate platform. This thesis addresses how that unusual association could have occurred and lasted 15 Ma and the effects it had on the margin carbonates. Several carbonate morphologies and two separate systems will be discussed – ramps near the delta and a platform to the southwest. Highs produced by allochthonous salt beneath the Sable Delta localized oolite shoals and possibly atolls. Carbonate production on abandoned, flooded lobes and on prograding ramps generated carbonate oolite-quartz sandstone proximally and slope thrombolites distally.

Sediment loading, bypass onto the deeper slope and faulting on the delta front, and flexuring and faulting on the near-delta platform margin, may have helped generate a proposed bathymetric separation between the delta and the near-delta platform margin. This long-continued bathymetric separation maintained a carbonate platform relatively clean of siliciclastic influx. However, prodelta sedimentation did affect two of the three major Late Jurassic reef/mound types – siliceous sponge and thrombolitic-microbial slope mud mounds – but not coral reefs nor the oolitic shoals of the shallow platform. Lateral changes in the coral-stromatoporoid shallow reefs and oolite shoals are identifiable only relative to their quartz content.

Carbonate transitions influenced by deltaic sedimentation are revealed in two cores and give major insights — within the Sable Delta by a thin ramp limestone series and on the carbonate platform margin by deepening reeflets on a pinnacle slope. The deeper foreslope mounds reveal a gradient with increasing shale interbeds and distinct colour changes distal to the delta. The uppermost Abenaki and sections above show the diachronous development of sponge-rich beds and reef mounds at the toe of the expanding Sable prodelta succession. Condensed and palimpsest shelf sediment packages are identified further southwest by coated-ironstone redbeds in a marine setting, and more distantly by continued shallow carbonate sedimentation on the margin and nearshore ridges into the Early Cretaceous.

Descriptions and interpretations from cuttings and sparse core from all available margin wells are presented using an updated Abenaki carbonate facies association template supported by seismic and biostratigraphic data. Major facies such as oolite, oncolite and all three mid-Mesozoic reef/mound types are illustrated using cored intervals.

The currently producing Deep Panuke reefal and Venture shelf deltaic gas fields are both shelf margin accumulations of contemporaneous age. This thesis highlights the effects produced by the Sable Delta on the regional petroleum systems relative to the margin carbonate, and in particular to the reservoir/seal pairs and gas-prone source.

LIST OF ABBREVIATIONS AND SYMBOLS USED

A = Alma gas field [the area includes gas fields Venture (V) and Glenelg (G) below]

A.&E. (paleo-marker) = Ammobaculites sp.-Epistomina sp. paleontological marker

AVO = amplitude versus offset analysis

BCT = Baltimore Canyon Trough area

BS = boundstone or bindstone

C = coarse

CAMP = Central Atlantic Magmatic Province

CATT = Carbonate Analogs Through Time Hypothesis (Markello et al. 2008)

CNSOPB = Canada-Nova Scotia Offshore Petroleum Board

DNR = Department of Natural Resources

DP = Deep Panuke (area)

DSDP = Deep Sea Drilling Project

DU = Drowning Unconformity

FA = Facies Association template (referring to Table 7.1, Figure 7.8)

F-C = fine to coarse

FSST = Falling Stage Systems Tract

FMI = Fullbore Formation Imager, Slumberger term for borehole electrical imaging, now with "HD" added for high definition)

FZ = (Wilson (1975) standard carbonate) facies

G = Glenelg gas field

GOM = Gulf of Mexico

GOMH = Gulf of Mexico Haynesville shale area

GSC = Geological Survey of Canada

HA = horizontal axis/width

HST = High Stand Systems Tract

HTD = Hydrothermal Dolomite

JABK = Jurassic Abenaki Formation

LC = lost circulation

LST = Low Stand Systems Tract

MFS = maximum flooding surfaces

NBCU = Near Base Cretaceous Unconformity

NSRL = Nova Scotia Resources Limited

OERA = Offshore Energy Research Association (of Nova Scotia, recently supersedes OETR)

OETR= Offshore Energy Technical Research Association (of Nova Scotia)

PCP = PanCanadian Petroleum

PDC = polycrystalline diamond compact bits

PFA (study) = Play Fairway Analysis

PEX = Petro-Canada Exploration

RR = rig release

RSL/rsl = relative sea-level

SB = sequence boundary

SMF = Standard Microfacies types (as in Flugel)

SP = Spontaneous potential

SU= Subaerial Unconformity

SWC = sidewall core

TS = thin section

TD = Total Depth

TST = Transgressive Systems Tract

 \underline{V} = Venture gas field

WS = Western Shelf (area)

UWI = Unique Well Identifier

XC = extremely coarse

Abbreviated Dunham classification terms, modified by Kloven and Embry:

BS = Boundstone, bindstone

FS = Floatstone

GS = Grainstone

MS = (Lime) Mudstone

PS = Packstone

RS = Rudstone

WS = Wackestone

(Symbols Chart on Following Page)

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Some things are done for love of nature and curiosity, some to form a team and work together, some to make a living and raise a family, some to share interests and enjoyment with, some to contribute and give back for what has been received, and some just to see what happens. If all these things can be done at once you are truly blessed. For all these and more I thank God.

CHAPTER 1. INTRODUCTION

List of Topics

- 1.1 Abenaki-Sable: an Unusual Pair a Thick Carbonate Platform by a Large Delta
- 1.2 Problems and Hypothesis
- 1.3 Overview Strategy and Outline

"Rivers, not temperature, organisms or chemistry, appear to control the distribution of carbonates." Chave 1967

"Although no one can draw a line between dawn and dusk; day is on the whole tolerably distinguishable from night." W. Blake 1757-1827

1.1 Abenaki-Sable: An Unusual Pair - a Thick Carbonate Platform by a Large Delta

Deltas and reefs are both modern and ancient producers of sediment. Seen at the land-water interface, they are important features that 'create land.' Both infill up to sea level but they belong to very different realms of geography and sedimentology. Deltas originate from river-supplied eroded terrigenous sediment; reefs like most carbonates are the nearly *in situ* result of organic growth and aqueous precipitation. As Chave (1967) put it "rivers, not temperatures, organisms or chemistry appear to control the distribution of carbonates". There are now some exceptions to this mutual exclusivity with various types of carbonate reefs or mounds occurring in a variety of deltaic settings (see Section¹ 2.1 and Appendix A2.4). Although isolated reefs may occur, there are no extensive carbonate platforms in the present near a continental scale delta (see Appendix A2.3).

The exception and the subject of this thesis is the Late Jurassic through mid-Cretaceous thick Abenaki carbonate platform immediately southwest of the large Sable Island paleo-delta ('Sable Delta'). What allowed these two separate depositional systems to exist closely together and for so long? What were the effects if any on the platform margin carbonates themselves at varying distances from the delta?

¹ The word "Section" has been required instead of "Subchapter" and when used in this manner it will carry a capital letter. When the word "section" is used more generically or geologically it will be lower case.

The location of the study area and well control is shown on **Figure 1.1**. The Abenaki platform-Sable Delta regional paleogeography is illustrated on **Figure 1.2**. The Scotian Basin stratigraphic column and Abenaki type well stratigraphy are on **Figure 1.3**. Those type well columns reveal the Abenaki Formation comprises two of the most characteristic components – oolites and reefs/mounds. Of known Phanerozoic reef occurrences, the Late Jurassic is the fourth largest after Late Devonian, mid-Silurian and Miocene/Holocene (Kiessling 2002, **Figure 1.4**). Kiessling (2006) suggests the Late Jurassic exceeds the Modern in reef numbers and volumes.

The Late Jurassic has possibly the greatest variety of Phanerozoic reef/mound types (Leinfelder et al. 2002). In occurrences of oolites it is third of the four largest broad peaks – Late Cambrian, mid Carboniferous, Late Jurassic and Holocene – with aragonitic ooids for the first and last but mainly calcitic ooids for the middle two (Wilkinson et al. 1985, Eliuk 1987; **Figure 1.4**). High carbonate saturations coincide with high amounts of submarine cements and the last significant development of marine microbolite mud mounds² and hypercalcified sponges – coralline (stromatoporoids and chaetetids) and lithistid demosponges as seen on **Figure 1.3**. Clearly the Late Jurassic was one of the Phanerozoic's most favoured times of biotic and abiotic carbonate productivity.

The Abenaki Formation strongly reflects the Late Jurassic abundance of reefs and oolites. This may be the critical carbonate expression of the platform-delta-juxtaposition equation. There are no modern examples of major deltas with nearby large carbonate platforms. This is a fact that possibly reflects on the modern oceans' lower shallow-water carbonate productivity relative to times in the past. Probably this productivity change is linked to the onset of major deep-water carbonate sedimentation with the rise of chalk-producing nanoplankton like coccolithophorids in the later Mesozoic (DeVargas et al. 2007, Pomar and Hallock 2008, see Appendix A2.7). Perhaps not coincidentally, a drastic reduction in both reefs and oolites occurred at the same time, possibly due to reduced dissolved carbonate availability (**Figure 1.4, A2.17**).

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² The term **microbolite** and microbolite mound has been chosen to take the place of carbonate 'mud' mound or microbial/thrombolitic/automicritic mud mound used by the author in the past. Note that Leinfelder et al (2002 and previously) applied the term 'microbolite' or 'microbolite-dominated' to the third major Late Jurassic reef-mound type end-member. Here microbolite is used in a general descriptive sense for lime mudstones to bindstones often finely pelletal with thrombolitic and occasionally even stromatolitic textures with variously sized cavity systems with more or less geopetal infill and isopachous cements. Oncolites could even be encompassed by the term. Their origin is interpreted as mainly microbial or microbially mediated but automicrite is also possible with early seafloor diagenetic processes with or without microbial involvement. Stromatactis mud mounds do occur in the Abenaki as seen in Demascota G-32 Core 5 and are included in this general term. Origin of the cavities is controversial but early cementation or lithification maintained them. In many figures from earlier presentations microbial and mud mound may still be used.

While typical of Late Jurassic carbonates, in many other respects the upper Abenaki is an unusual carbonate as shown by the following features:

- 1) The Upper Abenaki is on the north end of longest reef chain and platform trend (gigaplatform) with shelf margin reefs in the Phanerozoic geologic record (Poag 1991, Kiessling 2001).
- 2) All three typical Late Jurassic reef/mound types are present, and indeed even in one well Demascota G-32 with siliceous sponge reef mounds, coral-coralline sponge shallow-water reefs and slope thrombolitic-microbial mud mounds (Eliuk 1978, 1998; Eliuk & Levesque 1988; Jansa et al. 1982, 1988; Dromart et al. 1994: Pratt 1982, 1995; Pratt et al 1988; Ellis et al. 1985, 1990; for Jurassic reef/mound types see Leinfelder 1994 and Leinfelder et al. 2002).
- 3) The Abenaki is the youngest reef-bearing carbonate complex in Canada that is already well known for its Devonian reefs and hydrocarbon-bearing Paleozoic carbonates (Eliuk 1988, James and Geldsetzer 1988).
- 4) The Sable-Laurentian delta complex³ was the largest delta on the North American Atlantic and Gulf of Mexico margin until the mid-Cretaceous when it terminated. It completely pre-dates the appearance of the Mississippi Delta in the Cenozoic, it arguably being a possible example of mega "stream capture" (Eliuk and Wach 2014a & b, see Cox and Van Arsdale 2002, Van Arsdale and Cox 2007 on origin of Mississippi Embayment).
- 5) Both ramp and platform margin morphologies are present including prograding ramps associated with the Sable Delta (Eliuk 1978, Wade and MacLean 1990, Kidston et al. 2005, OETR 2011).
- 6) Producing gas fields exist both in Late Jurassic-earliest Cretaceous siliciclastic shelf-margin deltas (e.g. Venture Field) and in carbonate shelf-margin reefs (Deep Panuke Field) (Cummings & Arnott 2005, Encana 2006, Weissenberger et al 2006).
- 7) Global Late Jurassic carbonate reservoirs contain huge hydrocarbon volumes (e.g. Saudi Arabia) but only a rare few are present in reefs at shelf margins since most fields are within shelf interior settings (Greenlee & Lehman 1993, Kiessling 2002).
- 8) Deep Panuke is the only commercial gas field in carbonates on the North American Atlantic offshore (Weissenberger et al. 2006, Encana 2006).
- 9) Exceptionally, a thick carbonate platform existed adjacent to a very large delta over an extended period of time circa 15 Ma. This last anomaly provides the focus of this thesis the origin and an understanding of how this unusual juxtaposition existed for so long and what was

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³ The 'Laurentian Delta' was the term for the northern Middle-Late Jurassic Sable precursor.

the delta's effect on the associated margin reefs and slope reef/mud mounds that rim the Late Jurassic shelf edge of the western Atlantic off North America.

From the economic perspective, the Abenaki is significant in hosting the Deep Panuke gas field located between the contemporaneous Sable Delta prograding ramp shelf to the northeast and the aggrading carbonate platform to the southwest. Published studies (Weissenberger et al., 2006; Wierzbicki et al., 2005, 2006; Encana 2006) give details on the hydrothermally-dolomitized reef margin gas field discovered below the depleted Panuke oil field in 1998 and starting production in 2013. Expanding on those earlier studies, Deep Panuke was placed in a larger petroleum systems context between the Sable Delta and the carbonate platform (various Eliuk, and Eliuk & Wach post-2006 abstracts and informal web publications and the PFA study, OETR 2011). The Sable Delta also has a number of producing shelf margin gas fields (Cummings and Arnott 2005).

The association of the Abenaki carbonate platform and Sable Delta closely sharing a common continental shelf on a passive margin was aided by the generally rising relative sea level. This resulted in repeated episodic flooding of the ever enlarging Sable Delta supplying the continental slope with prodeltaic sediments. Further this delta progradation resulted in salt movement, complex growth faulting, differentially expanded sections, and paleohighs localizing carbonate production as oolite shoals. Other similar mixed systems might exist in the rock record but likely require an ocean margin setting to allow major sediment influx and subsidence. One possible similar system is associated with the tectonics of the opening of the Bay of Biscay in the Aptian-Albian. Although apparently even thicker than the Abenaki-Sable system, it was not as extensive (Garcia-Mondejar 1990). Farther discussion of today's major river systems and carbonate platforms and why none of these qualify as a suitable analogue of the Abenaki-Sable system is presented in Appendix A2.4 and A2.5.

Gretener (1963) and later Ager (1973, 1993) both argued that with the vast spans of time available in the geological record the rare event is inevitable and in most cases expressed as a catastrophe. Perhaps even as a non-catastrophic event, two supposedly inimical sedimentary systems — a major siliciclastic delta juxtaposed with a large oolitic-reefal carbonate platform — must happen somewhere, sometime at least once and likely more than once. Ager (1973) quoted the dean of British Jurassic studies William J. Arkell: "All the occurrences of Jurassic formations . . . amount to little more than relics of marginal lappings of the sea around the edges of the continents; the sole exception being the Tethys."

That rare event is the Jurassic Abenaki Formation carbonate platform and the Sable Delta preserved on the North American continental shelf at the western edge of the greater Tethys seaway at the northern end of the Phanerozoic's longest reef tract and gigaplatform (Poag 1991, Kiessling 2001, see **Figure 2.1**).

1.2 Problems and Hypothesis

Carbonate and siliciclastic sediments are traditionally considered mutually exclusive due to the negative effects that river waters and terrigenous sedimentation have on carbonate-secreting photoautotrophic and filter-feeding organisms (e.g. salinity, pH, light penetration, fine material in suspension, high accumulation rates of sand in littoral and deltaic settings, and high nutrient levels; see Chave 1967; Schlager 1981, 2005; Hallock and Schlager 1986; Mutti and Hallock 2003; Vecsei 2003; Fabricius 2005; McLaughlin et al. 2003, Moura et al. 2016). However, individual colonial corals and small reefs are known to be associated with deltas (Niger deepwater - Allen and Wells 1962; Mahakam – Wilson and Lokier 2002, Wilson 2005, Saller et al. 2010; Shatt Al Arab – Pohl et al. 2014, Mouth of Amazon shelf edge – Moura et al. 2016; for generalization on coral occurrences in siliciclastic settings see MacDonald et al. 2005, Sanders and Baron-Szabo 2005; also see Appendix 2).

More recently an extensive linear reef system with high amounts of rhodoliths and large sponges has been described from the outer shelf at the mouth of the Amazon (Moura et al. 2016). Though not a shallow-water carbonate platform this may offer a modern analogue for some of the topmost Abenaki facies. The Flower Garden Banks' coral reefs in the Gulf of Mexico are over 200 km from the Mississippi Delta but are on salt dome paleohighs on a terrigenous shelf (Rezak et al.1985).

Thicker alterations of carbonates and siliciclastics do co-occur in the geological record but rarely by deltas (Fly River Delta – northern Great Barrier Reef in Gulf of Papua modern and Neogene – Tcherepanov 2008; Tcherepanov et al. 2008, 2010; Slingerland et al. 2008; Davies et al. 1989). The most common explanation is reciprocal sedimentation either controlled in time by oscillations of climate, sea-level or tectonic settings; or controlled in space by shifting depocentres, lobe abandonment, and/or longshore/oceanic currents (Wilson 1967, Mount 1984, Leinfelder 1997, Goldhammer 2003). Paralic terrigenous sediments adjacent to offshore carbonate are the usual ('classic') mixed siliciclastic-carbonate system. They are not uncommon and include the largest modern reef tract, Australia's Great Barrier Reef (Francis et al. 2007). Ancient

examples even include the Late Jurassic Abenaki platform system itself in regard to its nearshore-offshore sediment pattern (Eliuk 1978, see **Figure 1.5** and Appendix A2.1 on 'classic mixed systems').

However size and scale matters. There are no modern examples of coeval carbonate and siliciclastic sediment accumulation on the scale of a large delta beside a kilometre-plus thick carbonate platform hundreds of kilometres long. The Late Jurassic of Nova Scotia provides an ancient long-lived example of such a system with the differences between these two systems shown in **Figure 1.5** along with a depiction of the thesis problems.

PROBLEM #1 – Morphology, nature and origin of a large delta-thick carbonate platform juxtaposition and lateral ramp carbonates

The Abenaki carbonate platform persisted very near the large Sable Delta for millions of years without being overwhelmed and buried. Evidence of the nearby siliciclastics within most of the platform consisted of only quartz nuclei in ooids and occasional thin sandstone beds. The eventual diachronous replacement of the Abenaki platform by the Sable Delta is evidenced by prograding ramp profiles observed on seismic. But this resulted not in the abrupt end of carbonate sedimentation as might be expected but in a completely different style with variably thick typically oolitic limestones interbedded with and dominated by siliciclastics. This transition is the focus of the first part of the thesis.

HYPOTHESIS PART 1 - It is hypothesized that for much of their Late Jurassic existence the delta and carbonate platform initially were isolated from one another by mechanisms intrinsic to the delta itself, e.g. bathymetry, bypass channelling, lithospheric loading and salt tectonics. A narrow bathymetric separation is proposed to explain the long-lived juxtaposition of shelf-edge oolite-and-coral-rich then lithistid-sponge-rich reef and mounds in the north end of the Deep Panuke Trend platform. This is next to shelf-edge deltas at the Venture Field near Sable Island with lateral intervening mixed carbonate-siliciclastic ramps or distally steepened ramps. Indeed the main siliciclastic depocentre near Sable Island is interpreted to be subject to the buttressing effect of the Abenaki platform to the southwest and the possible interbedded armouring effect of mixed carbonates and siliciclastic ramps lateral to the Sable Delta. The lateral ramp carbonates are interpreted to form on abandoned delta lobes and in distal shelf-edge locations when terrigenous influx was low. Thus they differed from the carbonate platform since they were able to prograde, were diachronous, were able to become re-established and were controlled by the deltaic sedimentation both for their substrate and for their eventual demise.

PROBLEM #2 – Possible lateral effects on platform margin carbonates due to the proximity of deltaic sedimentation

Given the juxtaposition of the delta and carbonate platform, the expectation of an obvious gradient of effects of terrigenous sedimentation on the platform carbonates seemed reasonable. But lateral effects are far more subtle than expected within the shallow-water platform margin. Changes in the carbonates can be seen vertically and laterally at the top of the Abenaki shown mainly by change to argillaceous sponge reef mounds and along the distal slope shown by microbolite mud mound colour and biotic changes. Seismic shows systematic changes in morphological dip profiles both vertically and laterally in the Abenaki itself, and from near the delta southwest to the main carbonate platform. The Abenaki's Scatarie and lowermost Baccaro members evolved from ramps to rimmed platform profiles of the middle and upper Baccaro Member (see Figure 1.3, Chapter 2 and Appendix A1). Very near the Sable Delta, prodeltaic infill resulted in a reversion to ramp and distally steepened ramp profiles in mixed siliciclastics and carbonate successions that go from oolite to microbolite mud mounds downslope. Condensed intervals of marine redbeds and lithistid sponge-rich beds occurred on the shallow shelf above the carbonate platform at the southwestern limit of prodeltaic sedimentation. Along the far Western Shelf margin, shallow water carbonate growth was able to continue into the Early Cretaceous Neocomian and Aptian. Are all these changes linked to the delta and if so how? Could they be different responses mediated by more or less deltaic influence on the carbonates in recovery from stratigraphic gaps of parasequences, inter- and intra-formational unconformities of both subaerial and submarine origin?

HYPOTHESIS PART 2- It is hypothesized that the facies changes at the top Abenaki and along the distal slope are not coincidental but result from the influence of the Sable Island siliciclastic depo-center through increased nutrients and turbidity; reduced salinity, oxygen and illumination; potential fouling, hard substrate loss and burial (modified from Leinfelder 1997 and Mount 1984). The oolitic and coral reefal margins are proposed to have been too shallow initially to be affected by the prodeltaic fines deposited much deeper on the platform lower foreslope. When the isolating bathymetric low is filled, terrigenous sediment and nutrients influx should occur which would be hostile to coral reefs and favour formation of sponge reef mounds distally at the top of the platform. Near the limit of the effects of the delta, sedimentation may be very low, contributing to marine redbeds deposition. Well beyond it to the southwest, shallow-water carbonates would likely continue growing.

1.3 Overview – Strategy and Outline

"A chain is only as strong as its weakest link" OR "A cord of three strands is not easily broken".

The main contribution and source of data for this thesis is the examination and/or review of Abenaki carbonate cuttings (over 23 km of section) and core data (only about 167 m) in over 25 Abenaki Formation wells. Schematic lithologs from these data with interpretations are presented well by well along the Late Jurassic margin supplemented by information from published or publicly available seismic profiles and biostratigraphic studies. Aspects of thesis arguments are often introduced in the specific well results chapter then integrated in the discussion-interpretation chapter.

Both cuttings and particularly cores show a great variety of reef and reef mound types. This includes the three major Late Jurassic types - coral reef, siliceous sponge reef mounds and microbolite (microbial/thrombolitic/automicrite) mounds with huge ranges in thickness in their expression. This can be seen despite the limited number of wells drilled along the reef margin and the even smaller number of wells with reefal cores and of limited thicknesses. These reef/mound cores, as well as a few non-reefal ones, are illustrated in whole or in part to provide comparative information on the deltaic influence or lack thereof.

Chapter 2 – Geological Setting and Previous Work (also see Appendix A1, "Previous Work and Stratigraphy Critique") gives a brief review of the Abenaki geologic history, stratigraphy and paleogeography of the Scotian Basin and more broadly in the western Atlantic continental shelf margin relative to the two major continent-draining deltas. This delta/platform combination is compared to the pattern in the Gulf of Mexico with the younger continental-scale Mississippi Delta that post-dates both the Sable Delta and major Gulf and Nova Scotian carbonates. References to those previous studies relevant to understanding the Abenaki and its relation to the Sable Delta are given. The discovery of the Deep Panuke shelf margin reef gas field in 1998 increased the number of wells drilled, new seismic data acquired and subsequent Abenaki studies completed but the latter did not focus on the delta-platform transition.

Chapter 3 – Database and Methodology describes procedures and rationale for cuttings work as the prime source of this thesis data using the Abenaki carbonate facies association template. Wells included in the study are mainly in the Panuke Trend and carbonates close to and within the Sable

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Delta with comparison to Western Shelf margin wells. Appendix A3 has detailed lithologs of most of the Abenaki-bearing wells.

Chapter 4 - Results are presented on a well by well basis with one seismically-based Section of interpretation for the Abenaki-Sable transition. Simplified schematics have been composed from my detailed lithologs of the well data. Seismic from publicly available sources is shown as a necessary complement for most wells. Although consisting mainly of wells of the Panuke Trend and including details of their cores, wells of the Western Shelf are also included for comparison of wells far from the Sable Delta.

Chapter 5 - Discussion-Interpretation examines the why and how the Abenaki platform and Sable Delta co-existed in close proximity for over 15 Ma, answering problem 1, and the possible deltaic effects on the platform carbonates answering problem 2. Two long cores are used to compare carbonates of the deltaic ramp versus platform carbonate as affected by the Sable Delta. Reservoir development and exploration implications are also discussed.

The final Chapter 6 - Conclusions synthesizes the findings as a whole summarized in an explanatory historical model and suggests future research.

Appendix A1 contains a detailed illustrated discussion and critique of previous work plus stratigraphic issues. (All appendix chapters and figures begin with the capital letter "A" to differentiate them from chapter 1 to 3 text and figures.)

Appendix A2 presents a search for possible analogues/models from the modern and Neogene for large delta/platform associations.

Appendix A3 holds detailed Abenaki carbonate well lithologs as enclosures.

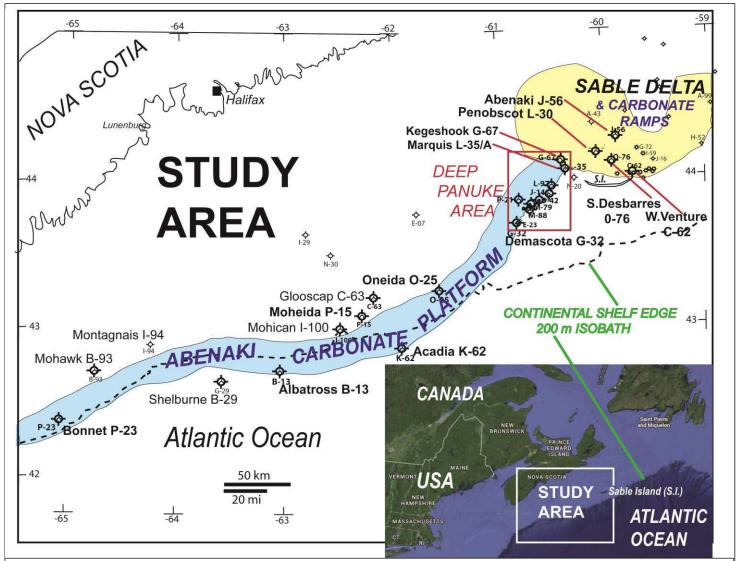


Figure 1.1 Study area and well location map. Southwestern Scotian Basin carbonate-bearing wells used in the study are in bold with the Late Jurassic Sable Island paleo-delta ('Sable Delta') and Abenaki carbonate platform outlined. The study concentrates on transition from the Deep Panuke area to Sable Delta with the Western Shelf mainly used for comparison. **Inset** shows the location of the Study Area on the continental shelf off Nova Scotia. Canada. See **Figure 1.2** for Deep Panuke area wells.

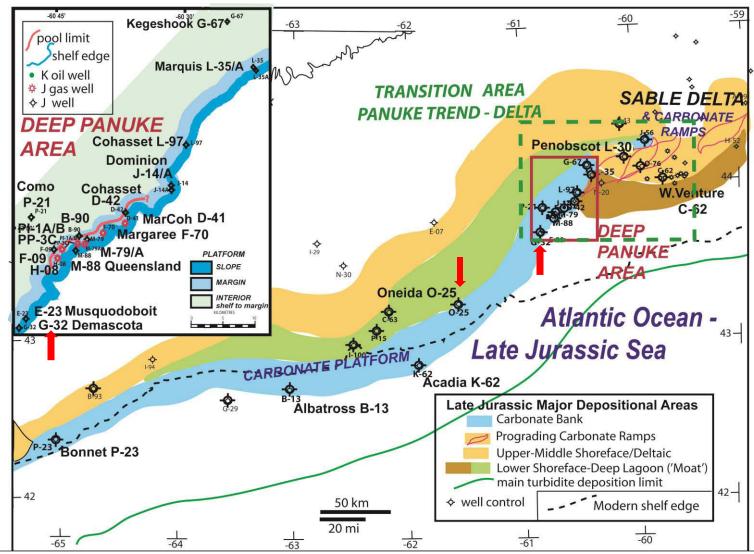


Figure 1.2 Abenaki Formation paleogeography southwest of Sable Island Delta and Deep Panuke well locations. Note the juxtaposition of the thick carbonate platform and the contemporaneous large Sable Island Delta with interbedded carbonate ramps. See Chapter 4 for well details. Red arrows indicate type section wells of **Figure 1.3**. Main map in part based on Pancanadian (John Hogg and Jim Dolph 1999 unpublished).

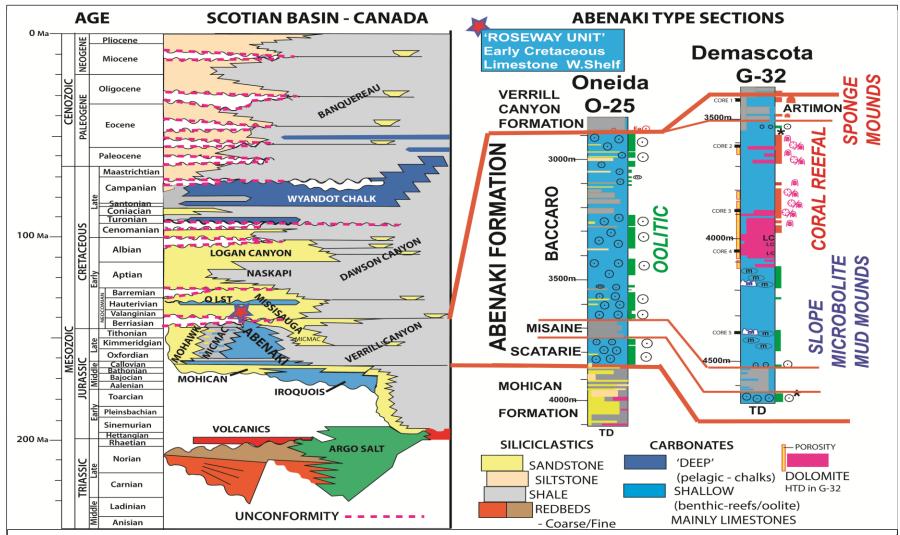


Figure 1.3 Stratigraphic column of Nova Scotia offshore and Abenaki type sections. The Scotian Basin stratigraphic column (modified Weston et al. 2012, OETR 2011) schematically shows the complex relationship of the Sable Delta terrigenous formations and the Abenaki whose platform termed the Roseway Unit extends into the mid Early Cretaceous. Oneida O-25 and Demascota G-32 bear the Abenaki Formation and its members' type sections as well as those of the Verrill Canyon and Mohican bounding formations (locations on **Figure 1.2**). These wells show the main Abenaki facies: oolites and the three main types of Late Jurassic reefs/mounds – sponge reef mounds, coral (& stromatoporoid) reefs, and microbolite 'mud' mounds. HTD = hydrothermal dolomite.

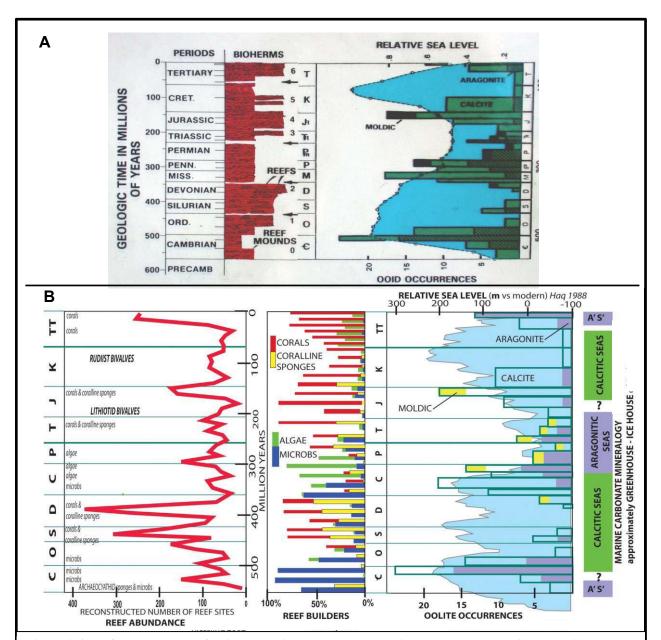
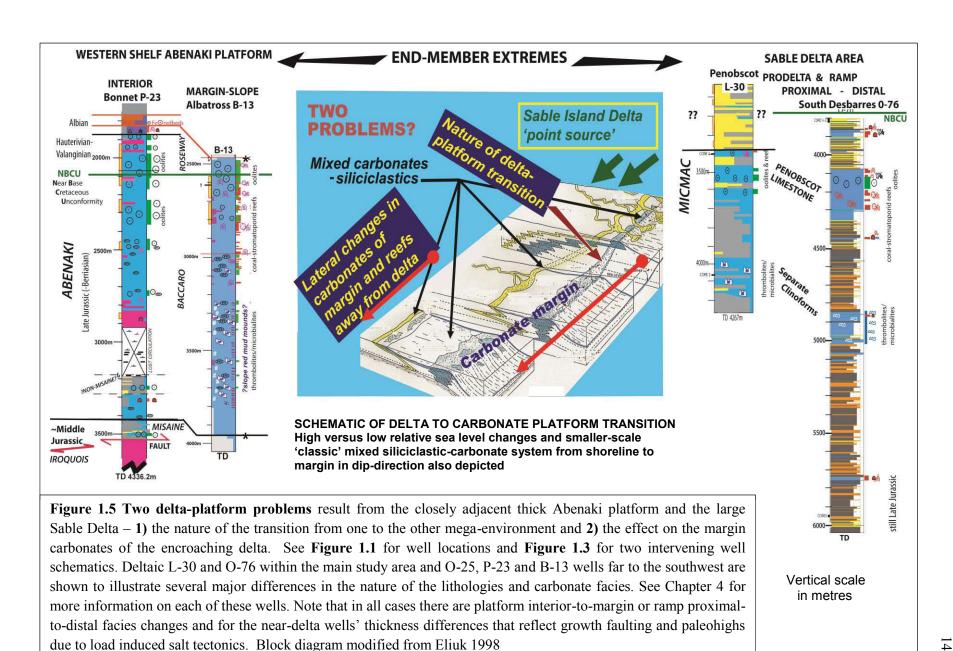


Figure 1.4 Reef abundance, reef builders, oolite abundance and mineralogy Phanerozoic comparison

A. Variations over time of the qualitative true reef-reef mound abundance and oolite (Eliuk 1987 Fig.1 discussion of Wilkinson et al. 1985 with Vail 1977 sea levels). B. Comparison of reef sites, reef builders, oolite and sea level using quantitative data on reefs and eustatic sea levels (left and centre columns modified after Kiessling 20002, right column after Wilkinson et al. 1985, sea level - Haq 1988, mineralogy - Sandberg 1983, ice/greenhouse - Fischer). Reef abundance peaks have been corrected for erosion by Kiessling (2002). The middle plots percentage-selected reef builders but with microbes-algae placed just left of corals-coralline sponges column to allow comparison. Note that the microbial reefs decrease with time and vary directly with the oolites in abundance and mineralogy even in the Jurassic (also see Riding and Liang 2005a&b). Reefs versus oolites vary inversely in the Paleozoic but directly in the Mesozoic-Recent even if the corals are aragonitic and the ooids calcitic. In A versus B high oolite abundances no longer closely correspond to transition times between highest and lowest sea levels for the Paleozoic but only after that era. In both A and B, the Late Jurassic has very high abundance (and varieties) of reefs and oolites in calcitic seas of a world-wide greenhouse climate and rising relative seal level. In the Cretaceous to modern seas pelagic calcitic nanoplankton become major carbonate producers. See Appendix A2.7 for further discussion and references.



CHAPTER 2. GEOLOGICAL SETTING AND PREVIOUS WORK

- 2.1 Setting and Short Survey of Abenaki-Sable Geologic History
- 2.2 Setting of Late Jurassic Continental Margin (Carbonate Gigaplatform) and Drainage of Eastern North America with Comparison to Gulf of Mexico Stratigraphy
- 2.3 Previous Work (Also see Appendix A1)

2.1 Geological Setting and Short Survey of Abenaki-Sable Geological History

This Section gives a short introduction to the stratigraphy, geologic history and setting of the Abenaki Formation with details of the complexities of the Abenaki platform/Sable Delta reserved for discussion in the following chapters as a main topic of this thesis. This is summarized from more detailed geological histories in Given (1977), Eliuk (1978), Wade and MacLean (1990), Poag (1991) Eliuk and Prather (2005), Kidston et al. 2005, Michard et al (2008), Pardo (2009), OETR (2011), and Weston et al. (2012).

The Late Jurassic paleogeography for the central North Atlantic and western Tethys Seaway is shown on **Figure 2.1** and for the Scotian Basin study on **Figure 1.2** with stratigraphic columns on **Figure 1.3**. The early Atlantic was a warm elongate small sea with the Nova Scotia side becoming much more humid as evidenced by coals and deltas. This is in contrast to its arid climate in the Triassic reflecting an interior location prior to the break-up of Pangea and the continuing mainly arid to semi-arid climate in Morocco where a mirror-image carbonate margin existed and even crops out near Agadir (Martin-Garin et al. 2007, Michard et al. 2008).

The Scotian Basin with several subbasins evolves from a rift system with major continental redbed fluvial-lacustrine deposition capped by CAMP (Central Atlantic Magmatic Province) basaltic flows and evaporitic conditions during its synrift phase. Following continental breakup and the formation of oceanic crust, a narrow basin was formed with a comparatively humid open ocean passive margin setting with an early carbonate-rich period then a terrigenous clastic-rich phase. This was followed by a flooded shelf margin with associated Late Cretaceous chalk to a long-continued low level of marine sedimentation on the continental shelf punctuated by an Eocene astrobleme on the western shelf (**Figure 1.3** and **2.2**).

The Abenaki responds to the opening and mid-oceanic ridge formation of a small mid-Mesozoic sea with peculiar seawater chemistry and warm temperatures at the western end of the Tethys Seaway that becomes the central North Atlantic Ocean (see **Figures 1.2, 1.3** and **1.4**). The upper Abenaki Baccaro Member carbonate responded, generally unsuccessfully, to tectonics associated with renewed rifting of the North Atlantic off Newfoundland and the input of a

continental-scale delta that eventually centered on the Sable Island area in the Sable Subbasin (Wade and MacLean 1990). Arguably the rapid regression in the lower Abenaki above the Misaine shale is global or at least circum-Atlantic in extent (Azeredo et al. 2002) and reflects Middle-Late Jurassic glaciation (Dromart et al. 2003).

The Abenaki occurs at the Jurassic continental shelf edge throughout the Scotian Basin when not replaced by deltaic terrigenous clastics and occurs as an age-equivalent shelf-edge carbonate in the Baltimore Canyon Trough. This is shown in **Figure 2.1** which also shows Morocco and Iberia with their age-equivalent strata uplifted and exposed due to Alpine orogenic inversion. Carbonates may have completely rimmed the early North Atlantic but can reliably be identified for the length of the eastern North American continent and into the Gulf of Mexico as the **Late Jurassic gigaplatform** (Poag 1991, **Figure 2.1** inset map).

The Abenaki Formation is mainly Middle and Later Jurassic in age but includes some Berriasian age carbonates. Dating of the Abenaki mainly follows the most current biostratigraphy of Weston et al. (2012) and OETR (2011) though some problems remain. On the Western Shelf the Abenaki platform continues into the Barremian-Aptian as the informal Roseway unit (Appendix A1 has a more detailed discussion). The Abenaki is mainly limestone and records the initial mid-oceanic ridge formation of the middle North Atlantic in its early cyclicity and major transgression (Eliuk 1978, Figures 1.3, 1.5, 2.1 and 2.2). The Abenaki ended around the level of an unconformity attributed to the Avalonian tectonics associated with the initial rifting of the north Atlantic (Wade and MacLean 1990; OETR 2011 and Weston 2012). This event is termed the NBCU (= Near Base Cretaceous Unconformity), and there is a time equivalent hiatus in the northern Gulf of Mexico and possibly in Baltimore Canyon Trough (Figure 2.2, Fig. 9 of Ringer and Patten in Eliuk and Prather 2005). Locally on the Western Scotian Shelf shallow-water carbonate deposition continued or was re-initiated in the Early Cretaceous, for instance as the Hauterivian-Barremian "O (oolitic) Marker" Limestone (Given 1977, Wade and MacLean 1990, Weston et al. 2012). It is also recognized in deep water to the east with rudistid bivalve-bearing Early Cretaceous limestone present on the J-Anomaly Ridge off the southwest Grand Banks (Gradstein et al. 1977, Figure 2.1),

The Abenaki consists of four members – the widespread **Scatarie** (Bajocian-Bathonian) composed mainly limestones that are often oolitic and cyclic; **Misaine** (Callovian) mainly calcareous shale; **Baccaro** (Oxfordian-Tithonian/Berriasian) that developed as a thick platform at the Late Jurassic continental shelf edge and is mainly limestone with scattered reservoir quality

hydrothermal dolomites, and the capping **Artimon** (diachronously Berriasian-Hauterivian = Neocomian, perhaps even Aptian-Albian of earliest Cretaceous age in Bonnet P-23) comprising argillaceous sponge-rich limestones and shale. The two well columns in **Figure 1.3** show the Oneida O-25 type section of the Abenaki Formation and the original Scatarie, Misaine and Baccaro members (McIver 1972) and the later Demascota G-32 well that included the fourth Artimon Member (Eliuk 1978). The formation is underlain by the Mohican Formation siliciclastics and overlain by the Verrill Canyon Formation shale (Given 1977). The contemporaneous Late Jurassic mixed sandstone-shale-limestone MicMac and deltaic siliciclastic Lower Missisauga formations are shown on **Figure 1.5** in the Sable Delta area wells and schematically in **Figure 2.2A**.

The basal Scatarie Member was deposited as a relatively thin but widespread platformal succession composed mainly of oolitic limestone. It was subsequently completely drowned and buried by transgressive Misaine Member shales, however carbonate deposition recovered but was never as widespread though it created much thicker successions. The subsequent carbonate sedimentation of the Baccaro (or Baccaro-MicMac) had two different styles – a thick continuous platform southwest of the Sable Island area and a mixed carbonate-siliciclastic system of ramps and distally steepened ramps to the northeast (**Figure 2.3**). The northeast area was dominated by terrigenous sediment with variably thick interbedded limestones and showed major seaward progradation. The southwest had an aggradational stationary margin that grew up to 1.5 km in thickness and continued growing in the Early Cretaceous on the far southwest.

The Artimon only occurs southwest of the Sable Delta discontinuously and is diachronously distributed. Arguably it should be placed in overlying formations (Wade and MacLean 1990 versus Eliuk 1978, 1985). The term 'Roseway Unit' was initially applied to the Early Cretaceous limestones on the Western Shelf on the nearshore ridge in Mohawk B:-93. This was later extended to include Cretaceous limestones indistinguishably overlying the Baccaro limestone (shown in **Figure 1.5**; Wade and MacLean 1990, MacLean and Wade 1993, Jansa 1991, 1993 on usage). The Roseway could even be included in the Abenaki as a fifth member (see **Figure 4.60** and Appendix A1.13 for nomenclatural suggestion of designating the Roseway a member in a number of formations). Note that Weston et al.'s (2012) Albian-age carbonate included in the uppermost Roseway of Bonnet P-23 is actually a red coated iron carbonate succession recording starved, extremely slow submarine sedimentation underlain by argillaceous skeletal limestone rich in lithistid and stromatoporoid sponges suggestive of Artimon facies.

Contemporaneously the Sable and earlier Laurentian paleo-deltas were prograding southwestward and seaward in the Laurentian Channel to the Sable Island areas mainly after the Callovian Misaine shale was deposited. The base Misaine/top Scatarie is recognized as a key regional seismic reflector though it is never reached by wells in the Sable Subbasin or in shallow successions northeast of Sable Island. Although this latter area is not dealt with in this thesis. wells show that during the Jurassic deltaic sedimentation alternated with shallow-water oolitic to mudstone carbonates. These carbonate sediments can be as thick as 200m continuously and greater then +1000m with 40% siliciclastics as in Dauntless D-35 (Eliuk 1978, see Figure 2.1). Seismic mapping (Wade and MacLean 1990, Fig. 5.25 and 5.28) shows the termination of the Scatarie reflector on the northeast shelf 30 km or more northwest of the eventual end Late Jurassic shelf flexure. Thus a mixed carbonate-siliciclastic system prograded 30km or more on a 200km front during the Late Jurassic from the Laurentian Channel to the Sable Island area where the Sable Delta was located. Similar mixed sedimentation occurred on the southwest flank of the Sable Delta and is included in this thesis. Appendix A1 on previous work gives more background on the development of the understanding of the Abenaki. This relationship is shown schematically in different depictions of the Late Jurassic Scotian Basin over the years on Figure 2.3.

2.2 Setting of Late Jurassic Continental Margin (Carbonate Gigaplatform) and Drainage of Eastern North America with Comparison to Gulf of Mexico Stratigraphy

Bob Ginsburg, the long-time proponent and originator of comparative carbonate sedimentology, wrote an article (Ginsburg 2005) on "disobedient sediments" and their feedback relationships. His examples included grainy sediments like onlite shoals and crinoids that subsequently determined tidal currents or inhibited growth of other organisms and the 1600 km long fluid mud flats northwest of and fed by the Amazon River that so dampen the waves that they face the open Atlantic Ocean.

Analogously, the presence of the large Sable Delta beside the thick Abenaki carbonate platform might be considered an example of "disobedient depositional systems" in comparative basin studies since typically they do not occur together but have somehow interacted over a long time period. Like Ginsburg's (2005) 'disobedient' oolites, encrinites, and river-sourced muds, the Abenaki-Sable too had interesting feedback relationships. **Figure 2.2A** illustrates simplified stratigraphic columns of the Scotian Basin versus the northern Gulf of Mexico and **Figure 2.2B** shows a schematic map of the eastern seaboard of North America in the Late Jurassic. Together they are used to contrast the two major deltaic areas at either end of the world's longest

Phanerozoic reef-tract carbonate platform. A comparison is drawn to the much larger Cenozoic-Recent Mississippi Delta and the Late Jurassic-Early Cretaceous carbonate ramps and platforms in the Gulf of Mexico – the archetypical continental drainage system and well-studied Mesozoic platforms with well control in the tens to hundreds of thousands. The Gulf carbonates are well behaved or "obedient" in being either on the outer shelf relative to the inboard shelf siliciclastics, or reciprocal, but not present at the same place and time. In the Late Jurassic and also the Early Cretaceous for the Gulf of Mexico (= GOM) both it and the Scotian areas are mixed carbonate-siliciclastic systems. However the expectation of an analogue for the Abenaki from the GOM was dashed because the continental scale Mississippi River and Delta only started after the mid-Cretaceous and at the end of significant shallow-water carbonate deposition in the northern GOM.

Both the Baltimore Canyon Trough (BCT, see Appendix A2.5 for details) and the GOM have Late Jurassic-Early Cretaceous inboard parallic-to-deltaic siliciclastics and outboard carbonate platforms or ramps. This is the same style for part of the Abenaki located on the Nova Scotia Western Shelf. Both the GOM and BCT carbonate platforms originated over earlier prograded siliciclastic shelves, arguably for BCT and definitely in GOM as shown by well control, (see Meyers 1989 and Galloway 2011 respectively). The two US examples thus differ from the Western Shelf Abenaki margin which is nearly stationary and developed above basement highs. However in addition and uniquely the Abenaki has a major contemporaneous delta that cuts through the carbonate platforms near Sable Island. Only laterally and close to the Sable Delta do Abenaki-like carbonates of various thicknesses cap Late Jurassic to earliest Cretaceous deltaic sediments during a final period of prograding mixed-system ramps. This complicated relationship is possibly implied on OETR'S (2011) Nova Scotia stratigraphic column (Figure 2.2A) by the term "LOWER" seaward of the Abenaki. This includes not just the lower Missisauga, but also the MicMac Formation that by definition can have sandstones, shales and limestones in highly variable thicknesses and proportions.

In the opening Section, many Abenaki features were said to be unusual and were listed, but the presence of thick clean carbonates along a continental shelf edge laterally and closely adjacent to a contemporaneous very large delta has to be the most unusual, possibly unique relationship in the modern and geological record. Nevertheless there are two well-known mixed-system scenarios which certainly apply to GOM: 1) contemporaneous mixed carbonate-siliciclastics due to near shore siliciclastics fed by smaller-scale deltaic and inter-deltaic deposition with offshore-to-shelf edge carbonate shelves and 2) large-scale reciprocal sedimentation of non-contemporaneous carbonates and siliciclastics. The first of these is quite

appropriate for the nearshore-to-offshore facies of the Abenaki-Mohawk formations on the Nova Scotian Western Shelf portion (Eliuk 1978). However neither of those two mixed-systems is adequate in explaining the close Abenaki-Sable association.

So the Abenaki is the carbonate part of two mixed carbonate-siliciclastic systems – one fairly common as described and one highly unusual namely the Sable Delta-Abenaki platform juxtaposition (see central panel in **Figure 1.4**). Studies of margin position and drainage supply for the western Atlantic to Gulf of Mexico for the Late Jurassic and Recent are important for understanding the land-ocean linkages of these systems' unusual association. (Blum and Roberts 2012, Galloway 2009, Galloway et al. 2011, Jansa in Gradstein et al. 1990, Miall and Blakey 2009, Milliman and Farnsworth 2011, Poag 1991, Poag and Sevon 1989, Poag et al. 1990, Poppe and Poag 1993, Romans and Graham 2013, Syvitski and Milliman 2007). From some of these workers a summary continental-shelf edge map shows the carbonate margin of Poag's (1991) Jurassic gigaplatform with river input versus the present day shelf edge (**Figure 2.2B**). Stratigraphic charts (**Figure 2.2A**) modified from Nova Scotia offshore of Weston et al. (2012), OETR (2011) and Gulf of Mexico of Galloway (2008) allows a comparison of depositional styles and timing.

The reason the Sable-Laurentian paleo-delta is considered continental scale is because it is one of only two areas along the continental shelf that, like the later Mississippi in the northern GOM, progrades over the Late Jurassic (and Early Cretaceous) carbonate margin such that the present-day continental shelf edge (200 m isobath) is basinward as shown on Figure 2.2B. Elsewhere between the Sable-Laurentian and the later Mississippi deltas, the Late Jurassic carbonate continental margin is beyond the modern 200m shelf edge indicative of relatively modest land sediment input since that time. Indeed, in the Heezen Submarine Canyon on Georges Bank continental slope Early Cretaceous (Berriasian) Roseway-Abenaki carbonates actually crop out and were interpreted to be reefal (Ryan et al. 1978, Ryan and Miller 1981). The post-Jurassic sediments are typically siliciclastics except in the Blake Plateau and Florida-Bahamas. There terrigenous sediment is lacking and results in either a drowned relict carbonate shelf in 800 m water depth or continued carbonate sedimentation in a much reduced area including large isolated carbonate banks. In contrast, in the two deltaic areas the shelf edge prograded well into the oceanic basins. In the case of the Abenaki-Sable however, progradation is on the order of 100 km versus 300 to 400 km for the northern GOM. In the latter, not only the shelf edge but even the shoreline moved beyond the former Mesozoic carbonate shelf edges during a similar time span of about 50 Ma, indicative of a far greater sediment supply.

Since the Late Cretaceous three continental-scale river drainage systems existed in eastern/central North America – the early Tertiary Hudson Bay-Labrador "Bell River" emptying into the Saglek Basin (McMillian 1973), and the current St. Lawrence and Mississippi rivers (all three in Fig. 1 of Sears 2013 after Duk-Rodkin and Hughes 1994). The first and last of these terminated in major deltas, emptied in former epeiric seaways (Zeigler and Rowley 1998) and were involved in complex river capture histories (Sears 2013, Cox and Van Arsdale 2007). Perhaps it is a coincidence that the mid-Cretaceous timing of major deltaic sedimentation cessation on the Scotian Shelf is the same as the initiation for the Mississippi Delta as dramatically obvious on the simplified small stratigraphic columns (**Figure 2.2A**).

Equating common timing to common origin is tempting – namely continental river capture after the collapse of the Appalachian-to-Ouachita mountain barrier so drainage changed to the south instead of flowing somewhere to the interior and conjecturally to the northeast. The collapse that allowed the Mississippi River to begin reaching the Gulf of Mexico is the final part of the explanation for the Mississippi Embayment (Cox and Van Arsdale 2002, Van Arsdale and Cox 2007). Their explanation of the Mississippi Embayment origin calls for uplift above the Bermuda Hot spot during the Cretaceous superplume event beneath the formerly continuous mountain belt such that it is differentially eroded. It then subsides with continued continental plate movement westward to leave a low after the mid Cretaceous, and, a locus for the embayment and river. However, large scale river capture is rare (Bishop 1995).

The different size scale of the two deltaic infills is not very comparable but much more significantly, detailed provenance studies show that most of the Scotian Basin sediment comes from nearby land in the Maritimes and Labrador-Newfoundland (Pe-Piper et al. 2005, Pe-Piper et al. 2013, Zhang et al. 2013). Their pattern of river drainage shown on **Figure 2.2B**, is still a large area that with a humid subtropical climate may be sufficient to create a delta the size of the Sable-Laurentian. The present day water discharge of the St. Lawrence River is Canada's largest but its sediment load is negligible with no associated delta despite being claimed by many as the world's largest estuary (Milliman and Farnsworth 2011, see Appendix **Table A2.4** for a table of large coastal rivers). But the fact that it cuts through the Appalachian mountain ranges can be taken as evidence for an ancient drainage system that pre-dates some of the mountain building. So it is speculatively included as existing in the Late Jurassic.

This interpretation would be similar to that of Poag (1991, Poag and Sevon 1989, Poag et al. 1990) where the present-day eastern USA river systems were considered to be already feeding

the Baltimore Canyon deltas and deep-sea fans starting in the Mesozoic. Certainly large-scale river capture is a very unlikely hypothesis, but the drainage basin for the Scotian Basin is approaching at least sub-continental size. For whatever reason, significant deltaic sedimentation essentially ceases off Nova Scotia in the mid Cretaceous. Some of that could be attributed to the worldwide high sea levels of the Late Cretaceous with both the GOM and Scotian Basin having significant chalk deposits and much reduced sandstone influx (compare Figure 2.2A). But deltaic sedimentation in the latter does not restart in the Cenozoic as it does in the GOM. However, as shown by the modern St. Lawrence River, a large drainage basin and a lot of water does not necessarily mean a lot of sediment (Appendix Table A2.4).

This late origin that post-dates most shallow-water Gulf of Mexico (GOM) carbonates shows the Mississippi Delta cannot be an analogue for the Sable-Abenaki. Even the older GOM is not appropriate at least not for the stationary carbonate platform bisected by a prograding delta transition. But it has some instructive similarities to the GOM, with alternating carbonates and siliciclastics on and flanking the prograding Sable Delta itself (see Appendix A2.5 for details on a GOM Jurassic example if not analogue). The early history of the northern GOM Mesozoic is an instructive lesson in contrasts showing what could be considered the more usual relationship of mixed carbonate-siliciclastic systems. As elegantly summarized in a series of maps by Galloway (2008), the depositional evolution of the Gulf of Mexico is seen as an alternating stack of either wholly siliciclastic sedimentation versus mainly carbonate phases that have a nearshore siliciclastic component (rarely locally evaporitic when the platform is sufficiently large and arid) and an offshore platform that has an only slightly mobile set of reefal margins during the Early Cretaceous (see simplified stratigraphic column Figure 2.2A). As with the world-wide high-sea levels of the Late Cretaceous so evident on both columns, they both share a post-Jurassic unconformity involving the basal Cretaceous Berriasian-Valanginian. This is also about the time Cuban carbonate platforms became much reduced (Pardo 2009) and the Baltimore Canyon platform drowned (Meyer 1989, Prather 1991, Pattern in Eliuk and Prather 2005). Poag (1991) stated much of the Late Jurassic gigaplatform ended just after the Late Jurassic. He cited Eliuk (1978) for timing of Abenaki termination which was then interpreted to be circum-Atlantic and linked to subsequent deep sponge reef growth. Appendix A2 further surveys world river systems and platforms for possible analogues and models that may help to understand the Abenaki-Sable relationship.

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2.3 Previous Work (Also see Appendix A1 and footnote)

This is an abbreviated review of previous publications including non-formally peer-reviewed articles available on the internet relevant to the Abenaki-Sable carbonate platform-delta transition. **Appendix A1 – Previous Work and Stratigraphy Critique**⁴ - has extended discussion including annotated comments on selected published illustrations.

Sources both published and industry data on geometries were particularly helpful contributions that used and showed seismic relevant for imaging and mapping the Abenaki and the transitional area near the Sable Delta. Some of these key sources were Shell-associated work (Eliuk 1978; Eliuk, Levesque and Cearley 1985: Ellis, Crevello and Eliuk 1985), Encana-associated work (Wierzbicki, Harland and Eliuk 2002, Wierzbicki et al. *including Eliuk* 2005, Weissenberger et al. 2006), Geological Survey of Canada work (Wade and MacLean 1990, MacLean and Wade 1993), Canada-Nova Scotia Offshore Petroleum Board-associated work (CNSOPB; Kidston et al. 2005, CNSOPB bids 2012 NS12-1) and Offshore Energy Technology Research Association-Play Fairway Analysis-associated work (Play Fairway Analysis OETR 2011, Weston et al. 2012) and most recently Qayyum et al. (2015) interpreting the small Penobscot 3D survey.

The presence of a large delta beneath Sable Island was known very soon after the first offshore well was drilled by Mobil Canada in 1967. Regional drilling by Shell Canada soon established that thick carbonate banks existed not far from that delta both to the southwest and interbedded with siliciclastics to the northeast. The thinner prograding carbonate ramps seen

⁴ Author's Abenaki involvement: Leslie Eliuk has been involved with the Abenaki for nearly a half century working for Shell Canada (1969 – 1999) and then consulting to Encana (formerly Pan Canadian), El Paso Canada, Ammonite Nova Scotia and Beicip-Franlab for the Play Fairway Analysis (OETR 2011) among others as GeoTours Consulting Inc. The first Abenaki carbonate margin well with all three Late Jurassic reef/mound types cored was located, wellsite sat and made public by him. That interest starting in 1973 continued and was reinvigorated by the discovery of the Encana Deep Panuke carbonate margin reefal gas field in 1998. John Wade of the Geological Survey of Canada encouraged his first publication on the Abenaki Formation (Eliuk 1978, 90 pages). Subsequent Abenaki relevant publications (*= peer reviewed) and core presentations include the following: Eliuk (1981, 1985*, 1987, 1988*, 1989*, 1998*, 2000, 2004*, 2008, 2009, 2010a, 2010b), Eliuk et al. (1986), Eliuk and Levesque (1988*), Eliuk and Pemberton (2002), Eliuk and Prather (2005), Eliuk and Wach (2008, 2009, 2010a, 2010b, 2014a, 2014b), Ellis et al. (1985*), and Wierzbicki et al. (2002, 2005). All the drill cuttings and core logging and interpretation of new Encana wells was provided by Eliuk to Rick Wierzbicki and Nancy Harland of Encana and used in Weissenberger et al. (2006) and Wierzbicki et al. (2006). Similarly discussion, interpretation and 12 new well logs and all the 1978 wells were provided to Stefan Doublet and Beicip-Franlab for use in Chapter 9 Play Fairway Analysis (OETR 2011).

seismically were first cored by Penobscot L-30. The nature and relationship of that well is a key to understanding the transition between delta and carbonate bank. Penobscot L-30, drilled by Petro-Canada and Shell in 1976, is located just north of Sable Island and in an intermediate position between the Jurassic-Cretaceous Sable Delta and the thick Abenaki carbonate platform as also shown by its mixed siliciclastic-carbonate lithologies. The first published interpretation of Penobscot L-30 limestone and its correlation based on biostratigraphic paleo-markers was in Eliuk (1978, p. 496 of Appendix). Seismic and further interpretation of Penobscot L-30 was first shown in Eliuk et al. (1986) and published in Ellis, Crevello and Eliuk (1985) and subsequently in Jansa et al. (1988), Jansa (1991, 1993) and MacLean and Wade (1993).

Although the closely adjacent location of these very different sediment accumulations was known almost at once, the rarity and very unusual nature of their juxtaposition seemed not to be appreciated or at least not mentioned as strange for decades. In the original definition of the Mesozoic offshore Nova Scotian stratigraphic units, McIver (1972) anticipated the mixed nature of the Jurassic sediments by grouping the dominantly limestone Abenaki Formation with the siliciclastics and lesser associated carbonates of the MicMac and shales of the Verrill Canyon formations all together in the Western Bank Group. Jansa and Wade (1975) mapped the Western Bank Group showing the delta and carbonate banks. Soon the Mohawk Formation of mixed carbonate-siliciclastics on the western shelf was found to be Late Jurassic-Cretaceous in age. So the Mohawk was also placed in the Western Bank Group and the Mohican Formation replaced it for older underlying Middle Jurassic sediments by Given (1977). Given also showed the diachronous nature of the top Abenaki in maps.

Just how much carbonate is needed to support the use of Abenaki as opposed to MicMac terminology is debatable (see Appendix A1.04 on Wade and MacLean 1990). Both Wade and MacLean (1990) and Ellis (1984, Ellis et al. 1990) interpreted a much lower angle slope morphology in what became known as the Panuke Trend of Kidston et al. (2005) of the Abenaki platform than that shown by Eliuk (1978). More recent seismic and well control associated with the Deep Panuke gas field play (Kidston et al 2005, Weissenberger et al. 2006) showed the Abenaki carbonate platform slope was quite steep not only on the Western Shelf but also relatively close to the Sable Delta. However the interbedded carbonates and siliciclastics lateral to the Sable Delta do show gradual slopes of ramps and distally steepened ramps (Eliuk 1978, Eliuk et al. 1986, Welsink et al 1989, Jansa 1991, 1993, Kidston et al. 2005).

Depictions of the Late Jurassic Scotian Basin on Figure 2.3 (Eliuk 1978, Wade and MacLean 1990, OETR 2011) show that this two-fold style of shelf-slope morphology was recognized early and depicted similarly as a southwest stationary aggrading platform margin separated by the main Sable deltaic depocentre from northeast prograding ramps of mixed siliciclastics and lesser amounts of carbonates (Jansa and Lake 1991, Wade 1991). These previous authors differed in seeing the extreme northeast shelf Banquereau Bank near Dauntless D-35 and the Laurentian Channel as an isolated carbonate bank continuing into the Early Cretaceous (Jansa and Lake 1991, Jansa 1993) as opposed to a mixed system dominated by siliciclastics (Wade and MacLean 1990, Wade 1991). Subsequent dating using palynology, micropaleontology and nannofossils (Weston et al. 2012) indicates the carbonates end in the Late Jurassic and it is only in Dauntless D-35 that the limestone is as high as 60% of the interval (Eliuk 1978). There is a seismic argument that a deep block underlies that area acting as a paleohigh and in fact is a remnant of Africa analogous to the much older Meguma Group remnant (John Harper CSPG talk 2007 and pers. comm. 2007, 2016). The presence of sandstones in Dauntless D-35 at several levels indicates that even if a paleohigh it was not isolated from siliciclastic influx.

Welsink et al. (1989) interpreted a long-continued extensional regime established with the initial rifting that formed the Atlantic Basin to explain the shape and fault distribution as well as its hydrocarbons of the Scotian Shelf subbasins. Their linkage to some of the tectonic events on the Grand Banks and Iberia was repeated in part in the PFA Chapter 9 (OETR 2011) for margin depositional style changes and unconformities in the Late Jurassic and NBCU (Near Base Cretaceous Unconformity). Their depiction of the Hauterivian-Barremian O Marker Limestone (Welsink et al. 1989, fig. 18) that subdivides the Missisauga Formation may be an analogue for some of the MicMac-Abenaki ramp carbonates of the underlying older Sable Delta flanks. Wade and MacLean's (1990 Fig. 5.33, also see Fig. 2.3B) interpretation was based on newer seismic with isotime mapping of major intervals and many more wells in the Sable Delta area, and showed the importance of growth faulting contemporaneous with deltaic deposition and thinner, usually oolitic, limestone interbeds. They showed various named limestone members of the MicMac Formation down-dropping across faults. Subsequent biostratigraphy using palynology, micropaleontology and nannofossils (Weston et al. 2012) has shown some of these correlations are not supported by age dating.

Wade and MacLean (1990) like Ellis (1984) interpreted a ramp-like transition of the carbonate platform into the basin but subsequent 3D seismic and well control shows that cannot be the case at Deep Panuke where the slope is relatively steep. Wade and MacLean's interstratified

carbonate-siliciclastic ramp model is possible basinward of the last thick continuous carbonate in Abenaki J-56 into the immediate Penobscot area to somewhere north of the Marquis L-35 margin test that drilled continuous slope, reefal and oolitic carbonate (Figure 1.2). Cummings and Arnott (2005) interpreted shelf margin deltaic settings with incised valley channels for several of the Early Cretaceous Sable gas fields. The Venture field area of Late Jurassic-earliest Cretaceous age is a contemporary of the Abenaki carbonate platform and was seen as such. Gould et al. (2012) mainly concurred but interpreted considerably fewer incised valleys and more lateral continuity of the deltaic facies. At the base of a long set of cores the #9 Limestone marking the top MicMac was erroneously thought to be a transgressive condensed lime mudstone (acid etching revealed a complex of carbonate facies – see Section 5.2 example #1). Carbonates can be sensitive indicators of depositional paleo-environment and likely paleo-depths. The #9 is much more varied with microbolite bindstone mound and sponge-coral reef mounding. It may give the missing paleoecological evidence in Venture for Cummings and Arnott's (2005) interpreted forced regression of the initial sequence at least. At any rate it is the extreme thin end member for carbonates in deltaic settings and will be discussed further in Sections 4.01 and 5.2.

Pancanadian's 1998 discovery of the Deep Panuke reef margin gas field resulted in much more seismic and a near doubling of well control plus follow-up publications. Kidston et al. (2005) used this modern seismic to review most of these new and older wells in the Abenaki southwest of Sable Island in a regional study of the carbonate margin and interior including some seismic from possible analogue basins. They subdivided the Abenaki bank margin into three segments, and from southwest to northeast were designated the Shelburne (with no well control), Acadia (with a few older wells drilled on the modern continental slope) and Panuke (with many new wells). Their emphasis was on the Abenaki carbonate reservoir potential, not the relationship of the Abenaki-Sable Delta and its ramps. They even included seismic from a couple new wells that were omitted in operator publications due to confidentiality. Many of their detailed seismic profiles have been used in this thesis to illustrate the setting of key wells in the Results chapter.

Encana (previously Pancanadian) geoscientists placed a lot of data on the Abenaki and their new wells into the public domain relatively soon after and even during Deep Panuke field development – Weissenberger et al. (2000), Wierzbicki et al. (2002), Wierzbicki et al (2005, 2006), Encana (2006, development report to CNSOPB), and Weissenberger et al. (2006). All these publications concentrated on the petroleum geology of the Deep Panuke gas field and its discovery, facies, sequence stratigraphy, reservoir development and diagenesis. Late diagenesis particularly burial dolomitization and hydrothermal leaching were the main reservoir creating

process and even resulted in partial lateral stratigraphic trapping with shallow-water carbonates acting as both tight seal and porous reservoir (Wierzbicki et al 2006). Except for their conceptual schematic block diagram (Weissenberger et al. 2006, Fig. 12) and their regional paleogeography map (their Fig. 7, see Figure A1.14), the relationship of the Deep Panuke area Abenaki carbonate bank to the Sable Delta was not considered. The schematic block diagram showed small margin pinnacles and minor siliciclastic-filled inter-reef channels (Weissenberger et al. 2006 Fig. 14). Curiously the only two cores used as sequence examples in Weissenberger et al. (2006, Fig. 17) were dominantly siliciclastics northeast of the Abenaki carbonate platform. Encana's sequence subdivisions, often based on the presence of thin sandstones, were based and age dated in the deepest field well (Appendix II by B.G.T. van Helden in Weissenberger et al. 2006). Their sequences are applied in this thesis to the wells in the Panuke Trend to generate a set of lithofacies maps that show lateral and vertical changes over time. The vertical changes in the uppermost Abenaki facies to argillaceous sponge-rich carbonates also provided additional top-seals and perhaps a waste-zone below the Verrill Canyon Formation shales.

The large, well-illustrated and detailed Play Fairway Analysis (PFA, OETR 2011) dealt with the Abenaki carbonates mainly in their Addendum Chapter 9 'Late Jurassic Carbonate Play,' dealing only with the area southwest of Sable Island. It concentrated on the upper Abenaki carbonate platform southwest of the Sable Delta. **Figure 2.4** illustrates some of the results with facies mapping of their four major seismically defined Abenaki intervals. Details derived from seismic interval mapping on the prodeltaic sediment infill in front of the Abenaki carbonate platform nearest the delta with potential for loading flexure is an aid in understanding the delta-platform interaction. Penobscot L-30 was the furthest northeast well specifically discussed and illustrated on a correlation section in PFA (OETR 2011). Areas over the whole shelf were dealt with in the other chapters though not in as much detail as for the Abenaki.

PFA Chapter 5 and its associated annexes on structure are useful for the greater coverage at the top (J150 – top carbonate) and near the base (J163 – Scatarie). Penobscot L-30 was the one example of carbonate ramp shelf oolitic and quartz sandstone and prodeltaic slope shale interbedded with microbial carbonate slope deposits in proximity to the Sable Delta and its siliciclastic shelf. But no seismic nor interpretation of L-30 or the apparent shelf edge to the west were given.

Paleontological or biostratigraphic studies were done for the PFA as a whole in PFA Chapter 3 and then supplemented by four additional wells in PFA Chapter 9. Perhaps not

surprising for such a large and multi-authored study there are some inconsistencies and even omissions of particular wells and dating from one part of the study to the other. A major contribution was the revision and new biostratigraphy that was further modified by the involved authors in Weston et al. (2012). A complicating factor was the common reworking of older fossils into younger sediments with resulting confusion and need for caution. Similar problems of reworking were noted for the Jurassic carbonates off the United States East Coast by Poag (1991). However the details of the diachronous termination of the top Abenaki platform (Figures A1.20 and 5.11), do aid in understanding the influence of the Sable Delta. And the fact that some of the carbonates interbedded with the deltaic siliciclastics are both older and younger than the top carbonate platform is important for realizing that that the two areas are likely independent systems as regards carbonate growth and sediment input. Some of these diachronous changes with loss of carbonate at the top are also recorded by seismic correlation from southwest to northeast in the PFA study and independently by Ammonite Nova Scotia (pers. comm. Bob Merrill and Kevin Hill 2011). Appendix A1 provides more discussion, details and annotated illustrations that are not germane to this thesis topic but might be helpful for Abenaki researchers making use of the study and comparing it to Encana's sequences and Qayyum et al (2015) third sequence proposal. Appendix Figures A1.17, A1.20 and A1.21 with my annotations are particularly useful to show some of the problems.

Qayyum et al. (2015a) is one test case study of a relatively new automated procedure of sequence and seismic stratigraphic analysis applied to the Penobscot 3D survey and some regional 2D lines at the Abenaki-early Sable Delta stratigraphic level (see Appendix A1.11, Section 4.02 and 4.05, Figures 4.12-4.14, 4.24 and 4.39). The location, amount of seismic data and the apparent ability of the technique to give interpretable patterns within what are usually massive carbonates makes their study a very useful addition to understanding the transitional area. Based on their analysis of the seismic using Wheeler diagrams, a sequence stratigraphic scheme was proposed for the Abenaki. No detailed discussion of their seismic sequence stratigraphy for the whole Abenaki is given here since biostratigraphic dating in key carbonate wells invalidates the key basic assumption of the synchronous age of top carbonates as discussed below. The other required assumption that no tectonics can occur during use of the technique is likely invalid given the geometries occurring above, below and within the Late Jurassic sediments in the Penobscot area. This does not necessarily invalidate the use of their seismically-based sequencing for gaining insights of more limited areas near Penobscot. However major revision of its relationship to the main Abenaki would be needed and should include biostratigraphically-dated well control since only one well that does not have revised biostratigraphic analysis was used in the study. Nevertheless their processing techniques, if valid, give important carbonate sedimentological insights, and some of their lines are used in the Results chapter. Particularly significant contributions, that complement my facies interpretations from well lithologs, are the evidence for probable deep-water mounding on the slope of the lower Abenaki and apparent separation of shelf-edge margin reefs from shelf interior sediment at various times and places.

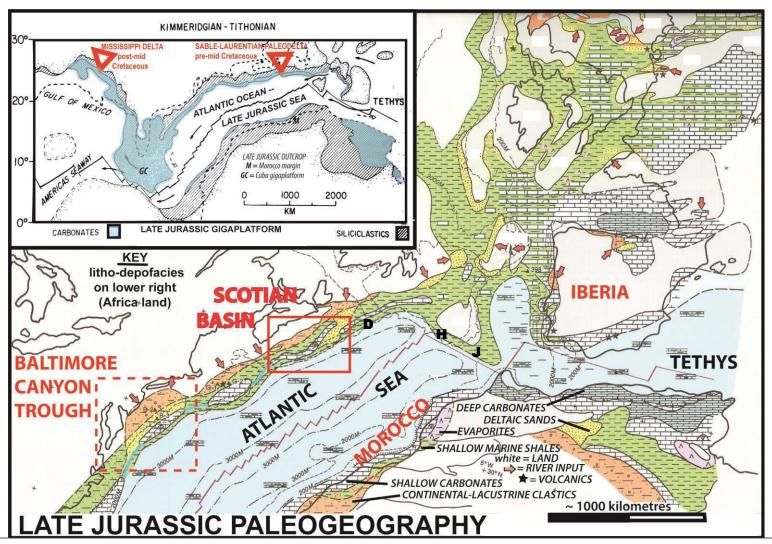


Figure 2.1 North Atlantic Late Jurassic paleogeographic setting (modified after Jansa in Gradstein et al. 1990). Red boxes show two areas offshore western Atlantic with well control at the carbonate margin of the Late Jurassic gigaplatform. See Fig.1.2 for details of Scotian Basin and see Figure A2.6 and A2.7 for details of Baltimore Canyon Trough. D = Dauntless D-35, H = Heron H-73, J= J-Anomaly Ridge DSDP site 384 (Early Cretaceous shallow-water carbonates). INSET: Late Jurassic gigaplatform map (Poag 1991 modified) shows the extent of the longest Phanerozoic reef tract-carbonate platform (Kiessling 2001) and the location of two continent-draining major deltas but only the Sable-Laurentian is contemporaneous; in contrast the post-Mesozoic Mississippi is typical of very large deltas in lacking associated carbonates, GC and M show the Late Jurassic outcrop areas of NA gigaplatform in Cuba and mirror-image reef margin in Morocco Western Atlas coast.

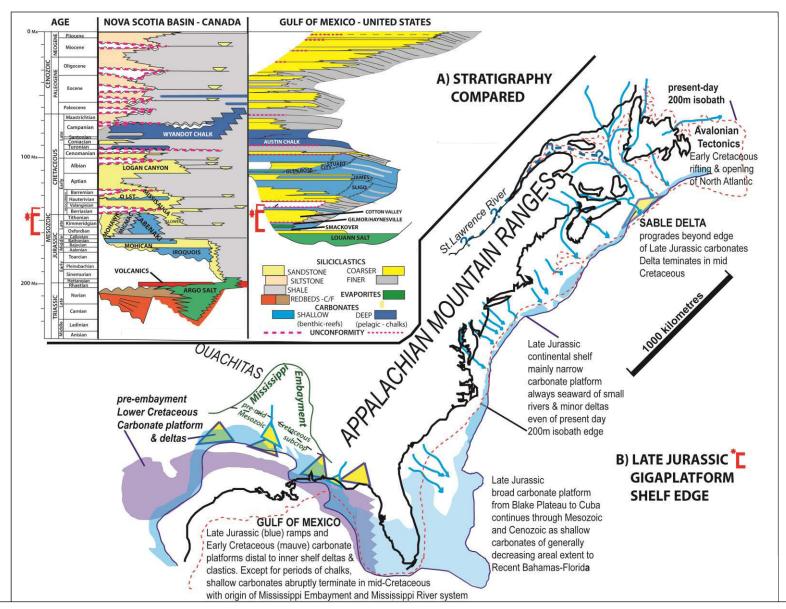


Figure 2.2 Comparison of two North American continental-scale deltas of different ages and different relationships to major carbonate platforms. A) Comparison of stratigraphic charts (Scotian after, OETR 2011, Weston et al. 2012; Gulf after Galloway 2008) and B) paleogeographic sketch (compiled from Poag, 1991, Jansa in Gradstein et al. 1990, Cox & Van Arsdale 2002, Pe-Piper et al. 2013). See Appendix Figure A1.32 for enlarged and more detailed depiction of Figure 2.2A.

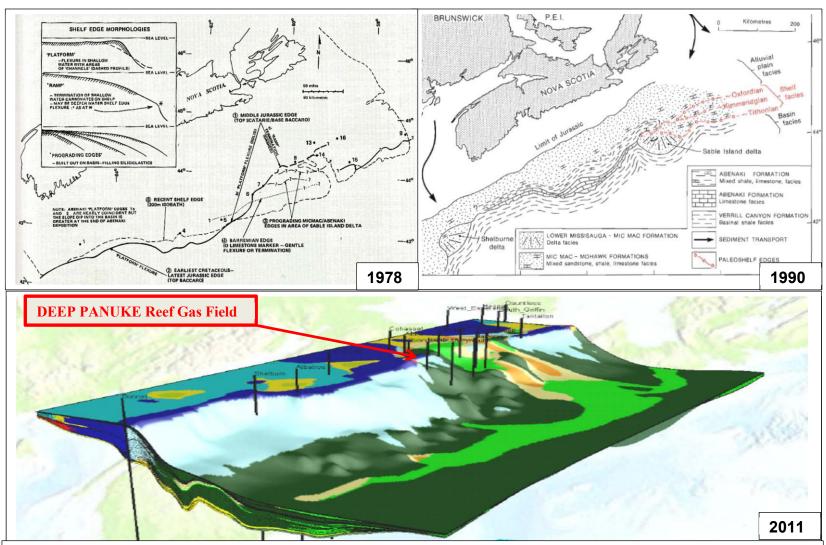


Figure 2.3 Successive study visualizations of the Late Jurassic Scotian Shelf with two main areas of carbonates separated by the Sable Island Delta. The delta gas fields and Panuke reef margin discovery are located in the transition between the northeast shelf prograding mixed siliciclastics—carbonates and the southwest shelf aggrading carbonate platform. 1978- Eliuk (1978) presenting Shell Canada exploration results. 1990 — Wade and MacLean (1990) Geological Survey of Canada study. 2011 — OETR (2011) Chapter 9 Play Fairway Analysis by Beicip-Franlab (Stephan Doublet team lead) using new data after 1998 Encana Deep Panuke discovery (Weissenberger et al 2006).

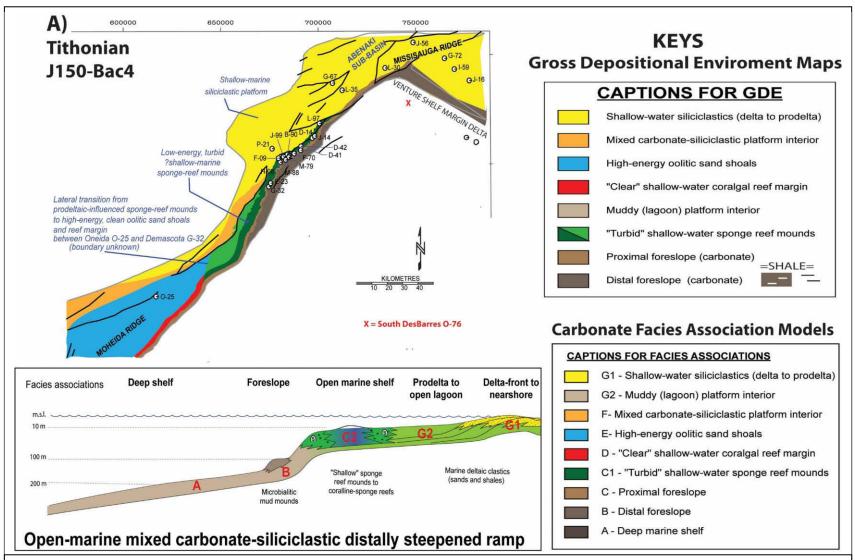


Figure 2.4A Depositional map between regional PFA seismic markers (J150, Bac-1 to -4 = A to D) and facies model A)Tithonian – delimited to northeast, simplified and rearranged from OETR (2011) PFA Chapter 9 (PL.9-202b Fig.3 PFA models and PL9-9-1 to -4 GDE maps) to show interpreted changes and associated facies models. Note that the interpretation for the sponge mounds-delta is similar to the Ringer-Eliuk model (in Eliuk and Prather 2005, 2008) for the Baltimore Canyon Trough and also applied to Nova Scotia (Eliuk 2008, 2010a, b; Eliuk and Wach 2008, 2010)

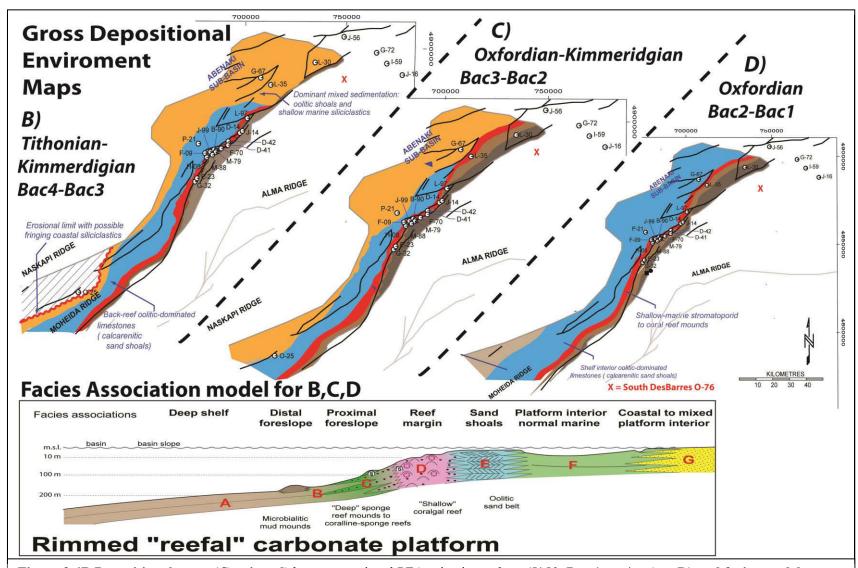


Figure 2.4B Depositional maps (Continued) between regional PFA seismic markers (J150, Bac-1 to -4 = A to D) and facies model – B) Tithonian-Kimmeridgian, C) Oxfordian-Kimmeridgian, and D) Oxfordian. The model for intervals B to D is similar to that of Wierzbicki et al. (2002) and Weissenberger et al. (2006). Note that South Desbarres 0-76 was omitted on all PFA Chapter 9 maps.

Chapter 3: DATABASE and METHODOLOGY

List of topics

- 3.1 Database
- 3.2 Methodology
- 3.3 Brief Overview of Drill Cuttings Examination Methods and Uncertainty
 -the Data Source Providing the Main Contribution of the Thesis
 - A. Introduction to Cuttings
 - B. Details of Methodology.
 - C. Sources of Problems, Error and Uncertainty
- 3.4 Abenaki Carbonate Facies Association Template

"What we observe is not nature itself, but nature exposed to our method of questioning."

— Heisenberg

3.1 Database

Looking at the rocks as brought up from offshore wells is primary to this thesis and to subsurface geological studies. The structures those wells drilled were located using seismic. For this study, well seismic mainly derived from the literature was used to support the carbonate rock studies and allow development of more specific depositional models. Because two major problems are addressed in the thesis, the focus is split in two. Firstly, the wells and area on the southwest flank of the Sable Delta complex are studied for the nature of the platform-delta transition. Secondly, the Late Jurassic carbonate-margin wells and their morphologies are studied for reef/mound and other facies comparisons in a search for possible deltaic influences.

The well locations and conventional core control are shown on **Figure 3.1A** and lithologic profiles of some of the longer wells with cores in **Figure 3.1B**. Most of the wells included in this study and all wells with thick Abenaki Formation carbonate are listed in **Table 3.1** with details of data sources, status of wells and related play/structural information and additional explanatory comments in the caption. Wells at the margin in the Baltimore Canyon Trough (see **Table 3.2** and **Figure A2.7**) are also included mainly as core studies (Eliuk and Prather 2005). In summary over 23,350 m of cuttings and 167m of conventional core were logged or examined from the Nova Scotia offshore. To show the relative contribution from cuttings, less than 1% of the rock data is from conventional cores. But of course cores are the best data source after outcrops and allow one to understand contextually and look more accurately at the cuttings.

Seismic profiles were available from industry, government and research groups i.e. Shell Canada, Encana (Pancanadian), El Paso Canada and Ammonite Nova Scotia, the Geological Survey of Canada, Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), OERA (Play Fairway Analysis) and the recent paper of Qayyum et al. (2015). The seismic shown in this study is mainly from CNOSPB's Kidston et al. (2005). As indicated on **Table 3.1** all wells had publicly available seismic as referenced. The online-available data from CNSOPB Data Management Centre was the source of data used for the seismic in Section 4.02.

Biostratigraphy is a key component of stratigraphic studies and a check on sequence stratigraphic schemes that often are mainly based on seismic. A great aid was the updated biostratigraphy resulting from the Play Fairway Analysis study (OETR 2011, Weston et al. 2012) that is as the main age-dating source supplemented by Van Helden's dating of Encana sequences in Panuke M-79 (Appendix II in Weissenberger et al. 2006). The importance of understanding cuttings with the aid of a carbonate depositional facies template is part of my interpretative feedback loop. An up-dated template completes the final Section contribution as both a methodology and a result.

3.2 Methodology

The main technique applied in this thesis is the logging of carbonate well cuttings using a good quality, low-power binocular microscope – a 1972 Leitz-Wetzlar of 10 to 400 power magnification with changes in oculars. It also has a polarizing stage for thin section examination. The starting point for cuttings re-examination of previously logged wells was the available well history reports, well site logs and Canadian Stratigraphic Services lithologic logs. Usually the main lithologies did not change but more detail was added on biota. Occasionally even other collections of cuttings from the same wells were checked to determine if there were significant differences in carbonate interpretation.

Well cuttings were plotted in a specially designed Excel log format with an example shown in **Figure 3.2.** An example of my cuttings information used in PFA Chapter 9 but displayed in the Beicip-Franlab format is shown in **Figure 3.3**. The well data in the figures of this study are mainly given in simplified logs with only some of the more easily seen major lithofacies highlighted as indicated on the accompanying index keys. Subdivision of the wells is only approximate to the sequence stratigraphic scheme proposed by Encana workers. The PFA scheme differs in many details from Encana's (see Appendix A1.09 and **Figure A1.2**) but their four-fold

mapping (see **Figure A1.23**) was based on regional seismic picks that can be equated roughly to Encana sequences (see Appendix A1.07 and A1.09 for discussion). A comparable, simplified schematic small-scale well log is shown in **Figure 3.4** on the left. On the figure's right is a schematic core log and its interpretation (see Section 4.08). Analyses of some well textures using infrared cathodoluminescence were undertaken as indicated in **Table 3.1** with the aid of Dr. Peir Pufahl of Acadia University. Ultraviolet examination of fresh drill cuttings done routinely on well sites to find oil shows was also useful for highlighting mineral fluorescence in core that in some cases was associated with phosphate enrichment and apatite in sponges (Eliuk 1978).

Although based on Eliuk's sample examination and observations, the presentation used in the PFA Chapter 9 is quite different (See Beicip-Franlab in **Figure 3.3 versus** Eliuk in **Figure 3.2).** There is a continued difference in generalized presentation of wells between this study (see **Figure 3.4**) and Beicip-Franlab's (see **Figure A1.22**). Neither is 'right' or 'wrong' but represents two styles of pigeon-holing. The Beicip-Franlab style attempts to place each portion of a well in the appropriate facies of their depositional model(s) whereas Eliuk's tries to place each sample into a slot of the carbonate facies template (Wilson 1975, Schlager 2005, more specifically Eliuk 1978 and Wierzbicki et al 2002) with a range of possibilities usually given.

When placing generalized facies on simplified schematic logs, certain less arguable facies are noted to leave more equivocal intervals more loosely defined. For instance, even definitive facies like onlite or coral reef may not be as they seem but rather allochthonous having been carried down slope into deeper water. So, as a preference an appropriate analysis is attempted short of what could be considered over-interpretation. Cuttings logs themselves are interpretive which in a well-known basin is highly appropriate and linking it to appropriate depositional models is also a best practice. But if trying to see areal changes of lithofacies that may indicate provenance or proximity of allochthonous material including carbonate debris, a more general usage may be more useful to avoid accumulating too many layers of arguable interpretation.

Figure 3.5 illustrates the potential of cuttings to identify important fossil groups that characterize major depositional facies. They are from the Dominion J-14 vertical well that was then side-tracked (J-14A). Bothe boreholes were turbo-drilled with PDC (poly-crystalline diamond compact) bits that result in bad bit bruising and mostly unusable, small size cuttings. Since no core or sidewall core was taken, the few identifiable cuttings made possible carbonate characterization a challenge.

A carbonate facies template organizes the data relevant to identifying the main depositional facies association as shown in **Table 3.3** and discussed in Section 3.4. Identification of the contributing biota is key in order to assign carbonate depositional facies and variations. The biota is what creates carbonates for the most part and particularly by reef-building metazoans such as corals and sponges. Even microbial, or more generally thrombolitic and stromatolitic, early-lithified textures can be identified but the term is often used in a generic sense similar to microbolite terminology and classification (Leinfelder 1994, Schmid et al. 2001, Leinfelder et al. 2002, Azeredo et al. 2010). Obviously identification is much more likely in core, although with the ease of diagenetic alteration in carbonates even that can be difficult or impossible particularly with dolomitization or thorough recrystallization. Stromatactis textures along with thrombolitic and stromatolitic fabric are seen in several cores that could be taken as evidence for Paleozoic-style mud mound presence in the Late Jurassic (see **Figure 5.16**).

Nevertheless, this characterization of fossils is the main contribution provided in this thesis by looking closely at the cuttings and core. To date only two macro-paleontological studies to identify mainly coralline and lithistid sponges to species level in a few cores have been undertaken by G. and H. Termier (in Jansa et al. 1982) and also by Ellis (1984). Although much more fragmentary, cuttings can be likened to thin sections. The main means of identifying the fossil content of limestone penetrated by the drill is referencing microfacies illustrations, starting with Flügel's (2004) excellent text. Even in core on polished or wetted flat surfaces useful identification is possible. My photo-paleontology is also aided by consulting relevant literature mainly of an overview nature (Adams and MacKenzie 1998, Finks et al. 2004, Flügel 2004, Johnson 1961, Majewske 1969, Murray 1985, Scholle 1978, Scholle and Ulmer-Scholle 2003) and some more specifically on Late Jurassic fossils (Dupraz and Strasser 1999, 2002, Flügel and Steiger 1981, Insalaco 1996,, Lathuliere et al. 2005, Leinfelder et al. 1994, 2005, Martin-Garin et al. 2007, Turnsek1997, Turnsek et al. 1981).

3.3 Brief Overview of Drill Cuttings Examination Methods and Uncertainty -the Data Source Providing the Main Contribution of the Thesis

A. Introduction to Cuttings.

Cuttings logging or sample examination is not a quantitative method but certain aspects of its results can be analyzed or presented quantitatively (see **Figure 3.2**). Carbonate cuttings observations, along with supporting observations from sidewall cores and, the few but much more useful, whole conventional cores are the primary source for past and present understanding of the offshore Abenaki Formation and its complex carbonate margin and slope. Wells are drilled with

various types of bits and drilling fluids resulting in different types and qualities of cuttings generated. Once this was the only subsurface data but with more sophisticated logging suites and even 'logging while drilling,' the potential to analyze well bores without resorting to cuttings is possible and can with enough types of logs give very precise petrophysical interpretation of the lithology and porosity. However with carbonates (and even with sandstones as to grain size with implications for permeability) once a mineralogy or composite mineralogy and porosity is assigned not much more can be inferred other than it being a limestone, dolomite or combination with argillaceous material. This is unlike siliciclastics that have various gamma ray or resistivity log responses that can be interpreted as depositional facies, though not always correctly of course. Because carbonates are formed nearly *in situ* and predominantly by fossil organisms, much can be learned by looking at them, barring problems generated by drilling and diagenetic overprints. And while sometimes losing some earlier depositional data, cuttings can also give important information on diagenesis.

Rationale for cuttings analysis - There is a temptation to forego the time-consuming detailed logging of well cuttings in the presence of modern geophysical logs and in the absence, or even more likely, in the presence of some amount of core. This is particularly so if a well-site mud-log with general lithology noted "shows" and porosity and/or the area is considered to be well known geologically due to previous drilling. Coffey and Read (2002) showed that thin sections of cuttings could generate high-resolution sequence stratigraphy in shallow variably consolidated carbonate-prone basins that lack cores and high-quality wire-line logs. This is an echo from four decades earlier of Conselman (1960) who called for a "revival of the lost art of sample examination" which was being displaced even then by petrophysical logs. Maher (1959), who in outlining the composite interpretive method of logging well cuttings (see later), observed that the accuracy of the stratigraphic analysis of basins is affected greatly by the type and quality of well logs used, including not just geophysical logs but also cuttings as primary. The Shell Sample Examination Manual (circa 1967) modified and published by the American Association of Petroleum Geologists (Swanson 1981) showed that at one time detailed cuttings analysis was a basic work of petroleum geologists in at least some of the large oil companies.

Even with the best of modern petrophysical logs, only mineralogy and porosity can be ascertained for clean (non-radioactive) carbonate. Permeability in subsurface reservoirs cannot be measured by petrophysical logs but can be estimated from cuttings examination (Archie, 1952, Lucia 1995). Depositional, paleontological and diagenetic features that vary immensely can be seen in tiny rock fragments even without thin sectioning. Borehole electrical imaging (FMI or

"Fullbore Formation Microscanning Imager" = Schlumberger phrase, now with "HD" added for the high definition tool) can do better by showing resistivity patterns of bedding and vug distribution but again, it is costly and ideally needs sidewall core calibration.

B. Details of Methodology.

Obviously subsurface sedimentary geology is based on inferences from remote analyses, mainly reflection seismic, and from variably sparse control points at wells. Geophysical well logging of rock properties gives information that allows close comparison of the two data sets. Cuttings and cores recover the only actual rock material. Commonly the wells are continuously cored in mining and near-surface studies (Bouma 2003). But in hydrocarbon exploration the depth, thickness and cost preclude continuous coring, and in most cases any coring at all.

Cuttings generation — Cuttings are produced by the bit at the bottom-hole rock face and circulated up in the mud system to be recovered by screens called 'shale shakers'. Either water-based mud or less commonly oil-based mud can be used. With oil-based mud, the potential problem with seeing hydrocarbon shows and possibly doing geochemical analyses is obvious, but its benefits may receive higher value in faster drilling, therefore lower costs, and prevention of reservoir damage and evaporite solution. Some wells are drilled under-balanced by air or foam to further prevent reservoir damage but the cuttings are then usually too fine to use. Drilling mud is used to give the hole stability ('mud cake') and to cool and clean the bit. In turbine drilling (turbo-drilling) mud pressure through pumping also turns the bit for horizontal or planned deviated hole. The bit type and cutting action may have important effects (Grave 1986). This will be discussed again later under "uncertainty" for PDC bits that can give unusable cuttings. A small amount of representative cuttings is aggregated into a sample bag (also into vials of cleaned chips done onsite or usually later) from regulatory-set intervals (10 feet or 5 metres etc.) after a calculated lag time to return mud and cuttings to the shale shaker from the bit.

Cuttings analysis – Sample examination of cuttings is done through a low power binocular microscope on cleaned material observed dry for porosity and wet for most other details. The lithologic log generated can take many formats one being a percentage system by logging percentages of all rock types except obvious cavings from up-hole (usually done while drilling where the section is not well known). Another would more usefully be an interpretive system by logging rock types as discrete beds and interbeds where there is a variety of such but again excluding obvious cavings. This is done with the assistance of geophysical logs and especially where the local stratigraphy is reasonably well known (see Maher 1959 for an excellent summary

of the interpretive composite cuttings logging process; in this thesis a less graphic Excel spreadsheet is used). Figure 3.2 shows a litholog and header with the various features logged with examples of the drill cuttings Figure 3.5A and 3.5B (Enlargement) and product (schematic log Figure 3.4). Samples are laid out in trays of 5 compartments (see Figure 4.79A) that allow continuous comparison of the lithologies with depth. The depth increments are usually determined by regulation sampling intervals. They can be modified where closer spacing might be needed as in a reservoir zone and allowed by slow drilling rates or further apart where more section must be covered for reasons of uniformity of lithology, time or cost. For this study the author typically then photographed the trays in sequence for overviewing color/texture differences in a broad sense.

Cuttings analysis continued and application – Rather than a complete and systematic outline of the logging procedure, an overview is given of some carbonate logging aspects specific to particle and fossil identification at the Abenaki carbonate margin.

Carbonate rocks are often examined in thin sections as microfacies. More generally Flügel in his 976 page tome (2004, p.1) defines microfacies as "the total of all sedimentological and paleontological data which can be described and classified from thin sections, peels, polished slabs or rock samples." Cuttings can be made into thin sections too (e.g. Figure 4.80). However, well lithified cuttings that are thin enough can be observed in both reflected and transmitted light, so thin sections might not even be needed to simulate microfacies analysis based on cuttings examination. Therefore if the fabric or fossil is small enough, or even a piece of it has unique characteristics, many of the procedures and possibilities of carbonate petrography and microfacies analysis is available to those studying cuttings (see Figure 3.5). Similarly modern techniques like microprobe isotope work and even bulk fluid inclusion analysis have been applied to cuttings (Smith 1997).

But before one stops taking cores and stops going to the outcrop, many things such as the critical relationships between the larger particles and fossils, or even the identity of really large fossils, their bedding attitude and contacts, and their vertical sequence on a scale smaller than the sample interval are not available and must be inferred or interpreted. This distinction is well shown in **Figure 3.4** where the longest core in the Abenaki Formation was obtained from the north end of the Deep Panuke gas field in Margaree F-70. The logging form format of recording the reef framebuilding fossil groups in order of inferred depths (or perhaps turbidity's) was applied to the core. An unusual deepening-upward sequence was seen rather than the usual

carbonate shoaling-upward parasequence. On the cuttings log shown schematically, the same "deepening" change from shallow (coral and coralline sponges/ stromatoporoids/ chaetetids) upward to deeper (lithistid sponges and minor microbialites) reefal facies can be seen. In addition *Microsolena*, a fairly unique colonial coral on a microscale because of its "tire-track" fine septal pattern (see **Figure 4.43**), can be used in both cuttings and core to refine relative water depth since it ranges fairly deeply according to European studies (Insalaco 1996, Dupraz and Strasser 2002). In fact in the subsurface, sequence stratigraphy, even though it is based on the nature of major surface contacts, is largely uncontrolled by precise rock data due to lack of core and must be inferred from geophysical logs, cuttings analysis and biostratigraphy.

C. Sources of Problems, Error and Uncertainty

Cuttings are far from ideal but they are usually all there is of actual rock from subsurface. The cuttings are a very small subset of the interval drilled that is itself a tiny portion of the rock formation. Of course the same can be said of sidewall cores or even whole cores and scattered outcrop when compared volumetrically with the whole rock body of any formation. When investigated in conjunction with geophysical logs, the very small cuttings sample can be more correctly placed relative to measurable changes in the borehole (porosity, argillaceous breaks, sandstone stringers but unfortunately not usually changes within the limestone or dolomite itself) and tied to areally extensive seismic.

Cuttings acquisition problems:

- 1. *Cavings:* Geophysical calibration also helps identify possible caved lithologies from up-hole collapse particularly in shaly intervals along with previous observations if the lithology is different enough.
- 2. *Lag or travel time* of cuttings in the mud stream from bit to shale shaker must be calculated correctly and again comparison to geophysical logs may help correct errors.
- 3. *Proper and timely sampling* by the wellsite personnel is essential so there is no 'dog housing'. This is a drillers term for staying in the operations shack and not taking samples at the proper intervals but rather taking many together as a cluster then mislabelling samples as if they had been taken sequentially.
- 4. The problem of *oil-based mud* for compromising oil shows and geochemistry but also making samples difficult to clean and therefore to examine.
- 5. A major problem in the Deep Panuke field has been the use of *PDC (polycrystalline diamond compact)* bits and turbo-drilling in carbonate sections (Graves 1986). These techniques give faster bit penetration but at the cost of lost lithologic information since the limestone cuttings

come up as chalkified, lighter-colored, sheared platelets or booklets. A whole sample tray may consequently have only 5 to 20 identifiable chips (see example in upper middle photograph in **Figure 3.5**).

Cuttings analysis problems – As previewed at the beginning of this section on errors, there is always a question of how representative a sample is of an interval. The use of estimated percentage framebuilders and oolites for an Abenaki sequence slice (Figure 3.2) not only shows facies differentiation but also hints at the problem of sampling control. Note that hexacorals because of often-large corallite size and diagenetic biasing (aragonite is easily leached) are underrepresented in cuttings but were present in sidewall cores taken over the interval. The bias is even more dramatically shown when reef framebuilders in cuttings (estimated at 10 to 20%) are compared to whole core (estimated at 30-70%) as in Demascota G-32 (Eliuk 1978). Therefore, importantly, a cut-off of only 10% in cuttings justifies designation of reefal beds. Of course even more extreme diagenetic biasing occurs when an interval is dolomitized (see Figure 4.70). In this particular core where even though not fabric-preserving, the dolomite retains enough original features to allow defensible interpretation of original deposition). Many of these errors are systematic as a result of the method of sampling based on drilling in as fast and economical manner as possible⁵.

Data appropriate analysis –There can be a danger of too many levels of interpretation. Cuttings logs themselves are interpretive though this is not a significant problem where the basin stratigraphy is well known from previous wells and depositional models are well understood and reasonably applied. But it may be problematic in a frontier basin or lightly drilled part of a known basin and if trying to see areal changes of lithofacies that may indicate provenance or proximity of allochthonous material including carbonate debris. A more general classification may be more useful to avoid too many layers of interpretation.

3.4 Abenaki Carbonate Facies Association Template

The carbonate depositional facies association template for the Abenaki for this thesis originated with Eliuk (1978) and followed a Shell Canada format which Wilson (1975, a Shell Oil research geologist) had put into the public domain. This most recent template update closely follows Wierzbicki, Harland and Eliuk (2002, modified from Eliuk and Levesque 1988 and Eliuk

⁵ Sample quality may not be the highest priority in industry, unfortunately for the petroleum geologist tasked with identifying carbonate facies. A quick (and not very helpful) word search for "drill cuttings" in GEOREF produced 400 entries and probably half of those had to do with environmental effects of cuttings disposal, which really is mostly a drilling fluid or mud problem. Cuttings apparently are seen as a problem

rather than a benefit to much of the oil industry!

1978, 1981) and is offered as a renewed resource for subsurface interpretation and classification of cuttings, sidewall and whole core data from the Abenaki or carbonates of similar age and settings e.g. the conjugate Jurassic carbonate margin of offshore Northwest Africa. The template differs from the 2002-version by reorganizing and renaming some of the sponge-rich deeper shelf margin facies (3B and 3C), by showing more biota with reefal framebuilders high-lighted in quasi-depth order, and by increasing the number of well and core examples. A few insets noting easily recognized thin marker beds of particular significance are another addition. The standard facies belt presentation of Wilson (1975, also see Flügel 2004 for application of standard microfacies and Schlager 2005 for examples of more recent use with variations) is applied in a carbonate facies template format that organizes the data in **Table 3.3**.

Table 3.3 does not exactly follow Wilson's numbering system since even in 1978 the Abenaki was seen as a mixed carbonate-siliciclastic system without even considering the Sable Delta and ramp area. Therefore additional differently numbered facies had been added. Given the evidence in the Abenaki and offsetting siliciclastics for a generally humid climate, Wilson's (1975) bias toward evaporitic facies was omitted and a nearshore siliciclastic depositional facies added. After 1978, new wells resulted in new subfacies and new interpretations requiring more labelling and numbering differences. Thus in showing a shore-to-basin profile the numbers are out of alphanumeric order. The carbonate template has been modified so that major reef framebuilder biota distinguishable even in cuttings are listed. The same fossil categories are used on Eliuk's detailed lithologs in the Appendix A3. The TUBIPHYTES category is for the small characteristic problematic microfossil popularly called *Tubiphytes* which is herein used. No application is made of suggested taxonomic name changes that include *Shamovella* (Riding 1993, Schmid et al. 2001) and *Crescentiella morronensis* for *Tubiphytes morronensis* (Senobari-Daryan et al. 2008) the latter of which is the very common Jurassic-Cretaceous taxon.

Note that interpretation is involved, particularly for cuttings, and that the categories are descriptive as well as genetic and quite broad so they can be applied even to cuttings. Resedimentation and even multiple origins for a similar allochem are possible and are seen in cores such that depositional settings of the same lithofacies may be radically different. An example is 'pelletal mudstone to grainstone' which may be on the slope or in the platform interior depending on the concentrations of associated features. *Tubiphytes*-serpulid concentrations, high amounts of spar calcite likely due to submarine cements and micritic peloidal cements together indicate slope deposition (Facies #3C). On the other hand low amounts of such features plus more bivalves and perhaps ooids place it in the shelf interior (Facies #5C). Flügel (2004, his Fig. 14.29) tried to deal with the same peloid problem for his standard microfacies applied to Wilson's (1975) facies belts.

Another example is the presence of ooids that can be an *in situ* oolitic shoal or an allochthon carried down the slope or transported back into the shelf interior by storms. For instance, in the Abenaki only oolites are present in all of a 5.5 m core (Albatross B-13 core 1) near the southwest shelf margin; only a 3.5 m thick oolite bar (Penobscot L-30 core 1) is on a carbonate ramp near the Sable Delta: and only a 1.5 m oolite bar is capped by a hardground with *in situ* colonial coral (Mohican I-100 core 4) in the far shelf interior of the Mohican Subbasin. Given cuttings sampling intervals of 5 m or 10 feet prior to 1977, some of those might not even be recognised. Obviously other characterizing criteria may be critical such as seismic geometries. Because of these relatively coarse sampling intervals, interbedded thinner lithologies are difficult to distinguish and tend to get described as a range of textures. If different depositional facies are involved then the confusion increases.

For that reason, fairly broad lithofacies categories on schematic logs from cuttings have been used in this thesis to show vertical and lateral changes. Specifically, oolite or peloid is used for cuttings with grain-supported allochems and identified by green (image borders, lithology vertical bars etc.). Where 10 % or more of the cuttings are corals, lithistid or coralline (stromatoporoid and chaetetid) sponges, then 'reefal' facies are highlighted by red. This percentage may seem like a low cut-off to define reef or reef mound, as deep or shallow bafflestone or framestone core, reef flat, reef debris, proximal forereef are all depositional possibilities. But where sampled by core or sidewall cores as described previously the actual amounts of fossils were demonstrably greater. This is particularly true of corals that due to large corallite sizes and poor preservation are typically under-represented. Microbolite (thrombolite, stromatolite and the like termed microbialite on most figures) is based on micro-textures, fine peloids and associated encrusters like *Tubiphytes* in cuttings.

The carbonate facies template has many more potential environments categorized but they were not all applied in the thesis schematics. This is similar to past practice when the known depositional facies alternatives (Eliuk 1978) were much fewer than are now known. Based on Eliuk's well lithologs, including suggested depositional environments sometimes with multiple alternatives for each cuttings sample, Encana (Wierzbicki et al. 2002, 2005, Weissenberger et al. 2006) on post-1999 wells and Beicip-Franlab (PFA Chapter 9 of OETR 2011) used this facies association technique for most wells but were presented as one or more shore-to-basin depositional models such as shown on **Figure 2.4**.

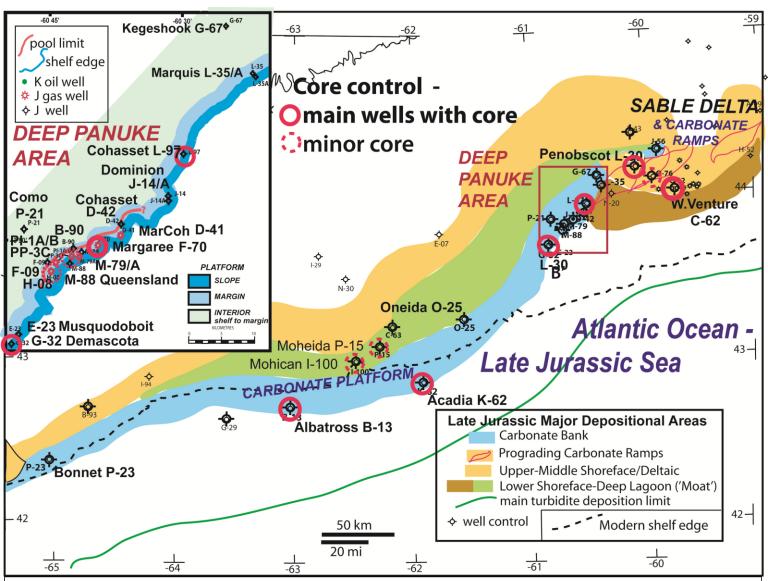


Figure 3.1A Well and core control in upper Abenaki on depositional maps. Well and conventional core control is widely distributed but sparse areally and vertically. Two wells indicated by heavy red circles - West Venture C-62 and Margaree F-70 - have longer cores with a succession of facies in a deltaic ramp and a carbonate platform setting.

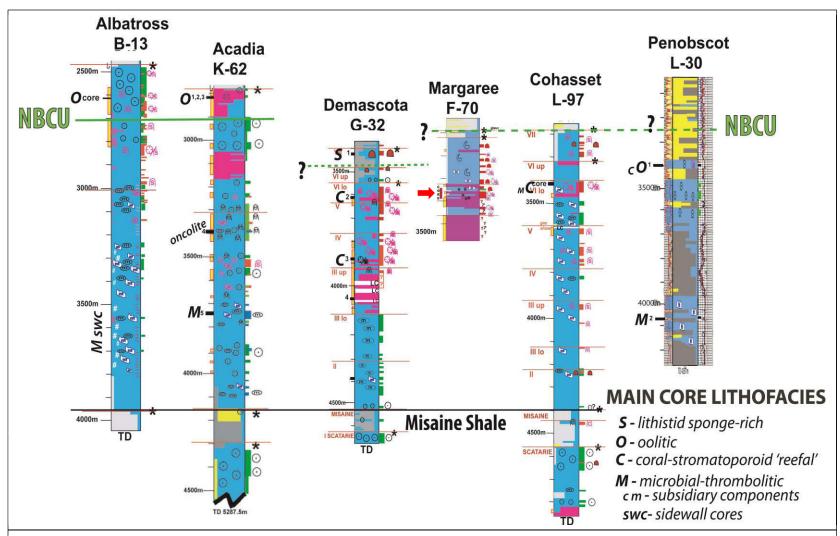


Figure 3.1B Lithologic profile of Abenaki wells with main conventional cores. The principal carbonate facies is indicated by letters beside the cores (bar with number if more cores than one). Misaine Member shale top used as datum for platform wells with Penobscot L-30 ramp and prodeltaic well only placed approximately since Scatarie-Misaine reflector much deeper seismically than well penetration. Margaree F-70 core (red arrow) is the longest in Abenaki and has several minor reefal intervals with mainly dolomitized grainy slope beds and a crinoid-rich lime grainstone. NBCU = Near Base Cretaceous Unconformity.

Table 3.1 Abenaki Well List.
Includes wells relevant for Abenaki-Sable relationship and for Late Jurassic reefs off Nova Scotia. (Table on 2 pages)

Year	Operator	Name	ID	FTD (m)	Status (m of gas)	Litholog Eliuk	PFA	Seismic	Comments (of Kidston et al 2005)	EnCana Sequence ID = I P=%s A=appendix	NIHIL	CORES
1970	Shell	Mohawk	B-93	2126	D&A	1978		M	Nearshore ridge, Roseway Ur	nit 'type section'		
1970	Shell	Oneida	O-25	4110	D&A	1978 S	аC	M,K	Platform-on basement structure	type section	SECTION	∐∞ L
1971	Shell	Abenaki	J-56	4569	D&A	1978 S	a	M	Platform-salt diaper flank		∐∄L	
1971	Shell	Sauk	A-57	4575	D&A	1978	a	M	Not included (NE platform)			
1971	Mobil-Tetco	Dauntless	D-35	4741	D&A	1978	аE	M	Not included (NE platform)		#	1
1972	Shell	Mohican	I-100	4393	D&A	1978	аC	M,K	Platform-over salt swell			5
1973	Mobil	Cohasset	D-42	4427	D&Aoil	1978 d, S	a	M,K	Bank edge/back reef-some φ, K oil	I PA		
1974	Shell	Demascota	G-32	4672	D&A	1978 d, S	аC	S,M,K,P,Q	Bank edge- 186m φ, test W	I P	+36	5
1976	PetroCanada	Penobscot	L-30	4267	D&A	1981/85 d S	s aCd	S,M,Q	(*)Bank edge/back reef- no ø	P?A	4*	2
1977	PetroCanada	Moheida	P-15	4298	D&A	1978 p-core	e aC	S,M,	Platform-basement structure		1	2
1978	Chevron	Acadia	K-62	5283	D&A	1981, d, S	аC	M,K	Bank edge-good ø	(PA)	61	5
1978	Mobil	Cohasset	L-97	4872	D&A	d, S	aCdE	M,K	(*)Bank edge-some ф	I PA	5*	1
1984	Husky	Glooscap	C-63	4542	D&A	cuttings	aCE	M,K	Platform,-salt swell	PFA lith log, p		
1984	PetroCanada	Bonnet	P-23	4336	D&A	d, S	aCdE	M,K	Back reef- major lost circ'	(PA)		
1984	PetroCanada	Dover	A-43	4525	D&A		a	M	Platform-fault block			
1984	Shell	S. Desbarres	O-76	6039	D&A	d, S	a	M	N/A (distal ramp)			
1985	Mobil	West Venture	C-62	5522	gas	Core only		M	Shelf lime beds under delta	Cummings 2004	4	2+
1985	PetroCanada	Albatross	B-13	4046	D&A	d, S	aCdE	M,K	(*)Bank edge-some φ	(PA)	47*	1
1985	PetroCanada	Shelburne	G-29	4006	D&A		a	M,P	Lost core at TD - oolite	200		
1986	Shell	Panuke	B-90	3445	D&Aoil	d, S	С	M,K	(*)Bank edge- no ø, K oil disc	I PA		
1987	Shell	Kegeshook	G-67	3540	D&A	d, S	aCd	M,K	Platform-basement structure	I PA		
1987	PetroCanada	Como	P-21	3540	D&A	d, S	С	M	Platform-basement structure	I PA		1
1998	PanCanadian	Panuke PP-3C	J-99	4163	Gas -97	d, S	С	K	Bank edge- Ab5 gas disc'	I P		
1999	PanCanadian	Panuke PI-1A	J-99	4030	Gas -6.9	d, S	Cd	K	Bank edge-thin gas ∴whip	I PA	14	1
1999	PanCanadian	Panuke PI-1B	J-99	4046	Gas -49	d, S		K	Bank edge-24.2m pay	I PA	6	
2000	PanCanadian	Panuke	H-08	3682	Gas -112	d, S	С	K	Bank edge-108m pay	I PA	11	1
2000	PanCanadian	Panuke	M-79	4598	D&A-14	d, S	Cd	E,K,P	Bank edge-no gas ∴whip	I PA	97	1
2000	PanCanadian	Panuke	M-79A	3935	Gas -21	d, S	Cd	E,K	Bank edge-11.4m pay	I PA		
2000	PanCanadian	Panuke	F-09	3815	D&A-27	d, S	Cd	K	(*)Back reef-low φ, oolite	I PA	34	
2001	PanCanadian	Musquodoboit	E-23	3818	D&A	d, S		K	Bank edge- some ø,wet	I PA	5	

Year	Operator	Name	ID	FTD	Status	Lithe	olog	Seismic	Comments (Kidston et al)	Sequence ID	TS	Core
2002	PanCanadian	Queensland	M-88	4401	D&A	d, S	Cd	K	Fore reef- no φ, by-pass sst	I PA	19	
2002	ElPaso (CdnSup)	Marquis	L-35/A	4501	D&A	d, S	Cd	K,P	Bank edge - no φ, whipped	I PA		
2003	EnCana	Margaree	F-70	3677	Gas-76	d, S	Cd	K	Bank edge – 70m pay	I PA	56	1
2003	EnCana	Marcoh	D-41	3625	Gas-122	d, S	С	K	Bank edge – 100m pay	I PA	50	
2006	EnCana	Dominion	J-14/A		D&A	d, S	Cd	X	Bank edge – no φ, whipped	I PA		

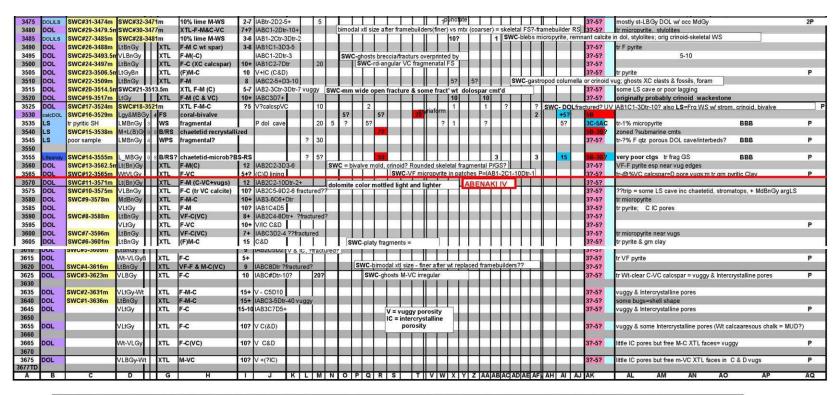
Table 3.1 Abenaki well list. Includes wells relevant for Abenaki-Sable relationship and for Late Jurassic reefs off Nova Scotia

NOTES: 1) Year column - date of drilling completion (3 activity phases - initial in 1970's, middle in mid-1980's and Deep Panuke phase around 2000's). 2) Operator column - PanCanadian became Encana. 3) Well name column - names given by operators (most used names of Nova Scotia towns, Shell mainly used eastern North American first nation names except 'Demascota' which was a Portuguese ship wrecked on Sable Island 1815-01-01 after that well was D&A no more wells were named after ship wrecks). Deep Panuke Gas Field = all gas wells and M-79, F-09: the Panuke discovery and immediate follow-up were deepened from the Panuke oil field platform where PI = platform injector and PP = platform producer; L-35/A & J-14/A includes both original and whipped (=A=deviated from same well bore) holes. Wells northeast of Sable delta and on nearshore ridges not included in list except Dauntless D-35, Sauk A-57, Mohawk B-93 logged in Eliuk 1978. 4) ID column - well identification by chart/map geography; bolded ID's indicate well logged and used in thesis by Eliuk (mainly prior to 2006). 5) FTD - Full Total Depth drilled in meters. (= m). 6) Status column - D&A=dry & abandoned, Gas 97=97m gas-bearing reservoir=pay; oil = Cretaceous oil discovery wells of Panuke and Cohasset fields in margin-drape sandstone reservoirs. 7) Litholog column - Eliuk 1978, 1981'= year published by Eliuk on left with d=detailed log (some confidential; p=partial study e.g. core), S=schematic log, cuttings = partial cuttings check e.g. C-63 Roseway & top Abenaki; PFA (Play Fairway Analysis, OETR 2011) on right with 'a'=Annex 3 Well Data generalized with GSC multi-ages, 'C'= Carbonate play Chapter 9 (Stefan Doublet lead geologist) in PFA Enclosures (from GeoTours-Eliuk if detailed log=d), 'E'= ENCLOSURES key wells with biostratigraphy (see Weston et al. 2012 for authors and details). 8) Seismic column – data sources – 'S'= Shell, 'M'=MacLean and Wade 1993, 'E'=Encana, 'K'=Kidston et al. 2005, P=PFA (OETR 2011), 'x' = J-14 well history report, Q = Qayyum et al. 2015. 9) Comments column: Kidston et al. 2005 is source of most seismic used in study, (*)=my lithofacies not in agreement with geometry-based interpretation of Kidston et al 2006, '\phi' = porosity, "K'=Cretaceous, "W'=wet, 'circ'=circulation,' disc'=discovery 10) EnCana Sequence column - 'I' = follows the format and close to or same as EnCana tops (2006, Weissenberger et al. 2006) and have been shown on schematic logs but considered quite tentative and even wrong where dating is contradictory. Is not compatible with PFA Chapter 9 (OETRE2011) sequences. See appendix which shows maps in Panuke Trend by EnCana sequences with percentage pie diagrams of major lithofacies; P=%'s = percentage major lithofacies estimated from well logs for pie diagrams by approximate EnCana sequences; A= DETAILED LITHOLOG IN EXCEL FORMAT; 11) Thin section #'s column - number of thin sections totalling over 450 (does not include Eliuk 1978's Demascota G-32 cores and cuttings thin sections, +100 lost from Shell archives); mainly from logging SWC's and cores in Encana wells; elsewhere in cores mainly, except Acadia K-62 (43) Albatross B-13 cuttings courtesy of PetroCanada (Eric Bogosloski, pers. comm. Dr. Gordon Tebbutt, deceased); some large thin sections from cores in G-32, L-30 and K-62 courtesy of Jansa of Geological Survey of Canada, '*' = infrared cathodoluminescence thin section study courtesy of Prof Peir Pufahl and the equipment at Acadia University 12) Core #'s column - number of cores in Abenaki or age equivalent; in West Venture C-62 basal two cores carbonate-bearing in long succession of cores; in Panuke M-79 in Scatarie Member; in Margaree F-70, the longest core in Abenaki at ~25m. Total of 23350 m of cuttings logged and 167 m core (0.7 % cored versus drilled carbonates and associated lithologies).

Table 3.2 ABENA	Table 3.2 ABENAKI FORMATION REEFAL (margin-slope) CORE											
(Baccaro, Artimon ar	id Roseway	members; MicMac	Formation limesto	ones)								
WELL	CORE#	CORE INTERVAL	FACIES	COMMENTS								
	('reefal')	(original units)	NUMBERS									
West Venture C-62	12,13	<5255-5276.5 m	3C/4B in 8	thin shoaling facies - thrombolitic to coral-sponge reef mound								
South Desbarres O-76	1,2	3799-3827 m	8 (reeflet 5B)	Smallest coral reeflet in bottom of marine deltaic channel (~15cm)								
Penobscot L-30	1	11231-11269 feet	5D(5A/B/C)	minor thin layers corals-chaetetids amongst oolite								
	2	13285-13316 feet	1/3C	slope stromatactis-thrombolitic/microbial 'mud' mound-depauparate								
Cohasset L-97	1	3407-3426 m	5B(?3B)	very large in situ corals (complicated diagenetic overprint)								
Margaree F-70	1	3434-3458.6 m	5B. 3B, 4B (3C?)	deepening trend - coral reef rubble to slope sands with reeflets of								
			pinnacle -W side	microsolenids corals up to lithistid sponge with ?microbialite								
Panuke PI-1A (J-99)	1	4029.3-4030.3 m	vuggy dolomite	dolomitized questionable coral reef								
Panuke H-08	1	3446-3449 m	5B (3B)	recrystallized (micro-porous) crinoid- and chaetetid-rich								
Demascota G-32	1	11228-11251 feet	4A	sponge reef mound in Artimon Member type section								
	2 3	11836-11862 feet	5B	coral-stromatoporoid reef with marine filled ?cave (HTD altered)								
		12704-12720.5 feet	5B	coral-stromatoporoid reef								
	5	14400-14424 feet	3C(5C)	thrombolitic-stromatactis slope mound								
Moheida P-15	1	2562-2564 m	4A	Marly sponge reef mound debris over coated red ironstone								
Acadia K-62	(1, 2, 3)	2811.4-2822 m	5D?	Dolomitized oolite?, possible dedolomite cements								
	4	3380.8-3399.2 m	5E(5A,B,D)	reef flat – back reef (oolitic, oncolitic and mollusk-rich)								
	5	3736.8-3753 m	3C-5C	thrombolitic/microbial mud mound (shallower than G-32 C5)								
Albatross B-13	(1)	2511.5- 2517 m	5D	White oolite; vertical open fractures = ?neptunian dykes, geopetals?								
2000 000 200 200 000		cutting-sidewall core	red-white 3C	cyclic red-pink-white slope thrombolite-microbial slope carbonates								
Shelburne G-29	(1 lost)	3991-4005.5 m lost	5D reddened	Sample – lost bottom of hole and core; light oolites, some reddened								
		BALTIMORE	CANYON	TROUGH (USA)								
OCS-A0317 (Hyena)	4	11563-11586 feet	3C	slope 'microbialite' -near base well in top of seismic clinoforms								
OCS-A336 (Rhino)	3	14882-14912 feet	3B	shoaling? proximal forereef (corals & crinoids) argillaceous								
	4	15970-15999 feet	5B	in situ and debris coral-coralline sponge reef								

Note: about 180 m of core listed above. No core is listed for the Scatarie Member or for any shelf interior wells unless reefal. Of the most recent wells, Panuke M-79 did have a core in the Scatarie Member (4532.7-3535.7m) consisting of mixed quartz sandstone and solitic limestone probably in a shoal, not porous. FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-stromatoporoid reefal, 5C=mud/pelleted; 5D=oolitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Chapter 4 on the Abenaki carbonate facies template for details and illustrations of these cores as well as Chapters 5 and Appendices.

				ΕN	CANA	A Margaree F-	70			GenT	oure	Consul	ting Is	ıc I	Flink	P Go	ol.	П			T	П					8 2	PAGE
DEPTH	LITH	modifier I	COLOR	П	TEXT	JRE modifier	POR	OSITY	ACC	ESSOR		Johnson	ung m	1990	ossi	10.000		enhanc	ed by	SWC	data i	f avail	able)	П	\neg		18 H	COMMENTS
(metres)	T LS T DO H SH O SS L ar	Elimestone DL=dolomite H=shale =seristone TST=sistone g=argillaceous Ic=calcareous y= sandy/qtz	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	PS=F GS=F BS=t (FS/F FS=f RS=r	mudstone 1 -wackestone 3 -packstone 5 -grainstone 7 -boundstone 9 -RS=XC size) -loatstone 4 -rudstone 8 -crystelline	%	modifier (Archie)	SGIOO	PELOIDS	LITHOCLASTS	FRAM	STROMATOPOROID	MILLEPORID SAN		HEXACORAL	BRYOZOAN	CRINOIDS	ECHENOIDS G	VES	OSTRACODS	TUBIPHYTES	BORINGS	HIGHER -green etc	Thrombolites	ONCOIDS-PISOID	Flugel82&Wilson75&Elluk7	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
A	В	С	D	Ш	G	н	_	J	К	L N	N	0 F	Q	R S	S	T	VV	v x	ΥZ	Z AA	AB A	AD A	AE AF			AJ /	K	AL
3140 3145 3150 3155 3160 3165	SH+SS SH SH+SS	5/5 VF(F)sl.calc silty, pyritic, soft 7/3 sltySh+calc S	D-M GyB DkBnGy D-M Gy			ss=qtz w carbonace ??organic rich SS=VF-M rd qtz, cal						icropyri		iderite			e MS)										3-5F 2 2-5F	ClayeySS+sitySH P SAMPLES BADLY BIT BRUISED (BBB) LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB P
3170 3175	SS+SH	6/4 VF-F qtz SS	D+M Gy			SS=calc & pyritic	-								-						-	Н	-				2-5F	SS has F-M carbonaceous-liginitc fragments
3180 3185 3190 3195	SH	sl silty, tr pyrite	Dk Gy				ABE	NAKI VII		2 2		tr sider	ite Md	Brwn I	MS						2				10			
3200	L3733	5/5 VF-M(VC) qtz	100	4	WPS	sandy-frag-skel				2 20	4	1					ò	4		3	· ·	ы	-		1?		A-5F	
3205 3210	SS+SH	5/5 VF-F Qtz glau	5.00			SS calc&glauc mica	ceous											1	100								3-5F	silty SH; SS = lignitic qtz w/ DkGm biotite-glauconitic mica
3215 3220	LS+SH	7/3 argLS/calcSH	93		W(P)S	20 20		G		20			_	te Md I	Brwn	MS	71	3	?	2							3-5A	pyritic Calc SH & argill -sandy frag-skel LS P
3225 3230	LSarg	2-6% Lt Gm clay		3	ws	fragmental (F-M)		nil? tr calcs	par	15		AB	ENAK	IV	4			2		1?							37-57	tr pyritic Tr Clear Calcspar Very small ctgs = BB 25%
3235 3240	LS	1-2% Grn clay	LMGyBn	2	M-WS	fragmental				9								1		?		?					37-57	tr pyritic Very small ctgs = BB 30%
3245 3250	LS	2-5% sity calc SH	LMBnGy	2	M-WS	fragmental (F-M)				? 8								1				н			?		37-57	tr pyritic Very small ctgs = BB 30% P
3255 3260	LSarg	green clay	MdBn	4	W-PS	sponge-skel-frag				7		15					?1	3	1	1 1	?	?	1		3		2-4A	tr pyritic ??calcispheres? 3P
3265 3270	LS	sl arg	MdBn	4	WPS	sponge-fragmenta	tr?	calcspar		15	5	8		1			1	2		?			? 1		1		7-4A	hexactinellid spg; tr free VC dogtooth calcspar BBB 2P (x16 of spg)
3275	LS	tr Gm SH	MdGyBn	2	M-WS	frag-skel	tr?	vug-shelter		5		3	?					П		1	?	П	? ?		=		3-5A	styloilites porosity on logs??= only cl spar ctgs BBB P
3280 3285 3290	LS	tr Grn SH	MdGyBn	2	M-WS	frag (-skel)				3 5		?	2					2		2		?	Ε	1	2		8-5A	tr pyrite; tr clear calcspar 2P (x16)
3295	LS	tr Gm SH	MdGyBn	4	W-PS	stromatop-frag				5 10		?	17		?	?		П	1	1 2	1	П		П	?		3-5B?	tr pyritic Clear-brwn spar = rextl coral?? BBB 2P
3300 3305	LS		MdGyBn	3	W(P)S	skeletal-fragmenta				5 15	5	3	3		?		П	?	1	1 2	Ξ	?	Ε		_		3-4C7	tr VC clear calcspar BBB
3310 3315	LS	grn sh infill	MdGyBn	6	P(B)S	strom-spg-skel-frg				5 10		8	10	1?	Ξ	1?		2	1 ?	2 3	1 1	1	?	1?	_		C-3	tr pyritic BBB 3P
3320 3325	LS	+ grn SH seam	MdGyBn	3 4	FWS	skel-frag				12	2	3 1	4	1	T	?		? 3		2	1 1	П	encn 1	tint	4	1 :	A-4C?	tr pyritic ribbed shell = pecten? brach? BBB 3P (x16)
3330 3335	LS	poor sample	MdGyBn	3	ws	fragmental				7		?						2	т			П	т		2?	-	37-57	v≔ry poor sample very BBB
3340 3345	LS	+ Gy pyritic SH	DMBGy	3	ws	frag (microbial?)				? 5-		1	2					2		2		П	1 1?		5+		C?-5A	micropyritic P
3350	LS sdvar	SWC#46-3450m	10000		WPS	sponge-skel		nil			ra .	20				2		3		1000	2	2	1		10		A-JC?	
3355 3360	LS	poor sample		2	MWS	fragmental				10		1	1					1?		1?						3	17-57	slightly pyritic very poor samples very BBB light
3365 3370	LS LSdolm	poor sample SWC#44-3466m			WS F-BS	frag (microbial) spg-strom-skel				3 15	45	1 26	2			?	Н		2 2	?	4	1	1		7	3	7-57	poor samples BBB P tr grn SH TS 10% VF qtx sandy
3375	LS sdy	SWC#43-3474m	(L)MBGy	5 4		skel-microb-ORAL		nil ?REW	ORKE CE?	D>>	10	1	2	T	Τ	50	1	2	3 2	- B (0000 S	Ϊ	2	2 3		10	2	B-3C?	VF-F-silt qtz in matrix tr pyrite BBB P
3380 3385	LS	sl arg	(L)MBGy	4	M-PS	microbial-frag				20		3	2			2		1			1 1				15	3	IC-5A	SWC43=coral w micritic rim bored tr micropyrite BBB 2P
3390 3395 3400	LS	sl arg; dolm 3%?	(L)MBGy	6	w-gs	Microb-skel-frag	tr-1	V-shelter		20		8			st	nid 2		1		1	Ι	?	?		10		C-4A	??calcispheres? BBB 2P
3405 3410	LS LS	sl arg; dolm3%?	(L)MBGy		WPS	fragmental	2	IAB1C1		?3 15		46	1				la la				_				?	3	?-5?	very poor spl BBB P
3410 3415 3420		SWC#41-3413m	(L)MBGy		P/F/BS M-FS	frag-microb-spg? microbial?spomge	-	1AB2-3Ctr		15		10	10/	?	3	1	inid						3			2 3	C?-4ACY	15 15% F-M matrix dolom very poor spl BBB P
3425			LMBGy			VF-C+arg skel RS/WS		IC (+V)		15	?	7	15		37	7	1			5	0.1	3EN/	IKI V				C-5B	8/2 dol/ls; tr pyrite(VF-F). Seems mostly DOL vs log?? Fract-doln P
3430 3435	DOL DOLarg	SWC#39-3427.5m SWC#38-3431m	L(M)BGy		XTL XTL	VF-F & M, VUGGY VF-C		iabc5d20+ V dolospar							1			3			A		NI V			3	17-5? 17-5?	# % remnant calcite-calcitic dolorhombs seen in thin section +2% VC clear-wt calcspar
3440 3445	LS/DOL	WC 3441-3465.4n	n	7 0	BS&GS	spgBS&skelG/RS	5-10	CC	RE	20	15	45			3	solit	ary 1	7	3	5	1	2	1 1		10		17-57 IA-4A	Depth correction: 3434m core = 3441m in wellbore 2.5m graded skeletal-clast debris flow in slope? sponge: microbial F/WS
3450	DOL	SWC#37-3450m			XTL	framebuilder? FS	5-10	V PH	OTOS OG	20	13		15?	aty	2		4	15	3	5	1	-			10?		C-6/38	FS(RS) platy framebuilders (lighter and finer xtl size = bimodal xtlinity/porosi
3455 3460	DOL LS/DOL	SWC#36-3454.5n SWC#35-3460m		9 4	XTL	vuggy & breccia crinoid-strom-cora	5-10 FS(B	V s)	ETCH			5	15.9	,	3	10		10		2			2		??		E/3B	vugs to 10cm with XC calcite infill very common; stylolites articulated echinoid/crinoid calyx = very low enery waters; stylolites
3465 3470	DOL	SWC#33&4-3467	0		XTL	framebuilder B/RS VF-C vs bimodal	5-10	V IABCtr-1		-			207		2	207		5					3				A-5A	XC calcspar in vugs for comparison P ctgs 5-40% XC calcspar; micropyrite; stylolitic; crinoid-skeletal P?GS
3470	DOL	SVVC#33&4-3407			VIL	VS Dimodal	1 4	INDUI-1										307									H SH	0-40 % AC Carcopar, micropyrite, stylonice, crinoid-skeletar P7GS



FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-'stromatoporoid reefal, 5C=mud/pelleted; 5D=colitic, 5E= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic. SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details

Figure 3.2 Example lithologic log - Margaree F-70. Based on purpose-designed EXCEL spreadsheet and used for all recent wells and many older ones drilled after 1978. Most earlier carbonate-bearing Abenaki wells are available in Eliuk (1978). Except for Glooscap C-63 the recent wells in PFA Chapter 9 and appendices (OETR 2011) are available as Beicip-Franlab simplified format logs and were based on lithologs such as above supplied by GeoTours Consulting Inc. logged by L. Eliuk. For F-70 the core was also plotted in this format. Some wells skip every second cuttings sample and have descriptions of sidewall cores (SWC) inserted. All cuttings and cores were macrophotographed (e.g. Dominion J-14 **Fig. 3.5**)

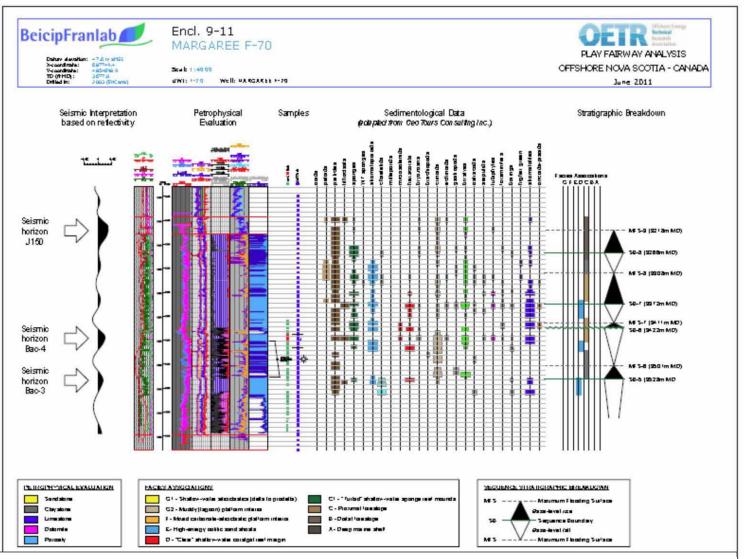


Figure 3.3 Example Beicip-Franlab lithologic-facies log - Margaree F-70 (PFA Chapter 9 Enclosure, OETR 2011). Converted from the text-tabulate format shown in **Figure 3.2.**

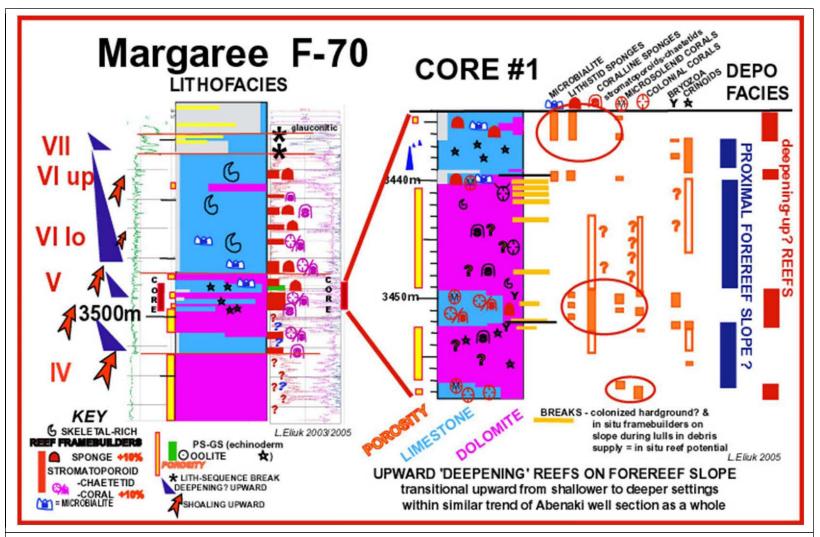


Figure 3.4 Example schematic litholog of Margaree F-70 well and core. Style of log used to show key features of wells throughout report based on detailed logs as shown in Fig. 5.2. The sequence tops are similar to those tentatively used in Encana studies. All Encana Abenaki wells were originally logged by GeoTours to aid Encana's development and exploration in the Deep Panuke play. Some additional infill cuttings logging was done for both Shell Canada and Encana. Marquis L-35 and L-35A were originally logged for El Paso Canada. Most pre-1978 wells were not contracted with Eliuk (1978) wells not redone in Excel format.

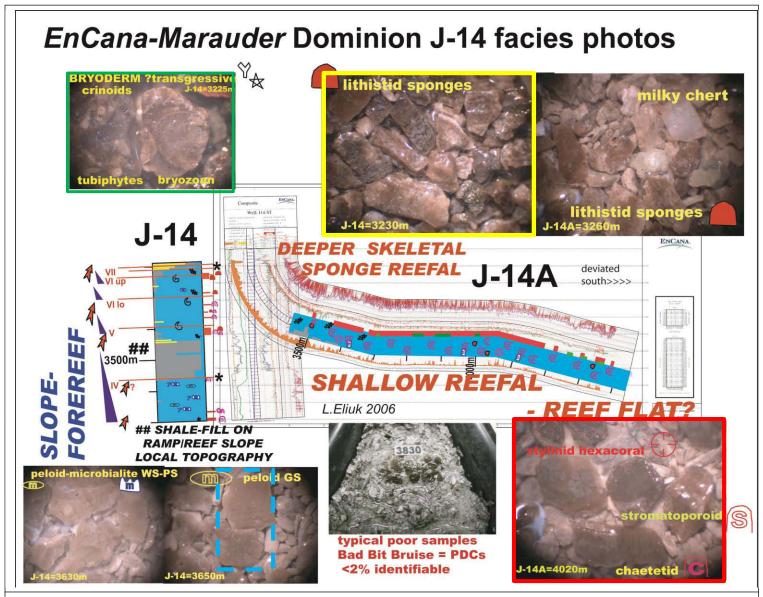


Figure 3.5A Examples of key facies fossils in cuttings in Dominion J-14 and sidetrack J-14A. Fossil symbols on well logs beside named on photos and lithologic key in Figure 3.4. Enlarged fossil views shown in Figure 3.5B.

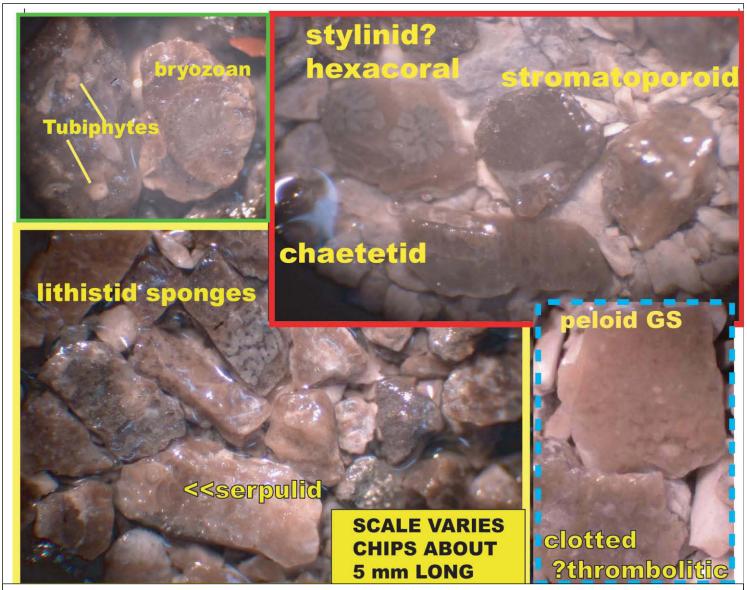


Figure 3.5B Enlarged views of some indicator facies fossils. Coloured borders match areas in Figure 3.5A.

TA	BLE 3.3 Abena	ki Carbonat	e Deposition	al Facies Asso	ociations Temp	olate - left side	,			
		OPEN MARINE	OPEN MARINE		FORESLOPE	311	OPEN MARINE	CARBONATE OFF	SHORE BANK	
		BATHYAL	THE RESIDENCE OF THE PARTY OF T	FORESLOPE	DISTAL	PROXIMAL	DEEPER SHELF MARGIN REEFS & MOUN			
FACIES ZONE NAME		national and a second a second and a second	NERITIC	S. ESPERANTEMENT PRINTED	FORESLOPE	FORESLOPE	'DEEP' SILICEOUS	MICROSOLENID	'SHALLOW' SPONGE	
		'BASIN/SLOPE'	'DEEP SHELF'	CHANNEL	MUD		SPONGE MOUND	CORAL & SPONGE	(CORALLINE-	
	NUMBER	1	2	3A (TOE-OF-SLOPE)	3C MOUNDS	3B (FOREREEF)	4A & INTERMOUND	4B REEFLETS/MOUND	4C LITHISTID) REEF	
	SYMBOLS			ىر ىر	_ب_ب_	ىم ھ	△LH	ODM □L	ଜାମି △ୂ	
	LITHOLOGY	SHALE MARL (CHERT?)	SHALE, MARL MINOR LIMESTONE & SILTSONE	LIMESTONE & SHALE WITH SILT/SANDSTONE	LIMESTONE SHALE SILTSTONE	LIMESTONE SILTSTONE	ARGILLACEOUS LIMESTONE & SHALE (HEXACTINELLID & LITHISTID SPONGES)	ARGILLACEOUS LIMESTONE & SHALE (MICROSOLENIDS- LITHISTIDS-MICROBS)	LIMESTONE ARGILLACEOUS & CLAY/SST/SLTST/DOLF (LITHISTID-CORALLIN SPONGES)	
	COLOUR	DARK, RARE BLACK	DARK, RARE BLACK	DARK (LIGHTER TO SW)	DARK (LIGHTER TO SW)	MED-DARK (LIGHTER TO SW)	DARK GREY-BROWN WITH GREEN (RED)	MEDIUM (DK) BROWN	LT-MED BROWN GREY	
	GRAIN TYPE AND POSITIONAL TEXTURE	MUDSTONE	MUDSTONE SHALE	MUD to GRAINSTONE, TURBIDITE, DEBRIS FLOWS	PELOIDS & MUDSTONE SKELETAL WACKESTONE	WACKE/PACKSTONE OCC' GRAINSTONE FLOATSTONES	WACKESTONE SPONGE FLOAT/ BOUNDSTONE	SKELETAL WACKESTONE SPONGE-MICROSOLENID- MICROB FLOAT/BOUNDSTONE	STROMATOPOROIDS- LITHISTIDS-MINOR CORA FLOAT-BOUNDSTONE	
	BEDDING	MASSIVE, GRADED	LAMINATED	GRADED, CHAOTIC INCLINED	LAMINATED, BURROWED INCLINED	BEDDED TO POORLY	MASSIVE,	MASSIVE THIN BEDS	MASSIVE?	
SEDI	IMENTARY STRUCTURES	LAMINATED	BURROWED	SLUMP BLOCKS, SUB- MARINE CEMENTS, GEOPETALS	HARDGROUNDS BIOEROSION	HARDGROUNDS GRADED BEDS	BURROWED & SOME BORING	(INCLINED ON FORESLOPE) BORED		
7000	ERRIGINOUS CLASTICS MIXED OR INTERBEDDED	DOMINANTLY FINE SILICICLASTICS	CARBONATE NEARLY ABSENT	COMMON (ADJACENT TO SABLE DELTA)	COMMON (ADJACENT TO SABLE DELTA)	RARE TO UNCOMMON	SHALE COMMON DISTAL PRODELTA SHELI	THIN SHALY INTERBEDS	SHALE, SILTSTONE CLAY SANDSTONE	
DISTE	TA GENERAL DESCRIPTION RIBUTION ant common accessory rare	MINOR SILICEOUS SPONGES SPICULES, PELAGIC BIVALVES & FORAMS, AMMONITES RADIOLARIA	SPONGES BIVALVES, FORAMS LOW AMOUNTS	PLATFORM & SLOPE DERIVED	PLATFORM & SLOPE DERIVED MICROBIAL & SPONGE MOUNDS -COMPLEX TAPHONOMY	IN-PLACE & MARGIN-DERIVED	ABUNDANT-MODERATELY DIVERSE BUT NEARLY LACKING ALGAE & RARE CORALS AHERMATYPIC OR MICROSOLENID	ABUNDANT-FAIRLY DIVERSE UNCOMMON RED ALGAE & CORALS MAINLY MICROSOLENID MICROBIAL ENCRUSTERS	ABUNDANT DIVERSE CORALLINE & LITHISTID SPONGES BUT MUCH FEWER CORALS	
	ALGAE - HIGHER				1010-007-007-007-0				RED	
RS	Automicrite - 'MICROBIALITE	' (suspect textures)		THROMBOLITES	THROMBOLITES			9		
DE	HEXACTINELLID SPONGES									
FRAMEBUILDERS	LITHISTID SPONGES									
ME	CALCI-& CORALLINE SPONGE	S (CHAETETID & STROM	IATOPOROID)					ST	ROMS & CHAETETIDS	
-RA	MICROSOLENID CORALS HEXACORALS						COLUTABY			
	BRYOZOANS						SOLITARY			
	(CRINOIDS) ECHINOIDS					te .				
	BIVALVES/GASTROPODS									
	SERPULIDS-TUBULES									
	TUBIPHYTES									
	OTHERS	SEE ABOVE	(NOTE - FORAMS	OCCUR IN ALL FACIES)		BRACHIOPODS, BELEMNITES	BRACHIOPODS			
	BIOEROSION-macro									
	DIAGENETIC		OCCASIONALLY VERY PYRITIC		COMPLEX EARLY DIAGENESIS- GEOPETALS SUBMARINE CEMENTS EARLY LITHIFICATION &	SUBMARINE CEMENTATION EARLY LITHICATION SYTLOLITIZATION	(HALMYROLITIC) SUBMARINE OXIDATION GLAUCONITE(?) &	SUBMARINE ENCRUSTATION & LITHIFICATION (CEMENT)	DOLOMITIZATION & LIMESTONE MICRO POROSITY LOCALLY	
	FEATURES	CAP BANK ON WES	OATED IRONSTONE (' TERN SHELF FAR FROI OR DIAGENESIS - HAL		FRACTURING, STYLO- LITIZATION	'SANDY' BEDS CAN BE DOLOMITIZED	PHOSPHATIZATION (+ DOLOMITE EUHEDRA?) STYLOLITIZATION			
POR	ROSITY DEVELOPMENT	VERY SLOW TO NON	VERRILL CANYON IN		WEST VENTURE C-62 C13	MARGAREE F-70 dolomite			PANUKE H-08 AB5 C1 microporous limest.	
EXAMPLES		QUEENSLAND M-88 PENOBSCOT L-30 C2 foreset section	ONEIDA 0-25 &	COHASSET L-97 C1-partial DEMASCOTA G-32 C5-top ACADIA K-62 C5-top	PENOBSCOT L-30 C2 QUEENSLAND M-88 DEMASCOTA G-32 C5-base ALBATROSS B-13 lower	MARGAREE F-70 C1- crinoidal graded bed & dolomite 'sands'	DEMASCOTA G-32 C1	MARGAREE F-70 C1- reeflets on slope sands W VENTURE C-63 C13 #9 LS	PANUKE H-08 C1 PANUKE M-79 AB6L&5 BONNET P-23 top	

	OPEN MARINI	E CARBONATE OF	FSHORE BANK -	PLATFORM - RAN	1P		MIXED CARBONATES	COASTAL
SHELF MARGIN		MARGIN TO I	OPEN INNER	SILICICLASTICS				
REEFS	(NOTE facies sche	ematically arranged so	alphanumerics out of	order and differ from	Willson 1975)	SHELF	PLATFORM INTERIOR	DELTAIC
CORALGAL REEF	SKELETAL RICH	ONCOLITIC 5E REEF FLAT-BACKREEF	OOLITIC 5D	MUD/PELLETAL 5C SEE Mud Mound 3C*	SANDSTONE 5F 'hiatal-unconformity'	(DEEP LAGOON) 6 'MOAT'	'NEARSHORE 7 RIDGE'	LAGOONAL CONTINENTAL
CE	GG	ର ଗ	00	\(\mathbb{m}^*\)\(\mathbb{m}^*\)	··			士工工
LIMESTONE AND DOLOMITE	LIMESTONE AND DOLOMITE	LIMESTONE (DOLOMITE)	LIMESTONE (DOLOMITE) THIN SANDSTONE	*WITH STROMATACITIS SLOPE MUD MOUNDS & MARGINS DURING 'DROWNED' PERIODS LIMESTONE WITH SS & SH IN SHELF INTERIOR, MINOR COAL OR DLOLOMITE	SANDSTONE WITH SHALE & THIN LIMESTONE	LIMESTONE (ARGILLACEOUS) & SHALE WITH SILTSTONE & SANDSTONE	SANDSTONE, LIMESTONE & SHALE WITH COAL	SILICICLASTICS WITH MINOR LIMESTONES CYCLIC LOFERITES
MED-LT BROWN-GREY	MED-LT BROWN-GREY	MED-LT BROWN-GREY	DARK-MED-LT BROWN (LIGHTER TO SW)	LIGHT TAN (WHITE) MEDIUM BROWN	LIGHT BROWN-GREY	DARK BROWN & GREY	MED FROWN-GREY RED&GREEN GY SHALE	LIGHT FROWN-GREY RED&GREEN GY SHAL
CORAL-STROMATOPOID FS-BS, SKELETAL WS-PS MINOR GS	SKELETAL WS-PS/FS w/ OOID-PELOID WS-GS	ONCOID FS-RS, MOLLUSK FS, OOID-PELOID WS-GS	OOID GRAIN/PACKSTONE ONCOID FS, PELOID PS	PELOID MUD TO GRAINST MINOR OOLITE & SKELETAL WS (DEBRIS RS)	C-MEDIUM-FINE-VF QUARTZ SANDSTONE	MUD-TO WACKESTONE MINOR OOLITE	OOLITE, ONCOLITIC WACKESTONE	ALGAL LAMINITES, ONCO MEGALODONT FLOATS PELOID MS-PS, OOLITE
MASSIVE, IN SITU TO RUBBLE HIGHLY BIOERODED, NTERNAL SEDIMENT	MASSIVE, BEDDED BURROWED	MASSIVE BEDDED BURROWED CLASTS BIOERODED MINOR CORAL BS	MASSIVE BEDDED CROSS-BEDDED BURROWED	MASSIVE, BURROWED ON SLOPE -'DEBRITES' THROMBOLITES & STROMATACTIS	BY-PASS PERCOLATES INTO EXPOSURE SURFACES PRESERVED IN LOWS (LOW-STANDTRANSGRESSIVE)	BURROWED THIN BEDDED HARDGROUNDS	CROSS-BEDDED BURROWED	STORM DEPOSITS DESSICATION FEATURE
TRACE CLAYS IN SHELTER CAVITIES	MINOR TO ABSENT (INCREASE TO NE)	MINOR TO ABSENT	SOME SANDSTONE INTERBEDS QUARTZ NUCLEII (DECREASE(/BSENT TO SW)	MINOR INCREASES TO NE/DELTA OR 'MOAT'	ABSENT TO SouthWest NEAR MARGIN	FINER CLASTIC BEDS OFTEN DOMINANT, CYCLIC?	REDDENED SHALES & SANDSTONE DOMINANT	CONTINENRAL SS & SE EXCEPT ON SALT HIGH
ABUNDANT & DIVERSE DOMINATED BY REEF FRAMEBUILDERS -CORALS VARIED) WITH ENCRUSTERS & BORERS	ABUNDANT DIVERSE BUT FRAMEBUILDERS MINOR (LESS 10%)	ABUNDANT DIVERSE LARGE NEREIDS & MEGALODONTS	SPARSE IN MOBILE BARS SOME DASYCLAD ALGAL NUCLEII	SOMEWHAT SPARSE (MINOR RESTRICTION)	POORLY FOSSILIFEROUS BIVALVES & OSTRACODS AND LITHOCLASTS	FAIRLY SPARSE BUT OPEN MARINE OF DEEPER NERITIC ORIGIN		SPARSE TO ABUNDA BUT LOW DIVERSITY INDICATES SEMI-RESTRICTED
RED & GREEN			GREEN-DASYCLAD				COALS	COALS
		ONCOIDS		*THROMBOLITES ON SLOPE		ONCOIDS	ONCOIDS	MATS & ONCOIDS
				MAINLY SLOPE-MARGIN				
RARE								100000000000000000000000000000000000000
IIAIL				VODERALIED ANGRESSINE				
			thin be	RYODERM 'TRANGRESSIVE' eds of high amounts echino	derms-bryozoa			
		GASTROPODS large						
		NEREIDS MEGALODONTS		MAINLY SLOPE-MARGIN				OYSTERS MEGALODO
		large BIVALVES		ONLY ON SLOPE-MARGIN				
	OSTRACODS			CALCISPHERES ON SLOPE		OSTRACODS		
	5311/10053			C. LEUSI FILILES ON SEOFE		3311110003		
RECRYSTALLIZED, LEACHED, FRACTURED DOLOMITIZED, MINOR CHALKYTO MICROPOROSITY	RECRYSTALLIZED, LEACHED, FRACTURED DOLOMITIZED, LST MICROPOROSITY	HIGHLY BIOERODED RECRYSTALLIZED & LEACHED (DOLOMITIZED)	THIN EARLY (SUBMARINE) CEMENT BUT MAINLY BLOCKY BURIAL SPAR, RARE REDDENED ZONES, MINOR DOLOMITIZATION	PELOID 'CEMENT' (SLOPE) VS FECAL etc. (INTERIOR) ON SLOPE - SUBMARINE ISOPACH' CMT & GEOPETAL HARDGROUNDS, DEBRIS	GENERALLY WELL CEMENTED BY CALCITE OR QUARTZ	SUBMARINE (HARD- GROUNDS) BUT MAINLY BURIAL CEMENTS STYLOLITIC	SUBAERIAL/ GROUNDWATER OXIDATION, EROSION	RECRYSTALLIZATIO LEACHING OF FOSS & CHALKY ON SALT HIGH
PANUKE M-79 AB4 G-32 171m@6.5%			ACADIA K-62 ALBATROSS B-13	HERON H-73 148M@7% chalky on shallow salt dome (shelf interior)			SANDSTONE USUALLY MORE POROUS THAN LIMESTONES	HERCULES G-15 71m@16% LST on salt dome
PANUKE M-79 AB4 DEMASCOTA G-32 C2 & 3 COHASSET L-97 C1	COHASSET D-42 DEMASCOTA G-32 C2top	ACADIA K-62 C4 mid Baccaro Mbr	PENOBSCOT L-30 C1 PANUKE F-09 ONEIDA O-25 ALBATROSS B-13 C1	DAUNTLESS D-35 C1 DEMASCOTA G-32 AB2&3 HERON H-73 Grand Banks	KEGESHOOK G-67 COMO P-21 PANUKE F-09	MOHICAN SUBBASIN MOHICAN I-100 C1-4 MOHEIDA P-15	MOHAWK B-93 NASKAPI N-30 Leslie Eliuk 2010 & 2015-11	ORPHEUS BASIN HERCULES G-15 SABLE DELTA ARI

Chapter 4. RESULTS

From Near-Margin and Mixed-Lithology Well-Control and Western Shelf Wells – Seismic Setting, Mid-Mesozoic Lithologies and Depositional Facies in Cuttings and Core – the Initial Interpretative Framework

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 - Albatross B-13 and the Full Shoaling Sequence with
 Red and White Slope Microbolites Up to Coral Reefs and White Oolites, and
 - Bonnet P-23 with the Return of Shaly Carbonates and Sponge in a Near-Margin Shelf Interior Setting.

"It is possible to interpret without observing, but not to observe without interpreting"

4.0 Introduction

The basic data given in this chapter are from the rocks in the wells – cuttings, sidewall cores and whole cores. It is an illustrated tour from the Sable Delta to the last well on the Western Shelf by wells or groups of similar wells whose main relevance is indicated by the Section titles. Although already interpretive in nature, the data represent the results of the study concentrating on limestone-bearing wells in the transition from Abenaki platform northeast to the Sable Island paleodelta. Carbonate-bearing wells shown on **Figure 4.1** are listed in **Table 4.1** from the Sable Delta and Panuke Trend areas with some of their characteristic sedimentological-stratigraphic features grouped for comparison. In addition, several wells distal to this transition are included to contrast and compare facies development and history on the Western shelf: the type section Oneida O-25 of the shelf interior and even further west at or near the platform edge – Acadia K-62, Albatross B-13 and Bonnet P-23. **Figures 1.1** and **4.58** give larger map areas and **Table 3.1** a longer well list including these Western Shelf wells. Most of these 23 wells with four side-tracks/whipstocks will be presented in a northeast to southwest well by well manner with some minor additional data from off-setting wells.

Published seismic sections and seismically-based maps (mainly Kidston et al. 2005 but also Wade and MacLean 1990 and PFA Chapter 9 of OETR 2011) as well as biostratigraphy resulting from the PFA study (OETR 2011, Weston et al. 2012) are very important supplements that I used as a framework for a better understanding of the lithologic data results. The seismic in the Penobscot area is key to understanding the relationship of the deltaic siliciclastics to the clean thick carbonate platform. So prior to considering the wells in the area, the seismic merits an additional review in its own Section concluding with some seismic lines by Qayyum et al. (2015a).

For the Panuke Trend and Field, Encana's depositional sequence are used for 8 lithofacies pie-chart maps and for a dip and strike well section (the latter is from Weissenberger et al. 2006) to show lithologic-depositional facies. Some features of relevant core are shown and are critical to better understanding the cuttings and for comparing changes in coral reef and microbolite (thrombolitic) mound facies. The sponge-rich facies is an interesting reef mound phenomenon on its own and is also an indicator of the distal effects of the delta in slightly deeper waters. So the comparison with this facies as well as the sometimes associated red coated ironstone sediments and certain specialized biota are dealt with in some detail.

The three southwestern-most near-shelf margin wells are included at the end of this chapter as a contrasting comparison with delta-affected carbonates both at the end of carbonate sedimentation in uppermost Abenaki and along the slope where lateral changes occur. Changes, most notably colour, seen in the slope microbolite mound cores relative to proximity of the Sable Delta are obvious and significant. Changes are not so obvious in the coral-stromatoporoid or coralgal reefal facies association of the platform perhaps due to the lack of detail available when only cuttings and few cores are available. In contrast when core is available, within even deltaic sediments, small colonial coral complexes down to a few decimeters in height are recognizable as well as carbonate complex successions involving microbolite mounds up to lithistid-microsolenid coral reef mounds over a short interval of about 10 metres.

The first part of this study is limited to the general area of transition from the Abenaki carbonate platform of the Deep Panuke Trend (term from Kidston et al. 2005) northeastward to Sable Delta siliciclastics. So the rather different, more thoroughly mixed nature of the prograding carbonates and siliciclastics to the northeast illustrated in **Figure 2.3** is not considered except in two representative wells just off the carbonate platform nearest the Sable Delta. Three wells northeast of the Venture area with several carbonate intervals of over 100 metres are not included in this study (Arcadia J-16, Citnalta I-59 and Uniacke G-72) even though shown on **Figure 4.1.** Within this limited area, groups of common features regarding topmost carbonate lithofacies or presence of pinnacle reefs or occurrence as ramp-only facies can be distinguished in a matrix of comparative sedimentology-stratigraphy shown as **Table 4.1.** Such groupings and their general locations not only give appreciation for the amount of well control and its distribution but may be a good start on understanding their process controls and patterns.

Details from core control are shown in the same section as the core-bearing wells. In Chapter 5 reef/mound cores will be compared to assess their relevance to delta proximity. The purer carbonates and near-shore mixed carbonates-siliciclastics to the southwest on the Western Shelf are included as a contrast to the carbonates closer to the Sable Delta.

NOTE that Encana used Roman numerals and Arabic numbers for their Abenaki sequences interchangeably so that AB IV is the same as AB4 or Ab4 (or even A4 of Kidston et al. 2005). And AB6 L is the same as AB VI lo or lower and so on. Over time and herein neither the literature nor I have been consistent. Usually in this text I use Arabic numbers for reading clarity and on my figures Roman numerals as the figures are often collages of other people's works plus my own, or a different re-interpretation of other works.

4 .01 West Venture C-62 and Nearby Venture Wells – Deltaic Limestones – Minor Thin Limestones of the #9 Limestone in the Late Jurassic Sable Delta

The #9 Limestone Marker at top MicMac Formation in Mobil West Venture C-62 represents the thin end-member of a spectrum of Abenaki-equivalent limestones. This core and nearby offsetting well cuttings (**Figure 4.2**) show that limestone can occur within the Sable Delta itself, albeit thin and certainly nothing like a carbonate platform or even the generally thicker limestones occurring on the ramps flanking the delta. The details from the limestone give major insight to the associated terrigenous sediments.

The C-62 core has several vertical facies changes that can be interpreted to result from shoaling and/or reduced turbidity, only to be abruptly terminated then followed by prodeltaic shale deposition. Figure 4.3 shows schematically the facies changes (numbered) in the #9 Limestone at the base of a long series of C-62 cores. The main lower facies are very argillaceous limestone to calcareous shale or marl that can be subdivided into a (1) highly bioturbated lower interval lacking in body fossils with a great number and variety of ichnofossils including *Zoophycos* indicating an oxic deep shelf/upper slope environment. That is overlain by (2) a depauparate massive marl to argillaceous micro-packstone. Then (3) an encrusted debris bed forms a substrate for (4) a pure microbolite (thrombolitic) mound with a limited variety of micro-encrusters (*Tubiphytes*, serpulids, nubeculinellids). This grades upward with increasing *in situ* skeletal content to (5) a microbial-microsolenid coral-lithistid sponge-red algal (?solenoporid) reef mound suffering some bioerosion (mainly clam borings). That is abruptly overlain across a pyritized hard ground(?) by (6) dark laminated prodeltaic shales or clay mudstones with some ironstone cemented layers and thin beds of siltstone to fine sandstone that become burrowed and more common upward. These subfacies are illustrated and described in more detail in Section 5.2 (Figure 5.5 series).

What had previously been interpreted in the West Venture C-62 core as condensed lime mudstone without framebuilders (Cummings and Arnott 2005; Gould et al. 2012 also examined this core but did not include this limestone), in fact had a succession of mound and reef facies that changes over just 9m vertically before being buried by prodeltaic shale. **Figure 4.2B** tabulates the #9 Limestone lithologies seen in cuttings and core from five wells of a few samples over a thickness of 7 to 40 metres (location on **Figure 4.1**).

Onlite and possible reefal beds of lithistid sponges-stromatoporoids (coralline sponge)-corals are the two main lithologies with marls and skeletal-fragmental-pelletal wackestones as well. Although onlite can be transported from its place of deposition, it is fairly obvious that the

West Venture C-62 core along with N-91 cuttings were deposited in less agitated (deeper) water than the wells to the east which seem to be part of a thin onlite shoal complex. The widespread but differing nature of Abenaki or equivalent limestones and their utility even when very thin for giving depositional information will be enlarged upon in a more comprehensive treatment of the #9 Limestone and its reef mound succession in Section 5.2.1 where they are divided into upper and lower units (**Figure 5.4**). There this limestone will be put in context of the Late Jurassic Sable Delta in the Venture gas field and provide support from a very different perspective for Cummings and Arnott (2005) shelf margin delta and forced regression interpretations.

4.02 Review of Seismic through Penobscot L-30 & B-41 and South Desbarres O-76

Relevant seismic lines are shown on **Figure 4.4**, a screen capture of the DecisionPoint GIS map from CNSOPB Data Management Centre's website. The 2D seismic control with the lines through Penobscot B-41, Penobscot L-30 and South Desbarres O-76 are highlighted in black. A 1990's vintage 3D seismic study is shown in a dashed rectangle where some lines from Qayyum et al. (2015a) are taken from and shown with alternative interpretation. **Figure 4.5** is a summary display of all the lines reviewed. Note that the east-west regional tie line is considerably longer to the southwest than the base map (**Figure 4.4**) and ties Kidston et al. (2005, **Figure 4.21**) dip seismic through Kegeshook G-67 and Marquis L-35. These same lines will be shown in more detail in subsequent figures but even at the reduced scale several features are obvious. Prograding ramp morphologies are more common to the northeast.

A channel, interpreted to be feeding a depositional thick, separates the main Abenaki platform from the Penobscot area. This lower slope Jurassic depositional thick was independently seen by different workers as depicted in **Figure A1.19** based on data from the PFA Chapter 9 (OETR 2011) study and also shown as an isotime thick on seismic mapping by Ammonite workers (Pers. Comm. Robert Merrill). The following are some personal observations on the 1980's vintage seismic lines obtained on the DecisionPoint program of the CNSOPB Data Management Centre.

Penobscot B-41 (**Figure 4.6**) dip seismic line is interpreted as an area of prograding and climbing clinoforms over eight miles to the south of a possible thick platform margin. The B-41 well barely tested the Abenaki with less than 30m penetration with some samples of oolitic limestone. While uplifted by the probable salt-cored structure, the B-41 would likely not have very thick Abenaki carbonates with much of the lower half to two-thirds probably a mixture of

slope limestones and shales. The possibility of interbedded sandstone with porosity cannot be ruled out. On the regional strike line (**Figure 4.9**) the area just to the southwest of Penobscot L-30 is a thick sag which may be the basinal part of a wide channel that separates the Penobscot area from the main Abenaki platform to the southwest. Thus the clinoforms over 8 miles may be flank deposits to a feature that is a major re-entrant, if not a break in the carbonate platform. The area of the channel aligns with one of the major transfer fault zones in Welsink et al.'s (1989) extensional tectono-stratigraphic interpretation of the Scotian Shelf. (see **Figure A1.4**). An alternative interpretation of contemporaneous Abenaki-time salt tectonics may have generated small fault blocks prior to burial by only slightly deformed uppermost Abenaki sediments that provide the regional top Abenaki reflector. Such contemporaneous un-roofing tectonics might also explain the presence of slightly older palynomorphs in many of the progradational limestone wells (see comments on dating for South Desbarres O-76 and Uniacke G-72 in 1.09 and appendices of PFA OETR 2011).

The **Penobscot L-30** (**Figure 4.7**) dip seismic line has been used by many workers but all with relatively similar interpretations (Ellis et al. 1985, Eliuk et al. 1986, Jansa 1991, 1993, MacLean and Wade 1993). Penobscot L-30 tested topset prograded shallow-water carbonate shelf on foreset shale and slope limestone clinoforms. The slope beds probably derive from the rimmed carbonate margin rather than the later ramp settings that develop basinward and southward. The margin may be for a separate atoll instead of the main regional Abenaki platform, possibly developed on an early paleohigh at the downdip edge of the Abenaki subbasin due to salt swelling in front of the early Sable Island deltaic sediment pile. **South Desbarres O-76** (**Figure 4.8**) is the furthest northeast of the 3 dip lines crossing the eastern end of the Penobscot structure at its updip north end and going through O-76 near its south end. Eight kilometers or so of prograding and climbing clinoforms separate them. Thus O-76 tested a more distal ramp topset-foreset pair with its two thick limestones.

Blue lines indicate top limestones in South Desbarres O-76 well trace with two thick units and a topmost thinner limestone at top MicMac/"Jurassic". Similar to Penobscot L-30, the two thick limestones are topset horizontal-bedded and foreset clinoform-bedded. In the same manner the topset beds have shelf oolite over and underlain by coral-stromatoporoid reefal beds and the clinoforms have slope lithologies (see **Figure 4.14A and B**). On the north end of the seismic line, the Penobscot structure is quite pronounced and the margin of a possible thick reef interval is developed on the structure's south flank. The structure is approximately a kilometre wide; the presumed thick carbonate is similarly narrow and possibly a small atoll. Below the top Abenaki

reflector over the high there are well developed strong reflectors indicating a mixture of lithologies (porosities??) within the supposed Abenaki interval. As already mentioned shallow-water carbonate and reefs may have developed preferentially on an early high generated by salt movement and swelling in front of the advancing Late Jurassic Sable Island deltaic depocenter.

Regional strike tie line (Figure 4.9) is over 40km long with the west half on the carbonate platform and the east half in the basin or slope. Between these two major depositional settings is an anomalous thick interval below top Abenaki and long-continued sag seen even on the modern seafloor. This can be interpreted as the debouchment of shaly sediments from a channel that cuts across the carbonate platform separating it on the southwest from the Penobscot structure. Updip of the interpreted carbonate margin is another edge analogous to that shown on other seismic lines by the Canada Nova Scotia Offshore Petroleum Board (CNSOPB Bid 12-01, Mark Deptuck) and PFA Chapter 9 (OETR 2011, Stefan Doublet) where the LaHave platform basement edge is no longer situated below and controlling the Abenaki carbonate margin. Instead it occurs beneath the platform interior, and perhaps older delta-derived sediments provide the paleohighs that localized carbonate deposition. As previously mentioned, this is about the area and trend where Welsink et al. (1989) had one of their major transfer fault zones in their extensional tectono-stratigraphic interpretation of the Scotian Shelf.

'Channel'/re-entrant/sag (Figure 4.1) dip seismic line cuts the regional tie line (Figure 4.9) just off centre of the Abenaki level sag-thick. If the selection of the platform margins (blue ticks on Figure 4.4 map) is correct then the re-entrant is most landward near Penobscot B-41 and the axis would trend north-northeast rather than due north as the seismic line was shot. The geometry into the basin shows a major basinal thick very close to the carbonate margin.

Seismic in the Penobscot 3D survey from Qayyum et al. (2015a) is reviewed in Appendix A1.11 on Previous Work using selected lines from parts of their figures. There it is suggested that the assumption of no structural movement that is important in the application of Wheeler diagram sequence stratigraphic interpretations is likely not true for the Penobscot area (see Figures A1.28 C&D and A1.30A). Qayyum et al. (2015a) saw the Penobscot area as an isolated atoll but localised by a pre-Abenaki structure. Alternatively 3 of their lines in Figures 4.11 A&B and 4.12 can be re-interpreted as a progression of increasing contemporaneous structural influence that converts dominantly shale-based foresets into a local carbonate atoll. Basically, it is here interpreted that salt tectonics associated with loading from the advancing Late Jurassic delta in 'mid-Abenaki' time generated a paleohigh (or paleohighs) that resulted in a local

carbonate mini-platform or atoll forming, rather than the more usual prograding foresets of prodeltaic shales with capping oolitic carbonates and thin slope carbonates of microbialites. That paleohigh not only allowed carbonate growth but deflected shale sedimentation around it on both sides. Qayyum et al. (2015a) showed that influx on the north as shown on **Figure. 4.13** of the Penobscot area 3D survey play ideas. Some of the complex mounded morphologies north of Penobscot L-30 were viewed as either carbonate mounding or deltaic channelling with more work needed (see **Figure. A1.28D**), whereas it is personally speculated that in the third dimension prodeltaic lobes might better explain the mounding.

Summary - This short survey of a small suite of lines supports the separation of the main Abenaki platform from the Penobscot area by a long continued channel. The pattern so far indicates that if a carbonate platform exists in the Penobscot and east area then it is a salient into the basin southeast of the main bank or even an isolated atoll. Qayyum et al. (2015a) also saw the Penobscot area as an isolated atoll. Re-interpreting some of their seismic lines indicates the progressive development of an isolated carbonate buildup was due to deep, probably saltgenerated movement starting in 'mid-Abenaki time' after the regional basal ramp phase. A channel interpretation seems most easily accepted for the dip line furthest east through South Desbarres O-76 (Figure. 4.8). The presence of a thick pod off-bank southwest of Penobscot in isopach mapping of the Abenaki including basin-fill by Ammonite (Pers. Comm. Robert Merrill 2011) and Chapter 9 PFA (OETR 2011) may be fed by this channel from the Abenaki subbasin as it was filled by the advancing Sable Island Delta and the Missisauga ridge over-ridden or bypassed to the south; it may have even caused salt withdrawal below. Contemporaneous Late Jurassic salt tectonics may explain some of the complication such as at Penobscot B-41 and especially explain the presence of reworked Late Jurassic palynomorphs in only slightly younger Jurassic deposits eroded from salt domes such as at Abenaki L-57 uplifted near-contemporaneous sediments. Now there are two wells, Penobscot L-30 proximal and South Desbarres O-76 distal, where depositional facies from core and/or cuttings relates well to seismic geometries. With the thin but highly informative carbonates within the Late Jurassic Sable Delta itself at the Shelf margin at Venture (C-63 core), these wells and seismic will allow a much better picture to be drawn of the relationship of delta to prograding ramp to carbonate platform.

4.03 South Desbarres O-76 – Distal Ramp Well - Smallest Coral Reeflet, Bryoderm Transgressive Markers

Shell South Desbarres 0-76 unsuccessfully tested a roll-over anticline between two normal-growth faults. As reviewed in the preceding Section, seismic geometries in O-76 (see

Figures 4.5 and 4.8) are similar to those in Penobscot L-30 with topset and foreset reflector limestones but over 8 km and several prograded clinoform sets basinward of a possible Abenaki platform edge, or more likely an atoll margin. Thus these wells represent proximal (L-30) and distal (O-76) ramp examples. A schematic lithofacies log of O-76 Figure 4.14B is shown (with Penobscot L-30 plotted beside it for comparison, Figure 4.14A). Unfortunately the seismic correlations are not obvious between the two wells and there is no new/revised dating in L-30 as discussed in the review of new age dating for the PFA study (OETR 2011, see Appendix A1.09) and Figure A1.20). The actual dating of the top limestones may be particularly difficult since top limestone in Marquis L-35 at the Abenaki platform margin somewhat south of this area is older than top limestone in South Desbarres O-76, suggesting that there might be renewal of carbonate sedimentation in distal ramp settings after it had terminated on the Abenaki platform margin. In both O-76 and L-30, the facies show a shoaling upward trend into the oolitic beds from reefal beds with corals and stromatoporoids which are better developed in O-76 and underlain by a bed of lithistid sponges and microsolenid corals indicating even greater depths distally. In South Desbarres O-76, bryoderm beds with one just above the last onlite but within the thick topset limestone may represent transgressive sequence breaks. In O-76 a higher thin limestone marking top MicMac (sometimes taken as top Jurassic) was rich in sponge reefal beds with cuttings greater than 10% lithistid sponges and possibly sponge mounds thus likely associated with deeper or more turbid waters.

The lower thick limestone in a foreset clinoform position consisted mainly of mudstones and thrombolitic beds of a deeper-water distal slope facies. This clinoform-associated facies was cored in Penobscot L-30 and is similar to distal slope beds along the platform margin but seemingly with a more depauparate restricted biota. O-76 and L-30 foresets are unlikely to be correlative limestone given the difference in numbers of clinoforms and much greater distance from the main Abenaki edge in South Desbarres O-76.

In South Desbarres O-76 cores 1 and 2 above the highest limestone beds, channel sandstones with basal thin conglomerates had an extremely thin but *in situ* bioeroded coral reeflet (**Figure 4.15**) with various other fossil-rich layers including lithistid sponges and crinoids-bryozoans (bryoderm beds) mainly in shales that are partly reddened. Although stratigraphically in the Missisauga Formation, the cored interval was dated as Late Tithonian (Weston et al. 2012) and their NBCU placed above it at 3770 m so it is age equivalent to Abenaki. This reeflet represents the thinnest shallow-water coral reef development yet found and shows that for brief periods

conditions were favorable for shallow-water bioherm development, even in deltaic to inter-deltaic siliciclastic settings.

A third core near the base of the deep South Desbarres O-76 well was considered to be in a section no older than Late Jurassic (Weston et al 2012) which is a revision from their PFA Chapter 3 (OETR 2011) dating of Middle Jurassic (see **Figure A1.20**) for the lower 800m possibly across a normal fault(?). Weston et al. (2012, their Fig. 14) showed evidence for sedimentary redeposition by gravity-flow processes in a prodelta setting and called the thin sandstone-shales turbidites.

Alternatively and perhaps surprisingly, Gould et al. (2011, GSC open file report 6945) interpreted the thin-bedded heterolithic sandstones and irregularly laminated shales-sandstones as shallow tidal flat. However given the setting, deeper water facies would be expected under a prograding delta. To accept the shallow alternative, either there was an early salt-cored paleohigh that collapsed or the basin at least locally was less deep than expected or the tidal flat beds were transported downslope and are allochthonous (latter a suggested possibility by pers. comm. D. Piper). The numerous seismically-defined ridges shown by Deptuck (2011; see **Figure A1.26**) may explain this hypothetical shoal or the source of the allochthonous tidalites – perhaps on the Migrant Ridge.

The distal South Desbarres (O-76) topset limestones comprise more reef constituents than the proximal unit in Penobscot L-30 that are oolitic with thin interbeds of corals-stromatoporoids-chaetetids. A similar interbedded oolitic limestone and sandstone succession caps the shelf margin Marquis L-35 (and slightly basinward side-track L-35A) and that section has even more oolite and only one stromatoporoid-rich interbed. This pattern is expected on a ramp going basinward into deeper water.

Placement of sequence breaks or shallowest deposition with possible capping unconformities in the absence of core is also problematic. Typically onlite is a very good indicator of very shallow marine water in carbonate regimes and the associated overlying siliciclastics tend to be coarse, suggesting shallow upper shoreface or paralic sedimentation perhaps in lagoon-like lows landward of outer ooid shoals. Delta lobe shifts may also explain the alternating main lithologies. The presence of a bryoderm bed just above the highest South Desbarres O-76 onlite would support the placement of a break or even unconformity with deeper transgressive somewhat reefal carbonates above the onlite going up into varied siliciclastics that clean up into the topmost

thin sponge reefal limestone mixed with bryoderm beds (up to 20% bryozoans and 15% crinoid). The overlying siliciclastic cores 1 and 2 were discussed above, but the common presence of open marine fossils indicates that the sandstones and shales are marine.

4.04 Abenaki J-56 – Mixed Deltaic-Carbonate Shelf Beds On the Side of Abenaki Subbasin Salt Dome

Shell Abenaki J-56, the formation namesake, was drilled in 1971 shortly after Oneida O-25 which is the formation's first well and type section. J-56 tested the south flank of a large northeast to southwest elongate salt dome or ridge. On most regional maps of the Abenaki platform, J-56 is shown at the northeast end of the western platform (e.g. **Figures A1.6, A1.14** shown incorrectly as 'L-57'). Compared to most other complete Abenaki sections on the platform, the thickness of the upper Abenaki Baccaro Member is comparatively thin at 792m, because the younger Late Jurassic sediments are in deltaic-clastic facies of the 170m thick MicMac Formation (**Figure 4.16A**), and because there is thinning of the units near the salt dome (**Figure 4.16B**). This thinning indicates that prior to diapiric intrusion the Abenaki was deposited on a salt-cored high. Abenaki carbonate intervals in Penobscot wells L-30 and B-41 may be part of a continuation of that, or a similar paleo-high.

The nearly continuous presence of oolite indicates a long-lasting shallow-water setting. However oolitic grain-packstones occur mainly in the lower 500m and are rare in the upper 300m (53% versus 3% from Eliuk 1978; also see **Fig. 4.17B** % pies). Potential reefal framebuilders, corals and stromatoporoids, are ubiquitous throughout J-56 Baccaro except for the lower 100m, but they are in very low amounts with only 2 intervals having even 5% hexacorals visible in cuttings. Their presence along with the oolites indicates an open setting such as a shoal or ramp where facies migration or sediment transport is more easily accomplished, initiated by minor relative sea level (or seafloor) changes.

Quartz grains form thin sandstone interbeds mixed with the ooids as particles and nuclei indicating proximity to terrigenous clastics but did not overwhelm the carbonate sedimentation because the presence of a shoal would force bypass of most siliciclastics into deeper off-shoal lows. The amount of oolite is much less, both in bed thickness and total amount in the top 150m of limestone, which indicates deeper bathymetry allowing ingress of sandstone and termination of carbonate sedimentation.

No cyclicity or sequences could be discerned in Abenaki J-56 (Eliuk 1978, see **Figure A1.2**; unlike the Baccaro cyclic shelf interior wells on the western shelf, such as Mohican I-100, Oneida I-100 and more recently Glooscap C-63). Abenaki J-56 does not have the same style of topmost Abenaki as either regional capping lithologies of sponge-shaly or oolite-sandstone capping beds, likely due to a paleohigh generated by underlying salt. Another striking difference between the two areas is the near absence of reefal framebuilders and of sandstone (shale and siltstone are more usual) versus their presence in Abenaki J-56. Further comparisons for J-56 are made at the end of Section 4.06.

4.05 Penobscot L-30 – Proximal Ramp Well with Seismic Ties to Abenaki J-56 and Nearby Wells

Shell-PetroCanada's (PEX) Penobscot L-30 at the Jurassic Abenaki level drilled a prograded ramp and slope and tested a probable salt-cored structure. **Figure 4.17** is a collage of vintage seismic, simplified interpretation and schematic well log for L-30 (Eliuk 1978, 1981, Eliuk et al. 1986, Eliuk and Wach 2008 and 2010 AAPG Discovery website). The deeper section of Penobscot L-30 penetrated Upper Jurassic interbedded limestones and sandstones that are relatively flat-lying topset in attitude. These overlie inclined major basinally inclined or foreset reflectors consisting of limestones and thick shale. The topset limestones (Penobscot Member of Wade and MacLean 1990) connect northwest to the nearby interpreted Abenaki platform or atoll and prograde over the basin-filling shales and limestones.

Penobscot L-30 has both seismic and core control (see **Figures 4.18** and **4.19** for details) that independently provide criteria for slope sedimentation with foreset geometry having microbial (thrombolitic) limestones and for shelf-shallow ramp with topset geometry having mainly oolites, thin coral-chaetetid boundstone biostromes and skeletal-rich muddy limestones that are in part oncolitic. Minor dolomite in burrow walls was seen in L-30 core 1. These lithologies can also be seen more widely in cuttings. The **Figure 4.17C** schematic litholog has been updated to reflect this re-examination and a short updated summary follows.

Of the topset three shallow ramp limestones, the uppermost 40m limestone had intermixing of 38% oolitic pack/grainstones and 31% stromatoporoid-chaetetid-coral beds; the middle 91m limestone had 70% oolite and only 7% stromatoporoid-chaetetid-coral beds indicative of the shallowest most restricted deposition; and the lower combined 101m limestones had a shoaling-up pattern with some lower shale-sandstone (10m) in fragmental-low skeletal lime wackestones that upward had 25% stromatoporoid-coral-chaetetid beds with more lithistid sponges and 10% oolite.

The intervening sandstones were poorly fossiliferous and very fine to medium-coarse quartzose (upper sandstone coarser than lower). Unlike the limestones they had porosity. This high variability of shallow carbonate ramp depositional facies reflects the control that highly photic settings subject to high wave-energy variations has on the biota producing the sediments and where minor transgression-regression can shift ramp environments significantly. Even the lithologies of mixed-siliciclastics and carbonates can alternate rapidly in such a setting (see Weissenberger et al.'s 2006 figure of two cores in wells northeast of Venture as a siliciclastic-rich example). This characteristic variability is in marked contrast to the uniformity of sediment on the distal slope which is either dark calcareous shale to marl or mainly in situ thrombolitic-peloid lime mudstone to bindstone. That is similar to Queensland M-88 slope limestone but in Penobscot L-30 even less variable with microbolites associated with encrusters like Tubiphytes, tubular foraminifera and serpulid worm tubes but only extremely few skeletal framebuilders. Compared to those of L-30, microbolites seen elsewhere in the Abenaki have more associated framebuilders and often show better developed submarine cement-lined cavity systems and lighter colors. L-30 dating has not been restudied so Figure A1.20 shows Ascoli (1990) age dates and likely is too old especially for the bottom of the well.

Of major significance, Penobscot L-30 is slightly (a kilometre or less) in front of the interpreted carbonate atoll (or less likely platform) edge similar to the Abenaki platform margin tested in Marquis L-35/L35A about 20 km to the southwest. The nearby Penobscot B-41 only penetrated 23m of tight Abenaki limestone with some oolite leaving a question about what lies deeper. The area has several large faults. Such faulting and fractures may provide a pathway for dolomitizing and leaching fluids which at Deep Panuke resulted in deep burial diagenesis and reservoir development including stratigraphic trapping of tight limestones lateral to porous carbonates. Such diagenesis post-dates the depositional events in the Abenaki so that clean carbonates and proximity to appropriate fluids are the key to porosity rather than a particular age or Abenaki depositional sequence. Shallow stromatoporoid-coral reefal facies are associated with the Deep Panuke reservoirs. Onlite is often tight there. Such reefing is typical of the whole Abenaki carbonate platform margin and uppermost slope over 300km. This important association has significance for trapping and porosity. While the Abenaki limestones when deeply buried typically lack porosity, associated sandstones often retain some amount of porosity increasing the likelihood of reservoir. Still the likelihood of stratigraphic trapping is much reduced in areas with significant sandstone beds due to lack of lateral seals, such that structural or fault closure may be required for traps to be effective.

4.06 Marquis L-35 & L-35A – Ramp-platform with Sandstone-oolite Couplets and Kegeshook G-67 Platform Interior Connection

El Paso Marquis L-35 and the basin-ward sidetrack, L-35A shown with dip seismic on Figure 4.20, are the north-easternmost Abenaki shelf margin tests of the Panuke Trend. Hydrocarbons or significant reservoir were not found in those wells nor in Kegeshook G-67. Figure 4.21B shows a longer dip seismic line linking Marquis L-35 with the shelf interior well Kegeshook G-67 partial penetration (Figure 4.21A schematic litholog) that has a highly oolitic section lacking reefal beds and capped by two sandstone-oolite couplets as compared to the minor thin sandstone beds at likely sequence breaks in the underlying upper Abenaki. As could be anticipated from the seismically well-defined placement (Figure 4.21B), El Paso Marquis L-35 showed a full shoaling sequence from thrombolitic-peloidal slope beds through massive shallowwater reef up into well-bedded oolitic limestone intercalated with sandstone at the top that progrades basinward of L-35. The basal 100m were coral-stromatoporoid reefal beds with very minor amounts of oolite (see Figure 4.22). The L-35A side-track had similar oolite-sandstone capping beds but probable foreslope beds were laterally equivalent to the basal onlite and upper reefal beds of Marquis L-35. However the L-35A well also bottomed in 100m of reefal beds that appear to deepen up from reefal coral to stromatoporoid to lithistid sponge to thrombolitic slope beds.

The presence of shallow reefal beds basinward of L-35 slope beds indicates variable bathymetry at the margin with carbonate encased pinnacles. The **Figure 4.20** schematic well depiction displays accompanying seismic irregularities probably generated by local buildups and incipient limited progradation, likely aided by near-margin basin-filing prodeltaic shales. The alternating onlite and terrigenous clastics at top Abenaki are much more extensive prograding in nearly flat-lying beds above the deltaic basin-fill as seen in the wells further to the northeast.

A seismic line crosses the Abenaki margin about half-way between Marquis L-35 and Cohasset L-97 (**Figure 4.23** after Qayyum et al. 2015a). Qayyum et al.'s (2015a) special processing-interpretation technique gives an interesting rendering worth considering as an aid in understanding both wells. Even with a lower Cretaceous datum, the slightly deeper Drowning Unconformity reflector (their DU at top Abenaki carbonate) is already rolling over into the basin which Eliuk interprets as due to early deltaic loading. The seismic not only shows a thick package of deltaic shales going onto the continental slope but some later presumably submarine channelling was feeding further slope sedimentation probably post-Abenaki deposition. Clearly in this area top-most carbonates may only be a subsidiary sediment factory relative to terrigenous

clastics seen as quartz sands and other siliciclastics with oolitic limestones in the upper few hundred metres of Marquis L-35. Relative to understanding the deeper Abenaki in L-35 and L-35A, the line shows various shelf-slope mounds with separation from shelf interior flat-lying back-reef beds. If their mound correlations are accepted, then the mounds back-stepped with considerable relief above the seafloor even on the shelf interior flank (100's of metres). On the shelf interior side there is a pattern of slope-onlap-surfaces. So the presence of slope facies both basinward and landward sides of the mounds would not be surprising. That both the vertical and side-tracked Marquis wells drilled slope facies of microbolite yet bottomed in more coral-stromatoporoidal reefal beds is in agreement with multiple mounds shown. They apparently had a catch-up pattern of shoaling in the topmost beds since both wells go through a reefal interval before becoming oolitic with the onset of the extensive basin-capping oolite shoals termed the Sequence 1 ramp margin by Qayyum et al. (2015a).

The age and alternative sequence correlations for Marquis L-35 are reviewed on **Figure A1.21** based on the PFA Chapter 9 study (OETR 2011) with comparison to Encana's dating in Panuke M-79 (Weissenberger et al. 2006). From that at least 200m of section and most of the uppermost two sequences (AB7 and AB6 of Encana *-note Roman and Arabic numbers are used interchangeably-* and Sequence 8 and part of 7 of PFA) have gone from carbonate in M-79 to siliciclastics in L-35. This was seen seismically both in the PFA study and independently by Ammonite Nova Scotia workers (pers. comm. Robert Merrill). The age in Marquis L-35 is given as early Tithonian for the oolite-sandstone interbeds and correlated to PFA Sequence 6 or Encana's AB5 and AB4 but there is a slight age discrepancy since AB4 is likely partly Kimmeridgian (**Table A1.1**) in M-79.

As discussed and shown in the Appendix A1 (**Figures A1.11, A1.12** and **A1.23**) the Marquis wells are likely underlain by salt rather than a basement ridge of the LaHave platform which is seen to have a hingeline updip of Marquis L-35 between L-35 and Kegeshook G-67. This resulted in down-to-the-basin normal faulting so the Abenaki section is expanded. The L-35 Abenaki is over 1.2km thick since the Misaine shale was not reached, although present on seismic (**Figure 4.20B**). Likely about 200m or so remained to be drilled above Misaine shale. This 1400m or so represents the thickest development of upper Abenaki Late Jurassic (and Berriasian sub-NBCU for the Western shelf) carbonate tested on the Scotian Shelf. Age-equivalent carbonates are thicker in the Baltimore Canyon Trough off the USA east coast. There 1440m of Berriasian-Late Jurassic limestone was drilled without reaching the Oxfordian age lower third of the Late Jurassic.

For offshore Nova Scotia, L-35 had the fastest rate of Abenaki carbonate net accumulation given that the latest Jurassic late Tithonian is already in a siliciclastic facies. Yet its rate is easily exceeded by deltaic terrigenous clastic sedimentation of the Sable Delta, represented for instance by South Desbarres O-76 with over 2km of late Jurassic sediment that bottomed still within the Late Jurassic (according to Weston et al. 2012) that is younger than the Misaine shale of Middle Jurassic Callovian age.

Somewhere between Marquis L-35 and Cohasset L-97 to the south there is a fundamental change in the main type of **Abenaki capping lithologies** from shallow-water mixed limestones and quartz-rich sandstones to argillaceous sponge-rich limestones with variably-present calcareous shales as shown on **Figure. 4.1** map. Also between these two wells, carbonates are first seen to prograde beyond the platform margin on seismic. In the platform interior a similar oolite-sandstone lithology is developed from Kegeshook G-67 south to Como p-21 with admittedly dubious correlations. To the southwest near-margin interior Panuke wells such as B-90 and F-09 have thick clean oolitic limestone that is overlain by sandstone interbedded with argillaceous limestone having varying amounts of lithistid sponge beds. These relationships are shown in map view by lithofacies pie diagrams using Encana sequences for the Panuke Trend from Kegeshook G-67 and L-35 southward to the Deep Panuke field area on **Figure 4.57**.

To the northeast (see Section 4.04), Abenaki J-56 drilled on the side of a salt dome is 40 km from Marquis L-35. Abenaki J-56 does not have the same style of vertical development as either regional capping lithologies. **Figure 4.17B** shows pie diagrams comparing lithologies above and below a J-56 paleomarker (Eliuk 1978 his Fig. 14; see **Figure A1.2**) which was correlated to top Penobscot L-30 slope shale. The highly diachronous relationship of top carbonate in these wells, where a paleomarker indicates 170m of siliciclastics in the more landward Abenaki J-56, equates to oolitic limestones and sandstones in Penobscot L-30 which show the effect of closer proximity to the terrigenous Sable Delta depocenter.

4.07 Cohasset L-97 – Northeast-most Argillaceous Sponge Facies Platform Well 'Protected Promontory' on Margin and Slope

Mobil-TETCO-PetroCanada Cohasset L-97 drilled a faulted structural feature in a near margin test that penetrated the complete Abenaki Formation but left untested nearby amplitude anomalies (**Figure 4.24**). Minor oil and gas shows and traces of porosity were present with some dolomite lenses (Kidston et al 2005). The upper Abenaki (Baccaro) is very thick at over 1.2 km and thus represents the thickest fully penetrated unequivocally Late Jurassic section even compared to the margin wells on the far southwest margin. (Bonnet P-23 is thicker at 1450m but

includes Early Jurassic carbonate and both the NBCU top and Misaine base are problematic picks.) But Cohasset L-97 is still thinner than the partially drilled section in Marquis L-35.

Cohasset L-97 was placed alternatively as "bank edge" test (termed by Kidston et al 2005 Table 1, p.18) or sometimes as "back reef, slightly away from the margin" test (Kidston et al 2005 Table 8, p.101). This problematic placement becomes even more interesting after Eliuk's cuttings analysis indicated that the well may be dominantly in a low energy slope and deeper reef setting, not back bank nor all reefal at the margin, based on the presence of peloids and microbolite textures in mud-wackestones (**Figure 4.24B**). *Tubiphytes* and tubular foraminifera occur in low amounts continuously though all but the top 150 m and calcispheres, a pelagic deeper-water indicator in the Late Jurassic (Flügel 2004), occur in much lower amounts scattered through the Baccaro. The usual development of oolite at the base of the Baccaro just above the Misaine shale is only represented by a red-stained 5m interval of fragmental-skeletal-peloidal wacke-packstone with about 5% dark ooids. The *in situ* and phaceloid nature of some of the largest corals in the single Cohasset L-97 core (see **figures 4.27** and **4.28**) within 200m of the top plus the high amount of thrombolitic and encrusting content supports a deeper quieter coral reef setting. But core interpretation is difficult due to complicated diagenesis (pers. observation, and Pratt and Jansa, 1989 fig.6; see **Figure 4.27** whole core photograph with framebuilder tracings).

The Baccaro has a large-scale shoaling-up pattern typical of many bank margin wells but the lower 'deeper' beds are dominated by thrombolitic-peloidal mudstones to wackestones with shoaling indicated by lesser amounts of variably thick stromatoporoidal floatstones to packstones (boundstone in core). These reefal and skeletal-rich intervals helped to define tops of sequence and subsequence (or perhaps parasequence) boundaries following Encana terminology. Dating in the PFA report (see Appendix A1 Figure A1.20) lacked precision due to poor microbiota content. Furthermore a close look at the PFA sequence boundary tops or SB's versus Encana's sequences corresponds in six of nine picks but the major unconformity shown at SB6 shows no lithological or petrophysical log character changes. Conversely the major lithological change at AB6 U is not seen as important in the PFA sequences.

Weston et al. (2012) placed their NBCU in shales at 3015m just above the Abenaki that poor biostratigraphic recovery suggested was Late Jurassic intra-Tithonian to Kimmeridgian. The capping limestones are argillaceous above AB6 U (or within it if AB7 is considered earliest Cretaceous from Panuke M-79, Weissenberger et al. 2006). Crinoids and bryozoans are common but more stromatoporoids and less lithistid sponges indicate perhaps shallower depths than top

Abenaki to the south. Still heterotrophs with only a few microsolenid corals dominate, signifying poorly photic, turbid waters.

From CNSOPB open file Encana 3D seismic, the structure maps at top Scatarie Member (Figure 4.26A) and O Limestone Marker (Figure 4.26B) show the underlying and overlying major reflectors (no map available for top Abenaki). They allow some insight into the nature of the Abenaki margin. Cohasset L-97 that is seen to be on the south side of a promontory into the basin is perhaps somewhat sheltered from basin-filling shales from the north. Dominion J-14 seems to have its relief decrease between the reflectors. Major basin fill occurs on the northeast mainly in latest Abenaki time. Figure 4.30 shows dip seismic of Cohasset L-97 and Dominion L-14. The older seismic is fairly massive at the margin. But reprocessed seismic (Figure 4.23 from Qayyum et al. 2015a Fig. 7a) does display much more character to interpret. The line is half-way between Cohasset L-97 and Marquis L-35. The uppermost part of the Abenaki is much closer to deltaic influx and thus is not very relevant to the Cohasset L-97 area. But in the lower part of the formation, the interpreted margin mounding with high relief and their isolation from the shelf interior sediments for much of the time are most relevant features. From those it is very reasonable to interpret the more distal or basinward features as deeper-water slope mounds which is the interpretation given to much of Cohasset L-97 from cuttings. Even where coral reefal beds were seen in core they were undisturbed phaceloid and massive corals suggesting they were not suffering from storms and shallow wave energy. In cuttings peloidal, micritic and thrombolitic limestone textures are interpreted to indicate slope deposition.

Of the early platform margin tests drilled prior to the Abenaki Deep Panuke discovery Cohasset L-97 was the third following Cohasset D-42 and Demascota G-32 (**Figure 4.25**). Cohasset L-97 is the furthest north that capping argillaceous sponge-rich beds have been documented (although stromatoporoids are even more plentiful). As shown using pre-1998 margin wells in **Figure 4.25**, Cohasset L-97 is interpreted as mostly in a slope setting and most basinward in a facies progression from Cohasset D-42 in the near shelf interior to Demascota G-32 with slope microbolite mounds up to coral-stromatoporoid reefs up to sponge reef mounds at the margin to Cohasset L-97 with more slope microbolite mounds than coral-stromatoporoid reefal beds capped by argillaceous sponge-bearing limestone. Reservoir development was absent in Cohasset L-97 where micritic limestones dominate. Of the three only Demascota G-32 has a significant amount of dolomite and porosity. Cohasset D-42 had no effective reservoir with reefal and dolomite intervals thin and uncommon though oolitic beds are present, unlike the other two

wells with almost no oolite. Cohasset D-42 is within the Deep Panuke gas field about one kilometre from MarCoh D-41, a gas well that was drilled 30 years later.

In Cohasset L-97 the cored coralgal lithofacies (5B; see whole core photo Figure 4.27) is almost wholly colonial corals including a minor amount of microsolenid corals. The core was taken 200m below top Abenaki (see litholog Figure 4.24B). Except near the core and in Encana's AB5 sequence, the Abenaki limestones were very lime mud prone with evidence for slope deposition. Above the hermatypic-coral-rich intervals, the top 1.5m of core may sample a slope environment indicated by debris beds that are sporadically micrite encrusted and submarine cemented. Features associated with and interbedded with conglomeratic clasts show thrombolitic (and/or automicritic) and lithistid (perhaps tiny sphinctozoan as well) sponge involvement with geopetal lime mud/wackestone in shelter cavities or on inter-debris surfaces as shown in Figure 4.28B-E.

A whole core photo mosaic (**Figure 4.27**) shows no identifiable coralline sponges but varied hermatypic corals with many poorly-preserved suspect framebuilders. The suspect framebuilders were massive forms with only obscured organized internal textures that did not look like grains or smaller skeletons. Single colonial corals can be quite large and both massive and phaceloid such as shown in **Figure 4.28A**. Macro-bioerosion was not nearly as profuse compared to most other Abenaki occurrences of corals and coralline sponges whether *in situ* or just fragments. That lack of bioerosion likely due to burial while alive, presence of microsolenids, more common *in situ* corals and association with overlying deeper facies all support deposition in a quieter and deeper water depth than for the Demascota G-32 reef cores.

Understanding the original depositional setting of this core has been a problem over the decades. Interpretation is qualified by the difficulty of identifying even major groups and sedimentological relationships due to a diagenetic overprint that obscures textures in the limestone generally and at several levels shows as angular breccias with granular crystalline matrix, pyritic irregular surfaces and some fractures with white calcite cement. If not for that, it is tempting to see the differences in the cored reefs as not just depth related but showing delta proximity effects. Cohasset L-97 is 40 km miles closer than G-32 to the Sable Delta. Of course the reduced amount of bioerosion does not fit the nutrient excess model, but there is an undetermined but clearly-seen organism that superficially looks like fucoid algae. If that speculation is correct that certainly would fit with expectations of fleshy algae. Then the change to overlying microbolite and conglomeratic sediments may record some kind of coral reef demise. The unknown fossil is

macroscopically well illustrated as **Figure 4.29** in the hope that some reader might know what it is and increase our understanding of the Abenaki. At higher power it unfortunately appears recrystallized.

4.08 Dominion J-14 & J-14A – Southwest-most Thick Shale at the Margin Allowing Sponge Facies Progradation

Encana-Marauder Dominion J-14 and its' side-track or 'whipstock' Dominion J-14A tested what was hoped to be a long northward extension of the Deep Panuke gas field. Located on a good structural and amplitude anomaly, J-14 is about 10 km northeast of both the last gas well at MarCoh D-41 and Cohasset D-42 about 1 km north of D-41 (**Figure 4.30B** seismic; see **Figures 4.26A & B** maps and **Figure 4.51** seismic structure schematic of Deep Panuke area at AB5 level). Unfortunately the amplitude anomaly resulted from shale at the AB5 level rather than porosity in Dominion J-14. The shale was variously interpreted as an isolated pod (pers. comm. Rick Wierzbicki & Norm Corbett of Encana) or a tongue coming from the north (pers. comm. Stefan Doublet of Beicip-Franlab).

Dominion J-14A side-tracked almost horizontally for over a kilometre due south from below casing in the top of the Abenaki of Dominion J-14 and succeeded in finding shallow reefal limestone without shale but unfortunately also without porosity. Therefore the northeast limit of the Deep Panuke field is not precisely known but an area of significant discovery was proposed by Encana with a boundary halfway between MarCoh D-41 and Dominion J-14A. The wells were drilled with polycrystalline diamond compact bits (PDC) that result in chalky bit-bruised samples of poor quality for the most part, and no side-wall or whole cores were taken. Nevertheless facies interpretations were possible as in **Figure 4.31** showing interpretive composite schematic lithologs and an interpretive facies diagram. **Figure 4.31A** (see **Figure 3.5** for larger view of cuttings) also shows some examples of the cuttings with diagnostic fossils and textures that identify the three main reef/mound types in the Abenaki: 1) shallow coral-stromatoporoid-chaetetid reef, 2) deeper argillaceous lithistid sponge reef mound, and 3) microbolite (thrombolitic) mound typical of distal forereef.

Both Dominion J-14 and J-14A show the uppermost Abenaki to be in an argillaceous sponge reefal facies with more stromatoporoids in J-14A and additional but still small amounts of microsolenid corals in Dominion J-14. The common presence of chert shows local remobilization but not complete removal of the silica in the siliceous lithistid sponges that are now calcitic. Downward just above the shale in J-14 there are increasing amounts of stromatoporoids and

chaetetids possibly indicative of shallower or clearer waters. As indicated on **Figure 4.31A** logs there are several intervals rich in crinoids and bryozoans interpreted as bryoderm communities associated with transgressions. Except for a thin shallow reefal interval near total depth indicating the top of the next lower sequence, the limestone below the Dominion J-14 shale is indicative of distal forereef slope not unlike Queensland M-88. In contrast, the Dominion J-14A near-horizontal beds were mainly shallow reefal with grainy textures indicating reef, uppermost forereef and reef flat. Although only based on cuttings, it may be significant that the sponge reefal intervals are relatively thin and discontinuous but the shallower-water stromatoporoidal reefal interval is nearly continuous over a very long distance albeit in a sub-horizontal section.

4.09 MarCoh D-41 and Margaree F-70— Carbonate-encased Pinnacle Reef Wells at North End Deep Panuke Compared to Reef-bearing Demascota G-32 and Contrasted with Non-pinnacle Musquodoboit E-23

Margaree F-70 and MarCoh D-41 were not included in the refereed Encana publications (Weissenberger et al. 2006, Wierzbicki et al. 2006) but F-70 was discussed in some detail as the subject of a core conference article (Wierzbicki et al 2005) and the CNSOPB Encana report (Encana 2006). Both F-70 and D-41 were part of the Encana (2006) CNSOPB field development report including Eliuk's figures and photographs on F-70. Figure 4.32 compares seismic over Margaree F-70 and Demascota G-32 and is contrasted with Musquodoboit E-23 on Figure 4.33 (also see caption comments) to show variable local relief (pinnacles reefs or small relief buildups) near the margin. Figure 4.34 compares various vintages of seismic over Demascota G-32 that all differ, including from the previous line shown for Demascota G-32 (Figure 4.32B). This probably results in part from location errors since marked lateral variability was observed on seismic even in 1974 (Eliuk 1978, see Figs. 10 to 12) that is confirmed with 3D seismic (pers. comm. Rick Wierzbicki 2005, Encana). Note the more complex internal seismic character beneath the break in slope on all of the more modern vintage lines. This contrasts with the character just back of the edge as seen in the south Deep Panuke dip line through Queensland M-88 with Panuke M-79 projected on Figure 4.54. So the somewhat layer cake sequence stratigraphic interpretation for the more southerly Deep Panuke Field by Weissenberger et al. (2006, their Fig.15 shown herein as Figure 4.53 and see Section 4.12) cannot be applied to the north end of the field. Thus correlation and lateral facies relationships are likely more complicated as is reservoir variability, especially nearer the platform flexure. As shown by Figure 4.35, Margaree F-70, MarCoh D-41 and Demascota G-32 are anomalous for Abenaki wells in completely or nearly completely lacking oolite which is a very common facies in almost all the Abenaki wells.

Musquodoboit E-23 very near Demascota G-32 is included for a comparison with these anomalous wells. Seismically E-23 is unequivocally on the platform lacking pinnacles at least as deep as it was drilled (Figure 4.33). This test of the downdip extent of the Deep Panuke reef margin gas-bearing reservoir failed since porosity was below the gas/water contact and wet. Little dolomite but both oolitic and coral-stromatoporoid reefal limestones occur at the equivalent stratigraphic level of the reservoir. Similar to the rest of the Panuke Trend margin wells, Musquodoboit E-23 upward became more carbonate mud prone, slightly argillaceous and lithistid sponge-rich. In contrast these three oolite-lacking wells are likely small pinnacles and did not have sufficient area to allow in situ ooid formation. Because they have relief off the surrounding sea floor, deposition of allochthonous ooids due to downslope debris flows or tempestites from storms is unlikely. This argument from absence is supported by various present features indicating the local positive relief including dipmeter readings in Margaree 70 and MarCoh D-41 and seismic geometry. Both F-70 and D-41 show inclined bedding but landward to the northwest indicating irregular bathymetry along the margin with both wells drilled on the landward side of small carbonate pinnacles or ridges (pers. comm. Rick Wierzbicki 2005, Encana). As an interesting comparison, the one well drilled in the Baltimore Canyon Trough off Delaware on the Abenaki-equivalent margin where there was a seismically-defined "catch-up" pinnacle/ridge also showed west dips on the dipmeter (Eliuk and Prather 2005). In fact, it was purposely drilled on the landward side in the hope of less submarine cements (pers. comm. Mike Bourque of Shell Oil 1985). Seismic from Encana 3D surveys also shows local small scale relief at the platform margin (Figure 4.32 and Kidston et al. 2005, PFA Chapter 9 OETR 2011).

MarCoh D-41 (see Figure 4.35 and associated notes) was drilled in 2003 about a kilometre south of the oldest Abenaki near-margin well, Cohasset D-42, that was abandoned at the Abenaki level in 1973 but had overlying sandstones with oil (see Figure 4.25 for D-42). At present MarCoh D-41 with a gas pay of 122m delineates the furthest northeast extent of Deep Panuke based on wells alone (Kidston et al 2005, Encana 2006). The porosity occurs almost solely in dolomite and is the field's thickest reservoir interval suggesting that the edge of the field is not very close but further northeast. Fracturing and even faulting are important components in Deep Panuke reservoir development. This is nicely shown in MarCoh D-41 since the uppermost Abenaki is faulted out (R.Wierzbicki, pers. comm. 2003 and seismic section in Kidston et al. 2005) and both limestone and dolomite sidewall cores show fractures. In many respects the upper Abenaki in this well is very similar to that in Margaree F-70 except that MarCoh D-41's has generally greater argillaceous content and also has common bryoderm beds. Reservoir development is similar but better with more dolomite in MarCoh D-41 above the gas/water

contact zone at 3515-3535m. Stromatoporoid-coral reefal beds with occasional microsolenid corals are common in the limestones remaining amongst the dolomite. Only minor (2% & 5%) questionable ooids were seen in 2 dolomitic sidewall cores.

Margaree F-70 gas well was drilled in 2003 in the north end of the Deep Panuke field. Unlike all the other field wells that had very poor or no core recovery, Margaree F-70 has the longest single continuous core of the entire Abenaki Formation at 24m as shown in Figure 4.36. Wierzbicki et al. (2005) provides the principal reference on this well including the nature of its reservoir and fracturing (both Wierzbicki et al. 2005 and Encana 2006 include Eliuk's core work and thin sections photomicrographs). No ooids were seen. The relationship of the whole Margaree 70 Abenaki well section to the core is shown in Figure 4.36 (see Figure 3.2 for a detailed well litholog). Both well cuttings and core tell a story of what happens around an Abenaki reefal buildup from shallower to deeper water, or from further to closer proximity to the major Sable Island paleodelta, or both as one goes upward stratigraphically. Set within an Abenaki section lithofacies transition from dominantly cleaner dolomite-rich carbonates up into slightly argillaceous lithistid sponge-rich limestone, Margaree F-70 core #1 (3434-3458.7m) also captures a depositional facies transition in reef types and water depths (and/or nutrient-argillaceous content) that increase upward. In Margaree F-70 core, dolomite was mainly indicative of proximal grainy slope beds. See Section 5.2 for detailed interpretation and illustration of the facies transitions in this Abenaki platform core with comparison to changes in a deltaic ramp core in West Venture C-62.

<u>Demascota G-32</u> drilled in 1974 was the second test of the Abenaki platform edge and showed the margin to be highly reefal. Located seismically on a promontory beside interpreted channels (Eliuk 1978, his Fig.10), even now it is not clear if it was on the margin or slightly down the slope as illustrated in **Figure 4.33B** with Beicip-Franlab's (PFA Chapter 9, OETR 2011) choice shown in **Figure 4.32B** preferred. All three main Late Jurassic reef and mound types (Leinfelder 1994, Leinfelder et al. 2002) were cored as shown in **Figure 4.37**. A poorly porous dolomite core was recovered in the thick middle porous interval with several lost circulation zones.

This was the first significant reservoir development drilled in the Abenaki where even highly oolitic limestones had little porosity. The Demascota G-32 pie diagrams give a comparison of vertical lithofacies compositional changes for Encana sequences (and a qualitative sense of depositional facies). Minor oolite occurs only at the base and at the top of the Baccaro Member. After the initial shallow oolite, Demascota G-32 deepens to peloidal-thrombolitic deposits, then

shoals up successively to coral-stromatoporoid reefal beds. The upper ooids cap AB6 L indicating the shallowest deposition and also occur at the base of AB6 U in most probably allochthonous deposits since they co-occur with lithistid sponges in argillaceous limestone (from G-32 log in Eliuk 1978) which shows a change to a deeper/shalier capping environment.

With the poor core control only inferences from cuttings and seismic can be used to identify these surfaces and their accompanying maximum flooding surfaces (MFS). Encana (Weissenberger et al. 2006) tended to use siliciclastic influxes with key lithofacies changes (reefal beds, oolite) and PFA (pers. comm. Stefan Doublet of Beicip-FranLab 2011; also see Demascota G-32 log in Chapter 9 well Appendix of OETR 2011) used interpreted relative depths of depositional environments with comparison to some regional seismic markers. In fact the seismic markers and not the sequences were the basis of four regional mapped intervals in PFA Chapter 9 (see Appendix Figure A1.21). Ooids could be reworked at the base of a sequence, or define a top (cf. AB6 L vs PFA 7). These pinnacle-bearing wells can be contrasted with those in the south end of the Deep Panuke Field which like Musquedoboit E-23 have greater amounts of oolite as shown in Figure 4.35. For example, Figure 4.51 uses lithofacies pies to illustrate lateral variability in Deep Panuke Field at the level of the main reservoir sequence and to show that disjunct oolite distribution. In Figure 4.52 Demascota G-32 is projected into a dip section across south Deep Panuke from shelf interior to basinal-slope. Note the continuity of the basal onlite but then the absence of oolite except for thin likely allochthonous beds near the AB6 L and AB6 U boundary in Demascota G-32 and amongst shales in the top AB6 well down the slope in Queensland M-88. Using novel processing-interpretive techniques, Qayyum et al. (2015a) presented a dip seismic section fairly close to Demascota G-32 shown as Figure 4.38 which appears to image reflectors where seismic intervals previously lacked them (Figure 4.34). If G-32 is projected on Figure 4.38 as shown then some of their seismic patterns can be speculatively assigned well-controlled carbonate facies as discussed in the caption. Curiously some of the deeper mounds show shelfward dip. G-32 may have penetrated these deep mound facies that on the basis of core and cuttings are interpreted as distal slope automicrite-microbolites.

Demascota G-32 has two **cores with coral-stromatoporoid reefs (coralgal lithofacies 5B** - coral-stromatoporoid-chaetetid-algae boundstone-rudstone) – perhaps the most common of the 3 main Late Jurassic reef/mound types and likely in the shallowest-water of the Abenaki platform margin. Cohasset L-97 (see Section 4.07, also see Eliuk 1978, Eliuk and Levesque 1988) has the other core in the same facies with Acadia K-62 core 5 (see Section 4.15) oncolitic facies

possibly sampling a reef flat. All do not seem to show obvious lateral changes other than thicknesses with respect to delta proximity.

With only cuttings and few cores this apparent lack of changes may be a sampling artifact but seems to coincide with the widespread presence of oolites irrespective of delta proximity. This depth bias may be borne out when comparing the coral-bearing cores in the only two wells where they were obtained in any significant amount – Demascota G-32 and Cohasset L-97. Whole core photograph mosaics (Figure 4.39) are colourized to show concentrations of the major framebuilders that can also be recognized in cuttings. This reassessment (Eliuk 1978 had similar B&W foldouts) shows more clearly dominance of hexacorals (none were microsolenids) over coralline sponges (stromatoporoids and chaetetids) in Demascota G-32. Unfortunately this is not likely to be recognizable in cuttings since coral fabric is coarser and solution/recrystallization more common as compared to coralline sponges. The two coral reefal cores in Demascota G-32 though widely separated are placed together. A close-up (Figure 4.40) shows the typically common bivalve bioerosion and the *in situ* overtopping of one coral by another. The general distribution of displaced and rubbly framebuilders fits Leinfelder's (1994, 2001) debris reef classification in his more detailed subdivisions. Given the *in situ* position of several coral heads, the cores seem most reasonably interpreted as in the reef itself but badly storm affected. Repeated storm movement may explain their small size due to interrupted growth. The prolific bioerosion of 10 to 50% (Eliuk and Pemberton 2002) probably aided this destruction and indicates dead coral exposed on the seafloor readily infested by clam and sponge borers.

An anomaly visible even with the limited resolution of the whole core presentation and labelled in core 2 is the surprising presence of very high angle lime mudstone with rounded mud clasts between reefal beds. The interpretation of a possible cave or Neptunian dyke later filled by marine sediment is still maintained. (**Figure 4.40A**; Eliuk 1978 and 2004 with some close core slab photographs; also see Wierzbicki et al. 2002 for an alternative interpretation of slope). Later diagenesis generated cement-lined fractures, pyritized breccias and dolomite, the latter complete at the base of both cores. This did not obscure the depositional fabric that can be seen quite well.

The **lithistid sponge reef mounds (4A 'deep' siliceous sponge mound)** represents the only facies in core 1 from the top Abenaki of Demascota G-32 (**Figure 4.37**). Two core mosaics (**Figures 4.41** and **4.42**) show the high concentration of lithistids to the near exclusion of framebuilder types and some representative lithistid sponges including a rare example in this core of bioerosion by sponges. Only a few hexactinellid sponges were seen. Corals present were deep-

water types – tiny branching delicate ahermatypic oculinid corals and lamellar microsolenid corals (**Figure 4.43**). Plentiful *Tubiphytes*, bryozoans, serpulids, echinoderms were small accessory fossils. No undoubted algae, no significant micritic crusts nor submarine cements were seen.

Bioerosion particularly by bivalves as *Gastrochaenolites* is rare to absent in the sponges but clionid-like sponge borings occurred occasionally (**Figure 4.42B**). Bioeroded clasts do occur but in a single debris bed composed of various shallower water skeletal clasts including corals and a clam shell (**Figure 4.44**). The clam is thought to be a rudistid giving possible macrofaunal support for the Early Cretaceous (Berriasian-Valanginian) age dated by microfossils and nannofossils (Eliuk 1985). This is the rare evidence of a rare event such as a major storm that brought in skeletal fragments from some distance upslope. Likely the mound was at or below wave base which might have been at significant depth since Demascota G-32 was drilled at the Jurassic continental shelf edge. The sponges show fluorescence under ultraviolet light (**Figure 4.46**) but the initial euphoria in the offshore geologist shack was soon replaced by the understanding that it was due to minerals not hydrocarbons. Analyses showed low phosphate enrichment (1% still 10 times normal sedimentary background). That and the reddened patches were interpreted as due to upwelling nutrient-rich phosphatizing and oxidizing currents at the shelf-edge (Eliuk 1978).

Another intriguing set of macro-observations shows early seafloor diagenesis with the following features shown by **Figure 4.45**. Some of the sponges were dissolving (or not being calcified) leaving molds. The calcified sponge material collapsed down into geopetals some of which are reddened. The question of where and how early this was happening may be shown by a *Tubiphytes* encrusting the wall of a former sponge cavity. That coelobite or cavity dweller dates the cavity creation as penecontemporaneous with deposition. That also indicates early lithification or at least rigidity. This view may explain the origin of numerous sponge-shaped micrite-filled forms termed 'suspect sponges' shown on **Figure 4.42A**. The fill is very unlike the enclosing fossiliferous often argillaceous lime mudstone to wackestone matrix. That figure shows that 50% or more of the mound space was occupied by sponges. Much of the carbonate sediment is possibly supplied by disintegrated sponges.

The lack of submarine cements and perhaps micritic crusts typical of many microbolite mounds may be due to the general lack of an interconnected semi-open submarine cavity system likely present in thrombolitic mounds and stromatactis mud mounds. But the early paragenesis of the sponges supports the idea that they could have been common in some carbonate mud mounds

but disappeared early in the formation of the mounds. Only moulds and maybe spicules would remain as cryptic evidence, and even the spicules may dissolve and reform as chert, which happens to be present in this core. Two modern studies are relevant to what is seen in this sponge mound core and well. Neuweiler et al. (2007) study of a modern siliceous sponge in the Great Bahama Bank documented degradative calcification just below the seafloor which may explain some of the relationships seen in **Figure 4.45**.

Even though some of these Artimon Member sponges were in growth position they likely did not make a rigid framework. They were not framebuilders *per se*. Yet their abundance created relief on the seafloor. This is similar to the modern siliceous sponge mounds trapping terrigenous mud but creating relief off the British Columbia coast including in the Fraser River prodelta (Conway et al. 1991, Conway et al. 2002). The modern Canadian examples are in shelfal but relatively deep water and likely that is the same depth setting for the Artimon sponge mound facies.

The final Demascota G-32 core 5 recovered the third main Late Jurassic reef/mound type – microbolite mud mounds (thrombolitic, lesser stromatolitic and stromatactis textures present) with submarine cements and slope debris beds as shown in Figure 4.47 whole core photo and with large framebuilder clasts and bindstones high-lighted by colours in Figure 4.48. The core was originally described as coated, skeletal grainstone and stromatactis pelletal mudstone (Eliuk 1978). Even at the reduced scale of whole core photos the pervasive early isopachous cavity and breakage/fracture-filling cements with geopetal micrite are obvious in these mounds. Thus the fracturing-breakage highlights areas of early seafloor cementation as opposed to grainy debris flows that have large angular colonial coral and sponge clasts amongst lithoclast-skeletal micrite-coated grainstones interbedded in the upper part of the core.

These two main sediment types are shown on **Figure 4.49** for microbolite mud mound bindstones with a schematic core log (log from Eliuk 1981, 'algal coats' = microbolite/automicrite) and on **Figure 4.50** for skeletal-micrite lithoclast debris beds. Except a few small rare lithistid and hexactinellid sponges, macrofossils are essentially lacking in the mound bindstone themselves where small encrusters such as serpulids, tubular forams, *Tubiphytes* and bryozoa occur in shelter cavities and stromatactis cavity structures. Bioerosion is absent in the bindstones but in the debris beds some of the larger coral clasts show clam boring (e.g. *Comoseris* in **Figure 4.50A**).

Comoseris is considered an indicator of shallower reefal waters (Turnsek 1997, Garin-Martin et al. 2007, Lathuiliere et al. 2005) from which it may have been derived from an upper slope-margin reef where bioerosion tends to be very prevalent. Another coral clast may have come from the same shallower source – Meandrophyllia(?) along with lithistid sponges (Figure 4.50D). But some material in the debris flows are mudstone fragments sourced from the mounds (e.g. Figure 4.50C).

Many of the clasts in the grainstone/rudstones are micritically coated such as bryozoans that also have associated encrusters like serpulids and *Lithocodium-Bacinella* consortia (e.g. **Figure 4.50B**) and solitary corals (e.g. **Figure 4.50C** centre). Stabilized debris beds were overgrown by thrombolitic crusts to thicker bindstones. Since first shown in Eliuk (1978, 1981) and called stromatactis, these interesting boundstones have received a number of studies that often included petrography by Dromart (1986, Dromart and Elmi 1986, Dromart et al. 1994), Ellis (1984, Ellis et al. 1985, 1990), Jansa et al. (1982, 1988) and Pratt (1982, 1995). The consensus is that the bindstone mud mounds are microbial in origin (not necessarily cyanobacterial as originally suggested) and formed in deeper slope waters.

4.10 South Deep Panuke Field Wells Comparison (Panuke F-09, H-08, PP-3C, PI-1A, PI-1B, M-79, M-79A, B-90)

Deep Panuke was discovered by Encana (Pan Canadian) in 1998 by deepening wells from the depleted overlying Panuke oil reservoir discovered in 1986 by Shell Panuke B-90. That well in the upper Abenaki although highly oolitic was non-reservoir as was the other pre-Deep Panuke well in the field, Cohasset D-42. Following discovery of the gas field, Panuke F-09 was drilled to below the Abenaki reservoir level stratigraphically and structurally and found even more oolite but was also tight. So the Abenaki carbonate is both porous reservoir and tight lateral seal for the gas accumulation.

The general structure of Deep Panuke Field along with its lateral lithofacies variability at the reservoir level is shown in **Figure 4.51**. A dip section in **Figure 4.52** (with Demascota G-32 projected in from the far south) illustrates the three major lateral facies changes which are 1) interior-inner margin oolite, to 2) outer margin reef, to 3) slope shale and microbolite. The variably complicated progression of vertical changes shows a generally deepening up in Panuke M-79, a generally shoaling up in Demascota G-32 until abruptly deepening near the top Abenaki, and a generally deepening up, or more exactly shaling up in Queensland M-88. **Figure 4.53** (by Rick Wierzbicki in Weissenberger et al. 2006) illustrates the depositional facies development and good lateral continuity along strike in the south end of the field. Details on the Deep Panuke Field

by Encana workers in peer-reviewed publications (Weissenberger et al. 2006, Wierzbicki et al. 2006) covered only the main part of the field excluding the northern wells: Margaree F-70, MarCoh D-41 and the unsuccessful long step-out Dominion L-14 & L-14A. However these wells were part of the field development submission by Encana (2006; see Appendix **Figure A1.15** - simple map view of pool, **Figure A1.16** - a schematic stick cross-section of the whole field; **Figure A1.17** - a gamma cross-section showing sequences and age dating for most of the southern field and down to the Scatarie Member in M-79; note the very helpful use of formation imagining tools [FMI] in several wells).

The main reservoir occurs within Encana's Sequence AB5 that is gas-bearing and AB4 that is generally wet. Porosity occurs in dolomite and microporous limestone, both of which can be vuggy. The vuggy microporous limestone reservoirs occur in only two Panuke wells, H-08 and PP-3C, the latter being the 1998 discovery well. Panuke H-08 has a short 3.2m core having an upper 1.7m chaetetid-rich limestone and a basal crinoid-bryozoan-rich limestone with some possible megalodont bivalves (considered possible early precursors to rudistid clams), both limestones with high microporosity. (See Appendix A3 enclosures for core litholog and photographs as well as the 1.1m vuggy dolomite core in Panuke PI-1A.) The porous limestone reservoir was identified using wireline logs only, since both wells were drilled through lost circulation zones in the south end of the field as shown by **Figure 4.53**. These reservoirs were created by a complex diagenesis of deep hot subsurface fluids following faults and fractures involving multiple dolomitization and even later corrosive dedolomitization events (Wierzbicki et al. 2006).

Accurately predicting reservoir development with seismic is difficult and many poor porosity wells were followed up by short side-track holes to more porous areas as can be seen in **Figure 4.51** that maps lithofacies in Sequence AB5 (and Appendix **Figure A1.16** shows this variability in a schematic cross-section). Although most porosity is late secondary, the earlier matrix dolomitization occurred preferentially in originally porous grainier limestone sediments often reefal rudstones and boundstones. So given access to diagenetic fluids along fractures, original depositional fabric had a significant control on porosity location as shown by the field depositional facies cross-section in **Figure 4.53** (Weissenberger et al. 2006). A highly stratified layering is interpreted for that part of the field. Such layer-cake stratification is in marked contrast to the likelier situation in the north end of the field discussed in Section 4.09 with its more irregular reefal and slope depositional bathymetry of local small buildups. The difference may be due to the wells in the south half of the field being slightly back of the shelf-edge flexure.

4.11 Queensland M-88 – Proximal/Distal Slope Facies of Deep Panuke Platform Margin with Dip Comparison to Platform Wells (Panuke F-09 Oolitic Margin Interior to Panuke M-79 Oolite/Reefal Margin to Demascota G-32 Reefs & Slope)

The dip section **Figure 4.52** is an introduction to Queensland M-88 just basinward of Panuke M-79. M-88 is completely off the Abenaki platform with the most basinal-slope Abenaki control south of the Sable Delta as shown in **Figure 4.55** with representative depositional textures from sidewall cores. In 2002 Queensland M-88 drilled seismic geometries of major foresets to test a by-pass sandstone play basinward of Deep Panuke as shown by **Figure 4.54** with on and off platform schematic lithologs. However, very little sandstone was found as shown by **Figure 4.56** schematic logs with lithofacies pies comparing margin Panuke M-79 to slope Queensland M-88. These geometries clearly show M-88 tested far down a carbonate slope. Thus they strongly support the interpretation here and elsewhere in this study that limestone lithologies of mainly microbolites are mostly distal carbonate slope deposits.

Queensland M-88 has no whole core, but rotary sidewall cores strongly support cuttings observations that the foreset limestones are mainly peloidal mud to packstones and microbolites with early cements (**Figure 4.55B-E**). Thin lithistid or coralline (chaetetid and stromatoporoid) sponges and very rare delicate branching corals boundstone layers cap the microbolites before minor sandstone influx and more shale deposition, sometimes initially very dark (in basal AB7 and AB4 possibly dysaerobic maximum flooding intervals = MFS). Skeletal framebuilders and bivalves are often highly bioeroded. Sequence boundaries (as defined by Encana for Deep Panuke and slightly different than those of Figure 26 in Weissenberger et al. 2006 shown below in Panuke M-79 to Queensland M-88 comparison) are placed at these lithologic breaks above framebuilderrich beds, or based on the biota alone in massive carbonate.

Higher in the section (AB7 to AB5) shale is dominant with sequences (and seismic reflectors) defined by very thin sponge-microbolite limestones or capping sandstone/ siltstones. The shallowest thin limestone (in AB6) has ooids, likely allochthonous, with sponges amongst sandy limestone. Since oolite only occurs below the lower half of AB6 in Deep Panuke wells on the platform, it also is suggested that correlation likely is mid AB6 where there are still ooids to be shed.

Shale-rich AB5 has a thin sponge-microbolite limestone cap but also basal onlite interpreted as slope debris (arguably these might be considered a cap to the underlying AB4). AB4 has a major lithologic change of shale grading up to limestone that also changes upward from

microbolite peloid mud(wacke)stones up to lithistid then coralline (stromatoporoid) sponge capping beds. AB3 and AB2 are limestone with the upper sequence slightly more radioactive on gamma log with the separation placed at a sponge-rich bed capping AB2. The third occurrence of ooids is as oolitic pack- to grainstone in the regionally developed "basal transgression" of Baccaro Member sedimentation within AB2 sequence since the Misaine is included by Encana definition. An associated sidewall core showed microbolite peloid clasts and sponges that suggest that these oolites might also be re-sedimented locally. Relative to this basal oolitic interval, PFA Chapter 9 (OETR 2011) placed the basal part of Encana's AB2 as a separate sequence top (SB1) with downlap on seismic indicating regression (compare Figure 4.52 or 5.10C with M-88 in Figure **5.11**). This was also noted and illustrated by Weissenberger et al. (2006) whose similar interpretation probably justifies separating out the basal portion of this Encana sequence. Given the seismically indicated deeper slope setting, none of these M-88 sequence capping surfaces are likely to be subaerial unconformities but they can be used for practical sequence subdivision as maximum regressive intervals and are quickly overlain by interpreted maximum flooding surfaces. Arguably if located on a shallow shelf they might have been considered condensed intervals during relative sea level high-stand flooding when siliciclastic supply was starved. Major transport of the fine siliciclastics from the Sable depocenter was along the slope, not across the shelf. While present this far south, the shale was not yet sufficient to bury the Abenaki platform and just onlapped the slope.

4.12 Lithofacies Distribution Maps in the Panuke Trend by Approximate Encana Sequences

Using Encana's sequence subdivisions (note that Roman and Arabic numbers are used interchangeably), the lithofacies lateral variability of the Deep Panuke Trend for eight sequences or subsequences is shown on **Figure 4.57A** to **H. Figure 4.56** gives an appreciation of vertical succession in single wells on and off the platform and has keys to the lithologies, abbreviations and icons on the maps. Most of the field wells and many others were only drilled to the Deep Panuke reservoir level or no deeper than middle to upper Abenaki. Several of the field wells had long-lost circulation zones or were mainly horizontal in one sequence so those are omitted.

Compare **Figure 4.57E** with 10 pie charts to **Figure 4.51** with 15 pie-charted wells in the limited Deep Panuke Field area at the main reservoir level of Ab5 (ABV) for some of the omitted detail, including estimates of framebuilding fossils. There are no significant differences between the two AB5 maps. However it is interesting to see that in the side-tracked near-horizontal M-79A well, two small pie charts show the near versus the far lithologies changing from 30% oolitic

limestone to over 50% dolomite with no oolite closer to the shelf edge. In the larger area (**Figure 4.57E** and all other **Figure 4.57** maps) only five wells actually reached the shales of the Misaine Member. So partial penetrations of a sequence are noted and isopach thicknesses are given in metres. These are margin to near-margin shelf-interior wells with rarer slope intervals in portions of a few wells and in all of Queensland M-88.

In the northeast during the uppermost Abenaki, deltaic siliciclastics replaced the platform carbonates and these wells are noted but not displayed as pie charts. These maps show that at almost all sequence levels there is a pattern of increasing lime mud and decreasing oolite content basinward with an intervening zone of high reefal content. The only exception is in the more landward shelf interior wells where pelletal grainstones to wackestones occur with oolites. There is seldom porosity despite the higher amounts of oolitic grainstones. Dolomite beds are closely linked with coral-stromatoporoid reefal beds. These dolomites usually are porous. Upward increasingly coarse siliciclastic influx is seen from the northeast but involves mainly those upper sequences that become ramp-like or may be areas in the shelf interior. Oolitic grainstones are closely associated with these sandstones. To the southwest fine siliciclastics and carbonates with sponge-rich beds occur in the higher sequences with the main change-over about AB6 U (= AB VI up) over the whole southwestern map area. Slope beds are indicated by high lime mud content, microbolite (thrombolitic) textures even fine peloid grainstones often accompanied by coarse cements seen as isopachous submarine cement and geopetals in cores. Shale is associated with these beds especially above AB4. Prior to the uppermost Abenaki and Artimon Member, thick shales are confined to the slope indicating that prodeltaic shale was transported not across the shelf but along the slope southwestwardly from the Sable Delta area.

4.13 Western Shelf Setting of Abenaki and Associated Carbonates Southwest of the Panuke Trend – Non-delta-influenced Control

To the southwest of the Panuke Trend there is a dearth of carbonate wells. Though only seven or eight wells, their long distance from the Sable Delta area allows comparisons to be made of carbonates not influenced by that large delta. Those wells are named with the four main wells shown by schematic lithofacies columns on **Figure 4.58.** Also identified, Mohawk B-93 has Cretaceous carbonates on the nearshore ridge and Montagnais I-94 tested the central uplift of a Tertiary impact structure. Three wells (Mohican I-100, Moheida P-15 and Glooscap C-63) in the Mohican embayment document the far shelf interior wells – the moat zone of Eliuk (1978, in a lagoon positon but open circulation, a term used similarly by Darwin 1842).

In **Figure 4.59** two long seismic lines perpendicular to the Late Jurassic shelf edge through Albatross B-13 and Demascota G-32 show the contrasting morphologies of the two areas during the Mesozoic. Due to infill by the Mesozoic Sable Delta the present-day continental shelf edge is tens of kilometres seaward of the Jurassic edge in the northeast but on the southwest it has retreated landward significantly. The north line (**Figure 4.59B**) at the south end of the Panuke Trend (Deptuck et al, in prep. 2010) shows Demascota G-32 Abenaki buried by the prograding Early Cretaceous Sable Delta. In contrast, the south line (**Figure 4.59A**) shows very little Mesozoic siliciclastics above the Abenaki in Albatross B-13 on the southwestern Jurassic shelf edge drilled in deep water on the modern continental slope.

There were smaller deltas and nearshore ridge sources of siliciclastics that resulted in mixed lithologies in the open shelf interior zone of the Abenaki (Given 1977, Eliuk 1978, Wade and MacLean 1990). Siliciclastic influx is mainly seen in the upper parts of the Abenaki carbonates. But in the extreme southwest where the shelf was narrower, the Shelburne Delta (Wade and MacLean 1990) contributed shales to the lower Abenaki in Bonnet P-23 of the outer shelf (shown in yellow west of P-23 on **Figure 4.58**).

As shown by the Roseway seismic reflector (**Figure 4.59A**) in the southwest, shallow-water carbonate sedimentation was able to continue on into the Early Cretaceous near the margin and on the nearshore ridges such as at Mohawk B-93 (Eliuk 1978, also see comments on **Figure 4.60**). Morphology — such as thinned intervals beneath downlapping marine beds — and sedimentology — such as marine red coated ironstone beds — both indicate an intervening area of more limited low net-accumulation especially over the former outer carbonate platform. Intra- and supra-carbonate shelf erosion, presumably subaerial, has been proposed in seismic sequences and mapped as thin or absent on parts of the Western Shelf by the PFA Chapter 9 workers (OETR 2011, see Appendix A1.09). However this might be difficult to distinguish from apparent gaps due to condensed marine sedimentation and even subaqueous erosion with low-net accumulation as indicated by the marine redbeds. Well samples and even cores with reworked older marine microbiota in younger marine sediments (OETR 2011, Weston et al. 2012) could be evidence for either or both situations. As shown in **Figures 4.58** and **4.61**, wells at the margin and most in the interior west of the Panuke Trend have red coated ironstones in the diachronous transition from carbonate platform up to siliciclastics.

As shown on **Figure 4.58**, the nearest well control to the southwest of the Panuke Trend is Oneida O-25 far back (15 km) of the shelf edge and about 75 km from Demascota G-32. Oneida

O-25 fills a 150km gap between Acadia K-62 and Demascota G-32 where the younger Sable Delta, as shown by the downlap of the O Limestone, is at its greatest extent (see **Figures 5.18** for an idea of the extent of the delta in the Barremian). Southwest of Oneida O-25 the Cretaceous is comparatively thin with condensed beds as indicated by the presence of red coated ironstones containing open marine biota. The most distal well on the Scotian Shelf, Bonnet P-23, is over 350km away from Demascota G-32 and 5km behind the shelf edge. Albatross B-13 and Acadia K-62 are near the shelf edge. **Figure 4.58** shows the map location and schematic section of these 4 wells that will be reviewed in this and the following Sections. Other nearby wells mentioned more briefly are shown in smaller print.

The three near-shelf-edge wells are in marked contrast to Oneida O-25 and the other two widely separated wells drilled first for the Abenaki – Abenaki J-56 and Dauntless D-35. Oneida O-25 was the first of the oldest three Abenaki wells drilled by industry in 1970 and 1971. Oneida O-25 is 175km southwest of Abenaki J-56 drilled next just landward of Sable Island and then Dauntless D-35 drilled about as far to the northeast on the edge of the Laurentian Channel (see **Figure 2.3A** where these three wells are numbers 5, 8 and 9 respectively). All were shelf interior and all are characterized by different major lithologies – Oneida O-25 oolite, Abenaki J-56 mixed sandstones and limestones mainly oolitic, and Dauntless D-35 mainly pelletal mud-wackestones with significant shale and sandstone intervals (Eliuk 1978).

In contrast, Acadia K-62, Albatross B-13 and Bonnet P-23 are much thicker carbonate, have some reefal beds, include slope beds (or deeper argillaceous beds) in their lower section and continue carbonate deposition, usually oolitic, into the Early Cretaceous (post-Berriasian NBCU of PFA study, OETR 2011). Termed 'Roseway unit', just how thick and where these Cretaceous carbonates start is controversial as shown in Figures 4.58, 4.60 and 4.61. See Appendix A1.13 for a brief nomenclatural discussion of the unit and recommendation that the Roseway be called a member of various formations. The favored horizon shown in green (Figures 4.58 and 4.61) is that picked in the PFA Chapter 3 and 5 (OETR 2011). The lower and middle picks shown by dotted lines (Figure 4.58) were those suggested by GSC geoscientists (MacLean and Wade 1993, Jansa 1993) and the upper dashed line is that of Beicip-Franlab workers (PFA Chapter 9 OETR 2011). The great variation reflects poor biostratigraphic control in the clean carbonates and different opinions on seismic correlations and significance of lithologic changes. They will be dealt with in more detail in the following Sections.

The small Shelburne Delta proposed from seismic data by Wade and MacLean (1990, their Fig. 5.31) is a locally significant feature just northwest of Bonnet P-23 and labelled on the P-23 lithologic column of **Figure 4.58.** The high shale content in lower Baccaro of Bonnet P-23 and resulting problems in identifying the true Misaine shale is likely due to the position of P-23 closer to the shelf interior lagoon or 'moat' and the proximity of Shelburne Delta prodeltaic shales.

Shelburne G-29 has a surprising occurrence of oolite at the bottom of the well, considering it appears to be deeper and basinward of the Abenaki shelf margin and penetrated mostly fine Mesozoic siliciclastics (location on Figure 4.58). G-29 was drilled in deep water on a large anticline basinward of the Abenaki shelf edge west of Albatross B-13. The core and bottom of the Shelburne G-29 hole were lost but the last ditch cuttings were reddened oolitic packgrainstones (pers. observation – calcite oolite with miliolid forams plus lesser amounts of coated ironstone as shown in Figure 4.65A & B). The immediately overlying shales were dated as Late Jurassic (Weston et al. 2012, PFA Enclosure 3-15 OETR 2011; seismic in MacLean and Wade 1993 and in OETR 2011 Chapter 5 termed as a "bible line," or regional reference seismic line). What is not known is whether the carbonate represents a foundered outlying atoll possibly on a salt structure, or an allochthonous slid block of earlier or later timing, perhaps associated somehow with the Tertiary-age Montagnais I-94 impact structure (Jansa et al. 1989, Deptuck and Campbell 2012). But the location and presence of oolites that far into the basin is potentially significant. The reddening may have been subaerial or just as likely seafloor diagenetic in origin on a long-exposed drowned-carbonate edifice that may in fact be much older than Abenaki.

Note that similar to Shelburne G-29 bottom-hole carbonate, almost all wells on the Western Shelf as shown on **Figures 4.58** and **4.61** have some degree of **reddened capping carbonates**, either simply as reddened calcium carbonate ooids and/or as red coated ironstones. In the case of the nearshore ridge well Mohawk B-93, there is variegated red shale below and within the limestone section (schematically shown in **Figure 4.60** but see log in Eliuk 1978). Except for Mohawk B-93 all these wells below the reddening have shallow marine carbonates as usually oolitic limestone. Above the reddening they have fossiliferous open marine siliciclastics, sometimes with argillaceous sponge-rich limestone on the shelf. In the case of all the shelf-margin wells, seismic geometries indicate the overlying beds were in a continental slope bathymetric setting (see Section 4.15 for details). So post-carbonate deposition was followed by major foundering of the platform into deep water. The reddening based on the evidence of the marine red coated ironstones is interpreted to be submarine due to long-continued exposure and early redox diagenesis in sediment on and just below the seafloor (further discussion Sections 4.14 and 4.15).

4.14 Abenaki Type-Section Oneida O-25 – a Semi-isolated Non-margin Well and Other Western Shelf Interior Wells

- Moheida P-15 with Red Coated Ironstones and/or Sponge-rich Beds

Figure 4.61 shows simplified Abenaki lithologic columns of all the shelf interior wells on the Western Shelf connecting the three Mohican subbasin/graben wells to Oneida O-25, the type section and first well into the Abenaki (McIver 1972). They record the occurrences of red coated ironstones (informally called Fe-oolite) and sponge-rich beds of the Artimon Member just above the Baccaro Member of the Abenaki. As shown in Figure 4.62A, Oneida O-25 tested a rollover anticline but lacked both porosity and hydrocarbons. O-25 is about 15km landward of the Jurassic carbonate shelf edge (Figure 4.58). That roughly defines the width of the carbonate platform before it goes to a deep lagoon or distal shelf interior setting called a 'moat' (Eliuk 1978).

Although far back of the margin and the only shallow platform interior well, the Oneida O-25 Abenaki is highly onlitic with an average of 50% on grain-packstones (60% lower half, 38% upper half split at the Ammobaculites & Epistomina biomarker, Eliuk 1978, see Figure. **4.62B**). Arguably one could interpret the uniform smooth rollover of seaward bank margin without positive relief to indicate the style of a distally steepened ramp. Thus energy from the Atlantic (paleo-Gulf Stream driven?) helped develop a broad ooid shoal complex interior of an unrimmed deep shelf edge. This is opposed to Eliuk's (1978) original interpretation of oolite developed on the landward side of a bank forming ooids in restricted higher salinities from wave energy coming off the deeper lagoon. If the top Abenaki is flattened to remove probable basinward flexure then my original interpretation is more likely. The near absence of framebuilders in cuttings also supports a shelf interior salinity-restricted setting (Eliuk 1978). Whatever the true setting, there were four vertical subdivisions observed (see oolite intervals in Figure 4.62B) – with three possible onlite capped sequences/cycles below an argillaceous zone in middle third of Baccaro then one or two more oolite capped cycles/sequences above. The other three Mohican subbasin wells are more argillaceous and less oolitic than Oneida O-25. None of the four have significant amounts of reef or mound frame-building organisms whether corals, sponges or microbolites.

Dip seismic shows terrigenous clastics down-lapping onto the top Abenaki at Oneida O-25 and on its outer platform (**Figure 4.62A** from Kidston 2005 Fig. 115, see their Fig. 116 enlargement at O-25 that also shows local downlap) This geometry is indicative of significant submarine exposure of the Abenaki carbonates top and/or of the thin beds immediately above. The strike down-lapping northeast to southwest relationship, seen in **Figure 4.61** at a well-section

scale and in **Figure A1.2** at a basin-scale, is seen seismically along strike in **Figure 4.63A** between Glooscap C-63 and Moheida P-15 (from Kidston et al. Fig.120, see their Fig. 121 for closer detail of downlap at Moheida P-15).

Red coated ironstones occur beneath (or within) these down-lapping beds. In Oneida O-25 and in the offsetting two wells to the south (**Figure 4.61**), these are associated with marine fossils and burrows on or slightly above top Abenaki or Artimon/Roseway. They are the physical evidence for prolonged diagenesis near the seafloor with low sedimentation suggested by the seismic morphologies. They could be seen as basal beds to marine transgression and deepening above a sequence boundary.

The relationship to Oneida 0-25 shales and the seismic geometries indicates an influx of marine prodeltaic siliciclastics. Moheida P-15 core #1 (Figure 4.63B) shows argillaceous sponge-rich limestone (Artimon Member lithology) abruptly overlying marine red coated ironstones. Unfortunately the contact is not preserved in the available core recovery. Examples of the macro- and micro-features are shown on Figure 4.63C (sponge), Figure 4.63D and Figure **4.64A-E** (coated ironstones). Importantly the coated ironstones are the product of repeated burial and uncovering required for redox reactions to occur on and just below the seafloor in sedimentstarved settings (for coated ironstone background information see Bayer 1989, VanHouten and Bhattacharyya 1982, Pufahl 2010). Dating of the core is post-NBCU Valanginian-Hauterivian by Weston et al. (2012) who interpreted Berriasian calpionellids (i.e. pre-NBCU) as reworked and correlated the limestone to the O Limestone marker. Contrary to their comments regarding MacLean and Wade (1993) this does not negate the use of Artimon or Roseway for these limestone and siliciclastic beds (see Appendix A1.13). They placed the intra-Hauterivian unconformity slightly higher in red shales around 2528m that they interpreted as indicating an unconformity. However the possibility of submarine red ironstones as in the deeper core could also indicate simply low marine accumulation and condensed submarine sediments at several levels with palimpsest-reworked fossils to be expected. Clearly the whole interval is highly condensed compared to the thick Lower Missisauga deltaic beds near Sable Island. Obviously within P-15 Core #1, a major change is recorded in marine water-chemical conditions that go from iron-rich highly oxidizing but still well-burrowed marine to more reducing with glauconite-like minerals present amongst the sponges along with robust echinoid spines.

In cuttings, red coated ironstones were seen in several other shelf interior wells such as Oneida O-25 (**Figure 4.64F**). Both reddened calcitic ooids and associated and/or overlying red

ferruginous ironstones occurred in all the Western Shelf bank margin wells (**Figure 4.58**, see Section 4.15 for more details with schematic logs and seismic and note the downlapping relationship of beds overlying the carbonate platform). As already mentioned, probable marine reddening includes the limestone at the bottom of Shelburne G-29 (**Figures 4.66A and B**). Acadia K-62 has pink ?inoceramid bivalve prisms amongst the red coated ironstone (**Figure 4.66C**). Albatross B-13 has both reddened calcite ooids and trace amounts of coated ironstone (**Figure 4.66D**). Thin sections of cuttings (Eric Bogoslowski of PetroCanada kindly allowed examination) show a complex early depositional and diagenetic history in Albatross B-13 and even allow interpretation of a geopetally-orientated chip that indicates early cementation and associated fine red sediment infill (see comments **Figure 4.65E** & **F**). Bonnet P-23 (**Figure 4.65G**) has the thickest development of red coated ironstones at about 15-25m (see litholog **Figure 4.81** and Section 4.15 for details) in a unit dated as Albian (Weston et al. 2012) just beneath Tertiary shales.

4.15 Western Shelf Margin Wells Continue into the Cretaceous Neocomian for Comparison:

- Acadia K-62 and the Start of Bivalves in Reefs and Oncoid Beds,
- Albatross B-13 and the Full Shoaling Sequence with Red and White Slope Microbolites Up to Coral Reefs and White Oolites, and
- Bonnet P-23 and the Return of Shaly Carbonates and Sponges in a Near-Margin Shelf Interior Setting

On the Western Shelf only three near-margin Abenaki wells occur in an area at least five times greater than the Deep Panuke Trend with its more than 20 wells. But these three wells penetrated thick intervals and have some intriguing and very different carbonate lithologies and facies. It is reasonable to assume that these distant wells are uninfluenced by the Sable Delta and potentially can be used as a counter example to contrast with carbonates near the delta. The three wells have features in common and, importantly, different from those in the Deep Panuke area that will be reviewed following a discussion of seismic and depositional features common to all three wells. Finally, on a well by well basis, specific features will be illustrated and considered in more detail including problems arising from recent revision of age dating particularly in Bonnet P-23. Because these wells are mainly included for comparative purposes to the main topic of this thesis on delta transitions nearer the Sable Delta, more interpretive considerations are included in this chapter. Only certain features at the top and on the slope are relevant for dealing with the thesis problems and these will be discussed in more detail in Chapter 5.

Bonnet P-23 was drilled just back of the modern continental shelf edge; the other two wells were drilled in deep water on the continental slope. The modern shelf edge is considerably landward of the Late Jurassic shelf edge, except again for P-23 where the edges nearly overlie one another (see **Figure 4.66** and seismic figures in MacLean and Wade 1993). Before the earliest

Tertiary and latest Cretaceous the Abenaki carbonate margin itself was also drowned and in deep water in all three wells and submarine exposed or nearly so as shown on **Figure 4.66** by the downlap relationships of reflectors above and below the yellow Base Tertiary marker onto the Abenaki carbonates. These morphologies indicating deep water are supported by the presence of capping much younger shales and chalks above thin condensed marine red coated ironstones already discussed in Section 4.14.

As can be seen on **Figure 4.58**, these three wells are separated from each other by greater than a 100km but are all within three kilometres of the Late Jurassic continental shelf edge. That proximity and their seismic relationship to the Jurassic shelf edge are shown in **Figure 4.66** where Kidston et al. (2005) figures have been collaged with the Jurassic break-in-slope serving to align the three dip lines through the near-margin wells. The wells' small but varying shelf-edge proximity is neatly reflected in the lateral variation of their major lithofacies and a kilometre-scale vertical shoaling sequence. **Figure 4.67** shows both patterns.

The main Abenaki platform section in all wells starts in the Misaine shale then is overlain by microbolite (thrombolitic) peloid lime mudstones to bindstones of decreasing thickness (almost absent in Bonnet P-23) then various other lithofacies related to margin proximity. The vertical pattern, best seen in Albatross B-13, is indicative of a large second-order shoaling sequence with slight basinward progradation from deeper-water microbolite thrombolitic slope limestones up through coral-stromatoporoid reefal limestones to oolitic limestones of very shallow waters. In classic Walther's Law style the vertical changes are repeated laterally from slope to shelf interior, reflecting the original depositional environment relationships. Depending on distance behind the shelf edge the wells go from slope thrombolitic mound to coral-stromatoporoid reef prone, to oolitic-oncolitic prone with minor reefal beds of a probable reef flat, to muddy pelletal-oolitic prone shelf interior. The shallower or more shelf-interior the setting is; then the greater are the facies repetitions that indicate cyclicity or para-sequence/sequence development.

None of the wells are right at or downslope of the final seismically defined platform edge of Early Cretaceous age (late Neocomian; Hauterivian-Valanginian). All are capped by thick oolite. Even the dolomite in the Acadia K-62 topmost cores is seen as cross-bedded and likely oolitic. The Near Base Cretaceous Unconformity (NBCU = 'Top Jurassic' of some others) is not obvious lithologically and has been variously placed in different publications (see **Figure 4.58**). So unlike the Abenaki to the north, carbonate growth continued beyond the end Jurassic or earliest Cretaceous Berriasian after the NBCU.

The **seismic above the Abenaki** over all three wells shows downlap of a very large scale indicating, as already discussed, the likelihood that the Abenaki was in deep water and drowned by the middle Cretaceous, probably Aptian-Albian. There appear to be major slide blocks and deformation of the continental slope in the Albatross B-13 line just basinward of the Abenaki slope in younger sediments (see **Figures 4.66B** and **4.59A** respectively). Although Kidston et al. (2005, their yellow reflector) correlated base Tertiary above some of these blocks, it may be that they are younger and associated with the early Eocene (51Ma) Montagnais impact structure and resulting mega-debris event (Deptuck and Campbell 2012).

Montagnais I-94 drilled the centre of an astrobleme far updip of and between Bonnet P-23 and Albatross B-13 (see **Figure 4.58** for location). A glide block is interpreted immediately above the B-13 Abenaki seismically (PFA study of OETR 2011, Deptuck and Campbell 2012). Fossil dating indicated highly mixed Eocene to Late Cretaceous ages with Santonian to Turonian aged lower lithologies still relatively intact (Weston et al. 2012). Possibly the top of the B-13 carbonate was affected and involved in the glide block movement but not too likely, since similar to the other wells on the Western shelf, the topmost beds contained reddened calcite ooids. Additionally unlike those wells the presence of actual coated ironstone was very rare (see **Figures 4.61, 4.67**) but reddened geopetals occur in fracture-fills in B-13 Core #1 just over 45 m below top Abenaki (see Section 4.15). So there is still remnant evidence for a post-Abenaki Albatross B-13 history involving marine condensed beds and submarine drowning similar to that of the other wells southwest of the Panuke Trend as discussed at the end of Section 4.14.

In Bonnet P-23 seismic (**Figure 4.66C**), major normal faulting is present that is absent in the other well seismic sections. That faulting appears to predate the Tertiary (see Bonnet seismic in MacLean and Wade 1993; Deptuck and Campbell 2012 do not mention such faulting in their analysis of the effects of the Montagnais impact) and postdate even the Roseway reflector. As shown by Kidston et al. (2005, see **Figure 4.66C**) one of the faults is crossed in the lower Abenaki in Bonnet B-23. Based on that, in **Figure 4.81** it is here interpreted that the dolomite below Misaine shale is the Iroquois Formation across a fault contact rather than a dolomitized Scatarie Member as interpreted by Weston et al. (2012).

Although based on only three widely separated wells, the Western Shelf (WS) area shows similarities to, and significantly, differences from the Deep Panuke (DP) area with its greater well control. To keep things simple the Panuke Trend north of Cohasset L-97 is excluded since it is so close to the Sable Delta and has some fundamental differences including prograding-distally-steepened ramp profiles that it deserves a consideration all on its own relative to the areas to the south (see Sections 4.02 and 4.06 for more details and Chapter 5 Discussion-Interpretation).

Also excluded are the 4 bank interior wells of the Mohican subbasin that have siliciclastic influx from the nearshore ridge area (see Section 4.14). The listing below of common and differing features is aided by comparing the dip sections of the Western Shelf (WS, **Figure 4.67**) with that of Deep Panuke (DP, **Figure 4.52**) along with the set of Panuke Trend lithofacies maps (**Figure 4.57A-H**).

The following are some things common to the Western Shelf and Deep Panuke areas:

- 1. All of the Western Shelf wells and most of the Deep Panuke are within five kilometres of the Late Jurassic shelf margin.
- 2. That margin typically had great relief into an oceanic basin (even the distally steepened ramps).
- 3. Reservoir development is most often associated with secondary dolomite and much less common in limestones with coral reefal facies (DP) and solite (WS) sometimes having porosity. Shallower effective burial depths favoured porosity retention in Western Shelf wells. Thrombolite (microbolite) facies and slope have not been porous anywhere.
- 4. All wells very near the shelf edge or on the slope have thrombolite-peloid lithofacies mainly in the lower Abenaki (lower Baccaro).
- 5. In addition, such wells usually have coral-stromatoporoid reefal and oolitic lithofacies.
- 6. Such wells also show a large scale shoaling up ('catch-up' pattern or alternatively slight progradation seaward) as indicated by the vertical arrangement of the foregoing facies.
- 7. Wells just slightly shelf-ward of the edge have greater amounts of oolite and may completely lose the coral reefal facies and have increased pelletal and lime mudstones towards the shelf interior.
- 8. Vertical facies variation-repetitions that can be seen as cyclicity or parasequences or sequences are evident in most wells and generally appear thinner and more plentiful in the upper half of the Abenaki Formation.
- 9. The lateral facies transition can be fairly rapid over less than a kilometre to a few kilometres.

Because these lithofacies features seem widely shared in the Abenaki and generally in the Phanerozoic (Wilson 1975, Schlager 2005), they are formalized in a carbonate facies template with assignment of depositional facies associations (see Section 3.4, **Table 3.3** after Eliuk 1978, Wierzbicki et al. 2002).

The following are ways in which Deep Panuke (DP) and Western Shelf (WS) differ:

1. The simplest and most obvious difference is the colour of ooid grainstones and microbolite

- (thrombolitic) slope beds from wells in the two different areas very light (WS) versus darker (DP) and very dark nearest the Sable Delta area (see **Figure 4.68**, Penobscot L-30 and West Venture C-62 are in the prograding ramp-delta area to northeast).

 Albatross B-13, the furthest southwest margin test in the Abenaki, even has red then pink limestone interbedded with near-white microbolite (thrombolitic) peloid limestones in the lower third of the Baccaro (**Figure 4.68B**).
- 2. Ooid nuclei in WS may also be fossil fragments but rarely quartz grains as is common in DP oolite.
- 3. No basal oolite above the Misaine (WS) contrasts with the case to the northeast (DP) where some amount of oolite occurs just above the Misaine shale even in the off-bank Queensland M-88. Only Cohasset L-97 has minimal basal oolite (5% in 5m cuttings interval). But in both areas (WS-DP) the overlying beds are in a muddier (deeper?) depositional setting, sometimes coral reefal (rarely sponge reefal Bonnet P-23) and often microbolite (thrombolitic) slope.
- 4. Thin sandstones occur in the upper Baccaro amongst oolite (DP) but not to the southwest (WS) including the south end of the Panuke Trend Demascota G-32 and Musquodoboit E-23. Neither thin sandstone nor much oolite occurs in interpreted margin pinnacle wells (see Section 4.09). Bonnet P-23 is unusual in having shales and argillaceous limestones in the lower quarter of the redefined lower Baccaro likely related to proximity to the postulated Shelburne Delta to the southwest (see Bonnet P-23 well discussion below in this Section).
- 5. Oncolite facies and large mollusks occur only in the mid Baccaro of Acadia K-62 (WS). This may be a limitation of sampling and their inclusion in the Abenaki carbonate facies template as characteristic of reef flat is reasonable or they may be a specialized unique association (see discussion below under Acadia K-62 in this Section).
- 6. Near top Abenaki there are increasing amounts of thin sandstone, shale and argillaceous limestone (DP) but to the southwest the top Abenaki has an abrupt change from usually oolitic carbonates to much younger shale (WS).
- 7. Associated with this difference is the presence of sponge-rich argillaceous limestones (DP=Deep Panuke) but its absence to the southwest (WS=Western Shelf) and also to the northeast in the ramp-Sable Delta area where sandstone and oolite interbed at top Abenaki. A possible exception to points six and seven occurs in Bonnet P-23 topmost 50m which has lithistid sponge-rich beds but also, anomalously perhaps, associated stromatoporoids in cherty light grey limestone.
- 8. All the WS wells at the very top Abenaki have reddened calcite ooids and/or capping red

- coated ironstones as do most of the shelf interior wells of intervening Mohican Subbasin (see Figure 4.61) but these facies do not occur to the northeast (DP).
- 9. Finally on the WS the Abenaki shallow-water deposition, mainly oolites, continues past the end Jurassic and the NBCU whereas to the northeast DP carbonate sedimentation has ceased or is in deeper or turbid water facies. Unfortunately there is no well control on the Jurassic slope of the Western Shelf as occurs in front of Deep Panuke with Queensland M-88. So the increasing presence and thickness of slope shales in the northeast end of the Panuke Trend and in the prograding ramp area even closer to the Sable Delta cannot be compared. Seismic (Kidston et al. 2005) shows much steeper carbonate slope profiles to the southwest suggesting under-filled and bypass type margins with a lack of shale infill. This likely lack of contemporaneous shale is also reflected in the fact that Tertiary and latest Cretaceous sediments downlap onto the top Abenaki to continue well down the carbonate slope in the Western Shelf.

Acadia K-62 in 1976 was the earliest well to test the bank edge southwest of the Panuke area finding good but water-bearing porosity in Abenaki limestone and dolomite (Eliuk 2004, Kidston et al. 2005, PFA Chapter 9-OETR 2011). Although the furthest north of the three southwest near-margin wells as already discussed, the seismic setting of Acadia K-62 (Figure **4.66A**) and inferred depositional facies places it between the other wells relative to the margin edge as shown on Figure 4.67. Figure 4.69 shows a bit more detail on a schematic lithologic column flanked by the PFA facies association-sequence plot and schematics logs of two of the three intervals cored. While Albatross B-13 shows a nearly continuous kilometre-scale shoaling sequence, Acadia K-62 similarly shoals upward but in a number of more obvious shorter sequences (perhaps five to eight). The PFA facies column shows a continuous shoaling progression unlike the stepped or serrated pattern indicated by the logged lithofacies changes (on Figure 4.69A see my regressive-transgressive arrows on left; Acadia K-62 was not part of the data package Beicip-Franlab acquired from me for the PFA study). It is possible that some of the oolite intervals were considered allochthonous deposited downslope below their original formation site. However it is more likely that the increase in number of shoaling cycles or sequences is real since they individually have similar vertical facies changes. This increase in cycles reflects the somewhat more interior platform settings as opposed to more massive facies right at the margin.

Three of four major Abenaki lithofacies types were cored and they capture the deeper-to-shallow broadly-transgressive shoaling patterns. The deepest core 5 was microbial/thrombolitic-

peloid limestones (see K-62 in **Figures 4.69C**, **4.73 and 4.74**). Core 4 was oncolite-mollusk limestone interpreted as reef flat (see **Figures 4.69B**, **4.71**) with a few very thin highly bioeroded coral beds (**Figure 4.72**) perhaps indicating that the coral-stromatoporoid reefal facies was nearby. The topmost cored interval was dolomitized onlite (cores 1 to 3, see **Figure 4.70**). Either because of the rarity of core control or because they only occur in Acadia K-62, a closer look at these cores will aid understanding of the Abenaki both generally and far from the deltaic influences.

This thesis study concentrates on the original depositional relationships and early history of the Abenaki-Sable association and reef/mound formation, and does not deal with late diagenesis of Abenaki carbonates such as the review for Deep Panuke by Wierzbicki et al. (2006). But many diagenetic features that can result in completely cemented or dolomitized carbonate are very early and can correctly be considered indicators of original depositional settings or of submarine and seafloor effects on long-exposed carbonates and/or of intra/inter-formational subaerial unconformities. Dolomitization by penecontemporaneous tidal flat and evaporitic-reflux processes are examples of such early diagenesis; there is no evidence of either in the Abenaki.

Another early intraformational dolomitization process was applied by Eliuk to dolomite in Demascota G-32 (Eliuk 1978) – namely a mixing zone where limestone is subaerially exposed so that a freshwater lens forms and dolomitization occurs in the shallow subsurface where it mixes with sea water. Even cave formation was suggested in one of the reefal cores (Figure 4.40A Demascota G-32 Core #2). Based on the research done on the similar dolomite in the Deep Panuke reservoir wells, late burial dolomitization by hotter subsurface fluids along fractures and faults seems much more likely (Wierzbicki et al. 2006). Thus, absent of a faint plea of overprinting, Eliuk's (1978) dolomite interpretation seems well refuted as admitted and discussed in Eliuk (2004), but the cave interpretation has not been abandoned. However in that same short paper, an instance was suggested where the model of mixing zone dolomite might still be appropriate - Acadia K-62 core 1 to 3. This is the only occurrence of dolomite at the top of the Abenaki Formation and three cores over a short interval (<13m with poor recovery) were recovered just 33m below the formation top. This dolomite shows petrographic features (Figure **4.70**) that may indicate a mixing zone origin as well as (?or) dedolomitization, both of which support subaerial exposure in humid climates with fluctuating phreatic water chemistry. The core is interpreted to have originated as an oolitic grain-packstone and has unusual petrographic features of zoned calcite and dolomite and late calcite cement that often are seen in mixing zone dolomites and dedolomites.

Evamy (1967) gives a discussion of possible analogous dedolomite diagenesis. In respect of the somewhat 'zoned' relationship of the larger dolomite and calcite rhombs (interpreted as dedolomitized but perhaps due to alternating cements of a fluctuating pore water system), the fabric is somewhat similar to the Pleistocene mixing zone dolomite with banded calcite-dolomite of Yucatan (Ward and Halley,1985) and Barbados (Humphrey, 1988). However as mentioned in 2004, this is an idea for investigation and it has not personally been taken any further since then. Thus there is still the possibility of several mechanisms for dolomite origin in the Abenaki although none of regional extent (see general dolomite discussion by Moore 2001) and of course the Abenaki dolomites unlike those of the Iroquois Formation are locally developed. As used originally (Eliuk 1978) and reiterated (Eliuk 2004), mixing zone dolomitization can be related to seismic paleo-highs furthering hydrocarbon exploration, but with caution.

Core 4 in Acadia K-62 is the type example for the **oncolite (mollusk-rich) lithofacies**. That 18m core is schematically illustrated in **Figure 4.71B** (modified from Eliuk 1981 with porosity shown). Oncolitic fabric in the core can be identified in the cuttings showing presence of the facies in about 50% of a 520m gross interval associated with lesser amounts of reefal (+10% corals or sponges), pelletal and oolitic lithofacies (see **Figure 4.69** 3270 to 3790m). Core 4 has a few thin intervals (few decimetres) of the only coral reefal facies seen in Abenaki core on the western shelf. One coral interval (reeflet or biostrome), dominated by *Isastrea* (**Figure 4.72**) shows both inner coral cross-section and the outer coral surface. The inner slabbed section is so highly bioeroded, mainly by boring clams and inhabited by various cavity dwellers, as to be difficult to recognize the coral colony outline. In contrast the near-outer 'living' surface is nearly pristine colonial coral in appearance. Then as now most bioeroders attack the non-living inner and underside of corals and supply fine sediment to infill reef cavities.

Figure 4.71 comments on and shows typical fabrics of oncoids and large mollusks. Particularly common are large nereid gastropods and even more bivalves interpreted as megalodont clams with a few possible dicerid clams which are early forms of rudistid clams (Clarkson 1998). As discussed and illustrated in Eliuk (1998, Fig. 3 reproduced in part as the conceptual depositional block diagrams in Figure 1.4), the oncolite facies of core 4, also seen in cuttings that have associated coral and oolite zones, is interpreted as a reef flat (the oncolite and coral areas) and proximal backreef zone (the mollusk-rich lower core) occupying a stressed environment (high wave energy, potential periodic exposure, variable higher/lower water temperatures). The drill cutting-based pattern on a well-scale shows the core located in a transition interval from greater amounts of coral-stromatoporoid reefal beds below and more oolite beds

above, also supporting the interpretation of a reef flat-near backreef setting in keeping with a Walther's Law of correlation of facies relationship (Middleton 1973).

A possible anomaly to this interpretation is the presence of four samples with low amounts (10%) of oncoids just below core 5 that has thrombolites and is interpreted as distal slope. This could be caving of cuttings or deep water stromatolites but they are considered allochthonous carried down the forereef slope even though no metazoan framebuilders are associated. A smaller-scale analogue is a Pleistocene fringing reef outcrop in Barbados where oncolite occurs on the forereef slope as well as its site of origin in the immediate backreef lagoon (James et al. 1977). The seismic-defined position of K-62 slightly inboard of the Jurassic-Cretaceous shelf edge supports the reef-flat to proximal back reef interpretation.

An addition to this interpretation addresses the apparently uncommon occurrence of the oncolite facies (only in Acadia K-62 Baccaro) and the interesting association of large bivalves and simple algae (cyanobacteria or microbial oncoids). This bivalve-oncoid association was surveyed for the Canadian Phanerozoic (Eliuk 1998) using as examples Western Canada Sedimentary Basin Devonian carbonate and Mesozoic Abenaki carbonates with the suggestion that the additional stress of nutrient excess favoured oncoids and mollusks over coral-stromatoporoid communities. Considering the eventual dominance of rudistid bivalves in near shelf-edge positions in the much warmer Middle and Late Cretaceous seas, perhaps temperature may have been an important environmental driver for this change in carbonate platform communities (see **Figure 1.3** and **A2.17**). The Acadia K-62 oncolitic-mollusk facies may have been an early excursion into this later global change in temperatures.

Core 5 in Acadia K-62 (**Figure 4.69C** and **4.73**) is stylolitic and superficially carbonate-mud rich but on closer is seen to be *in situ* **microbolite** (thrombolitic/ stromatolitic/automicrite bindstone and mudstone intervals) and chaotic accumulations of mudstone and bindstone clasts indicating mechanical collapse (*in situ* brecciation). As well there are delicate branching corals at several levels and occasional lithistid sponges and small corals, some of which appear to be microsolenids. **Figures 4.73** and **4.74** respectively show the overall distribution of these two main carbonate types in whole core and closer views of some diagnostic features. Previous work includes Eliuk (1981), the source of the core schematic **Figure 4.69C**. [Subsequent work, in many cases with illustrated paleontological-petrographic detail, on this and similar microbolite mound facies in Penobscot L-30 and Demascota G-32 core are by Dromart (1986), Dromart et al. (1994), Ellis (1984), Ellis et al. (1985), Ellis et al. (1990), Jansa et al. (1988), Pratt (1982, 1995). Pratt

(1995) is a comprehensive synthesis and argument for the microbial origin of Phanerozoic mud mounds.]

While the presence of *Tubiphytes*, tubular forams and serpulids in Acadia K-62 is similar to L-30 and G-32 cores, the amount of bryozoans, corals and sponges is much greater and large open cavities is much less. These could be taken to indicate better environment for macrofossil growth, greater rates of accumulation and correspondingly less times of non-deposition and seafloor cementation. Clast-rich intervals consist of lime mudstone and thrombolitic or automicrite bindstone clasts often with miss-oriented geopetal micrite-filled small cavities (**Figure 4.74A** green-bordered enlargement show multiple geopetal infill after rotation) indicating early mechanical collapse so common in sponge-rich stromatactis carbonate mounds (Bourque and Boulvain 1993).

Many intervals show pervasive stylolitization suggestive of very uniform and perhaps less lithified sediment that subsequently suffered chemical burial compaction. In the lower part of the core *in situ* delicate branching corals occur at a few levels in the lime mud/wackestone matrix. The lower amount of seafloor cementation may have allowed movement and fragmentation of the thinner bindstone layers on the slope with the resulting clast rich layers probably with resedimentation locally sourced. Some core intervals of inclined bedding support a slope setting interpretation. This core is interpreted as a **deep-water slope 'mobile' mud mound.** As seen in the colour differences (**Figure 4.68**) this core will be part of an exercise in comparative carbonate sedimentology with respect to proximity to the Sable Delta in Section 5.4.

Albatross B-13 tested a structural high as the furthest southwest test at the Jurassic bank edge finding scattered porosity in limestones and minor amounts of dolomite but no hydrocarbons and was abandoned without testing (Kidston et al. 2005). The Abenaki in Albatross B-13 is a nearly continuous upward shoaling sequence over a 1.5km section going from Callovian shales up into Valanginian-Hauterivian (Neocomian – Early Cretaceous) oolitic limestone with the intraformational Top Jurassic (about NBCU) placed at widely differing levels by different workers due in part to the often poor recovery of datable microfossils (see Figure 4.58). The NBCU as shown on Figures 4.67 and 4.75 is from Weston et al. (2012, NBCU = unconformity above Late Jurassic plus Berriasian if not eroded). The only core was near the top Abenaki in oolite but cuttings and some sidewall cores with thin sections allow the full succession to be documented as shown in Figure 4.75 by the transgressive-regressive trends and by labelled depositional environments.

Above a basal 150m of darker slightly argillaceous limestone across a possible fault, more than half of the Abenaki is white and varicoloured red-pink microbolite (thrombolitic) peloid limestones interpreted as slope mud/bindstone mounds that pass up into coral-stromatoporoid reefal lithofacies interbedding upward into nearly white oolitic limestones with the succession capped by a very thin reddened oolite discussed at the end of Section 4.14 (see **Figure 4.65D-F**). All these reddened limestones have various marine biota such as crinoids and very rare bryozoa, foraminifera, and only trace amounts of framebuilders like stromatoporoids and are interpreted to be deeper-water than the underlying limestones.

Only two good whole core examples of limestone in **oolite lithofacies** occur in upper Abenaki (post-Scatarie/Misaine) wells – Penobscot L-30 core 1 (9m) and Albatross B-13 core 1 (6.5m). Representative slabs of the cores (**Figure 4.68A**) show the marked colour contrast similar to that of the slope limestones in being dark near the Sable Delta and light far away from it. A third well, Mohican I-100 core 4, has a 1.2 m oolitic grainstone that was stabilized then colonized by a single three centimetre coral head that was rapidly buried in burrowed lime mud (Eliuk 1978, plate 3-fig. 1; see **Figure 5.1A** - enjoy the photo because the coral head and contact are now lost from both CNSOPB core slabs!) That limestone is in the far bank interior-deep lagoon ('moat') and was relatively dark and showing that minor amounts of supposed index fossils-lithofacies are not restricted to their ideal setting.

Details on the Penobscot L-30 core 1 were shown in **Figure 4.18** of Section 4.05 and, typical of a ramp setting, show the mixing of a variety of depositional facies over a relatively limited interval including an interpreted 3.5m graded ooid bar. In contrast Albatross B-13 core has all 6.5m of the core in uniform fine to very coarse oolitic grainstone with only low amounts of abraded macrofossils. Presumably this lack of macrofossils is due to the thick widespread inhospitable mobile ooid substrate seen in over a 100m of adjacent cuttings with only a few thin reefal beds of stromatoporoids and corals. **Figure 4.76** shows several features of this oolitic lime grainstone core including a thin lamellar coral possibly *in situ*. Abraded oyster and other bivalve shells, tiny gastropods, rounded coral and sponge fragments, rare serpulid fragments but no quartz nuclei are seen. This lack of quartz contrasts with its common presence in the Panuke Trend (e.g. **Figure 4.76F**). All oolite illustrated here is essentially completely cemented and non-reservoir which is the usual situation for Abenaki oolites particularly those of the Scatarie Member and those deeply buried to the northeast. But porosity does occur in some oolitic limestones, even in this core with porosities of 9.5 to 9.9 % measured in the bottom 1.3m, but the permeabilities were poor at less than 0.5 millidarcies.

Figures 4.76E and 4.77 show some geopetal reddened linings and cements of large mostly-cemented near-vertical fractures that run through much of the core. The fact that such fractures were even captured in the core indicates that they must be very plentiful. With the core close to the top Abenaki (less than 50m) they may represent Neptunian dykes (or subaerial joints later water filled) open to the Mesozoic seafloor where reddened onlites and coated ironstones elsewhere cap the Abenaki. The latest fracture-filling cements are extremely coarse, even dog tooth calcspar. But the apparent fine to coarse (F-C) blocky inter-ooid and fracture-lining calcite cement that appears to precede it obscures a more complex cementation story.

A minor amount of petrography was done including some cathodoluminescence to aid understanding the oolite and fracture history and is illustrated in Figure 4.78. The cathodoluminescence clearly shows the zoning with the red iron-rich calcites possibly showing up by their quenching effect. However the study of red origins and microbial mediation in the Jurassic Ammonitico Rosso (Preat et al. 2006) indicates that the absolute amount of iron does not explain reddening – much more work should be done to understand both these infill sedimentscements and the more widespread red carbonates discussed below. Figure 4.76E (thin section sample lost in preparation), the ever-enlarging series in Figure 4.77B-E and Figure 4.78A (thin section = TS sample macro view) on a fine even subtle scale clearly show the geopetal filtering of red and possibly even-earlier green (glauconitic) sediment and perhaps red cements. A couple thin sections were analyzed with cathodoluminescence (courtesy of Prof. Peir Pufahl at Acadia University). Prior to the coarse (=C) and extremely coarse (=XC) blocky calcspar fracture-fill cements the thin sections showed that there was an early period of zoned calcite cements isopachously coating the geopetal sediment and ooids. This is presented on Figure 4.78 as sets of photomicrographs in normal, cross-nicol and cathodoluminescence views related to a low power thin section macro-view and the original sample of fractured oolitic lime grainstone. Another sample showed scalloped possibly corroded edges to more faintly zoned isopachous cement on ooids. This zoned cement and late fracture fill still must have been preceded by pervasive early cementation - enough to allow the impressive fracturing of the rock but not enough to have occluded all the porosity that in places was invaded by the infiltered geopetal sediment. The features seen in these reddened fracture fills will be compared with the marine redbeds already discussed in Section 4.14 with interpretation in Section 5.4.

A feature that occurs in no other Abenaki well is the **white and varicoloured red and pink limestone** in the lower half of the Abenaki (Baccaro Member) as schematically shown on **Figure 4.75**. Unfortunately it was not sampled in whole core but is seen mainly in cuttings as

shown in **Figure 4.79.** There are also some sidewall cores of mostly poor quality (the result of blasting into carbonates as opposed to the more modern technique of drilled sidewall cores as was used in Deep Panuke). A few thin sections were made from them and from cuttings intervals by the operators (Dr. Gordon Tebbutt, pers. comm. and internal report 1990s, deceased but formerly of PetroCanada reported cryptalgal fabrics). About 10 cycles go from lighter pinks at the top to darkest reds at the base as shown in the layout of cuttings trays (**Figure 4.79A**).

The cuttings have microbolite and peloidal mudstone to wackestone textures with minor amounts of *Tubiphytes*. The thin sections confirmed these observations and also had some examples of possible small stromatactis with isopachous cement-lined geopetally filled cavities (**Figure 79B & C**). Based on cuttings examination and re-examining the thin sections, the interval is interpreted as a **deep water slope deposit with microbolite (thrombolitic) carbonate mounds**. Still the **red colour** is very unusual. It is particularly interesting that these red and pink colours are repeated in cycles starting fairly strong and plentiful then fading upward to white over the total interval— the reverse of what might be expected if due to caving from a narrow interval(s). As shown by **Figure 4.79**, about seven red and three pink colour cycles occur. Other than the colour there is no obvious correlation to changes in cuttings textures — some intervals are more microbolite peloid rich and in the upper quarter or so fossils and framebuilders increase in amount upward until stromatoporoid-coral reefal beds start occurring.

Bonnet P-23 is the furthest southwest of the Scotia Shelf wells and targeted a tilted fault block behind the carbonate margin. The Abenaki in B-23 with good porosity in dolomite and limestone had extensive lost circulation zones due to either greater porosity or involvement of fault zones and was abandoned without testing (Kidston et al. 2005). As already discussed and illustrated in Figure 4.67, the Abenaki (Roseway and Baccaro) lithofacies of oolitic and pelletal limestones places Bonnet P-23 in a shelf interior setting in keeping with its seismic location relative to the Jurassic shelf edge (Figure 4.66). Subsequent biostratigraphic studies by Weston et al. (2012) have significantly revised dating and stratigraphic placement with younger Oxfordian ages in what had been lithologically considered Misaine shale. Appropriate Callovian ages now apply to an underlying shale, the revised Misaine. A deeper carbonate is now considered Scatarie with Callovian-Bajocian ages by these paleontologists. The revised tops placement is shown on Figure 4.81 since diachronous relationships were considered and rejected. This differs from a year earlier biostratigraphy and sequence results in the PFA study (OETR 2011) as well as previous tops by both the industry and MacLean and Wade (1990). The PFA Chapter 9 (OETR 2011) sequences as shown on Figure 4.81 would also have to be revised or abandoned. The PFA

facies associations shown in colour were derived from Eliuk's detailed litholog which is supplemented by additional logging in 2014 of the deeper interval and shown with the revised dating and additional facies as black bars on **Figure 4.81**.

Even prior to the revised dating and lowered formation tops the P-23 Abenaki was seen as somewhat dirty, even shaly, on gamma logs particularly in the lower lost circulation zones. This probably resulted from a bank interior setting closer to the deep lagoon or 'moat' as in the Mohican subbasin Abenaki plus the proximity to the undrilled Shelburne Delta to the west. The common but not abundant presence of lithistid sponges and *Tubiphytes* may also indicate a somewhat more open marine and deeper (or turbid) setting for the lowermost Baccaro as well. Weston et al.'s (2012) placement of Scatarie is shown. If true this would be the first time that member is dolomitized which is not an impossibility given the faulting seen on seismic and likelihood of associated hydrothermal dolomitization.

However an alternative interpretation of faulting from Misaine to Iroquois is proposed as shown on **Figure 4.81** since the Misaine is anomalously thin. The dating for the dolomite, Callovian-Bajocian, is not too far off Weston et al.'s (2012) proposed first age determination of the Iroquois Formation in the Mohican I-100 of "no older than Middle Jurassic and possibly no older than Bajocian". Either way, the lithology and stratigraphy is anomalous as compared to the regional Misaine-Scatarie patterns. Examination of the cuttings over the interval in question shows that it is not as oolitic as shown on industry logs. One interval even has high amounts of lithistid sponges in argillaceous limestone and the very base of the limestone has microbolite textures both seen as indicating deeper water settings than usual for Scatarie or even most basal Baccaro limestones. If the base is not faulted out, the revised Misaine shale is comparatively thin with a 5 m and a 10m oolitic limestone bed, perhaps debris beds or local shoals in not so deep-water shales. The downward change to near white dolomite is abrupt with the top 15 m reddened.

Above the shaly and argillaceous limestones of the lower 500 m (some inferred from gamma logs since in lost circulation zone), a 100m porous dolomite is overlain by almost a kilometre of light coloured fragmental-pelletal and oolitic limestones with oolite becoming dominant in the top half. Reefal framebuilders are nearly absent except for two separate five metre beds where combined stromatoporoid and hexacorals did not reach 10%. These are shown by the stromatoporoid symbol in the schematic litholog **Figure 4.81** along with the other main lithologic features discussed. So a sheltered bank interior going up into a high energy ooid shoal complex is the envisioned setting of most of the Baccaro-Roseway with ages by Weston et al. (2012) from

Kimmeridgian to Hauterivian-Valanginian with the NBCU not very discernable in the massive oolitic limestones. Some pervasive dolomite is found near the top of the oolitic limestones.

Unlike the two other Western Shelf Abenaki wells, the top of the carbonate is not oolite but has a marked lithofacies change to slightly darker cherty limestones with plentiful fossils. It is very like the Artimon Member because lithistid sponges are common with minor amounts of *Tubiphytes*. But it differs in having more stromatoporoids than typical of the member including a possibly transgressive bryomol bed near the base with high amounts of bryozoan and bivalves along with a variety of other biota including echinoderms and serpulids. **Figure 4.82** illustrates some of these potential mound-forming sponges and bryozoans as seen in cuttings.

This Artimon-like facies (differs in having plentiful stromatoporoids as well as the characteristic lithistid sponges) is markedly distinct from the overlying coated ironstones and redbeds (see Section 4.14 and **Figure 4.65G**) dated as Albian (Weston et al. 2012) and from the underlying very light colored oolitic limestones. Weston et al. (2012) dated both this very different carbonate unit and the underlying oolites down to 2065 m as Hauterivian-Valanginian and tentatively placed the intra-Hauterivian MFS (maximum flooding surface) at a gamma spike at 1903 m. A more likely placement would have the MFS at the base or within this clearly deeperwater Artimon-like unit perhaps at the 1865 m bryozoan-rich bed. Thus a deepening or even 'drowning' sequence for the ultimate end of the Nova Scotia Jurassic-Cretaceous Abenaki carbonate platform may have occurred in the last well in the Canadian part of the trend. The termination is occurring diachronously and later than the sudden-older drowning once proposed by Eliuk (1978) based on just the first two margin wells

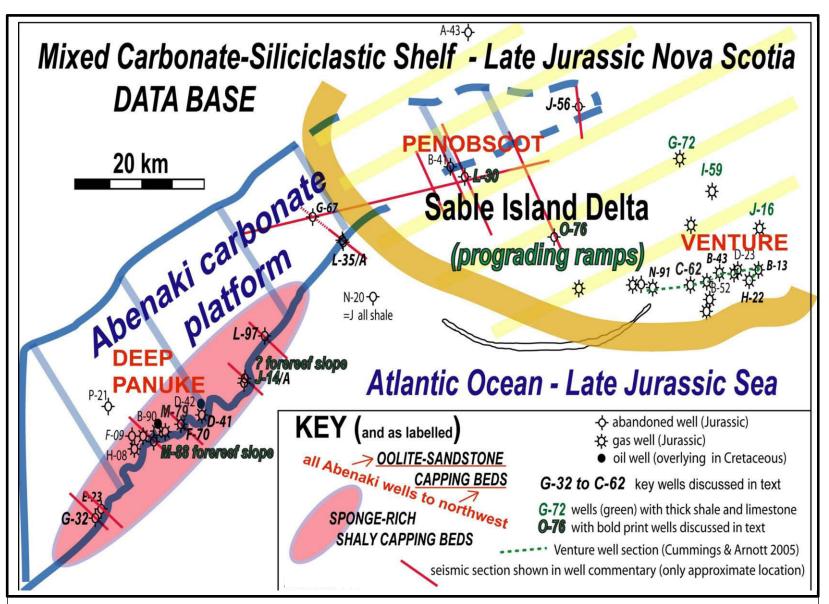


Figure 4.1 Location map Panuke Trend to Venture area showing well and seismic data included in results sections and main edges and major facies areas in Late Jurassic.

Table 4.1 – Well List for Comparative Carbonate Sedimentology Sable Delta-Panuke Trend ABENAKI PLATFORM – SABLE DELTA TRANSITION					
SETTING – RAMP VS PLATFORM - Slope, Margin, Interior	Oolite- sandstone capping beds	Shaly- sponge- rich capping beds	Pinnacle reef at margin	Thick shale inter bed(s)	Comments Drill Date & cores
Interior, far?	X? salt-shoal			Upper very sandy	1971
DELTA – shelf margin (condensed)					C-62 cored & 5 offsets Gas 1985
(distal)					1984 - (2)
RAMP (proximal)	X			X	1976 - 2
	X				1987
& slope	X		X?		2002
Slope		90339			1978 - 1
Slope		***************************************		X in J-14	2006
Margin & Interior, near		X			1973
Margin 'p' (faulted)		X	X In carbonate		Gas 2003
Margin 'p' (& slope)		X	X In carbonate		Gas 2003 - 1
Slope, distal		(X)		X	2002
Margin		X			M-79A gas 2000 - 1
Interior, near		X?			Cretaceous oil 1986
Margin		40/400771			PI-1B gas 1999 - 1
Margin		X			PP-3C gas 1998
Margin		X			Gas 2000 - 1
Interior, near		X			2000
Interior, far	X Sands thin				1987
Margin		X			2001
Margin 'p' & Slope		X	X	X Artimon	1974 - 5
	ABÉNAK SETTING – RAMP VS PLATFORM - Slope, Margin, Interior Interior, far? DELTA – shelf margin (condensed) RAMP (distal) RAMP (proximal) Interior, far Margin & Slope Margin & Slope Margin & Slope Margin fp' (faulted) Margin 'p' (& slope) Slope, distal Margin Interior, near Margin Margin Interior, near Margin Margin Interior, near Margin Margin Interior, near Margin	SETTING — RAMP VS PLATFOR Siope, Margin (condensed) RAMP (distal) RAMP (distal) RAMP (solution of the state o	ABÉNAKI PLATFORM – SABLI SETTING – RAMP VS PLATFORM - Slope, Margin, Interior Interior, far? X? salt-shoal DELTA – shelf margin (condensed) RAMP X (distal) RAMP X (distal) Interior, far X Margin X Slope Margin & X Slope Margin & X Interior, near Margin 'p' (& slope) Slope, distal Margin X Interior, near Margin X Margin X	ABÉNAKI PLATFORM – SABLE DELTA TR SETTING – RAMP VS PLATFORM – Slope, Margin, Interior, far? DELTA – shelf margin (condensed) RAMP X (distal) RAMP X (proximal) Interior, far X Margin & X Slope Margin & X Slope Margin & X Interior, near Margin 'p' (faulted) Margin 'p' (& slope) Slope, distal Margin X Margin X Margin X Margin X Margin 'p' (faulted) Margin X Margin X Margin X Margin X Margin X Margin X Margin 'p' (faulted) Margin X Margin 'p' & X Sands thin X Margin 'p' & X X X X X X X X X X X X X	ABÉNAKI PLATFORM - SABLE DELTA TRANSITION SETTING - RAMP VS

NOTE: Non-limestone-bearing Jurassic-earliest Cretaceous wells on Figure 4.1 map are omitted. Migrant N-20 is completely shale of that age. Uniacke G-72, Citnalta I-59 and Arcadia J-16 have a similar stratigraphyage as South Desbarres O-76 but are not included in this study (but see Figure A3.20 for revised dating of G-72). Penobscot B-41 is just west of L-30 but barely penetrated oolite. Dover A-43 is more siliciclastic-rich than Abenaki J-56 and is omitted. 'p' = shelf margin pinnacle or small buildup at platform edge or upper slope.

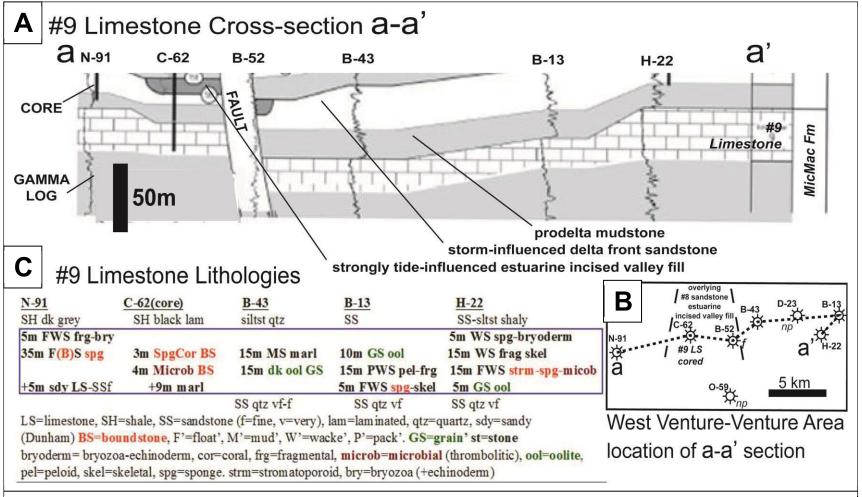


Figure 4.2 #9 Limestone cross-section and cuttings lithologies in Venture area Late Jurassic Sable Delta. A) Cross-section a-a' of #9 Limestone and overlying deltaic facies. **B)** Well location map of wells. Note that incised valley overlies the deeper non-oolitic facies of the underlying #9 Limestone. **C)** Venture area #9 Limestone lithologies – based on 5m cuttings samples for all but C-62 well. Colors indicate either <u>red</u> for reefal (10% or greater framebuilders – lithistid/siliceous sponges, stromatoporoids, corals mainly microsolenid) or <u>green</u> for oolite grain/packstones. In Venture B-52 (between C-62 & B-43) most of the #9 Limestone is faulted out except for 10 m of marl- argillaceous mudstone with minor black ooids. Section modified from Cummings and Arnott (2005) and shown with interpretation in Section 5.2.

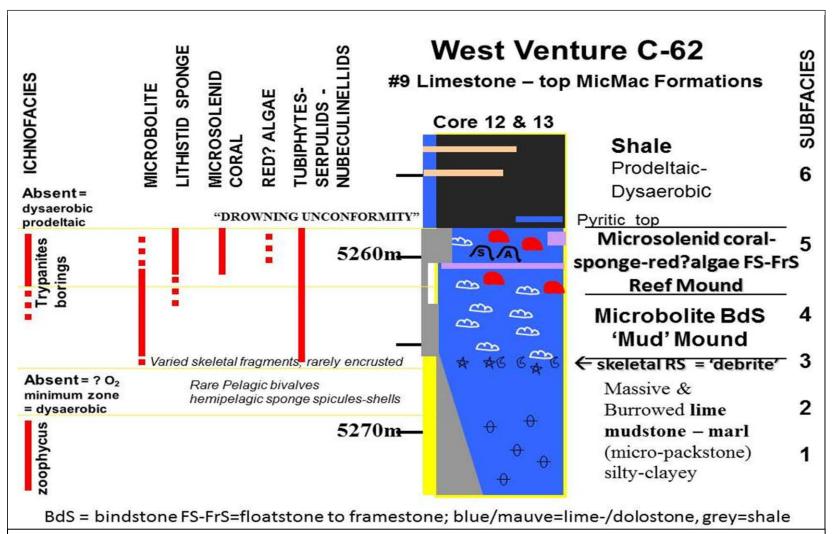


Figure 4.3 West Venture C-62 #9 Limestone schematic core log summary. The vertical distribution of key fossils allows subfacies to be distinguished. See text for numbered subfacies discussion. These subfacies are illustrated and described in more detail in Section 5.2.1 (after Eliuk and Wach2008, 2009). See key in Figure. 4.14 for most symbols, star is crinoid.

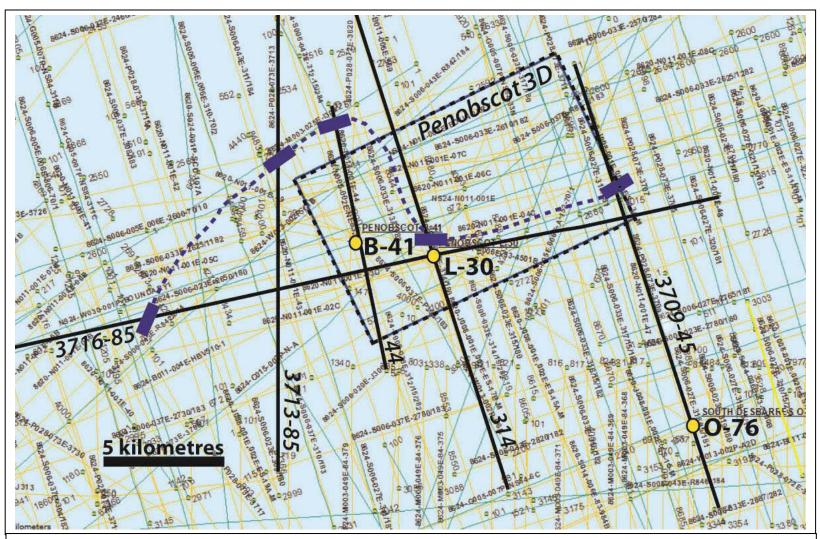


Figure 4.4 Seismic base map in Penobscot-Desbarres area northwest of Sable Island (original from Canada-Nova Scotia Offshore Petroleum Board [CNSOPB] Decision Point program display). Seismic lines in following **Figures 4.5-4.10** shown by heavier black lines with CNSOPB Data Management Centre's numbers. Penobscot B-41 and L-30 and South Desbarres O-76 wells on N-S dip lines with regional W-E tie line through L-30 and extending westward 30 km to Kegeshook G-67 off this map. 6713-85 (and 44) cut axis of sag or 'channel' re-entrant but may not be aligned with the trend of sag channel re-entrant. Blue marks indicate margins of platform (or atoll? on east-centre). Dashed rectangle is 1990's 3-D survey [reprocessed by Ammonite Nova Scotia in their former exploration lease area, also by Qayyum et al. (2015a) for seismic sequence stratigraphy].

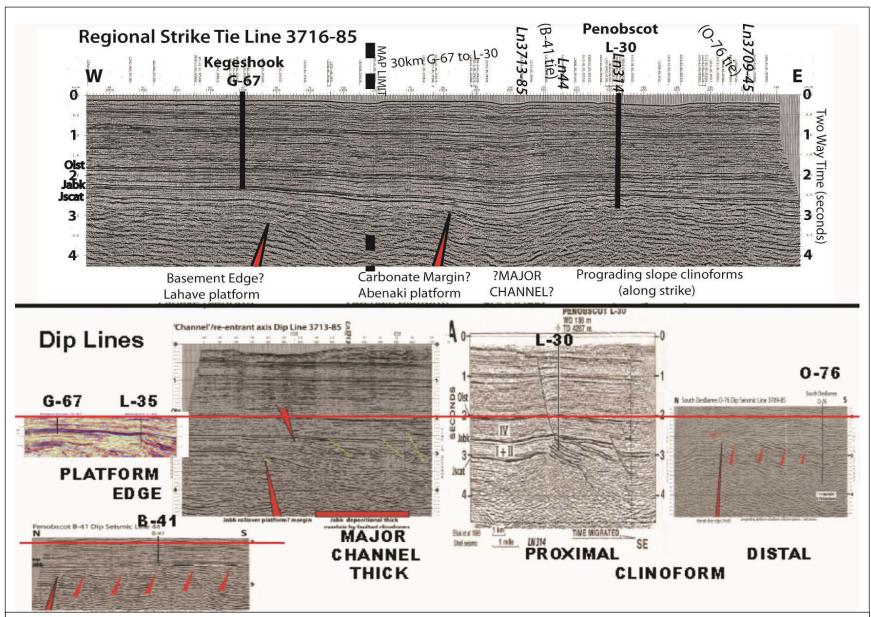


Figure 4.5 Summary seismic lines in greater Penobscot area. Dip lines through indicated wells and intersect long regional strike line. Vertical scale (two-way time) is all the same and horizontal scale about the same. Note areas of clinoforms and location of depositional thick with feeder clinoforms in 'channel' just south of Penobscot L-30. See following figures for more discussion.

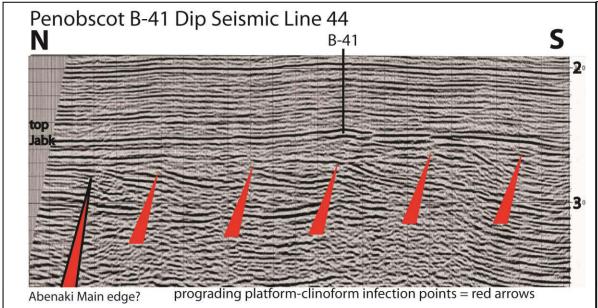


Figure 4.6 Seismic line through Penobscot B-41 that just penetrated a few 10's m of Abenaki oolitic limestone (strong reflector at 'Jabk'). The underling reflectors are interpreted as a series of climbing and prograding clinoforms possibly developed adjacent to a large channel just to the south off structure (see Fig. A1.4). A possible Abenaki carbonate platform margin is indicated at the north end of the line about 5 km north of B-41 which may indicate that the Abenaki carbonates to the southeast are an isolated atoll. ALTERNATIVE INTERPRETATION – series of rotated small fault blocks formed by salt uplift before end of Abenaki deposition with arrows at faults. Seismic line is about 9 km long.

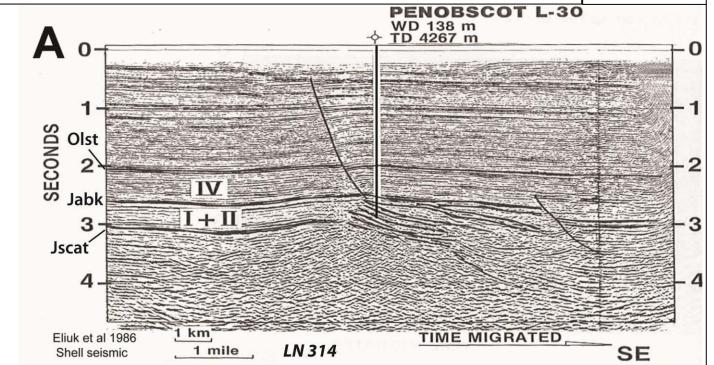


Figure 4.7 Interpreted seismic through Penobscot L-30 shot by the well operator Shell Canada (modified from Eliuk et al. 1986). The well penetrated flat-lying shallow-shelf beds above topset prograding clinoforms of deeper-water limestones and shales. The more massive beds immediately to the north of L-30 can be interpreted as aggradational reef margin. The O Limestone Marker (Olst), top Abenaki Baccaro (Jabk) and Scatarie Member (Jscat) are regional seismic reflectors. IV designates the Lower Missisauga, I and II the Baccaro and Misaine Abenaki members.

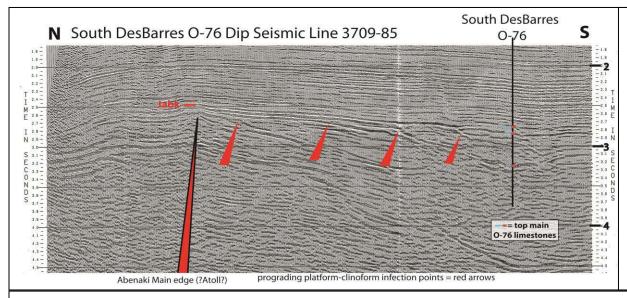


Figure 4.8 South Desbarres O-76 seismic is about 8km south of the Penobscot structures and possible reef margin of the Abenaki platform or atoll. The strong reflectors below the top Abenaki (Jabk in red) may indicate mixed lithologies. A series of prograding clinoforms extend to O-76 - as indicated by the blue-red markers. Down-to-the-south normal faults bracket O-76. O-76 has 2 thick limestones separated by shale with the upper flat-lying shallow onlite over reef and the lower microbolite (thrombolitic) slope beds. Line is about 14 km long.

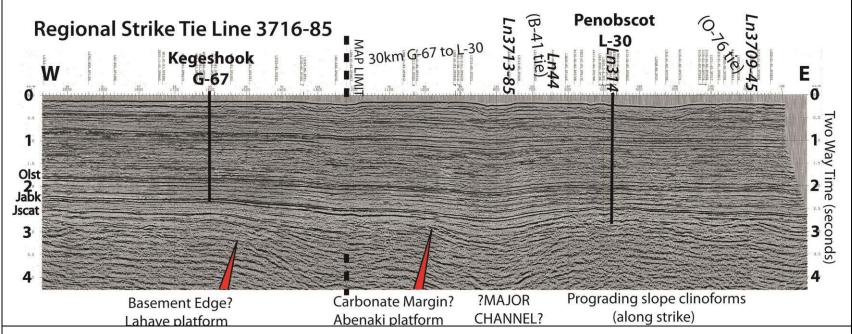


Figure 4.9 Long seismic strike line through L-30 that ties the 4 dip line and extends beyond the Fig. 4.4 map to Kegeshook G-67. The west half of the line is on the Abenaki platform and the east half is near off-reef slope with an intervening deep thick sag that may indicate a wide channel break in the platform.

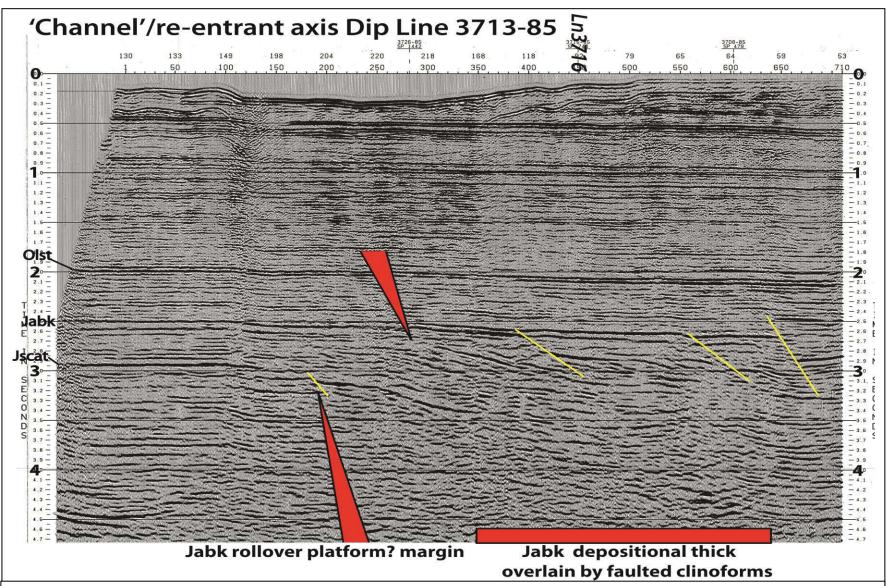


Figure 4.10 'Channel' or re-entrant axis dip seismic line located just east the centre of the sag or 'channel'/re-entrant on regional strike tie line (**Figure 4.9**). Interpreted platform margin seems to 'roll-over at all levels prograding a short distance. Basinward clinoforms are not as well developed as on other dip lines. (Deeper water bottom seems to have depressed the reflectors above the margin.) The line is about 14 km long.

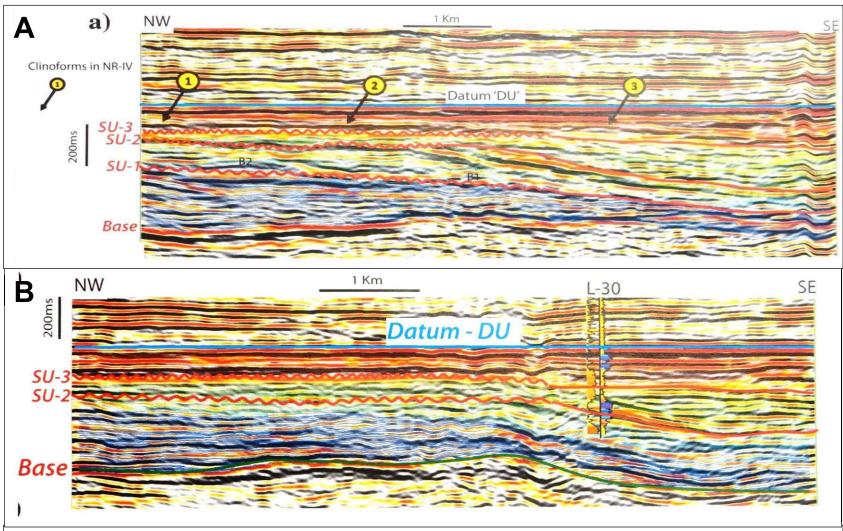


Figure 4.11 Penobscot area flattened 3D seismic lines (Qayyum et al. 2015a -their figure numbers in brackets) A) Unlocated 3D dip line of foresets (Figure. 12a) note the greater number and lower angle of clinoforms as compared to those of the L-30 line. B) Penobscot L-30 dip line (Fig 13a) note even with flattening the greater relief of 'Base' reflectors which is even more without flattening and shows structure affecting beds above DU. Thus structural uplift, or a pre-existing paleohigh, was reactivated. L-30 lithofacies show that most of the basin-filling progradation is due to shales with the carbonates capping the section in depositionally-shallowed waters or 'armouring' the slope as low-energy microbolites. See Fig. A1.28C for the unflattened seismic through L-30; note that with increased carbonate content velocity pull-up can occur. Modified from Qayyum et al. (2015a)

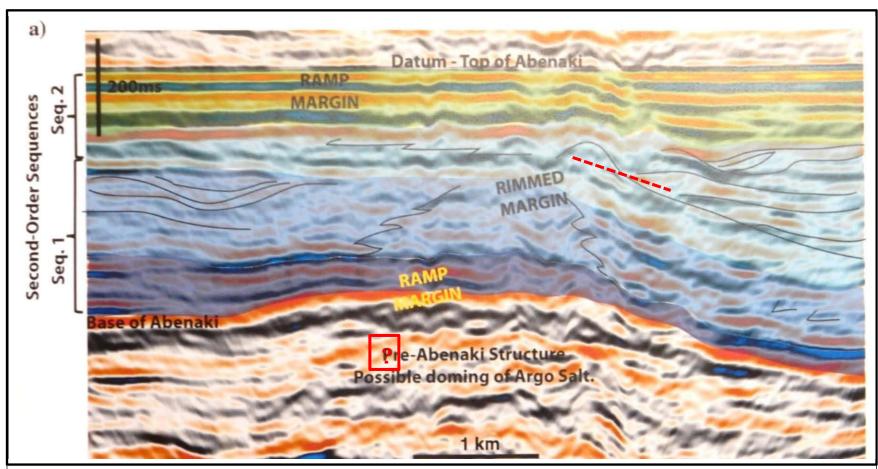


Figure 4.12 Penobscot area flattened dip line with Qayyum et al.'s (2015a, Fig. 10a) interpretation and alternatives. This line summarizes their concepts of Abenaki carbonate history as an initial ramp to rimmed margin (in this case of an atoll over a paleohigh) back to capping ramp. It is debatable whether this is a regionally applicable time sequence (their Seq. 1 & 2) or instead a local process response dependent mainly on sedimentology of first carbonate platform growth and then carbonate-siliciclastic interactions. Here Eliuk re-interprets it as the final in the series of increasing structural control where the base Abenaki shows even more relief than in Fig. 4.11B. The structure was active during Abenaki deposition not just prior. While this could be seen as their paleohigh that localized the rimmed margin, the fact that structure is developed in the Penobscot feature also above the Abenaki suggests that it had continued growth. Thus the anomalous situation of the lower ramp margin somehow climbing over the supposed pre-existing structure would not exist. The uplift could be due to deep salt movement fed from loading elsewhere of the nearby advancing Sable Delta with episodic movement into the Cretaceous. Some of the correlation lines such as just to the right and above 'rimmed margin' seem not to be supported by actual reflectors. Given the lack of many reef framebuilder intervals in near-delta carbonates, but rather plentiful oolites, maybe such supposed reefal relief should not be expected (dashed red line alternative).

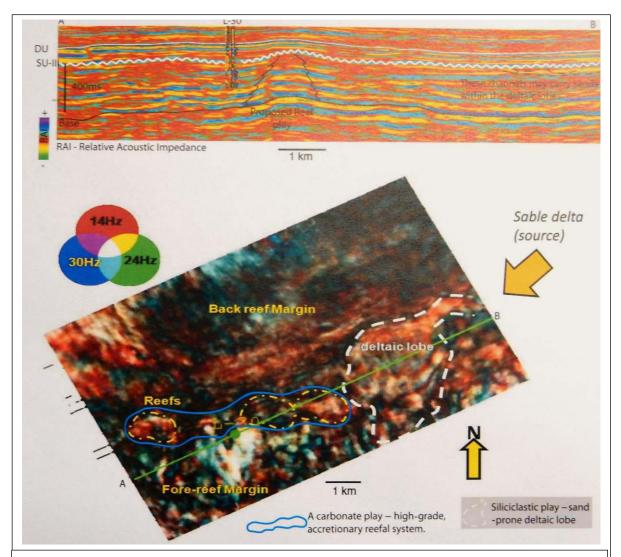


Figure 4.13 Composite illustration of 3D seismic area and play ideas. (Qayyum et al. 2015a Fig. 15) Play ideas, reef and delta lobe, with strike section AB and 3D area map prepared by color blending the three spectral decomposition maps generated at 14, 30, and 24 Hz around this horizon (SU-III). Green dot locates Penobscot L-30 location. See Section 6.05 for an alternative interpretation. A reef play as outlined in blue and a deltaic lobe play were proposed. Although pursued by operators – the deltaic play combined with a structure found oil in L-30 in the Missisauga and the reef play was part of Ammonite Nova Scotia's former portfolio.

The term 'back reef margin' seems to imply a bathymetric low between the carbonate margin and the shelf interior so that two sediment factories seem to be operating. The nature of that factory is not well defined literally and figuratively in the Penobscot area. Mixed siliciclastics and oolitic carbonate are a reasonable guess given the lithologies in Abenaki J-56 and the topmost Abenaki of the wells from Marquis L-35 northeast. In areas further south perhaps ooid shoals alone constitute the factory. Patch reefs are reasonable to expect but so far no shelf interior well control has shown significant amounts or thicknesses of reef framebuilders.

The AB strike section where interpreted as a reef on a paleohigh with drape, could alternatively be seen as later structural uplift.

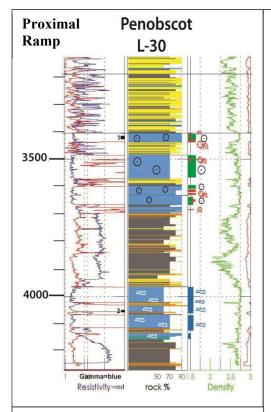


Figure 4.14 A) Penobscot L-30 comparative schematic log from Fig. **4.17C.** Section thickness less by $1/3^{rd}$ than O-76 but correlations not known. Topset shelf beds more oolitic with thinner coral-stromatoporoid/chaetetid layers in L-30 as opposed to thicker coral-stromatoporoid reefal beds in O-76 where topmost thinner limestone and upper beds of thick topset limestone are deeper or dirtier reefal (more lithistid sponges) and transgressive (bryoderm beds). In both wells clinoform beds are depauparate microbolite (thrombolitic) slope peloid mudstones. Only traces of macrofossils other than *Tubiphytes*-serpulids occur, except for a sponge reefal bed near top of clinoform limestone in O-76 at about 4900 m.

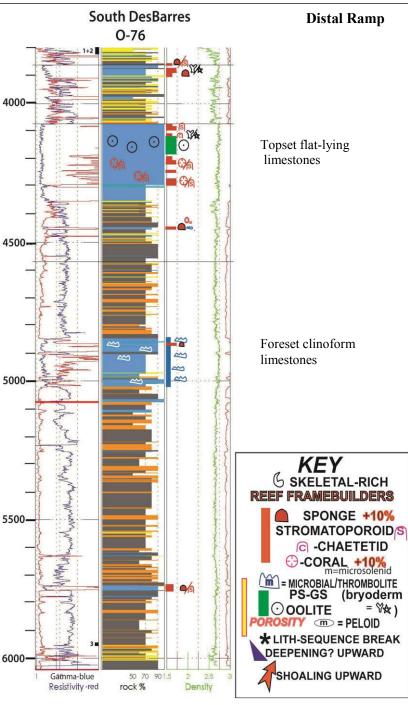


Figure 4.14 B) South Desbarres O-76 schematic litholog. Note conglomeratic sandstone and shale cores 1&2 above limestone beds have smallest 'coral reef' in bottom of a channel.

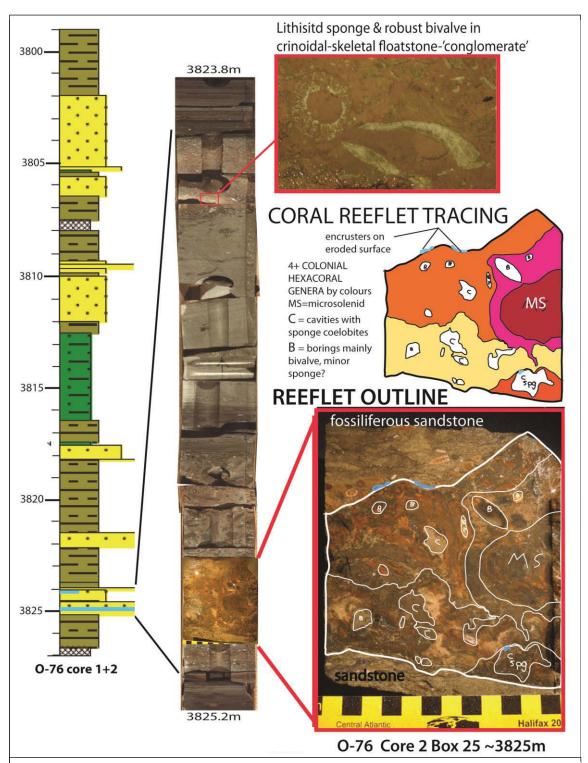


Figure 4.15 South Desbarres O-76 core 1 and 2 GSC (Gould et al. 2011) litholog (based on grain size graphically shown with standard lithology colours) – note 5 thin conglomerate beds with 15cm reeflet just above basal conglomerate, then 1.4 metre interval shown in whole core photo with reeflet shown enlarged from that with tracings of frame-building corals (at least 4 genera including a microsolenid) and highly bioeroded. Thin conglomerate at top of metre core photo has fossiliferous layers with large clams and a whole lithistid sponge. These fossils occur elsewhere in core but crinoid ossicles and bivalve fragments are most common. Many conglomerate fragments appear to be rounded calcareous clasts sometimes bioeroded and encrusted and occasionally large colonial and solitary coral fragments.

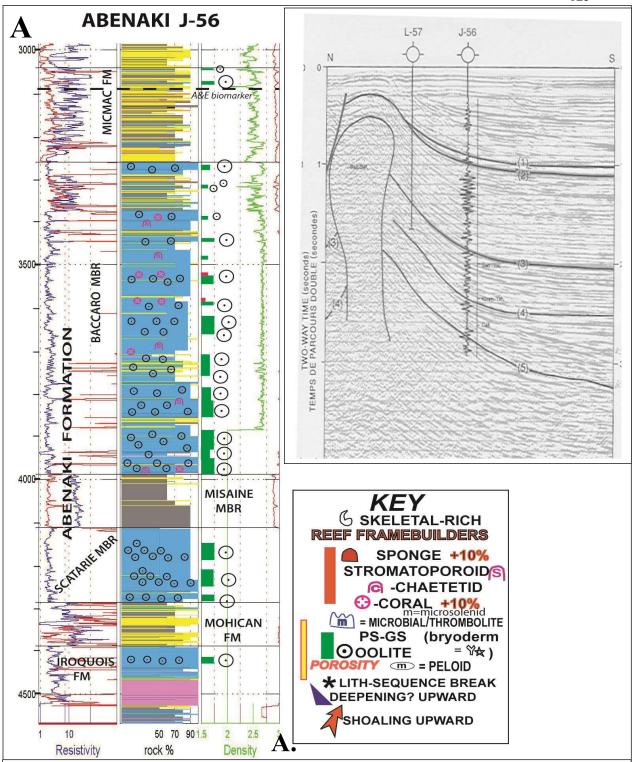


Figure 4.16 A) Abenaki J-56 schematic \log – reefal framebuilders are present but in low amounts and rarely up to 5% hexacorals as shown by 2 red intervals. Interval shown is Middle to Late Jurassic with A&E = Ammobaculites & Epistomina paleomarker (Given 1977, Eliuk 1978, see Fig. A1.2). Highly oolitic with common thin sandstones and intermixed quartz grains that also compose many of the ooid nuclei (hence lower density and velocity than pure limestone). Wireline log trace modified from PFA Chapter 9 (OETR 2011).

B) J-56 seismic over Abenaki salt dome (MacLean and Wade 1993) – note the thinning of all formations onto the salt dome indicating positive growing relief during deposition prior to diapirism (in part may be due to higher velocities of limestones). Reflectors: 1=Wyandot chalk, 2= Petrel limestone, 3='O' Marker limestone, 4="Top Jurassic" (actually top Abenaki/Baccaro and older already within Late Jurassic), 6= Scatarie limestone. See **Fig. A1.25** for location of J-56 well on south flank of large linear salt dome in Abenaki subbasin.

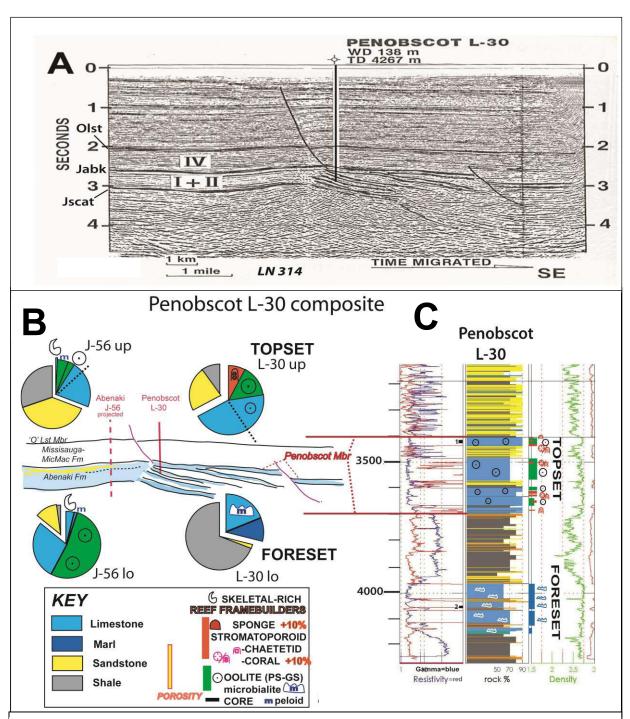


Figure 4.17 Penobscot L-30 area - A) dip seismic line (from Eliuk et al. 1986 similar but clearer than published seismic line in Ellis et al 1985); IV is - lower Mississauga-MicMac formations below O Limestone and I & II Late Jurassic Abenaki Formation); **B) trace of seismic line** above with Penobscot L-30 contrasting major lithofacies in topset ramp beds and foreset slope beds basinward of upper and lower Abenaki carbonates and siliciclastics in Abenaki J-56 projected south, and **C) L-30 schematic lithology-gamma-porosity log** showing major lithofacies. Penobscot Member (Wade and MacLean 1990) dominantly oolitic with biostromal limestone on a prograding ramp basinward of the northeast end of the Abenaki Formation carbonate platform that grades upward into siliciclastics. The deeper ramp and distal platform slope are dominantly shales derived from the Sable Island Delta with deep-water microbolite (thrombolitic) limestone interbeds. Modified Eliuk & Wach 2008

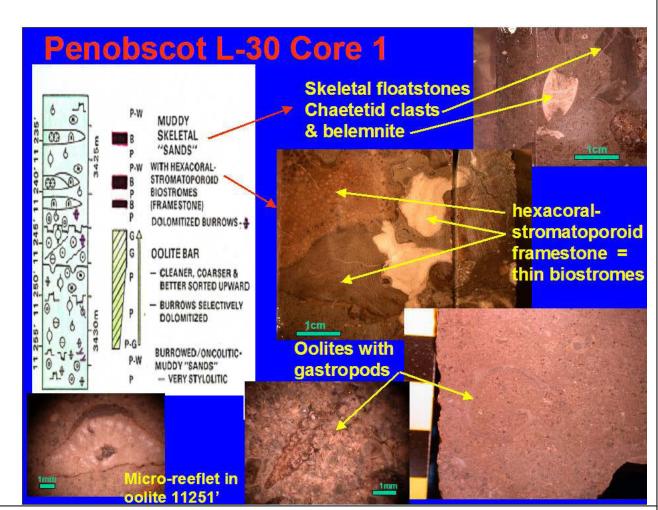


Figure 4.18 Penobscot L-30 core 1 schematic log and analogue for shallow inner to mid ramp carbonate (core log after Eliuk 198; refer to Fig 4.14 and Swanson 1981 for symbols) - illustrates chaetetid-coral-stromatoporoid biostromes in broken-fossil-rich packstones-floatstones, oolite and oncoliticoolitic-peloidal packstone-floatstones (variably and slightly argillaceous). There may be a deepening upward or protected to less protected ramp trend in the core with sheltered shallow facies in the lower core that has burrowed 'muddy' ooids, peloids, oncoids and coated fossil clasts including mollusks grading up through an interpreted onlite bar complex with gastropods into a more open setting with angular skeletal clasts including dispersed framebuilders like chaetetids and thin reefal rudstones and in situ coralstromatoporoid boundstones as biostromes plus nektonic forms like belemnites. The micro-reeflet in the oolite is a small coral shaped for stability in agitated waters and over grown by a chaetetid but soon buried in carbonate ooid sand. Curiously considering the general proximity of siliciclastics, the ooid nuclei are apparently not quartz grains. In a relatively thin interval of less than 10m there are a great variety of depositional facies. All of the gastropods are replaced, some more typically by spar calcite but some by mud infill indicating early aragonite replacement possibly showing instability in calcitic seawater chemistry rather than simply subaerial exposure to freshwater. The walls of some burrows show minor dolomitization. Stylolites are fairly common showing burial compaction and in part reflect the low-level argillaceous content and original high carbonate mud amount.

Modified from Eliuk and Wach 2008

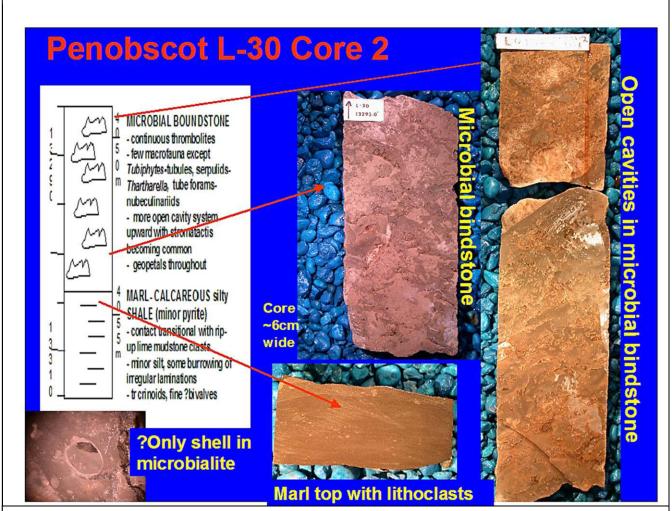


Figure 4.19 Penobscot L-30 core 2 schematic log and analogue for deep-water ramp and slope under siliciclastic influence – the depauparate 'pure' microbolite boundstone (perhaps 'bindstone' but not by trapping sediment as much as by very early penecontemporaneous cementation by the microbes that also likely produced peloids) with plentiful geopetal shelter fabric and minor but well distributed calcite cement in cavities that range from millimeter to centimeter and larger size in the upper part of the core. Except for a small possible lithistid sponge and small shell (?brachiopod shown) the only accessory biota is a limited variety but plentiful number of micro-encrusters – *Tubiphytes*, serpulids-terebellids-thartharellids (worm tubes) and nubecularid forams. Among the microbolites seen in the Abenaki Formation distal slope this represents an end member in terms of dark color, limited accessory micro-encrusters, uniformity of fabric and lack of different interbeds. The underlying calcareous shale to marl is also fairly uniform throughout with minor silt and some burrowing of irregular laminations and traces of crinoids and fine ?bivalves. The transition to microbolite is abrupt with small (less than a centimetre) limestone lithoclasts just below the contact. Note the inclined bedding = slope. For additional interpretation and photomicrographs on this core and Abenaki interpreted microbial sedimentation see Pratt (1982, 1985, where the Penobscot UWI was often mislabelled) and Jansa, Pratt and Dromart (1989).

modified from Eliuk and Wach 2008

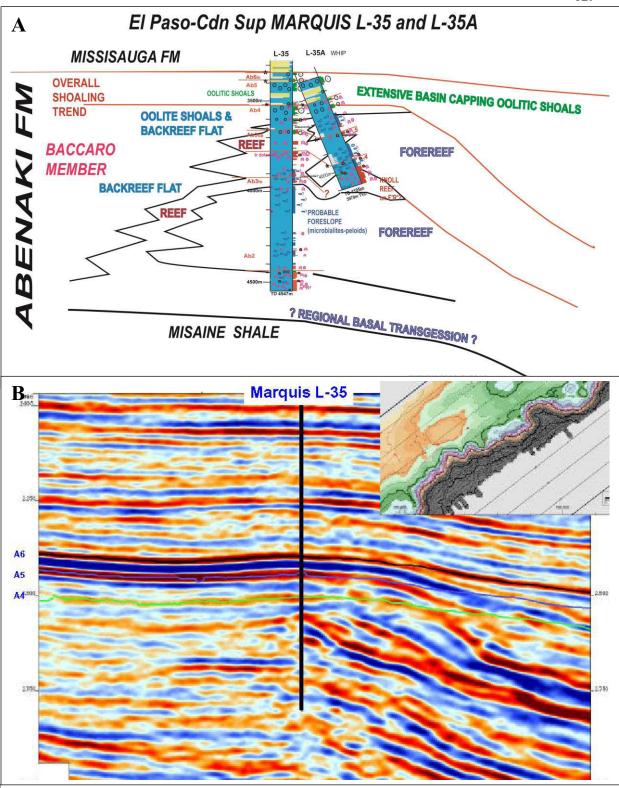


Figure 4.20 Marquis L-35 and L-35A (A) schematic well logs with depositional settings shown – see **Figure 4.22** for lithofacies. (B) Dip seismic section showing shelf margin position as well as prograded capping onlite-sandstone beds that extend with clinoforms into basin as prograding ramps (from Kidston et al. 2005 including their sequence picks on left – only a thin partial AB6 is developed. Green correlation line seems to cross reflectors as do overlying black traces which should dip downward beyond shelf break following the reflectors). Seismic from Kidston et al. 2005

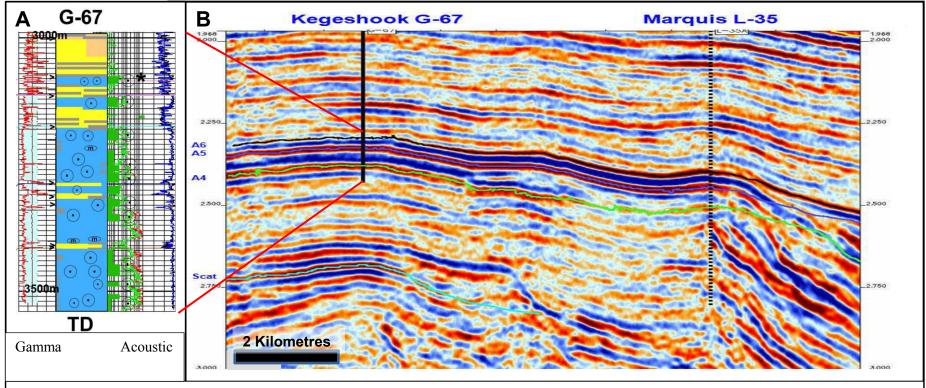


Figure 4.21 (A) Kegeshook G-67 shelf interior partial Abenaki well. (B) Dip seismic from Kegeshook G-67 to Marquis L-35 (from Kidston et al 2005 Fig. 117). Note this appears to be the central part of the seismic line for OETR (2011) PFA Chapter 9 interpretive seismic stratigraphic cross-section PL.9-6-2b (Fig. A1.23). Also note that the correlations into the basin tend to follow the steeper slope on Fig. A1.23 rather than the 'Ab4' and 'Ab5' staying relatively flat and high as shown here. In A the upper sandstone-oolite couplets correlate to those of Marquis L-35 (see Figure 4.21A and 4.22 for litholog). And seismic 4.21B and 4.22B indicates that these upper beds extend relatively horizontally into the basin on top of older basin fill. This is more limited progradation but similar to the style in the Penobscot area as shown in Figure 4.7 and Figure 4.11B. Seismic Kidston et al. (2005).

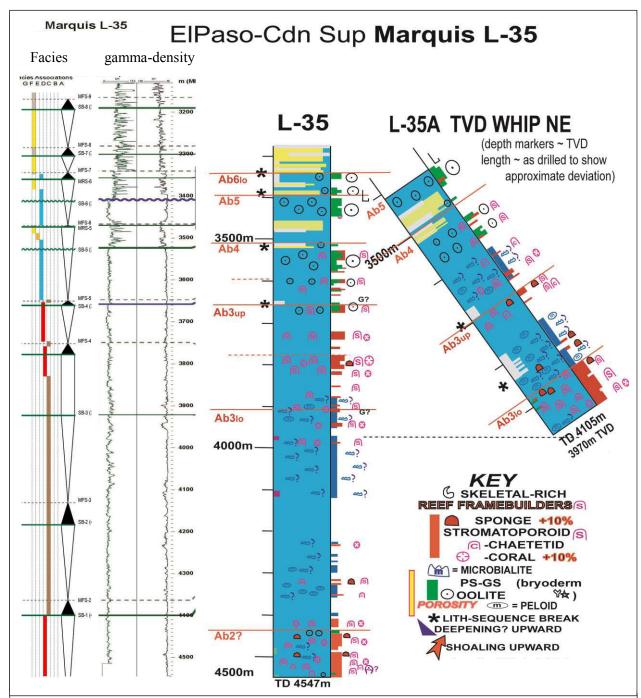


Figure 4.22 Marquis L-35 and L-35A side-tracked (whip-stocked) schematic litholog comparison Original tops revised in text and on sidebar. L-35 TD likely at least a several 100 m above Misaine shale. L-35 comparison on left of facies and gamma-density log with PFA Abenaki sequences (Stefan Double in OETR 2011) to litholog schematic with my interpretation of Encana sequences (after Weissenberger et al. 2006) on right. Neither well encountered significant porosity. The side-tracked L-35A did penetrate more distal deeper facies but the coral-rich beds at the bottom indicate local reefal buildups on the slope with slope beds landward of buildup in L-35 at same depth.

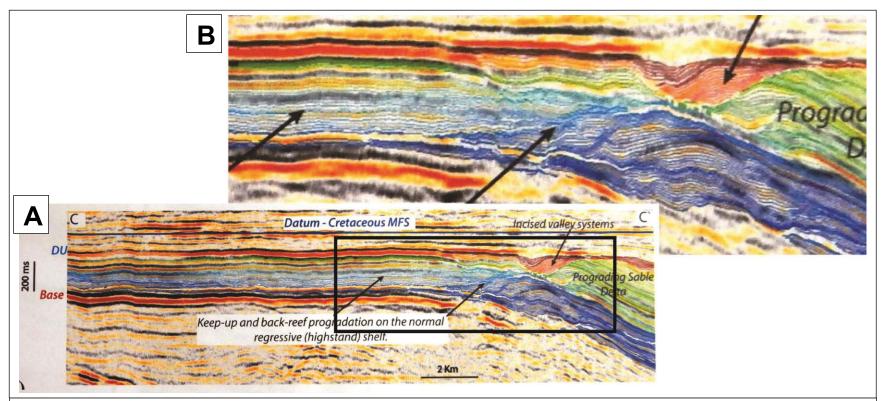


Figure 4.23 Dip 2D seismic line across Abenaki margin between Marquis L-35 and Cohasset L-97 (from Qayyum et al. 2015a Fig.7a).

A) Line as published. B) Enlargement to show details of interpreted geometries at margin. See text for discussion Section 6.06 and 6.07. See text for discussion in Section 6.06 and 6.07. Note the margin mounds/reefs had considerable relief on the order of 100's of metres. If the surfaces are properly correlated they were isolated from the shelf interior by a significant depth of water for a long time. One option is to interpret the seismic mounding as catch-up buildups that go through a slope-reef-oolite shoal succession as in Marquis L-35 or (particularly for the more distal mounds) deeper water microbolite mounds as in much of Cohasset L-97. In both cases the morphology-bathymetry may appear rimmed but it is not necessarily in shallow water. In L-97 the uppermost morphologies do not apply and the L-97 uppermost beds are argillaceous limestones that are stromatoporoid and lithistid sponge-rich. See Figure A1.28A for location. In L-35/35A the interbedded quartz sandstones of the oolite-sandstone couplets shows the proximity of deltaic sediment influx that on this section is certainly shown by the additional presence of incised channels. Modified from Qayyum et al. (2015a).

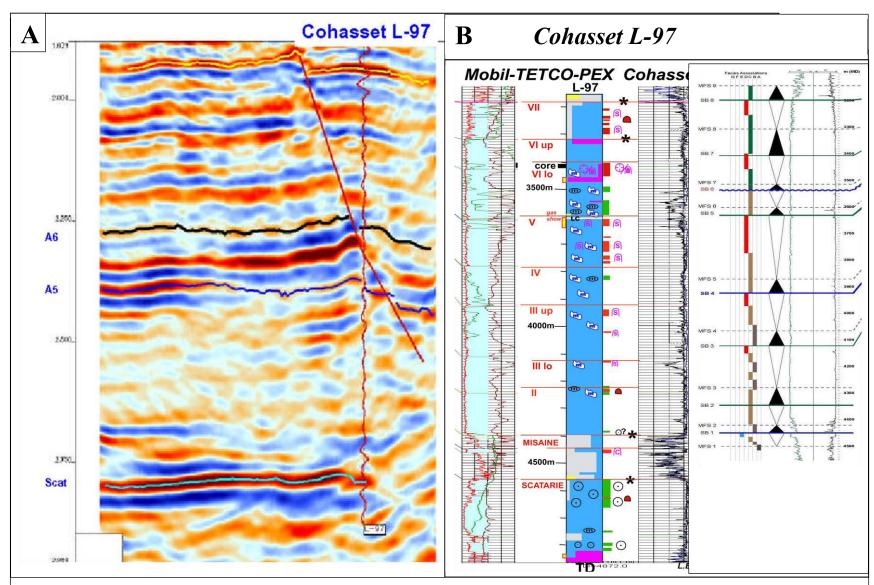


Figure 4.24 Cohasset L-97 A) dip seismic from 3D volume (Kidston et al 2005) basin to right (SE), **B) L-97 schematic litholog** with gamma/SP/density/acoustic traces the sequences are Eliuk's tentative Encana-style sequence tops versus OETR 2011 tops. Biostratigraphic dating (Weston et al. 2012) indicates the Abenaki is all Late Jurassic with their NBCU break placed at 3015 m between Valanginian and intra-Tithonian so correlations to earliest Cretaceous sequence ABVII in Demascota G-32 and Panuke M-79 queried. Symbol key on Fig.**4.22.**

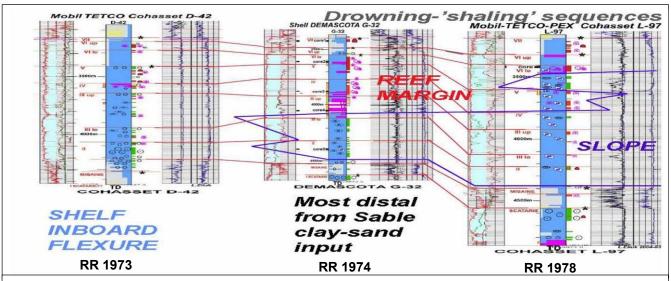


Figure 4.25 Shelf margin wells prior to Deep Panuke discovery in a shelf to slope facies continuum. (Eliuk 2005 talk). Cohasset D-42 was in the field but had no effective porosity. Demascota G-32 had all 3 reef/mound types and significant porosity and dolomite but was structurally too deep. Cohasset L-97 had no reservoir development. L-97 dating (Weston et al. 2012) is all Jurassic thus AB VII absent. RR=rig release. See symbol key **Figure 4.22**

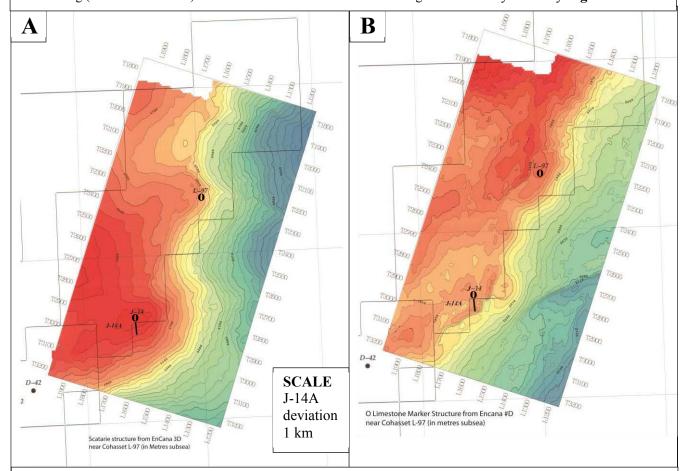


Figure 4.26 Structure maps over Cohasset L-97 and Dominion J-14/14A from Encana 3D volume (open file CNSOPB – Encana seismic submission) **A) Scatarie structure** Note that the overlying Baccaro platform margin is above J-14 and within a few 100s of metres of L-97 so roughly but not exactly over the steeper inflection contours of the more widespread basal Abenaki Scatarie Member. **B) O Limestone Marker structure** The basin-fill of Abenaki platform on the west and deltaic MicMac-Missisauga siliciclastics on the north have significantly filled the basin and moved the shelf flexure east on the northeast part of the map. The shelf flexure has not moved near J-14A and is close to the underlying Scatarie flexure.

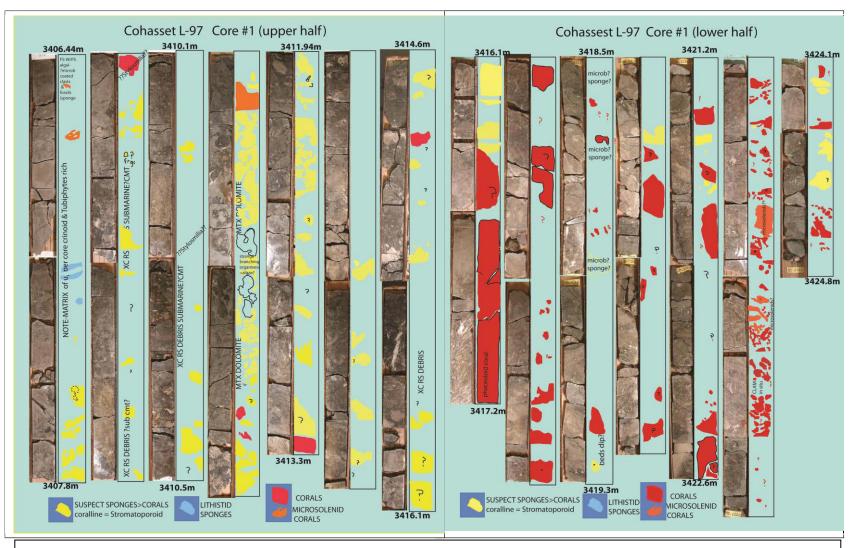


Figure 4.27 – Cohasset L-97 core 1 coral reef (some massive and phaceloid; deeper *in situ* with microsolenids, suspect framebuilders, minor lithistids) capped by rudstone debris beds with ?microbial coating submarine? cement. Core 1 diagenetically altered so many suspect framebuilders unidentified and sedimentology obscured.

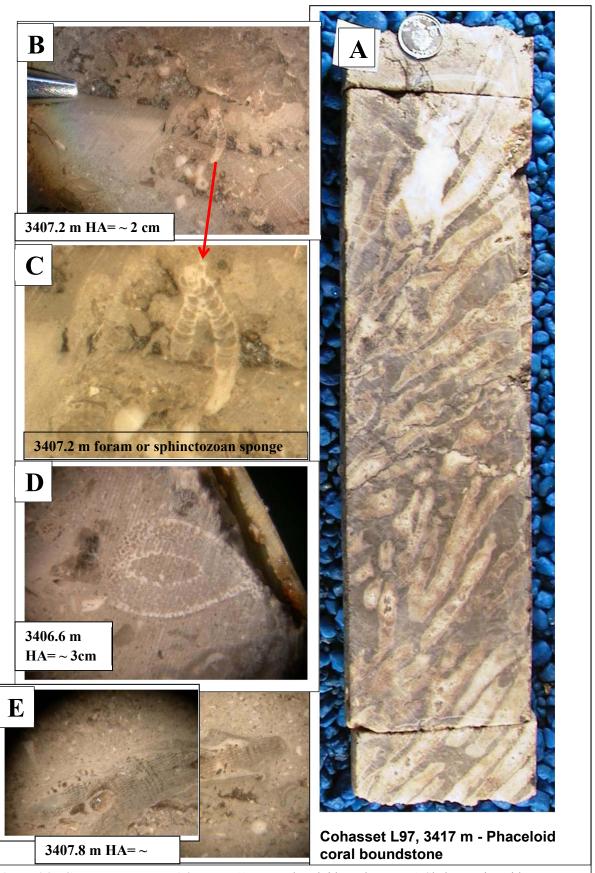


Figure 4.28 Cohasset L-97 core 1 features A) Large phaceloid coral *in situ* **B)** Shelter cavity with microbial-auto micrite encrustation above internal geopetal fines with pendant coelobites **C)** enlarged view of cavity-dwelling sphinctozoan? sponge **D)** Lithistid sponge **E)** microsolenid coral and microbial encrusters on thrombolitic surface with shelter cavity HA = horizontal axis = width

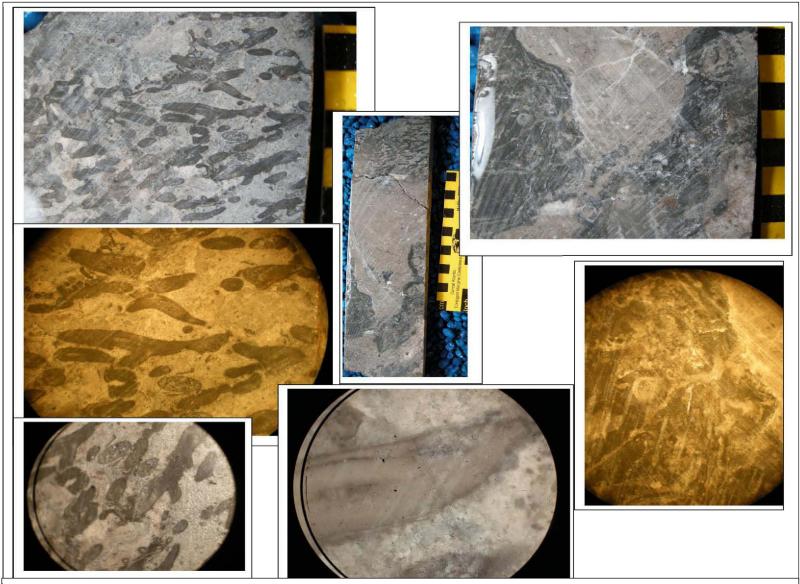


Figure 4.29 Cohasset L-97 core 1 Enigmatic creature quiz – Is it a branching sponge or maybe a fleshy fucoid-like or other algae – very obvious and possibly significant for interpreting water depth and possible delta sourced nutrient influence. No help in the books or from a few specialists. Depth about 3407 -3411m (Slabbed core trays 7 and 8, see column 4 of **Figure 4.27**)

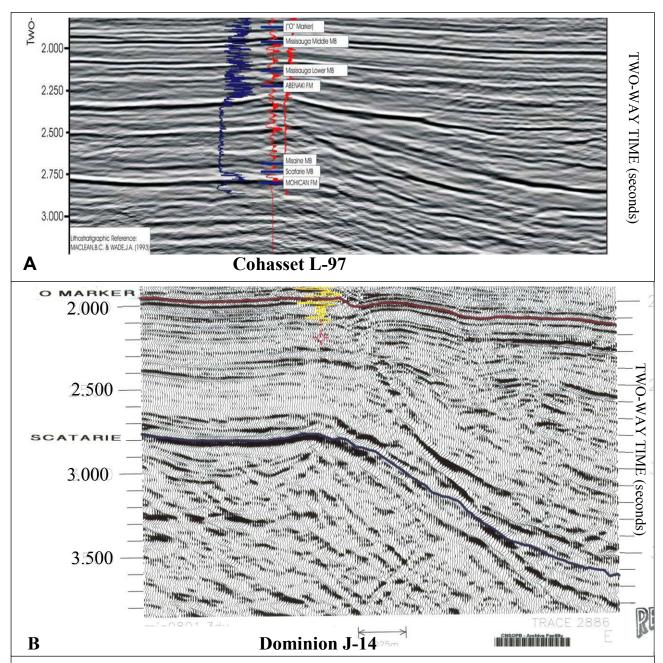


Figure 4.30 Dip seismic margin wells in northern Panuke trend with capping sponge-rich beds A) Cohasset L-97 seismic 2D dip line into basin (McLean and Wade 1993 GSC website) with gamma = blue, synthetic & acoustic = red traces, 2-way time in seconds on left. Infill of the main basin occurred after all but the topmost Abenaki was deposited.

B) Dominion J-14 seismic dip line into basin. This section is from the CNSOPB Data Management Website and shows J-14 is back of the margin flexure about a kilometre with the underlying Scatarie showing more apparent structural relief than the top of the Abenaki carbonates. CNSOPB Open file Encana 3D volume Grand Prēs. See **Figure 4.26** for Scatarie and O Limestone structure map.

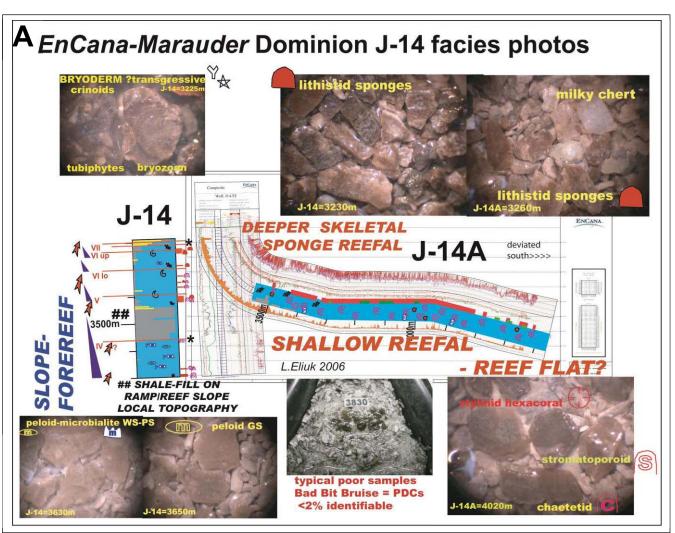




Figure 4.31 Dominion J-14 and 14A wells A) Schematic lithologs with key facies textures and framebuilder fossils in cuttings with labels and symbols. Note the poor cuttings quality due to bit type however on well-preserved cuttings, textures and biota are quite definitive. No sidewall or whole cores were taken.

B) Interpretive facies diagram to show the various reef margin and forereef slope environments that were sampled by the vertical J-14 and near horizontal J-14A side-tracked hole.

See Fig 4.22 for Symbol Key with enlarged cuttings photographs on Figure 3.5.

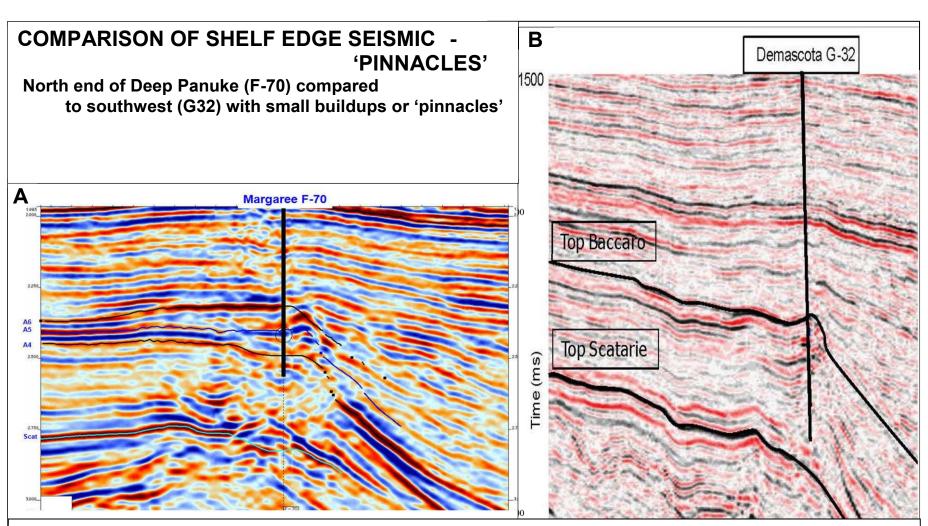


Figure 4.32 Comparison of shelf edge seismic - 'pinnacles' A) Margaree F-70 and **B) Demascota G-32** (dip lines from 3D seismic surveys at same vertical time scale). F-70 internal 'pinnacle' encased in carbonate and drilled on shelfward flank. G-32 from Encana 3D seismic confirms Shell's original prognosis of a small morphologic bump at the carbonate margin interpreted as reefal (Eliuk 1978, figs. 10, 11 and 12 showing reefal promontory beside channel re-entrant). **A) F-70** is from Kidston et al (2005) and **B) G-32** is slightly modified from OETR (2011 PFA Fig. 1 PL.9-8-1) by adding dashed red line to show that G-32 penetrated top Scatarie Member at total depth. Note the line is quite different from **Fig. 4.33B.** Both Kidston (2005) and the PFA study (OETR 2011) erroneously showed G-32 well not reaching the Scatarie reflector. Seismic from A) Kidston et al. 2005 and B) PFA Chapter 9 (OETR 2011).

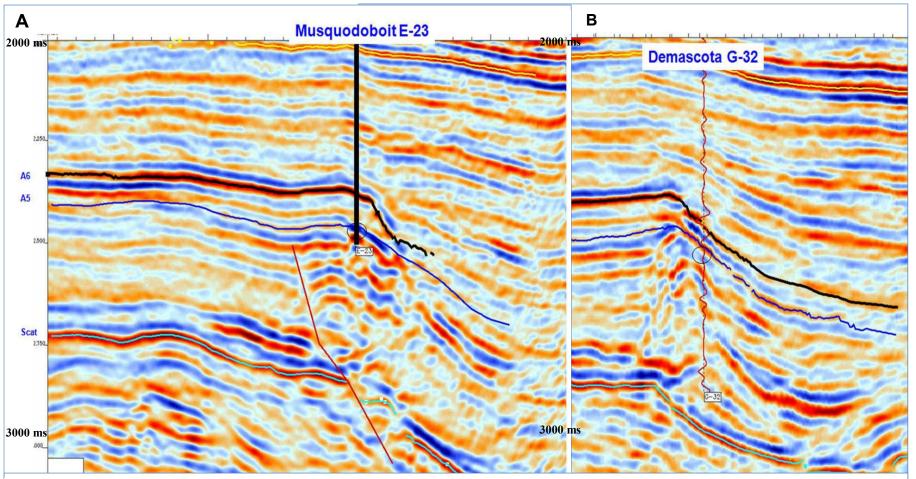
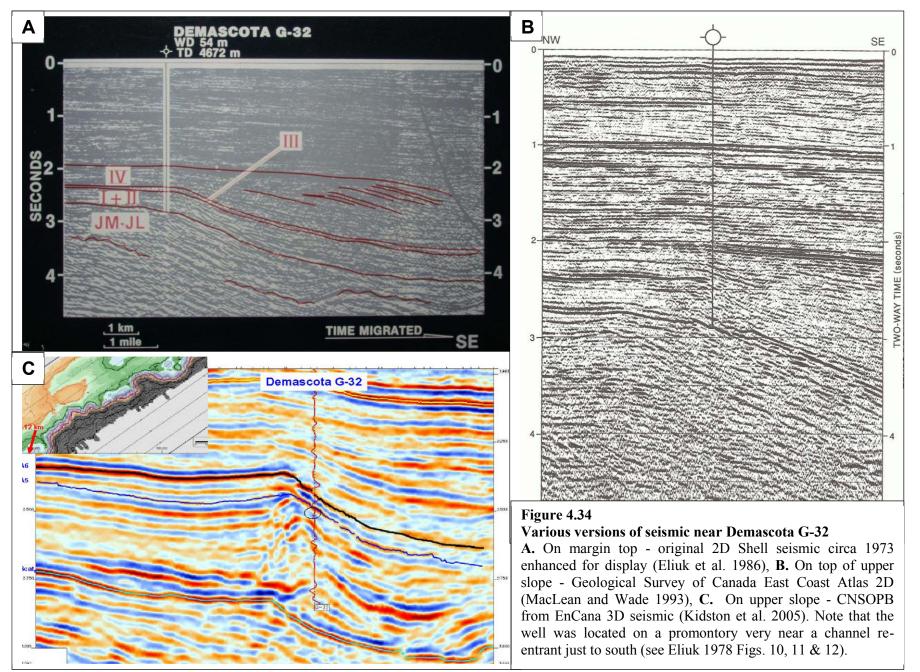
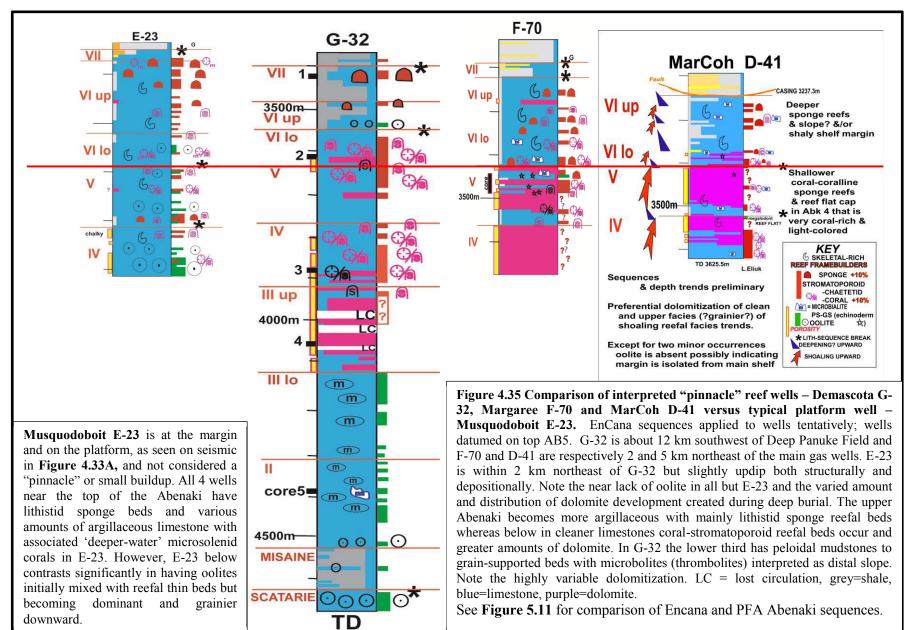


Figure 4.33 Shelf margin seismic lines at south end of Panuke trend (Kidston et al. 2005 from Encana 3D survey) **A. Musquodoboit E-23** on the platform within a few kilometres northeast of G-32. **B. Demascota G-32** drilled in 1974 and believed to be located slightly downslope as shown. Note: this placement differs from **Fig. 4.32B** of the same 3D survey but located by PFA workers (OETR 2011) on a small shelf edge bump. In both studies the G-32 well synthetics as placed do not reach the Scatarie reflector despite G-32 having penetrated that deep which leaves some doubt as to which if either placement is correct. Seismic from Kidston et al. 2005).





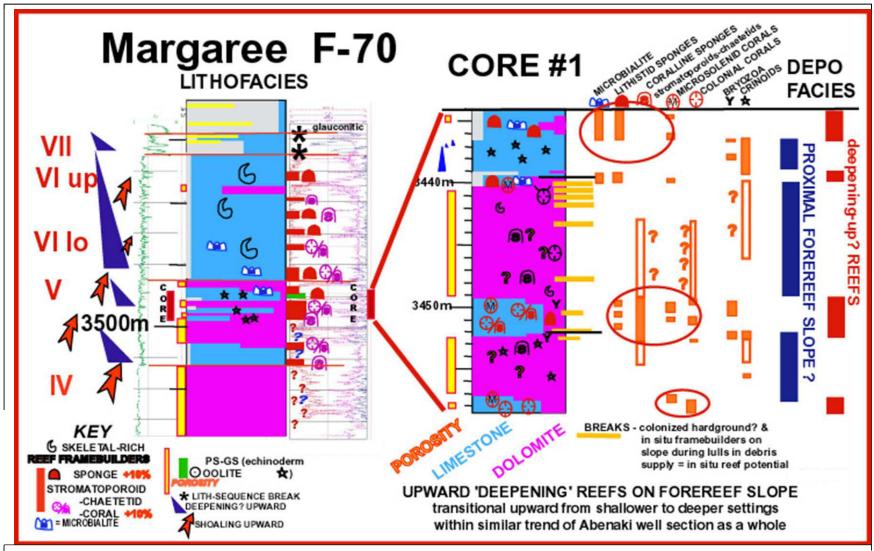


Figure 4.36 Margaree F-70 cuttings schematic litholog with Core #1 litholog. Sequence subdivision follows Encana sequence stratigraphy. Note upward change from coral-stromatoporoid reef beds to lithistid sponge reef mound beds. Core #1 is in the midst of that transition. Core litholog shows main framebuilders and interpreted depositional facies. The ovals around framebuilder groups in core interpreted as deeper-upward reef communities. The thin reefal intervals tend not to have been dolomitized as opposed to the dolomite intervals that are interpreted to have been originally grainier less submarine cemented proximal forereef slope 'sands'. See Chapter 5 (Discussion-Interpretation) for more details and illustrations of this core. (from Eliuk 2008)

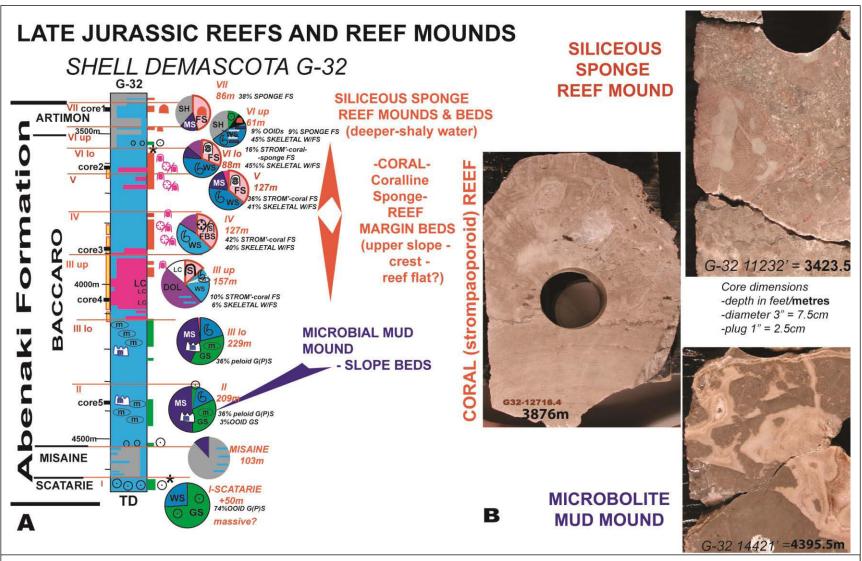


Figure 4.37 Demascota G-32 A) lithofacies schematic log B) G-32 core examples of three main types of Late Jurassic reefs and mounds (Leinfelder 1994, Leinfelder et al. 2002). A) Shows percentage lithofacies by pie distributions plus some of the main framebuilders amounts (see Fig. 4.35 for key) and approximate Encana sequences after Weissenberger et al. (2006). See Fig. 4.52 or 4.56 for symbol and lithofacies key. B) Core depths on photos in feet as drilled and metres in bold. Note bioerosion of corals by bivalves (*Gastrochaenolites*) and less commonly bioerosion of lithistid sponges by boring sponges (*Entobia*) and absence of macro-bioerosion in mud mound that has stromatactis textures well developed.

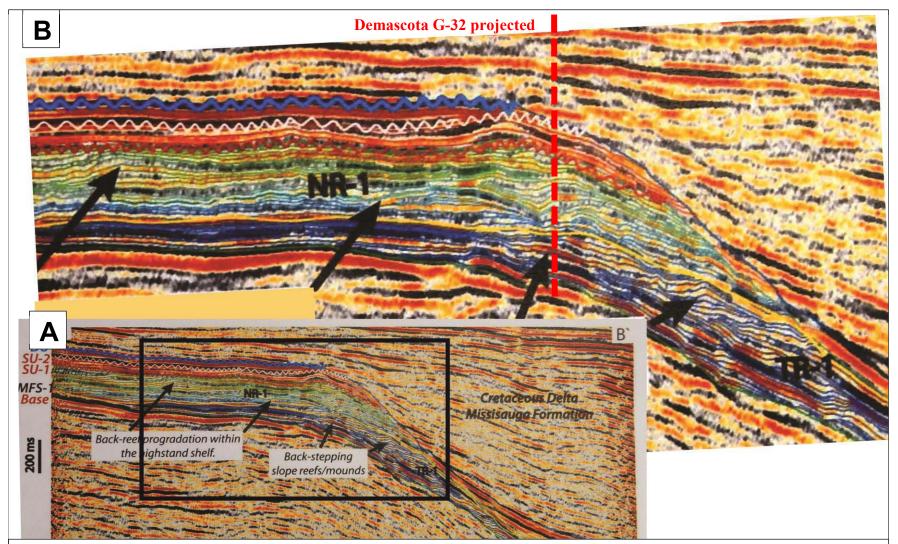


Figure 4.38 A) Dip line across margin near Demascota G-32 (Qayyum et al. 2015a Fig. 6a) B) Enlarged and modified with well added. G-32 has been projected onto the line just basinward of the top carbonate break-in-slope similar to its position on most seismic lines. As compared to the major lithofacies shown on figures 4.38 and 4.42 the lower third 'bluish mounded' interval is slope microbolite mounds, the middle third to half 'greenish lower-relief mounded' interval is coral-stromatoporoid reefal, and the upper quarter layered to low mounded is lithistid and sponge reef mounds. As in their lines to the north across the margin, the shelf interior called 'back-reef' often lags behind shelf edge sedimentation then catches up. Based on G-32 well facies their white top SU-2 unconformity would seem to be placed higher than a likely shallower position in the well. Observe that the enlargement has been flattened on the "DU" = their drowning unconformity. SU = Subaerial unconformity or sequence top, MFS = maximum flooding surface, Base = top Misaine. See Appendix 3.11 for some details of their technique and Figure A1.28A for location of this line. Modified from Qayyum et al. (2005a).

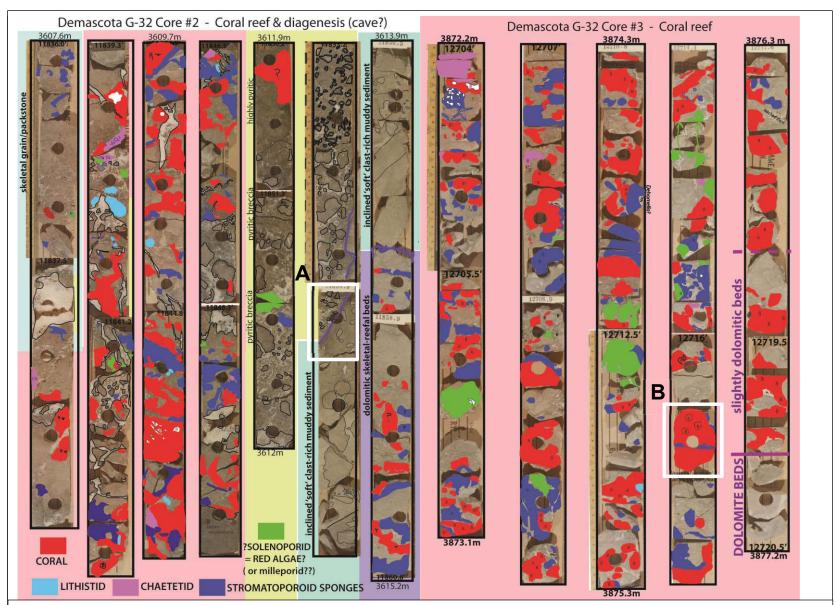


Figure 4.39 Coral-stromatoporoid debris reefs (Coralgal reefal 5B) in Demascota G-32 cores 2 and 3. - Whole core coloured framebuilder tracings. Core 2 also has skeletal sand at top and high-angle lime mud and rounded clast fill (marine-filled cave? or Neptunian dyke?) above dolomitized reefal beds. Late diagenetic fractured pyritic breccia and cements occur above the lime muds also at high angle. All framebuilders highly bioeroded averaging 20% providing fines for geopetals and matrix (Eliuk and Pemberton 2002).

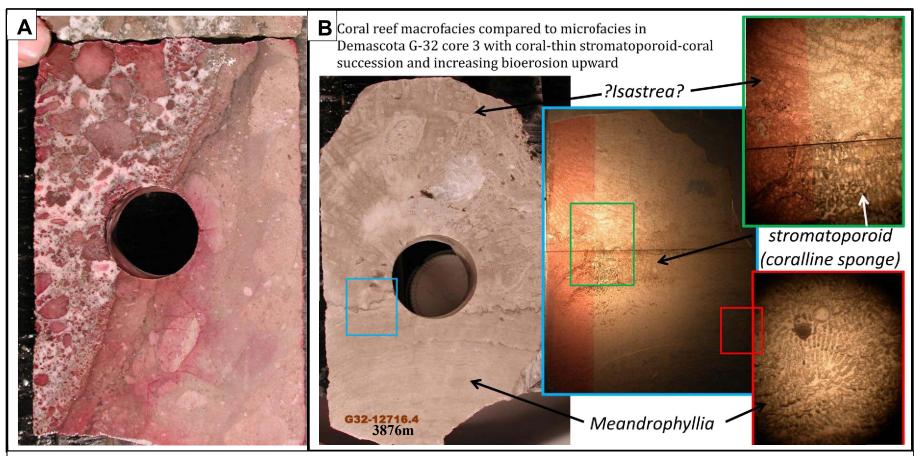


Figure 4.40 Coral-stromatoporoid debris reefs (Coralgal reefal 5B) in Demascota G-32 close-ups

A) Soft sediment rounded soft lithoclasts in slope lime muds filling submarine cave or Neptunian dyke within reefal beds (L.E.) OR all slope mud & lithoclasts (Rick Wierzbicki.); angular brecciated-fill later diagenetic with dolomite cements, Demascota G-32 core 2 - 3613.4 m, red = alizarin staining. B) Colonial hexacorals *in situ* and bioeroded by clams Demascota G-32 Core 3 - 3876 m – core slab with thin section comparison. Massive fine meandroid coral fabric can be mistaken for stromatoporoid textures in macroview so comparison of this thesis core slab tracings show much more coral than that in Eliuk (1978). Cuttings can be even more difficult and likely stromatoporoids are over identified compared to corals; both are likely under-represented due to diagenetic obscuration. For location on Figure 4.39 see white boxes with A and B to upper left.

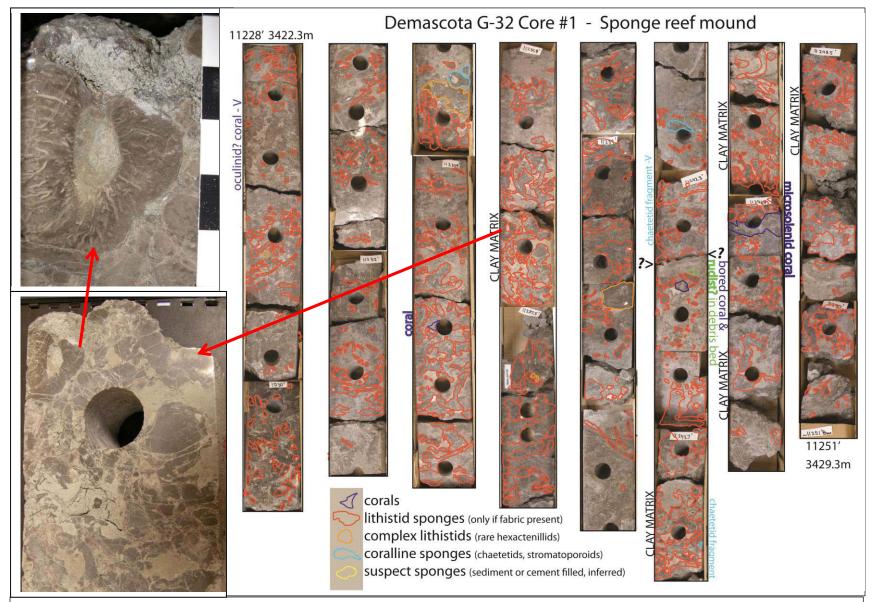
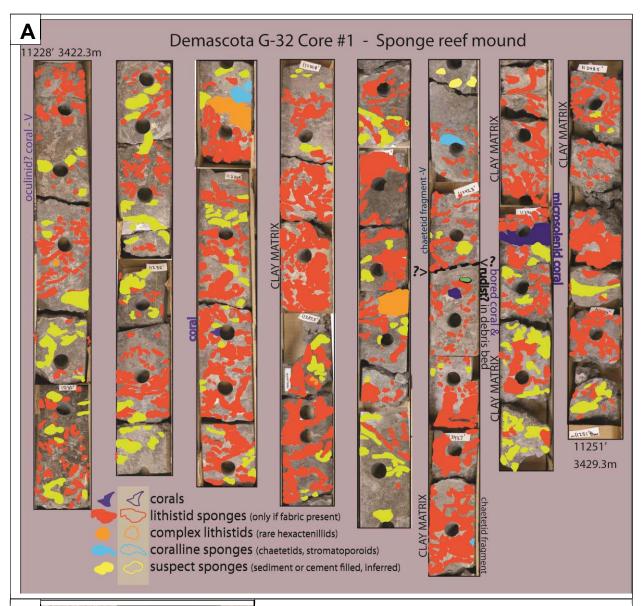


Figure 4.41Siliceous sponge reef mound ("Deep" siliceous sponge mound 4A) framebuilder tracing in Demascota G-32 core 1 - note the high concentration and nearly lithistid-only make-up. The two inset photographs show the same vase shaped sponge and other more massive forms sometimes collapsed-overturned. *Doryderma* was identified (pers. comm. Keith Rigby in Eliuk 1978). Scale in centimetres on lithistid sponge close-up photos.



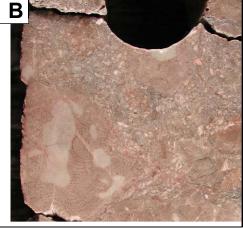
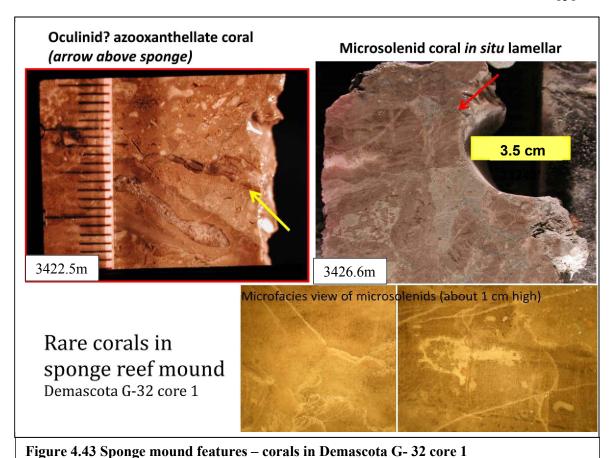


Figure 4.42 Siliceous sponge reef mound in Demascota G-32 core 1.

- **A) coloured framebuilder tracing** note the high concentrations of lithistid sponges. Corals present are either microsolenid colonial or solitary. There are many suspect sponges that have either disintegrated *in situ* or did not get calcified showing the potential cryptic nature of this important mound former. There does not appear to be any evidence of algae, submarine cements or microbial crusts
- **B)** Lithistid sponge bound/rudstone in crinoid-tubiphytes packstone matrix. Borings? by *Entobia* (clionid sponge) in lithistid sponge. White blebs are tubiphytes. Demascota G-32: 3423.5 m = 11232'



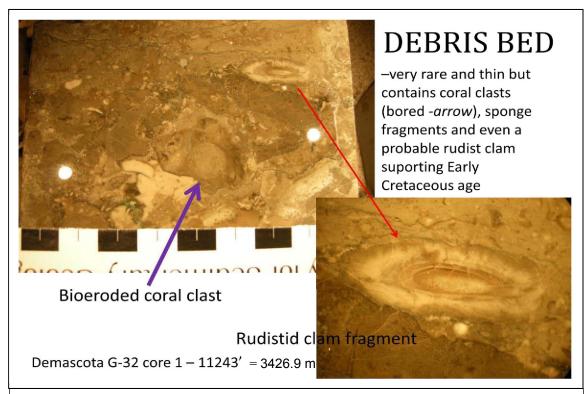


Figure 4.44 Sponge mound features – debris bed in Demascota G- 32 core 1 – possibly sourced from shallower shelf waters brought in by a storm (tempsestite?)

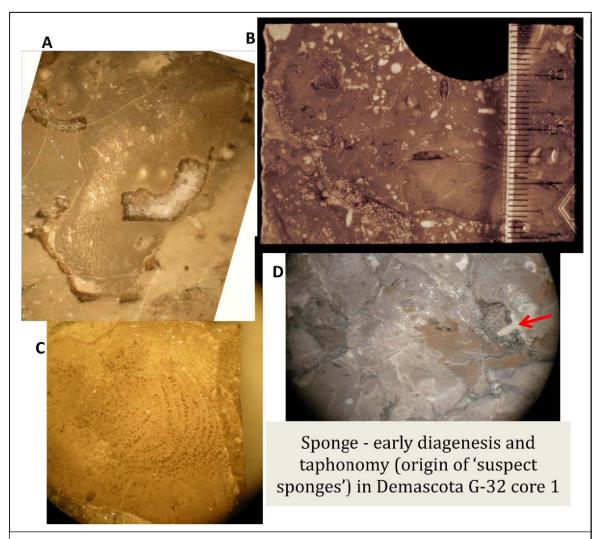


Figure 4.45 Sponge mound features –very early diagenesis in Demascota G- 32 core 1 – note A) collapsing sponge material becoming internal sediment, B) similar initial collapse of sponge C) disintegrating layers in Dactylocoelia? D) collapse of sponges on seafloor contemporaneous with sedimentation as shown by pendant tubiphytes (arrow) with reddened geopetal infill

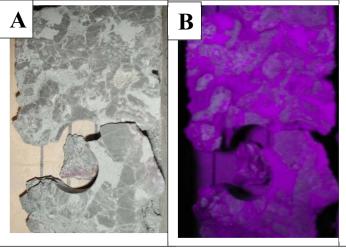


Figure 4.46 Sponge fluorescence in Demascota G- 32 core 1 - A) white light on lithistid sponges (darker **B)** ultraviolet light - the brown), lithistid sponges (lighter than reflected UV) show mineral fluorescence due to high apatite indicating content phosphatizing processes thought to be due to upwelling waters at the shelf margin (Eliuk 1978) but possibly due to input of Sable Delta river waters.

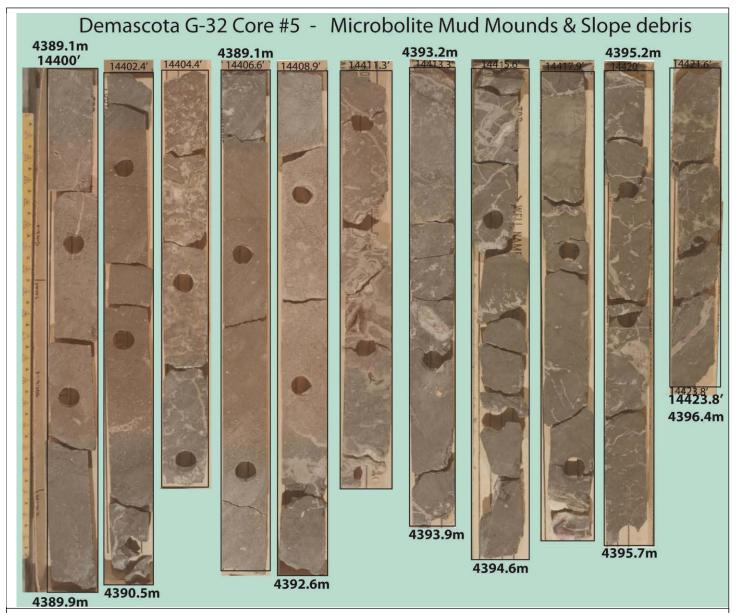


Figure 4.47 Thrombolitic Stromatactis mud mound (and slope debris bed (3C and 3A) in Demascota G-32 core 5 – note early fractures that have isopachous cements. Photograph of whole slabbed core pieces

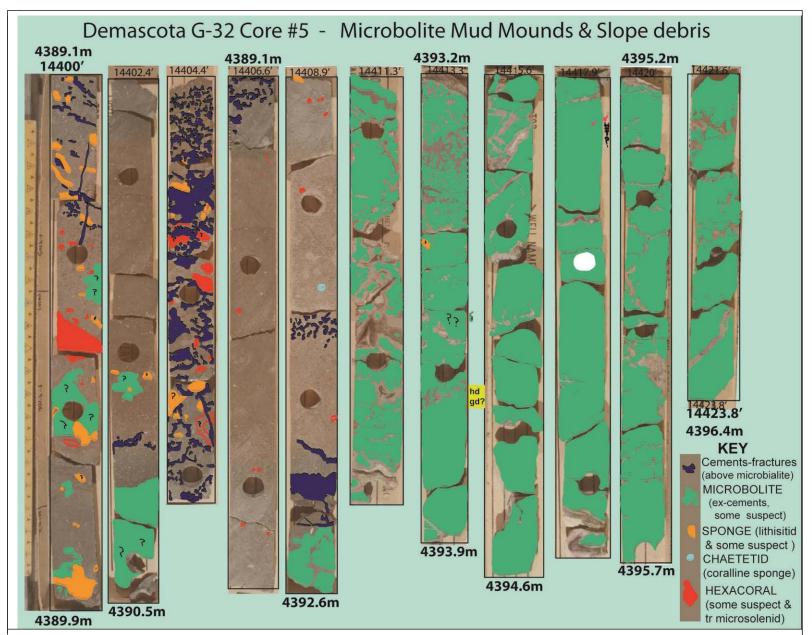
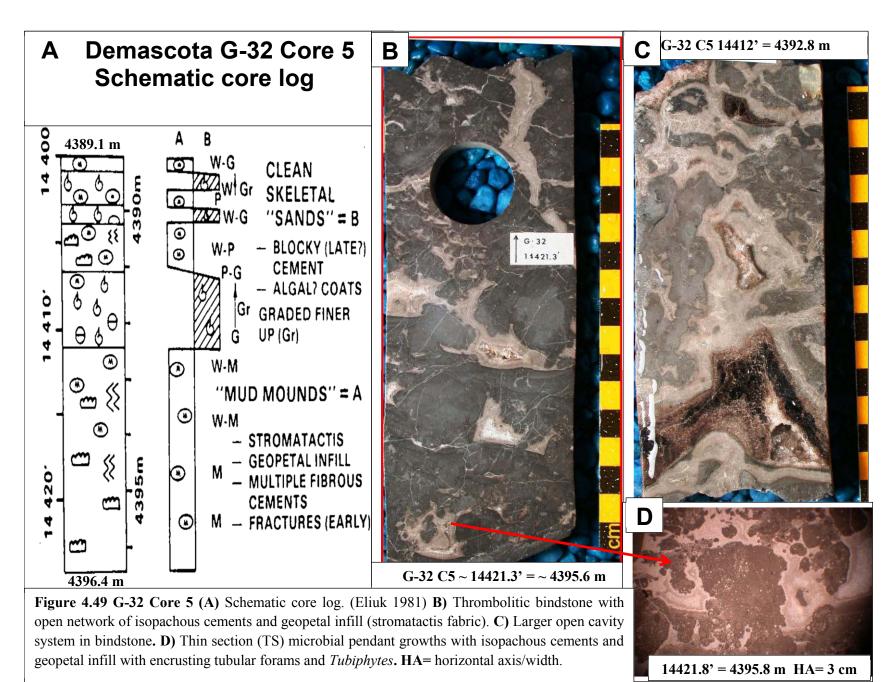


Figure 4.48 Thrombolitic stromatactis mud mound and slope debris bed fabric coloured in Demascota G-32 core 5 – the upper half of the core is mainly debris beds with some thrombolitic layers and reworked clasts with shallower-sourced skeletal clasts.



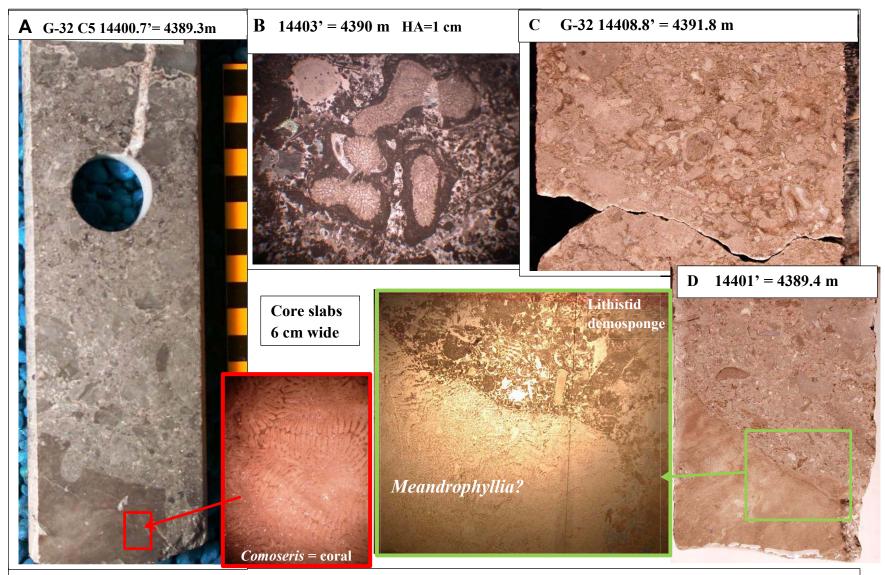


Figure 4.50 G-32 Core 5 details relative to grainstone-rudstone debris beds A) Possibly normal graded skeletal rud/grainstone bed with large coral clast (enlarged coral) and at top shelter cavity has isopachous cements cut by later fracture. B) Bryozoa with thick micrite coats and various encrusters. C) Grainstone/rudstone of micrite fragments similar to bindstones plus some coated skeletal material. D) Large coral clast at base of another debris beds.

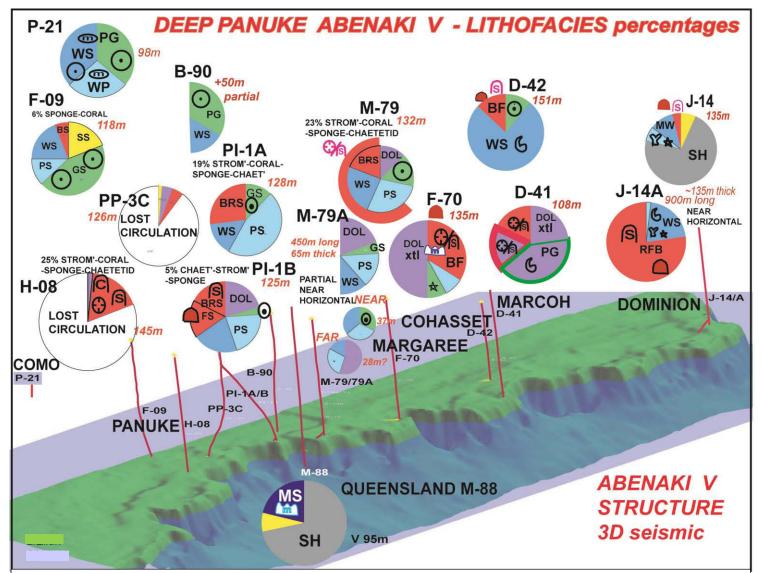


Figure 4.51 Abenaki AB V lithofacies pie map to show lateral variability in a single sequence. G-32 is just off the southwest corner. Note the lack of oolite in F-70, D-41 and J-14 that are nearest the shelf edge flexure as compared to its presence in the main portion of the Deep Panuke pool to the south. Increasing amounts of oolite occur in platform interior wells. Dolomite development also is highly variable. D-41 dolomite beds show fossil-rich grainy textures (green outline). Note lateral changes in deviated M-79A side-track (near-far). See **Fig. 4.52** or **Fig. 4.56** for symbol-lithofacies key. Seismic-based 3D rendering from Wierzbicki et al. 2005).

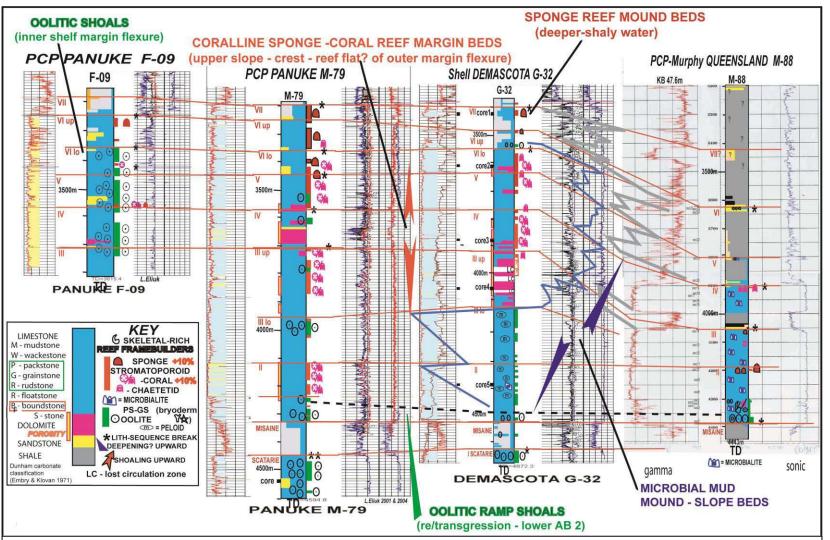


Figure 4.52 South Deep Panuke platform inner margin to slope section. Between M-79 and M-88, well G-32 is projected northward to show a transitional setting where minor platform progradation is indicated by the presence of slope peloidal-'microbial' facies in AB II and the lower half of AB III (III Lo). A basal oolite is developed in all wells right above the Misaine shale. The partial F-09 well shows the highly oolitic shoals of the inner margin. In F-09 no oolite occurs above AB VI Lo and lithistid sponge beds are developed in argillaceous limestone of upper AB VI Up. AB VII is mainly calcareous shale with sponge-rich beds near the margin. Petrophysical logs = gamma on left, density then acoustic on right of lithologs.

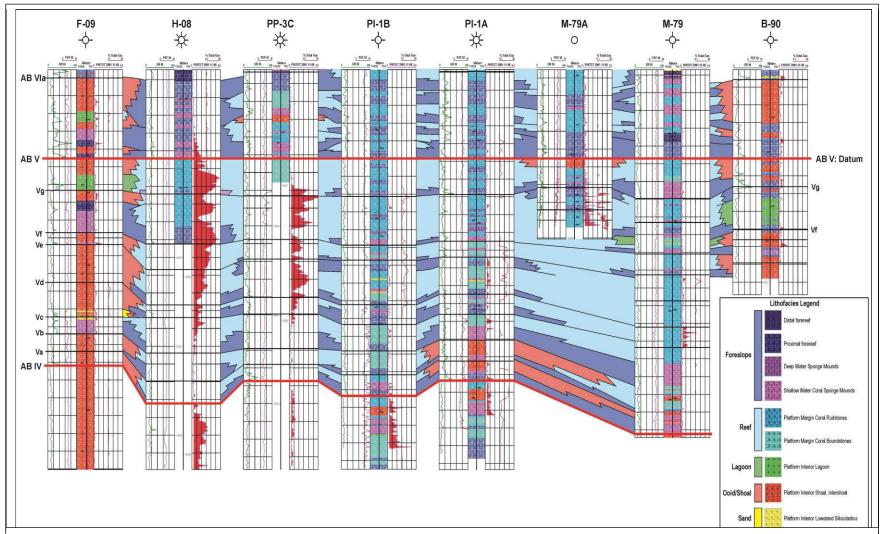


Figure 4.53 South Deep Panuke reservoir lithofacies stratigraphy from Weissenberger, Wierzbicki and Harland (2006 Fig. 15; Encana's play initiator & carbonate specialist, development geologist and exploration geologist respectively). Note that some of the side-tracked wells such as M-79A and lowermost PI-1B were highly deviated and drilled much longer intervals than are apparent since they stayed near horizontal at the same stratigraphic level.

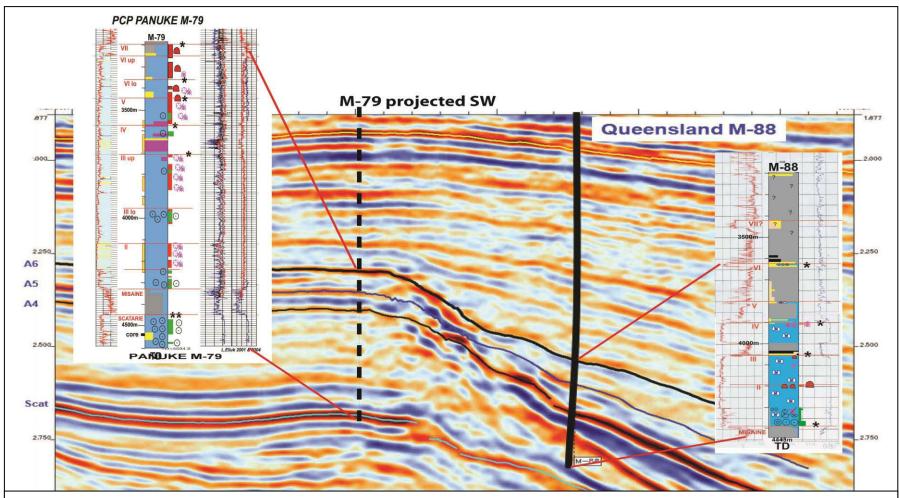


Figure 4.54 South Deep Panuke platform margin to slope seismic and M-79 to M-88 well control. Platform to basin relief increases upward but then starts to reverse as more shale contributes to the basin fill (may be some apparent thickening due to slower velocity as well) after AB V. Not surprisingly few carbonate facies are shared, but a basal oolite is common immediately above the Misaine shale. On the slope in M-88 it likely is allochthonous. In M-88 minor platform-derived debris with ooids also occurs at the base of AB V and top AB VI. While the dominant facies is microbolite peloidal limestone or shale, each sequence has a thin cap of lithistid or coralline sponges possibly indicating shoaling and maximum regression. Thin sands are associated or reworked just above these beds. Basal shales of AB IV and AB VII are black which may indicate dysoxic maximum flooding intervals. On the platform margin the lower sequences of M-79 show shoaling trends with greater amounts of reefal beds or oolites upward. Above AB V the coral-stromatoporoid reefal intervals are replaced with lithistid sponges in slightly argillaceous limestone. See Fig. 4.52 or 4.56 for symbol key. Seismic from Kidston et al. (2005).

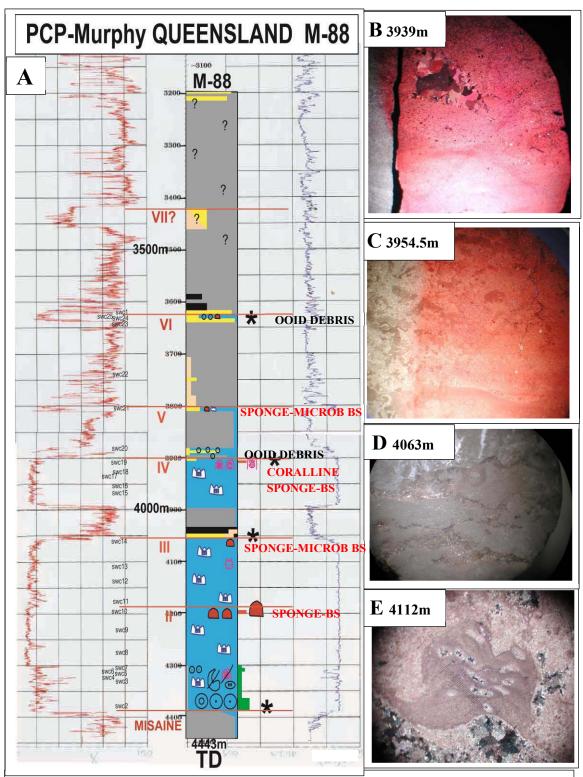


Figure 4.55 Queensland M-88 slope well and microbolite mound facies (3C) A) litholog with sequence capping shoaling facies shown in red and debris events in black. B-E) Drilled sidewall core thin sections: B) thrombolitic-stromatolitic-peloid bindstone with unsheltered cement filled cavity TS $VA = \sim 3$ CM swc plug, C) thrombolitic-stromatolitic-peloid bindstone with geopetal micrite TS $HA = \sim 2$ cm D) thrombolitic-stromatolitic-peloid bindstone with some open sub-crust cavities with geopetal micrite eroded contact near top (truncated ?tubule swc core diameter = ~ 3 cm. Encrusting *Lithocodium* $VA \sim 3$ mm SWC= sidewall core, TS=thin sections, VA = vertical axis. Alizarin red stain in B and C.

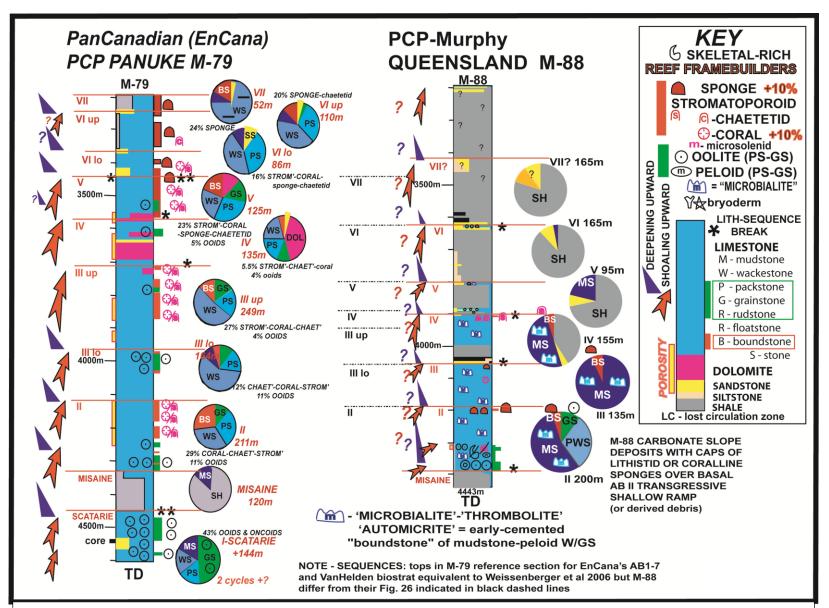


Figure 4.56 Comparison of south Deep Panuke shelf margin (Panuke M-79) and slope (Queensland M-88) wells. Lithofacies shown as pie charts for sequences approximately those of Encana (2006) and Weissenberger (2006) except as noted. Note that both on platform and slope the wells have basal oolite immediately above the Misaine Member shale. Shoaling and deepening trends are indicative only.

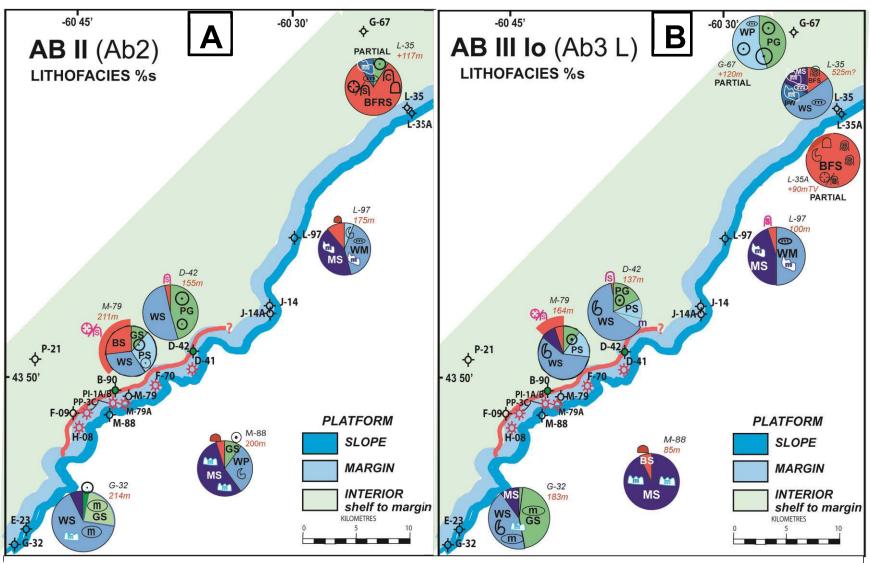
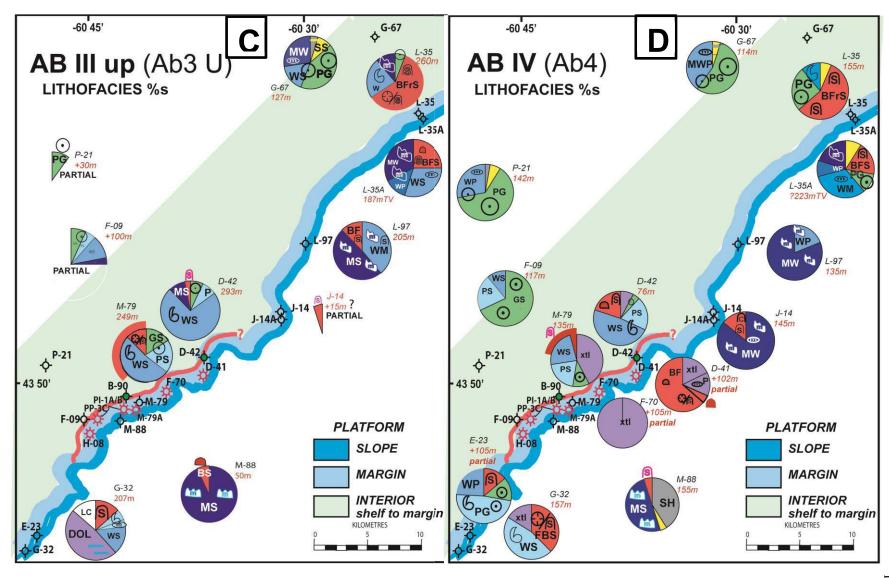
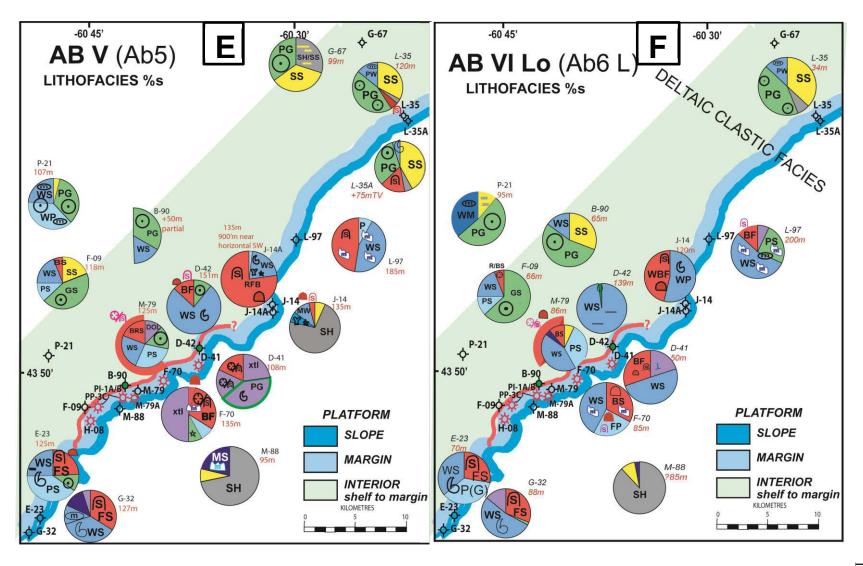
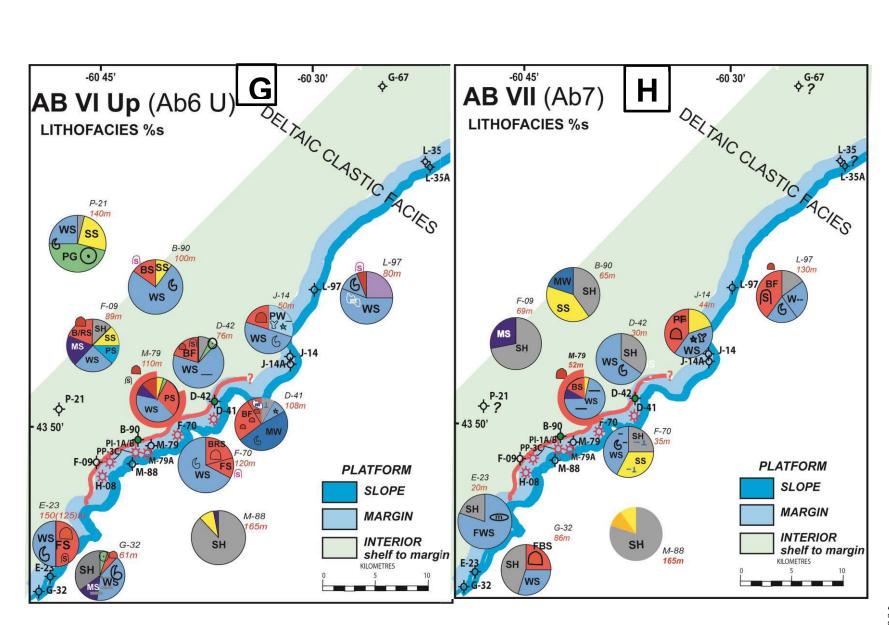


Figure 4.57 Eight Lithofacies pie-chart maps of Deep Panuke Trend. Base Baccaro Member **A) ABII** to top Artimon Member/top Abenaki carbonate (partial MicMac Formation?) H) ABVII by approximate Encana sequences (Encana 2006, Weissenberger et al. 2006) from base up to top. See **Fig. 4.56** for key to symbols and lithofacies based on Dunham texture and major allochem content (M-79 extra exterior red fringe indicates +10% framebuilders in different Dunham textures). Pies are placed in relative relationships but widely spaced as compared to actual positions indicated by mapped well UWI identification. Absence indicates lack of penetration for deeper sequences and change to deltaic siliciclastics in shallower sequences for northeast wells. Note that AB VII may be mostly latest Jurassic rather than Berriasian due to varied biostratigraphic dating.







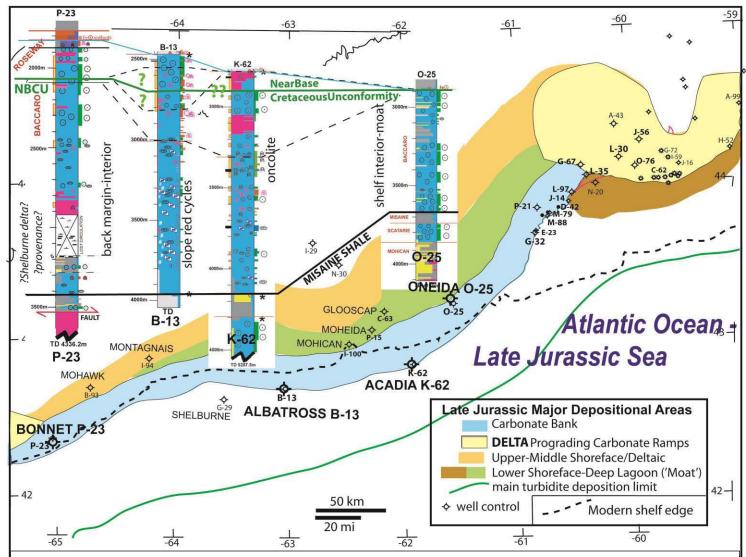
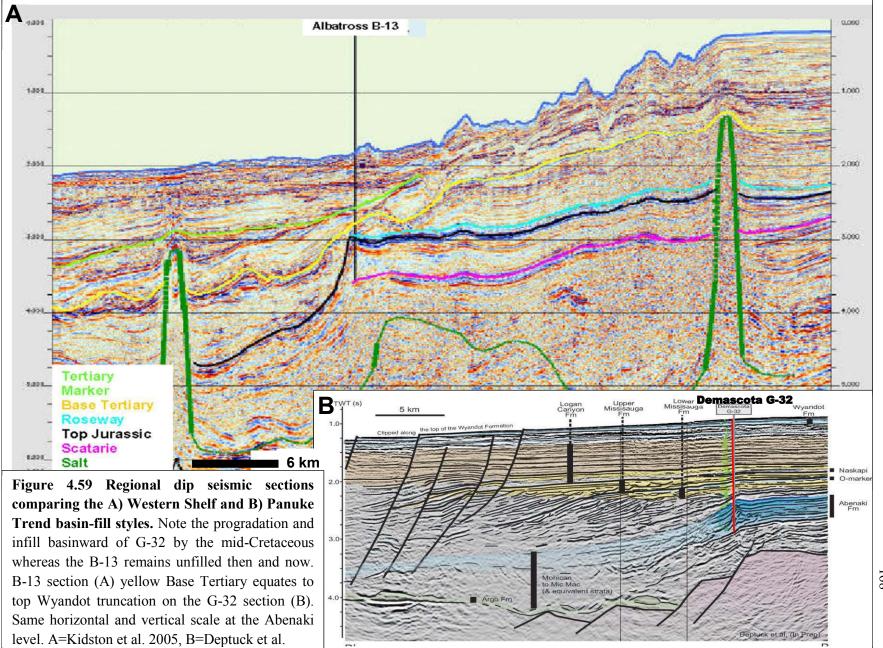


Figure 4.58 Western Shelf platform margin wells and Abenaki type-section Oneida O-25 locations and well schematics on a generalized depositional facies map relative to the delta transition area. Note the many alternative interpretations for the presence of post-Jurassic (actually post-Berriasian post-NBCU) carbonates on the Western Shelf that have been termed the Roseway unit. Note the presence of red coated ironstones ('iron ooids'') capping all carbonates. See **Figure 4.56** for lithologic key. Map based in part from Encana (John Hogg and Jim Dolph 1999 unpublished)



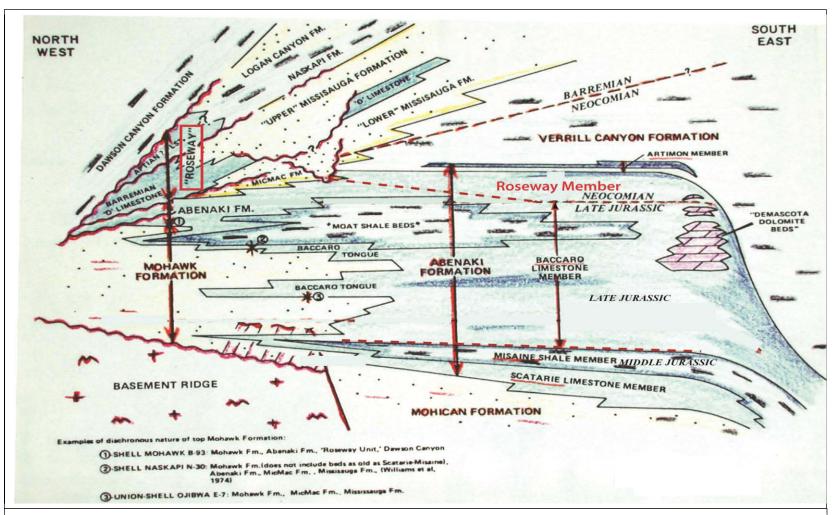


Figure 4.60 Western Shelf stratigraphy schematic (very slightly modified and colourized from Eliuk 1978 Fig. 3; also see Wade & MacLean 1990, Fig. 5.39) with addition of the Cretaceous Roseway Member (added in red above Baccaro Member) that can occur in the Mohawk, Missisauga and Abenaki formations. The Artimon Member is diachronous and can be part of the Abenaki, Verrill Canyon or Missisauga formations. Whatever the stratigraphic placement or age (even latest Jurassic in the NE Panuke Trend), the Artimon is lithologically characterized by having lithistid sponge-rich argillaceous limestones. Within the Abenaki Formation intraformational breaks or even unconformities may occur. Such breaks are implicit in the use of sequences and apparently some on the Western shelf may be of considerable duration. Unfortunately the biostratigraphy is often hampered by poor microfossil recovery in the carbonates. Note the Middle to Late Jurassic contact is placed top Misaine. Modified from Eliuk (1978).

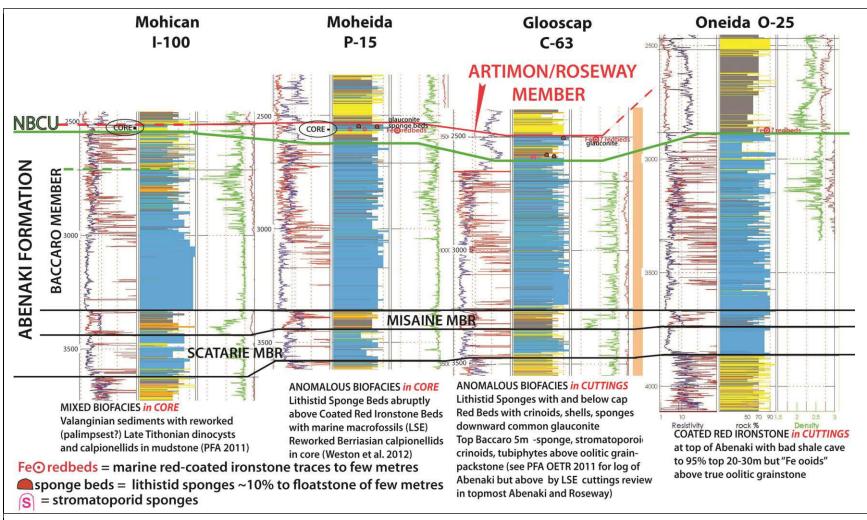


Figure 4.61 Red coated ironstone and sponge-bearing beds of the Mohican Subbasin on the western shelf Abenaki carbonate platform interior. The well columns are from the Appendix of the PFA report (OETR 2011) with log based lithologies and gamma, resistivity and acoustic log traces; the lithologic observations are Eliuk's. Note the greater amounts of argillaceous beds in the upper Baccaro Member. The green line marks the top of the Baccaro (Late Jurassic Abenaki member) and is about the NBCU = Near Base Cretaceous Unconformity of PFA study (OETR 2011) and Weston et al. (2012). In Glooscap C-63, Moheida P-15 and Mohican I-100 the Artimon/Roseway interval is dated as Valanginian to basal Barremian and the top-most Abenaki as Tithonian (OETR 2011, Weston et al. 2012). Problematically but not easily resolvable due to the thinness of the units, the J-150 regional top-carbonate reflector may be from above and considerably younger than its name and association with the Abenaki indicates.

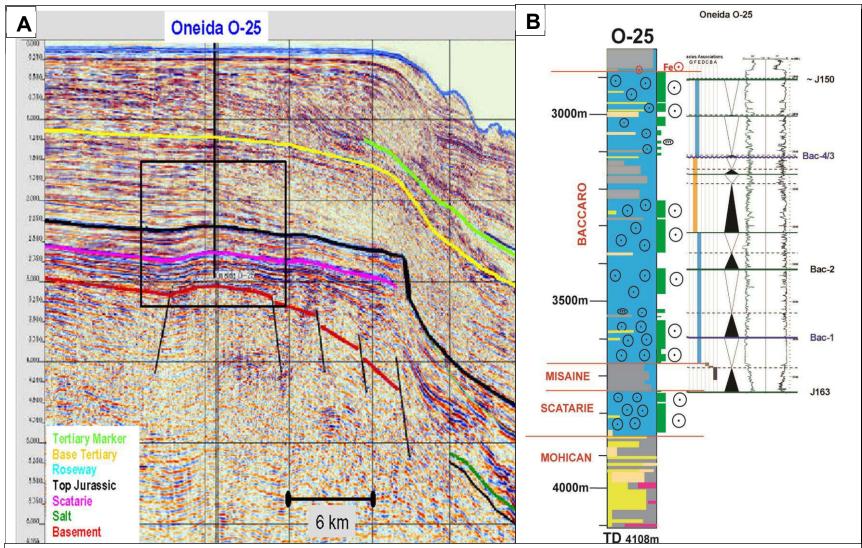


Figure 4.62 Oneida O-25 A) regional seismic dip section through O-25 (Kidston et al. 2005). **B)** Schematic lithologic log (created from Eliuk 1978 detailed log, see **Fig. 4.61** index, red coated ironstone at top Abenaki) and seismic sequences of PFA Chapter 9 (OETR 2011, gamma log on left and acoustic on right). Note the basinward downlap of beds onto the Abenaki. Comparing the acoustic log to the sequence tops some do not seem to correspond with obvious velocity changes and at least for Bac-4/3, the lithofacies do not seem to necessarily connote an unconformity even if a potential reflector may arise from the lithologic change. A & E biomarker – *Ammobaculites-Epistomina* biostratigraphic correlative marker (Given 1977, Eliuk 1978). See **Fig. 4.56** for lithologic column key. Seismic from Kidston et al. (2005).

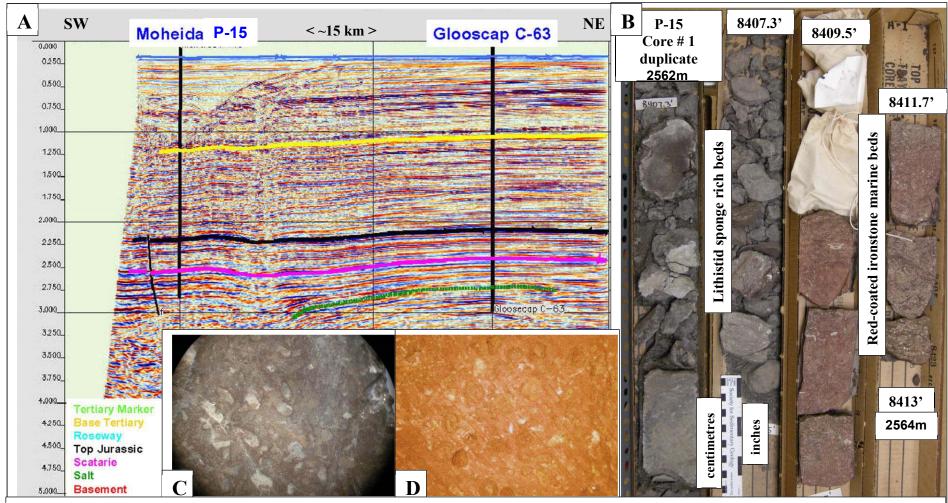


Figure 4.63 Moheida P-15 A) Strike Seismic line P-15 to C-63 Note downlap of reflectors onto Abenaki towards SW and compare to Figure 4.62 with similar geometry of thin beds sourced from northeast Sable Delta area.. B) P-15 Core #1 – thin argillaceous glauconitic sponge-rich limestone beds abruptly overlying thin marine redbeds of coated ironstones ("Fe ooids"). Depths as originally drilled, C) Sponge from upper core (view 2cm across) D) Red coated ironstone 'Fe-ooids' from lower core (view 2cm across). See below for more petrography on red coated ironstones. Seismic from Kidston et al. (2005).

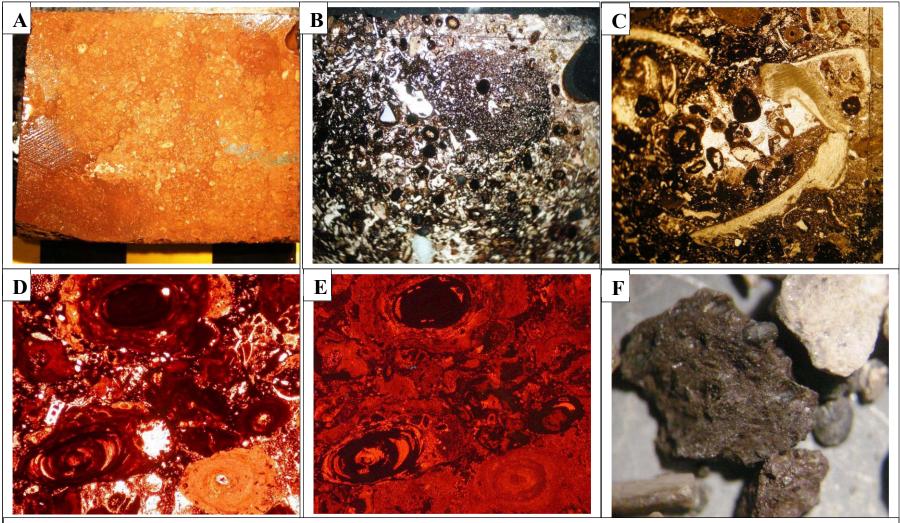


Figure 4.64 Red coated ironstones in core thin section and cuttings. A-E) Moheida P-15 core #1 – 8410'=2563.4m A) Thin section sample of coated ironstone packstone with burrows upper right and lower left (cm scale at bottom), B) thin section of upper right burrow and "Fe-ooids" (1.5cm VA), C) thin section broken brachiopod-bivalve shells with minor serpulid encrustation, ostracod and echinoderm fragments and coated-ironstone grains and minor very fine quartz grains (1 cm VA), D) thin section coated-ironstone ooids-pisoids, some encrusting forams on lower left 'ooid' (0.5cm VA), E) same view but cross-nicols under cathodoluminescence F) Oneida O-25 cuttings 9520'=2901.7m (GSC Calgary 10 foot dry sample) rare red coated ironstone grain-packstone amongst shale cavings top Roseway/Baccaro carbonate (about 0.7cm VA). VA= vertical axis or height of photo.

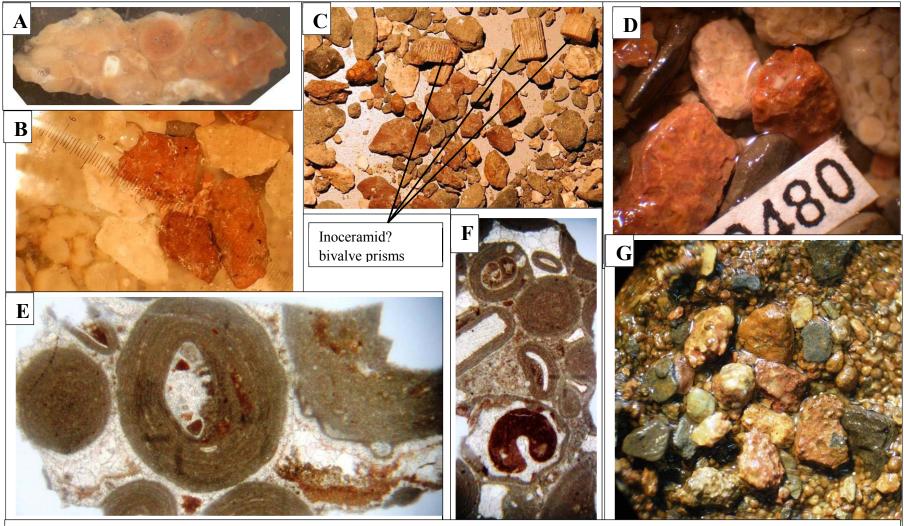


Figure 4.65 Red coated ironstones (and some red calcium carbonate ooids) in cuttings and thin section. A-B) Shelburne G-29 cuttings — 3990m bottom hole sample A) Ooid grainstone chip- reddened calcite ooids, note white miliolid foram (0.5 cm HA), B) oolitic limestone and red coated ironstone (~1.5cm HA), C) Acadia K-62 cuttings — red ferruginous coated grain/packstone, note 3 pink prismatic fragments of inoceramid bivalve shells top centre to right (~4 cm HA), D-F) Albatross B-13 cuttings — 2480m (E & F thin section of cuttings. Scale = ooids 0.5-1mm) D) oolitic lime grainstone with some iron content in pink to red calcite ooids, E) oriented cutting as shown by shelter cavity with geopetal in lower right with red sediment fill after isopachous cement after pendant encrusting? foram or possibly Bacinella microproblematicum; note the central mm ooid has a ?Trocholina foram nucleus. Clearly the grainstone was cement-stablized in a phreatic or marine setting allowing silt-sized iron-rich infill, F) nuclei of forams, ?ostracods, crinoids, recrystallized gastropod with iron-rich infill at bottom centre. Note borings in top centre ooid cortex, very fine cloudy isopachous cement rind then some fine sediment infill and later blocky calcspar cement (2 mm HA), G) Bonnet P-23 cuttings — 1815 m (Nova Scotia DNR 5 metre wet sample in Roseway unit or above of Albian age) coated red-yellow iron grain-packstone ("Fe ooids") note disaggregated loose coated particles, some patches of green ?glauconitic minerals, rare crinoid ossicles (~ 3 cm HA). HA- horizontal axis of photo.

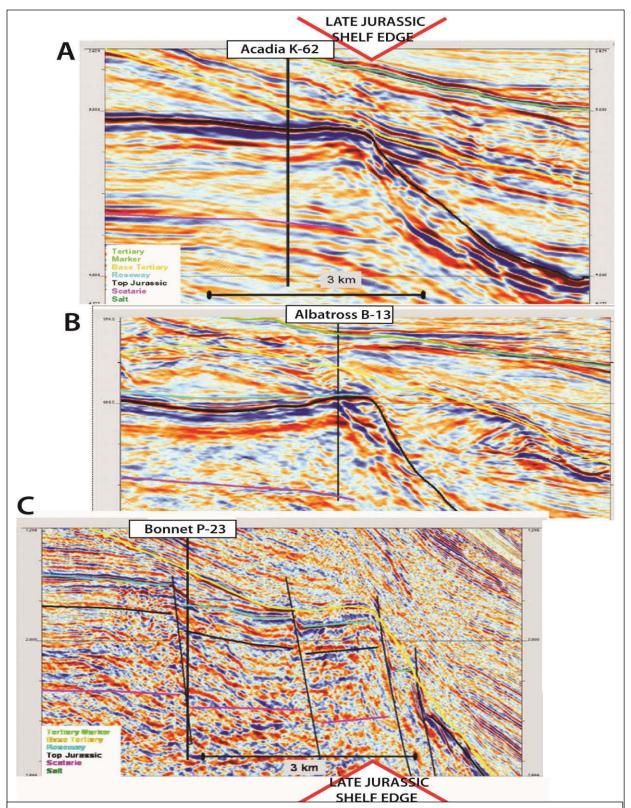


Figure 4.66 Dip seismic across Abenaki Western Shelf Jurassic shelf-margin wells. Reflectors overlying the Abenaki show marked downlap geometries consistent with a long submarine hiatus eventually in fairly deep neritic water as seen in dating as relatively thin Late Cretaceous shales and chalk. A) K-62 is slightly back of the shelf edge. B) B-13 closest to the Abenaki shelf edge has a raised rim with subhorizontal layering underlain by massive to possibly inclined layers below (complicated geometries basinward of the Abenaki may be slid blocks related to the Miocene Montagnais impact). C) P-23 is farthest back of the margin with horizontal layering complicated by pre-Tertiary but post-Abenaki (including Cretaceous Roseway) normal faulting that the well cuts near base Abenaki. Seismic from Kidston et al. (2005).

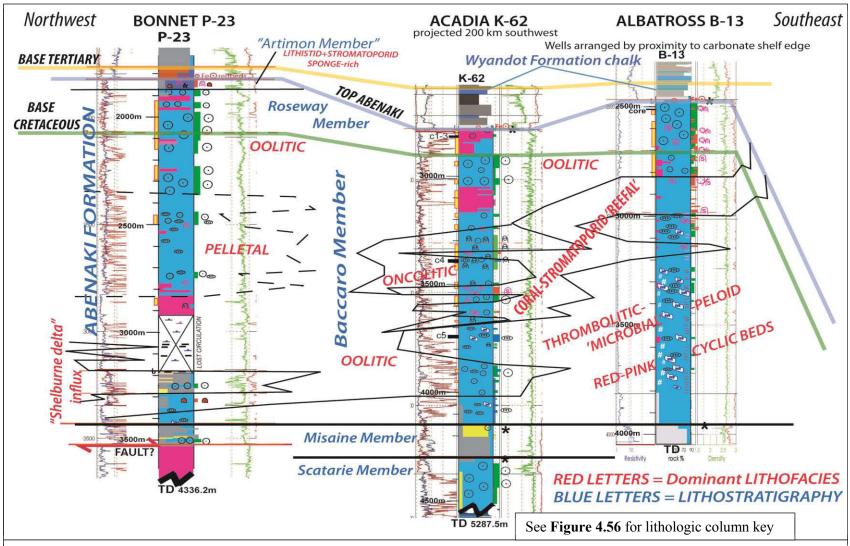


Figure 4.67 Dip section Western Shelf wells near Late Jurassic shelf margin showing lithofacies and Abenaki lithostratigraphy. Although hundreds of kilometres apart, these wells are 3 km or less from the margin and have been arranged in proximity to the margin. They show a kilometre-scale second-order-sequence shoaling trend. They have marked vertical and lateral facies changes from:peloidal-thrombolitic-microbial slope carbonate to coral-coralline sponge reefal margin to oolitic shoal at the margin and interior becoming more pelletal. In K-62 there is a mollusk-rich oncolitic facies interpreted as a reef flat. In the lower P-23 siliciclastics indicate proximity to the deep shelf interior ('moat') and postulated Shelburne delta. Top P-23 has argillaceous lithistid sponge-rich beds that have more stromatoporoids than typical Artimon Member. Red coated ironstones cap Abenaki in all wells but are thickest in P-23 where the post-carbonate Cretaceous is thinnest as reddened marine beds.

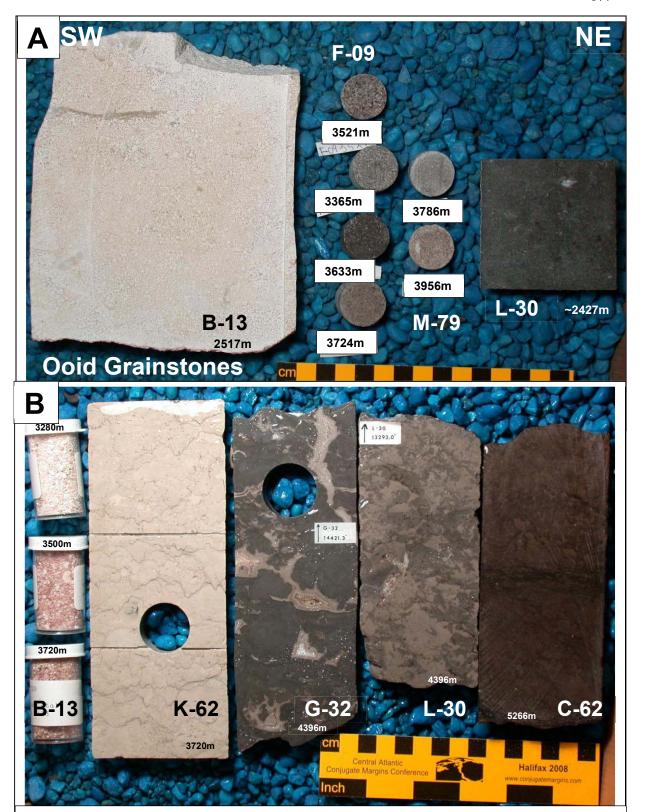


Figure 4.68 Southwest to northeast colour comparison of Abenaki lithofacies A) ooid grainstones and **B)** microbolites (thrombolites). Albatross B-13 core 1(in A) and cuttings (in B) and Acadia K-62 core 5 of Western Shelf, Demascota G-32 core 5, Panuke F-09 and M-79 sidewall cores, Penobscot L-30 cores (1 in A, 2 in B), and West Venture C-62 core 13 of Panuke Trend to Sable Delta.

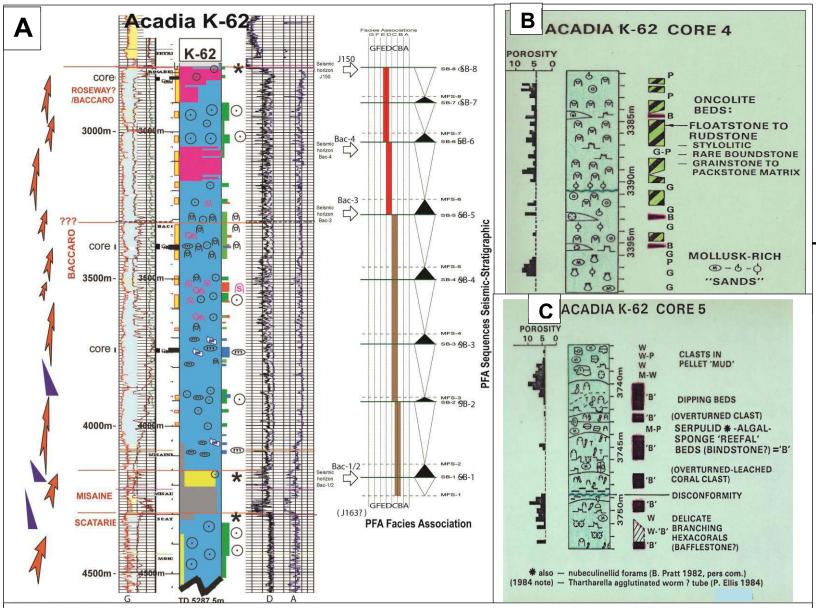


Figure 4.69 Acadia K-62 A) well schematic log with PFA sequences (OETR 2011), **B) Core 4** schematic oncolitic and mollusk-rich facies (modified from Eliuk 1981) and **C) Core 5** metazoan-rich microblite/thrombolitic ('algal'= cyanophytes but more probably non-photosynthetic microbes) facies. See **Fig. 4.56** and **4.75** for litholog and PFA keys and most allochem symbols.

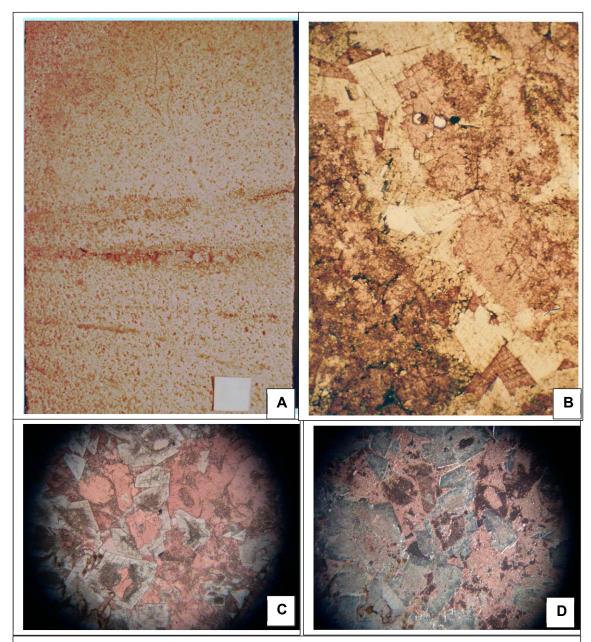


Figure 4.70 Acadia K-62 core 1,2,3 dolomite of suspect oolitic limestone, 2811.4-2824 m (recovered 9m, porosity 1.1-14.8%). A) 2817.5 m Oolitic(?) calcareous dolograinstone – well sorted massive M-C sucrosic dolomite with suggestion of oolite texture and crossbedding. Some bedding is high-lighted by pyrite and limonite. White square = 1cm scale. B) Photomicrograph showing dolomite (light toned rhombs) and calcite (dedolomites?) rhombs and recrystallized finer calcite matrix (darker toned alizarin—stained). Coarser rhombs (0.25-1mm) show replacement of dolomite by calcite and late intercrystalline calcite cement = zoned alternations. Calcite matrix mottled due to 10-20% remnant? dolomite. Minor amounts of pyrite as rhombs and along microstylolites in calcite matrix, apparently rusty. C) Photo-micrographs 2823 m normal and D) crossed-nicols of partly dolomitized limestone (alizarin stained), allochems suggest nuclei present of ooids, dolomite rhombs (about 1 mm) have calcitic centres either remnant or dedolomite, note rusty microstylolite in bottom right. (A and B modified from Eliuk 2004)

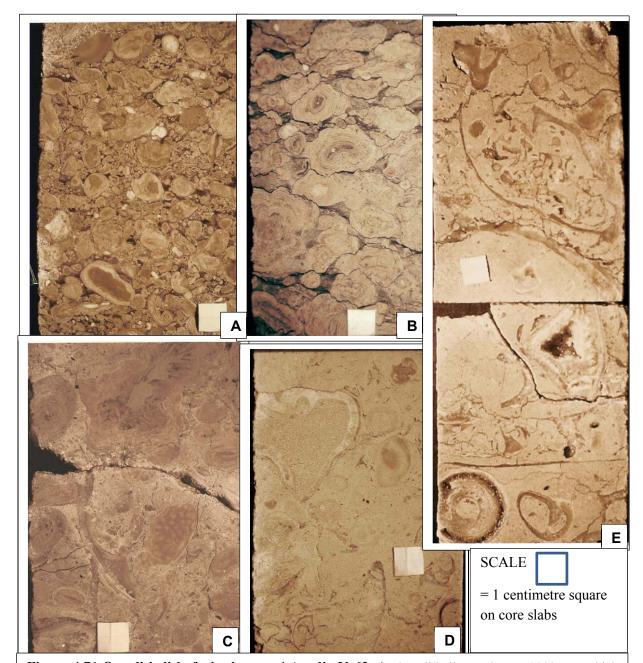


Figure 4.71 Oncolitic lithofacies in core 4 Acadia K-62. A) Oncolitic lime rudstone, 3389.5 m. Thick cyanophyte algae/microbolite coat hexacorals, stromatoporoids, chaetetids, mollusks, echinoderms and possible red algal fragments. **B)** In parts of the core (3384.2 m) the oncoids display stylolitic fitted textures and are 'stylo-rudstones' to 'stylobreccias'. **C)** Oncolite lime floatstone (to rudstone) with oolitic to pelletal grainstone matrix, 3390.7 m. Oncoid are locally very large when large coral fragments, mollusks or lithoclasts (including older oncoids) form nuclei. **D)** Mollusk lime floatstone with pelletal grainstone to wackestone matrix, 3398.9 m. Large leached gastropods and bivalves, interpreted as megalodonts, plus broken fragments occur in peloid matrix which may also have ooids and superficial ooids becoming oolitic grainstone in places. Note the large leached bivalve, (?)megalodont clam. These mollusk-rich sands grade up into oncolite beds at about 3936 m. **E)** Mollusk lime floatstone with pelletal wackestone to grainstone matrix, 3396.7 m. While the gastropods are completely leached only a portion of the bivalve walls are. Note the grainstone texture of the peloids in the articulated bivalve versus the compacted pack/wackestone texture of peloids outside. Note some rounded coral clasts are blackened. Depths as measured by operator in core boxes. Augmented and in colour from Eliuk (1998).

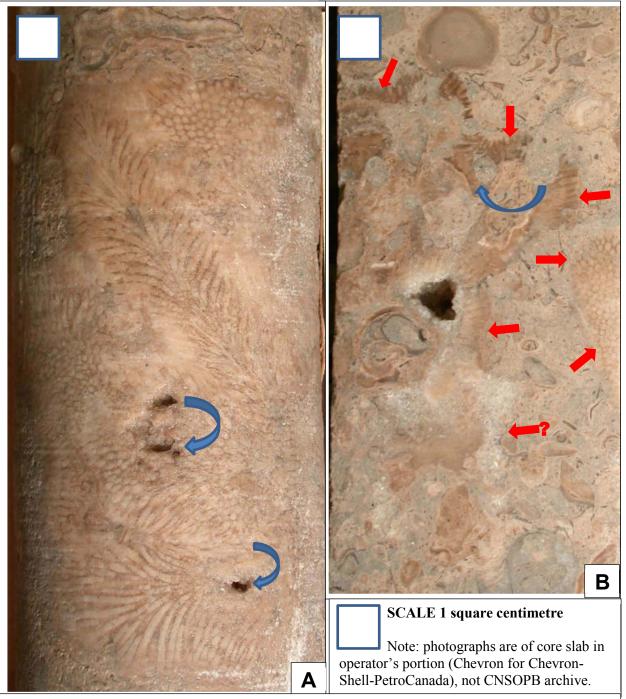


Figure 4.72 Acadia K-62 core 4 bioeroded hexacoral reefal layer or biostrome in oncolite lithofacies, 3393 m. A) Outer surface (?) Isastrea coral reeflet – outside of core fortuitously shows the probable outer 'living-surface' nearly intact except for the incurrent and outcurrent openings (blue arrows) of boring bivalves (ichnologic genus Gastrochaenolites). B) Bioeroded inner section of reeflet (red arrows show edge of former coral colony and blue arrows show 2 examples of rounded excavations of Gastrochaenolites with arrow-head pointing to an *in situ* lithophagid boring clam as occurs in several other cavities). Note the variety of shelter and cavity dwellers (coelobites) present and fine sediment infill. Some of the coral also appears to be leached and recrystallized subsequently possibly aided by the earlier bioerosion although the edges of most clam cavities seem sharp.

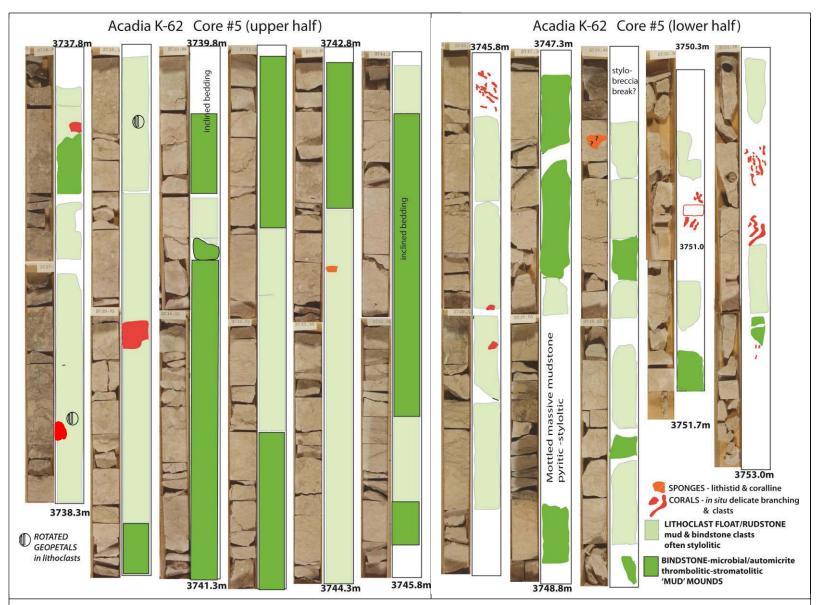


Figure 4.73 Acadia K-62 Core 5 – Microbolite mud mound depostional facies association. Microbolite bindstones and lithoclast layers partly derived from bindstone. Note *in situ* delicate branching and/or phaceloid corals in lower half of core.

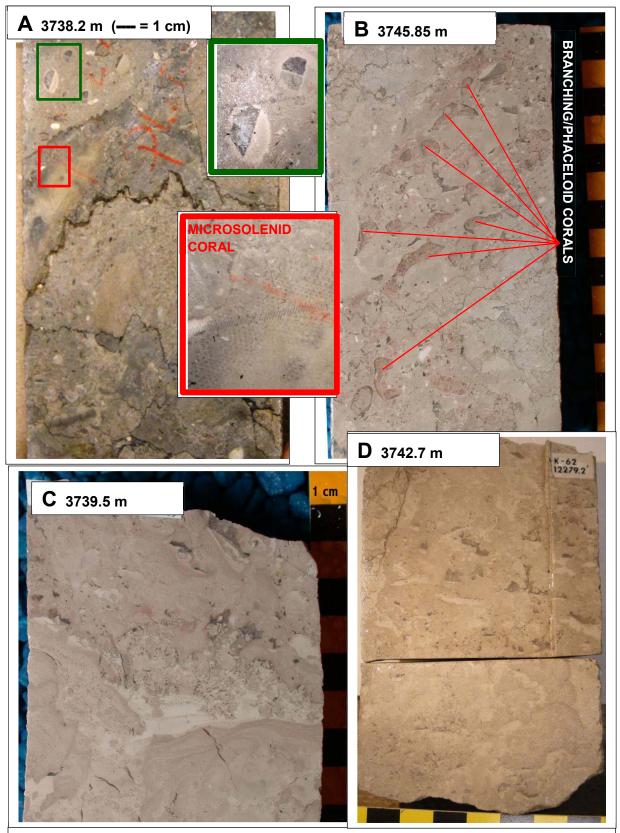


Figure 4.74 Acadia K-62 core 5 – some features in microbolite mound facies. A) Stylolitic clast rudstone with rotated geopetals (2 periods of fill - green box) and microsolenid coral fragment (red box). B) Delicate branching/phaceloid coral *?Calamophylliopisis*. C) Microbolite bindstone – stromatolitic fabric with irregular cavities and geopetal infill. D) Microbolite bindstone – thrombolitic fabric small cavity system variably infilled by geopetals.

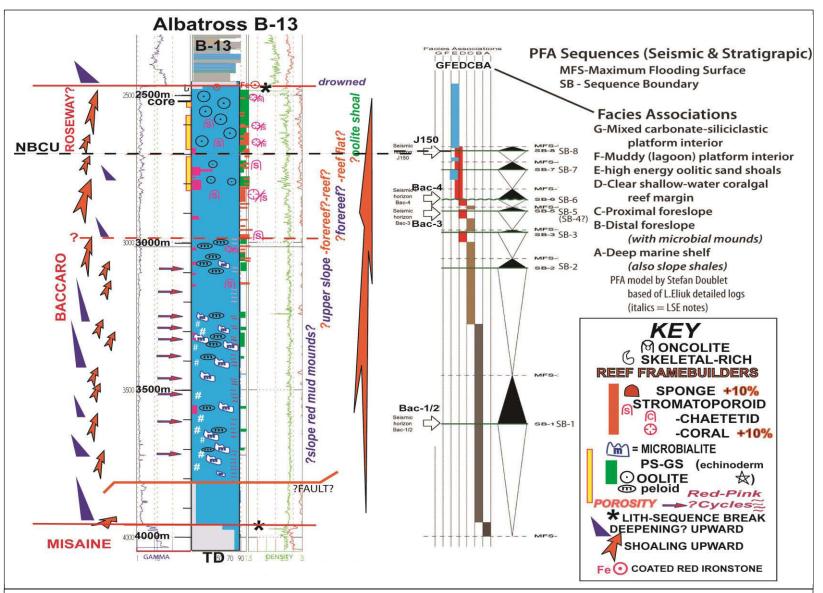


Figure 4.75 Albatross B-13 well schematic log with PFA sequences (OETR 2011) with key for sequences (Seismic on left e.g. J150 and depositional on right e.g. SB-8) and facies associations (bar columns e.g. G-A). NBCU= Near Base Cretaceous Unconformity.

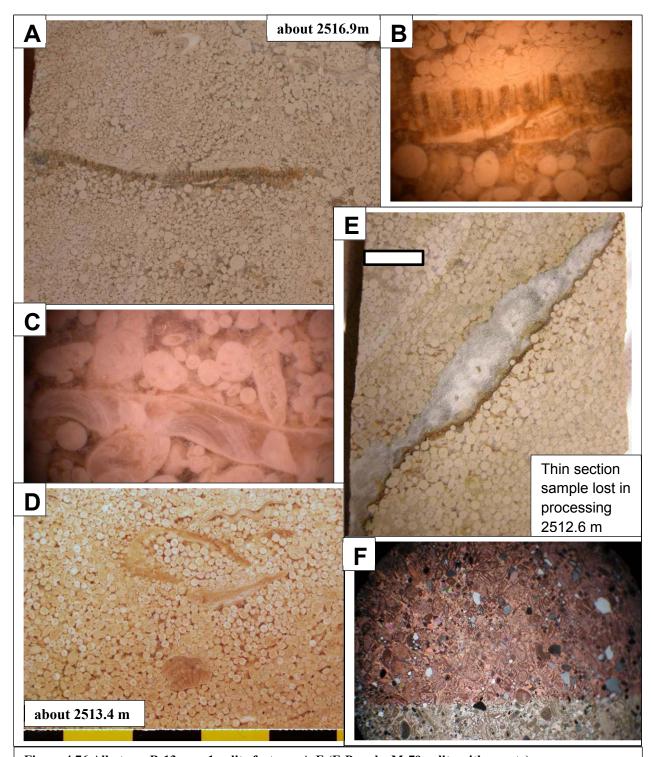


Figure 4.76 Albatross B-13 core 1 oolite features A-E (F-Panuke M-79 oolite with quartz).

A) Platy coral with only a single layer of corallites short-lived but 'floating' in ooids analogous analogous corallites short-lived but 'floating' in ooids analogous corallites short-lived but 'floating' in ooids analogous coral short-liv

A) Platy coral with only a single layer of corallites short-lived but 'floating' in ooids analogous to *Fungia* life style. B) Close-up of coral showing compaction breakage and sheltering from fines infill that collect on top surface. General lack of fines infilling cavity may indicate coral 'buried alive.' C) Abraided oyster fragment and small high-spired gastropod. D) Bivalve shells current-aligned, partly dissolved/recrystallized, rounded coral fragment in middle bottom. E) Fractured oolitic M-C grainstone with reddened geopetal sediment and possible red cements that also occur sporadicallybetween ooids above the fracture. F) M-79 3613 m SWC alizarin stained M-C oolitic grainstone with quartz (white). Non-destructive microscopy of surface only, except thin section in M-79 sidewall core. Bars = 1 cm.

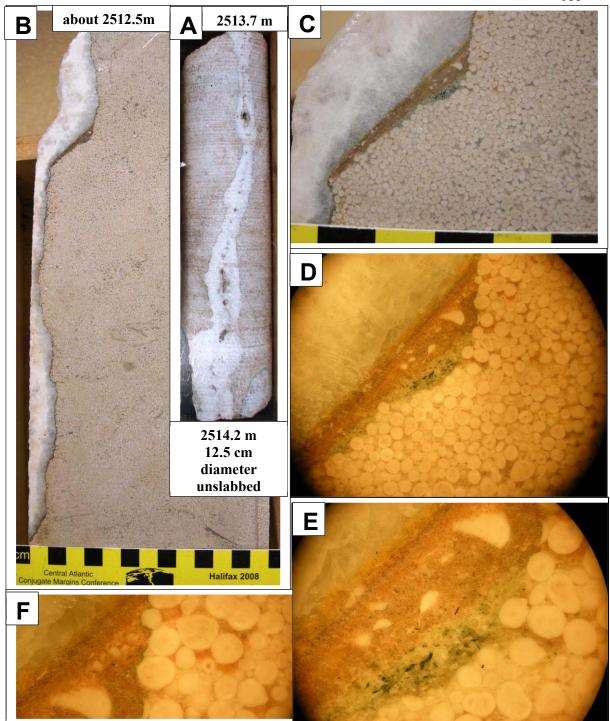


Figure 4.77 Albatross B-13 core 1 fractured oolite features. A) A half metre of unslabbed whole core with vertical fracture mostly cemented (ruler is in cm). B) Core slab view of oolitic lime grainstone with near vertical fractures note hanging geopetal on ledge (avalanche 'angle of repose'?) beneath XC calcspar. C) Closer view of geopetal ledge note lower green and clear sediment/cement overlain by red layered sediment. D) Microscopic surface view of layered F debris with M-VC broken ooid fragments above country rock of a well-cemented well-sorted M-C oolitic limestone. E) Closer view showing scattered green and clear grains below red geopetal sediment. F) Yet closer view of red sediment note that some infiltrates between the ooids indicate porosity was much better during early fracture fill.

Non-destructive microscopy of surface only; CNSOPB did not allow sampling. A similar sample (Fig.4.76E) was taken but destroyed in thin section preparation. Third try is left to the future.

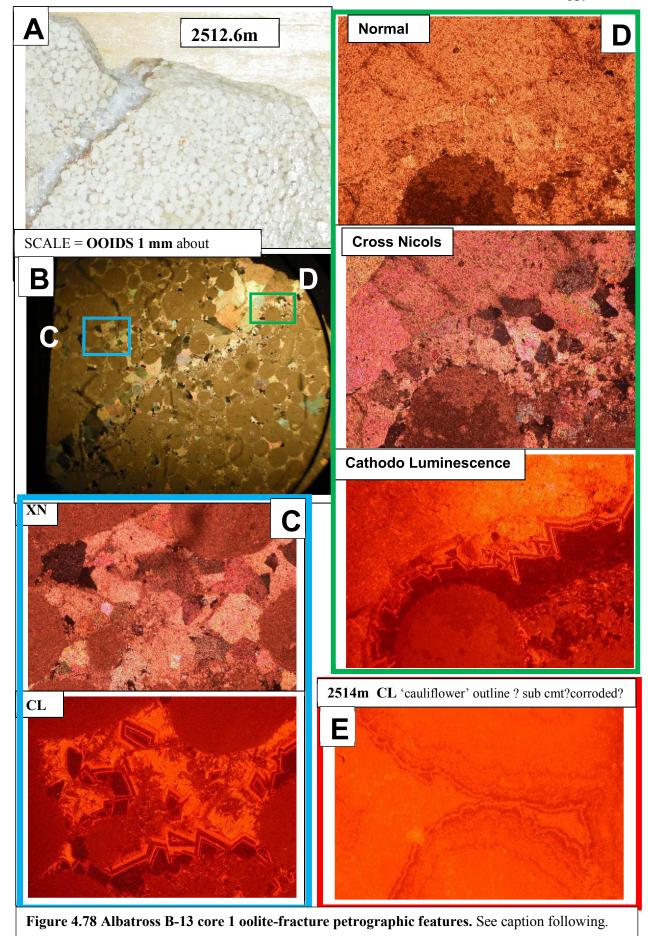


Figure 4.78 Albatross B-13 core 1 oolite-fracture petrographic features.

A) Thin section sample at 2512.6 m showing macro-view of oblique cemented fractures in white M-C oolite lime grainstone. Note the thin red sediment-cement occurring only on the lower side of the fracturing in a geopetal manner. B) Low power thin section crossed-nicol view of sampled fracture. The blue rectangle by the white C is the area of view of the higher power view of the sample in Figure 4.78C and similarly the green rectangle by D in Figure 4.78D. Horizontal view about 1.5 cm and larger ooids about 1 mm (coarse) for scale. C) Crossed nicol and cathodoluminescence views of inter-ooid cements. Note the earliest cement is dark and interpreted as quenched due to iron content followed by thinner zoned cements. The general pattern seems the same as the cements along the fracture shown in Figure 4.75D giving a cement stratigraphy. D) Normal, cross nicol and cathodoluminescence of the lower edge of the fracture. Again the first cement is dark and covers both the recrystallized ooids and a layer of very fine sediment. That the cement post-dates the sediment infill is consonant with the observation in Figure 4.77D-F of some red material getting in among the ooids. However there must have been significant early cementation for the oolite to retain its form and brittle fracture. E) Oolite thin section view of sample at 2514 m of two ooids and isopachous cement. The cementation must have been in a phreatic environment with no hint of meniscus cements. The zoning is present but thinner and fainter. The cement crystal termination seems somewhat rounded and perhaps suffered some kind of corrosion. Horizontal area of view about 1 mm.

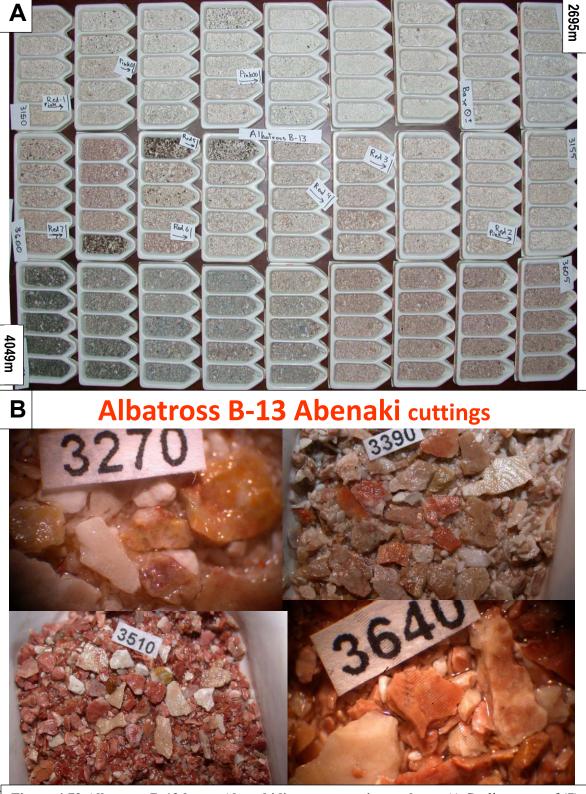
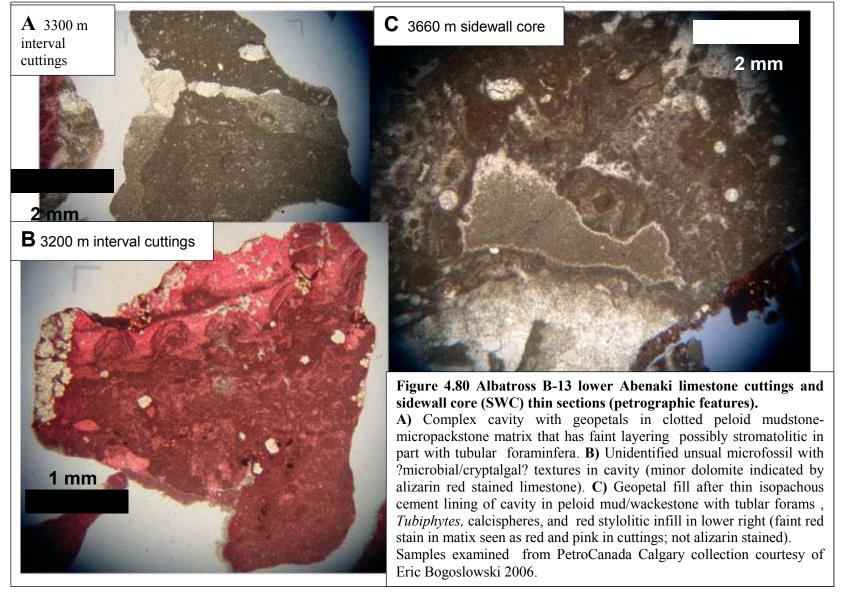


Figure 4.79 Albatross B-13 lower Abenaki limestone cuttings colours A) Cyclic repeat of (7) white up to red then (about 2-3) white up to pink in trays going from base lower left to top upper right with paper labels at top of cycles or giving depths (darker bottom 5 trays on lower left = argillaceous limestones; dark cuttings in 3 middle left trays due to lost circulation material such as mica). **B)** Representative cuttings close-ups with peloid and microbolite thrombolitic textures.



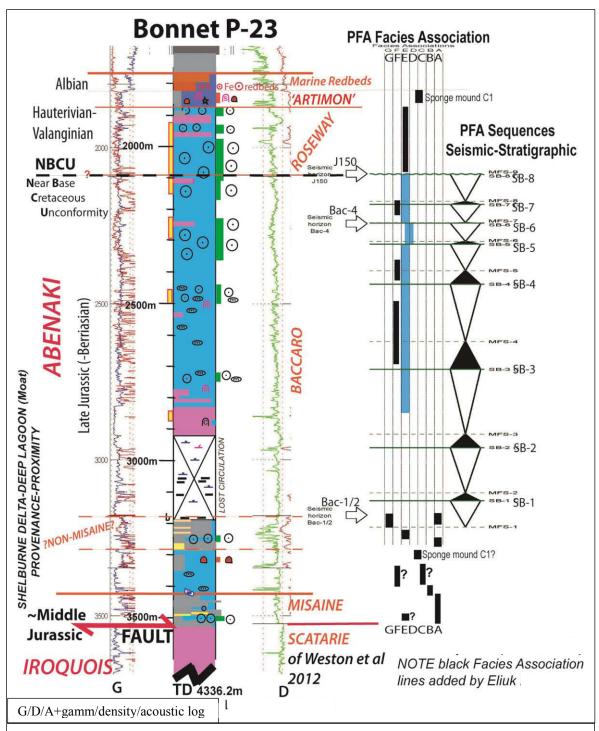


Figure 4.81 Bonnet P-23 well schematic log with PFA sequences (OETR 2011). New dating by Weston et al. (2012) indicates that a lower shale is the Misaine rather than the former "non-Misaine" placement. As shown on the right Weston et al. (2012) identify the Scatarie as a dolomite which is a unique lithology for that member. Alternatively there may be a fault from the anomalously thin Misaine to the Iroquois Formation that is usually dolomite. With new dating the lower PFA sequences are too high. See **Fig. 4.56** & **4.75** for litholog and PFA keys

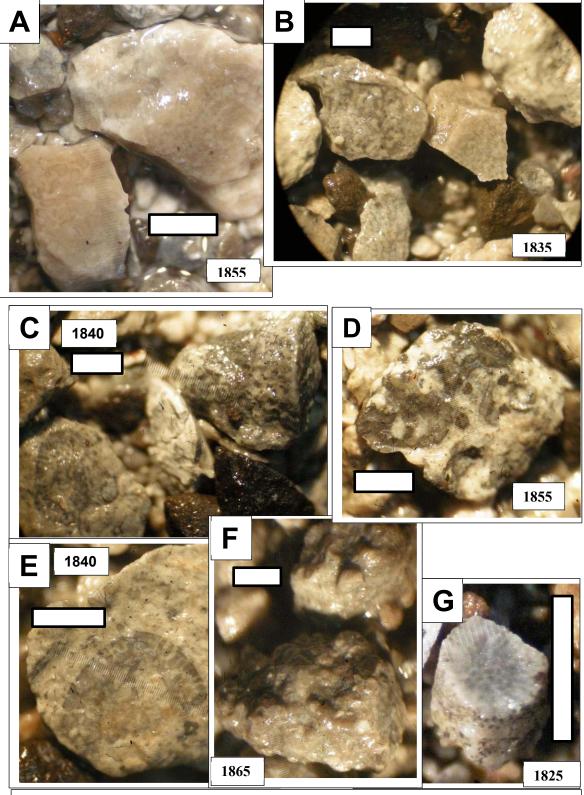


Figure 4.82 Bonnet P-23 fossils in cuttings of 'Artimon'-like facies and subfacies 4C ('shallow' sponge reefal). A-B) Stromatoporoid sponges, C-E) lithistid demosponges, F-G) bryozoans. Scale: white bar = ~ 2 mm. Drilled depths in metres shown on photographs.

CHAPTER 5. DISCUSSION and INTERPRETATION

List of Topics

- 5.1 Introductory Overview and Possible Controls on Delta-Platform Mixed System
- 5.2 Comparative Carbonate Sedimentology of Contrasting Carbonates (Core Stories)
 - -West Venture C-62: Sable Intra-deltaic, Ramp, Shoaling, Thin Limestone
 - -Margaree F-70: Abenaki Margin, Platform, Pinnacle, Deepening, Thick Carbonate
 - 5.2.1 First Example West Venture C-62 core #9 Limestone in Venture Shelf-margin Delta
 - 5.2.2 Second Example Margaree F-70 Core Abenaki Platform in Deep Panuke Field
- 5.3 Problem #1 Nature of Juxtaposition and Abenaki Platform -Sable Delta Transition with Mixed Carbonates-Siliciclastics in Ramps Lateral to Delta
 - 5.3.1 Carbonates Proximal to the Sable Delta A Partial Solution to Problem #1:
 - 5.3.1a Thin Limestone in the Venture Shelf-margin Delta Compared to the Thick Platform Limestones #9 Limestone West Venture C-62
 - 5.3.1b Facies and Accessory Fossils Ramp versus Platform Rimmed and/or Sheltered Morphologies in Abenaki J-56 to Penobscot L-30 (Distally Steepened Ramp or Salt-cored Shoal and Atoll Capped by Ramps)
 Versus Kegeshook G-67 to Marquis L-35, (Platform Wells Capped by Ramps)
 - 5.3.2 How Prodeltaic Shales Onlap or Interact with the Platform Slope Comparing Margin Transects and Shelf Margin Wells (Second Part of Solving Problem #1)
 - 5.3.3 Age of Top Abenaki Carbonate Along the Margin and the Margin Wells in a Regional Abenaki Section Penobscot L-30 Area to Panuke Trend Margin-slope (-Third Part of Solving Problem # 1)
 - 5.3.4 Delta Models Relevant to Problem #1 Delta-lobe Switching and Dailly's Delta Loading
 - 5.3.5 Arguments for an Isolating 'Gap' Between Delta and Platform
- 5.4 Problem #2 Lateral Changes Within Abenaki Carbonates
 Relative to Delta proximity
 - 5.4.1 Abenaki Slope Shales and Adjacent Slope Limestones a Systematic Gradient
 - 5.4.2 Lateral Changes in the Uppermost Abenaki and Overlying Beds Relative to Deltaic Sediment Input, Sponge Reef Mounds, Condensed or Red Coated Iron Carbonates and Platform Growth into the Cretaceous:
- 5.5 Hydrocarbons Exploration and Development Implications

"Every theory of the course of events in nature is necessarily based on some process of simplification of the phenomena and is to some extent therefore a fairy tale."

— Sir Napier Shaw in his Manual of Meteorology 1926

5.1 Introductory Overview and Possible Controls of Delta-Platform Mixed System

Reefs come in many different sizes. Riding (2002) gave a succinct reef definition which avoids subjective elements by stating that "**Reefs** are calcareous deposits created by essentially in place sessile organisms. Scale, wave-resistance, & primary relief ignored." If this is accepted then

there is no minimum reef size. By that standard **Figure 5.1A** depicts the Abenaki's smallest shelf interior coral patch reef and the smallest shelf-margin coral reef complex, both in situ and less than a fifth of a metre in height. As expected, the patch reef is much smaller with less coral diversity than the shelf-edge reef. Perhaps exceptionally, the more complex coral 'reeflet' shows reefs can grow in terrigenous deltaic sediments including the Sable Delta at least for a brief time. Use of such tiny examples are a reminder that certain universal reefal characteristics can be illustrated at many scales. These includes reefs (and corals) initiating on hard or stabilized surfaces, showing relief above the seafloor, suffering bioerosion particularly of later mid-Mesozoic-to-Recent non-living coral zones or fragments, showing competitive overgrowth and encrustation, growing attached coelobites in shelter cavities or in borings that also may have early geopetal infill and submarine cementation. Rapid sedimentation by fines whether carbonate or terrigenous turbidity can kill and bury reefs. Perhaps that is another variation of 'reefs being shot in the back by their own lagoons' to quote Prof Conrad Neumann (pers. comm.1985). Or vice versa – bury and kill - for the patch reef corallite cavities did not get infilled since they were likely still occupied by the living coral which also helps explain the lack of borings. In contrast the larger complex coral reeflet did undergo submarine erosion and bioerosion. This process is postulated for reef demise in stressed nutrient-rich settings by Hallock and Schlager (1986). Corals and reefs do occur in siliciclastics on various scales and to different degrees over geologic time (Figure 5.1, Figure 1.3, Table 4.1 and A2.2). But do these small-scale examples constitute an explanation for the large-scale Abenaki-Sable juxtaposition?

Could there be a simple scaling-up of what is seen in a hand sample - probably not. Carbonate platforms are more than just reefs. And large dimensions of pure carbonate need to be otherwise explained when they co-exist beside large deltas. But as stated in the opening paragraphs of this thesis, the Late Jurassic is one of the most prolific times of shallow-water carbonates both reefs and oolites. If a large carbonate platform is going to be found growing juxtaposed to a major delta then the Late Jurassic is the best time for a likely candidate.

Across the opening Atlantic in Portugal there is a smaller mixed system analogue of the same age (Leinfelder 1997). **Figure 5.1B** is his composite schematic of the main example used to illustrate his mixed system explanation of shelf-edge carbonates on small deltas, of scattered small reefs within fan deltas and a small isolated carbonate platform rimmed by reefs. **Figure 5.2** takes his explanatory ideas along with those of others (Leinfelder 1997, Wilson 1967, Mount 1984, Goldhammer 2003) to list and illustrate what applies to the much larger Abenaki-Sable situation. All of these controls may apply. The relationships shown in the lower two block diagrams

illustrate the traditional mixed system terrigenous nearshore to offshore carbonate pattern. Reciprocal sedimentation of slope-onlap-surfaces is shown in the middle block by the grey prodeltaic shales lapping onto the lower distal carbonate slope and the carbonate platform top. The idea of slow sedimentation with vigorous or adapted biota is illustrated by microbolite (thrombolitic) carbonate mounds on that distal slope and somewhat shallower but still relatively deep siliceous sponge reef mounds on the uppermost slope and platform top in distal prodeltaic marls. These ideas, including their relationship to condensed marine redbeds, will be addressed further in Section 5.4 and problem #2.

The main control to allow Abenaki-Sable continued juxtaposition is believed to have been a simple bathymetric gap (perhaps with occasional salt-cored shoal barriers/atolls) maintained over a long time span. This idea will be developed in Section 5.3 in answer to problem #1 and will be incorporated into a model of the Abenaki-Sable relationship and the implications for hydrocarbon exploration and development (Section 5.5 and 5.6).

Section 5.2 presents a comparison of the contrasting limestone environments within the intradeltaic ramps of the Sable Delta area and the Abenaki carbonate platform margin as it came under the influence of the encroaching delta. Two long cores allow detailed comparisons of limestone facies successions within these two very different settings. The vertical successions involve the principal reef/mound types of the Late Jurassic – coral (& coralline sponge) reefs, siliceous sponge mounds, and microbolite mounds. Figure 4.37 illustrates these with Demascota G-32 core slabs. Figure 5.3 shows Leinfelder's (1994) ternary classification diagram of these three end members based mainly on European outcrop data. On that figure, the various Abenaki or equivalent reef/mound cores are placed in approximate positions based on biotic content. Most of these cores are illustrated in Chapter 4 under the respective well Sections. Aside from a few with associated debris beds they show only a single reef or mound facies hence their depictions as single points. Those dominated by thrombolite and/or automicrite often termed mud mounds show interesting lateral changes on the shelf slope with further subdivision using another ternary diagram (Figure 5.16 modified after Schmid et al. 2001), and discussed in Section 5.4. The two succession cores show a variety of reef/mound facies briefly discussed in Chapter 4. West Venture C-62 and off-setting #9 Limestone well cuttings (Section 4.01) within deltaic terrigenous sediments enhanced the understanding of Cummings and Arnott's (2005) shelf margin delta interpretation. Margaree F-70 was one of several pinnacle wells occurring at the Abenaki platform margin (Section 6.09) that showed upward changes from coral reefal beds to sponge-rich beds and in the longest Abenaki core show that facies change.

- 5.2 Comparative Carbonate Sedimentology of Contrasting Carbonates (Core Stories)
 - -West Venture C-62: Sable Intra-deltaic, Ramp, Shoaling, Thin Limestone
 - -Margaree F-70: Abenaki Margin, Platform, Pinnacle, Deepening, Thick Carbonate

Two cores each show a succession of different reef, non-reef and microbolite mound depositional settings. Both are relevant to addressing the thesis problem on potential delta effects on carbonates and to clarifying features seen in cuttings. They also are end members of carbonate deposition from very thin ramp limestone encased in deltaic siliciclastics to thick platform margin of pure carbonates. The thin #9 Limestone of the shelf-margin deltaic Venture gas field is encased in terrigenous sediments yet still has oolitic facies in nearby correlative limestones. Margaree F-70 at the north part of the Deep Panuke shelf-margin-reef gas field shows a succession of different reefal and non-reefal sub-environments that appear to become increasingly under the influence of deltaic input higher in the core and well. Margaree F-70 was one of several pinnacle wells occurring at the Abenaki platform margin (Section 6.09) that showed upward changes from coral reefal beds to sponge-rich beds and in the longest Abenaki core captured that facies change. West Venture C-62 and off-setting #9 Limestone well cuttings (Section 4.01) within deltaic terrigenous sediments showed both a variety of carbonate facies that are very relevant to understanding the nature and history of the surrounding siliciclastics.

The C-62 core is from thin limestones within the Sable Delta. The only other cores of near delta ramp limestones were recovered in Penobscot L-30 from thicker carbonate intervals. They were illustrated and discussed in Section 4.05. Topset flat-lying onlitic core with thin reefal beds (+10% chaetetids, and mainly stromatoporoids in cuttings) and foreset clinoform-slope core of depauparate thrombolitic bindstones illustrate other major facies characteristic of the intradeltaic and interbedded limestones adjacent to and capping prograding prodeltaic shales. Based on cuttings and supported by these cores, onlite is very common in the limestone interbeds of the shallowest limestones of the mixed system ramps with coral reefal limestones never becoming dominant or vertically continuous. Similarly sponge mound beds are also uncommon. Most ramp slope beds seem to be mainly thrombolitic mound facies and also the main facies in the relatively thin limestone succession of the C-62 core described in more detail below.

How the limestones relate to sequence breaks is arguable but often are considered to have formed during transgression and maximum flooding periods when siliciclastics would be trapped landward. But these assumptions need to be examined for at least two reasons. With the potential for deltaic lobe shifts there could be decreased local terrigenous sediment particularly when replacing carbonates often consist of shallow-water oolite. And with major deltas having greater

sediment supply regional transgressions may not be apparent. Similarly the assumption of limestones being correlative just because they occur in similar vertical and thickness patterns needs to be assessed against both seismic and depositional facies data. As discussed in Chapter 4 these considerations are critical to understanding the ramp and even platform carbonates of the Abenaki and equivalent Late Jurassic carbonates that show evidence of forming in different geometric and depth settings.

5.2.1 First Example - West Venture C-62 core #9 Limestone in Venture Shelf-margin Delta

This core illustrates the utility of thin carbonates to elucidate aspects of their host terrigenous sediments. Second it can be considered a small fractal model for what occurs at a large scale lateral to and in front of the Sable Delta with oolite on abandoned lobes laterally but turbid-water reef mounds in distal deeper water at the shelf edge in front of an estuarine-style delta during transgression and early highstand. It could be compared to the recently described turbid water reefs at the mouth of the Amazon River (Moura et al. 2016). Third and specifically, the core can be seen as a fractal model for the facies pattern elsewhere. This is seen in cuttings in the slope well Queensland M-88 sequences where slope limestones of microbolite, mostly thrombolitic with some local areas stromatolitic, facies were capped by thin sponge or deeperwater coral facies abruptly overlain by shales (see Section 4.11). Fourth, this thin limestone was part of Cummings and Arnott's (2005) Venture shelf-margin delta study in which they applied a sequence stratigraphic model with forced regression to the deltaic facies development history. The C-62 cores were seen as a series of stacked estuarine valley fills lateral to wells with less channeling (Figure 5.4D). Gould et al. (2012) interpreted less valley fill with greater continuity of the marine beds involving widespread river mouth turbidites. But in C-62 they also interpreted two thick estuarine valley fills (Gould et al. 2012, their fig.13). Cummings and Arnott (2005) mistakenly interpreted the C-62 #9 Limestone as a transgressive condensed lime mudstone but in fact it is much more complicated and interesting. Gould et al. (2012, Table 1) listed only oolitic and bioclastic (mainly shelly) limestones in their sedimentary facies. The cuttings interval with the C-62 core (Figure 4.2 and 4.3) is the basis of the maps in Figure 5.4A-C. The features of the facies succession shown by Figure 5.5-1 (C-62 core) is shown by closer views of important depositional features (Figure 5.5-2 to 5.5-7). Based on these, Figure 5.6 shows how the #9 Limestone augments the sequence stratigraphic model of Cummings and Arnott (2005)

#9 Limestone Lithologic Observations – cuttings and core: Lithology of the Venture Field area #9 Limestone was logged from cuttings in four wells, namely N-91, B-43, B-13 and H-22 and from core in C-62. Figure 4.2 summarizes those lithologies which are written as vertical

sections below their respective wells on the bottom of Cummings and Arnott's (2005) crosssection. Clean limestone varied from about five to 35m thick. The biota and Dunham texture (Embry and Klovan 1971) differed in each well with no single limestone lithology prevalent but all were dark to medium grey in colour. Limestones varied from a thrombolitic (minor stromatolitic) bindstone (seen in core only) and sponge-coral-stromatoporoid float-boundstone, to lithistid sponge only to peloid wacke/packstone, to argillaceous lime mudstone (marl), to peloid wacke/packstone, to argillaceous lime mudstone (marl), to oolitic grainstone with skeletalfragmental mud/wackestone the most common. In facies other than oolitic, *Tubiphytes* was always present and for cuttings only the lower sponge-stromatoporoid-rich interval in H-22 had significant (10-15%) thrombolitic textures. In Venture B-52 as shown in Cummings and Arnott (2005, Fig 5) about 100m of the lower Missisauga Formation is faulted out above and possibly includes some of the #9 Limestone. The limestone seen in about 10m of cuttings was mainly a slightly argillaceous lime mudstone or "micro-packstone" with a near absence of fossils (trace of Tubiphytes, bryozoa with pyritized thin shells and round peloids in a large chert chip) similar to the marl interval below the thrombolite in core 13 of West Venture C-62 but minor amounts of small black ooids did occur although they were most probably allochthonous. The deepest core in West Venture C-62 (Figures 5.5-1 to 5.5-7, Figure 4.3) has a succession of highly calcareous shales (marls) to limestone facies that include from the base upward –

- 1) an extremely bioturbated calcareous shale to marl lacking body fossils with ichnofauna possibly indicative of deep neritic-upper bathyal depths (e.g. *Zoophycos*),
- a massive marl (lime mudstone to very fine micro-packstone) with minor amounts of delicate articulated bivalves, sponge spicules and crinoid columnals,
- 3) a couple decimeter skeletal packstone-floatstone of varied broken fossil fragments including small colonial corals, sponges, *Tubiphytes*, crinoids, bryozoans that in places become microbially encrusted, possibly a storm-derived debris bed from adjacent carbonates that acted as a hard substrate for attachment of the next facies,
- 4) Four to five metres microbolite with stromatolitic and thrombolitic textures with encrusting and attached *Tubiphytes*, nubecularid forams and serpulid-terebellid worm tubes as accessories (only a few small lithistid sponges seen; this depauperate biota and microbial fabric are very similar to the slope microbialite in Penobscot L-30 core 2) upward some of the geopetally-filled cavities are quite large and have pendant coelobites,
- 5) transitional change to three to four metres of *in situ* mixed microbolite-skeletal framebuilders including branching and tabular microsolenid corals, lithistid sponges and lesser amounts of recrystallized, very fine textured, evenly laminated columnar

fossils interpreted as solenoporids (red algae) with bioerosion by bivalves and sponges very prevalent.

Complex intergrowth of the relatively small framebuilders and initiation on microbolite hard surfaces is common. The in situ growth and rare, still-articulated partial crinoid calyxes indicate quiet water conditions. Accessory fauna includes bryozoa, bivalves including some oyster-like, possible brachiopods, crinoids and similar microbolite micro-encrusters/accessories as in pure microbolite. This skeletal reef mound is abruptly overlain by laminated shale with an intervening pyritized capping interval that has some infiltration by shale and was likely a dysaerobic hiatal surface. That shale is the beginning of a shoaling shoreface section depicted on Figure 5.5-1 and **5.4D** (the latter modified from Cummings and Arnott 2005) as a prodelta claystone then delta front sandstones incised by estuarine-fluvial-deltaic channels. Although not the emphasis here, the core does show diagenetic features of note - pyrite is common in most facies, recrystallized zones have been partly dolomitized and others appear to be argillaceous pressure-solution concentrates with remnant 'refractory' calcite fossils not easily dissolved, like Tubiphytes, crinoids, and bryozoa. In the bottom of the C-62 well no petrophysical logs were taken but a core gamma was measured (shown with the schematic log in Figure. 5.5-1) and the least radioactive interval equates to the pure microbolite, with clay amount again increasing upward in the transition to the overlying microbolite-skeletal boundstone.

#9 Limestone Lithologic interpretations - Precursor limestone facies to incised **channels:** Core in C-62 provides the most comprehensive detail of the facies relationships. The core succession mimics on a much smaller scale, the pattern seen at levels considered sequence breaks in Queensland M-88 (3900m, particularly 4100m) where thick microbolite facies are overlain by thin deeper reef mounds then a sharp break to prodeltaic grey shale and in some cases even black shale. If only this core was available, without the data from the #9 Limestone cuttings of the other Venture wells, the interpretation of the succession would simply be a vertical sequence of facies, reflecting changing carbonate paleoecology, responding to decreasing then increasing clay influx affecting turbidity, nutrient and oxidation levels in a relatively deep shelf setting (see Figure 5.5-1 and also supporting Figures 5.5-2 to 5.5-7). As well, a probable change to increasing photic, conditions follows the reduced clay sedimentation, but then surprisingly is interpreted to continue as increasingly photic in spite of the reversal to an increasing clay influx that ultimately buries the carbonate reef mound in prodeltaic shale. Except for this last inference, either delta lobe switching or relative sea level fall could apply. But, given a thin facies succession interval of less than 8m and the argument that there was increasing light in spite of increasing clay influx, then the hypothesis of relative sea level fall must apply (or tectonic uplift), but not sedimentation (and/or carbonate growth) infilling the seabed thus raising it into the photic zone. Just as there are more facies in the limestone than Cummings and Arnott's (2005) original single "facies 1 - condensed lime mudstone," the scenario is more complex but fits and supports their depositional model of relative sea level changes (Figure 5.6 where the C-62 core is shown with their model and labelling). The potential existence of limestone implicit in their model is on the outer shelf during three to four of their six sea level stages. With organisms' sensitivity to their environment, changes should be expected and they do occur. The base of the cored interval starts during later transgression (TST- Fig. 8e) on an open marine relatively deep siliciclastic shelf indicated by the high bioturbation with Zoophycos ichnofauna (Figure 5.5-1). The near lack of macrofossils may indicate some stress, perhaps depth. Approaching maximum flooding (TST-Figure 5.6 e to MFS- Figure 5.6 a, see also Figure 5.5-2) clay supply is nearly absent but oversupply of nutrients continues with establishment of an upper slope to deep shelf, oxygen minimum zone with dysoxic conditions. This is interpreted from the loss of burrowers and with carbonate sediment supplied from the overlying water column and fines winnowed off adjacent shoals. There are probable silt-sized bioerosion chips from the skeletal boring by clionid sponges. The slow growth of only microbolite (MFS-Figure 5.6 a to HST- Figure 5.6 b, also see Figures 5.5-3 to 5.5-5) is initiated on a microbolite stabilized debris bed derived from a shallower setting with a great variety of invertebrates, including some small colonial coral clasts and lithistid sponges, but lacking really shallow water indicators like ooids. In spite of increasing influx of clays, the pure microbolite is gradually joined by deep-water sponges-microsolenid corals indicating more oxic or oxygen-rich conditions. The presence of other types of corals and especially the suspect solenoporid red algae indicate photic conditions prevail. These are most easily explained by significant relative sea level fall (falling RSL- Figure 5.6 c, or FSST- Falling Stage Systems Tract; see also **Figure 5.5-6** and **5.5-7**). This decrease in sea level produces a forced regression and influx of prodeltaic sediments that kill off the microbolite-skeletal reef mound in a dysoxic or even anoxic setting. This is shown by the high amount of pyrite and the abrupt top surface interpreted as a hardground with infiltered clays. Then the 'dead' limestone is buried in laminated very dark prodeltaic shale showing continued dysoxia. The clay mudstone coarsens and shoals upward into storm-dominated delta-front sandstones with evidence of incision and estuarine valley fill representing both the maximum lowstand tract and infill in transgressive system tract in the next sequence. The C-62 single well core interpretation is more complex when limestones in offsetting wells are included but can still be encompassed within the forced regression model.

Examination of the cuttings indicate the #9 limestone is neither solely condensed nor always in a deep-water shelf setting in the Venture area. Although generally thin, the thicker

limestones near or beneath overlying incised channels C-62 and possibly H-22 (where Gould et al. 2012 do not interpret a valley fill channel) are deeper-water reefal with possible microbolite admixtures. However wells B-13 and B-43 shown between and located more shelfward (north) had more ooids, cleaned upwards with B-13 having the shallowest, shoaling upward ooliticpelletal facies pattern. B-43 limestone had blackened small ooids, that may be allochthonous, capped by mudstone indicating decreasing energy, as also seen in the #9 Limestone, not faulted out in B-52, and not included on Figure 5.4D. It is representative of the lower #9 is argillaceous lime mudstone (micro-packstone) with a minor amount of small black ooids, similar to the marl below the microbolite in C-62 core. There are a couple of alternative explanations for the pelletal pack/wackestones in B-13 – either slope microbolite peloids or shallow shelf sediments, perhaps a lagoonal correlative to the B-43 oolite. The lack of cements, lack of Tubiphytes, lack of bryozoa and abrupt change to ooids without reefal beds, the shelf interpretation is preferred. The only other oolite was a basal five metres in H-22, possibly a transgressive interval or allochthonous debris. H-22 also had the thickest clean blocky outline on gamma logs with N-91 nearly as thick. Both have reefal intervals that were dominantly lithistid sponges in N-91 versus a mixture of lithistid and stromatoporoid sponges in H-22 that upward became fragmental-rich. A five metre limestone cap in both these wells was *Tubiphytes*-bryoderm (bryozoa-echinodermal) rich possibly indicating a flooding and/or nutrient-siliciclastic influx. The lack of many stromatoporoids in West Venture N-91 may indicate a deeper or more nutrient/clay-rich setting as compared to Venture H-22.

An interpretation (refer to **Figure 5.4D**) links the later stacked incised channel in West Venture C-62 and Venture B-52 and the underlying deeper-water carbonate fabrics and original depositional settings and depths. In contrast shallower more oolitic facies (Venture wells B-13 and B-43) on relative paleohighs and more shelfward would not become the locus of valley channeling later. Perhaps tidal influence in the Venture area siliciclastics interpreted by both Cummings and Arnott (2005) and Gould et al. (2012) is the main mechanism for water agitation for the oolite formation as well. Whereas deeper settings (C-62 and B-52), that also may have been a relative sink for clay and nutrient-rich currents perhaps in part as hyperpycnal flows (and deeps for periodic oxygen minimum zone occurrences), would favour filter feeders like sponges and stromatoporoids and sessile predators like microsolenid corals, as long as the currents were also strong enough to inhibit sediment burial. The gamma scan of the C-62 core (**Figure 5.5-1**) shows the lowest radioactivity in the pure microbolite facies and begins to increase slightly upward as reefal heterozoans and red algae also start to appear – indicating a greater tolerance of claysnutrients and/or increased yet limited photic conditions for the metazoans. In wells the #9

Limestone gamma curve shows gradational decrease at the base and abrupt increase at the top with replacement by prodeltaic shale (**Figure 5.4D**). It is also likely that the limestones in the B-52 and C-62 were buried by clay mudstone before the end of #9 Limestone sedimentation on the interpreted paleohighs or their non-channel upper slopes. When the lower versus upper #9 Limestone maps are compared (**Figure 5.4A & B,** also see comments in captions) there is an expansion of deeper water marly facies away from the channel area at C-62 and B-52 up onto the interpreted paleohigh reducing the area of oolite deposition.

Overall the #9 Limestone is not a condensed limestone, certainly not a lime mudstone, but rather a thin shelf carbonate starved of siliciclastics that mimics or "armours" the pre-existing siliciclastic shelf bathymetry. Thicker limestone, particularly since it tends to be reefal, may simply indicate a position further down the local ramp slopes (see schematic profile **Figure 5.4C**). A corollary of this second interpretation would be that only relative sea level fall and not local tectonic uplift would be the overall control; since a local tectonic/structural uplift to explain the inferred shoaling would not produce a low occupied by later channels. The mechanism for the topographic lows on the shelf could range from underlying salt movement, to previous submarine erosion of the shelf, to carbonate buildup on the shelf forming areas of subtle positive relief. The core contains the formation top of the MicMac. It is debatable whether the pyritized hardground surface in the core should be considered near a maximum flooding surface (MFS) and the switch over point to a regressive phase with the influx of prodeltaic shales above. Or, instead, the limestone succession with the change from microbolite carbonate mound to metazoan reef mound facies is already recording shoaling as interpreted herein and therefore the MFS occurs in the marls below or at the debrite bed. Somewhere in the interval a correlative conformity defining a sequence top may be lurking. Argument over nine metre intervals perhaps is not worthwhile but it does make one wonder about how to deal with sequence definitions that do not have core control and involve 10's to 100's of metres of only cuttings and petrophysically logged intervals.

In summary, this discussion opened with four interpretations for this #9 Limestone core and the cuttings. It is a possible analogue for facies patterns seen near the top of thicker sequences in the platform slope well Queensland M-88 and other microbolite-rich slope wells. It is significant since the C-62 core represents the end member with both the thinnest and most delta-proximal properties in a spectrum of carbonate slope environments that change laterally away from the Sable Delta and may be a small-scale analogue to the general pattern of ramp carbonates associated with deltaic siliciclastics near Sable Island and to the northeast. It is surprising that the #9 Limestone is locally oolitic. Cummings and Arnott (2005) reasonably interpreted it to be

condensed limestone in deeper water due to lack of siliciclastics during transgression and early highstand where the deltaic source of sediments had been pushed landward. But closer observation shows it is hardly, or at least only partly, the expected condensed deeper water lime mudstone sediment interpreted by Cummings and Arnott (2005). The succession of depauparate marl up to the varied facies of deeper water microbolite mound and then sponge-microsolenid coral reef mound indicates deeper water conditions becoming shallower. In offsetting wells this interval is oolitic or coral-stromatoporoid reefal. This shoaling up trend indicates relative sea level fall or forced regression as discussed, but in **Figure 5.5A-C** the lateral variation between wells and their relationship to the apparent main channel of the early Venture Delta may be an analogue for thicker and more widespread Sable Delta terrigenous-associated ramp limestones.

There are deeper water mound facies in front of the main channel, identified by its 'reentrant' pattern on the maps, that later form an incised valley, river mouth or estuary (**Figure 5.4D**) hence may be seen as an earlier distal setting perhaps shelf-edge setting. During what may be the lowest influx of fine siliciclastics, identified by the cleanness of the gamma log, the microbolite (thrombolitic) mound was present. As the clay influx increased upward heterotroph framebuilders such as sponges and microsolenid corals start to take over and red algae indicating low light in the turbid waters. Then carbonate growth was buried with the influx of prodeltaic sediments possibly preceded by a hardground and earlier submarine drowning. Laterally the oolite shoals are surprising if this is part of a maximum flooding event that pushes the terrigenous sediment shoreward. Alternatively this may indicate delta lobe abandonment. But presence of the overlying deltaic succession does not support this unless it was short-lived below stratigraphic resolution (see Section 5.3-4 for lobe-switching model).

Whatever the sedimentological-stratigraphic explanation – forced regression, lobe switching or some other – even at this small vertical scale the terrigenous deltaic sediments are interbedded with carbonates of two major types, oolite and reef mounds. The *in situ* reef mounds are also of two types – microbolite bindstones, perhaps of a slope, in deeper water and sponge-coral boundstones in somewhat shallower water. It is intriguing that a rare example of a subtidal microbolite in the form of stromatolites in the Early Jurassic of Portugal's Lusitanian Basin outcrop (Azeredo et al 2010) also occurs sandwiched in a shale and marlstone section though not considered delta associated. Water restriction behind shoals was offered as a possible explanation for the thin solely microbial interval but perhaps the nature of the turbid water itself may explain both occurrences of pure microbolite.

A possible analogue and a big surprise is the long narrow reef tract recently described along the edge of a wide continental shelf off the mouth of the Amazon River (Moura et al. 2016). The main reef framebuilders are rhodoliths and large sponges with much lesser amounts of coral. These red algae and sponges are more prevalent in front of the main axis of the estuarine river mouth, in turbid waters, with the corals becoming more common to the southeast. To the extreme southeast side, two shallow-water reefs occur. This is the up-flow end of the strong northeast trending North Brazil Current with the huge river plume pushed to the northwest (Moura et al. 2016, fig. 1A). A smaller scale modern and Miocene example with a similar current controlled pattern occurs in the Mahakam Delta but with coral reefs (Wilson 2005, Wilson and Lokier 2002) and at the base of some reef even microbolites. Pretkovic et al. 2016 called such features 'microbial,' either large mega-oncoids or domes with associated red algae. So there is a similarity with the Late Jurassic, at least for sponge reefs and the change from coral to sponge prone, (and microbolites in the Mahakam). But of course the Amazon reefs are in deeper water and oolites are lacking. Indeed oolites are lacking worldwide near major deltas (see Appendix A2), but during the post-Pleistocene transgression relict oolite is recorded northwest of the Amazon on the continental shelf (Milliman and Baretto 1975), near the Ganges (Nageswara Rao et al. 2005), and elsewhere (see Appendix A2). The necessity of reciprocal sedimentation to get mixed carbonatessiliciclastics seems to be in at least a little doubt. Apparently they can be contemporaneous though still somewhat separated if the right local conditions of favourable currents and resilient framebuilding organisms are available to allow interfingering.

5.2.2 Second Example – Margaree F-70 Core Abenaki Platform in Deep Panuke Field

The longest core (24 m) taken of Abenaki carbonates comes from Margaree F-70 and is also Deep Panuke field's main source of rock-based reservoir data including fracture measurements. Much of the discussion here and in Section 4.09 is based on Eliuk's contribution in Wierzbicki et al. (2005) and the Encana (2006) development plan. Seismic (**Figure 4.32A**) and a schematic well and core log (**Figure 4.36**, detailed cuttings litholog in **Figure 3.2**) were discussed in Section 4.09 of pinnacle buildups encased in margin carbonates. Therefore Margaree F-70 is not a typical reservoir well for the Deep Panuke field to the south which are laterally quite correlative (**Figure 4.53**). The well produced gas and the long core demonstrates an apparent deepening-upward sequence that displays a series of depositional facies of reef types with framebuilder fossils derived from reefs or thin reef developments on an interpreted slope as shown on more detailed schematic core log. (See **Figure 5.7-1**, and Appendix A3 for the detailed litholog with the percentage framebuilders). Since the uppermost Abenaki limestone becomes slightly more argillaceous, and even before that lithistid

sponges dominate the cuttings, the succession may result from a change to not just deeper waters but more turbid waters, reduced light penetration and consequent changes in biota. This can be seen as evidence for the distant effects of the enlarging Sable Delta.

Set within an Abenaki section lithofacies transition from dominantly cleaner dolomiterich carbonates up into slightly argillaceous lithistid sponge-rich limestone, Margaree F-70 core #1 (3434-3458.7m) also captures a depositional facies transition in reef types and water depths (and/or nutrient-argillaceous content) that increase upward. Jurassic-earliest Cretaceous carbonates show three reef and reef mound type end members (**Figure 5.3**) and aspects of all three types are present in Margaree F-70. The core has four reef intervals transitional between the three end-member reef types. Based on F-70 cuttings analysis, the mainly argillaceous-carbonate mudsupported limestone of the upper Abenaki (sequences AB7 and AB6) are interpreted to be dominantly forereef slope with intervals of thin deeper-water reef colonization (see **Figure 4.36**). At the base of the core, the reefs are a mix of corals, coralline sponges (stromatoporoids-chaetetids) and lithistid sponges with a progressive decrease in corals then stromatoporoids, leaving only the lithistid sponges up section. Tentatively the AB6 U versus AB6 L transition can be placed about 3360 m where there are mainly sponge-rich beds above but coral and stromatoporoids are mixed with lithistid sponges below. A reworked surface was seen in a sidewall core at 3374m.

The lack of even derived oolites as parts of slope debris in the whole section supports the seismic evidence that the Margaree F-70 drilled on the 'back' or bankward-side of a margin-edge build-up and penetrated material shed in deeper water on the northwest side of a local pinnacle or raised rim. In sequence AB5 there is a decrease in sponge and microbial content and in sequence AB4 there is an increase in dolomite to 100% in the bottom 100 metres. The presence of abundant crinoids at the top of sequence AB5 indicates slope deposition continued interbedded with increasing amounts of coral and stromatoporoid reef or reef-derived sediment downward. This depositional facies is problematic and in the dolomitized sections in lower AB5 and all of AB4 are inferred to be reefal or at least shallow-water carbonate bank. Margaree F-70 demonstrates the litho- and depo-facies transition of the Abenaki section (**Figure 4.36**.)

Here the long core is reviewed using **Figure 5.7-1** schematic log with photographic illustrations for an upward trend (**Figures 5.7-2 to 5.7-6**). Core #1 shows the dolomite-to-limestone and depositional facies transitions. The limestone intervals are reefal except for three metres of well-cemented normal-graded crinoid-rich slope debris beds, which are interpreted as a channel with possible submarine cement near the core top (**Figure 5.6-3C and 5.6-4**). The thick dolomite intervals

are interpreted as proximal forereef slopes with debris from a shallower-water coral-stromatoporoid reef intermixed with minor slope material such as crinoids and bryozoa (**Figure 5.7-3B**). An originally porous finer sand matrix may have localized the dolomitization. During breaks in slope sediment supply, hardgrounds and framebuilder colonization occurred. For instance the still articulated body of an echinoid or crinoid calyx helps define one of these surfaces in the dolomite (**Figure 5.7-3A**). Platy or vase-shaped sponges and corals (**Figure 5.7-6C**) occur, broken *in situ* during burial. Some are seen in the dolomite and helped define sedimentation breaks (**Figure 5.7-1.**) If the breaks were long enough a deeper-water reef built up. Analysis of percentage framebuilder contribution (see detailed core log in Appendix A3) shows a progressive change that is interpreted to result from increasingly deeper and/or more turbid environment with greater nutrient-rich and argillaceous content that has the effect of increased depth if the organisms can adapt to the greater clays-nutrients. Thin shales or highly argillaceous limestone occur and may represent a significant break at 3440 m below the crinoid rich debris bed.

Starting from the bottom of the core, reef interval #1 in the basal few metres has 16% microsolenid hexacorals and 28% other large colonial hexacorals in a rudstone indicating shallowwater reef-derived or even storm-affected *in-situ* reef (**Figure 5.7-2**).) One coral is overturned. These rubbly beds are capped by a 0.5 m in-situ pure microsolenid coral reeflet. This is an example of Subfacies 4B (Table 3.3), the "microsolenid coral and sponge reeflets and mounds" which are relatively rare in the Abenaki probably due to their thin development and small constituent in the cuttings samples. The next limestone reef interval #2, above a thin crinoid-rich possibly transgressive lag limestone, has less hexacorals (15%) and microsolenids (8%) but more stromatoporoidschaetetids (21% collectively coralline sponges) and lithistid sponges (14%). Capping the thick foreslope dolomite bed with its increasing number of sedimentation breaks is a microbolite crustsponge-microsolenid coral reeflet #3 (0.5m thick and 12%, 15% and 11% respectively). Of the colonial hexacorals, microsolenids range into deeper and more turbid waters. At the top of the core a microbolite-lithistid sponge reef #4 with scattered microsolenids (16%, 21% and 9% respectively) form complex consortia with early-cemented high depositional angles and possibly structural dip due to later whole section rotation (Figure 5.7-5 and 5.7-6D). Rarely solitary corals or broken Thamnasteria are present (Figure 5.7-6A). Locally there are crusts of lithistid sponges overgrown by sponge-microbolites (poorly developed thrombolitic-stromatolitic) capped by bioeroded tabular microsolenid corals. Taken as a whole these changes indicate progressively deeper and possibly more nutrient-rich water upward, recorded over the cored interval. The presence of reefing periods on the slope indicate that the forereef slope is not just a sediment sink but supplied significant amounts of

sediment. The water was quiet enough and the slope sediment stable at times, so that the seafloor could be colonized by reefal metazoans or microbolites.

The seismic, cuttings and core support the interpretation that the Margaree F-70 drilled the flanks of a carbonate encased pinnacle buildup. Much of the core is dolomitized but original depositional fabric is discernable and most of the dolomite was originally grainstone with areas of larger clasts and fossils including larger coral fragments. There are surfaces of in situ fossils and thicker intervals of reefal development, often slightly argillaceous limestone. Although not taxonomically analyzed, percentages of major framebuilding groups showed an upward increase in lithistid sponges with associated microsolenid corals becoming less common after starting with robust colonial hexacorals. This represents deepening and encroaching of fine terrigenous matter upward and/or the buildup was retreating laterally perhaps unable to produce enough carbonate due to a shallow water area too reduced for vigorous growth. Those more argillaceous limestone beds became part of the seal for the dolomitized underlying grainier rock, prone to greater fracturing even better than in vuggy dolomite (Wierzbicki et al. 2005). So the changing ecology of the framebuilders responded to the effects of the encroaching Sable Delta and produced conditions within the Deep Panuke area for future reservoir development with porosity mainly the result of later dolomitizing fluids sourced along fractures and following more permeable layers produced during deposition.

In summary of the two cores, the West Venture C-62 #9 Limestone and the Margaree F-70 are exceptional both in length and variety of major facies changes recorded. They strongly support the important influence of the delta on carbonates whether within the delta in an apparent shoaling sequence of a thin limestone or the platform in a deepening sequence of carbonates increasingly affected by terrigenous fines and nutrients. The cores also demonstrate the information derived from fossil-rich limestones then applied to cuttings data.

5.3 Problem #1 - Nature of Juxtaposition and Abenaki Platform-Sable Delta Transition With Mixed Carbonates-Siliciclastics in Ramps Lateral to Delta

Publications (see Chapter 2. **Figure 2.3** and Appendix A1) document the coexistence near Sable Island of a thick carbonate platform proximal to and progressively bisected by a large delta in the Late Jurassic-earliest Cretaceous. There is a change in geometry to ramps interbedded with the siliciclastics laterally and ending in burial of much of the carbonate platform. Limited well control leaves questions as to where the continuous Abenaki platform ends on the southwest flank of the Sable Delta. Some well control and a very mappable reflector (top Scatarie, J-163 of the

PFA study, OETR 2011) show that carbonates older than the thick Abenaki/Baccaro bank are present under the Sable Delta at least in the updip areas in the Abenaki Subbasin. However there are alternative late platform-delta relationships for the overlying platform (**Figure 5.8**). Two alternative delta-carbonate margin depositional relationships are shown – burial (**Figure 5.8A**) and envelopment (**Figure 5.8B**). A third is reasonable – the absence of continuous carbonate platform between the Penobscot L-30 well and the northeast end of the platform northeast of Marquis L-35, where Eliuk interprets a separating channel in Section 4.02. Similarly Qayyum et al. (2015, see **Figure 4.13**) used 3D seismic to interpret an isolated atoll just west of Penobscot L-30. These interpretations are not mutually exclusive but rather imply a major change in shelf margin trends and bathymetric profiles.

Figure 5.8A illustrates the platform buried by the delta or, more likely, as finally overriding an earlier channel separating the platform from the Penobscot area. In Figure 5.8B the carbonate margin and a narrow platform continues growth while being enveloped but not buried by the deltaic sediments. South of Penobscot, deltaic sands and less common ramp-like oolitic carbonates localized by the basin-filling prodeltaic shale produce a major basinward swing in the northeast shelf edge. The models and maps developed for the PFA OETR (2011; Figure 2.4) capture much of this progressive change but perhaps skip a map step and a depositional model that would cover the combination of deltaic-carbonate ramps as seen in Penobscot L-30 and South Desbarres O-76 (latter well omitted in their Chapter 9 study). The switch from a vertically aggrading platform to overlying progradational ramps is seen on seismic and is supported by uppermost Abenaki stratigraphic styles of oolite-sandstone couplets as far southwest as Marquis L-35 (see Section 4.06, Figures 4.20, 4.21, and 4.22) but not much further southwest (absent in Figure 4.23 seismic and Cohasset L-97, Figure 4.24).

Problem #1 asks how and why the carbonate platform and delta co-existed for such a long time. Possible controls on mixed carbonate-siliciclastic systems are listed in **Figure 5.2** with an Abenaki platform/Sable Delta depositional block diagram set (**Figure 1.4** after Eliuk 1998). Most of the list is appropriate explanation for the interbedded nature of limestone and shale/sandstone typical of the near-delta ramps and Abenaki-MicMac northeast of the delta. The possible relationships of carbonates on terrigenous clastics are shown in an age-equivalent example schematic **Figure 5.1B** (Leinfelder 1997) but the model has limitations as analogue being a small rift subbasin, in an arid climate, similar to reefs along the margin of the modern Red Sea. When limestone is very thick on the order of 1 to 1.5 kilometre with only thin or no interbeds of siliciclastics, then only isolation or separation by some form of barrier is an adequate explanation. This postulated gap is thought to be a long-continued channel or deeper water separation possibly

maintained by deltaic loading. Onlapping relationships particularly of basinal shale along the carbonate slope, should also be considered near the end of Abenaki deposition, close to the delta, (middle sketch **Figure 5.2**) where drowning could be load-induced or some other relative sea level event, probably after subaerial exposure. Addressing a solution to problem #1 can be explained by 1) the various types of non-platform carbonates in or near the Sable Delta, 2) shales that onlap the carbonate platform slope, and 3) the ages of the top of the Abenaki platform lateral to the delta.

5.3.1 Carbonates Proximal to the Sable Delta – a Partial Solution to Problem #1:

The Abenaki or equivalent carbonates near or amongst Sable Delta siliciclastics is expressed in a range of parameters from thickness, to interbedding of major lithologies. A comparison of five wells in the Sable Island/Penobscot area shows this variety. The first is from a fortuitous core of a thin limestone (Section 5.2 – the Venture #9 Limestone), presented as an extreme end member that illuminates the occasional tolerance of siliciclastic input by limestone building organisms. These environmentally-sensitive creatures yield useful information on their environment. On the other data extreme, the remaining four wells' intervals are compared over much thicker sections based mostly on cuttings evidence. They also show a lithologic linkage to seismic morphology of ramp, platform and inferred salt-generated-high carbonate shoals at Abenaki J-56 and maybe a salt-generated-high atoll at Penobscot L-30. With limited well control the application of Walther's Law, or its reciprocal, may be needed at a formation scale and can be applied to most of the platform margin wells at a 2nd Order sequence scale and avoids differences of opinion on sequence placement. Walther's Law (Middleton 1977) states "Only those facies and facies areas can be superimposed which can be observed beside each other at the present time." Assuming no major unconformities and appreciating but ignoring that almost all stratigraphic sections have many gaps hence making sequence stratigraphy possible (see Appendix A1), the law allows geologists to 'reverse engineer' the well column to interpret and compare the lateral depositional environment.

5.3.1a Thin Limestone in the Venture Shelf-margin Delta Compared to the Thick Platform Limestones - #9 Limestone West Venture C-62:

The supposed condensed #9 Limestone at the top MicMac Formation in the Sable shelf margin delta is the end-member for small size and has significant associated terrigenous clastic content. In nine metres of core, depositional facies changes from depauparate marl to microbolite (thrombolitic) mound up to lithistid sponge-microsolenid coral-red ?algal reef mound Sections 4.01 and 5.2). This was abruptly terminated by a hardground and dark prodeltaic shales - possibly the only sequence break, a correlative conformity, visible in core. Well cuttings showed the #9

could be oolitic and may document a forced regression with marked depth variations over a small interval. A thin limestone will not be conspicuous on seismic like the other four wells in the area, but does show the ability of carbonate facies to co-exist in the delta for a very short geologic time and not be easily detected. These would not be mistaken for a carbonate platform or development of ramp carbonate but do give insights to thicker limestones seen only in cuttings.

5.3.1b Facies and Accessory Fossils –Ramp Versus Platform Rimmed and/or Sheltered Morphologies in Abenaki J-56 to Penobscot L-30 (Distally Steepened Ramp or Salt-cored Shoal and Atoll Capped by Ramps) versus Kegeshook G-67 to Marquis L-35 (Platform Wells Capped by Ramps)

The basic assumption is that rimmed and unrimmed platform shelves have sharply differentiated lateral facies, whereas ramps will show greater intermixing of sediment and depositional environments with even slight changes in relative sea-level. This is seen in their vertical facies as uniform versus mixed lithologies. Figures 4.16, 4.17, 4.20B and 4.21B show the geometry on seismic for these two wells and Figure 5.9 presents the 2-well sections together. **Table 5.1** compares interpreted aggrading with overlying prograding facies settings. The G-67 to L-35 wells are close in dip direction with a single seismic line nearly through both; J-56 to L-30 project to a similar relative position but are three times further apart with J-56 closer to the Sable Delta depo-centre and overwhelmed by siliciclastics prior in age to top carbonate in L-30. Significantly, Abenaki J-56 differs from the other three wells and most Abenaki wells in lacking sequences, or having no obvious sequence breaks (Figure 4.16A), or indicative lithologic patterns. Its position in a thinned Abenaki on the flank of a salt dome (Figure 4.16B) indicates a completely different setting and control on its depositional history. It is in the table as nearly the only well control available in the interior. Dover A-43 (not included in this cuttings study) is 20km northwest of J-56 with half the thickness of mainly oolitic limestone and even more interbedded sandstones (PetroCanada well history report, CNSOPB). Table 5.1 and Figure 5.9 show lower G-67, lower L-35 and L-35A, and limestones of lower L-30 with thick uniform carbonate lithofacies of markedly different origin, consonant with a rimmed platform interior, to margin to slope transect. However above the black arrows (Figure 5.9), the mixed lithofacies of thick sandstones and oolites with thin framebuilder biostromal intervals have little relief especially in L-30 and fit best on a ramp. In J-56 the upper interval is mostly deltaic siliciclastics and the lower interval has a surprisingly thick interval of oolite with large amounts of thin sandstones and shales. Perhaps J-56 is a salt-cored paleohigh with an oolitic shoal close to coarse deltaic influx but high enough to avoid being overwhelmed by siliciclastics. The shoal may have been

aggradational. The thin nature of the J-56 Abenaki section compared to L-35 and Panuke Trend wells further southwest supports such an interpretation of Late Jurassic allochthonous salt growth.

The much greater thickness of L-35 Abenaki and initial lack of sandstone support the existence of a barrier between the delta and L-35. This could be the Missisauga Ridge an open channel. Unstable substrate could have allowed fault and subsidence thickening at L-35. (**Figure 5.11** thickness of L-97 and L-35). The L-35 is surprisingly thicker, even given the loss of carbonate section at the top of Marquis L-35, because of a change to siliciclastics of the same age closer to the delta. L-35 did not reach the Misaine Shale by +200m. Reasonably it can be interpreted as a carbonate platform easily able to keep up with subsidence caused by loading and associated normal faulting due to the Sable Delta.

Abenaki J-56, the formation namesake but not the type section well (Oneida O-25), is an anomalous choice to represent the Abenaki carbonate platform given its proximity to the Sable Delta with unusually high amounts of intermixed siliciclastics near the end of the Jurassic, coupled with the possibility it is not continuous with the platform to the southwest. It is dominantly onlitic with quartz nuclei and thin sandstone interbeds with reefal facies suppressed perhaps by proximity to the nutrient-rich and turbid delta. Although usually shown as the termination of the carbonate bank, it is not interpreted as that here. In addition, the separation of J-56 and L-30 is such that the margin that appears on seismic just updip of Penobscot L-30 may not relate well to J-56. Both wells are considered to be developed on underlying early salt swell highs isolated from the southwest Abenaki platform.

Lack of biostratigraphic control or consensus, and questions of identifying any sequences such as in Abenaki J-56 and then of correlating them accurately, as well as being based on cuttings, necessitated this more general comparison using location in relative paleogeography and position in seismic morphology (interior/margin/slope or proximal/distal and topset/foreset). No exact correlation or age equivalency is implied but depositional patterns can be seen. The same is true of Penobscot L- 30 and South Desbarres O-76 (see **Figures 4.14** for the wells; **Figures 4.7** and **4.8** for the seismic) that show the expected gradual change in the topset ramp pattern and the same microbolite (thrombolitic) facies in the foreset distally steepened section. Giving in to the temptation to correlate these beds based on their same facies, similar thicknesses, and relative position would be wrong as seismic shows they are completely separate clinoforms.

5.3.2 How the Prodeltaic Shales Onlap or Interact with the Platform Slope Comparing Margin Transects and Shelf Margin Wells (Second Part of Solving Problem #1)

Wells with side-tracks in the nearest margin well (Marquis L-35 and L-35A; Figure **5.10A**) and the third nearest (Dominion J-14 and J-14A; Figure **5.10B**) to the Penobscot area complement the seismic and show near-well variation at the margin. A dip transect (Figure **5.10C**) of proximal shelf interior oolitic (Panuke F-09) to margin reefal (Panuke M-79) and reefproximal forereef (Demascota G-32 projected) and off-bank distal slope to shale (Queensland M-88) allows comparison of lateral depositional facies to show variation in the Deep Panuke gas field that defines Abenaki margin models. The field has two side-tracked wells (M-79A and PI-1B) re-drilled to find gas and dolomite porosity in the usual reservoir level of Encana sequence Ab5 when dolomite and porosity occurred below the gas-water contact in the underlying sequences (see Figure 4.51, 4.53 and 4.57). This great variability reflects both the complex burial diagenesis responsible for the reservoir and the original depositional variability of irregular buildups and intervening channels or lower areas. Two wells in Deep Panuke likely drilled the inboard flanks of pinnacle reefs encased in carbonate as shown by dip meter logs with a landward dip of proximal forereef beds – MarCoh D-41 and Margaree F-70. Margaree F-70 has a long core where dolomite beds were interpreted to be forereef sands with many thin reefal intervals remaining as tight limestone possibly due to early cementation on the seafloor (Eliuk in Wierzbicki et al. 2005; see Sections 4.09 and 5.2). Along with Margaree F-70 and MarCoh D-41 in the Deep Panuke Field, Demascota G-32 based on seismic (Figure 4.32B) could also be interpreted as testing a small reef pinnacle or buildup at the margin and again on the inboard side. All three wells are similar with a near absence of oolite suggesting their small areal extent, unlikely to become restricted enough to form an ooid shoal. In addition any down-slope allochthonous ooids would by-pass these reefal highs. The single occurrence of ooids in the uppermost Baccaro of Demascota G-32 (Figure 4.35 or 4.37) amongst argillaceous limestone and shale is likely allochthonous after the pinnacle was buried and sponge mounds started forming. Similarly the rare ooids in the slope well Queensland M-88 are too deep for in situ growth and have been carried down slope at maximum regression marking sequence boundaries (Figure **5.10**C above Ab4 and at Ab6). The seismic (Qayyum et al. (2015, see Figures 4.23 and 4.38) interpretation of a periodic separation during deposition of the margin and shelf interior carbonate sediments immediate behind the margin supports the isolation from the main platform in these pinnacle wells. This seismically interpreted separation was shown as a re-entrant low on maps at the northeast end of the Deep Panuke Trend by Encana (2006, their fig. 2.55 shown as Figure A1.15 and partially shown on Figure 4.51). It may also be reflected in Eliuk's idea of a double flexure along the Panuke Trend platform with an inboard (oolitic) bank flexure and a deeper outboard (reefal) margin flexure (Eliuk 2004, Fig. 3).

Platform margin wells tested nearer the Penobscot area also show rapid lateral variation but relatively thick uniform vertical facies development. In Marquis L-35 (Figure 5.10A) after an initial basal reefal development microbolite distal forereef limestones shoal up to reefal beds that end in oolite and then mixed oolite and sandstones. This is the furthest south control on the presence of Abenaki-capping onlite and sandstone development. All wells at the margin to the south are capped by lithistid sponge-rich argillaceous limestones and shales. L-35A drilled basinward of L-35 showed randomly developed small coral-stromatoporoid buildups indicating irregular platform topography. Again there are capping sandstone and oolite beds interpreted to extend into the basin over prodeltaic shales that infill it at Penobscot L-30. In contrast at Dominion J-14 (Figure 5.10B) the Abenaki is capped by lithistid sponge-rich beds. This is the first and most northeastward occurrence of thick interbeds of shale with that carbonate facies. Beneath that shale Dominion J-14 drilled the forereef slope of the carbonate bank in microbolite slope facies similar to those of the Queensland M-88 (or lower Demascota G-32) that were then buried in prodeltaic shale that gradually shallowed enough that sponge reefs could colonize up to the level of the Abenaki platform. The side-track J-14A, drilled nearly horizontally to the south, found almost a kilometre of platform margin reefal beds composed mainly of stromatoporoid coralline sponges plus some lithistid sponges and lesser amounts of hexacorals and microbolites indicating a shallow-water reef complex interbedded with deeper facies of proximal slope at the platform margin. These wells lacked significant carbonate reservoir development. Lack of reservoir at Dominion J-14 and presence of shale at the margin is problematic. On seismic the presence of low-velocity shale could be mistaken for a low-velocity porosity notch such as occurred and was drilled in the Deep Panuke field (Section 4.10). Although not illustrated in their report (OETR 2011 PFA chapter 9; Stefan Doublet pers. comm.. 2011) the 3D seismic survey over J-14 showed a connection of the shale with slope reflectors northward whereas the operator Encana mapped the shale interval as an unconnected pod, interpreted and drilled as a porosity anomaly (Rick Wierzbicki, pers. comm.. 2007). Obviously the interpretation of the drilled anomaly was difficult, and hind-sight is always easier, but there is reason to expect geometric criteria to separate and identify alternative interpretations before deciding to drill.

The occurrence of shale flanking the platform is seen in three wells: Dominion J-14, Queensland M-88 and Demascota G-32. With Penobscot L-30, the shales below the uppermost thick carbonate are stratigraphically lower and older from north to south even though M-88 and L-

30 were drilled on the slope off the shelf margin. This is as expected for provenance from the Sable Delta. Except perhaps for G-32 the shales have a slope onlap surface relationship and are not contemporaneous facies equivalents to the adjacent platform. In Dominion J-14 interbedded shale occurs much higher than in Queensland M-88 slope well for the same age/sequence (Figure 5.10B versus 5.10C). This also demonstrates a wedge of prodeltaic shale from the Sable Delta. Mapping in the PFA Chapter 9 carbonate play (OETR 2011, their plates 9-7-8, -9, -10 and composited on Figure A1.19) showed progressive southward shale infill and progradation of ramps (the sandstone and oolite couplets of Figure 5.9) obliquely in front of Marquis L-35 and Penobscot L-30. This prodeltaic shale on the platform distal foreslope and adjacent basin could have caused loading that depressed the margin. If already stressed and perhaps not recovered from an exposure event such as the NBCU (Near Base Cretaceous Unconformity) the carbonate platform might have slowed growth so that the lithistid-rich argillaceous limestone replaced the drowned shallower facies of the shelf margin.

5.3.3 Age of Top Abenaki Carbonate Along the Margin and the Margin Wells in a Regional Abenaki Section - Penobscot L-30 area to Panuke Trend Margin-slope (Third Part of Solving Problem # 1)

Regional correlations may be used to infer similar porosity-associated events or particular facies that might be targets or analogues for exploration. Penobscot L-30 appears to preserve slope beds from a bank or atoll. A distally steepened ramp lacking a carbonate shelf edge updip is less likely though still reasonable. Penecontemporaneous tectonics adds further complications (Sections 4.02 and 4.05). Biostratigraphically data and/or correlation demonstrate whether the top of the Abenaki is diachronous becoming older toward the delta. Correlation arguments (Figure **5.11** uses PFA Chapter 9 -OETR 2011 well logs show an alternative sequence scheme to Encana's included on G-32 and M-79). See Figure A1.20 for a compilation of the PFA version of well correlation to L-30. Unfortunately L-30 was not re-dated or reanalyzed. On Figure 5.11 Eliuk's lithologic columns for Demascota G-32 Penobscot L-30 and South Desbarres O-76 have been added. O-76, a key biostratigraphic well in PFA Chapter 3 (OETR 2011), was omitted in any form in PFA Chapter 9. Eliuk placed part of a figure from Venture field by Cummings and Arnott (2005) at an inferred biostratigraphic datum and finally put on the location of the regional Shell biostratigraphic marker for Demascota G-32 and Penobscot L-30 (Eliuk 1978, Given 1977). Top Abenaki carbonate is shown by the dashed blue line and is diachronous becoming generally older to the north with the greatest change at the margin between Cohasset L-97 and Marquis L-35. Together they show that top carbonate in Penobscot L-30 correlates to near the top of Encana's Ab5 and PFA's SB6 (OETR 2011).

The Deep Panuke gas reservoir level correlates to Penobscot L-30 that has an entirely different facies of prograding tight oolitic limestones and somewhat porous quartz sandstones. If a well were drilled at possible margin just updip of Penobscot L-30, it would probably test a similar stratigraphy to the topmost beds drilled in Marquis L-35 (Figure 5.10A) which had mixed oolite and quartz sandstone. However, as shown in Demascota G-32 where the main porosity development (dolomite with lost circulation intervals) was much deeper in the underlying Ab3, deeper potential reefal intervals in a Penobscot margin would be correlative to the G-32 reservoir level assuming Penobscot was a pure carbonate atoll or continuous with the Abenaki platform to the southwest. Flexure lineaments whether at shelf edges or prograding ramps are always likely places for reefs and/or metazoan concentrations of various sorts to form. Whether they are porous would depend on the deep burial history of a Penobscot prospect. If in fact the area is affected by salt movement then it differs radically by what is believed to underlie much of the platform margin to the southwest. The Penobscot B-41 well near to Penobscot L-30 appears to be in a position to have tested a margin at Penobscot. But B-41 only drilled the uppermost 23m of Abenaki with cuttings of light grey, non-porous, partly onlitic limestone in the bottom 10m of samples (Shell Well History Report in CNSOPB Data Management Centre website).

Important sedimentological generalizations have been noted (Figure 5.11) for the wells as to paleogeography of reef and margin type and the depositional pattern for second-order sequences in response to relative sea-level rise using Neumann and MacIntyre's (1985) terms: catch-up (initial lag in carbonate growth so that the vertical section shows shoaling upward facies; could also been viewed as a progradational pattern), keep-up (carbonate sedimentation continues to keep pace so that section appears as a thick same-depth shallower facies; could also be viewed as an aggradational pattern) and give-up (carbonates do not respond rapidly enough to sea level rise so that a drowned condensed deep-water layer or/and replacement by fine siliciclastics occurs; could also be termed a retrogradational or backstepping pattern). While similar profiles can be generated by different histories, it does give a short-hand comparison of well-to-well differences along the margin. Figure 5.10 illustrates these vertical styles in more detail for most of the wells then Figure 5.11 displays the log columns. The locations of the two main types of platform-margin capping beds are indicated – sponge-capped or oolite-quartz sandstone with the latter also typical of ramp shelves. It is worth emphasizing that the term – "Artimon Member" - by definition applies only to argillaceous limestones rich in sponges with lesser shale interbeds and not simply to siliciclastic-rich carbonates such as the mixed oolite/sandstone beds typically nearer or on the delta.

Keep-up pattern is only seen in M-79 that likely resulted from being a paleohigh so that response to rise was very rapid. Many other wells after a basal oolite-rich regression/ transgression (equivalent to OETR 2011 PFA's SB1-Bac-1 event) were initially down the slope of the platform margin but grew into shallower depth facies resulting in catch-up. The distinct separation of the two Abenaki-capping facies associations may result from a lack of accommodation space in the case of the oolite-sandstone couplets due to lowered relative sea-level and associated progradation responding to Atlantic-basin scale tectonics, argued in OETR 2011 PFA Chapter 9. Alternatively the control may not be external but related to deltaic processes such as infill of the shelf and slope by Sable prodeltaic-deltaic sediments and/or shifting of deltaic lobes with slight relative sea-level changes allowing carbonate growth. In contrast the presence of argillaceous sponge-rich limestones and shales indicates a more distal deeper-water setting from the main siliciclastic input at the toe of prodeltaic sediment. Lithistid sponges adapted to survive or even thrive in more turbid and nutrient-rich waters than coral-stromatoporoid reefs. Even further away condensed beds and coated ironstones (Fe-oolites) appear to occur in starved shelf conditions (Eliuk 2010a, b; Eliuk and Wach, 2010).

5.3.4 Delta Models Relevant to Problem #1 – Delta-Lobe Switching and Dailly's Delta Loading

As outlined by Tipper (2003; 2008), scientific modelling has the twin goals of understanding and prediction. A scientist makes a model to express a particular set of ideas that then can be worked with. That model may be physical, numerical, graphical, verbal or even visual. Tipper suggested two reasons for modelling, "Either it may be hoped that experimentation with the model will help in understanding the structure and function of the parent system, or it may be believed that the model can predict how that system will behave under specified input conditions." Tipper believed a good model will 'talk back' as it is tested, becoming closer and closer to being logically identical to its parent system. A conceptual sedimentological and an isostatic loading model are applied to the Abenaki-Sable association.

Two simple models are outlined and may be linked. The first is my adaptation of the **delta lobe switch transgressive-regressive model** (Blum and Roberts 2012 after Penland et al. 1988) of a repeating cycle of delta abandonment and reoccupation developed for the Mississippi Delta with a capping carbonate added. It cannot be tested but can be compared to the Abenaki-Sable situation where carbonates are found as a component of the prograding delta complex.

The second model explains deltaic geometries and bathymetric troughs around depositional lobes of major deltas – the **delta load pendulum effect model** (Dailly 1975; 1976). Numerical modelling of 2D seismic data in the dip or shore-to-basin direction could be enhanced as done in 3D with new programs (pers. comm. Chris Beaumont and Sofie Gradmann; see Watts et al. 2009 Amazon study for an example). Yet Dailly's model can be applied to the Sable-Abenaki to account for a deeper water separation of the two systems as interpreted from subsurface data reviewed in Section 4.02. The presence of horst and grabens of various dimensions (see Appendix A2) may make loading effects locally variable as would the presence of thick salt. The bathymetric trough between delta and carbonate platform may migrate with delta growth and prodeltaic-shale loading of the slope in front of the shelf could depress the outer shelf. Such a situation could contribute to progressive drowning of the carbonate platform already compromised by turbid and nutrient-rich water resulting in condensed net accumulation in deeper water. Compensatory peripheral bulges might generate inner shelf highs and erosion.

The two ideas or models can be linked with the delta load pendulum model being the origin of a depression followed by a delta lobe switching and local transgression. Distally the delta depocenter load creates a deep on its flank initiating delta lobe avulsion and abandonment. This mechanism is different than the usual avulsion concept of building river levees so high above overbank deltaic plains that when breached fluvial switching occurs proximally by a change in the upstream main river channel location. The situation northeast of Sable Island is not an area considered in this thesis but these mechanisms might be particularly useful in explaining where the shelf prograded 30 km over a 200km front during the Late Jurassic.

The delta lobe switch transgressive-regressive (TR) model of a full cycle (Figure 5.12, modified Blum and Roberts 2012 after Penland et al. 1988) shows an active delta abandoned and undergoing transgression due to lack of continued sediment supply, keeping pace with sediment compaction and subsidence. Reworking by wave action produces a thin sand-rich barrier system with interdistributary bays behind. This is followed by submergence and isolation of the barrier system with continued shoreline retreat and ultimately an offshore sand shoal. Before reoccupation of the area by a new delta lobe, Eliuk's addition would have the offshore sand shoals evolve into sites of carbonate production, especially onlite since an offshore barrier or bars would likely have higher wave energy. Given highly-carbonate-saturated warm seawaters, part of the transgressive trend could be the development of an ooid shoal followed by associated carbonate facies like back-shoal peloid muds with shell accumulations, shoal-front reefs and distal-slope microbolite deposits. Note that this model does not require eustatic sea level changes except

perhaps a relative one generated by loading and sediment compaction. Neither a "transgressive sea level systems tract" for the back-stepping of siliciclastics and the creation of condensed carbonates, nor a "falling or low stand sea level systems tract" for replacement of carbonates by siliciclastics are required; just a large delta complex prone to delta lobe shifts. This could also be the mechanism in the Cenozoic as to result in "delta-top platforms," one of Bosence's (2005) eight carbonate platform types. Or the mechanism may happen just once when the paleohigh deposited by a basin-filling delta is drowned and attracts carbonate sedimentation. Given continued deltaic sediment supply with infill then progradation of a suite of overlying shallow water carbonate facies could occur.

Dailly's (1975, 1976) applied his **delta pendulum model** to the Niger, Mackenzie and Mississippi deltas. He cited Walcott's (1972) 2D gravity and flexural modelling of sedimentary basins at a continental-edge. In **Figure 5.13**, the creation of lateral depressions may cause the depositional axis to swing to the lateral lows from time to time in a pendulum fashion. He suggested sedimentological implications of such alternating depositional shifts might be more asymmetrical if there were preferred current directions so that fine versus coarse material was segregated. Keen and Beaumont (1990) showed 2D dip models for the Sable Subbasin and LaHave Platform off Nova Scotia. The presence of thick salt complicates the modelling further (see Appendix A2). Both Chris Beaumont and Sofie Gradmann (pers. comm. 2014) thought that Dailly's development of crustal depression and his 'moat' zone was feasible. Beaumont commented that at least in a dip direction in Nova Scotia the sediment supply was quickly filling any depression created and the crustal depression might be very broad. Watts (1989) argued that lithospheric flexure due to prograding sediment loads could be a source of coastal offlap/onlap and downlap aside from or in addition to eustatic or other tectonic origins commonly cited in sequence stratigraphy.

Just as Dailly suggested deltaic sedimentation consequences from his model, the effect of loading by a very large delta would also have consequences for carbonate sedimentation. For instance it potentially results in thickened sections with subsidence (see **Figure A1.22**) and as an isolating mechanism. It is speculated the area of the Sable Delta, including the area to the northeast on the Banquereau Bank was a major load that may have initiated a depression (Dailly's moat) for the northeast end of the Abenaki platform. Conceptually, Dailly's delta loading model has aspects of foreland systems with a foredeep near the load and a forebulge some distance away with the created basin variously under to overfilled (e.g. see fig, 2.64 in Catuneanu 2006) but obviously at a smaller scale and with greater relative sediment supply.

In summary the thickest Abenaki section penetrated by a well is nearest the Sable Delta in Marquis L-35. There are a number of thin areas, some even making the units inseparable, in the four Abenaki seismic map units on the Western shelf in the PFA Chapter 9 study (OETR 2011, PL. 9-7-9 to 9-7-11). These features could be seen as first, a reflection of carbonate sedimentation able to keep up with loading subsidence in a moat area for the thick L-35 and second, a flexural crustal uplift distally on the Western Shelf as thins in a forebulge response to the delta load. This seems like a testable mechanism though one complicated by additional salt tectonics associated with the Early Jurassic salt layers and in part have been shown with recent numerical modeling (Albertz et al. 2010, Albertz and Beaumont 2010; also see Appendix A2) and may warrant further investigation and testing.

5.3.5 Arguments for an Isolating Gap Between Delta and Platform:

Figure 5.14 (modified Eliuk and Wach 2014b) has delta and platform depositional block diagrams with features both data-based and postulated for an isolated gap to mainly explain the long co-existence of the Late Jurassic Sable Delta and the Abenaki platform. Arguments include sediment supply and loading effects of the delta as it progrades from the Abenaki Subbasin into the Sable Subbasin causing salt tectonics more locally and lithospheric depression more broadly. The gap area of separation is between the last platform well control and the Penobscot area as shown on Figure 5.8A. The main arguments on Figure 5.14 in numbers 1, 2, 3, and 6, are linked. Basinal sediment thicks in the transition area (see Appendix Figure A1.19 and J163-J150 isopach map of PFA OETR 2011) and updip lows including seismically indicated channels (Section 4.02) support the existence of a long-continued by-pass channel. That and other differential loading would generate salt cored paleo-highs that can become diapirs. These highs would act along with the basement ridges as another isolating mechanism that could focus terrigenous sedimentation around them. Initially the carbonate platform would both focus bottom-hugging fines away with only its distal deeper slope affected. Some salt paleohighs would be capped by carbonate shoals and atolls independent of the main carbonate platform. They might easily be mistaken for the northeast end of the main platform but a clue would be their comparative vertical differences (Walther-like application, see Section 5.3.1), thinning and related complex tectonics indicating sedimentation contemporaneous with salt movement up and/or down. The shale causing the loading on the lower slope in front of the platform would not initially affect shallow-water carbonate sedimentation. However the thick load might depress the shelf margin area so that pinnacle reefing (5) would occur. This may also be part of the cause of separation into downslope microbial mounds/coral reefs from updip shallow-shelf sediments as seems to be seismically evident (Qayyum et al. 2015, Sections 2.3, 4.07 and 4.09, **Figures 4.23** and **4.38** and Appendix A1.11).

These effects of loading related to salt tectonics are part of a broader effect of the total deltaic sediment load that results in tectonostratigraphic subprovinces (Albertz et al. 2010, Appendix A2.6). Loading may cause lithospheric depression (6) depicted in a revised model of mixed carbonate-siliciclastic sedimentation (Figure 5.14 lower right 6; see Appendix A2.1 and Figure 2.1). The model is flipped 90° to show a transect of delta-to-platform or even delta-to-Western Shelf. The figure shows a nearer loading-generated Dailly-style (1976) moat/depression and the platform could be interpreted as the resultant bulge. The moat/depression represents first the partial origin of the by-pass channel in the Late Jurassic and then the much broader low sedimentation flooded shelf in the Cretaceous Neocomian to the southwest with the much enlarged Sable Delta.

These ideas are highly speculative with scale issues and warrant further investigation. However if there are even small scale effects on water depths, it could initiate the changes seen in those slow-growing siliceous sponges of the Abenaki carbonate platform top and marine redbeds facies illustrated in the block diagrams on **Figures 5.2** and **5.14**.

5.4 Problem #2 - Lateral Changes within Abenaki Carbonates Relative to Delta Proximity

Of sedimentary rock colours there are only: ... "dark, light and red," J.L. Wilson 1975

Problem #2 asks what changes are happening laterally within the carbonates of the platform margin due to Sable Delta proximity. Besides carbonates interbedding with shales, are there changes within carbonate-producing organisms themselves of a single facies association or a succession of changes from one carbonate community to another other than the simple replacement of carbonates by siliciclastics? An obvious change related to delta proximity is the change from platform to ramp morphology. Besides ramps being by definition not part of a platform and so in that sense not part of the problem, ramps are seen here as related to terrigenous settings and are not relevant to understanding the thick clean platform versus delta relationship. But certain major carbonate facies occur in both settings and their changes will be considered.

The simple presence or absence of siliciclastics is a very good indicator of the potential influence of the delta on the associated carbonates. In most of the Abenaki platform there are only minor amounts of thin sandstones that are more prevalent nearer the delta, as are quartz nuclei in oolite. With the available data, mostly cuttings, there is no obvious lateral pattern in the shallow-

water facies like onlite and coralgal reefs that indicate waters from the delta are forcing some gradual lateral changes. However on the foreslope there is an increasing amount of shales northeastward that a few wells have sampled and can be mapped on seismic data. Lateral changes in slope carbonates of the microbolite (thrombolitic) facies relate to distance from the delta although depth related changes might be a complication. Colour is the easiest parameter in both core and in cuttings though subject to drill bit alteration. Dramatic changes occur in Late Jurassic slope carbonate mud mound facies from very dark grey in thrombolitic slope beds of the Sable Delta area to white with red and pink cycles in the furthest southwest platform margin wells (Figure 5.16A).

Because the various type of mounds have been well studied in European Mesozoic outcrops (and even Canadian Paleozoic), a classification synthesizing some of that knowledge is used to plot the few Late Jurassic cores from the Canadian deeper-water mounds (Figure 5.16B). That plot shows some mounds in the Abenaki seem like hold-overs from the Paleozoic having plentiful stromatactis and/or being highly reddened. In the uppermost Abenaki there is an increasing amount of argillaceous content and sometimes interbedded shales. Vertically in wells the transition occurs over a short interval replacing the former shallower cleaner facies. Where sponge-rich beds are present these were termed the Artimon Member and lithistid sponges can occur in very high numbers, taking a place at the apex of any ternary mound diagram (see Figure 5.3 and compare Figure 5.16B which only has microbolite carbonate mounds plotted but the sponge mound position is shown). The Artimon Member has been found to be diachronous getting younger away from the delta and can be included in overlying formations. The lateral influence on the margin due to influx of deltaic sediments and/or waters is exhibited in gradual changes on the slope and by a major facies change at the top of the platform.

5.4.1 Abenaki Slope Shales and Adjacent Slope Limestones – a Systematic Gradient

The deeper Abenaki platform slope and distal ramp clinoforms of similar age are characteristically composed of carbonate muds with high amounts of peloids and microbolite mounds with automicrite, thrombolitic, stromatolitic and even stromatactis fabrics. The origin of these types of carbonates and mud mounds is controversial but most researchers favour a microbial origin (Pratt 1995, Neuweiler et al. 2001, Riding 2000, 2001; James and Wood 2010). Whatever the origin their stratigraphic position, seismic morphology and the presence of microencrusters like *Tubiphytes*, serpulids (*Thartharella*), tubular forams (nubeculinellids) and *Lithocodium* place them in a slope setting. Often associated with them in core are skeletal-rich debris flows of mixed and often shallower-water fauna. Such beds are less often inferred from

cuttings. The nine key wells with carbonate slope facies and their principal features are summarized in **Table 5.2** based on the respective well described in Chapter 4 and the detailed lithologs of Appendix 3. This table summarizes details supporting the interpretations presented in this Section with **Figures 5.10, 5.11** and **4.67** showing simplified lithologies and/or log character.

The shales and their under- and overlying carbonates are interpreted relative to their position along the shelf front and the prograding wedge of prodeltaic shale south from the Sable Delta to the lower platform slope. Four wells have at least some interbedded variably calcareous shales with sharp contacts with the over and underlying carbonates that in contrast are usually not very argillaceous. This indicates a later slope-onlap relationship rather than being the result of facies changes during syndeposition. The three wells with microbolite (thrombolitic) facies show delta proximity variations in both shale thickness-position and carbonate facies despite the complication of where a specific well was located and at what stratigraphic level it encountered shale. Penobscot L-30 (see Figure 4.17 for seismic and schematic lithofacies) is closest to the delta drilled on the slope just in front of the shelf break, likely an atoll rather than the platform. It has thick shale both above and below the slope limestone that is nearly all thrombolitic limestone with no discernable internal vertical facies changes. Both the ramp morphology and shale thickness attest to delta proximity. Seismic shows that the Scatarie reflector is much deeper so there was even more shale infill. The shales fill the basin so that the flat-lying carbonates prograding basinward at the level of the adjacent atoll area are shallow-water oolites with minor coral-chaetetid biostromes.

In contrast, 60km to the southeast and furthest from the delta, **Queensland M-88** (see **Figure. 5.10C**, **4.54** seismic, **4.55** and **4.56**) also tested the slope in front of the platform at Deep Panuke. M-88 never had enough infill either by carbonates or shales so as to be in shallow water during the Jurassic. Seismic and well correlations show that the relief from platform tops to M-88 slopes was on the order of 250m. Only at the base of the platform where the initial relationship was a distally steepened ramp parallel to the underlying Misaine shale, do oolites occur both in the platform and in M-88 indicating 'give-up' drowning for M-88. The 'give-up' drowning are seen upward in the section as each limestone interval becomes thinner and the shales thicker until the last few limestone are only 10m or so thick and consist of sponge reefal bed or oolite debris shed downslope. The water depth have shallowed but also became more turbid. The bases of two of the typically grey shales were black, possibly pointing to dysaerobic conditions near a maximum flooding surface. There are several pulses of shale influx but the thick carbonates remain deeper water microbolite (thrombolitic) limestones throughout on a distal slope. Those carbonates do

become slightly darker upward and thus mimic the lateral change to darker colors in the slope carbonates nearer the delta. Only at the top of the thick carbonates and at a possible sequence break within the lower one do very thin sponge or stromatoporoid beds occur. They are unlikely to indicate photic conditions of a relative sea level fall, but perhaps are a response to greater nutrients preceding the shale influx.

Between these wells about 15km north of M-88, **Dominion J-14** (see **Figure 5.10B**) encountered a thick shale above microbolite (thrombolitic) slope limestones. The shale is overlain by slightly argillaceous sponge-rich limestone with lithistid and coralline sponges (stromatoporoids) punctuated by thin bryoderm beds (bryozoa-crinoid assemblage seemingly an indicator of transgression). J-14A was a side-track drilled sub-horizontally south into platform margin stromatoporoid-rich limestones. Thus the shale allowed carbonates not only to become reestablished but to prograde several hundred metres from the platform into the basin. Seismic data shows that more significant progradation into the basin starts to occur further northeast between Cohasset L-97 and Marquis L-35.

The well relationships show a progression of shallower carbonate facies capping shales the closer they are to the Sable Delta. This can be interpreted as the response of the near platform (or ramp) carbonates to a wedge-like slope onlap infill by prodeltaic shales. Distally the shales were so far down the slope that they make no difference to the carbonate bathymetry and there are no depth-related facies changes in the distal deep water slope microbolites. But in the nearer intermediate areas they bury a distal slope infilling it so that turbidity-tolerant, slightly shallower-water sponge and stromatoporoid communities become established. And in the most delta proximate areas the shales dominate the section being armoured by dark thrombolitic slope carbonates that give excellent clinoform reflectors. Those prodeltaic shales infill the slope and basin so that shallow-water oolites form on ramps that prograde basinward for kilometres. In a similar manner the amount of progradation in front of the underlying older margin increases from south to north too.

At the extreme south end of the Panuke Trend, this pattern can be seen in Demascota G-32 but it does not involve the carbonate slope lower in the well section but rather the topmost Abenaki. Figures 4.35 and 4.37 or 5.10C show schematic lithologs and the lateral relationship to Queensland M-88. Figure 4.32B illustrates seismic evidence where G-32 forms a small buildup slightly downslope on the margin. Demascota G-32 has a shoaling up pattern through most of the Baccaro, but the overlying Artimon Member and uppermost Baccaro are argillaceous limestones

variably rich in sponges. This deeper and/or more turbid setting has interbedded shales but the same sponge-rich facies with bryozoa and *Tubiphytes* occurs both above and below the shales. The lack of change across the shale is like Queensland M-88 but involves facies in less deep settings and likely on the shelf or uppermost foreslope. The water depths of the shale deposition and in which the sponges grow are either very similar or insensitive in recording 20m to 40m variations (the non-compacted shale thickness) indicating probable shelf neritic depth in the 50m to 100m range. The thin oolite seen just 10m below the deepest shale is interpreted as allochthonous derived during the initial transgression of the sponge-bearing sequence.

Clearly there is interaction between the prodeltaic shales onlapping the slope and the nature of the carbonates that underlie and especially overlie them. There are also **changes within the slope carbonates** themselves. These could be due both or either to changes in depth of deposition/bathymetry and/or to the potential effects of deltaic turbidity and nutrient excess. Relevant carbonate features are compared in wells along the Late Jurassic shelf edge from within the delta to 300km southwest of it (**Table 5.2**). Marked colour changes occur in microbolite (thrombolite) cores over that same distance with the most dramatic change to reds, whites and pinks shown by cuttings (**Figure 5.16A**). Unfortunately that criterion is not only the main one but almost the only one given the limitations of most of the data based on cuttings.

The striking feature of the Abenaki platform and MicMac ramp carbonate slopes is the ubiquitous presence of microbolite-thrombolitic facies. This facies is seen in every core recovered in deeper sections of shelf margin-slope wells and can be inferred from cuttings elsewhere. Seismic lines (Qayyum et al. 2015; **Figures 4.23** and **4.38**) show large mounded morphologies down the platform slope at about the level sampled by these cores and cuttings. Perhaps the so-called microbolite (and mud) mounds of the slope are mounds morphologically. The other apparent laterally-varying factor may be the sedimentology of these microbolites and their associated macrofauna and debris beds if present. The reef/microbolite mound classification and comparisons (**Figure 5.16B**) based on outcrop studies show some potential to look for an along-slope variation since the Abenaki slope cores are easily differentiated when plotted on the diagrams. Another study asking why stromatactis is so rare in the Mesozoic carbonate mud mounds (Neuweiler et al. 2001) may be relevant for intraformational differences as well as Paleozoic versus Mesozoic differences because stromatactis is obvious in one core but not in the others (G-32 versus all others in **Figure 5.16A**). Whether that variation can be reasonably related to delta proximity is arguable and will be examined after discussing the colour variations.

Colour variations are marked in the slope beds. The darkest microbolite is in the Sable Delta in the Venture gas field (see Section 4.01 and 5.2 e.g. #1) and likely reflects trace argillaceous and organic (nutrient) contents although tests for organic richness proved negative (pers. comm. Hans Wielens 2008). The colours lighten away from the delta undoubtedly complicated by the actual original position of any given core as to bathymetry and relative age or stratigraphy relative to Sable Delta sediment influx. A roughly similar colour pattern is seen in cuttings, but badly compromised by drill bit alteration particularly in the wells drilled after 1998. The lightest slope sediment is white with red then pink waning upward cycles in the furthest southwest Abenaki margin well cuttings from Albatross B-13. Apparently some seawater or seafloor fluctuations in chemistry and/or oxidation occur that generate the colors. Perhaps some movement in stratified waters or oxygen minimum zones is recorded because the basic rock colour is so light. In typically darker rock such changes would not be seen. Reddened marine beds are very rare in the Phanerozoic as compared with non-marine redbeds. However they do occur in some mid-Paleozoic mud mounds and much more rarely in some Jurassic carbonates (Mather 1975, Neuweiler and Bernoulli 2005, Neuweiler et al. 2001) usually in interpreted deeper water settings.

Analogy and Walther's Law suggest these Abenaki rocks are from slope beds and may be a young example of the red stromatactis mud mound model developed for the Late Devonian of southern Belgium by Boulvain and co-workers (2001, 2004, Bourque and Boulvain 1993 Da Silva and Boulvain 2004). Perhaps these are also comparable to the steep microbolite boundstone platform margins of Spanish outcrop and Kazakhstan subsurface Carboniferous that have some red staining (Kenter et al.2005). Another Late Jurassic analogue may be the Ammonitico Rosso, a red argillaceous limestone, supposedly developed in deep water on drowned seamounts in the Mediterranean Tethys particularly Italy. The origin of the red in that formation plus mid-Paleozoic red rocks is interpreted as due to iron-bacteria microbe mediation within shallow carbonate sediment in low iron content, quiet, relatively deep waters with steep dysoxic-anoxic gradients (Mamet and Preat 2006). This interpretation may help in understanding the origin and setting of red coated ironstones.

Sedimentological-biological variations are not so striking as the colour variations (**Table 5.2.**) These variations in five widely-separated wells show when plotted on a process-related mound classification scheme derived from outcrop examples (**Figure 5.16B**). This plot gives insight into possible depositional conditions but separating ultimate causes due to delta proximity effects versus local controls like depth on the slope and upslope sediment supply is problematic. This should not be surprising whether increasing water depth or turbidity as both

decrease light penetrating the water column. Mainly cores exhibiting microbolites are used (e.g. Albatross B-13). There are very limited data with many unknowns even in the same facies of one well, however a few of the most obvious variations are worth noting. The ramp example by the delta (Penobscot L-30) has neither debris beds nor macrofossils with nearly continuous microbolite beds and the cuttings appear similar indicating sediment starved conditions. In the two cores furthest from the delta, Demascota G-32 and Acadia K-62, coarse debris derived from upslope and locally re-sedimented hard microbolite are seen and although uncommon appear in cuttings elsewhere. Possibly this indicates well-cemented sediment-starved mounds. The most distal much lighter coloured core differs from all others in having delicate branching corals in growth position as well as locally re-sedimented soft automicrite intraclasts and plentiful stylolites in lime mud even if that mud is thrombolitic with shelter cavities. This indicates more of a sediment continuum mound though it is not considered lagoonal. The core from Acadia K-62 was the only one located in a section that was sandwiched between oolitic intervals but based on associated microbiota and position relative to the shelf edge is interpreted as in a slope setting. These are some of the changes but hardly conclusive as evidence for deltaic proximity. This may support a reciprocal nature of slope carbonate versus prodeltaic sedimentation with slope-onlap surface relationships and most interaction minor just at the transition surfaces and the adjacent beds. Certainly the contacts are abrupt with a possible hard ground in West Venture C-62 cores at the top of the carbonate and also at the base of the carbonate in Penobscot L-30 core 2.

5.4.2 Lateral Changes in the Uppermost Abenaki and Overlying Beds Relative to Deltaic Sediment Input, Sponge Reef Mounds, Condensed or Red Coated Iron Carbonates and Platform Growth into the Cretaceous:

The effects of the delta can be seen in the uppermost Abenaki platform limestones with a lateral gradient of changes and evidence of minor backstepping close to the Sable Delta and major back-stepping on the Western Shelf into the Early Cretaceous (Figures 5.8A, 5.11 and 4.58, Section 5.3-3). Starting close to the Sable Delta platform, the uppermost limestones go from mixed oolite-sandstone couplets of slightly older age at the northeast corner of the platform margin and interior to the argillaceous sponge-rich limestones of most of the Panuke Trend area then to abrupt termination of an oolitic platform with marine red coated ironstones and minor sponge beds in thin shales in the Mohican Subbasin. Finally beyond the furthest extent of even the youngest Sable Delta sediments, the platform carbonates continue growing on the Western Shelf, capped by marine red coated ironstones near the drowned shelf margin. Carbonate sedimentation could not re-establish and was inhibited in the Mohican Subbasin area after the Near Base Cretaceous Unconformity of Weston et al. (2012). Seismic mapping (PFA Chapter 9 OETR 2011)

found Abenaki intra-formational reflectors and surfaces thin or merged in that area, so speculatively one could imagine a compensatory uplift or bulge relationship to the Sable Delta using a Dailly delta loading model (see Section 5.3-4) that could generate conditions for both unconformities and condensed submarine beds, palimpsest beds or even submarine erosion.

In the Panuke Trend almost all wells have some sponge-rich argillaceous limestones in the uppermost Abenaki (**Figure 5.8A**). Lithofacies maps (**Figure 4.57F-H** Encana sequences Ab6 to Ab7) show them located southwest of sandstone-oolitic limestones ramps and terrigenous deltaic beds nearer the Sable Delta. They occur as older minor thin beds on the deeper platform slope limestones in Queensland M-88. Thus their depositional setting appears to be the deeper shelf with tolerance of fine siliciclastics. Interpretation of core from the Artimon Member type section in Demascota G-32 (Section 4.09, Eliuk 1978, Eliuk and Levesque 1988) indicates a quiet environment below-wave base and likely below a turbidity reduced photic zone. This position fits with an analogue Baltimore Canyon Trough area of similar age with definitive seismic showing a small delta with slope beds going down to deeper mounded facies with cored sponge inter-reef beds at the shelf margin (Eliuk and Prather 2005).

Sponge-rich intervals become progressively more pervasive upward as mapped above the main reservoir zone in Deep Panuke. They do not show an obvious systematic thickening or shale pattern relative to the Sable Delta, likely due local variability in sponge facies development and well location. The best example with the Artimon Member type section and shale is at the far southwest end of the trend possibly slightly downslope (Section 4.09 and **Figures 4.37, 4.41 to 4.46**). Most wells lack shales and are not considered Artimon but simply 'Artimon-like' and often have higher amounts of stromatoporoids. Margaree F-70 is transitional from dolomite and coralgal facies up to sponge-rich facies but core shows much of this transition is on the foreslope dipping landward of a small pinnacle (see Section 5.2). The other and thickest shale occurrence within the Abenaki platform occurs in Dominion J-14 in closer proximity to the Sable Delta. There shales, unhappily for the operator, replace the usual reservoir carbonate in Ab5 above thrombolitic slope beds and below reefal beds with stromatoporoids and sponges becoming mostly lithistid sponges upward (see Section 4.08). The shale infill results in the furthest south example of basinward progradation from the platform. But the carbonate facies is very unlike the prograding ramps near Sable Island that have oolite or thrombolites but not lithistid sponge in any significant amount.

This facies, known from the first reef-bearing well drilled in the Abenaki, is the best example of the influence of the Sable Delta on the platform causing a change from clear shallow-water coral-stromatoporoid reefs and oolitic shoals to a deeper turbid environment populated by

heterotrophic biota lacking algae and dominated by lithistid sponges. It was first interpreted as the capping facies of a regionally drowned carbonate platform during the Berriasian-Valanginian after considering and rejecting the alternative interpretation of "a unique fauna adapted to turbid conditions and occasional periods of subaerial exposure occurring in an environment adjacent to the Sable Island delta. However, the preferred interpretation for this core makes it a deeper-water 'reef', laterally equivalent to a drowned carbonate bank" (Eliuk 1978, p. 470). Maybe both interpretations should be combined but the unconformity likely is the sub-Valanginian NBCU (Weston et al. 2012) and below the type Artimon Member. So a major unconformity runs through the Abenaki. Biostratigraphy in Dominion J-14 (see Fig. 3.22 from PFA Chapter 9, OETR 2011) shows that Artimon or Artimon-like facies – being highly enriched in lithistid sponges as well as stromatoporoids - can be all Late Jurassic. This is the oldest instance of the diachronous nature of the Artimon. Similar to the thin microbolite and metazoan-red algal reef mound carbonates of the Late Jurassic Sable Delta in West Venture C-62 core (Section 5.2 e.g. #1), the sponge-rich Artimon occurring at the toe of prodeltaic shales may have modern actualistic analogues in the siliceous sponges forming clay-cored reefal mounds in the Fraser River prodelta (Conway et al. 2004) and the sponge-rhodolite with minor coral reefs at the wide shelf in front of the Mouth of the Amazon (Moura et al. 2016).

The other examples of the sponge-rich Artimon are in the Mohican Subbasin as thin beds often associated with marine redbeds of coated ironstones as shown from several wells in **Figure 4.61** and core in Moheida P-15 (see **Figures 4.63** to **4.65**). Discussed in Section 4.14, the significant observation is that these sponge facies are at the distal end of prodeltaic beds before sediment supply becomes so low that only condensed beds and seafloor diagenesis afford conditions producing red coated ironstones at and just below the seafloor. Formation of these marine redbeds involves repeated burial and uncovering required for redox reactions to occur in sediment-starved settings¹ (for coated ironstone background information see Bayer 1989, VanHouten and Bhattacharyya 1982, Pufahl 2010). Not only do these beds indicate a slow and continued process, it is also repeated at various stratigraphic levels. It continues into the

¹ In Section 4.14 and this brief discussion of the distribution of the red coated ironstones (iron-ooids) reference was made to 'Fe-ooid' formation by complex redox chemistry during starved slow sedimentation on the seafloor by *in situ* repeated exposure then shallow reburial into the appropriate chemical environment. It is fascinating to compare the general similarities to that complex long-continued marine early diagenetic phenomena with the model presented for the formation of ooids in the Bahamian Archipelago by Duguid et al. (2010) also over long time spans of up to 3000 years and presently ongoing. Very briefly, amorphous high Mg/Ca calcium carbonate is seen as adding a veneer to ooid surface while on the seafloor (active phase) which is recrystallized to aragonite needles as a new cortex during resting (?)shallow burial times (stationary phase). Microbes and cyanobacteria do not play a role in ooid formation but micro-bore the cortices which are infilled by aragonitic cements with sea-water chemical signatures. Even before the coated or oolitic particles are cemented into rock they have a long history.

Barremian-Aptian but no longer with any connection to the Sable Delta in Bonnet P-23 where thick marine redbeds cap the Early Cretaceous Abenaki. The last Abenaki limestone in that sequence below the redbeds is slightly argillaceous with both lithistid and stromatoporoid sponges (see Section 4.15). On **Figure 4.81** the unit was loosely termed 'Artimon Member', since there are lithistid sponges though less numerous than the stromatoporoid sponges with intervals of higher amounts of bivalves and bryozoans in mainly light-coloured limestone. No hexacorals but also no oncoids and only one stromatolite/thrombolite were noted. Stromatoporoids are considered to tolerate higher temperatures than hexacorals (Leinfelder et al. 2005) so this could similarly be interpreted as higher temperature control along with some excess nutrient effect favouring heterotrophs. A completely different instance of marine redbeds occurs in Albatross B-13 in distal slope microbolite (thrombolitic) facies. It is the extreme end member in a spectrum of carbonate slope colours away from the Sable Delta. It is different and poorly understood since only seen in cuttings and a few poor sidewall cores. But it too may indicate long residence times on the seafloor but in deeper water microbolite bindstones (see Section 5.4-1).

5.5 Hydrocarbon Exploration and Development Observations and Implications

There are three world class carbonate platform edge outcrop areas but the shelf edge is not where the hydrocarbons are! Triassic Dolomites of Italy has spectacular outcrops but Triassic carbonates worldwide have few hydrocarbons (Bosellini 1988, Flügel 2002). Devonian Canning Basin of Australia has wonderful platform and reef outcrops and some subsurface reefs yet almost no hydrocarbons occur in the Australia Devonian but huge amounts occur in reefs of Canada and Russia (Playford 1980, Copper 2002). West Texas Permian outcrops are spectacular shelf margin exposures and the subsurface has huge shelf interior fields but none in the reef edge that often is tight (Saller et al. 1999). Likewise Late Jurassic carbonates worldwide led by Saudi Arabia have huge reserves of the hydrocarbons in the shelf interior not in reefs or buildups (Greenlee and Lehman 1993). But Deep Panuke is the reverse with the updip shelf interior, even though oolitic, being a seal rather than a reservoir which is at the margin in reefs. Figure 5.17 shows some of the few examples of reefal hydrocarbon areas with near shelf-edge subsurface exploration well tests or fields around the Late Jurassic Tethys and early Atlantic oceans. Some have nearby outcrop analogues though most do not.

The Abenaki Deep Panuke not only is juxtaposed to the Sable Delta but its hydrocarbon system is dependent on the delta. Near Sable Island, shelf margin gas fields occur contemporaneously in platform reefal and deltaic depositional environments. Continued delta sedimentation was critical to both for gas prone source rock and for shale seals. Additional earlier

seals for the carbonates is due to the upward facies change to the argillaceous sponge reef mound facies. Trapping for the deltaic fields is due to listric normal faulting and salt structures. Trap structure for the carbonate margin is in part due to the growth of the platform carbonate itself. This also results in overlying oil accumulations draped in sandstone over the Abenaki shelf edge. Deep burial under the younger delta results in porosity occlusion especially for carbonates and normal pressured reservoirs. This also provides a lateral and third seal of tight carbonates in updip platform interior for partial stratigraphic trapping. The main carbonate reservoir porosity was provided by burial diagenesis by hot subsurface fluids resulting in dolomitization and some limestones microporosity. Conduits were fractures and minor faulting in part due to the deltaic load above and on the slope (see Weissenberger et al. 2006 –Deep Panuke petroleum geology; Wierzbicki et al. 2002, 2005,–2006-reservoir diagenesis; Eliuk 2008, 2009, 2010a; Eliuk and Wach 2008; OETR 2011) and chapter four specific well sections of this thesis.

Much of the Abenaki porosity is very low particularly in limestones even if oolitic. Deep burial diagenesis and particularly dolomitization is the main factor in reservoir development though there are limited areas of vuggy limestone microporosity. Reservoir occurs related to fracturing and faulting mainly near the carbonate shelf edge. On the Western Shelf with less burial, porosity is more widespread both in dolomite and grainy limestones. However some early submarine cementation of oolitic grainstones also is seen and results in rock brittle enough to undergo early fracturing with formation of Neptunian dykes infilled by geopetals with redox colouration and loose and broken ooids (Albatross B-13). At the south end of the Panuke Trend a submarine filled cave or large Neptunian dyke is interpreted in coral reefal core indicating periods of early submarine and subaerial exposure (Demascota G-32).

Original grainy depositional texture appears to be selectively favoured for secondary dolomite distribution and hosts much rarer limestone porosity. The setting near the shelf edge or in faulted/fractured areas may be more important than the presence of a particular depositional facies type. Shallow coral reef complexes and associated skeletal rubble and sands seem preferred for reservoir development. Depending on the proximity to the shelf edge there appears to be a variation in depositional facies continuity and therefore reservoir continuity. The main south end of the field has more continuous facies slightly behind the shelf flexure as opposed to the north end where wells tested carbonate-encased pinnacles with more complicated geometries nearer the shelf edge. The argillaceous sponge reefs are never reservoirs and act as a carbonate top seal. Slope carbonates and microbolite mound limestones though clean also are non-porous except for unconnected stromatactis-like cavities. In the US Gulf Coast microbolites can be reservoir

carbonates but their depositional setting is very different and involves shallow-water restricted and even evaporitic conditions (Mancini et al. 2004, 2008, Moore 2001).

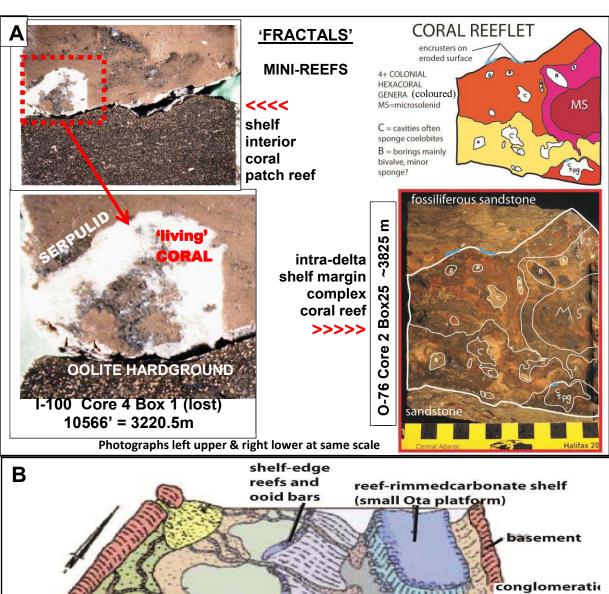
Nearer the Sable Delta in mixed sandstone-limestone beds the sandstones are variably porous but the carbonates non-porous. This has negative implication for stratigraphic trapping which is less likely with more sandstone interbeds even if carbonate was porous. So structural closure would be needed. The lack of effective seal of sandstone reservoirs and fault contacts are seen as key problems with the Sable Island gas field column lengths (Bill Richards pers. comm. talk 2010). The thick pile of deltaic sediments burying the nearer parts of the Abenaki carbonates results in porosity occlusion and possibly even darker colours.

Success and learning in one hydrocarbon basin can both encourage plays in other areas and provide a feedback loop to the original area. Such has been the case between the Sable Basin carbonate play and that in Baltimore Canyon Trough (BCT). Porous shelf edge wells in the Nova Scotian Abenaki were analogues for mid 1980s exploration off Delaware (Meyer 1989, Prather 1991, Eliuk and Prather 2005). **Figure 5.18** shows BCT margin wells and a seismic example of hydrocarbon implications and feedback loop of analogues. The wells were drilled on a huge anticline with Abenaki as analogue on the modern continental slope. But it was not significantly buried until later in its history as deltaic sedimentation was more limited. This probably resulted in no hydrocarbons. There was a good show occurring in the faulted, more buried shelf interior. Limited source rocks and possibly no seal in place until after early hydrocarbon migration are other risks to the petroleum system.

On the Western Shelf, there may also be an early charge and late burial problem for hydrocarbon trapping at the carbonate platform margin. Similarly problems may occur on Georges Bank where the carbonates actually crop out in Heezen Canyon on the continental slope. So being away from relatively early burial by a delta reinforces why the combination of platform reefs and deltas worked for offshore Nova Scotia while worldwide the Jurassic has few reef margin fields but numerous and huge shelf interior low relief anticlinal structure fields as in Saudi Arabia.

A specific feedback application of appreciating the nature and different types of Jurassic reefs and mounds between the Baltimore Canyon Trough and the Scotian Basin is displayed on **Figure 5.18** relative to the sponge reef mounds and intermounds. Prior to drilling well 0337, the mounding of mesa event was interpreted as due to karsting with associated porosity. In fact, it turned out to be due to sponge reef mound topography that was not considered by some of the explorationists even though they had a tested analogue off Nova Scotia. But relative to

understanding the setting of sponge reef mounds, the BCT seismic (**Figure 5.28 inset**) elegantly shows that the sponge mounds are forming in deeper water in front of prograding prodelta shales, thus feeding back and reinforcing the interpretation proposed for the Artimon Member sponge beds in this thesis.



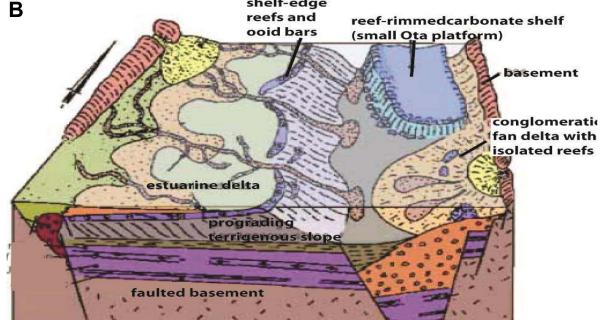


Figure 5.1 Reefs and carbonates in siliciclastics. A) Fractal-like Abenaki examples (mini-reefs of single or a few colonial corals). LEFT- Mohican I-100 lacks borings and coral not mud-infilled hence buried alive. RIGHT - South Desbarres O-76 highly bioeroded *in situ* diverse corals with coelobites in cavities in bottom of deltaic channel. **B) Possible outcrop analogue** Late Jurassic Arruda Subbasin mixed system sketch showing three varieties of reefal carbonates in siliciclastic settings of small reefs within fans delta, delta-edge carbonates and, isolated atolls but all small-scale and in arid setting of small pull-apart rift basin according to Leinfelder (1997, fig. 8 modified).

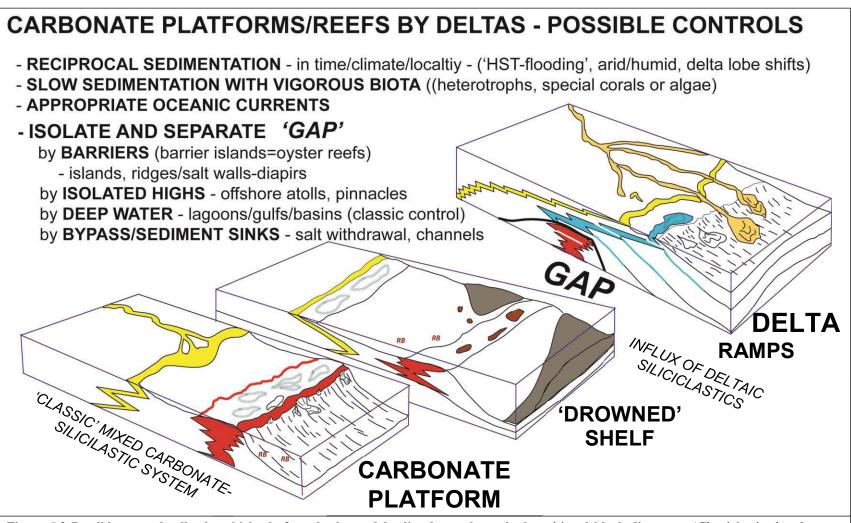


Figure 5.2 Possible controls allowing thick platform by large delta listed on schematic depositional block diagrams. 'Classic' mixed carbonate-siliciclastic controls modified and applied to the Abenaki platform-Sable Delta association of the Late Jurassic offshore Nova Scotia (see Wilson 1967, Mount 1984, Leinfelder 1997, Goldhammer 2003). The left block diagram depicts the 'classic' mixed system as occurs nearshore to offshore in the Abenaki platform-nearshore ridge. This is in contrast to the problem shown with all three of the blocks depicting the possible relationships in the earliest Cretaceous of the along-strike lateral situation of the large delta beside the thick clean bank (see Figure 5.14 for environment labels).

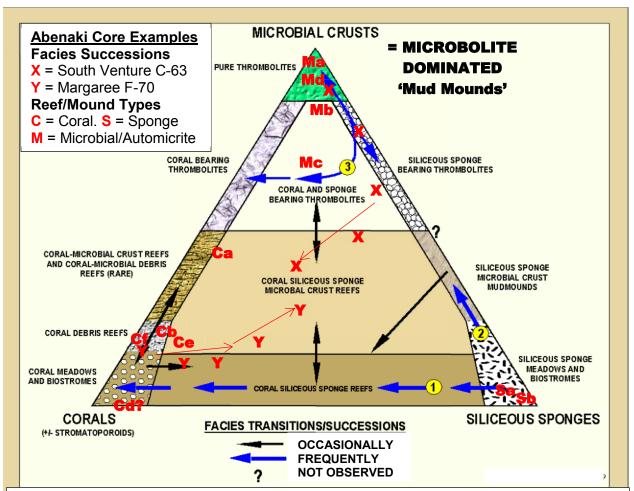


Figure 5.3 Late Jurassic Reef types (modified from Leinfelder 1994, see Leinfelder et al. 2002). According to Leinfelder reef types can be plotted on a compositional triangle with the end members coral (& stromatoporoid) facies, siliceous (& lithistid) sponge facies and microbial facies. Arrows in blue indicate his frequent successions and facies transitions of reef types. His dominant transitional lines are labelled 1, 2 and 3. Microbolite = microbialite (thrombolite, rare stromatolite and automicrite with submarine cements). Not captured in this grouping is the importance of microsolenid corals as good environmental indicators (Dupraz and Strasser 2002, Lathuiliere et al. 2005) and were used to subdivide the only outcropping Atlantic shelf-margin reef occurrence in Morocco (Martin-Garin et al. 2007).

Carbonate and Abenaki core facies have been placed on this diagram as seems appropriate and two show a succession of facies. They are shown by red letters keyed to the well UWI and core number from Tables 3.2 as follows X=West Venture C-62 #12&13 = (a thin succession in delta), , Ma=Penobscot L-30 #2, Ca=Cohasset L-97 #1, Y=Margaree F-70 #1 = (a succession with slope dolomitized grainstones), Cb=Panuke H-08 #1, Sa=Demascota G-32 #1, Cb=G-32 #2, Cc=G-32 #3, Mb=G-32 #5, Sb=Moheida P-15 #1, Cd?=Acadia K-62 #4 (mollusk-oncoid-biostromes), Mc=K-62 #5, Baltimore Canyon Trough wells (see Figure 5.18)– Md=A0317 #4, Ce=A336 #3, Cf=A336 #4 with topmost Abenaki cores inter-sponge mound beds.

C=coral, M=microbial, S=sponge dominated on listed core; X and Y successions in red arrows

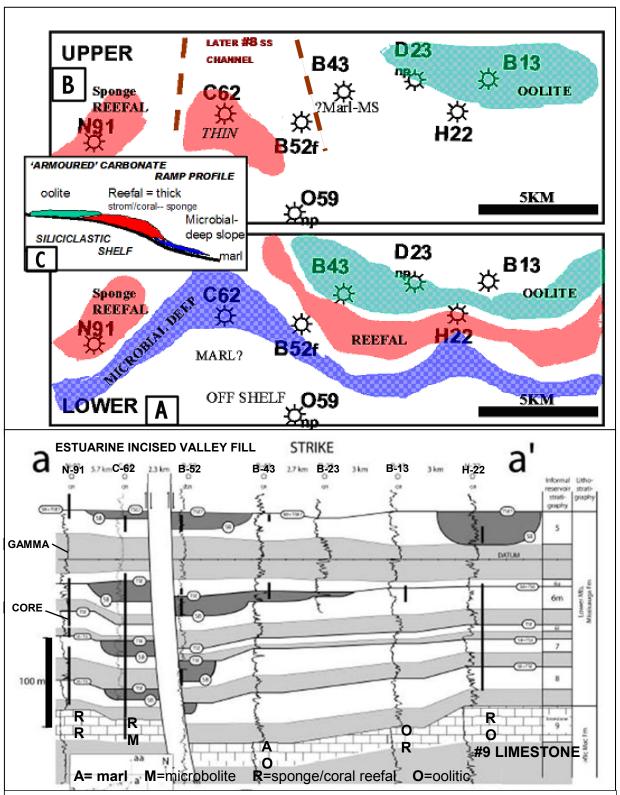


Figure 5.4 Venture area #9 Limestone depositional maps and strike section based on cuttings and core.

A) Lower half #9 sketch map, B) Upper half #9 sketch map, C) Schematic ramp facies dip profile and
D) Stratigraphic strike section (modified from Cummings and Arnott 2005, fig. 5). See Figure 4.2 for cuttings and core lithofacies summaries for #9 Limestone. See continued caption next page.

Modified from Eliuk and Wach 2008, 2009)

Figure 5.4A to C Venture area #9 Limestone facies sketch maps based on sample **lithologies** (also see Fig. 4.3: f = faulted, np = not penetrated)) and subdivided into A) lower and B) upper with C) a simplified depositional facies depth-profile of shallow onlite to reefal (coral-stromatoporoid or deeper lithistid sponge) to microbialite/thrombolite to deep marl (excluding the oolite this could also be seen as a trend to greater clays-nutrientsdysoxia). These limestone changes are interpreted to mirror or thinly "armour" pre-existing siliciclastic bathymetry on the shelf and/or over the shelf-slope break. Note that the C-62 relatively thinner limestones with the microbialite 'mud mound' and overlying skeletalmicrobial reef mound may all belong in the lower #9 Limestone. Lower #9 Limestone (map A) shows a deep or low on the shelf at the C-62 well where stacked incised channels occur for the #8 to #5 sandstones but to the northeast in a shelfward direction an oolitic shoal-sheltered peloid area (B-43 to B-13) with stromatoporoid-sponge-microbial reefal beds just basinward (H-22) indicating shallower depths and/or less clays-nutrients than the thicker lithistid sponge reefal beds in N-91. Upper #9 Limestone (map B) shows a northeastward shift in oolite deposition. At B-43 dark oolites are replaced by marl-argillaceous lime mudstone interpreted to be due to the shoaling trend forcing clay input into the deeper areas (future incised channel areas of C-62 and B-52) carried by underflows (hyperpycnal transport of siliciclastics). That process allowed continued carbonate sedimentation on lateral bathymetric highs until further regression and widespread burial by regressive prodeltaic mudstones overlying the #9 Limestone.

Figure 5.4D Venture strike section (Cummings and Arnott's 2005 modified fig. 5a-a') Generalized lithofacies in #9 Limestone added from cuttings and core (see Figure 4.2).

NOTE 1 on Cummings and Arnott's (2005) strike section: Venture area – interpreted stratigraphic strike section through the Venture field #5 to #8 sandstones showing the major facies association groupings and note the stacking of incised channels in the C-62 and B-52 wells. Siliciclastic facies – dark grey (channel form units) = strongly tide-influenced estuarine incised valley fill; remaining units (upward-coarsening units) very light grey = storm-dominated delta front sandstone; medium grey = prodelta mudstone; limestone pattern = condensed shelf limestone facies. Black bars are cores. Log trace is gamma radioactivity log indicating shaliness or 'cleanness' of sandstones and limestones.

NOTE 2 The deepest limestone facies in C-62 are located where the incised channels later become stacked on both sides of a growth fault. This fault could be interpreted following the tectonic ideas of Welsink et al. 1989 as one of their transfer fault zones that tend to be low entry points for sediment influx as shown on **Figure A1.4** separating their Abenaki and Sable extensional tracts.

NOTE 3 Gould et al. (2012), based on alternative correlations, re-interpreted the above set of wells. They do not see incised channels in the two lowest sequences in C-62 and B-52 nor any in H-22 and most of N-91 but note more correlative marine deltaic facies particularly delta-front turbidites. Their section hung on the O Limestone emphasizes thickened intervals adjacent to and in a somewhat deeper-water facies down dip of the growth fault between C-62 and B-52. These changes do not affect my interpretation of #9 Limestone. Both sets of authors interpreted significant tidal influence in the estuarine and valley-fill facies.

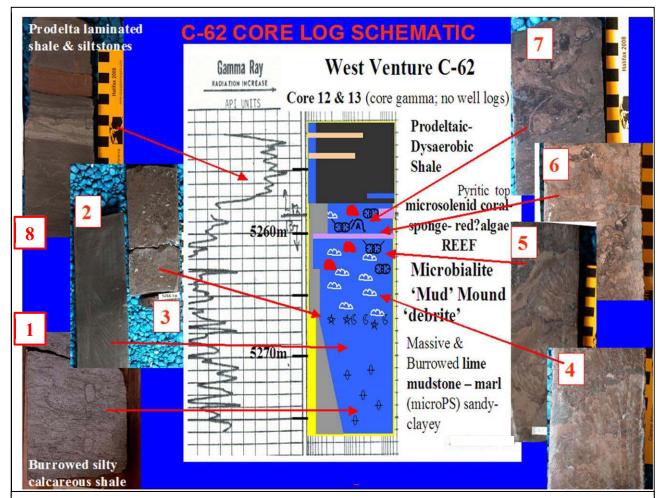


Figure 5.5-1 West Venture C-62 #9 Limestone schematic core log summary a number of facies features are illustrated in more detail in the following figures as indicated by the numbers (see key in Fig 4 for most symbols, purple lithology is fine crystalline dolomite, star is crinoid). No logs were run in the lower well but a core gamma indicates the relative radioactivity (indicative of argillaceous content or 'clean-dirty'). The main facies are very argillaceous limestone to calcareous shale or marl that can be subdivided into a highly bioturbated lower interval lacking in body fossils with a great number and variety of ichnofossils including Zoophycos indicating a deep shelf-upper slope environment that is overlain by a massive marl to argillaceous micro-packstone then a microbially stabilized debris bed that forms a substrate for colonization by a pure microbialite "mud mound" with a limited variety of micro-encrusters which grades upward with increasing in situ skeletal content to a microbial-microsolenid coral-lithistid sponge-red ?algal (= ?solenoporid) reef mound that is abruptly overlain across a pyritized hard ground by dark laminated prodeltaic shales or clay mudstones with some ironstone cemented layers and thin beds of siltstone to fine sandstone that upward become burrowed and more common. Except for the first and last facies these subdivisions are shown in more detail in the following 6 subfigures.

Modified from Eliuk and Wach (2008, 2009).

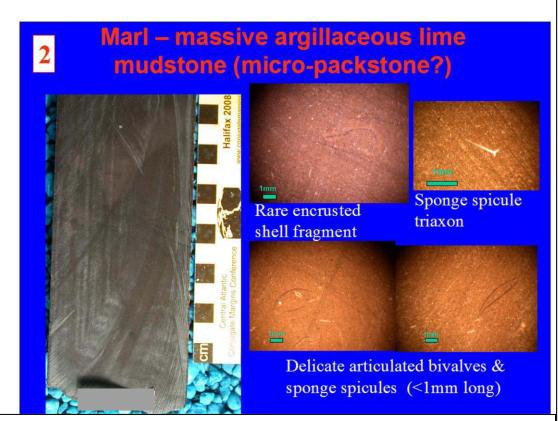


Figure 5.5-2 Venture C-62 #9 Limestone core facies - 2 massive marl-mudstone. Depth ~5269 m. See longer caption following 5.5-7.

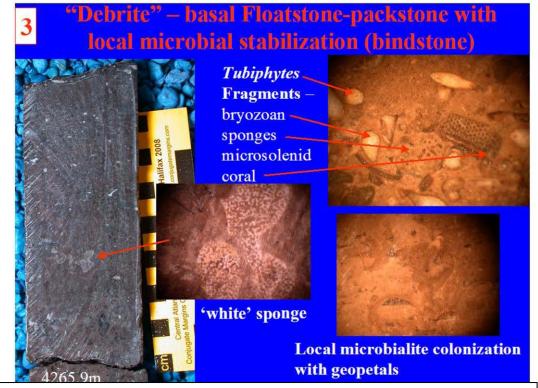


Figure 5.5-3 Venture C-62 #9 Limestone core facies - 3 debris bed. Depth ~5267 m. See longer caption following 5.5-7.

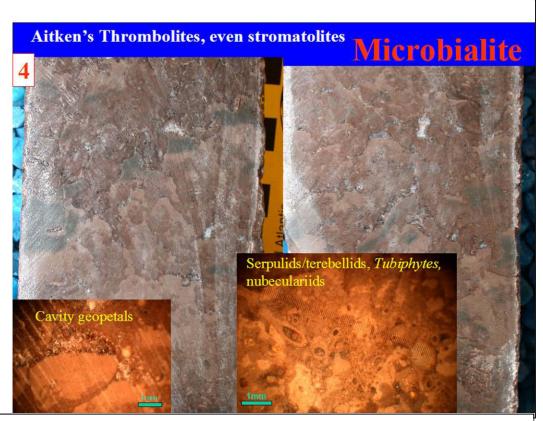


Figure 5.5-4 Venture C-62 #9 Limestone core facies - 4 microbialite (microbolite). Depth ~5265 m. See longer caption following 5.5-7.

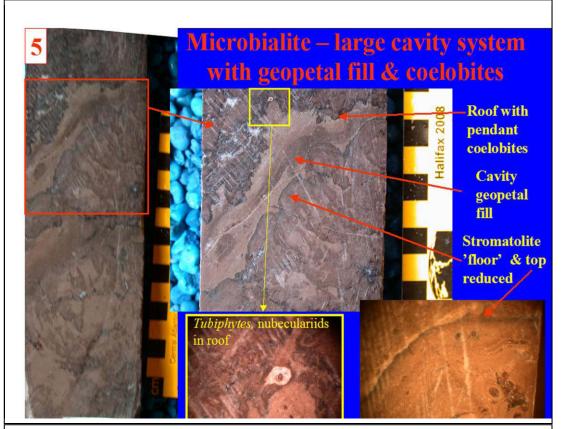


Figure 5.5-5 Venture C-62 #9 Limestone core facies - 5 microbialite (microbolite) & geopetals/cavities. Depth ~5262 m. See longer caption following 5.5-7.

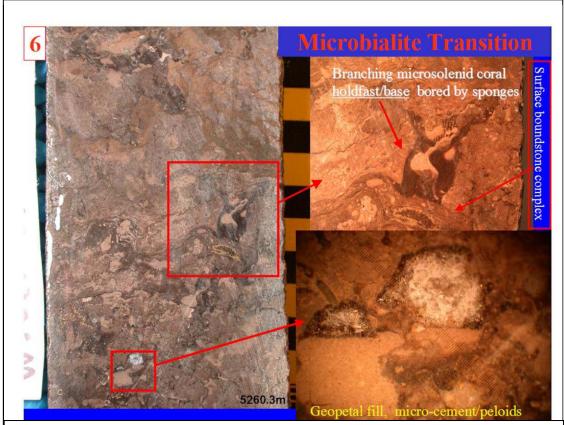


Figure 5.5-6 Venture C-62 #9 Limestone core facies - 6 microbialite (microbolite) transition to skeletal reef mound. Depth ~5259.5 m. See longer caption following 5.5-7.

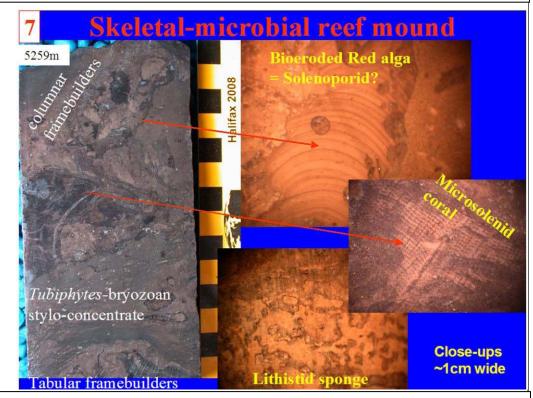


Figure 5.5-7 Venture C-62 #9 Limestone core facies - #7 reef mound framebuilders. Depth ~5259 m. See longer caption on following

DETAILED FIGURE CAPTIONS FOR FIGURES 5.5-2 to 5.5-7

- **Figure 5.5-2.** West Venture C-62 #9 Limestone: marl –massive argillaceous lime mudstone to micro-packstone this massive-appearing argillaceous limestone is composed of sublithographic to fine particles with only a few larger fossils hence the lime mudstone to micro-packstone designation. Some of the fine fragments appear angular and might be scallops from sponge bioerosion of shallower reefal beds and skeletons. Those few fossils are small and include crinoid ossicles, sponge spicules and small bivalve shells. One disarticulated bivalve was microbially coated but the few others were not encrusted and still articulated showing a lack of energy or even bioturbation and possibly originated from a nektonic mode of life. Therefore the lack of lamination is not thought to be due to burrowing but represents the original texture perhaps due to a 'soupy' nature or rapid sedimentation. The carbonate sediment is interpreted to be winnowed from carbonate shoals diluting the low amount of clays coming during near maximum flooding.
- **Figure 5.5-3.** West Venture C-62 #9 Limestone: skeletal packstone to floatstone debris bed (about 3 decimetres) with microbial stabilization a great variety of small fossil fragments mostly deeper? heterozoans such as crinoids, bryozoa, *Tubiphytes*, bivalves, gastropods, brachiopods?, sponges, forams but also microsolenid corals and a possible colonial stylinid or oculinid coral. Locally there is microbial encrustation and therefore stabilization of the fossil fragments which are interpreted as storm or avalanche derived debris from shallower carbonates. The whole bed serves as a hard substrate that allows colonization by the overlying microbolite 'mud mound'.
- **Figure 5.5-4.** West Venture C-62 #9 Limestone: pure microbial boundstone with thrombolitic to stromatolitic textures and limited but plentiful micro-encrusters about 5 m thick of peloidal to massive mudstone with numerous shelter cavities that are geopetally-filled by peloid grainstone with varied development of later calcite cements that often include a thin initial isopachous rim. The micro-encrusters occur in the mudstone but also can encrust both upper and lower microbolite surfaces. They include *Tubiphytes* (also known as *Shamovella* and possibly Jurassic foraminiferal-microbolite consortium that is characteristically in reef slope debris beds and outer ramps to deeper slopes, Flügel 2004), serpulids-terebellids-thartharelids (various encrusting worm tubes with some smooth-walled calcite, some agglutinated) and nubecularids (tubular foraminifera chambered and branching). (Jim Aitken coined the term 'thrombolite' for clotted fabrics interpreted as subtidal stromatolites in Lower Paleozoic rocks in the Southern Canadian Rockies).
- **Figure 5.5-5.** West Venture C-62 #9 Limestone: pure microbial (microbolite) boundstone large cavity system larger cavities of several centimeters height occur in the upper part of the microbolite interval and are filled by geopetal muds. Top and bottom surfaces appear slightly darkened grey possibly reduced (such color alteration occurs throughout the microbolite see previous figure) and may be colonized by micro-encrusters or show pendant microbialites. Often there are bewildering gradational transitions from 'hardened' microbolite bindstone fabrics to geopetal infill fabrics.
- **Figure 5.5-6.** West Venture C-62 #9 Limestone: pure microbolite to microbial-skeletal boundstone transition over a metre or so hard microbolite bindstone surfaces are increasingly encrusted by tabular skeletal framebuilders or colonized by holdfasts or bases of branching-columnar framebuilders like this microsolenid corals with a highly bored interior (the sponge-boring *Entobia* makes the coral superficially look like the central cavity of a framework sponge!). An *in situ* lithistid sponge is left of the *in situ* dark coral column.
- **Figure 5.5-7**. West Venture C-62 #9 Limestone: skeletal microbolite reef mound framebuilders include lithistid and 'white' sponges, minor chaetetids and microsolenid corals that show complex intergrowth with each other and the microbolites. The preservation of corals due to early dissolution often makes identification problematic but it appears that only microsolenid corals with their characteristic zigzag 'tire-track' pattern (see Fig. 5 of Dupraz and Strasser 2002) are present. All framebuilders are relatively small with the microsolenids perhaps as common as the lithistid demosponges. Their small size and dominantly *in situ* position indicates a low energy, deeper-water probably stressed setting. The high amount of bioerosion of skeletal framebuilders (microbialites are seldom infested)

by bivalves (*Gastrochaenolites*) and sponges (*Entobia*) suggest very high nutrient levels. Several occurrences of an extremely finely layered with thin dark and thick light bands is interpreted as a solenoporid (usually considered a red algae). Unfortunately the finest texture is uniformly recyrstallized and the identification is not positive with less preferred alternatives of milleporid (hydrozoan cnidarian with usually a coarser cell structure than solenoporid and therefore less likely to be completely and uniformly recyrstallized) or of some kind of skeletal stromatolite. In any case the argument for ameliorating and likely increasingly photic conditions for the skeletal reef mound as opposed to that of the pure microbolite is reasonable. Considering the increasing amount of argillaceous content indicated by the gamma log this is surprising unless there is significant relative sea-level fall. Although diagenesis is not the focus this bit of core does show a relatively common fabric due to high amounts of stylolitization aided by the high argillaceous content – solution seams and stylo-concentrates of refractory less soluble calcitic fossils like *Tubiphytes*-bryozoa-crinoids.

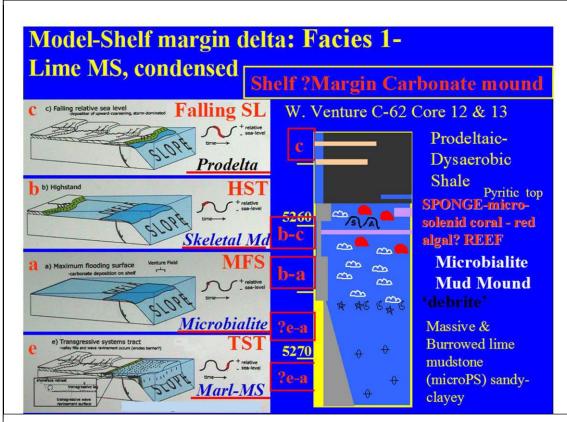


Figure 5.6 West Venture C-62 #9 Limestone core depo-lithofacies compared to depositional model of Cummings and Arnott (2005) – note the interpreted transgressive or deepening trend in the relatively thin limestone facies from highly bioturbated deeper-shelf calcareous shale/marl up to massive marl (micro-packstones) then microbolite boundstone ("mud mound") compatible with the model's transgressive (TST), maximum flooding (MFS) and highstand systems tracts then the reversal to a regressive or shoaling trend of microbial/microsolenid coral/lithistid sponge-red algal? (solenoporid?) reef mound abruptly overlain by laminated prodeltaic or lower shoreface shales/mudstones with a pyritized hardground contact that is the most abrupt lithologic change, but not the deepest deposition. Given the thinness of the limestone making depositional elevation into photic and less nutrient-rich depths unlikely, this reversal is best explained by falling relative sea-level that allowed skeletal framebuilder replacement of the pure microbolites in spite of the increasing clay content (see Appendix A3 for core gamma log and Section 5.2 for additional facies illustrations). Note that "Facies 1 – Lime MS, condensed" is the facies type originally used in Cummings and Arnott (2005) that is actually composed of a number of carbonate facies and textures. Eliuk & Wach 2009

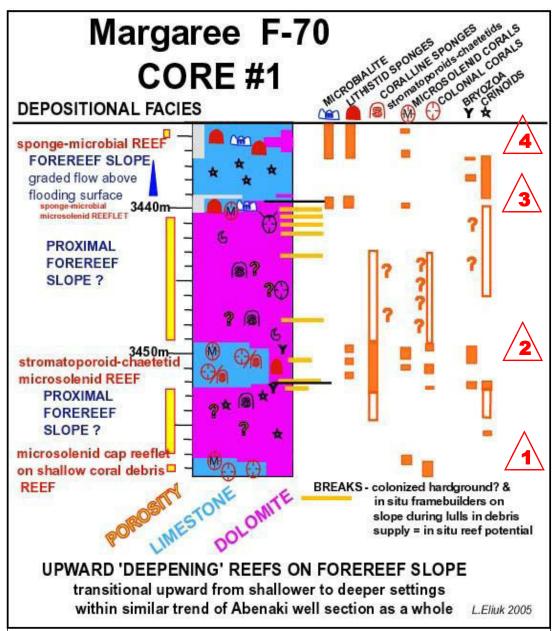


Figure 5.7-1 Margaree F-70 schematic Core #1 litholog. This more detailed interpretation of core shown on half of **Fig. 4.37** shows the upward change from coral-stromatoporoid reef beds to lithistid sponge reef mound beds. interpreted pauses in foreslope carbonate grain supply when the surfaces were briefly colonized or thin reeflets grew. The reefal intervals change in framebuilder composition core interpreted as deeper-upward reef communities. The thin reefal intervals tend not to have been dolomitized as opposed to the dolomite intervals that are interpreted to have been originally grainier less submarine cemented proximal forereef slope 'sands'. The numbers in triangles on the far right label the 4 reefal intervals that are discussed in the text and illustrated in the following **figures 5.6-1** to **5.6-6**. See the Appendix A3 for detailed cuttings and core logs.

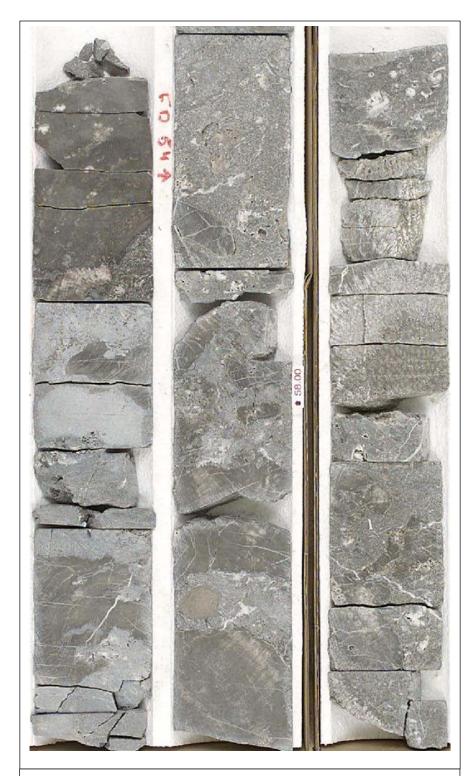
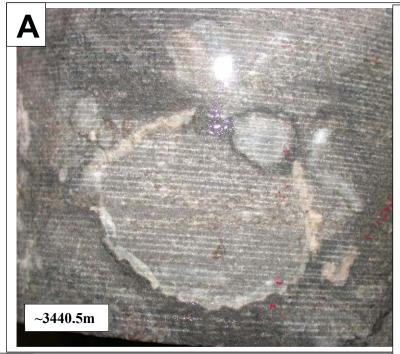


Figure 5.7-2 Margaree Core 1 Basal coral reefal slabs, dolomitic limestone, large stromatoporoid-bulbous coral rudstone in a skeletal packstone matrix most *in situ* with an overturned coral colony, F-70 core 1, 3457 to 3458.7m Core width each slab \sim 8.5 cm.



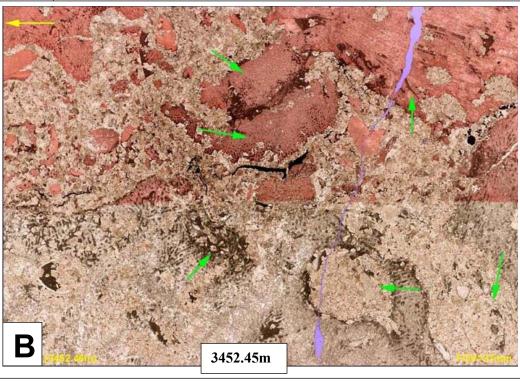




Figure 5.7-3 Margaree Core 1 photographs A) Articulated echinoderm calyx in fabric-preserving dolomite indicating low energy period on stabilized slope during 'break' in sedimentation, $HA = \sim 6$ cm. **B)** Upper foreslope skeletal packstone-rudstone of coral, stromatoporoid, sponge debris with dolomite replacing matrix and partially replacing fauna, HA = 3.7 cm, alizarin red stained upper half of thin section. **C)** Microsolenid coral clast near base of crinoid-rich lime rudstone-grainstone debris bed, $HA = \sim 3.5$ cm.

HA = horizontal axis or field of view

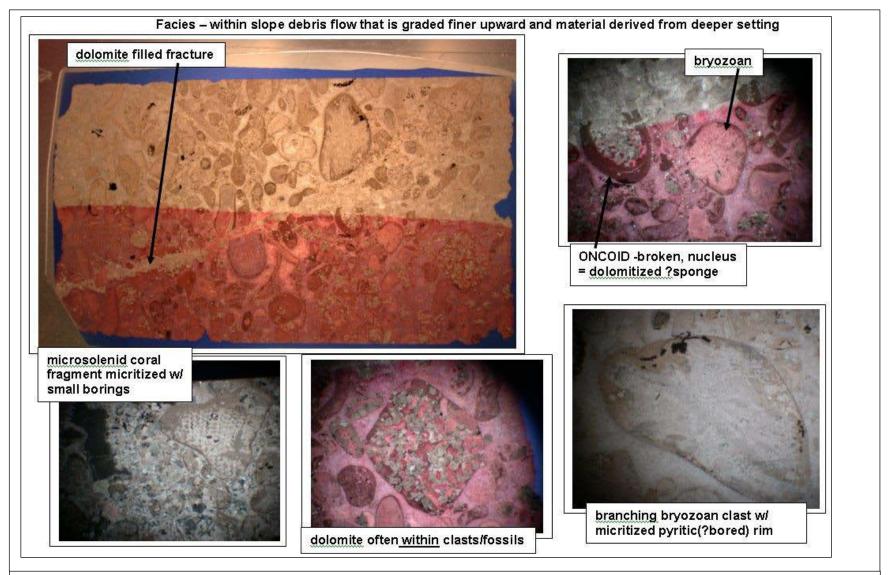


Figure 5.7-4 Margaree Core 1 photomicrographs Facies: slope debris flow, fining upward dolomitic limestone, crinoid bryozoan grainstone with scattered coarser reefal debris, F-70 core 1, 3437.5m.

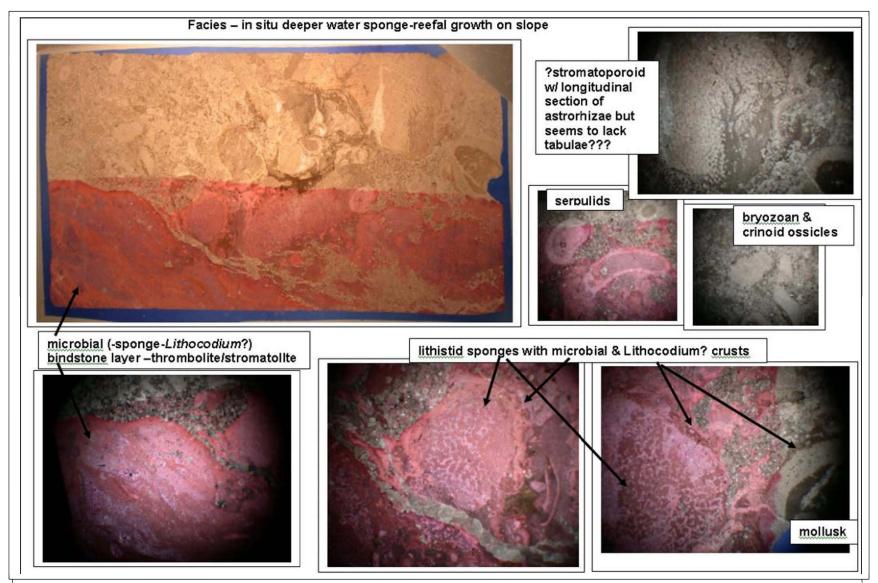


Figure 5.7-5 Margaree Core 1 photomicrographs Thin section photographs from a deeper water sponge reefal facies, F-70 core 1, 3438.6 m.

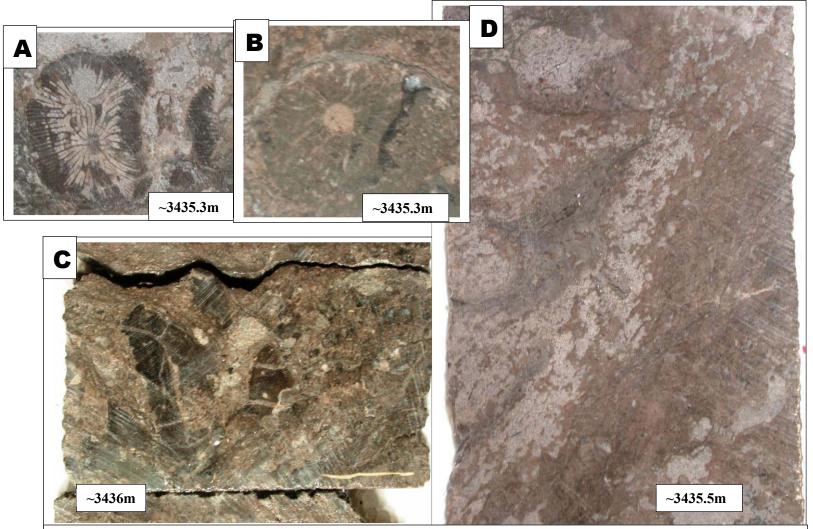


Figure 5.7-6 Margaree Core 1 photographs A) solitary corals or *Thamnasteria* fragment B) sponge C) broken platy microsolenid coral D) suspect microbolite crust at high angle Core slabs 8.5 cm wide

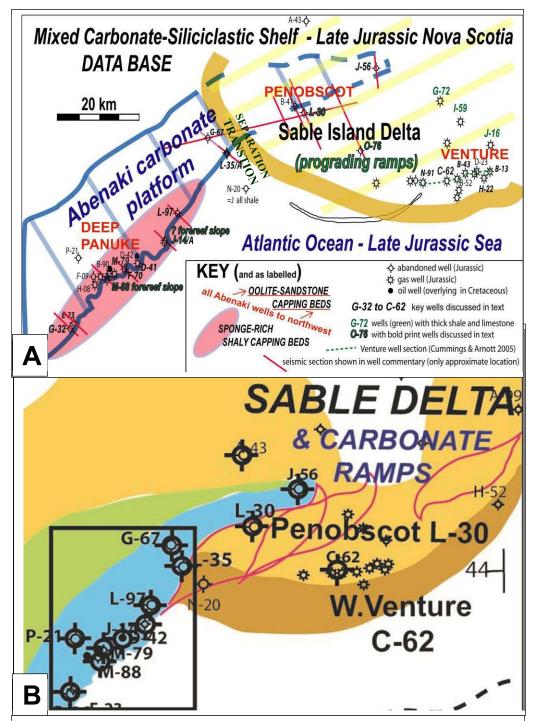


Figure 5.8 Alternative reef platform to delta relationships in Panuke Trend to Venture area –A) Delta with no platform scenario carbonate platform absent or buried by the Sable Delta with sponge-rich limestone sedimentation distal in front of shelf prodelta, Penobscot L-30 to Abenaki J-56 may be salt-high atolls/shoals separated from the platform by a gap as shown. **B) Platform envelopment scenario** (modified portion of Encana map with schematic ramps red, black box = Panuke Trend) platform extends into delta flank with delta wrapping around a still growing platform. In both alternatives there are two independent carbonate systems the oolitic-reefal platform with a deepening or increasing turbidity up trend and the mixed ramp system with thin oolites forming on abandoned or drowned portions of the delta. (see Weissenberger et al. 2006 for original Encana map).

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comparative 2 sets below	SHELF – flat-laying 'topsets'	MARGIN-FLEXURE	PROGRADED SHELF and SLOPE – clinoforms/'foresets'
UPPER sandstone and oolitic limestone	Abenaki J-56 (see pie Fig.4.18B) Mix of shale, sandstone, limestone lithologies with quartz-rich limestone, oolitic limestone & minor but widespread prevalent corals & stromatoporoids MIXED LITHOFACIES	NO WELL -Seismic (Fig. 4.18A) shows upper topset progradation over underlying clinoforms in 2 sets	Penobscot L-30 (see pie Fig.4.18B) thick sandstone & oolitic limestones with interbeds of coral-stromatoporoid framebuilders especially top & base MIXED LITHOFACIES so Core 1 very representative (Fig.4.19)
LOWER cleaner limestone section (on shelf & sandy) or thick shale on slope	J-56 (see pie Fig.4.18B) Mix of sand- stone, sandy limestone lithofacies of mainly oolite (over 50%) and lower energy limestone with widespread and prevalent but minor amounts of stromatoporoids and corals MIXED LITHOFACIES	NO WELL -Seismic (Fig. 4.18A) shows a near vertical to slight progradation from horizontal & massive strata to clinoforms then another basinward prograding clinoform before normal faulting down to basin	L-30 (see pie Fig.418B) clinoform geometry with mixed thick shales and thinner limestones of microbolite (thrombolitic) lime mud/bindstones w/ tubules, tr sponge & bryozoa 'UNIFORM' so Core 2 very representative (Fig.4.20)
UPPER sandstone and oolitic limestone	Kegeshook G-67 (see Fig. 4.22A) mix of quartz sandstone (porous) with shalier beds at base and limestone (tight) but limestone uniformly oolitic and poorly fossiliferous	Marquis L-35/A (see Fig. 4.23) topset sandstone & oolitic limestone (lower limestone has thin reefal beds at top and very minor corals & stromatoporoids in both limestones) perhaps indicative of ramp or open conditions	NO WELL - Seismic (Fig.4.22B) shows upper topset oolitic interval progradation over underlying clinoforms (PFA's forced regression of PL. or plate 9-6-2b)
LOWER clean limestone minor or no sandstone	G-67 only 460 m of section so lower Abenaki not sampled. Few thin sandstone but limestone nearly UNIFORMLY oolite with corals- stromatoporoids very rare (only 2-5% stromatoporoids-sponges above and below 3415m argillaceous interval)	L-35/A except for basal reefal limestone shows shoaling trend of slope up to reef up to oolite of fairly UNIFORM thick facies packages with transitional contacts, no sandstone & minor argillaceous limestone (most oolite & all SS in 'UPPER' subdivision)	NO WELL - Seismic (Fig.4.22B) shows progradation into basin of upper oolitic interval over clinoforms

Table 5.1 Features of two sets of dip transects from shelf carbonates to basin in Sable Delta area. Note: subdivisions not necessarily time correlative with top limestone likely older further east and north. (see appendix Figure A1.23 for PFA 2011 seismic interpretation through G-67 and L-35 into basin and Figure 4.18A&B for LSE interpretation between J-56 and L-30 into basin.)

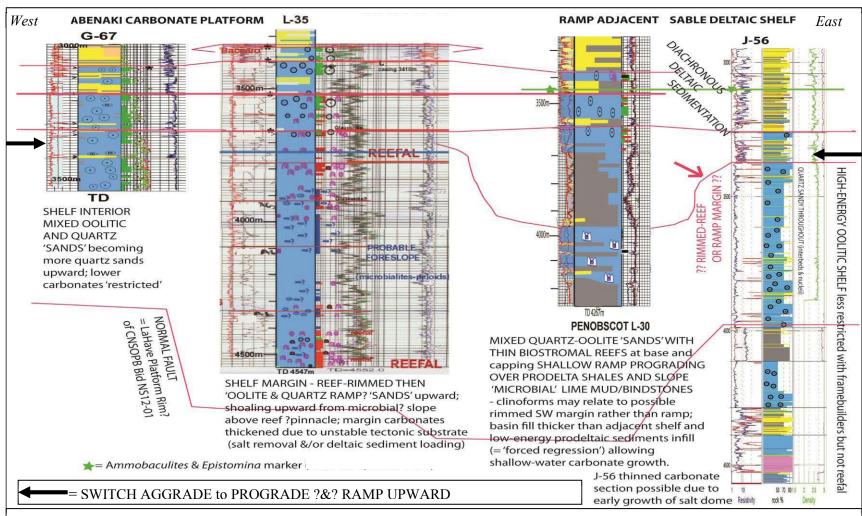


Figure 5.9 West to east section of northeast end of the Panuke trend that also can be seen as two parallel proximal-to-distal sections that face one another in mirror fashion with G-67 to L-35 the interior and margin of a rimmed platform but lacking basinal well control and with L-30 to J-56 the distal ramp slope to ?ramp interior across an untested margin of some kind. Given their mapped positions, L-30 and J-56 may not relate to one another at all and the postulated intervening margin would be more complex and transitional. See **Table 5.1** for tabulation of differences between the wells. Starred *Ammobaculites & Epistomina* fossil marker from Given (1977) and Eliuk (1978).

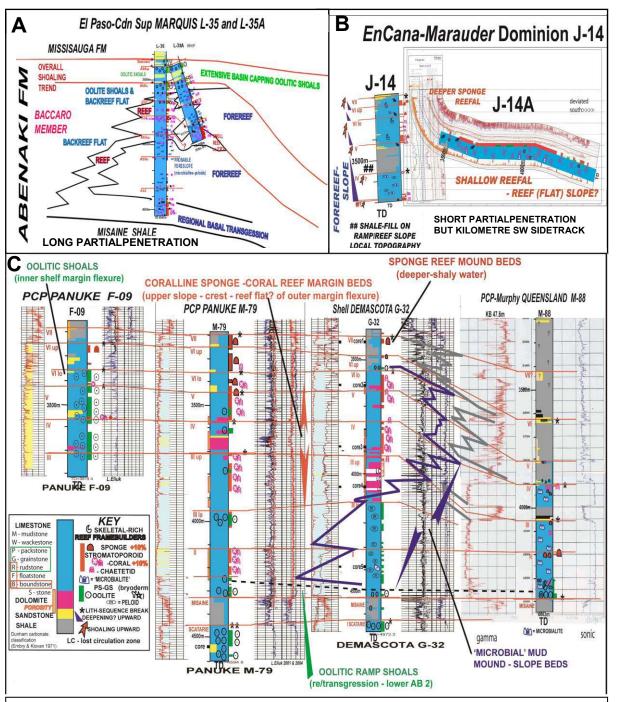


Figure 5.10 Comparative anatomy Abenaki margin of Panuke Trend southwest of Sable Delta A. Marquis L-35 and side-tracked L-35A – shoaling-up slope-to-reef-to-ooid shoal sequence on a rimmed margin with variably distributed reef knolls/pinnacles near Baccaro Member ?base. B. Dominion J-14 and side-tracked J-14A – encountered shale above slope limestones and capped by sponge-rich beds but the side-track to the south penetrated nearly a km of stromatoporoid-sponge-coral reefal beds. C. Deep Panuke dip transect – near-margin shelf interior shoals through variable margin reefal-oolitic carbonate to shoaling-up slope-reefal beds to distal slope carbonates and shales.

Larger individual figures available in Chapter 4 – Figures 4.21, 4.23, 4.31 and 4.52.

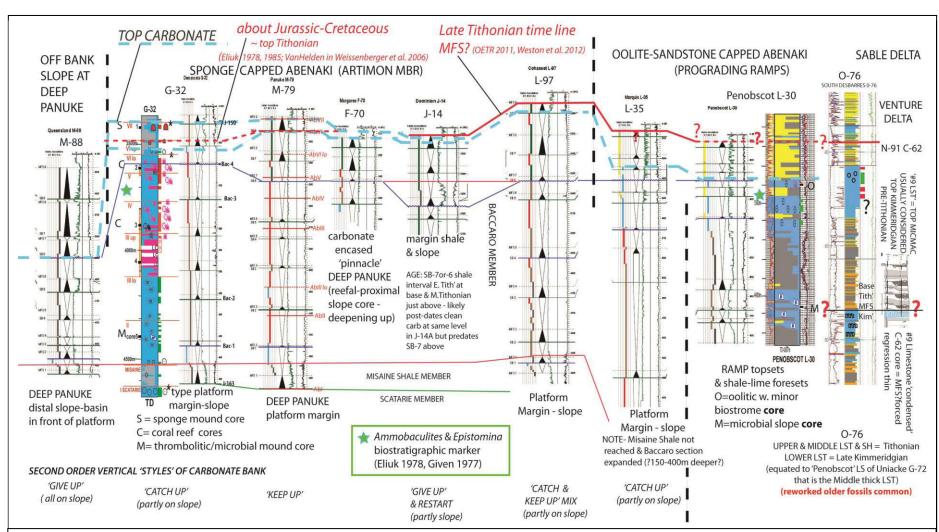


Figure 5.11 Regional correlation section from southeast end of Deep Panuke Trend to the Penobscot area and Sable paleodelta on the northeast. See text for discussion of this figure where various criteria from 1978 biomarkers to 2011 PFA sequence interpretation indicate that considerable amount of the uppermost Abenaki carbonate is in time-equivalent siliciclastic facies in the Penobscot area. But dating of interbedded thick carbonates and deltaic sediments even closer to the Sable Delta (S. Desbarres O-76; see Figure 4.15B for lithofacies) is younger than top carbonate in Penobscot L-30. The thin limestone below the Venture shelf margin delta in West Venture C-62 core shows a condensed section that shoals up over such a short 9 m interval due to a forced regression as postulated by Cummings and Arnott (2005; for fuller discussion see Section 5.2). See Figure 4.75 for key to depositional facies associations on OETR 2011 PFA Chapter 9 logs (note basic similarity but a few interesting discrepancies with Eliuk's G-32 & L-30 facies logs where figure 4.15 and 4.52 have keys). Loss from the top of Abenaki carbonates south to north was interpreted seismically independently by workers on OETR 2010 PFA Chapter 9 (pers. comm. Stephen Doublet) and Ammonite Nova Scotia (pers. comm. Bob Merrill).

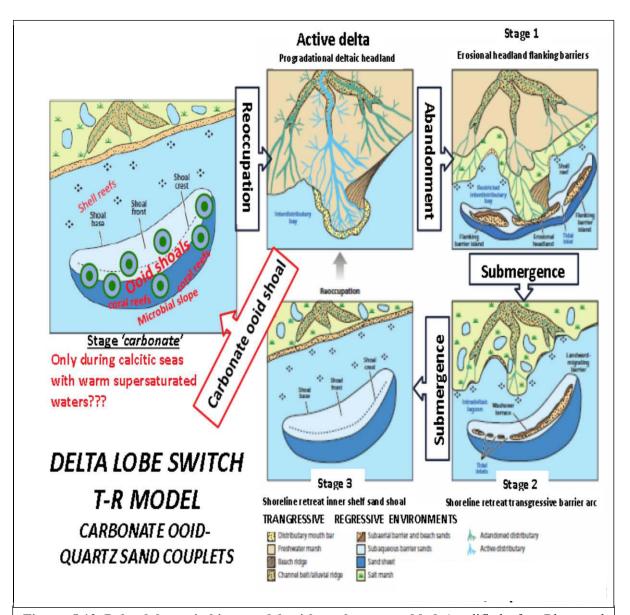


Figure 5.12 Delta lobe switching model with carbonates added (modified after Blum and Roberts 2012 after Penland et al. 1988). This visual model of a cycle of changes in major delta environments as a consequence of abandonment then reoccupation of a delta lobe was developed to explain the patterns seen in the Mississippi delta area. I have added a carbonate phase to the model. The development of offshore shoals with the absence of terrigenous clastic input seems a likely setting for shallow-water carbonates to develop given favourable seawater chemistry and climate. Wind or tidal wave energy associated with the exposed area would promote ooid development if carbonate saturation is high enough for precipitation.

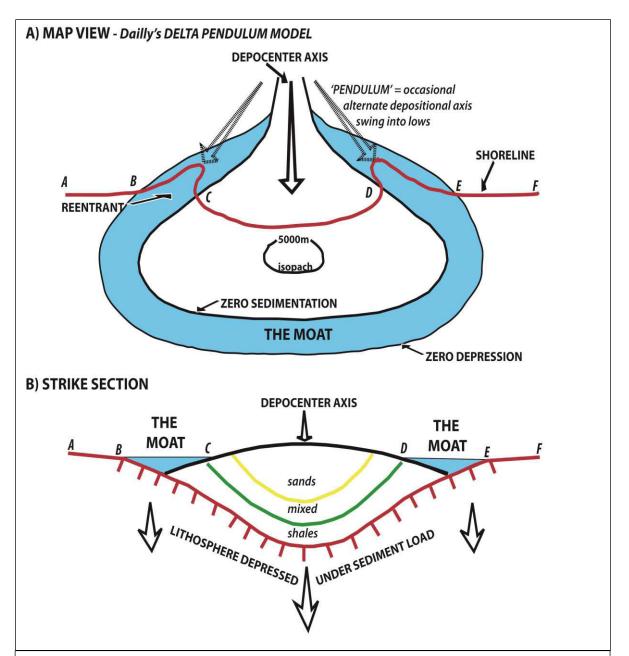


Figure 5.13 Delta-loading pendulum model of Dailly (1975, 1976 redrawn). The load of a large delta depresses the lithosphere so that a "moat' or flexural bathymetric trough is created. This deep potentially attracts sedimentation so the depocentre axis swings to one or other flanks hence the 'pendulum' term for the model. Dailly modelled consequences of this for changes in siliciclastic sediment patterns over time.

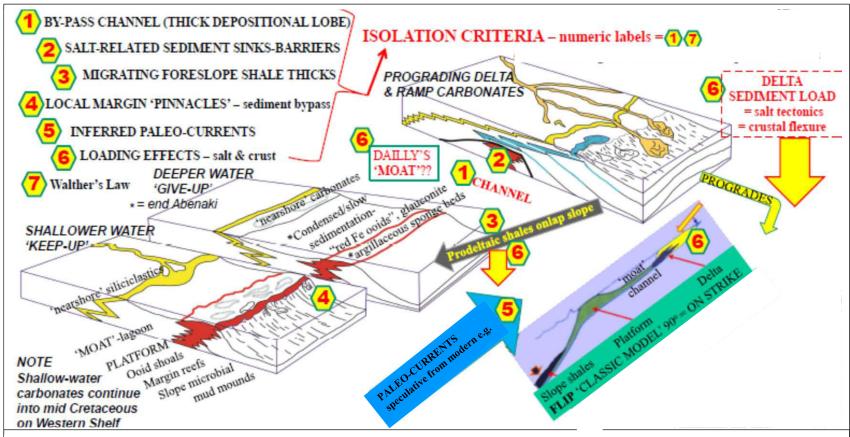


Figure 5.14 Criteria supporting isolation in the form of a physical gap to explain co-existence of the large delta and thick platform. See text for discussion of points and Appendix 2.4 for (5) speculative paleocurrents based on modern current examples in reef-bearing deltas. DAILLY'S 'MOAT' refers to the idea of delta load induced unfilled depressions as shown in Figure 5.13, See Appendix A2.2 and Figure A2.1 for 'classic model' mixed carbonate-siliciclastic system discussion. Some ancillary points are also included such as speculative paleocurrents (also see Appendix A2.4 and 2.5) along with some of the fully labelled depositional environment distribution that attempts to show the situation about and just after the time of the NBCU (Near Base Cretaceous Unconformity = latest Jurassic to pre-Valanginian).

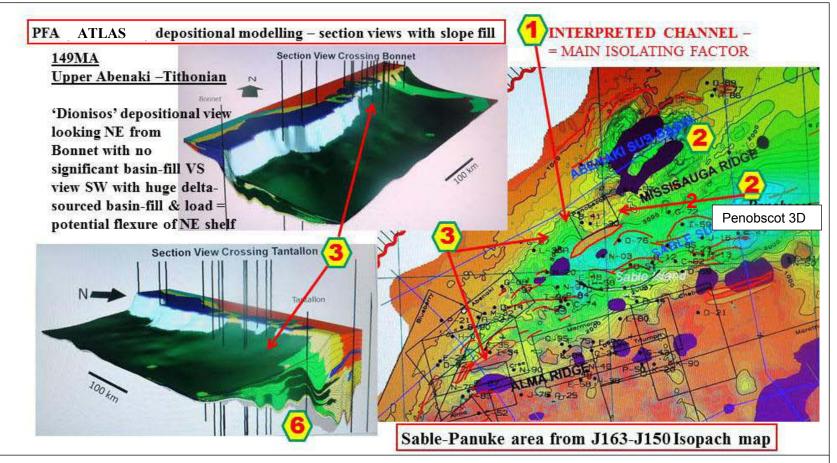
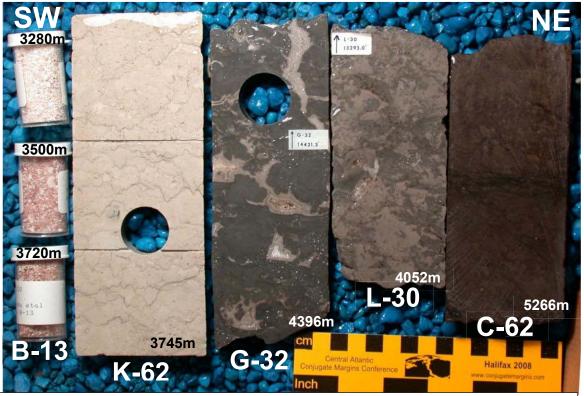


Figure 5.15 Examples of main features supporting isolation in the form of a physical 'gap', to explain co-existence of the large delta and thick platform (from Chapter 6 PFA Tectono-stratigraphic Evolution & Petroleum Systems OETR 2011 in Eliuk and Wach 2014). Refer to Figure 5.13 -1 = by-pass channel with thick depositional lobe in distal channel, 2 = salt-related sediment sinks and highs focusing sediment dispersal and ponding it, 3 = migrating foreslope shale thicks on the p latform slope, 6 = loading effects from thick prodeltaic shales possibly depress the Panuke Trend platform that with deleterious deltaic influx result in lithistid sponges replacing shallower-water corals and reefal facies.

Isopach map schematic with thickest = blue-green-yellow-light brown- darker brown = thinnest. Purple = salt diapirs



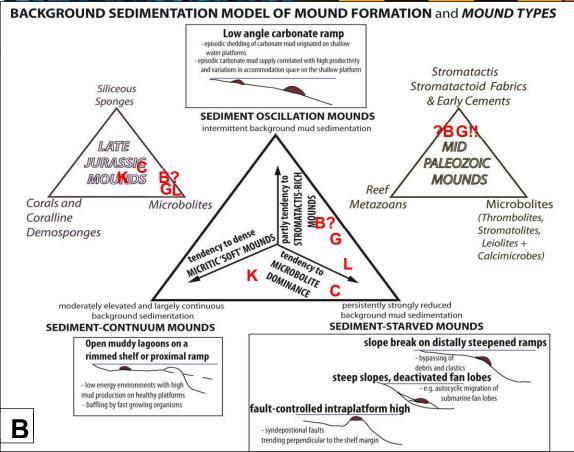


Figure 5.16 A) Abenaki or equivalent microbolite mounds examples relative to distance to Sable Delta. B) Late Jurassic and mid Paleozoic mound comparison and formation model based on outcrop studies (modified Schmid et al. 2001). Abenaki mound well letters give placement on model: B= Albatross B-13, K= Acadia K-62, G= Demascota G-32, L= Penobscot L-30, C= West Venture C-62

TABLE 5.2 Features of Abenaki margin-slope 'mud' mound and shale interbed well sections

Microbiota

Macrobiota

Eg Tubiphytes

Deep Framebuilders

marl to microb-

olite to sponge

-coral-red algal

reef mound

BB=bit bruise=lightens colour, stromtop, strom, strm = stromatoporoid, SH = shale, NA= not applicable, colours abbreviated West Venture C-62, Penobscot L-30, Marquis L-35, Cohasset L-97, Dominion J-14, Queensland M-88, Demascota G-32, Acadia K-62, Albatross B-13

WELLS C-62 L-30 L-35/L-97 J-14/ M-88G-32K-62 B-13 **FEATURES CORE CORE** L-35A J-14A **SWC CORE CORE SWC** Flat to Flat to Flat Pinnacle? Flat Seismic morphology No seismic Ramp: **Downslope:** Flat down Inclined All on platform margin deltaic shelf inclined inclined? Anomaly - inclined Inclined? Massive at to massive except C-62, L-30, M-88 edge (Ramp?) foresets (L35A ==shale +200m below & massive depth to ?inclined inclined) top ≡shelf L-30: two 'margins' 1) backreef Platform top margin (oolitic?) & back stepping downslope large mounds (microbial?} Seismic: more margin Near G-32 = true mud mounds??? detail Qayyum et al 2015 interior & 2) atoll margin Between L-35 & L-97 Thickness 30 - 60m 5-55m? +125m? 4 limestones: 3-80m 2 intervals 5-80m Overall (in well-defined (15-40m)continuous? 5 -135 m? 5, 10, 100 & 370m gross 190m & 800m gross gross gross by +15% microb-peloid) +500m? 300m gross 150m gross 2cm - +1m NA NA Mound/beds (in core) ~4 m Bindst NA NA NA 10cm-4m+ 10cm-1.4m Mainly shales 250m of SH 115m SH LS separated Only at top **Shale-shaley limestone** encasing 9m above, 2 thin overlies bv155,80 & w.sponges 15m marl to 6m SH beds, None None microbolite 50m of Dk (Artimon) None None limestone over 100 m & capped Gy SH,-2 None in. SH to TD with black microbolite by spongestrom beds bases peloid beds M-Dk Gv in Md-DkVL GvBn Colours Very dark Dk-M GvBn 10 cycles White (core in italic) Grev ?Lt-VLt Lt & Md Lt BnGrev SWC. GvBnDk-Md Gv-Gy & Bn Grev BB BB, sl.darker Lt GyBn Pink-White ?cream/Bn? Gv **BB**?? upward MDGyBn Red-White Associated facies In core cm Minor 5-Rare None? Minor oolite Minor oolite & 2nd order No debris but 5 & thin debris-2 debris beds **Debris beds** debrite 15m debris or strom' reef shoal up **Successions** localises 15m Strom Microb seq's ool-reefalbeds stromatop in situ w. corals & zones & microbial BS reefal beds microb BS interbeds sponge & capped by possibly slope up to reef =debris? strom at TD may deeper-water debris microbial Or reef? <1m be debris framebuilder beds=cave? mound mud Biota: in situ More fossils Tubiphytes, **Tubiphytes Tubiphytes Tubiphytes** Tubiphytes, Coral-skel **Tubiphytes Tubiphytes** serpulids calci-Delicate (uncommon debris) upward from serpulids, serpulids, debris beds Serpulids calcispheres tubular Calci-

Minor

macro-

fossils

Spheres

fossils

Minor

macro-

forams

Almost no

macrofossils

Few macro-

fossils

Lithocodium

sponge, strm

thin bed caps

Tubiphytes,

Tubulforam

Calcisphere

serpulids

corals in

sponges

microbolites

trm, classts

bryozoans

spheres

fossils

Minor

macro-

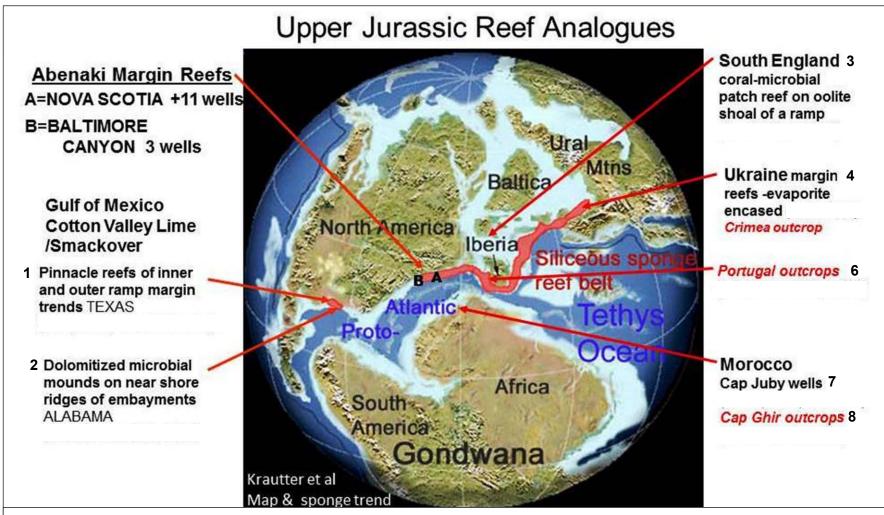


Figure 5.17 Upper Jurassic Reef Analogues. Most those listed are subsurface and hydrocarbon-bearing. They are characterized in a variety of ways by components and/or setting. The Moroccan Cap Juby offshore wells have heavy oil (HO) and unlike most of the others were at or near an oceanic shelf edge. The other subsurface examples are not appropriate for Deep Panuke but might show other play types for mid/early Jurassic and ramps. There are only a few shelf margin outcrops. Those in Portugal are in pre-Atlantic intra-shelf basins but are important for characterizing Late Jurassic reefs and mounds. The Cap Ghir reef outcrops of the Western Atlas Mountains of Morocco are likely at or near the oceanic shelf edge across the Atlantic from the contemporaneous Abenaki. Note that Krautter's sponge reef trend if accepted would make Poag's (1991) gigaplatform intercontinental and double the length; but the existence of a connection off Newfoundland is questionable.

References: 1 – Montgomery et al. (1999a & b), 2 – Mancini et al. (2004, 2005), 3– Sun & Wright (1999), 4 – Lukin (1999), 6 – Leinfelder (1994, 2001), 7– (Exxon-Mobil, Cairn websites, Kidston et al. 2005), 8 – Martin-Garin et al. (2007).

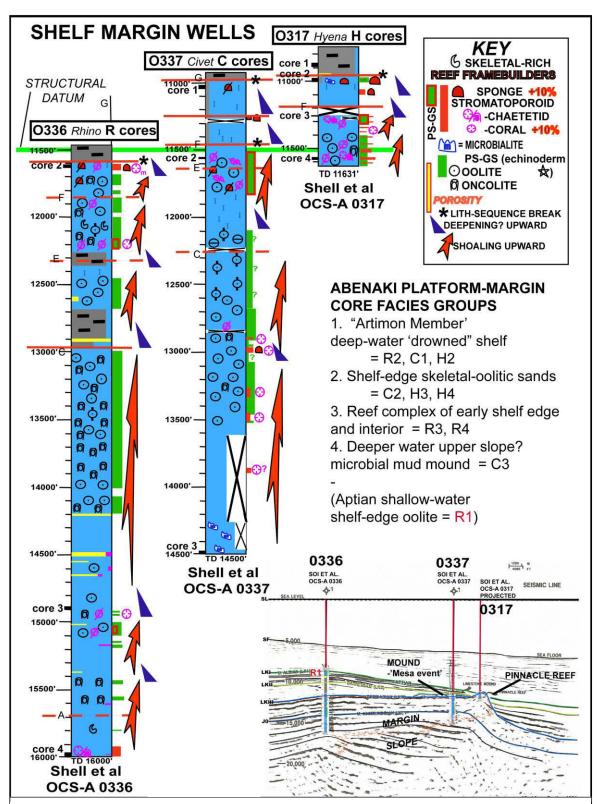


Figure 5.18 Baltimore Canyon Late Jurassic carbonate margin wells and seismic as an example of hydrocarbon application and 'feedback loop' for analogues. (Eliuk and Prather 2005 fig.4) This seismic is the best example to support a deeper water toe of a prodelta wedge location of sponge reef mounds. But it also illustrates the danger of interpreting mounded morphologies as karst when sponge reef mounds would likely be more accurate. The reservoir implications are drastically different – favourable for karst but unfavourable for sponge reef mounds. Lithologs simplified from Sylvia Cearley logging for Shell Offshore Inc 1985.

CHAPTER 6. CONCLUSIONS

List of Topics

- 6.1 Introduction
- 6.2 List of Conclusions Relative to the Two Problems
- 6.3 Suggested Future Work

6.1 Introduction

The object of this thesis study was to describe and understand the strange relationship of a thick extensive carbonate platform co-existing for a long time beside a continental-scale delta. After finding no analogues in the modern world oceans but some interesting examples of reefs in or near deltas a hypothesis was proposed to address two questions.

Suggested solution to Problem #1: *Morphology, nature and origin of a big delta/thick carbonate platform juxtaposition and lateral ramp carbonates – a bathymetric Gap best explains the systems' juxtaposition with their very different styles of .carbonates.* This is supported by seismic data and the nature of transition shown in well sections and cores.

Suggested solution to Problem #2: Possible lateral effects on platform margin carbonates due to proximity of deltaic sedimentation depends on location and can be nearly non-existent within the platform, subtle on the slope and profound, long continued and variable on the top during the expansion of the delta. This is supported by rare thin quartz sandstone beds or oolite nuclei on the main platform, increasing influence of slope onlap prodelta shales and some lateral changes in slope carbonates and wholesale reef mound community changes at top of the Abenaki succession but without presence of coarse terrigenous clastics.

The world's longest modern coral reef tract, Australia's Great Barrier Reef, ends in the large Fly River Delta of the Gulf of Guinea (Tcherepanov et al. 2008, 2010). The world's largest river, Brazil's Amazon, has a long narrow but cryptic reef tract on the edge of its wide continental shelf (Moura et al. 2016). Yet traditionally deltas and carbonate are not studied together since they seldom occur together and sedimentological investigation is in either one or the other topic. Still mixed carbonate-siliciclastic systems have received considerable study, just not for the combination of big rivers/deltas and thick carbonate platforms. There is a consensus on what controls explain or allow two, typically inimical, major sediment groups and very different complexes of depositional environments to coexist (Figure 5.2).

Hermatypic corals and even reefs are known to occur in tropical deltas but they are not forming significant thicknesses of clean carbonate. Modern sponges are seldom important producers of carbonate but some sponges are known to form reef mounds in prodeltaic settings. There were times in the Phanerozoic when sponges accounted for much of the reefal carbonate sediment. Similarly oolite has varied significantly in amount over time. The Late Jurassic was a time of prolific carbonate formation with high amounts of oolite produced. In addition extensive amounts and the greatest variety of reefs and mound types including coral reefs, siliceous sponge reefal mounds and the last major growth of microbolite (thrombolitic-microbial-automicrite-stromatactis mud) mounds. Concurrently high amounts of submarine cements and marine red coated ironstones were formed. For whatever reasons the Late Jurassic warm calcitic seas were a zenith of carbonate precipitation and hosted the Phanerozoic's longest reef tract-carbonate platform. The Sable Delta-Abenaki platform is at the north end of that gigaplatform.

This thesis examined the relationship in the Late Jurassic–Early Cretaceous offshore of the thick carbonate platform and large delta juxtaposition and lateral ramp carbonates; and the lateral effects on platform margin carbonates due to proximity of deltaic sedimentation. A bathymetric gap for keeping the two systems separate is an essential component of the hypothesis. Some of the carbonates were closely associated with and dependent on the sediment accumulation from the delta and others in the platform were little influenced. However on the platform slope and particularly at the top of the platform, a series of lateral changes in the carbonates and associated siliciclastics record the major influence of the Sable Delta on the Abenaki carbonate platform. Ultimately the delta buried much but not all of the carbonate. The unburied platform further southwest continued growing but with an intervening area where both carbonate and siliciclastic accumulation was slow and condensed.

The main conclusions arrived at in studying the relationship of the Abenaki platform and the Sable Delta result in a more complete understanding of this long-lived terrigenous and carbonate association. The historical geology is presented as a visual schematic model with **Figure 6.1** showing the development of the system vertically in five chronological steps. **Figure 6.2** is a map view of that history in the same five steps. Those figures graphically show the development of the Abenaki platform relative to the expanding Sable Delta with lithostratigraphic units, sequence intervals, possible mechanisms and geological products. This study's conclusions are grouped by their relevance to solving the two problems. For ease of reading the sources of information and citations are omitted and can be found in Chapters 4 and 5. The modern potential or inadequate analogues and some of the conceptual models are discussed in Appendix A2.

6.2 Conclusions Relative to the Two Problems

Problem #1 Conclusions – Nature of Northeast/Deltaic/Ramp Carbonates (Non-platform As Compared with Platform Carbonates) and the Gap between the Delta and Platform

- 1. Large scale vertical styles and interbedded siliciclastics show two major Late Jurassic carbonate groups of wells. Those within and flanking the Sable Delta area and on the shelf northeast of the Sable Island area are variable and usually have greater amounts of siliciclastics than carbonates (typically oolitic) versus those of the southwest Abenaki platform margin. The latter consist of a kilometre or more thick carbonates with no or only minor amounts of coarse siliciclastic thin beds except for the topmost interval in the Panuke Trend. The contrast between the two groups is stark and occurs over a short distance between the Penobscot L-30 well in the Sable Delta area and Marquis L-35 the northernmost platform margin well.
- 2. This lithologic subdivision is reflected in shelf morphology differences. The Sable Delta area and the shelf to the northeast have ramp and distally steepened ramp profiles with major progradation during the Late Jurassic. The northeast shelf prograded as a mixed carbonate siliciclastic system over 30km, on a +≥200km wide front, into an oceanic basin as part of the Sable-Laurentian deltaic complex. The southwest Abenaki platform has a steep slope mainly following the basin hinge line and is aggradational moving basinward less than a kilometre but extending laterally over 500km to the USA-Canada boundary.
- 3. Deltaic accumulation continued into the mid Cretaceous with periodic oolitic limestone interbeds such as the O Limestone Marker that subdivides the deltaic accumulation. The delta infill established the modern day continental shelf edge over 50km seaward of the Middle Jurassic shelf edge whereas the Abenaki platform margin is now under the continental slope off the Western Shelf. The modern shelf edge is in a back-step position relative to the older mid Mesozoic Atlantic continental shelf edge from south of the Sable Island area to Florida. This major progradational relationship of filling a basin-slope of oceanic depths is prime evidence for the continental scale of the Sable-Laurentian delta complex. In contrast the Late Jurassic gigaplatform shelf edge was always under the modern continental slope or even in drowned plateaus or beneath modern carbonate banks until the younger Mississippi Delta and Texas shelf prograded beyond the Late Jurassic and Early Cretaceous carbonate margin in the Gulf of Mexico.
- **4.** Three intradeltaic carbonate patterns occur within the Sable Delta area of the Abenaki Subbasin and near Sable Island. First, Abenaki limestones are associated with interpreted salt highs or swells that in the case of Abenaki J-56 became a salt dome but earlier allowed maintenance of an oolitic shoal with many thin sandstone interbeds. That carbonate terminated well before the

Abenaki platform did. Second, a more distal salt swell structure in the Penobscot area may be the locus of possible carbonate atolls evidenced by a marked seismic flexure just shelfward of foreset slope microbolitic limestones within prodeltaic shales in Penobscot L-30. A distally steepened ramp flexure is a possible alternative interpretation. The third type of intradeltaic limestone is in the form of thin marker beds such as in the Late Jurassic #9 Limestone in the Venture field shelf margin delta area. They often are oolitic in cuttings but the West Venture C-62 core has a complex variety of facies over a mere nine metre interval. They extend from depauparate marlstones through pure microbolite mound up to microbial/siliceous sponge/microsolenid coral/red algal reef mound capped by a hardground and prodeltaic shale possibly documenting a forced regression in the delta. These thin marker beds could be considered the thin end member of lateral and distal ramps discussed below.

5. Carbonates ramps and distally steepened ramps inherit their morphology from the underlying prodeltaic basin fill and are dependent on fill of available accommodation space to create shallow enough conditions for carbonate growth and progradation. During transgressive flooding phases on the outer shelf and following delta lobe shifts, carbonates alternate reciprocally with terrigenous deltaic sediments so they flank the active delta(s). A delta lobe switching model recording a complete transgression-regression cycle devised for the Mississippi Delta has been modified with the addition of a capping onlitic shoal on abandoned delta front bars for use in the Sable Delta area.

The delta and ramps developed as a complex response to extra-basinal sediment supply through a continent-draining delta, to salt movement and loading, to listric normal growth faulting and to relative sea level fluctuations. Thus correlation and compatibility of sequence subdivision between the deltaic area and the carbonate platform are not obvious and may not be possible. Age dating shows that the top carbonate is diachronous becoming generally older toward the delta in a possible stepwise fashion on the platform margin. Surprisingly, some of the deltaic carbonate ramps are younger than the termination of the Abenaki platform nearest the delta whereas other ramps are older as might be expected.

Ramp lateral facies changes are more gradual than those at the platform margin. A proximal ramp depositional association is seen as topsets on seismic data and consists of mainly quartz sandstone and oolitic limestone in couplets with the amount of thin coral-coralline sponge beds increasing basinward but never plentiful. A distal ramp depositional association is seen as foresets seismically and consists of prodeltaic shale encasing thinner dark limestones of lime peloid mud and microbolite-thrombolitic mounds with only characteristic small encrusters. Correlation of foreset limestones except along depositional strike is highly problematic. Indeed,

the ramp carbonates should not be thought of as continuous layer-cake sheets but rather as discontinuous shingles, growing somewhat haphazardly on local highs and at the shelf edge when terrigenous influx is low.

- **6.** A Gap due to bathymetric separation was hypothesized to explain the 15ma close juxtaposition of the delta and platform and to account for the marked differences between the platform margin carbonates and the delta associated ramp carbonates. Initially there also was a separation by distance, even an estuary, as the early Sable Delta prograded from the Abenaki Subbasin into the Sable Subbasin. Well control shows that the Sable Delta was active soon after the Callovian Misaine Member shale which must have been supplied by an earlier delta in the Laurentian Channel area. The East Wolverine G-37 well in the Laurentian Channel's South Whale Basin has continuous marine shale from the Middle Jurassic to the Late Cretaceous (Canada-Newfoundland & Labrador- Offshore Petroleum Board well files 2010). Seismic can be interpreted to show a bathymetric re-entrant between the Abenaki platform ending a bit northeast of Marquis L-35 and Kegeshook G-67 and southwest of the Penobscot and Abenaki salt-affected areas. In the regional strike directions (southwest-northeast) there appears to be a platform edge slope facing the channel that could have acted as a buttress to focus terrigenous sediment away from the platform and by-pass onto the deeper slope. That this was a long-continued low is supported by published seismic mapping showing a series of isotime thicks basinward that may have been deep sea fans fed through a channel. Unfortunately just as there is no well deep enough in the postulated gap to more conclusively support its existence there and no 3D seismic is available either.
- 7. At the furthest northeast end of the carbonate platform, Marquis L-35, like many of the terrigenous deltaic wells, had a thickened Abenaki section due to down-to-the-basin listric normal faulting. In fact it is likely the thickest Abenaki carbonate interval even though it terminates in the Tithonian (late Late Jurassic) before the younger termination in the Panuke Trend wells just to the south. This is also considerably older and prior to the next thickest platform wells on the Western Shelf that continue into the Early Cretaceous. Thus another influence of the delta on the carbonates was loading by prodelta shales resulting in overall section thickening. The load of this continental-scale delta may have depressed the lithosphere in addition to contributing to salt tectonism. Application of Dailly's (1975,1976) delta load pendulum model may explain the gap or unfilled depression on the flanks of the delta that is important in preserving an area that kept the delta and platform separated for much of the 15Ma when they were closely juxtaposed. A salt withdrawal low is also conceivable. Another consequence of the major delta load may be the development of bulge or uplift flexure on the Western Shelf. The Western Shelf has carbonate and overlying siliciclastics with thin intervals interpreted by others as due to unconformities.

Problem #2 Conclusions - Changes within the Platform Margin Carbonates Showing Sable Delta Influence.

8. Closing of the bathymetric Gap occurred in the Tithonian when prodeltaic shales along with ramp oolite and sandstone couplets filled the area. This deposition even occurred on the top of the Abenaki platform in Marquis L-35 and Kegeshook G-67. Marquis L-35 is the only Panuke Trend margin well to not have argillaceous lithistid sponge-rich beds (Artimon Member or similar lithofacies) at the top of the Abenaki. Instead it is capped by oolite-sandstone couplets similar to and probably correlative with the topset ramp carbonates in Penobscot L-30.

Seismic data shows a slight progradation of ramp sediments into the basin beyond the L-35 platform edge. Age dating shows these ramp style beds are older than the top Abenaki in the Panuke Trend to the south indicating that the platform has a retrograde relationship back stepping away from the advancing deltaic sediments. Further south the Sable Delta prodeltaic shales form a prograding wedge with a slope onlap surface relationship to the distal lower platform slope. Initially this did not affect the platform lithofacies which was in shallow waters unaffected by the deeper turbid influx. This sediment pile load potentially caused flexuring, fracturing and faulting of the margin that with deterioration in surface water conditions aided the change-over from shallow-water coral-stromatoporoid reefs to sponge reef mounds. This facies change was diachronous occurring first during the Late Jurassic in the north and progressing southward after.

A few wells in the Panuke Trend do have thick shale interbeds mainly because they were drilled in part on the slope and in the case of Queensland M-88 totally on the slope with only deeper water facies present particularly microbolite mounds. Platform slope onlap shales are inclined away from the Sable Delta. This wedge-like geometry is revealed by comparing the carbonate facies above and below thick shales encountered along the platform margin and slope. The underlying carbonate is usually replaced by a shallower carbonate facies in the overlying carbonate. Carbonate facies represent a distal slope setting in the Queensland M-88 where influx of shale does not result in shoaling perceptible to the carbonate communities. This illustrates a progression on the slope north of M-88 where first the overlying carbonate is lithistid sponge rich (Dominion J-14) then coral reefal and oolitic (Penobscot L-30) showing the dip of the prodelta southward.

9. Colour and sedimentological-biological variations within the slope carbonates demonstrate apparent delta proximity changes along with the slope onlap shales with associated carbonates. The most striking thing about the slope sediments and particularly the microbolites is the progression of colour changes starting from very dark grey and brown in the delta to near white

with red and pink colour cycles at the furthest well on the southwest edge of the Nova Scotia offshore. Except for West Venture C-62 that is slightly argillaceous to marlstone, the carbonates appear non-argillaceous so the colour change is due to other factors including even burial differences that would still be indirectly attributable to Sable Delta proximity.

The slope carbonates show a variety of microbolite textures including stromatactis mud mound types. The microbolites usually are devoid of large metazoans but have characteristic encrusting microbiota. Several cores show skeletal debris from upslope including bioeroded colonial corals. Only one core far from the delta shows *in situ* delicate branching hexcorals and displacement fabrics and repositioned geopetals within the mound sediment. These Abenaki examples have been plotted on mound classification charts based on European outcrop studies and show the stromatactis and reddened slope beds seem like hold-overs from the mid Paleozoic. With the limited data control, it is not apparent whether the differences relate to delta proximity or variations in position on the platform slope.

10. The two indicators of shallow water depositional facies - oolite and the slightly deeper coral-stromatoporoid reefal beds - do not show any obvious changes in the platform margin with respect to delta proximity based on cuttings evidence alone. However the presence of thin sandstone beds and quartz nuclei in ooids do occur in the Panuke Trend but most terrigenous transport occurred mainly as muddy sediment on the distal platform slope and not across the shelf. There is too little core to examine more subtle possible lateral changes though two sets of shelf margin coral-stromatoporoids reefal cores 40 km apart do show interesting differences – highly bioeroded debris reef with a possible cave or Neptunian dyke versus large *in situ* corals with little evidence of bioerosion and more associated microbolite crusts in separate debris beds. But rather than proximity changes they can just as well be understood as depositional depth differences

The platform carbonate margin in contrast to the ramps has a constricted lateral facies gradient. This is seen in many vertical sections as a 'catch-up' or slight progradational or shoaling 2nd order sequence. The succession begins with distal lime muds and microbolite-thrombolitic and mud mounds followed by coral-stromatoporoid reefal intervals and then up to oolite both vertically and laterally. Three shelf margin wells lack oolite and penetrate small pinnacles encased in carbonate. Core from the Margaree F-70 demonstrates the transition from shallower coral reef prone facies up to lithistid sponge reef mounding on the inboard grainy slope of the buildup with many thin reefal intervals as well as a crinoid filled channel or graded debris flow. This is a record of a keep-up to give-up reef being drowned and/or responding to deteriorating conditions due to influx of turbid deltaic waters on the shelf margin.

- 11. Strangely, with only two exceptions and these both on the Western Shelf, there are always some amount of thin onlite beds at the base of the Baccaro Member or sometimes even in the underlying Misaine Member shale that may rarely have sandstone beds capping the shale. This apparent anomaly of going from marine shales up to shallow onlite, even if partly allochthonous, then immediately deeper again to slope carbonates dated as the top Callovian may record a major sea level drop associated with glaciation²⁴ around the Middle to Late Jurassic age boundary. The morphological profile of the basal Baccaro mimics those of the underlying Misaine shale and dominantly onlitic Scatarie which are distally steepened ramps.
- 12. Unequivocal delta proximity effects occur at the top of the Abenaki platform with effects continuing into overlying terrigenous sediments. Minor sponge-rich limestones and bioelemental condensed beds of marine red coated ironstones are the two key lithologies. The coated ironstones appear to cap nearly all platform wells southwest of the Panuke Trend. Within the Panuke Trend such bioelemental beds are absent but in the uppermost platform margin there is an absence of oolite and a major change in reef community composition from coral-stromatoporoid reefs to siliceous sponge reef mounds. This is interpreted to indicate a drowning of the shallow-marine platform. This may result in part from possible initial subaerial exposure at one or more brief unconformities including the Near Base Cretaceous Unconformity (NBCU; above the Berriasian-Late Jurassic) followed by the deleterious effect of turbid waters associated with the ingress of the Sable Island prodelta clays and the apparent much slower growth of the lithistid sponge communities as compared to hexacorals and coralline sponges.

The transition is regionally diachronous in front of the expanding Sable prodelta. However, most of the Panuke Trend seemed to have near synchronous termination although the initial onset and mix of lithistid and coral-stromatoporoid communities started at different times. As already mentioned the downslope loading effects may have aided in the demise of shallow sedimentation in the Panuke Trend. Much further southwest, siliceous sponge-rich beds occur on many of the shelf interior wells in the Mohican Subbasin along with marine red coated ironstone beds at the top of the main Abenaki Formation and slightly above. That area was the distal limit of the Sable Delta. Further southwest beyond the presence of prodeltaic beds in Acadia K-62 and Albatross B-13 sponge beds are also absent although marine redbeds occur at the top of the younger Early Cretaceous age platform.

13. The Abenaki platform continued growing on the far Western Shelf when it had terminated in all wells to the northeast. In Bonnet P-23 slightly interior from the shelf edge, the platform continued growing even into the Aptian and possibly Albian. The topmost shelf limestone was slightly argillaceous with both high amounts of lithistid and stromatoporoid sponges. Finally the

platform was capped by the thickest development of marine red coated ironstones indicating long-continued sediment- starved conditions beyond the reach of the delta and unfavourable conditions for vigorous carbonate growth. All three near shelf margin Western Shelf wells are overlain by thin Cretaceous marine sediments including Late Cretaceous chalk (Wyandot Formation). This indicates the likelihood that the platform was drowned and exposed on the seafloor in deep water. Wide near vertical cement-lined fractures occur near the top of the Abenaki platform in Albatross B-13 with asymmetrical red and green geopetal bearing isolated ooids. These are interpreted as Neptunian dykes within cemented oolitic grainstones suggesting that the seafloor exposure started very soon after the end of the Abenaki platform.

14. The final point is a comparison with possible modern analogues. The siliceous sponge mounds in prodeltaic settings may have analogues in the Fraser River prodelta off Vancouver Canada and in the recently described rhodolith-sponge reef tract at the Brazilian continental shelf edge off the mouth of the Amazon. The cored #9 Limestone facies in West Venture C-62 in front of the Late Jurassic delta shows many similarities. Unfortunately modern demosponges are generally not calcified and the Fraser River mounds result from clay baffling by hexactinellid sponges liable to be preserved only as silica spicules leaving a mysterious shale mound as their taphonomic legacy. Reefs within modern deltas often show marked facies variation and distribution relative to oceanic current direction

In conclusion, there are no modern analogues for the ubiquitous presence of oolite deposits closely associated with delta-derived sandstones in the carbonate ramp settings. Similarly the presence of a thick clean carbonate platform very near a continental-scale delta also lacks modern analogues. This makes the Late Jurassic Abenaki platform and Sable Delta a very strange association in a former world much more hospitable to marine shallow-water carbonates then the seas of the twenty-first century. The long continued relationship of delta and platform are summarized in two diagrams:

First, **Figure 6.1** is a time series of schematic strike sections laying out some of the processes and products from older up to younger. These show how a gap could have long existed between the platform and the deltaic sediment pile with salt swell highs. The gap was then infilled with periods of ramp carbonate sedimentation over abandoned delta lobes or near the shelf break during transgressions. Loading and associated tectonics affected both delta and carbonate margin during and after the Late Jurassic. On the shelf and margin siliceous sponge reef mounds grew in turbid waters in front of the prograding delta as it progressively buried the northeastern half of the platform. More distally the shelf was starved of sediment shown by marine red beds of coated

ironstone. Yet further southwest the shallow-water platform continued growing into the mid Cretaceous until it too was drowned but not buried initially.

Second, **Figure 6.2** in a complementary time series of map views summarizes the long-continued relationship of carbonate platform and growing delta.

The Sable Delta and Abenaki carbonate platform interplay generated conditions that resulted in deltaic and reefal shelf margin gas fields by providing linked traps, seals, reservoirs, source rocks and migration paths. Cuttings, core and seismic data collected over a half century of exploration have been the basis of explaining the delta/platform relationship and the Scotian Shelf geohistory.

6.2 Suggested Future Work

- 1. A concentrated effort to prove (or disprove) the Gap, or presence of a channel separation between the Abenaki platform and Sable Delta should be done with use of modern seismic especially along strike at key points. There does not appear to be any 3D seismic surveys in the postulated channel location. The debate about the nature of the Penobscot structure and whether it is an atoll, the flexure point in a distally steepened ramp overlain by younger ramp topsets or less likely a part of the Abenaki platform has exploration implications if Deep Panuke is used as an analogue. Perhaps the delta load switching model from the Mississippi Delta with my addition of capping onlites could explain the deltaic and high energy setting. Or maybe the Sable Delta was a different type, perhaps not even always a river-dominated delta, but at times in its early history may have represented an estuarine deltaic morphology influenced by tides.
- 2. The Dailly (1975. 1976) deltaic pendulum load model was applied to examine the consequences of a huge deltaic load on the lithosphere and the potential generation of unfilled depressions, or 'moat,' to explain the separation of the Sable Delta and Abenaki platform. Salt tectonics have been modelled physically and numerically but has that or a lithospheric model ever been considered for potential effects on sedimentation with seafloor perturbations? As well, some of the differences that subdivide the Scotian Shelf into tectonic subprovinces (subbasins and platforms) may be responding to the presence of thick carbonates interbedded in the Late Jurassic interval that preclude diapirism and thus promote seaward expulsion of salt on the slope. Dalhousie is a centre for such numerical modelling would this not be an interesting project? In fact the effect of loading of the continental shelf edge by a carbonate margin early cemented and considerably

heavier-denser than terrigenous clastics could itself be a load potentially producing its own lagoon. Is the 'bulge' concept applicable to Western Shelf thins?

- **3.** The very interesting seismic of Qayyum et al.'s (2015) images downslope mud mounds and 'double' margins. It should be specifically applied over known facies in the wells, and if applied to the Deep Panuke 3D data set, might result in a better understanding of a complicated reservoir architecture of oolite shoals, encased pinnacle reefs and slope mounds overprinted by fractures, faults and diagenesis. This could lead to a possible extension of the life of the field which appears to be heading to a brief life and water-plagued death.
- **4.** The northeast Abenaki-MicMac carbonates are truly a mixed system that prograded over 30km along a 200km wide front. An integrated discipline approach including cuttings studies of the carbonates, cores, well logs, plus seismic data and biostratigraphic control might lead to an understanding of how it "worked". Its' highly oolitic nature makes it different from actualistic reefal analogues found associated with deltas of the Mahakam, Fly River, Fraser, Shatt al Arab, and the Mouth of the Amazon shelf edge.
- **5**. The distribution and significance of the marine redbeds during part of the history of the Scotian Shelf has been outlined. A more in-depth study of red coated ironstones might yield many more insights and increase our understanding of their relationship to submarine hiatuses and subaerial unconformities.
- **6.** The study of thin limestones or even micro-reefs within siliciclastic cores should be applied by surveying offshore Nova Scotia cores and similarly offshore Newfoundland whether exploration or field wells.
- 7. Macrofossil studies and the systematics and paleoecology of mound and reef framebuilders like hexacorals, siliceous and coralline (stromatoporoids and chaetetids) sponges, calcareous higher algae and the various microbolites has barely been started for the Abenaki and other offshore carbonates. Data from this study with whole core photo tracings and lists of fossil occurrences shows where future research studies might find their data.

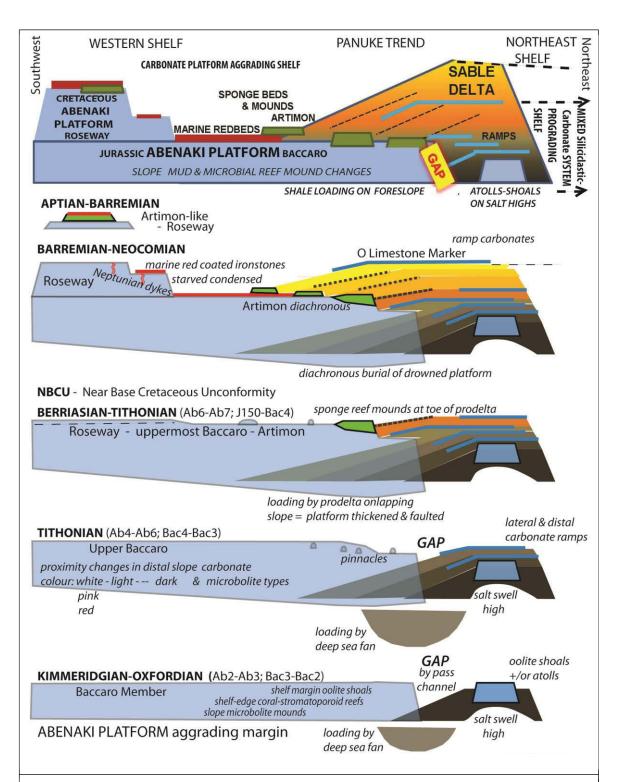


Figure 6.1 Summary model for Abenaki platform to Sable Delta relationship over time. Schematic strike sections from oldest up to youngest showing the changes as the Sable Delta expanded and eventually buried much of the Abenaki platform southwest of Sable Island. Approximate ages and sequences, lithostratigraphic names, processes and products shown. Neocomian considered to include Berriasian, Valanginian and Hauterivian . LSE 2016-07

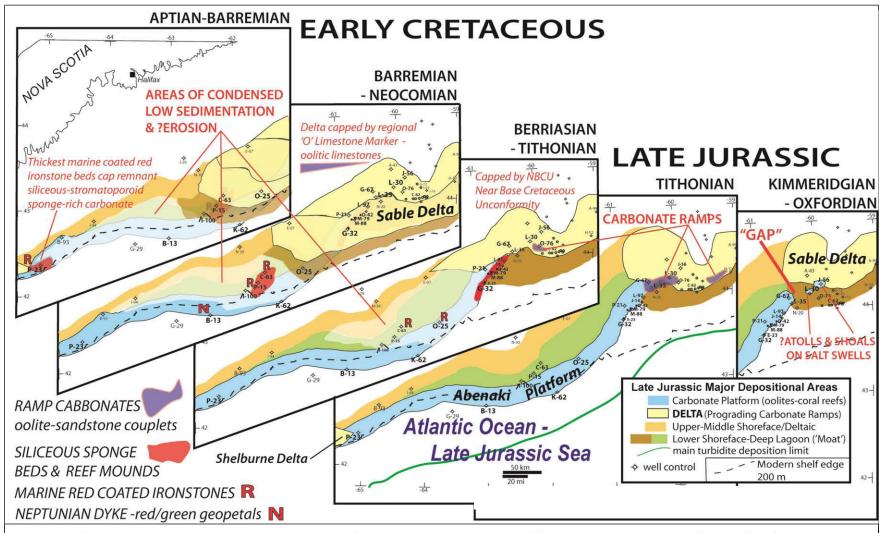


Figure 6.2 Sketch paleogeographic maps showing key features during expansion of Sable Delta on southwest Scotian Shelf.

During the Jurassic-Cretaceous the Sable Delta continuously enlarged to the southwest of the Sable Island area. Initially for millions of years the delta-Abenaki platform (Baccaro Member) co-existed due to separation by a bathymetric 'gap' or channel. After the gap infilled, the platform back stepped and changed to a siliceous sponge-rich facies (Artimon Member). It diachronously moved at the prodelta toe with an area of very low sedimentation with thin sponge beds and marine coated ironstone redbeds further southwest. The Cretaceous shallow-water platform reduced in area (Roseway Member) until it too was capped by thick marine red coated ironstones indicating long seafloor exposure and was buried by much younger sediment. Ramp carbonate intervals formed at different times on the abandoned delta lobes or during flooding at the shelf edge. Base map in part after Hogg and Dolph 1999 Encana talk. Delta edges modified from Deptuck (CNSOPB 2012).

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APPENDIX A1. PREVIOUS WORK AND STRATIGRAPHY CRITIQUE

List of Topics

- A1.0 Previous Work Introduction: The Abenaki-Sable Transition
- A1.01 Eliuk (1978) Penobscot L-30 Biomarker Correlation and Diachronous Prograding Relationship
- A1.02 Eliuk et al. (1986) and Elsewhere Penobscot L-30 Early Seismic
- A1.03 Welsink, Dwyer and Knight (1989) Tectono-stratigraphic Setting for Sable Delta to Carbonate Margin Controlled by Transfer Fault Zones
- A1.04 Wade and Maclean (1990) Near-delta Limestones Seen as Diachronous Members within Deltaic Growth-faulted Siliciclastics
- A1.05 Cummings and Arnott (2005) Shelf Margin Delta Model for Venture Gas Fields and #9 Limestone
- A1.06 Kidston et al. (2005 CNSOPB) Regional Review of Abenaki Margin Using Encana Sequences
- A1.07 Encana (2006) and Weissenberger et al. (2006) A sequence Stratigraphic Framework For the Abenaki at Deep Panuke and Porosity-Amplitude Anomalies (Harvey and MacDonald 1990, 2013, Harvey 1993) and Deep Panuke Reservoir Diagenesis (Wierzbicki et al 2006)
- A1.08 Eliuk and others Abenaki Studies 2000 -2014 Various Talks and Core Papers Including Eliuk and Wach (2008, 2010, 2014); Wierzbicki et al. (2002, 2005)
- A1.09 OETR 2011 PFA Chapter 9 Late Jurassic Carbonate (Beicip-Franlab; Stefan Doublet and Others) and Revised/New Biostratigraphy (PFA Chapter 3 and Annex 3 Published in Weston et al. 2012)
- A1.10 CNSOPB Bids 2012 NS12-1 Supporting Geological/Geophysical Studies
- A1.11 Qayyum, Catuneanu and Bouanga (2015) Penobscot Area Seismic Sequence Stratigraphy
- A1.12 Abenaki Stratigraphy Introduction:
 Lithostratigraphy, Biostratigraphy, Seismic Stratigraphy and Sequence Analyses
- A1.13 Stratigraphic Nomenclature
 - Lithostratigraphy, Scatarie Member and Suggestion on Usage of Terms
- A1.14 Biostratigraphic Dating and Correlation Issues
 - Inconsistencies, Reworking,
 - a Check on Diachronous Surfaces and Sequence Schemes
- A1.15 Gaps, Unconformities and Condensed Sections Seafloor Diagenesis as an Indicator
- A1.16 A Profusion of Previously Proposed Cycles and Sequences

A1.0 Previous Work Introduction: the Abenaki-Sable Transition

A survey of previous work in chronological order with assessment and even modifications on published figures illustrating alternative interpretations is followed by a review of different aspects of Abenaki stratigraphy. The first 11 Sections review previous publications including nonformally reviewed articles available on the internet relevant to the Abenaki-Sable carbonate platform-delta transition. The source of my insight and most data on geometries were particular

helpful contributions that used and showed seismic relevant for imaging and mapping the Abenaki and the transitional area. Some of these key sources were Shell-associated work (A1.0, A1.01, A1.02), Encana-associated work (3.07, 3.08), Geological Survey of Canada work (A1.04, part of A1.09), Canada-Nova Scotia Offshore Petroleum Board-associated work (CNSOPB; A1.07, A1.10) and Offshore Energy Technology Research Association-Play Fairway Analysis-associated work (OETR-PFA; A1.06, A1.10) and most recently Qayyum et al. (2015). Each Section includes observations and commentary using key published figures. Some figures are shown with clearly noted modifications - particularly where "re-purposing" the data illustrates my alternative or additional interpretations.

The presence of a large delta beneath Sable Island was known very soon after the first offshore well was drilled by Mobil Canada in 1967. Regional drilling by Shell Canada soon established that thick carbonate platforms existed not far from that delta both to the southwest and interbedded with siliciclastics to the northeast. The thinner prograding carbonate ramps seen seismically were first penetrated by Penobscot L-30. The nature and relationship of that well is a key to understanding the transition between delta and carbonate bank. Penobscot L-30, drilled by Petro-Canada and Shell in 1976, is located just north of Sable Island and in an intermediate position between the Jurassic-Cretaceous Sable Delta and the thick Abenaki carbonate platform as also shown by its mixed siliciclastic-carbonate lithologies.

Although the adjacent location of these very different sediment accumulations was known almost at once, the rarity and very unusual nature of their juxtaposition seemed not to be appreciated or at least not mentioned as strange for decades. In the original definition of the Mesozoic offshore Nova Scotian stratigraphic units, McIver (1972) anticipated the mixed nature of the Jurassic sediments by grouping the dominantly limestone Abenaki Formation with the siliciclastics and lesser associated carbonates of the MicMac and shales of the Verrill Canyon formations in the Western Bank Group. Jansa and Wade (1975) mapped the Western Bank Group showing the delta and carbonate banks. Soon the Mohawk Formation of mixed carbonate-siliciclastics on the western shelf was found to be Late Jurassic-Cretaceous in age. So the Mohawk was also placed in the Western Bank Group and the Mohican Formation replaced it for older underlying Middle Jurassic sediments by Given (1977). Given also showed the diachronous nature of the top Abenaki in maps. Just how much carbonate is needed to support the use of Abenaki as opposed to MicMac terminology is debatable.

A1.01 Eliuk (1978) – Penobscot L-30 Biomarker Correlation and Diachronous Prograding Relationship

The first published interpretation of Penobscot limestone and its correlation was in Eliuk (1978). Because the Penobscot L-30 well had just been released from 2 year confidentiality some observations on its facies and dating only appeared in the Appendix (Eliuk 1978, p. 496, first logged by Shell geologist Alison Essery). That paper showed the progradation of the Sable Delta over the carbonate bank in map view (ibid. Fig. 5, reproduced as **Figure A1.1**) and in a regional chapter (ibid. Fig. 14, reproduced as **Figure A1.2**) that had biostratigraphic markers indicating contemporaneous deposition across major facies and lithologies. In Eliuk (1978, his figures 18-20) at least 4 depositional sequences above the Misaine shale resulting from shallower versus deeper sedimentation were interpreted as models for the carbonate platform but could not be carried into the Sable Delta area.

In Penobscot L-30, Shell's *Ammobaculites*(sp.)-*Epistomina*(sp.) paleontological marker used as the section datum occurred at 3444m (11300 ft.) at the base of the uppermost limestone just 37m below top Abenaki (or the Penobscot limestone member of Wade and MacLean 1990). This put top carbonate at an intermediate position compared to a well nearer the Sable depocenter. For instance in Abenaki J-56, the *A.&E.* paleo-marker is in sandstones 168m above top Abenaki as opposed to wells further southwest where it is 213m below in Cohasset D-42 and 203m below in Demascota G-32 (or 317m if Artimon limestone and shale are included). The carbonate margin was seen as fairly steep alternating with less steep channels or passes and becoming ramp-like closer to the Sable Delta.

The Penobscot L-30 Abenaki-equivalent interval showed 3 facies: 1) prograding shallow shelf over 2) basinal shales and then 3) inclined forereef/slope carbonates. The L-30 upper limestones were often onlitic and interbedded with quartz sandstones indicating a relatively shallow shelf setting with a core containing a four metre onlite bar and coral-stromatoporoid-skeletal thin beds. The deeper carbonate was uniform in cuttings and seen in core to be very poorly fossiliferous (except for 'tubules') lime mudstone with small stromatactis structures and interpreted as a possible deep-water mud mound deposit. The intervening thick shale had Kimmeridgian palynomorphs and was thus not the Misaine shale. Eliuk's (1978 Fig. 14) early interpretation was based on few wells, 2-D seismic and some biomarkers. The Abenaki carbonate to Sable Delta was interpreted as a diachronous transition both to the southwest and northeast. The interbedded siliciclastics northeast of the delta were thicker and coarser sands as opposed to thinner less common shales and argillaceous limestones on the southwest. Except in the shelf

margin wells Demascota G-32 and Cohasset D-42 which were capped by sponge-rich beds, the uppermost Abenaki limestones were typically oolitic. Away from the delta the termination was seen as a widespread contemporaneous drowning of all the carbonates. Subsequent wells and data show that in fact the sponge-rich limestone beds typically occurring interbedded with shales are diachronous (see below Eliuk 2008 etc.). So the termination history is now seen as more complicated.

A1.02 Eliuk et al. (1986) and Elsewhere - Penobscot L-30 Early Seismic

Seismic and the interpretation that the Abenaki near Penobscot L-30 tested a prograding ramp topset and underlying foreset clinoforms of the slope was part of an Atlanta AAPG convention talk (Eliuk et al. 1986) as **Fig. A1.3**. That seismic and interpretation was again shown in Eliuk and Wach (2008) and is included with discussion in a subsequent chapter. The nature of the Abenaki just to the west of Penobscot L-30 seemed likely to be an aggrading carbonate platform edge but was not tested. The nearby Penobscot B-41 well only slightly penetrated the top Abenaki which was oolitic limestone. This same seismic line with similar interpretation occurs in Ellis et al (1985), Jansa et al. (1988, seismic from Ellis et al. 1985), Jansa (1991 with seismic wrongly reversed to interpreted schematic, 1993 same but correctly displayed), and MacLean and Wade (1993).

A1.03 Welsink, Dwyer and Knight (1989) Tectono-stratigraphic Setting for Sable Delta to Carbonate Margin Controlled by Transfer Fault Zones

Welsink et al. (1989) applied a long-continued extensional regime established with the initial rifting that formed the Atlantic Basin to explain the shape and fault distribution as well as its hydrocarbons of the Scotian Shelf subbasins. Their linkage to some of the tectonic events on the Grand Banks and Iberia was repeated in part in the PFA Chapter 9 for margin depositional style changes and unconformities in the Late Jurassic and BCU (Base Cretaceous Unconformity). Some of their figures with my added comments in **Figures A1.4**, **A1.5**, **A1.6**, **and A1.7** give some relevant ideas on the distribution and its interpreted tectonic control for both the carbonate margin and the Sable Delta.

A1.04 Wade and MacLean (1990) – Near-delta Limestones Seen as Diachronous Members Within Deltaic Growth-faulted Siliciclastics

Wade and MacLean's (1990 Fig. 5.33) interpretation, modified in **Figure A1.8**, was based on newer seismic and many more wells in the Sable Delta area, and showed the importance of growth faulting contemporaneous with deltaic deposition and thinner, usually oolitic, limestone interbeds. Their regional schematic Late Jurassic well section went from the Deep Panuke area

(Queensland M-88 is actually on the slope just seaward) through Penobscot L-30 to the Venture area. Note the southwest to northeast transition from a thick carbonate platform to a mixed carbonate-siliciclastic progradational ramp to the highly growth-faulted Sable Island paleo-delta area. There is faulting at Penobscot L-30 possibly due to underlying salt movement (see seismic and synthetic over Penobscot L-30 and nearby Penobscot B-41 in MacLean and Wade 1993 interpreted therein as a roll-over anticline structure above a deep salt pillow with non-commercial hydrocarbons occurring in overlying sandstone in B-41). Wade and MacLean (1990) designated various limestone beds or members by name and placed them in the MicMac Formation rather than consider them a part of the Abenaki Formation.

Interestingly there is a temptation to assume the non-correlative limestone members of the down-faulted blocks would be younger basinward. However dating, including new data from the PFA (2011 website) for Uniacke G-72, South Desbarres O-76, Griffin J-13, indicates that some of the MicMac limestone lentil/member age assignments may need revision. Or we may simply need to appreciate that rapid sedimentation is below the resolution of paleontological dating.

At Penobscot L-30 the relationship shown by Wade and MacLean (1990) does not reflect the fact that the lower limestone is clearly a slope clinoform on seismic and in core (hence my 2008 addition of the blue clinoforms). But it does fairly show Wade and Maclean's interpretation (1990 p.210) that shaly basin-fill was contemporaneous with carbonate platform aggradation from as far southwest as Demascota G-32 to northeast of Cohasset L-97 somewhere before Penobscot L-30 is reached. A similar ramp-like transition into the basin was also proposed by Ellis (1984; Ellis et al. 1985, 1990) for the same segment of the Abenaki margin. Subsequent seismic including 3D with confirmation by the slope well Queensland M-88 show that such a gradual ramp-like transition into the Atlantic basin is untenable south of L-97 (Kidston et al 2005, Weissenberger et al 2006). Nevertheless Wade and MacLean's interstratified carbonate-siliciclastic ramp model is possible basinward of the last thick continuous carbonate in Abenaki J-56 into the immediate Penobscot area to somewhere north of the Marquis L-35 margin test that drilled continuous slope, reefal and oolitic carbonate.

Another feature in **Figure A1.8** worth noting is their interpretation that the Scatarie and presumably overlying Misaine shale is very much deeper and well below the Penobscot L-30 TD despite GSC dating that the bottom shales are Callovian-Bathonian (Ascoli 1990). This problem between seismic geometries and apparent too old paleontological ages is recurrent in subsequent workers interpretations including new dating for the PFA (2011). See MacLean and Wade (1993)

for dip seismic over all available Nova Scotian wells up to that time. Therein are examples such as South Desbarres 0-76 (added to **Figure A1.8**) showing their idea of down to the basin displacement of limestone beds like the Penobscot with thickened intervening shales.

Wade and MacLean (1990) proposed the transfer of the Artimon Member from the Abenaki to the Missisauga (or Verrill Canyon) Formation since it was of various diachronous Early Cretaceous ages with intervening siliciclastics. As well Wade and MacLean (1990, their Fig. 5.39) showed the various facies relationships on the LaHave Platform for mid-Mesozoic limestones with various terms including 'Roseway unit', several Artimon Members, O' Marker limestone, and Baccaro Member. Jansa (1993) used the 'Roseway unit' versus the Abenaki Formation as separate terms to differentiate inferred Jurassic versus Cretaceous ages in continuous limestone sections. The same practice but considerably different tops were used by MacLean and Wade (1993) for Bonnet P-23, Albatross B-13, and Acadia K-62. As discussed in the stratigraphy Section A1.13, subdividing lithostratigraphic terminology based on biostratigraphic dating is not a good practice. As suggested in Section A1.13, perhaps 'Roseway unit' should be called Roseway Member of variously the MicMac, Missisauga and Abenaki formations.

A1.05 Cummings and Arnott (2005) - Shelf Margin Delta Model for Venture Gas Fields and #9 Limestone

Like Deep Panuke, the contemporaneously deposited Venture area gas fields are also interpreted by Cummings and Arnott (2005) as 'shelf-marginal' but having deltaic sandstones not reefal carbonates. The **Venture** (\underline{V}) and nearby fields (**Figure A1.9** showing the main facies) were the geologically oldest of the three field areas that included **Alma** (**A**) and **Glenelg** (**G**) in their suite of examples of Missisauga Formation growth-faulted shelf-margin deltas. They assembled seven criteria (reduced to 5 in their abstract) to identify ancient growth-faulted shelf-margin deltas (\underline{V} , \underline{A} , \underline{G} indicates presence):

- 1) thick upward-coarsening successions (V, A);
- 2) large-scale clinoform reflections (\underline{V} , A);
- 3) stratigraphic position over relatively mudstone-rich deposits (\underline{V}, A, G) ;
- 4) soft sediment deformed intervals and gravity-flow deposits (A, G);
- 5) growth faults (V, A, G); 6) evidence of storm-wave deposition (V, A, G);
- 7) paleoecological evidence of rapid shallowing (A).

Progradation across a continental shelf to the margin requires very high sediment supply relative to accommodation space. Thus it is aided considerably by relative sea level fall that reduces

accommodation space. In fact such a falling sea level or forced regression may be the key ingredient and perhaps can only be proved with assurance by paleoecological evidence of rapid shallowing not caused by thick sediment infill. Such evidence was unavailable for the Venture delta. Cummings and Arnott's (2005) shelf-margin depositional model for Venture is best summarized by their diagram (reproduced as **Figure A1.10**). Note the importance of falling sea level for both progradation and later incision. Also note that for at least three phases (a, b and c) and possibly four (including late e phase) of relative sea level stand there is carbonate sedimentation on the outer shelf. The changes in water depth have a good probability of being reflected in changes in carbonate sedimentation even if perhaps slow or condensed due to environmental stress such as turbidity and nutrient excess resulting from being on a siliciclastic-rich shelf. A more recent study of the same wells (Gould et al. 2012) interprets fewer incised valleys and more lateral continuity in deltaic facies as shoreface and river mouth turbidite deposits but also in widespread thin river sands and tidal-estuarine deposits rather than in storm beds.

Carbonates can be sensitive indicators of depositional paleo-environment and likely paleo-depths. The #9 limestone may give that missing paleoecological evidence in Venture for their forced regression of the initial sequence at least. A closer look at the core does not support Cummings and Arnott's (2005, p.217) Facies #1 description of the limestone as a carbonate "mudstone deposit lacking frame-building organisms, which pass gradationally upward into prodeltaic mudstone" that were "marine condensed sections formed during maximum transgression". Limestones in the C-62 core and cuttings in adjacent wells show a more complicated story for the #9 Limestone that has regional implications and represents one of the thinnest end-members in a spectrum of siliciclastic-associated limestones of Late Jurassic age. Yet the revised limestone story may still support their interpreted falling sea level or forced regression.

A1.06 Kidston et al. (2005 CNSOPB) Regional Review of Abenaki Margin Using Encana Sequences

This Canada-Nova Scotia Offshore Petroleum Board study by Kidston et al. (2005) applied new industry seismic and PanCanadian/Encana sequences from internal reports, talks and core conference publications (e.g. Wierzbicki et al. 2002) in a well-by-well survey. While a detailed regional correlation of the Encana sequence markers was not part of the study, the markers were placed on most seismic sections. Kidston et al.'s review (2005 Fig. 78 on p.102 as **Figure A1.11**) of Abenaki margin regionally and regional mapping of "near basement morphology" at "Lower Jurassic" time placed Penobscot L-30 about 20 km basinward of a basement trend that underlies Deep Panuke, Cohasset L-97 and, less probably, Marquis L-35.

Subtle salt features were suggested to underlie Penobscot L-30 and, like the Panuke and Cohasset areas sands above the margin, were oil-bearing but non-commercial at L-30. However a number of indentations show potential lineation at deeper levels aimed at L-30. From Demascota G-32 to Marquis L-35, the Ab6 sequence is shown as present. At Marquis L-35 they noted that the seismic showed a sigmoidal shape to the margin which may be a transition between escarpment-like and ramp profiles. Unfortunately only older seismic from MacLean and Wade (1993) without Encana sequences were used for Penobscot L-30 and Abenaki J-56 (seismic with sequence correlations for those 2 wells are also absent from subsequent publications by Encana such as Weissenberger et al. 2006 and from the OETR PFA Chapter 9 of 2011). But the latter does have Penobscot L-30 on a stratigraphic section with much of the uppermost Abenaki age sequences in a coarse siliciclastic facies and not carbonate. The seismic dip line with Kegeshook G-67 and Marquis L-35 (Figure A1.12. their Fig. 117) is very likely the same as the line used for the PFA Chapter 9 seismic stratigraphic interpretation for those same wells. Kidston et al. (2005) interpreted somewhat younger sequences in the upper Abenaki carbonates. Top Abenaki is equated to Ab6 and shown continuing into the basin beyond Marquis L-35. I cannot agree with Kidston's deeper correlation of Ab4 almost horizontally into the basin rather than down a steeper clinoform basinward of L-35 as indicted by the seismic reflectors (see Figure A1.23 = PFA 2012, Pl. 9-6-2b that similarly differs from Figure A1.12). New biostratigraphy in OETR PFA (2011) gives older ages for the top Abenaki limestone, invalidating the presence of the upper sequences as carbonate because they have changed to sandstones and shales. Figure A1.13 shows the regional 3D appearance of the top carbonates of the main platform and some of the ramp relationships to the Sable Delta in the northeast.

A1.07 Encana (2006) and Weissenberger et al. (2006) – a Sequence Stratigraphic Framework for the Abenaki at Deep Panuke and Porosity-amplitude Anomalies (Harvey and MacDonald 1990, 2013, Harvey 1993) and Deep Panuke Reservoir Diagenesis (Wierzbicki et al 2006)

With the 1998 discovery of the large Deep Panuke gas field in the Abenaki Formation reefal shelf margin, Encana (2006, Wierzbicki et al 2002, 2005, 2006; Weissenberger et al. 2006) set up a sequence stratigraphic framework for their new wells. Except for their conceptual schematic block diagram (Weissenberger et al. 2006, Fig. 12) and their regional paleogeography map (their Fig. 7 that I show as **Figure A1.14**), the relationship of the Deep Panuke area Abenaki carbonate bank to the Sable Delta is not considered. Unfortunately no bounding surfaces, such as unconformities, correlative deeper equivalents or maximum flooding surfaces – which are the basic building blocks of sequence stratigraphy – have been recovered in Abenaki core.

Surprisingly Weissenberger et al.'s (2006, Fig 17) only core descriptions (Peskowesk A-99, Citadel H-52) are from the Sable Delta area to illustrate the co-existence and switching of carbonate within dominantly siliciclastic settings for Abenaki time equivalent sediments (their p. 414-416). It was the presence of thin sandstones in dominantly carbonate settings of Deep Panuke that often were key to identifying their sequence-boundaries at interpreted unconformities at the top of shoaling trends. **Figures A1.15** and **A1.16** are from the Encana (2006) development report and show the structural-stratigraphic nature of the pool where reservoir porosity was secondarily developed due to burial diagenesis including late dolomitization (Wierzbicki et al. 2006). **Figure A1.17** compares the two Abenaki sequence stratigraphic schemes (Encana vs PFA 2011 Chapter 9) and also shows biostratigraphic ages as used by Encana (modified Weissenberger 2006 dating provided by Van Helden). Their regional map (**Figure A1.14**) clearly shows the late Abenaki carbonate bank contemporaneous with the Sable Delta. In fact the deltaic upper-middle-lower shoreface and even some of the subaerial delta at the Venture gas field area are shown as actively being deposited basinward of the still growing carbonates even at Abenaki J-56 (*sic* Abenaki L-57).

The discovery of Deep Panuke resulted from deepening to a seismic amplitude anomaly in the Abenaki margin through an existing platform producing well bore of an exhausted light oil pool. In 1985 Shell Canada discovered the Panuke Field in Cretaceous sandstones draped above the Abenaki margin. The first well, Panuke B-90, drilled the immediately underlying upper Abenaki oolitic limestones that were not porous. Before development, the field was sold to Lasmo who much later sold it to PanCanadian/Encana. It produced about 40MMbbl (6.36MMm³). Using amplitude anomalies as potential porosity indicators had been advocated for the Abenaki exploration by Harvey and MacDonald (1990, 2013 review) and Harvey (1993). Working for the Nova Scotia Department of Energy, they had modelled and even shot seismic over the carbonate shelf-edge Demascota G-32 well. G-32 was the first Abenaki well with any significant porosity and had amplitude anomalies. Their hypothesis was tested by Encana explorationists and succeeded at Deep Panuke. However AVO (amplitude versus offset) analysis cannot always distinguish between anomalies caused by carbonate porosity versus those by interbedded shale, particularly if the geometry is complicated by steep clinoforms or structure. That difficulty is a problem potentially evident in Demascota G-32 and certainly the cause for failure at Dominion J-14, given the Sable shale input and the ability of sponge reefs to still form limestone amongst shale. An Encana follow-up exploration well, Musquodoboit E-23 updip but near Demascota G-32, failed to find gas or significant porosity so even with a proven 'formula', results may not be as hoped. Wierzbicki et al (2006, and Wierzbicki et al. 2005 for the Margaree F-70 well excluded from the 2006 paper due to confidentiality) presented an explanation of the reservoir development and diagenesis. Deep burial dolomitization was the main component for effective porosity development.

A1.08 Eliuk and Others – Abenaki Studies 2000 -2014 Various Talks and Core Papers Including Eliuk and Wach (2008, 2010, 2014); Wierzbicki et al. (2002, 2005)

Several of the Encana publications noted above included me as co-author (Wierzbicki et al. 2002, 2005). As GeoTours Consulting Inc., I logged all of Encana's Abenaki drilling program well cuttings, sidewall and whole cores. Two long papers (Eliuk 2008 and Eliuk and Wach 2008; on CD and internet but not formally peer reviewed) were presented at the first Atlantic Conjugate Margin conference in Halifax in support of talks and poster displays as well as two repeats of core paper displays written from the 2005 joint CSPG-AAPG Conference in Calgary (Wierzbicki et al. 2005, repeated as Eliuk for Wierzbicki et al. 2008). Eliuk's facies template (Eliuk 1978, Eliuk and Levesque 1988) was updated based on additional well data from Deep Panuke in Wierzbicki et al. (2002). Additional internet-available but not peer-reviewed extended abstracts were presented at various AAPG (2010 talk slides on their DataPages), CSPG, Atlantic Geoscience Society and Atlantic Conjugate Margins conferences in Lisbon and St. John's (Eliuk 2004, 2008, 2009, 2010a&b; Eliuk and Wach 2008, 2010a&b, 2014a&b). They dealt with various aspects preceding or associated with this on-going thesis study dealing with the history of diagenetic studies, reefs and facies models, slope facies variations, #9 Limestone of Venture delta fields, and the delta-platform relationship with an explanation of their co-occurrence.

These ideas and papers, which have been available on the internet, were part of the data set that included the bulk of my detailed Abenaki well-cuttings lithologs used by Beicip-Franlab for the Play Fairway Analysis Chapter 9 (Stefan Doublet and associates' work). So the chronology of ideas will skip ahead to consider some aspects relevant to the Penobscot area and correlation in the comprehensive 2011 Abenaki study for the Play Fairway Analysis. A new and different second sequence stratigraphy was developed for the PFA. Although I did make editorial comments to them on the chapter, it did not seem reasonable for me to question why they did not continue to use the Encana sequence stratigraphic scheme from the Deep Panuke development, given the time constraints they were operating under. But as has already been shown in **Figure A1.17**, there are many sequence correlation differences in detail beyond simply sub-paralleling one another. However the identification and mapping of six key seismic horizons (with the distinct possibility that they are not uniformly synchronous) forming the basis of their 4 mapped intervals (see **Figure A1.21**) along with several instances of additional biostratigraphy and that from PFA work in other chapters are all good useful contributions. Certainly for me they broke an impasse I had as I realized my physical lithological correlations by themselves were dubious. At the same

time **Ammonite Nova Scotia**'s seismic studies and isotime mapping (pers. comm. Bob Merrill on work done with Kevin Hill on 2D and 3D seismic in the Penobscot area – the same 3D set that was used by Qayyum et al. 2015) independently corroborated the PFA studies - particularly the basin-fill anomalies (similar to parts of **Figure A1.19**) and diachronous top carbonate on seismic.

Eliuk's (1978) original end-of-Abenaki interpretation - a widespread synchronous termination that was reflected in the development of the 'drowned' Artimon Member, by definition lithistid sponge rich, was repeated in the extended abstract of Eliuk (2000) and augmented in a repeat of posters used at the 1991 Dolomieu Conference in Italy. With new dating (see Section 3A1.09) and the diachronous dating of the Artimon (Williams in Eliuk 1985), it seems many areas had shallow carbonate sedimentation re-established if there was a widespread drowning. Since the drowning was preceded by interpreted exposure and unconformity in places, the re-establishment of shallow water carbonates as opposed to Artimon-like facies may not be too surprising, even if difficult to detect. This diachroneity of the Artimon and its association with shales and prodeltaic settings links the member to the southwest progradation of the Sable Delta during the latest Jurassic and early Cretaceous.

A1.09 OETR 2011 PFA Chapter 9 Late Jurassic Carbonate Play (Beicip-Franlab; Stefan Doublet and Others) and Revised/New Biostratigraphy (PFA Chapter 3 and Annex 3; Weston et al. 2012)

The Play Fairway Analysis (PFA, OETR 2011) is a wonderful resource even if as usual I raise some objections of more or less import. This analysis dealt with the Abenaki carbonates mainly in their late Addendum Chapter 9 called the 'Late Jurassic Carbonate Play' and concentrated on the upper Abenaki carbonate platform southwest of the Sable Delta. OETR through RPS had Beicip-Franlab do the study with Stefan Doublet as lead geologist of the team. Through GeoTours Consulting Inc., I supplied all detailed carbonate well lithologs and facies interpretations except for Glooscap C-63. Beicip-Franlab reformatted my data into their facies association subdivisions keyed to the depositional models (see Figure 3.3 for example versus Figure 3.2). Penobscot L-30 was the furthest northeast well specifically discussed and illustrated on a correlation section in Chapter 9. Areas over the whole shelf were dealt with in the other chapters though not in as much detail as for the Abenaki in Chapter 9. Chapter 5 and its associated annexes on structure are useful for the greater coverage at the top (J150 – top carbonate) and near the base (J163 – Scatarie). Penobscot L-30 was the one example of carbonate ramp shelf oolitic and quartz sandstone and prodeltaic slope shale interbedded with microbial carbonate slope sedimentation in proximity to the Sable Delta and its siliciclastic shelf. No seismic nor interpretation of L-30 or the apparent shelf edge to the west were given. Paleontological or biostratigraphic studies were done for the PFA as a whole in Chapter 3 and then supplemented by four additional wells in Chapter 9. **Figure A1.18** shows Jurassic-age wells studied and **Figure A1.19** shows my tracings of some of the margins and depositional thicks at different periods plus locating 5 wells adjacent Penobscot L-30 with dating used for the **Figure A1.20** cross-section.

Biostratigraphy that is relevant to Jurassic-Cretaceous carbonate-deltaic sedimentation was also revised or new in PFA Chapter 3 on Stratigraphy. Annex 3 of that chapter gives summaries by simplified lithologs for 85 wells, about 28 relevant to the thick Abenaki. Older existing mainly Geological Survey of Canada (GSC) dating was shown, often in multiple sets from different workers as was biostratigraphy for 25 wells, 12 relevant to the Abenaki. Weston et al. (2012) published much of that PFA chapter with minor revisions. Like Poag (1991) for the US Atlantic offshore, they noted complications in many wells due to reworking as well as the more usual caving problems. Not all the wells with biostratigraphic dating of Jurassic age were included in Chapter 9 on the Upper Abenaki mainly because they were too far northeast and into the mixed carbonate-siliciclastic realm amongst the Sable Delta. Even Penobscot L-30 was only included in a peripheral manner but it did get placed on a correlation section (Figure A1.20). Many of these are outside the area of this thesis as shown in **Figure A1.18**. A few that involve thick carbonates interbedded with deltaic siliciclastics may eventually prove useful for understanding the nature of the limestones in Penobscot L-30. Four of the wells nearest to L-30 have been combined in a southwest to northeast section that captures the biostratigraphic conclusions derived for the particular wells (Figure A1.20 and caption). The observation and interpretation that reworked older fossils were common in the mixed lithology wells, Uniacke G-72 and South Desbarres O-76, is significant in indicating intra-Jurassic erosion and re-sedimentation probably due to the salt diapirism with uplift and unroofing in the updip Abenaki Basin. Indeed a prominent interpretation of PFA Chapter 9 (OETR 2011) is that widespread intra-formational unconformities occur on the shelf southwest of the Panuke Trend and explain major lateral progradation with clinoforms in the Sable Delta area. Unfortunately there was no new or revised dating in Penobscot L-30 which has only the well operator and older GSC paleontology (Ascoli's 1990 GSC age assignments are shown on Figure A1.20). Unlike the Encana sequence age assignments which derive from a single well, Panuke M-79, the deepest in the Deep Panuke gas field, the PFA dating of their Abenaki sequences are a composite from several wells – Cohasset L-97 the thickest at the margin, Queensland M-88 on the slope, Bonnet P-23 far to the southwest (plus 3 or 4 more others shown on Figure A1.18), and short shaly intervals in Dominion J-14 and Marquis L-35. The PFA recovery of useful fossils in the carbonates was rather poor. In argillaceous carbonates and shales the recovery and dating were better. But nowhere was there a lot of continuous usable data giving a good vertical sequence. This apparently was not true of the dating by Van Helden for Encana at Panuke M-79 (Weissenberger et al. 2006; see **Figure A1.17** for distribution, **Figure A1.22** and **Table A1.1**). Unhappily all we have are the age biozones and not the genera and species (there is no more-detailed report by Van Helden at CNSOPB and my efforts to get data directly from Encana have been unsuccessful – all original company reports are now in storage offsite, pers. comm. Norman Corbett).

Rather than attempting to use the published Abenaki sequence stratigraphy at Deep Panuke by Encana (2006, Weissenberger et al. 2006), a new scheme was proposed in the PFA study (OETR 2011). Eight sequence boundaries (SB 1-8) and 9 or more Maximum Flooding Surfaces (MFS) were proposed. Structural and isopach mapping were reduced to four units where 6 regional seismic reflectors (J-163, Bac-1 to Bac-4, J-150) approximated some of the key sequence boundaries (SB's). PFA Chapter 9 attempted to compare their ages and new sequences to Encana's using the key Panuke M-79 versus Marquis L-35 (Figure A1.21 modified by the addition of a more specific depiction of the Encana sequences and lithologies in M-79). Because PFA did not have Van Helden's specific taxa to assess, they did not attempt to explain some of the apparent age differences between nearly equivalent sequences. I do try to compare the two schemes by accepting Van Helden's biozones but then using the stage comparisons in Ogg et al. (2004) to change the Boreal (British) to Tethyan (French) stage terminology (see discussion in captions of Figures A1.17 & A1.21 and Table A1.1). The main difference is that Encana's Ab5, 4 and uppermost 3 were considered earliest Tithonian and mainly Kimmeridgian but the same interval in Panuke M-79 were PFA's SB6 and SB5 of mainly Early Tithonian age (Note – this was done with conversion to Tethyan/French stages). One unsettling inconsistency in the PFA report occurs in their comments accompanying their sequence correlation sections (e.g. Figure A1.22) of PFA 9-6 where in almost all cases the sub-SB6 (Bac-4) sequence is referred to as Kimmeridgian, which would fit with the dating given in Panuke M-79 by Encana for the equivalent Ab5 and Ab4, yet in their summary comparison (Figure A1.21) they show it as Tithonian (although a close look at the biostratigraphic tables of specific wells often notes "Tithonian to Kimmeridgian"). A less controversial observation on the age of top carbonates and of major significance for correlations to the Penobscot area is that the carbonates between those two wells terminate significantly earlier (i.e. older) to the northeast. In fact, the difference may be even greater since the topmost carbonate in Panuke M-79 was dated as Neocomian that is earliest Cretaceous similar to the dating of the sponge mounds at the top of Demascota G-32 which nannofossils indicate may be Berriasian-Valanginian (Eliuk 1978, Williams 1985). In addition the probable fractal nature of sequences (see Appendix A1 & Schlager 2005) is apparent when accommodation space is limited such that the number of sequences increase upward but their thickness decreases (this is the pattern of both Encana and PFA schemes even away from the delta and simply means in shallower settings unconformities are more likely). But as the delta is approached there is a doubling of sequences at the top of Marquis L-35 compared to the more distal Panuke M-79 or Cohasset L-97. See the introductory PFA **Figure A1.21** in which I add the additional sequences in red as used in the PFA section A-A' of **Figure A1.22** where shallow oolitic limestone and quartz sandstone alternate in Kegeshook G-67, Marquis L-35 and Penobscot L-30. In contrast, in Cohasset L-97 the four sequences reduce to two since they are likely in too deep a setting to be easily separated or they simply amalgamate. More rapid subsidence with loading and/or salt removal near the delta may also contribute to this change. Although not within the area of study, some Abenaki units, like Bac-3 on the southwest shelf, become so thin as to not be seismically detectable. PFA workers interpreted this as possible intra-formational erosion that may be caused by the same tectonic event (Grand Banks Avalon uplift?) and relative sea level lowering that is used to explain the progradation of the Jurassic delta in the Penobscot area during an interpreted forced regression as shown on **Figure A1.23**.

The PFA report while not dealing too closely with the Penobscot area has some possibly useful analogues and features that may be relevant for interpretation regarding seismicdepositional geometries, gross depositional facies changes and expected thicknesses of carbonates there. Margin carbonates may be thicker north of Cohasset L-97 towards Penobscot L-30 despite the fact that there is progradation and facies changes to siliciclastics in the upper Baccaro sequences. Several points show this greater thickness. First, one compares the differences in isotime intervals on various seismic sections (Figures A1.3 and A1.12). Second, by noting on Figure A1.22 the base of the Baccaro was still perhaps 150m or more below L-35 TD making it as thick or thicker that Cohasset L-97, which already is thicker than Deep Panuke's M-79. Third, the down-to-the-basin thickening in the Baccaro between Kegeshook G-67 and Marquis L-35 wells on Figure A1.23 adds considerable section. On examination there is quite a difference between the PFA prograding margins and likely trace of the combined carbonate-delta shoreline in the Tithonian as compared to the suggested deltaic shelf edges in the Tithonian and earliest Cretaceous of Cummings and Arnott (2005) and CNSOPB (2012; Deptuck et al.). More simply, there just was not much consideration given to the pattern of shelf edges north of Marquis L-35 in PFA Chapter 9. However there was an expected pattern of southwestward migration of slope depositional thicks with time during the growth of the carbonate platform (Figure A1.19) and that allowed progradation. Cummings and Arnott (2005) interpreted the Venture gas fields as shelfmargin deltas of Tithonian age. Therefore the amalgamated shelf margins are likely to have an east to west trend bending at the carbonate margin somewhere between Cohasset L-97 and Marquis L-35. Presumably the margin to the NE would then be buried in deltaic (or mixed) sediments. And the age of limestone in South Desbarres O-76 is younger than the top Abenaki in Marquis L-35 so that while the shelf margin is buried in sand and shale, there is still carbonate shoal growth on top of prodelta shales adjacent the Sable Delta. The non-definitive biostratigraphy must be supplemented by seismic in understanding and establishing a sequence stratigraphy. Unfortunately no interpretation of seismic or facies off-setting Penobscot L-30 was offered. But the U-shaped seismic lines of PFA Pl.9-7-3a Fig.1 did show the change from platform escarpment to prograding ramp on either side of Marquis L-35. Loss of carbonate at the top can also be inferred by loss of reflectors at top carbonate. An even more dramatic loss was seen by Bob Merrill and Kevin Hill (pers. comm. 2011) in a series of seismic lines from Panuke H-08 to Penobscot area. The Figures A1.20 to A1.24 have captions with some highlighting, circling or even adding more well logs (Figure 1.21) that show minor discrepancies within the PFA text and figures. But perhaps one of the greatest difficulties, which is not unique to the PFA report but is true generally, is the common disconnect of dating and seismic geometries that seem incompatible and incongruent. A more in depth review by paleontologists together with seismic interpreters is needed.

A1.10 CNSOPB Bids 2012 NS12-1 Supporting Geological/Geophysical Studies

Some of the parcels posted in NS12-1 were adjacent to Ammonite Nova Scotia licenses (in blue) as shown below on **Figure A1.25.** Therefore some of the CNSOPB (Canada-Nova Scotia Offshore Petroleum Board) interpreted regional settings, tectonic features and depositional history derived in part from 3D seismic are quite relevant to understanding the Penobscot area. Some of the basement highs and salt basins as shown in **Figure A1.26** seem to be somewhat different than other interpretations and if valid have implications for likely structural controls and perhaps diagenetic fluid pathways. Even the carbonate shelf edge or at least the presumed controlling basement feature – LaHave platform edge (hingeline) – is placed in an unusual manner. Finally some of the interpreted Jurassic-Cretaceous shelf edge trends as shown in **Figure A1.27** have implications for the correlation and timing of the carbonates at Penobscot. These interesting differences are pointed out and discussed in the appropriate figure captions below.

On the tectonic framework side, (see **Figure A1.26** caption) placement of Abenaki J-56 and Abenaki L-57 – salt diapir wells – are on a basement ridge, yet Penobscot L-30 apparently near a massive carbonate margin is in the middle of a salt basin. The placement of the LaHave

Platform edge which in most cases underlies the Abenaki carbonate margin is well west of the carbonate margin Marquis L-35 well apparently over salt and no other ridge underlies it. At least if these interpretations are valid, there is now a drilled shelf margin test above salt at L-35. Therefore, even if the apparent margin just to the west of Penobscot L-30 is on salt that is no reason to discount the likelihood of it being an actual reef margin. Whether diagenetic pathways and history are also analogous to the dolomitized reef margins over basement highs such as Demascota G-32 and Deep Panuke is still an open question. The location of these wells relative to salt and basement highs has been informally discussed with Mark Deptuck and Kris Kendell of CNSOPB and they say they are not miss-plotted locations. Deptuck speculated that maybe the massive appearance of seismic in the Penobscot area is simply complicated salt structure features and not necessarily due to the presence of a carbonate margin.

Assuming the shelf break trends of the prograding delta continue over the older carbonate shelf margin and bury it, then they become another potential factor in dating the diachronous burial of the carbonate platform. There is the alternative that the delta does not bury the NE end of the platform but instead wraps around the basinward side of it leaving it to continue in existence behind the active lobe ((implicit in the Encana paleogeography as in **Figure A1.14**)

As well there is yet a third possibility that with successive rises in relative sea level or delta lobe shifting, the carbonate growth might re-establish over older siliciclastics preferentially on the margin as a pre-existing paleo-high. However accepting the first scenario allows proxy dating of the demise of carbonate margin growth as shown in CNSOPB Bid NS12-1 (2012, their Fig.17 and 20 combined as **Figure A1.27**). Even earlier, Cummings and Arnott (2005, their Fig. 15) interpreted similar shelf-margin trends from 2D seismic for their study of shelf-margin deltas. In that paper, for the Tithonian at Venture the deltaic shelf margin was aimed at the Cohasset-Panuke oil pools above the carbonate margin (roughly between A and B of **Figure A1.27**) and for the Barremian at Alma and North Triumph in a position similar to C and D of **Figure A1.27**. By dating prograding shelf edges, the top carbonate, or at least the mixed oolite-quartz sandstone alternating ramp sedimentation, is in the early Late Jurassic Oxfordian-Kimmeridgian.

A1.11 Qayyum, Catuneanu and Bouanga (2015a) Penobscot Area Seismic Sequence Stratigraphy

Qayyum et al. (2015a) is one test case study of a relatively new automated procedure of sequence and seismic stratigraphic analysis applied to the Penobscot 3D survey and some regional 2D lines at the Abenaki-early Sable Delta stratigraphic level. The location, amount of seismic data and the apparent ability of the technique to give interpretable patterns within what are usually

massive carbonates makes their study a very useful addition to understanding the transitional area. Based on their analysis of the seismic using Wheeler diagrams, a sequence stratigraphic scheme was proposed for the Abenaki. No detailed discussion of their seismic sequence stratigraphy for the whole Abenaki is given here since biostratigraphic dating in key carbonate wells invalidates the key basic assumption of the synchronous age of top carbonates as discussed below. This does not necessarily invalidate the use of their seismically-based sequencing for gaining insights of more limited areas near Penobscot. However major revision of its relationship to the main Abenaki would be needed and should include biostratigraphically-dated well control. Selected portions of their figures are shown - Figures A1.28 and A1.29 are regional seismic lines from parts of their figures to add to the morphological database. Figure A1.30 shows one of their seismic and interpretive Wheeler diagrams through the only well included in the study, Penobscot L-30. On that particular example, some queries of concern about correlations are reviewed. Figure A1.31 is their concluding composite showing their play ideas. Of significance on that diagram and on several others is the interpretation that carbonate shelf interior sediment (their "backreef progradation" interval) is being generated somehow separated from carbonate growth at the margin. More of their seismic figures will be used in the Chapter 4 Results albeit with different interpretation emphasizing depositional considerations.

In the early 1990's Nova Scotia Resources Limited (NSRL) shot a small 3D seismic program of an area approximately 6 by 12 km over the Penobscot B-41 and Penobscot L-30 wells. It is available to the public from the CNSOPB. See Figure A1.28a and Figure A1.5 for a location map of the dataset which also was reprocessed but using pre-stack migration and termed a 'pseudo 3D' (pers. Comm. Robert Merrill) by Ammonite Nova Scotia on their former license. The dGB Earth Sciences OpendTect software and HorizonCube programs enable automated data-driven seismic correlation using data dip-steering and interpretation using sequence stratigraphic concepts and Wheeler diagrams (i.e. relative time-stratigraphic plots generated from the interpreted surfaces). The reader is directed to Qayyum et al. (2012, 2015a, b, c) and Brouwer et al. (2010) for details and examples of the techniques. From these publications some limitations and potential pitfalls were compiled and many have direct significance to any interpretation of the Penobscot area Late Jurassic. Before those are discussed I quote from the Qayyum et al. (2015a) abstract their main results and conclusions: "We integrated the results obtained from a regional 2D study and a detailed follow-up study using 3D seismic data of the Scotian Shelf, Canada. The results were integrated with the prepared Wheeler diagrams, and a unified sequence stratigraphic framework was proposed. We determined that two second-order sequences were developed on a larger scale during the Jurassic Period. The first sequence developed during the transition from a ramp to rimmed margin. The second sequence developed during the evolution from a rimmed to ramp margin. These sequences formed a distinct stratigraphic style throughout the Scotian Shelf. The siliciclastic supply varied from the northeast to the southwest depending on the studied site; however, the regions close to the siliciclastic supply contained well-defined clinoform patterns. The topsets of such clinoforms were mostly eroded. Their directions were also found to be different than the carbonate-related clinoform geometries. Most of the carbonates were developed; as such, they kept up and prograded toward a backreef margin during the rimming stages. The second-order sequences were further subdivided into four third-order sequences. These were studied using the 3D seismic data and were found to contain several barrier reefs that could have stratigraphic exploration potential in the Penobscot area." The seismic visualizations by Qayyum et al. are very attractive leading to interesting conclusions. The eye of the reader is aided by many additional interpolated lines within some of their seismic sections generated by the dip-steering programing that then generates Wheeler diagrams. The danger of verisimilitude is its captivating visual appeal that may hide the danger of underlying problematic assumptions and procedures. It will be for geophysicists and seismic interpreters to judge the validity of the processing and interpretive techniques. Because portions of the study seem so useful from my point of view, comment will be made on some of its short-comings and problems as I see them about the seismic-sequence-Wheeler stratigraphic work.

More sequence schemes may not necessarily be a problem -but possibly a source of too much choice leading to confusion. Qayyum et al. (2015a) propose a third sequence stratigraphic scheme for the Abenaki based on seismic alone or nearly so with Penobscot L-30 as the only well control used to link rocks and wavelets. L-30 was also the only deep control in the 3D area; but their 2D lines went past many Abenaki wells including those used for sequence subdivisions by Weissenberger et al. (2006) and PFA Chapter 9 on the carbonate play (OETR 2011). All 3 sequence schemes differ from one another. That of Qayyum et al. (2015a) is unique in being derived from Wheeler diagram interpretation of the long 2D strike sections and 4 dip cross lines and the small 3D Penobscot survey rather than initially from wells. Several figures either in whole or composited from portions of their illustrations are included to illustrate seismic most relevant for insight into the morphology and stratigraphy in the transition area near the Sable Delta. Figure A1.28 (Fig. 15 of Qayyum et al. 2015a) illustrates aspects of their findings in the 3d area with suggested play concepts. Those plays had been previously proposed by others more informally as well. Figure A1.29 and A1.30 show other sets of lines that intersect to show local variations by direction and inferred lithology. From these comparisons some interesting differences and perhaps discrepancies arise that are discussed in the figure captions and below.

Though locally Qayyum's et al. (2015a) subdivision of the stratigraphy may be useful, biostratigraphic dating in key wells invalidates their seismic sequence stratigraphic framework being applied to all of the Abenaki. Rather than a synchronous time line as used in their Wheeler diagrams and continuous correlation as the DU surface, the top of the continuous Abenaki carbonates is diachronous being younger in the Deep Panuke area and significantly older at Marquis L-35, the last on-bank well before Penobscot L-30 which appears to be basinward of a possible platform or isolated carbonate bank. New biostratigraphic dating of prograding carbonates in the Sable Delta area shows they can be younger, being established on local paleohighs with the Barremian "O' Limestone illustrating this potential (see short discussion below and Section A1.09, Figures A1.20, A1.21, A1.22). Also their study would have benefitted from a fuller use of both the published and web-based informal literature on the Abenaki such as Wade and MacLean (1990) with its suggestions for alternative stratigraphic terminology and complications due to listric normal growth faulting, Kidston et al. (2005) with its review of seismic through nearly all Abenaki wells, Eliuk and Wach (2008) that gave an early version of the transition area including a seismic section and schematic lithologic log of Penobscot L-30, OETR Chapter 9 (2011) with its version of sequences and regional seismic mapping, and Eliuk and Wach (2014b) that briefly gave setting and possible modern analogues. Dating by Qayyum, et al. (2015a) is also problematic since the only well included in the study, Penobscot L-30, has disputed and varied older dating. Penobscot L-30 was not included in recently reassessed and new well dating for the Jurassic and earliest Cretaceous (Weston et al. 2012, OETR 2011). In fact as discussed in Section A1.09 the top of the Abenaki is diachronous from younger in the Deep Panuke area (Panuke M-79) to older nearer the delta (Marquis L-35 on the rimmed platform edge, South Desbarres O-76 on the carbonate ramp). Seismically (pers. comm. R. Merrill of Ammonite) and in PFA sequences (OETR 2011 Chapter 9, see my Figure A1.22) top carbonate thins and carbonate-bearing sequences become deeper/older northeastward. In short, the top Abenaki although a good continuous reflector - is not a time line along strike over long distances. In contrast, Wheeler diagrams assume continuous seismic reflectors to be time lines.

Some of the limitations and pitfalls of interpretation based on Wheeler diagrams and the data-driven sequence stratigraphic interpretation were given by the practitioners themselves (Qayyum et al. 2015b, Brouwer et al. 2010). One concern is the technique cannot be applied if there is structural-tectonic movement during deposition (see **Figure A1.28C** versus **Figure A1.30A** illustrating this problem). Another is that all reflectors are assumed to follow time lines, albeit relative not absolute. In addition condensed intervals appear similar to hiatuses and can be misidentified. For instance the thin #9 limestone and the presence of coated ironstone redbeds and

associated thin sponge-rich beds indicate condensed beds are present. On the data-driven seismic sequence interpretation workflow caveats were given by experts: 1) whether the seismic data is a true representation of the geological stacking pattern and 2) some geological configurations cannot be uniquely solved without additional information. Of course the initial problems present in any seismic work are data quality and resolution limits, both of which become more difficult with depth.

It can be problematic to expect two diverse systems, a delta and carbonate platform, to generate similar sequences simultaneously as they have completely different controls. While both will be affected by sea level fluctuations, a very large delta has a large outside sediment supply varying by hinterland tectonics, climate, and provenance type. This contrasts with a very thick carbonate platform that grows by in situ biota and chemical precipitation with varying seawater saturation controls, temperature and light dependence, with some adversity to siliciclastic-nutrient influx. The modern and geologic record have next to no large carbonate banks beside large deltas so the Abenaki-Sable is highly unusual if not unique. The very unusual juxtaposition of these two systems does occur at the Penobscot area and has produced complex anomalous results so that sequence patterns can perhaps be established locally but should not be applied to both systems. In other words - large deltas underlain by salt are going to have complex stratigraphy due to delta lobe switching that might generate progradation independent of relative sea level change, complicated further by early salt movement/uplift and growth faulting. Finding and believing a single sequence pattern for the full area of the delta except at a very high level order is unlikely. For carbonates maybe it is easier. But why should their sequences simulate the depositional patterns generated in the delta? With limited well control and only preliminary biostratigraphy to confuse or contradict me (Eliuk 1978), I could easily see at least four cycles or sequences in the upper Abenaki (Baccaro Member). But try as I might I could not see them in the wells of the Sable Delta; more data has not made it easier. Obviously seismic (BUT also using available wells) should make the exercise more do-able. Now we have two somewhat different Abenaki sequence schemes based on wells and seismic. This one by Qayyum et al. (2015a) would be a third based on seismic but given the dating problem it is only applicable in the Penobscot area. None of the sequences match. Maybe to test the applicability of these Penobscot sequences, they should be tried in the many mixed carbonate-siliciclastic wells northeast of Sable Island related to the Sable-Laurentian Delta complexes. It would be work in an area that is little studied even by the PFA study (OETR 2011) but some new biostratigraphy was done. Probably re-evaluation of the carbonate facies would be necessary. Eliuk (1978) only re-logged Sauk and Dauntless back before 1978.

A1.12 Abenaki Stratigraphy Introduction Lithostratigraphy, Biostratigraphy, Seismic Stratigraphy and Sequence Analyses

Stratigraphy is "More Gaps than Record" - Derek Ager 1973

The 1998 discovery of Deep Panuke shelf-edge reefal gas field resulted not only in a considerably increased number of Abenaki-bearing wells but also new studies and publications. As an aid to addressing the two primary problems of Chapter 1, the new stratigraphic information relative to sequence schemes and correlations and better biostratigraphic control with new and reinterpreted fossil data is reviewed herein. Results from some of that work, particularly the biostratigraphy (OETR 2011, Weston et al. 2012) necessitates a review of the correlation, subdivision and use of stratigraphic terms including those on the Western Shelf. More problematic is the proposal of two different Abenaki sequence stratigraphic schemes in the same wells of the Deep Panuke trend, one by EnCana (Weissenberger et. al. 2006) and the other by OETR's Play Fairway Analysis (OETR 2011, Chapter 9). Yet a third alternative scheme is the seismically-based sequence stratigraphy of Qayyum et al. (2015) using only one well (Penobscot L-30) and based on a very small 3D seismic area with a wider application on 2D lines. Thus another aspect of stratigraphy – namely sequences – needs some review.

Even before this last decade's much enlarged Abenaki data base and interpretations, there has been a history of differing lithostratigraphic terminology usage – some based mainly on assumed ages (e.g. Roseway) rather than lithologies and others on differing opinions on how much a particular lithology is required to use a particular name (e.g. limestones in MicMac Formation as members versus Abenaki with sandstone interbeds). All these "stratigraphic problems" are briefly addressed in this chapter covering not only the delta-platform transition area of the first two thesis problems but also the Western Shelf. The additional wells far from the transition area of the main thesis are needed to deal with the stratigraphic difficulties just mentioned. But those southwestern wells not under possible influence of that Sable Delta also allow for comparison to those that are. This chapter will offer suggestions for using earlier proposed member and "unit" terms across more than one formation into others both along the margin, in the western nearshore ridges and adjacent to the Sable Delta in the prograding ramps. It will not offer yet another and fourth sequence stratigraphic scheme. Instead some suggestions are given for possible future improvement and the need for caution where I do make use of the existing schemes in the Deep Panuke field area. Relevant illustration and some discussion of these authors various views are given in Appendix A1 on previous work under their respective names (Sections A1.04, A1.07, A1.09, A1.1). Although there is some repetition of discussion most figure illustrations from these Sections or others will mainly just be referred to rather than again shown for this Appendix.

A1.13 Stratigraphic Nomenclature

- Lithostratigraphy, Scatarie Member and Suggestion on Usage of Terms

For the Abenaki - "an unconformity 'runs through it' and members run beyond it"

The greater the difficulty of drawing a stratigraphic column; perhaps, the more interesting, or at least complex, is the depositional story. The recently revised Play Fairway Analysis column for offshore Nova Scotia (OETR 2011, slightly modified by Weston et al. 2012) is placed against Galloway's (2008) elegant column for the Gulf of Mexico offshore and coastal plain (see **Figure A1.32**, also **Figure 2.2A enlarged**). The differences and similarities are noteworthy because both were the locus of major deltaic sedimentation that at least for the Cenozoic Gulf resulted from a continental-scale fluvial drainage basin. The column for Nova Scotia is more complicated, even when all the stratigraphic units and varied age ranges are not included or depicted. But most striking is the long-continued contemporaneous deltaic and platform carbonate sedimentation in the Late Jurassic and the abrupt termination of the major input of siliciclastics in mid Cretaceous. More detail and the listing of the Abenaki lithostratigraphic subdivisions are shown on **Figure A1.33** (also **Figure 4.60**).

As shown on Figure A1.33 (also see Figure 1.2 for type section wells) the Abenaki has four formally defined members – Scatarie, Misaine, Baccaro and Artimon - plus the Roseway unit that was added to cover Cretaceous-age limestones in Mohawk B-93 nearshore ridge areas, then was applied to interpreted Cretaceous-age limestones near the Abenaki margin of the Western Shelf (see Section 4.13 for more details). The lower two members do not form part of this thesis since they mainly predate the Abenaki-Sable mixed depositional events. Even with all the new post-1998 wells, only one well, Panuke M-79, actually went deep enough to penetrate the Scatarie. However it also added a core to the Scatarie database. Another lithostratigraphic controversy, namely the use of the term "Abenaki" versus various limestone members in the MicMac (or Missisauga perhaps) is mostly avoided because this study area does not deal with wells northeast of Abenaki J-56 and Penobscot L-30 in the Sable Island area. Section A1.04 (Wade and MacLean 1990 and their figure modified as Figure A1.8) does show the idea that the limestones are considered diachronous markers developed on various normal fault blocks. More recent dating, examination of lithofacies and seismic clinoforms (some added on Figure A1.8) indicate that the relationship is more complex and not necessarily correlative as originally

suggested. The thickness and percentage limestone in Dauntless D-35 (see Section 1.2 and **Figure 1.1**) indicates that there may be an Abenaki bank northeast of the Sable Delta whether or not MicMac or Abenaki terms are favoured.

The Abenaki Formation was originally defined with 3 members – Scatarie, Misaine and Baccaro (McIver 1972, see Section A1.13 for additional historical background). Although the Abenaki Formation's lowest member, the Scatarie Member limestone is not part of this thesis, it is shown on many of the Abenaki well schematics and will be briefly reviewed here. With the minor amount of Scatarie control added since Eliuk (1978), the general interpretation of an oolite-rich formation with threefold cyclicity in the interior and more massive onlite near the shelf edge flexure can be maintained with a seismic morphology of a ramp or distally steepened ramp. This geometry is similar to the overlying Misaine Member shale and the basal Baccaro Member that also is usually oolitic. The newer core in Panuke M-79 has up to 50% quartz both as ooid nucleii and uncoated sand grains. Therefore the mapping of only nearshore oolite-sandstone couplets would need to be broadened. In Cohasset L-97 the presence of the Scatarie shows that it did not shale out as was suggested by Eliuk (1978) in Cohasset D-42 which bottomed in the thickest development of Misaine shale. As well E.H. Davies (in Wade and MacLean 1990, fig. 5.24) showed a much expanded middle Jurassic (Bathonian-Toarcian) Scatarie in Acadia K-62 (which has a limestone core in what had been considered Iroquois) on the Western Shelf where earlier assignments had been to the Mohican and Iroquois formations. Subsequent dating in Mohican I-100 (Weston et al. 2012) suggests younger ages again. Scatarie was not reached in Albatross B-13 but it may have been in the furthest southwest Nova Scotian well - Bonnet P-23. P-23 had numerous lost circulation zones but industry exploration well operators, the Geological Survey (MacLean and Wade 1993) and the Play Fairway Analysis study (OETR 2012) had interpreted the presence of all 3 members of the Abenaki with circulation restored just into the Misaine shale and an underlying Mohican Formation then thick Iroquois Formation dolomite (see figures 4.58, **6.67**, **6.81**). All this lithostratigraphy was overturned with new dating that showed the supposed Mohican calcareous shales were in fact Callovian in age and actually the Misaine (Weston et al. 2012). The overlying younger argillaceous beds were likely sourced from the previouslypostulated Shelburne Delta and proximity to the argillaceous interior 'moat'-lagoon zone. However if Weston et al.'s (2012) complete interpretation is accepted then this would be the first and only occurrence of dolomite in the Scatarie. I favour an alternative interpretation supported by seismic (see Figure 4.66C and 6.81) of a normal fault from Misaine shale to the Iroquois Formation dolomite. Regionally the Iroquois is mainly dolomite sometimes with restricted anhydritic beds with a few wells having limestones at the top. In contrast the Scatarie is nearly always dark limestones often oolitic but oncolitic in cyclic sections and not porous. More discussion on Bonnet P-23 is given in the latter part of Section 4.15. Although this is a digression, it may be significant as a possible depositional analogue to consider that the Scatarie and the basal Baccaro have similarities in sharing a ramp morphology with common oolitic and rare or absent reefal beds. That morphology is also true for limestones developed on top of Sable prodeltaic shales that also can be distally steepened. In the near Sable Island area ramps, reefal beds may occur but never become very thick. And that style and pattern of limestone facies is even typical for the my younger O Limestone marker of early Cretaceous Valanginian-Barremian age separating the lower and middle Missisauga Formation of the Sable Delta.

The Abenaki's highest member added later (Eliuk 1978) is the Artimon Member defined as lithistid sponge-rich argillaceous limestone and calcareous shale above the Baccaro and dated as early Cretaceous (early Neocomian = Berriasian to Valanginian). The member was found to have varied ages and was diachronous by Graham Davies (in Eliuk 1985. Davies pers. comm.1984 even suggested that the Artimon may better be considered as a facies rather than a stratigraphic unit but included it in the Lexicon he edited). Because of this diachroneity, Cretaceous ages and presence of the limestone in siliciclastics, Wade and MacLean (1990) suggested the member belonged in the Missisauga (or Verrill Canyon) Formation not the Abenaki. However my review of wells in the Panuke Trend (see Chapter 4) indicates that the member or Artimon-like facies occurs at the top of the Abenaki even in Late Jurassic age sections and even without shales. So applying their suggestion would lead to other stratigraphic confusion elsewhere. But, as will be discussed below along with the problems of the "Roseway unit," members need not be confined to one formation.

The informal term 'Roseway unit' was introduced by Jansa in Wade (1977) for Cretaceous carbonates that are above the type Mohawk Formation in Mohawk B-93 about 50 km northeast of Bonnet P-23 at the far southwestern end of the Scotia Shelf. Though used in the original sense in Wade and MacLean (1990, see their Fig. 5.39), Roseway was later also used in Western Shelf near margin wells for Cretaceous-age carbonates even if continuous with the underlying Jurassic Baccaro Member (Jansa 1993, MacLean and Wade 1993). To illustrate the nomenclature, Eliuk's (1978, Fig. 3) stratigraphic schematic is modified and shown as **Figure A1.33** (also as **Figure 4.60**). This topic is also discussed in Section 4.14 and the term shown in use in **Figure 4.58** where some of the numerous alternative Jurassic-Cretaceous contacts are shown and in **Figure 4.61** for Mohican subbasin platform interior wells.

A nomenclatural recommendation is that the "Roseway Unit" be called the "Roseway Member" of the Abenaki and other formations as shown on Figure A1.33 and used in Section 4.14 and 4.15. Thus the Roseway Member should be considered a member of Early Cretaceous age that can be part of the Mohawk and Missisauga formations as originally used. But the Roseway Member could also be a member of the Abenaki Formation where the Roseway is lithologically difficult to distinguish from the underlying Baccaro Member of Late Jurassic age, or even partial Berriasian age beneath the NBCU = Near Base Cretaceous Unconformity. Subdividing lithostratigraphic units based on biostratigraphic dating is not a good practice. Indeed formations such as the Abenaki when comprised of both the Roseway and Baccaro members may even contain unconformities such as the NBCU. In fact if the premises of sequence stratigraphy are accepted then formations such as the Abenaki are full of unconformities since they are interpreted to have numerous sequences. Perhaps using the hiatuses or gaps is how we supposedly better understand the record as discussed in the following section. As long as there is clarity as to usage and location; then members should be considered parts of various formations. A similar style of usage could be applied to the Artimon Member. Wade and MacLean (1990) did just that for the Artimon, placing it in the Missisauga and Verrill Canyon formations perhaps partly because it was of Early Cretaceous age. Of course terminological solutions may not really solve geological problems and will not satisfy all geologists. For example the Artimon in the Abenaki was based on the presence of 'first limestone'; Wade and MacLean (1990) obviously argue for the last shale and placing it in the Verrill Canyon. Since the drilling of Dominion J-14 and J-14A without shale separating the Artimon-like limestone, the problem continues. All the Dominion J-14 limestone is Late Jurassic, similar to the situation in Cohasset D-42 and Cohasset L-97, not earliest Cretaceous as further southwest. In its type section in Demascota G-32, the Artimon is the uppermost member of the Abenaki Formation (Eliuk 1978) but elsewhere (or even in Demascota G-32 if some stratigrapher desired) it could be a member of the Verrill Canyon or Missisauga or MicMac formations, particularly since dating indicates it is quite diachronous going from Late Jurassic age into early Cretaceous age as young as Valanginian-Hauterivian, however always with characteristic lithistid sponge beds present. Similarly even limestone members in the Sable Delta area, such as the Penobscot Member proposed by Wade and MacLean (1990, see Fig. 3.8), might in places be considered a member of the Abenaki rather than only of the Mic Mac or Lower Missisauga formations if correlated southwestward into dominantly carbonate-bearing wells such as Marquis L-35. Thus members while composing formations are not necessarily restricted to a single formation but can extend from one formation into adjacent ones.

A1.14 Biostratigraphic Dating and Correlation Issues - Inconsistencies, Reworking, a Check on Diachronous Surfaces and Sequence Schemes

"Correlations subject to change without notice" Ashton Embry 2010

Major new advances have been made in Jurassic-early Cretaceous biostratigraphic analysis and associated seismic and sequence stratigraphic proposals using some previous and the many new wells associated with the discovery of Deep Panuke (Van Helden in Weissenberger et al. 2006, OETR 2011, Weston et al. 2012). This is a brief look of some implications of this new information. For additional details see Appendix A1 on previous work (Sections A1.07 and A1.09) and Chapter 4 with its well-by-well survey but the thorough presentation of Weston et al. (2012) is the primary source which is supplemented in a few Abenaki wells by the PFA Chapter 9 addendum (OETR 2011). Three significant results (or problems) of better and more biostratigraphy are: first – there are inconsistencies between the new studies in part due to lack of overlap, second - significant reworking has occurred explaining many contradictory age assignments, and third - better or at least newer dating has aided but in some cases invalidated portions of both regional correlations and sequence stratigraphic proposals often between different studies but occasionally even within a single study or its immediate follow-up publication.

First, regarding inconsistencies, on completion of a study it is often concluded that "more work is needed." In this case it is because many key wells including formation type sections have not been re-examined or have been included in one group's study but not in the other's. As an example, the biostratigraphy to support Encana workers' Deep Panuke area sequence stratigraphy (Weissenberger et al. 2006) was done in only one well, the deepest, Panuke M-79, but M-79 was not included in the more comprehensive PFA biostratigraphic study (OETR 2011, Weston et al. 2012) of Abenaki and similar aged wells. As shown in **Table A1.1**, Van Helden's biozones are placed into the same Tethyan stage terminology as used in the PFA study and then in Figure A1.21 Marquis L-35 that was PFA dated is compared to Panuke M-79 and both groups sequence assignments are depicted. As discussed on those figures and in the Appendix A1 text they did not match in ages nor sequences. There were even a few inconsistencies within a single group's study. Similarly problems showed up elsewhere as discussed in Sections A1.07, A1.09 4.14 and Section 4.15 and shown in Figures A1.1, A1.20, A1.21 particularly, 4.671, 4.81. However as will be reviewed in Section A1.15.dealing with stratigraphic sequences, the third new Abenaki sequence stratigraphic proposal (Qayyum et al. 2015) resulted in even greater problems since it did not use biostratigraphy to back up the sequence methodology assumptions. To conclude, here is one example of a well, Penobscot L-30, not biostratigraphically reviewed but critical to understanding

the delta-platform transition. Penobscot L-30 has problematic older Jurassic dating (illustrated by **Figure A1.22** and comments) that may turn out to be yet another example of older reworked fossils – a common problem.

Second, regarding inconsistencies, reworking of older dateable fossils into sediments with younger biota is a major source of biostratigraphic confusion with multiple ages for the same well intervals according to the latest synthesis by Weston et al. (2012). The same problem was noted much earlier for Abenaki-equivalent well intervals on the United States offshore by Poag (1991) and the same explanation of reworking given. Reworking occurred in sediments throughout the Mesozoic and even Cenozoic section over the whole Scotian Shelf. Much of it occurred near sequence breaks seen as unconformities, some even with reddened shales. In many cases Weston et al. (2012) attributed it to downslope resedimentation of Late Jurassic-Early Cretaceous Sable deltaic siliciclastics onto the prodelta. Shelfal and nearshore erosion due to relative sea level falls and, independent of that, early salt tectonics with potential local diapiric unroofing due to deltaic loading would be an expected association with the large Sable Delta. Reworking in the Abenaki is not some problem with using drill cuttings in open holes but occurred in cores of several different wells (see examples and comments on Figure 3.61). But there prodelta resedimentation is not a likely explanation. Reworked sections often were near interpreted significant sequence breaks and unconformities, sometimes supposedly corroborated by the presence of reddened sediments. However the presence of marine condensed sediments indicated by glauconite, coated red ironstones with marine fossils including sponges closely adjacent offers the alternative of low or no sedimentation and submarine hiatuses and/or palimpsest sediments that will be discussed in Section A1.14.

Third, regarding inconsistencies, the new biostratigraphy and dated sequences based on it gives additional evidence for the diachronous age of the top Abenaki along the margin closer to the Sable Delta (Weston et al. 2012 specifically commented on this for Cohasset L-97, also see Figure 1.22 from Chapter 9 OETR 2011; Figure A1.21 composited from OETR 2011 and Weissenberger et al. 2006). These are much more precise than some of the early biostratigraphic work that was not so precise but generally accurate (see Fig. 3.2 from Eliuk 1978) in showing the diachronous nature of the Abenaki-Sable deltaic contact. That the carbonate reflectors are often used to define sequence boundaries (quasi-time lines) or even assumed to be time lines (Qayyum et al. 2015, also see Section A1.11 for more discussion) can lead to dubious conclusions. For instance new dating in Bonnet P-23 (Weston et al 2012; see details on Figures 4.58, 4.67 and 4.81 and text in Section 4.15) showed the Misaine shale much deeper than shown in OETR (2011)

and by most earlier interpreters so that their seismic markers BAC 1/2 and J-163 and the lower Abenaki sequence tops were off by 100s of metres. Another biostratigraphically based observation that seems counter intuitive is that some near-delta interbedded limestones are actually younger not older than platform margin carbonates much further from the delta as shown by Figure A1.20. That figure was based on dated columns by Weston et al. (2012) who also observed that some of Wade and MacLean's (1990) limestone members in the MicMac Formation such as the Penobscot had different ages (compare Figures A1.8 and A1.20). So even very much prior to the intradeltaic O Marker limestones of the Hauterivian-Barremian, some latest Jurassic carbonates within the delta area and to the northeast can have younger ages than the nearest top Abenaki platform wells to the southwest. Therefore conditions suitable for carbonate sedimentation can re-occur sporadically in part due perhaps to prodelta-deltaic production of paleohighs and then abandonment or shallow flooding of terrigenous lobes. A probable corollary is that there need not be any lateral continuity between the limestones whatever their origin. This poses yet another potential problem for assumptions needed for seismic stratigraphic correlation. This style of mixed carbonate and siliciclastic sedimentation near the Sable Island delta and to its northeast was considered so different from the Abenaki platform that Wade and MacLean (1990) recommended the use of only MicMac Formation not Abenaki (but see my comments in Section A1.13).

A1.15 Gaps, Unconformities and Condensed Sections – Seafloor Diagenesis as an Indicator

Stratigraphy is "More Gaps than Record" — Derek Ager 1973

"In fact we have an anomaly...areas most commonly cited as those of continuous sedimentation without breaks, ...are those of the thinnest sedimentation. Clearly...there may be few, if any, erosional breaks, but there must be immense non-depositional breaks...and a great deal of erosion by turbidity currents...." — Derek Ager 1973

This somewhat geo-philosophical discussion of gaps is not an aside but addresses the basic building block of sequences generally and those of the Abenaki in particular. Thinking about Ager's quotes and even more recent thoughts on the fragmentary nature of the geological record (Miall 2012), one appreciates that the gaps are not only numerous but fractal ranging greatly in duration. These gaps punctuate and define sequences and given their pervasive nature, geologists have perhaps too many options for subdividing stratigraphic intervals and may be getting confused while doing so particularly when trying to assign hierarchal orders. Gaps apparently are a relatively common feature of the Abenaki given the many sequences applied to it as will be discussed in the following section. Just as important, gaps are a key factor to a problem I may

have caused by originally placing the Artimon Member in the topmost Abenaki (Eliuk 1978). Since the Artimon consisted of both limestone and shale it could just as well be placed in the MicMac, Missisauga or less appropriately the Verrill Canyon formations as has been proposed by others (see Section 2.1). Since I fancied including the fate of the Abenaki, 'death by drowning', within the Abenaki itself and by definition sponge-rich limestones are a component, I placed it with the underlying limestones and noted that it could be as young as Valanginian-Hauterivian of the Early Cretaceous Neocomian in the type well Demascota G-32. However as readily apparent by the Berriasian-Valanginian unconformity (NBCU) on Figure A1.32 and noted in Weston et al.'s (2012) offshore Nova Scotia biostratigraphy review, the Artimon, like the Roseway, is mainly Cretaceous (post-Berriasian) and thus may be unconformably separated from the underlying section by the NBCU (Near Base Cretaceous Unconformity). This is where the gaps become interesting ranging from cryptic and so subtle as to be arguable differing among stratigraphers (Roseway on the Baccaro in Western Shelf margin wells, see Figure 4.58). Other gaps are easily seen by lithologic changes, though maybe not at the defined member contacts (Artimon in the type section versus more transitional in Panuke Trend margin wells further northeast (see Fig. 4.37 of Demascota G-32 with alternative sequences and compare Figure 4.35 wells. Gaps may even be flagged by reddened sediments in the Mohican subbasin (see Fig. 6.61). However as also shown on Figure A1.32 the Berriasian-Valanginian hiatus diminishes basinward and potentially downslope it may become a correlative conformity so the possibility remains that the Abenaki may be relatively continuous, perhaps even at the type section. Age dates for Artimon and upper Baccaro cores in Demascota G-32 support Berriasian to Valanginian ages (see species list by Roy Waite in Eliuk and Levesque 1988) and thus possibly a more continuous section with a shorter or no NBCU. A caution is that later review indicates Waite's age assignment may have been a half stage or so too old (pers. comm. Edward Ringer 2005) and these dates are not compatible with the well sequences dating given in the recent stratigraphic sequence studies (Weissenberger et al. 2006, OETR 2011). Considering Ager's quote again, thinned and missing section may not necessarily mean subaerial exposure at an unconformity but may result from a sea-covered hiatus with submarine non-deposition or condensed zones. Carbonate sediments are chemically reactive and may be better recorders of such events as suggested by submarinecemented hardgrounds resulting from seafloor diagenesis. Of course marine carbonates reworked beneath a true subaerial unconformity by subsequent marine flooding might mimic the totally marine event. Some of common features that might make identifying one or the other situation difficult include condensed sections so that on seismic they are so much thinned as to appear absent and condensed and palimpsest beds that either might be missed in sampling for biostratigraphic markers altogether or might be expressed or interpreted as reworked older fossils

in younger sediments. Schlager (1981, 2005) dealt at length with the difficulties of separating drowning unconformities from subaerial unconformities in carbonates particularly on seismic. But to come back the problem of whether to assign the Artimon or Roseway to some formation other than the Abenaki because of the existence of a significant intraformational unconformity; sequences are defined by unconformities or gaps. Perhaps their magnitude, particularly where it is arguably much reduced in certain areas/directions, is immaterial if the lithostratigraphic unit as a whole is of one mappable type.

It is common for reddened zones particularly when apparently terrigenous and non-marine to be taken as unconformity indicators. As a recent relevant example, Weston et al. (2012) combined biostratigraphic data with well log character and rock colours to specifically place several of their regional unconformities in various Nova Scotia wells citing red cuttings. However to quote an old geologist: Reddened zones are often offered as evidence for subaerial exposure but what they indicate is oxidation. Some of the most widespread reddened zones are the pelagic clays of abyssal depths. The Alpine-Mediterranean Mesozoic is well known for its stratigraphically condensed red biomicrite lithologies. These are interpreted as deep-water deposits, although the occasional presence of algae indicates that they sometimes were within the photic zone. (Eliuk 1978, p. 472 – this comment was in regard to analogues for the Artimon sponge-reefal beds and their reddened patches). Another, much more reddened biochemical sediment associated with very slow sedimentation is coated red ironstone beds ('Fe-oolite'). These are common on the Western Shelf in the early Cretaceous (again see **Figure 4.61** and discussion in Section 4.14 with additional illustration of these bioelemental sediments). For example Moheida P-15 core has two very different non-terrigenous lithologies but both clearly marine and condensed or slow growing that may represent the sediments across a sequence break argillaceous sponge-rich limestone above coated red ironstone carbonate of Moheida P-15 (see Section 4.14 for details particularly Figures 4.64 and 4.65). The specific depth where mixed dating was found is not given nor the presence of two very different sediments noted. This may actually sample a sequence boundary but it would appear to be totally marine – perhaps the rare capture of a correlative conformity. Intriguingly the only other cored example of even more likely sequence boundary I am aware is also in totally marine beds and even less likely to be hiding an unconformity. That series of cores occurs in West Venture C-62 in Sable delta and also contains the formation contact between the Missisauga and MicMac. The succession goes from dark prodeltaic shale with a few reddened layers downward into the thin #9 Limestone with an interpreted shoaling succession of deeperwater "reef-mound" limestones (see Sections A1.05 and 4.01 and Fig. 4.2). Is this support for Ager's observations on gaps in thin continuous sections? In this thesis the it will be suggested that the alternative to some of the supposed unconformities at various sequence surfaces in some parts of the Abenaki may be condensed zones perhaps of correlative conformities or maybe related to maximum flooding surfaces.

A1.16 A Profusion of Previously Proposed Cycles and Sequences

Precision is not accuracy. OR No matter how thin you slice it; it is still baloney.

The lithologic evidence for sequences in the Abenaki carbonate go back to Eliuk (1978, fig. 14 shown as Figure A1.2) where at least 4 cycles based mainly on oolite occurrences can be seen and then inferred in the 2 more reefal margin wells. Equivalent or comparable cycles could not be seen in the Sable Delta wells or to the northeast. Undoubtedly sequences of some kind exist with breaks of more or less magnitude in the Abenaki as elsewhere. In his sequence stratigraphy methodology series Embry (2009) made a plea for use of 'practical' that is material not timebased, techniques partly because of how very controversial defining and delineating sequences are based on so many different assumptions and procedures. And this seems borne out by the differing results in Abenaki sequence studies. Following the 1998 Deep Panuke reef discovery with increased well and seismic data, there are now 3 different stratigraphic sequence analyses for the Abenaki – Weissenberger et al. (2006, Encana 2006 but also used earlier in Wierzbicki et al. 2002, 2005, and Kidston et al. 2005; see Chapter 3 under their names), PFA Chapter 9 carbonate play (OETR 2011; see Section A1.09) and Qayyum et al. (2015; see Section A1.11). Unfortunately, on comparison their results and/or their basic assumptions differ and choosing among them is not easy. Even if contradictory and incompatible these three attempts at Abenaki sequence stratigraphy individually contribute significantly to understanding the Abenaki sedimentation and history. They are used throughout this thesis and particularly their supporting seismic.

The utility of the Encana sequence stratigraphy (Weissenberger et al. 2006, Encana 2006) for developing and following up on their Deep Panuke discovery is illustrated in **Figures A1.16**, **A1.17** and particularly **4.53**. But some of their later wells were not included in publications except for Margaree F-70 (Wierzbicki et al. 2005). Their sequences were not shown outside the Deep Panuke field area. So it does not constitute a regional Abenaki sequence stratigraphy but with the new and closely-spaced well control it was a good start. This thesis does show Encana sequence picks for these later wells from collaborative unpublished work (see **Figure 4.35** for an example of this infill). The PFA chapter 9 study (OETR 2011) was a regional study although it did not cover the Penobscot area transition into the Sable Delta proper. Some specific difficulties of the

PFA study are discussed in Section A1.09, but the main confusion, aside from major differences in age dating of the two sequence sets, arises from the non-parallelism of their sequences with those of Encana workers from well to well (see **Figure A1.17**). Assuming both groups are tracking real sediment packages but using different criteria to define breaks in wells such as presence of thin siliciclastics for Encana and facies-defined shoaling sequences for PFA such crossings are problematic. And either there are more unconformable surfaces to choose from and match up or some are incorrectly identified. Given the massiveness of the Abenaki carbonates with limited wells often lacking log character and only cuttings information perhaps the problem of recognizing sequence breaks is correctly shown to be subjective and inconsistent. Since I supplied the lithologic cuttings data and some preliminary interpretations to both groups I am not so happy with these contradictions either. Without a team approach and more biostratigraphy no alternative synthesis will be attempted that would result in a fourth sequence scheme. However on well figures throughout this thesis tentative placement of Encana style sequences are shown and even used for mapping in the Panuke trend (see **Figure 4.57**).

Similar to the Encana studies, 7 or more sequences were identified in the PFA scheme (see **Figure A1.17**) but a reduced four seismic sequences were used for regional map subdivisions as shown for facies in Figure A1.24. Those seismic surfaces merged or were difficult to follow on the southwest Mohican subbasin and Western Shelf. This was interpreted as resulting from large areas of erosion at unconformities although as discussed in Section A1.14 condensed sections and submarine non-deposition/hiatuses might be an alternative or additional explanation. Their mapping went from the far southwest over Bonnet P-23 ending near the Sable Delta by Penobscot L-30. The mapping in the far southwest is compromised by the revised dating in Bonnet P-23 (Section A1.13 and Section 4.15) that moved the Misaine down hundreds of metres invalidating the lower sequences and likely complicating the interpretation of seismic reflectors. In the northeast the PFA study although not adding much seismic stratigraphy did interpret an increasing number of sequences as shown and discussed in Figure A1.21 and A1.22. This may indicate greater sensitivity to relative sea level fluctuations because of lack of accommodation space which would be compatible with the prograding ramp geometries that occur near the Sable Delta. Or, just as likely or more likely, greater and variable sediment supply from the large Sable Delta, not relative sea level changes, controls near-delta sequences making them independent and different from the pattern in main aggradational Abenaki platform to the southwest.

The more recent seismic used in discovering and developing Deep Panuke is quite impressive and I have made much use of it 'second hand' from formal and informal publications

such as Kidston et al. (2005), the Encana associated workers (Wierzbicki et al. 2002, 2005, Weissenberger et al. 2006, Encana 2006) and PFA Chapter 9 (OETR 2011). However most of these publications seismic and sequence interpretations did not emphasize the transitional area from the Abenaki platform northeast into the Sable Delta near the Penobscot wells. I used older 2D seismic available from the CNSOPB database (see Section 4.02 and associated Figures 4.4 to **4.10)** to attempt to understand the transition. So the visually compelling seismic used in the third and most recent sequence stratigraphic analysis by Qayyum et al. (2015) using the small 3D seismic survey over the two Penobscot wells is a welcome addition particularly as it emphasized understanding a mixed siliciclastic-carbonate setting. For more detailed discussion of both positive and negative aspects of their novel seismic processing and Wheeler-based sequence analysis techniques see Section A1.11. They applied seismic stratigraphic sequencing to the small 3D survey centred on Penobscot L-30 the only well used in their study which also lacked biostratigraphic control. The imaging processing seems to show features like deeper water downslope mounding and an initial separation of carbonates near the margin that are not evident on other seismic and is a major contribution to understanding. However their assumptions about reflectors being time lines and lack of syndepositional tectonics required to use their Wheelerbased technique is shown to be erroneous by biostratigraphy in the first case and unlikely given the evidence for early salt tectonics likely due to delta loading on both their own seismic and in surrounding wells. The difficulty with diachronous reflectors is particularly problematic when they applied their local sequence interpretation to the main Abenaki platform based on a few 2D seismic lines. In addition, though their interpreted progression of sequence related changes may be reasonable locally to explain aggrading rimmed to prograding ramp relationships near the Sable delta; it is unlikely to apply to the southwest where no change to prograding patterns is seen and the topmost Abenaki facies are markedly different from limestone of clearly older ages closer to the Penobscot and delta area. As a final last point the presence of the much younger O Limestone marker and younger but still Jurassic dates for some limestones in some mixed sediment wells southeast of Penobscot L-30 even closer to the axis of the Late Jurassic delta. In summary these three sequence stratigraphies and their associated seismic may be incompatible or incomplete or based on questionable assumptions but they give data and interpretations not previously available. They can and will be used to further advance our understanding of the Abenaki and its unusual long-lived close relationship to the Sable Delta.

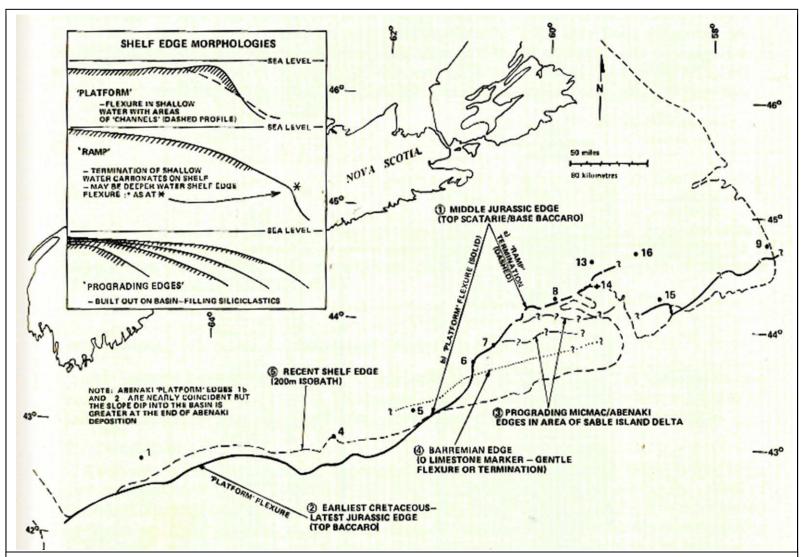


Figure A1.1 Shelf-edge map and Late Jurassic Morphologies (Eliuk 1978, Fig. 5) Based on wells and seismic up to 1976-1978 the variety of carbonate shelf edges and map view of prograding and aggrading shelf margins was made known. Note the modern 200m shelf edge prograded basinward over 50 km due to the Sable Delta but to the southwest the Jurassic carbonate edge is more seaward than the modern margin.

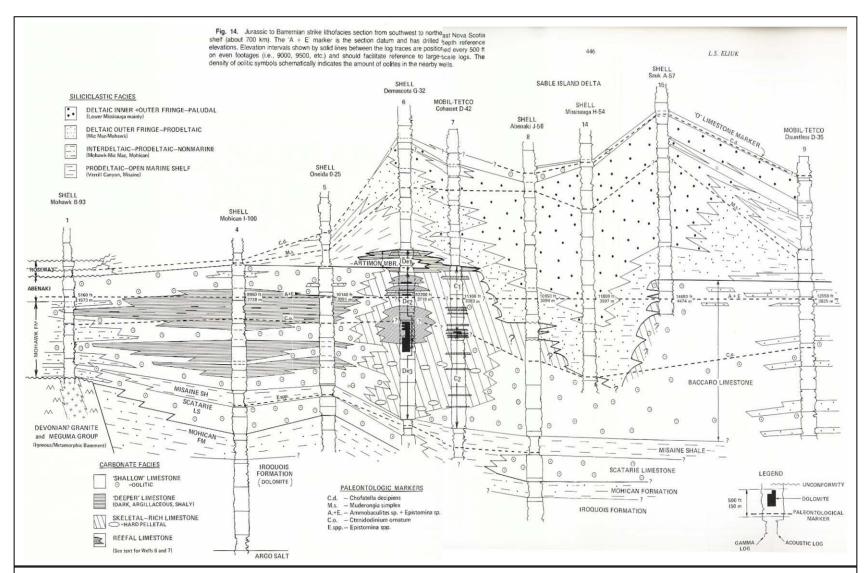


Figure A1.2 Regional Strike Section (Eliuk 1978, Fig. 14) Seven pre-1976 thick-Abenaki wells show the regional pattern of the Abenaki platform and Sable Delta with the biostratigraphic datum "A&E" nearly paralleling the top Jurassic carbonates. Cyclicity or sequences are easily seen to the west of, but not in, the Sable Delta. Note that to the southwest the shelf section is starved away from the delta. The Artimon Member while capping the Abenaki is a deeper-water carbonate relating to the Sable prodelta. The 'O'-Marker limestone caps the early delta during a regressive phase but obviously not very deep as shown by the oolitic sediments but is a possible analogue for older interbedded carbonates in deltaic clastics.

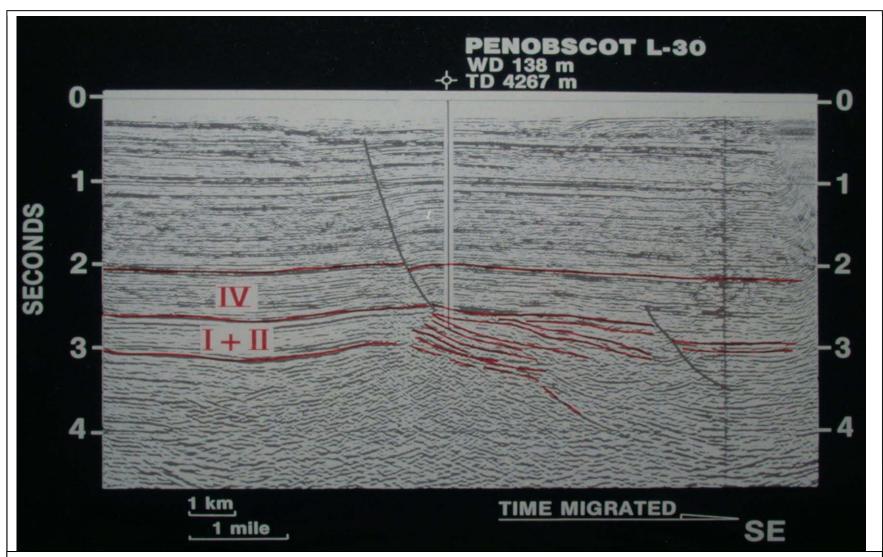


Figure A1.3 Dip seismic with prograding ramp over Penobscot L-30 (Eliuk et al. 1986 - AAPG talk based on Shell Canada data) where I and II between the top Abenaki carbonate and the Scatarie limestone reflectors and are mainly limestone of Late Jurassic Abenaki above Misaine shale and IV is mainly Early Cretaceous siliciclastics of the lower Missisauga Formation below the O Limestone marker. A tracing of this section was included in Meyer (1989).

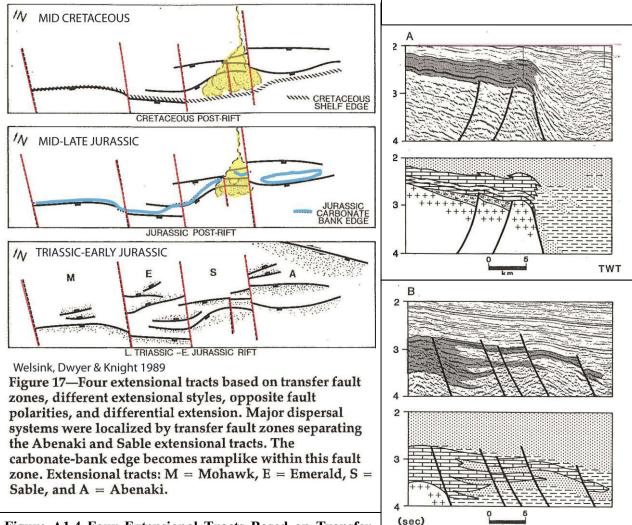


Figure A1.4 Four Extensional Tracts Based on Transfer Fault Zones (Welsink et al.1989. their Fig.17 color added) Their model calls for basement control initiated in the Meguma Group during initial rifting and that the tracts influence the location of the carbonate margin at the edge of the uplifts and the later sediment influx follows lows along transfer fault contacts. Thus there are some areas that may have always lacked the carbonate platform and its margin for morphologic then sedimentological reasons. Note the Sable Delta splits the carbonate bank in two as a long continued low. The mid Cretaceous shelf edge in fact steps back landward of the carbonate margin in the SW due to paucity of sediment to maintain its position into the Late Cretaceous and Cenozoic.

Figure A1.5 Seismic morphological end members of Jurassic carbonate bank (ibid Fig. 12 rearranged to fit); A) 'escarpment' above SW basement ridges (near Cohasset) and B) ramp over deep broad highs with MicMac clastics interfingering allowing progradation (near Citnalta)

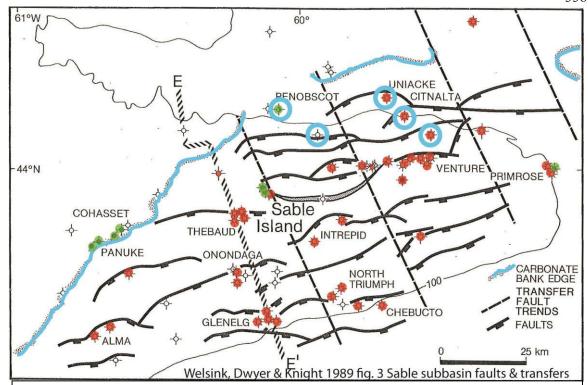


Figure A1.6 Generalized faults and gas accumulations in Sable Subbasin (Welsink et al. Fig.3, color added and modified by blue circles showing ramp limestone members), Bank edge gaps (at Penobscot & NE of Citnalta) may represent deltaic sediment input areas. The oil fields at Cohasset and Panuke are the eventual location of the Deep Panuke carbonate margin gas field.

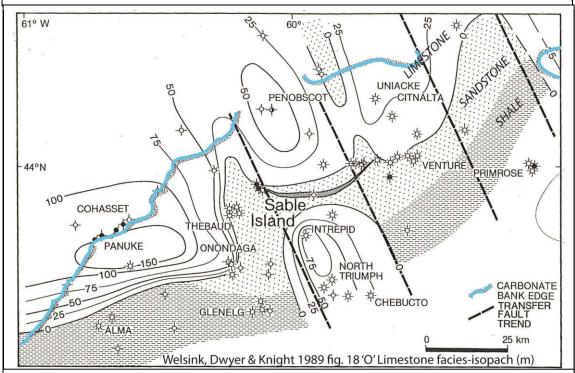


Figure A1.7 Regional 'O' Limestone marker isopach map (Welsink et al, 1989 Fig.18) separates the Missisauga into an Upper and Lower delta complex of latest Jurassic-early Cretaceous Neocomian age. Although more widespread than the older prograding limestones associated with the MicMac delta lateral to the Abenaki carbonate platform, the 'O' may be useful as an analogue. Note that it may be composed of separate bodies of limestone (possibly of slightly different ages) and non-carbonate areas (continuously deltaic?).

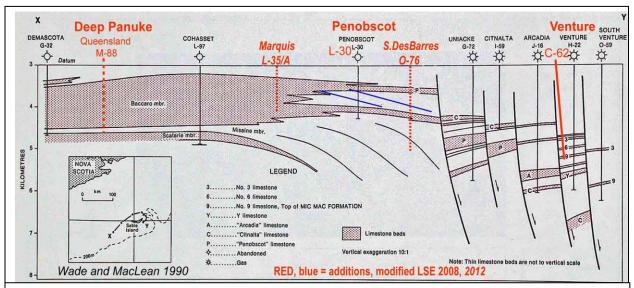


Figure A1.8 Schematic illustration of Abenaki break-up near Sable delta (modified Wade and MacLean 1990 Fig. 5.33). Added and newer wells in red. See **Fig. 3.14** map and **Fig. 3.18** for PFA 2011 dating including L-97 (dating not reassessed in L-30). Blue clinoforms added based on seismically seen clinoforms and bring into question horizontal correlation of the lower limestone as originally shown between L-30 and O-76 and probably many others to the right.

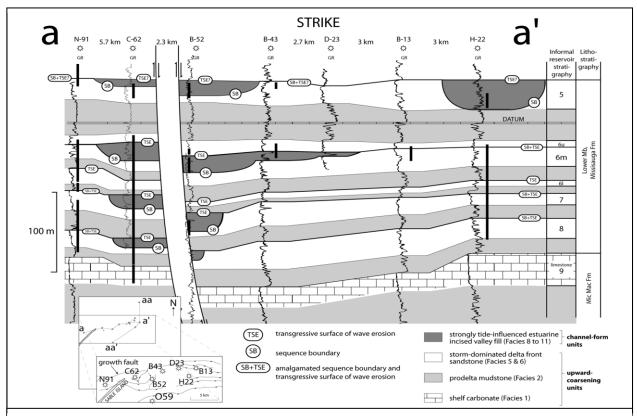


Figure A1.9 Cummings and Arnott's (2005, Fig.5) **Venture Field interpreted stratigraphic strike section** through the shelf-margin deltaic #5 to #8 sandstones as indicated on included map showing the major facies association groupings. Note the stacking of incised channels in the C-62 and B-52 wells. Inset map from CNSOPB and black bars indicate cored intervals. Cummings interprets the limestone at bottom of cores in C-62 as condensed limestone.

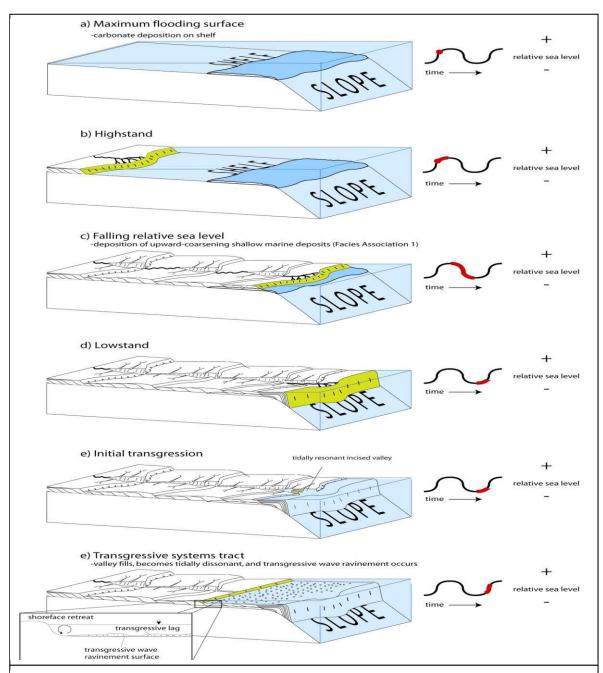


Figure A1.10 Sequence stratigraphic depositional shelf-margin delta model Lower Member of Missisauga Formation for Venture, West Venture and South Venture fields near east end of Sable Island (Cummings and Arnott 2005, Fig. 6). Note that shelf carbonate (Facies 1) potentially developed during 4 of the 6 relative sea-level stand periods.

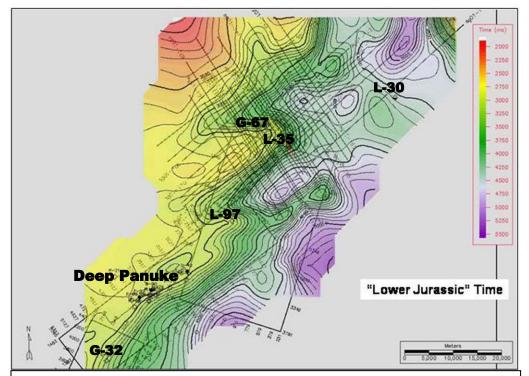


Fig. A1.11 "Near basement morphology" of Panuke Trend to Penobscot. (from Kidston et al. 2005, fig.78) modified by addition of well UWIs. Yellow contours show LaHave platform and most shelf edge wells are on the edge of the basement. Marquis L-35 appears slightly basinward of the basement high and Penobscot L-30 is far off likely underlain by salt.

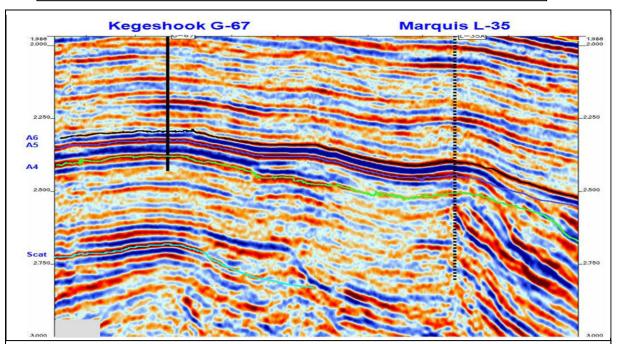


Figure A1.12 Dip seismic from G-67 to L-35 (from Kidston et al 2005 Fig. 117 'stretched'). Note this appears to be the central part of the seismic line for OETR (2011) PFA Chapter 9 interpretive seismic stratigraphic cross-section PL.9-6-2b (**Fig. 3.23**). Also note that the correlations into the basin tend to follow the steeper slope on **Fig. 3.23** rather than the 'Ab4' and 'Ab5' staying relatively flat and high as shown here.

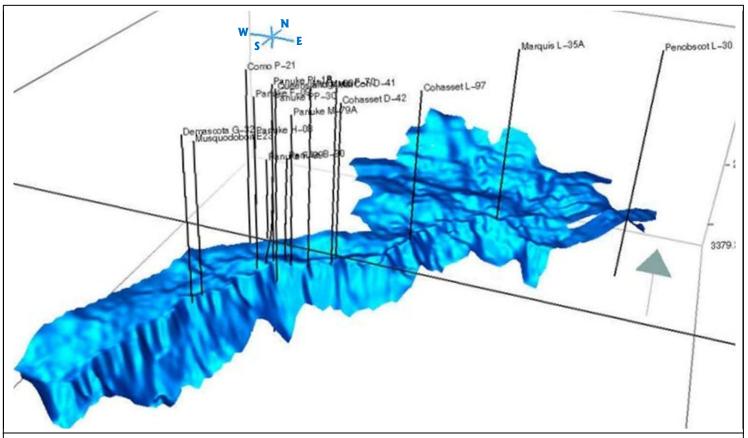


Figure A1.13 Panuke Trend carbonate margin 3D seismic image 'Ab6' = top Abenaki [from Kidston et al. 2005, Fig. 77 with caption: Isometric 3D image of the Abenaki-6 horizon (depth map), including the Marquis 2D survey to the northeast (coarse gridding). At its eastern end, definition of the Abenaki Bank margin becomes more difficult and reflects the transition from a rimmed margin to a carbonate ramp.] At the risk of over-interpreting a generalized image, it appears that there are two possible edge trends north and east of Marquis L-35/A. The likely bank margin edge heads northeast and another heads east into the basin. The latter may represent the margin of a mapped prograded-carbonate-ramp capping basin-filling shales. The surface breaks up with lack of data or interpretation of it closer to Penobscot L-30. Immediately west of L-30, there appears to be a low and a blank area just before the complete loss of mapping. Note that although the map is supposed to be of Ab6 it is better understood as the top of the Abenaki carbonate and is diachronous becoming gradually older northeast of Deep Panuke.

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Table A1.1: Ages of Abenaki sequences used by Encana comparing Boreal and Tethyan stages - biozones applied by VanHelden (Appendix 2 in Weissenberger et al 2006) to Encana sequences (Boreal-British stages) compared to portion of Figure 19.2 in Ogg et al. 2004. Note that almost 3 million years of Boreal Kimmeridgian time becomes Tethyan Tithonian and perhaps helps explain the necessity of both a "Base Tithonian MFS" and a "Tithonian MFS". To avoid confusion the Tethyan or French scheme is attempted to be used in this report.

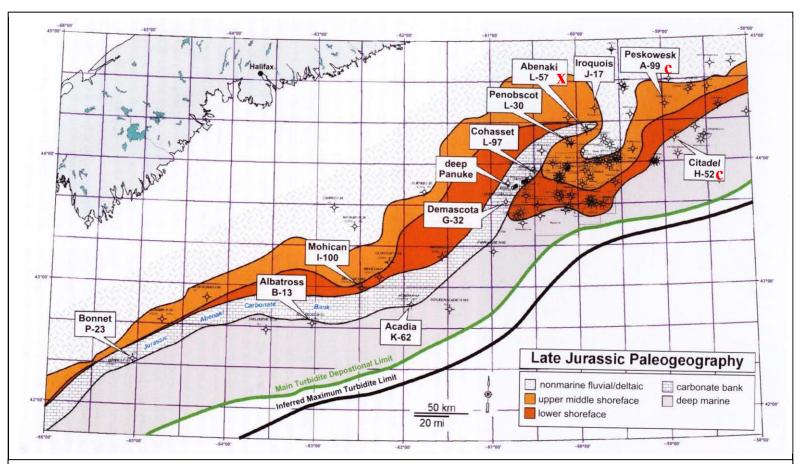
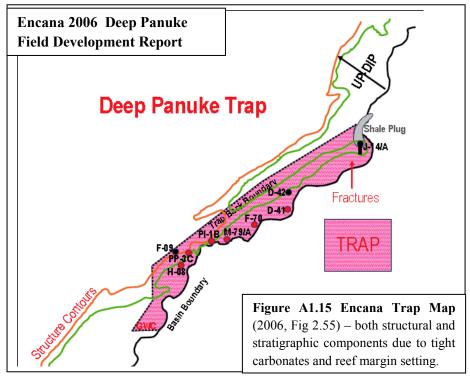


Figure A1.14 (from Weissenberger et al. 2006, Fig. 7) **Paleogeography of the upper Abenaki Formation**. Note that the bank is interpreted to be continuous all the way northeast to Abenaki **J-56** (**X**=erroneously shown as L-57 which is higher on the same salt dome flank but lacks Abenaki) and Penobscot L-30 is just basinward of the margin shelf edge. At Deep Panuke they specifically state (their p.404) the margin is not ramp-like but reefal and steep. Its nature northeast of Cohasset L-97 is not discussed. In this depiction prodeltaic sediments flank the deep carbonate slope of an actively growing carbonate bank even southwest of Demascota G-32. (**c** = core logs in their fig. 17)



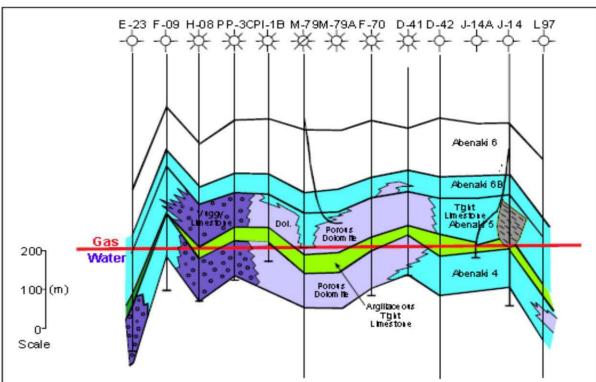


Figure A1.16 Upper Abenaki Stratigraphy at Deep Panuke Gas Field on structural datum from EnCana (2006). Note that gas is mainly in sequence Ab5 with most of upper Ab6 argillaceous limestone providing an intraformational top seal. However <u>dolomite and vuggy-microporous limestone</u> with <u>secondary porosity are **not** confined to AB5</u>. Dominion J-14 also shows an additional potential end-member lithology, shale, in the AB5 reservoir sequence that resulted in an amplitude anomaly that undoubtedly was originally interpreted and drilled as a porosity notch.

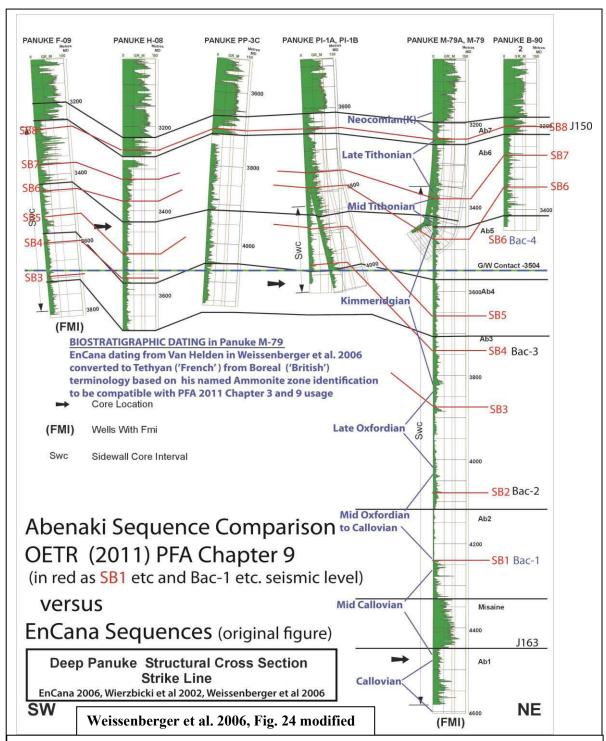


Figure A1.17 Abenaki Stratigraphic Sequence Comparison for Deep Panuke wells by Encana (2006) versus OETR PFA (2011) in red. Note the addition of biostratigraphic ages in M-79 used by Encana for its sequences (Appendix 2 by VanHelden in Weissenberger et al. 2006) with the terminology based on VanHelden's biozones compared to the stages in Ogg et al. (2004, Fig. 19.2; see Table 3.1). The criteria for defining sequences differed in defining principles – Encana emphasized log character, facies and presence of sandstones whereas PFA (Beicip-Franlab) used interpreted shallowest facies in shoaling from Maximum Flooded Surfaces to place their unconformable sequence boundaries (SB). See later PFA section and figures for additional assessment of some differences in the two studies dating of sequences.

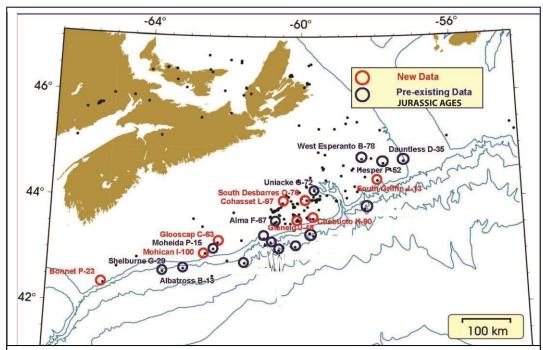


Figure A1.18 Biostratigraphic Control in PFA Report (modified from PFA 2011 Chapter 3 part of pl.3-3-1a but Jurassic wells only; also see Weston et al. 2012 Fig. 1B). Most biostratigraphy is not at the Abenaki bank-Sable Delta transition except **L-97** and **0-76** (latter near Penobscot L-30, but not discussed in Chapter 9, has similar but thicker stratigraphy). Chapter 9 did add Marquis L-35, Dominion J-14, Queensland M-88 and Oneida O-25 (latter SW of area) that give good control in the northeast part of platform. L-35 and M-88 have shales with M-88 continuously in a slope setting just east of Deep Panuke.

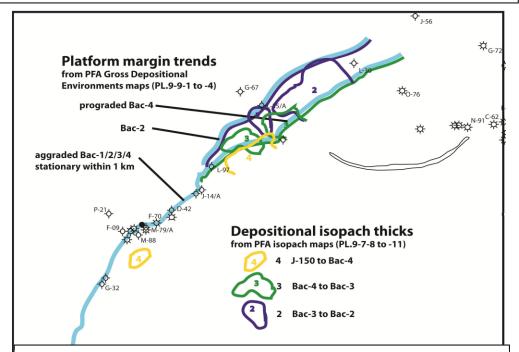


Figure A1.19 Shelf Edge and Slope Thicks Tracings compiled from PFA Chapter 9 Pl. 9-7-8 to -11 and 9-9-1 to -4. See text for discussion near end of Section A1.09. Red wells are used on **Fig. 3.20** biostratigraphic cross-section. Deep Panuke carbonate margin and west Venture shelf margin delta gas fields shown. Trace of 42km long Sable Island for scale where the Portuguese ship 'Demascota' was wrecked in 1815-01-01.

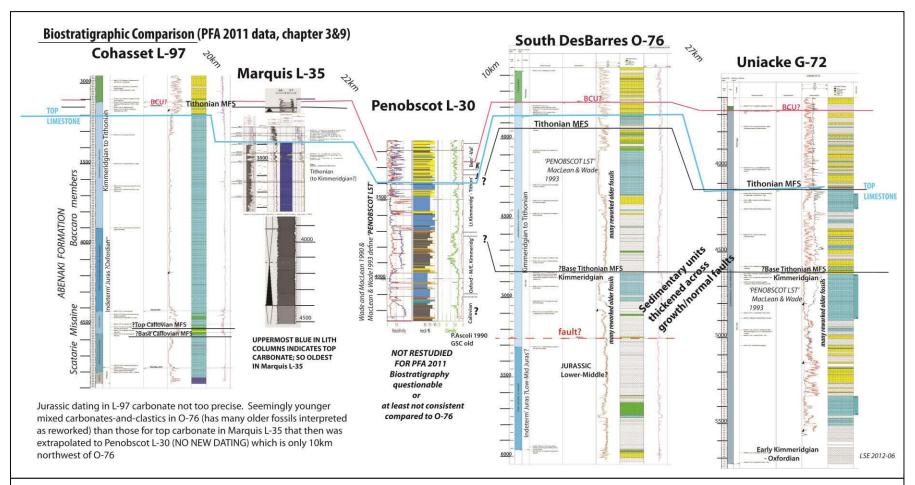
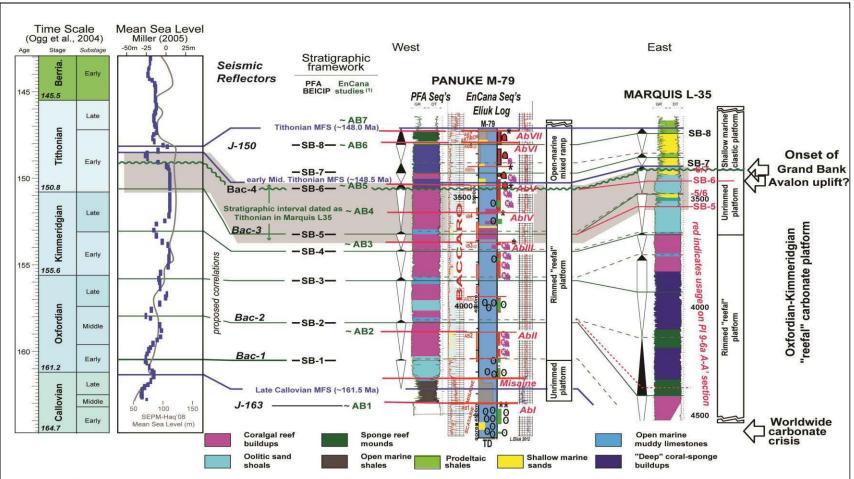


Figure A1.20 Jurassic Biostratigraphy for Wells Adjacent to Penobscot L-30. The above four well columns of Jurassic age represent the new or revised biostratigraphic dating done near Penobscot L-30 for the OETR 2011 PFA project. Unfortunately the Penobscot L-30 was not part of the PFA biostratigraphic work. With the dating assigned above, the carbonate growth at the margin terminates diachronously later (i.e. younger) at Cohasset L-97 than at Marquis L-35 which is possibly the same but difficult to assess at Penobscot L-30. But the more distal carbonate ramp shoals (=oolitic? - some more cuttings work required) at South Desbarres O-76 are an expanded section across growth faults compared to L-30 and continued carbonate deposition so that termination was apparently later (i.e. younger) than at Marquis L-35. Uniacke G-72 further away yet, and closer to the delta, may have carbonates terminate at an intermediate time. In both O-76 and G-72 much reworked older Jurassic fossils are interpreted which may also be the case in L-30.

NOTE: Weston et al. (2012) have revised the dating below the possible fault in South Desbarres O-76 as "not older than Late Jurassic."



Comparative biochronostratigraphic schemes of the Late Jurassic Baccaro Member. Modified from PFA 2011 Chapter 9-2-1

(1) The original PFA 2011 Chapter 9 biochronostratigraphic sequence summary figure has been modified by the addition of the EnCana sequences on a schematic Panuke M-79 litholog. EnCana chronostratigraphy presented is solely based on biostratigraphic summary of Van Helden at Panuke M-79 (Appendix 2, Weissenberger et al., 2006). Also see EnCana Deep Panuke wells section which shows VanHeldens's dating modified by using the Tethyan (French) terminlogy to be compatible with the PFA 2011 chronostratigraphy. The dating for EnCana does correspond with most sequences although an internal subdivision of the AB6 into upper and lower plus Eliuk's flagging of the basal Baccard transgressive oolitic ramp shoals' increases the similarity between the two approaches yet more. One area where there appears to be a discrepancy in age dating is the assignment of the EnCana AB5 and AB4 to Kimmeridgian as opposed to the grey interval being Tithonian in M-79 for the PFA interpretation. Note also at Marquis the upper PFA sequences 'subdivide'.

NOTE on M-79 litholog symbols: standard (Shell; Swanson 1981) symbols for oolites, reefal framebuilders (sponges, stromatoporoids, corals) and lithology colours (limestone, dolomite shale, sandstone), Yellow on left = porosity, Red on right = 10% or more framebuilders, Green on right = oolite grain/packstone. These are refliected in PFA deporacies interpretations.

Figure A1.21 Abenaki Formation Age Assignments and Sequence Correlations from Encana's 'type well' Panuke M-79 in Deep Panuke to northern end of Panuke trend at Marquis L-35 with oolite-sandstones replacing sponge-rich capping beds. Annotated and modified figure from PFA 2011 Chap 9-2-

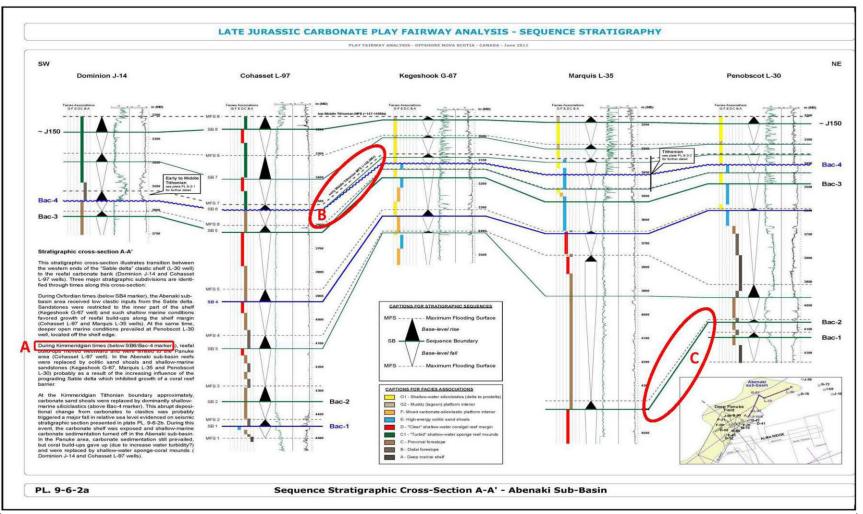


Figure A1.22 PFA Chapter 9 (OETR 2011) Correlations Northeast End of Panuke Trend - the stationary aggradational platform margin changes to ramp style and progrades over basin-filling prodeltaic shales as at Penobscot L-30. The red circles highlight features discussed in the text: A) use of Kimmeridgian rather than Tithonian, B) splitting and doubling of sequences where mixed delta-carbonate facies occur to northeast, and C) correlation forced by dating (Callovian in L-30 but needs to be reviewed given reworked-older-fossil problem) but a younger age is strongly indicated by clinoform seismic geometries and likely deepening into basin (compare geometry of Fig. 3.12 & 3.23 nearby in somewhat similar setting and seismic through L-30 of Fig. 3.3 with Scatarie inclined and much deeper basinward).

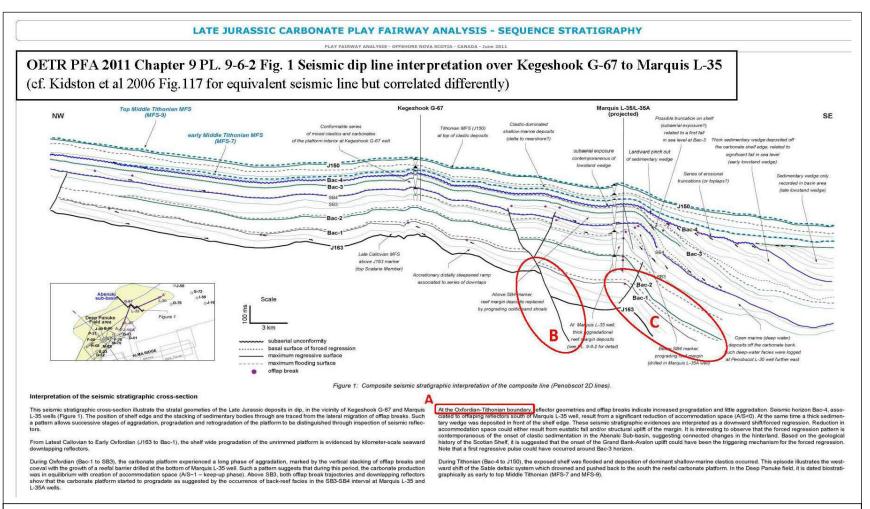


Figure A1.23 PFA dip seismic stratigraphic cross-section near Kegeshook G-67 and Marquis L-35 with interpretation. Some important points are circled in red. A) The PFA commentary points out the major change from aggradation to progradation of the margin is at the "Oxfordian-Tithonian boundary" (sic) perhaps meaning that most of the basin-fill and progradation was Kimmeridgian but perhaps there is also a biostratigraphic dating question. It is arguable whether abundant deltaic basin-filling siliciclastics are mainly responsible for progradation or whether lack of accommodation space resulting from lowstand unconformities. B) There is possibly down-to-the-basin growth faulting (probably equivalent to CNSOPB-Deptuck's LaHave platform hinge line between G-67 and L-35) that shows the carbonate margin is not always underlain by basement ridges as it is to the south. And there can be an increase in the total carbonate thickness despite the loss of section at the top by facies change to siliciclastics. C) The Scatarie limestone (J-163) is at great depth out into the basin and even the lowermost Baccaro (Bac-1) is unlikely to be encountered by a basin-slope well drilled in a setting a few kilometers beyond the platform margin (bringing some doubt to Callovian age for the shale below the deeper limestones in analogous Penobscot L-30 just to the northeast). NOTE see Fig.3.12 (copy of Fig. 117 in Kidston et al. 2005) for the probable seismic line in the centre of this tracing.

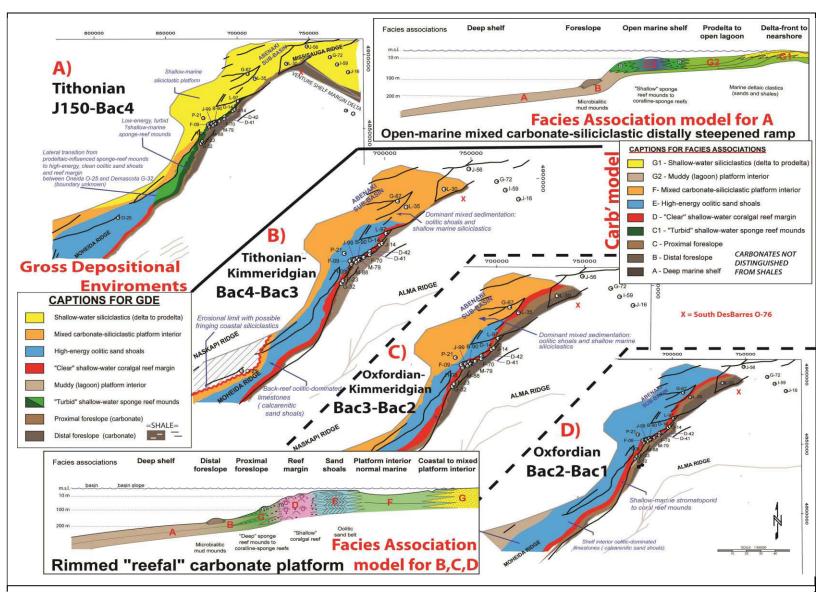
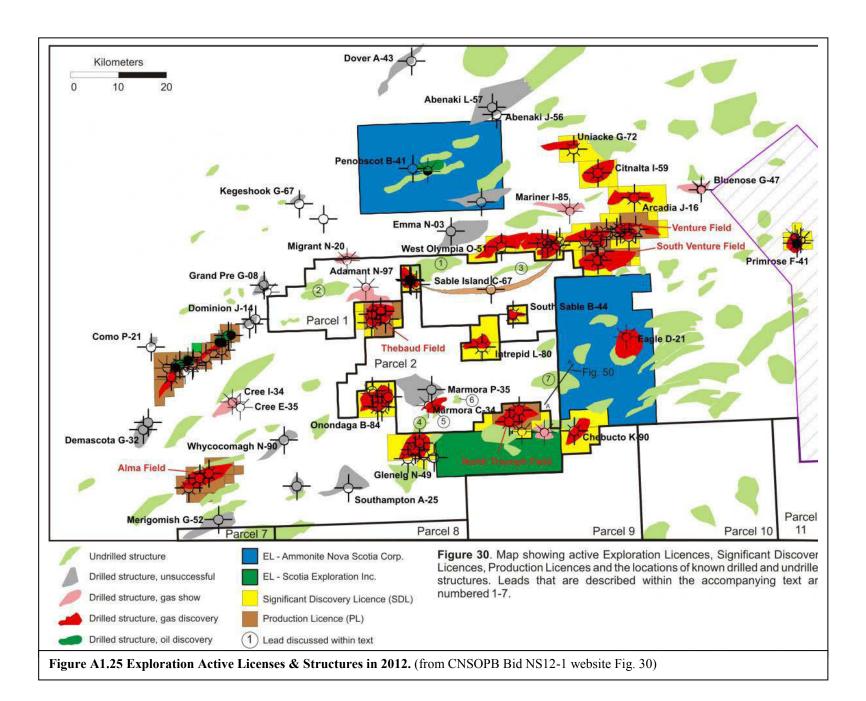


Figure A1.24 Depositional Maps between Regional PFA Seismic Markers (J150, Bac-1 to -4 = A to D) and Models – limited to northeast, simplified and rearranged from PFA Chapter 9 (PL.9-202b Fig.3 PFA models and PL9-9-1 to -4 GDE maps) to show interpreted changes and associated facies models. Note that the interpretation for the sponge mounds-delta is similar to the Ringer-Eliuk model (in Eliuk and Prather 2005, 2008) for the Baltimore Canyon Trough and also applied to Nova Scotia (Eliuk 2008, 2010a, b; Eliuk and Wach 2008, 2010). The model for underlying intervals is similar to Wierzbicki et al. (2002) and Weissenberger et al. (2006). Note that South Desbarres 0-76 was omitted



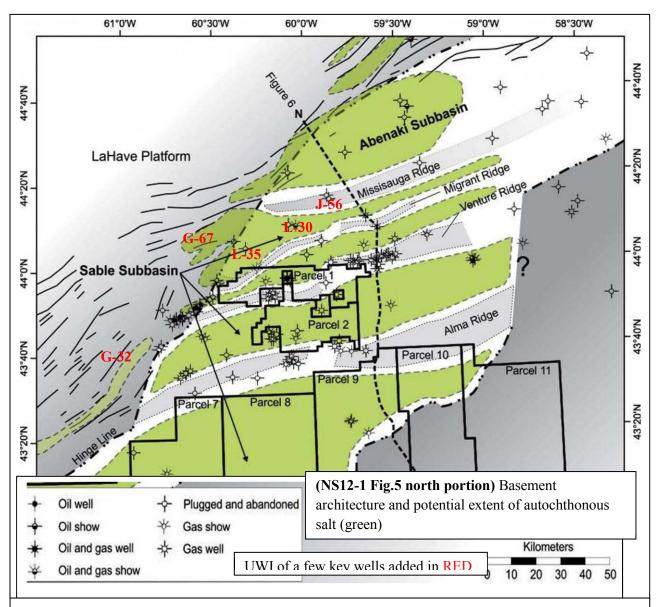


Figure A1.26 Tectonic Framework Centred on the Penobscot Area (L-30) from CNSOPB Bid 12-1 Fig. 5 upper half. Green is for deeper areas of autochthonous salt separated by basement ridges in grey.

Comments: It seems strange that Abenaki J-56 and L-57 drilled on the flank of a salt dome are shown over the Missisauga ridge. Perhaps the ridge acts as a barrier to salt movement down slope with loading and causes it to rise as a diaper – but why not close to the updip edge? Similarly the Penobscot L-30, even though it appears on seismic to be near a likely carbonate margin, logically localized by a basement (or early salt?) high, is shown instead in the middle of a salt basin. The edge of the LaHave platform localizes much of the Abenaki carbonate margin such as at Deep Panuke but it is well landward of the shelf margin well Marquis L-35. This may reflect the interpretation of the normal growth fault between L-35 and Kegeshook G-67 shown in the PFA seismic stratigraphic section (Fig.3.22) as the edge of the LaHave 'hingeline' by CNSOPB. Thus there are underlying salt then growth faulting resulting in thickened sections, north of about Cohasset L-97 up to Abenaki J-56. Therefore this style of tectonic control apparently occurs for the carbonate margin potentially from L-97 to Abenaki J-56 as drawn by Encana and not just for deltaic sedimentation. (2006, Weissenberger et al. 2006; see Fig.3.16)

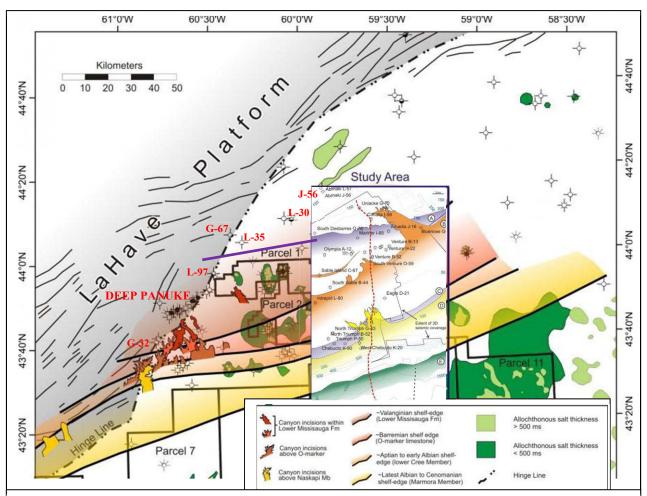


Figure A1.27 Shelf Break Trends from CNSOPB NS12-1 Fig. 17 at regional scale and inset of Fig. 20 showing detail. Shelf-break ages: A) Oxfordian (MicMac; LSE note = also considered Kimmeridgian and the W projection is mine & perhaps should be more N-NW), B) Valanginian (Lower Missisauga Formation), C) Barremian (O-marker limestone), D) Aptian to early Albian (Cree Member), E) Latest Albian to Cenomanian (Marmora Member). The presence of river-like channels on 3D time slice maps up dip of most shelf-edges (NS12-1, 2012) is certainly good evidence for early subaerial exposure. Obviously the pro-gradation is due to basin-filling prodeltaic sediments. Note the shifting of the axis of major submarine canyons possibly indicating a pattern of delta lobe shifts. Although several show multiple canyons of similar ages major canyons swing from northeast of Sable Island in the Valanginian to far southwest of it near Panuke in the Barremian back northeast to south of Sable Island in the late Aptian. Some unique well identifiers have been relabelled in red.

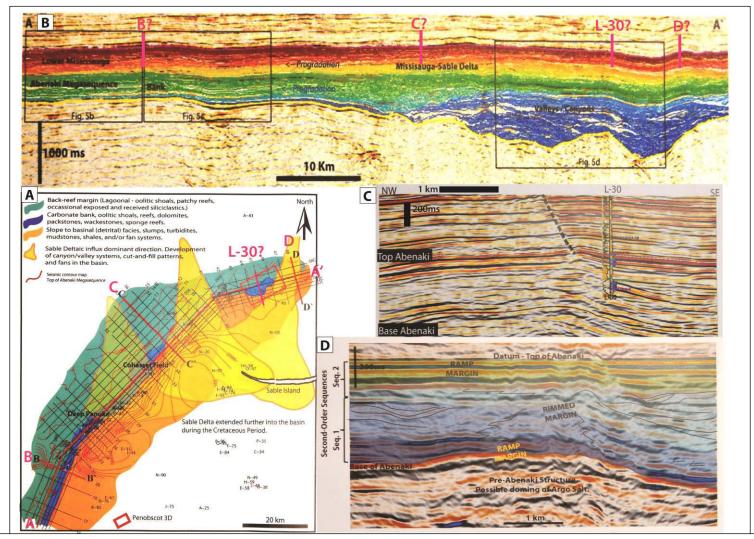


Figure A1.28 Base map and selected seismic Qayyum et al. (2015a) – A) Base map (Fig.1a) with dip lines shown on Fig. 3.29 as B, C, A (L-30) and D. crossing B) Regional strike line A-A' (Fig. 5a) Note the thickening of the interval into the margin and delta both carbonates and then siliciclastics and the thinness of the younger Missisauga deltaic-sourced beds since they have prograded basinward off the older Jurassic shelf. C) Penobscot L-30 dip seismic (Fig 4b) in structure after frequency enhancement and dip-steered-filter smoothing. Note faulted roll-over anticline that held non-commercial oil D) Penobscot 3D flattened interpreted dip line (Fig. 10a) nearby but not located on 3D survey at slightly exaggerated vertical scale shows the present day structure had early growth possibly as labelled but also likely during Abenaki time after their 'ramp' margin which anomalously 'climbs' over the deep structure but in time to localize the reef margin. Caution – map scale gives AA' line ~119 km but section scale gives AA' line only 84 km length.

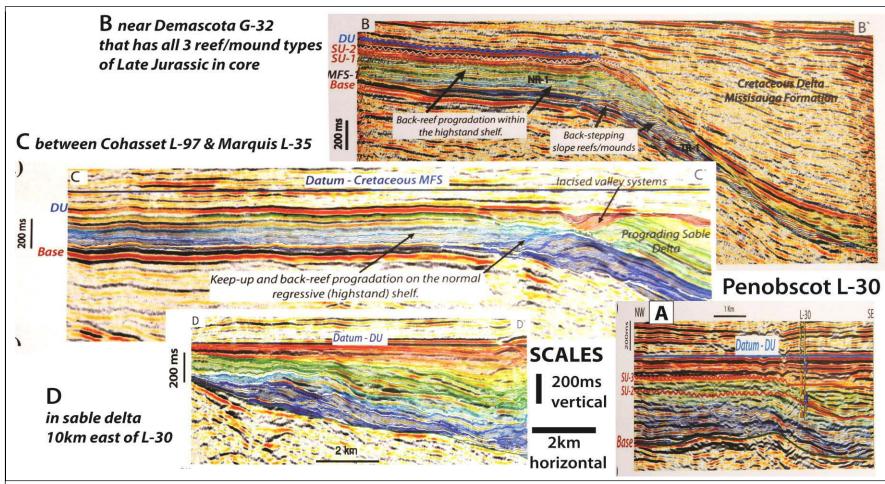


Figure A1.29 Interpreted Regional Dip Lines Qayyum et al. (2015a, locations shown on Fig. 3.28A, all scales the same) A) Penobscot L-30 (Fig. 13a squeezed to make horizontal scale the same-hopefully not in error) is the same as shown in Fig. 3.30A and close to 3.28D where the two fold 'Seq.1' of ramp up to aggrading margin (Base to SU-3 third order of Fig. 3.29A) versus 'Seq.2' late ramp (SU-3 to DU) is shown. This two fold subdivision may have as much to do with depositional regimes or styles as with specific sequences given the highly diachronous nature of the DU surface from biostratigraphy. B) Dip line near G-32 (Fig. 6a) more massive character of the margin far from the delta but of interest is the mounding in the lower Abenaki to be discussed in Chapter 6 results. Note the whole shelf and margin are thick. C) Dip line between L-97 and L-35 (Fig. 7a) shows the Abenaki thickening near the margin with interpreted mounded morphologies back-stepping up the slope. Without well control in the deeper bank interior the depositional facies can only be speculated but the uppermost limestone usually is oolitic and pelletal. So are ooid shoals generating the interpreted progradation "back-reef" (= shelf interior) or are siliciclastics also involved? D) Sable Delta dip line (Fig. 8a) differs from the other lines in having various complex clinoform and mounded patterns interpreted as carbonate but in their Fig. 9 enlargement terrigenous channelization is also suggested with upper beds incised by terrigenous influx. Alternatively the mounding may be prodeltaic sediment lobes.

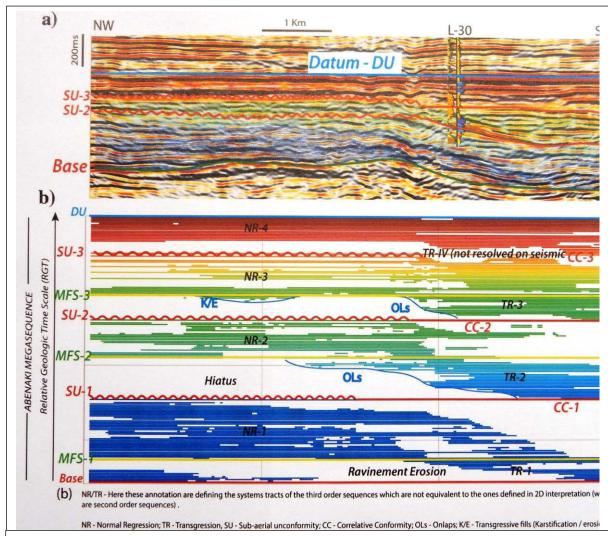


Figure A1.30 Penobscot L-30 Seismic Dip Line and Wheeler Diagram (Qayyum et al 2015a Fig. 13) A) Seismic line through L-30 ("structure domain") flattened at top carbonate and processed with dipsteering and gridding so that many short lines are generated that are said to aid detecting phase inconsistent features such as patch reefs (see Fig. 3.29C for un-interpreted structural line with only top and base Abenaki picked, SU-1 was omitted probably at strong reflectors at top blue tones below SU-2) As compared to interpretations on Fig. 3.29D presumably nearby on the same underlying structure the margin bump at both SU-2 & 3 levels is not well developed or poorly imaged. In fact the strong reflector just left of the SU-2 slope correlative line could have been selected placing all the carbonates above the SU-2 surface. In L-30 the cuttings indicate that they are mainly microbialites similar to what was seen in core with very little macrofossils or framebuilder debris. B) Wheeler domain diagram for L-30 seismic line is automatically generated in the HorizonCube program from the specially processed line assuming seismic reflectors are time lines and truly represent the stacking pattern and that there is no structural movement during deposition. Accepting for the moment the first two premises, the last premise is harder to circumvent at Penobscot. As already seen there is structure on the seismic both before and after deposition of the Abenaki-Sable beds so why not during them? In addition, the presence of hiatus and unconformity can be confused with condensed beds or slow sedimentation. Qayyum et al.'s (2015) interpretation of two sedimentation sources in carbonates (margin and backreef margin) with an intervening low or non-depositional zone could be taken as an incipient condensed zone. At a larger scale the carbonate factory and the delta lobes are separate sediment sources with intervening slow to no sedimentation intervals but still submarine being present in complex manner perhaps helping generate features as seen on Fig. 3.29D. Still there is new insight and a possible direction to follow in this attempt at sequence construction although for now it must be applied only to this limited area.

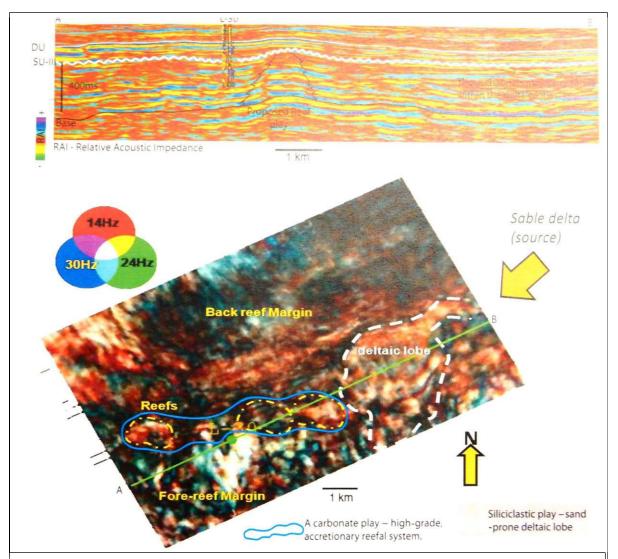


Figure A1.31 Composite Illustration of 3D Seismic Area and Play Ideas. (Qayyum et al. 2015a Fig. 15) Play ideas, reef and delta lobe, with strike section AB and 3D area map prepared by color blending the three spectral decomposition maps generated at 14, 30, and 24 Hz around this horizon (SU-III). Green dot locates Penobscot L-30 location. See Section 4.05 for an alternative interpretation. A reef play as outlined in blue and a deltaic lobe play were proposed. Although pursued by operators – the deltaic play combined with a structure found oil in L-30 in the Missisauga and the reef play was part of Ammonite Nova Scotia's former portfolio.

The term 'back reef margin' seems to imply a bathymetric low between the carbonate margin and the shelf interior so that two sediment factories seem to be operating. The nature of that factory is not well defined literally and figuratively in the Penobscot area. Mixed siliciclastics and oolitic carbonate are a reasonable guess given the lithologies in Abenaki J-56 and the topmost Abenaki of the wells from Marquis L-35 northeast. In areas further south perhaps ooid shoals alone constitute the factory. Patch reefs are reasonable to expect but so far no shelf interior well control has shown significant amounts or thicknesses of reef framebuilders.

The AB strike section where interpreted as a reef on a paleohigh with drape, could alternatively be seen as later structural uplift.

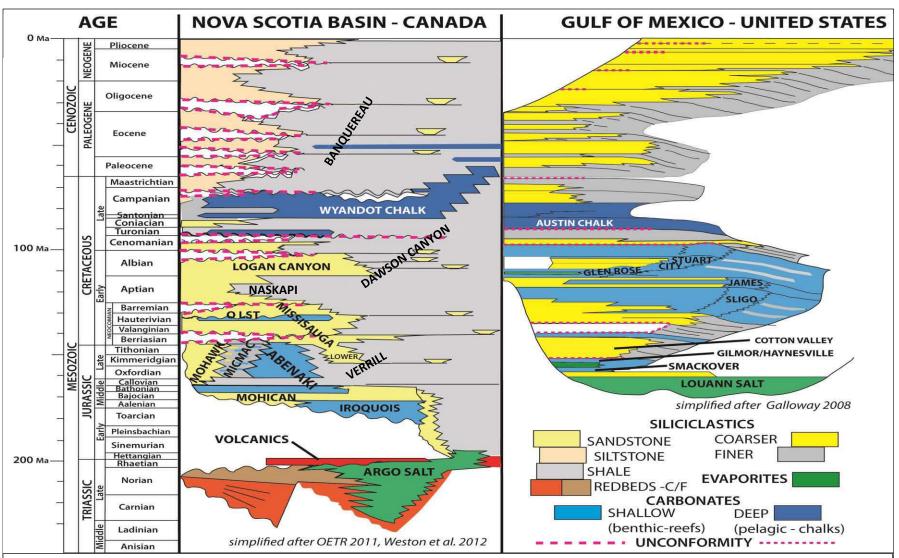


Figure A1.32 Stratigraphic columns of Nova Scotia offshore compared to Gulf of Mexico (modified & enlarged Figure 2.2A). Note the complicated depiction of the Abenaki-Lower Missisauga or contemporaneous Sable Delta. In comparing these two passive margin sections, except perhaps for chalk deposition associated with Late Cretaceous flooding; note the differences in major lithofacies of any given age likely linked to differences in basin initiation, sediment supply, paleoclimate and paleolatitude. A co-ordinated continental sequence pattern is not very evident although a Berriasian-Valanginian unconformity appears in both. Note that on the Western Shelf the Abenaki continues to the level of the O Limestone in the Upper Neocomian.

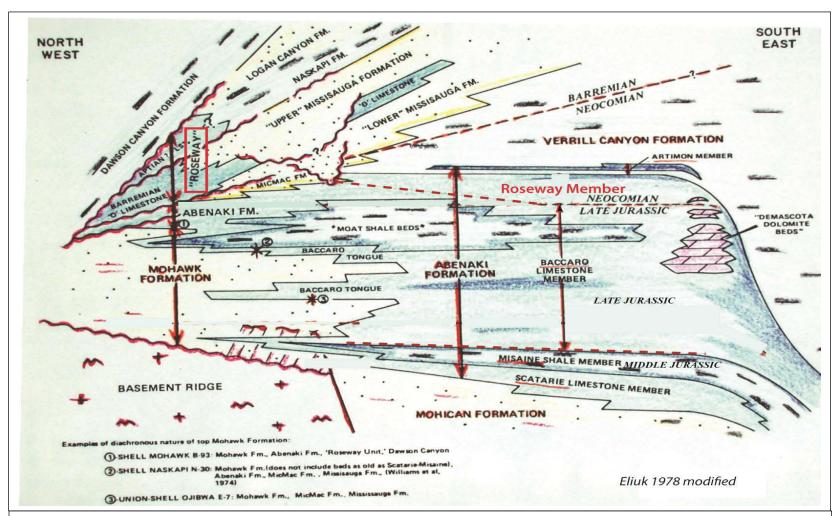


Figure A1.33 Western Shelf stratigraphy schematic (very slightly modified and colourized from Eliuk 1978 Fig. 3; also see Wade & MacLean 1990, Fig. 5.39) with addition of the Cretaceous Roseway Member (added in red above Baccaro Member) that can occur in the Mohawk, Missisauga and Abenaki formations. The Artimon Member is diachronous and can be part of the Abenaki, Verrill Canyon or Missisauga formations. Whatever the stratigraphic placement or age (even latest Jurassic in the NE Panuke Trend), the Artimon is lithologically characterized by having lithistid sponge-rich argillaceous limestones. Within the Abenaki Formation intraformational breaks or even unconformities may occur. Such breaks are implicit in the use of sequences and apparently some on the Western shelf may be of considerable duration. Unfortunately the biostratigraphy is often hampered by poor microfossil recovery in the carbonates. Note the Middle to Late Jurassic contact is placed top Misaine.

APPENDIX A2. ANALOGUES and MODELS of Modern (and Neogene) Mixed Carbonates-Siliciclastics (Big Deltas)

List of Topics:

- A2.1 First Principles and the 'Classic' Mixed Carbonate-Siliciclastic Model
- A2.2 Differences between Major Sediment Types and Carbonate Platform Morphologies
- A2.3 Modern Reef and Oolite Distribution (and Some Large Low-Latitude Deltas)
- A2.4 Analogues of Large Deltas by Carbonate Platforms Tabulated and Illustrated
- A2.5 Other 'Analogue' Considerations –
 Baltimore Canyon Trough, Haynesville Shale Reservoir Paleogeography,
 Giant Rivers and 'Bad' Analogues, and Insight from a Modern Fractal Analogue
- A2.6 Two Simple Models for Testing Delta-Lobe Switching and Delta-Loading Effects, and How Recent Salt Deformation Modelling Helps to Imagine
 Timing and Style That Potentially Influence the Abenaki-Sable
- A2.7 The Carbonate Side of the Equation of Reefs and Oolites versus Deltas
- A2.8 What Has Been Learned and What Can Be Applied?

A2.1 First Principles and the 'Classic' Mixed Carbonate-Siliciclastic Model

"Rivers, not temperature, organisms or chemistry appear to control the distribution of carbonates."

(Chave 1967)

This is the key thought that often introduces cool-water carbonate discussions. But it speaks to the typical absence of carbonates near deltas anywhere, especially classical warm shallow-water carbonates and particularly if oolitic. In searching for exceptions to this longstanding observation to use as analogues, not surprisingly, extremely few modern or ancient examples seem to exist. A large but lonely example is seen in the mainly Late Jurassic Abenaki platform with its shelf-edge oolites and gas-bearing reefs at Deep Panuke and the large gasbearing Sable Delta complex that at Venture includes shelf-edge deltas. Of course mixed carbonate-siliciclastic systems do exist and even have a large literature. But typically they are on a smaller scale with thinner alternations of the two major lithological types and less widespread development. This relationship is shown in **Figure A2.1** that depicts the typical or 'classic' model. Near shore are the terrigenous clastics and offshore are the carbonates. Another common relationship is the presence of downslope shales sourced from along or across the basin and flanking the carbonate-platform distal slope in a slope-onlap-surface. The modern Australian Great Barrier Reef is not only the world's longest reef chain; it is also one of the best examples of the classic mixed system with nearshore siliciclastic and offshore carbonate accumulation. The fine illustration by Francis et al. (2007 Fig. 2) of the Great Barrier Reef shows nearshore paralic

siliciclastics including small deltas and distant current-driven long-shore transport exiting through by-pass channels to deposit slope and basinal siliciclastics. In the Atlantic a good classic example is the second longest barrier reef system off Belize with the small Belize City delta and siliciclastics along the shore southward and carbonates to the north and seaward of a deep lagoon with carbonate mud (Purdy and Gischler 2003). Yet another example, the Abrolhos Shelf of Brazil, is one of the few reefal carbonate shelves of the South Atlantic. It has inshore siliciclastics including a small delta, coral reefs fringing the shelf edge and offshore islands, and an outer shelf consisting of rhodolith beds in water as deep as 60 m (Bastos et al. 2015). These however are not continental-scale deltas beside kilometre-thick carbonate platforms such as at the ancient Sable-Abenaki.

Size matters! To quote Sanders and Baron-Szabo (2005), "Since the papers of Schlager (1981) and Hallock and Schlager (1986) that underscored the sensitivity of corals to input of nutrients and sediment, there has been an inclination to view corals and siliciclastics as mutually exclusive." As seen in the opening quote by Chave, the case against carbonates associated with siliciclastics goes back even further. In contrast Sanders and Baron-Szabo (2005) argue "in the geological record, scleractinian-dominated 'turbid-water' bioconstructions that accumulated under substantial terrigenous input, along with shallow neritic marls rich in well-preserved corals, are common." But they observe that turbid-water bioconstructions are on the scale of metres to a few tens of metres thick, whereas scleractinian clearwater bioconstructions are on the tens to hundreds of metres scale. So the two conclusions are not so much in complete opposition, but rather are useful in distinguishing an apparent limit in size associated with high terrigenous content having small or no reefs and skeletal accumulations versus large reefs and reef complexes in clear-water settings, typically at shelf edges.

Reefs that put fear in the heart of mariners and joy in the heart of hydrocarbon explorationists are substantial and located in shallow clear water. A comprehensive review of rivers discharging into the world's coastal oceans (Milliman and Farnsworth 2011, see **Table A2.4** for data on selected largest rivers) shows almost none have nearby carbonate platforms. Similarly, McLaughlin et al. (2003) reported results of a global-scale statistical reconnaissance investigation of geographic relationships between reef occurrence and potential terrigenous sediment sources. They concluded that high annual runoff in coastal cells, over 4100 analyzed, are associated with strongly reduced coral reef communities but allowed more detailed analysis should be done. Some of their conclusions were correctly criticized for important omissions by workers in turbid-water coral occurrences (Macdonald et al. 2005) but even the critics admitted that the usual definition of

a reef as a "biologically influenced buildup" is often not met by turbid water coral growths. On a global scale even for modern isolated carbonate banks, an empirical analysis of their growth parameters supports the nutrient-control hypothesis (Vecsei 2003). Depth and area of carbonate bank summits were considered to be adversely affected by upwelling nutrients at depth. On an individual reef and coral scale, Fabricius (2005) also reviewed the deleterious effect of terrestrial runoff with regard to four key water quality factors – dissolved inorganic nutrients, organic particulate solids, turbidity (reduced light) and sedimentation. Some significant exceptions - two comparatively small rivers and the Shatt al-Arab (Tigris-Euphrates-Karum, Iraq-Iran) - do have nearby associated shallow-water carbonates, including reefs, and are discussed below (also see Table A2.2 and Table A2.4).

Can there be a fractal nature to carbonate-siliciclastic mixed sedimentation? (Eliuk and Wach 2010b see **Figure A2.13**; for review of fractals relative to carbonates see Schlager 2004, 2005). Or at some large enough scale should they simply be considered two separate systems that just alternate laterally or vertically in some not closely-connected manner? A proposed genetic classification of Cenozoic carbonate platforms based on their basinal and tectonic setting (Bosence 2005) came up with eight categories. At least three of these may apply to the Late Jurassic Scotia Shelf:

- 1. *subsiding margin platforms and offshore carbonate banks* (large to huge; e.g. much of the Abenaki and the rest of the mid-Mesozoic Atlantic margin gigaplatform and its successor carbonates of Florida and the Bahamas),
- 2. *salt diapir platforms* (usually moderate sized, often somewhat circular sites lifted into isolation from surrounding siliciclastics; e.g. arguably the Penobscot area and early Abenaki J-56 and L-57), and
- 3. *delta-topped platforms* (relatively small and thin; e.g. Barremian 0 Limestone Marker, various Abenaki equivalent limestone interbeds in the Sable Delta area like Penobscot L-30, South Desbarres O-76).

The last two "platform" types could be considered parts of mixed carbonate-siliciclastic systems. Even in the first-listed more typical platform - subsiding (passive) margins, the original understanding of the Abenaki Formation was a mixed system at least in the nearshore ridge and intermediate offshore ('moat') settings independent of the large Sable Delta (Eliuk 1978, see his fig. 19 and 20). Such a shore-to-shelf-edge pattern is illustrated in **Figure A2.1** showing the usual dip relationship or **model for mixed carbonate-siliciclastic systems** in shallow tropical-water benthic carbonate factory settings (modified after Schlager's 2003, 2005 subdivision of benthic

carbonate factories – 'T'= tropical, topmost, autotrophs/symbionts (biotically controlled, photic zone); 'M'= mud mound, micrite, microbolite (biotically induced) and 'C'= cool-water, biotically controlled precipitates, heterotrophs. Eventually the two major lithofacies become interbedded with progradation or change of varied origins.

Application of **general principles on controls** of mixed carbonate-siliciclastic studies may give insight (Wilson 1967 – concepts of reciprocal sedimentation, Mount 1984 – general model with at least 4 possible origins but a common 2D schematic diagram much like **Figure A2.1**, Leinfelder 1997 – mixed model emphasizing aridity applied to the Late Jurassic of Portugal, Goldhammer 2003 – encyclopedia contribution). Some controls that may apply include the following:

- reciprocal sedimentation (alternations in time/climate/locality/bathymetry arid/monsoonal, delta lobe shifts, high/low relative sea levels favouring one or the other sediment),
- 2. <u>slow sedimentation with vigorous/adaptable organisms</u> (heterotrophs, exceptional algae and atypical corals),
- 3. ocean currents of appropriate strength and direction, and perhaps most significant
- **4.** <u>isolate and separate</u> by barriers (islands/ridges/salt walls-diapirs), by isolated highs (offshore atolls, pinnacles), by deep water ('moats'/lagoons/ gulfs/basins = the classic controls), and by bypass and sediment sinks (deep-water channels and salt withdrawal).

Typically mixed siliciclastic-carbonate systems are mainly attributed to **reciprocal sedimentation** (alternating siliciclastic-carbonate-evaporite deposition) related to the following: **a**. changes in the sediment supply over time (temporal variation), or **b**. geographic changes of sediment input, e.g. delta lobe switching or river capture (spatial variation), or **c**. climatic variation, from humid to arid and semi-arid (latter less siliciclastic supply).

In adding details based on new coring to refine insight on mixed carbonate-siliciclastics in the South Florida late Neogene, McNeill et al. (2004) also gave possible application and especially caution to understanding similar ancient deposits. Many of their themes are even more relevant to much older deposits with more problematic dating such as the Abenaki-Sable. These themes are tabulated from their abstract as follows:

- 1. Concept of Template Control on Both Carbonate and Siliciclastic Deposition—precursor topography controls depositional geometry and location of subsequent depocenters for both carbonates and siliciclastics (see Purdy et al. 2003 for Belize examples);
- 2. Distal Transport of Coarse Clastics and Influence of Currents on Grain-size Segregation

- Conditions can exist for the long-distance transport (fluvial?) of extremely coarse siliciclastics (flat-pebble quartz in this Neogene example) from the source area, and regional currents help segregate grain-size populations and partition grain types;
- 3. Demise of the Carbonate Platform/Ramp: Smothered by Siliciclastics?
 - In this Neogene example, we recognize a hiatus of several million years bounding the top of a carbonate ramp, which indicates that demise of the ramp and subsequent input of siliciclastics are temporally distinct;
- 4. The Mixing Transition: Abrupt Vertical and Lateral Facies Changes
 - The lateral transition of carbonate to siliciclastic strata highlights the potential for abrupt facies changes both laterally and vertically. Interfingered carbonates and siliciclastics may form stratigraphic traps based on lithologic differences and differential diagenesis and can result in alternating reservoir pay zones and nonreservoir intervals;
- 5. Cryptic Sequence Boundary in Shallow-marine Siliciclastics and Carbonates
 - In cases where no distinct change in lithology exists, it may be inherently difficult to recognize major disconformity based only on lithologic changes. In settings dominated by admixing, sequence-boundary confirmation may require the integration of biostratigraphic and chemostratigraphic markers with any available textural indicators; and
- 6. Similarity in Acoustic Properties of Laterally Equivalent Siliciclastics and Carbonates
 - Shallow burial and early diagenesis have produced an almost identical acoustic signature for the two admixed sediment types. This acoustic similarity may make it difficult to distinguish specific lithofacies on seismic profiles and sonic logs (in the absence of cuttings). In ancient mixed-system deposits where only seismic data exist, problems in specific lithofacies or geometric characterization may occur.

All but possibly theme 2 have direct relevance to the Abenaki-Sable even if the size scale is seemingly not comparable. In the ramp areas near the Sable Delta and to the northeast, even this difference is not important and antecedent Sable deltaic topography permitted later shallow carbonate sedimentation. The presence of cryptic unconformities may also be important in the Abenaki. But like the phosphates that cap some of the Florida carbonates, coated red ironstones prevalent at the top of the Abenaki on the Western Shelf may be the important clue to watch for as well as deeper water facies above breaks.

Should one simply scale up the general model or is there a fundamental difference in process or origin for large deltas beside thick carbonate banks? What follows is a search for large-scale examples of shallow-water benthic mixed systems in the Holocene-Neogene as analogues. This is in contrast to the also unusual possibility of large-scale mixed pelagic systems with the

siliciclastic portion nearer shore on shelf and the carbonate portion in deep-water upper slope as occurs with the Cretaceous-Tertiary Banquereau Formation fine siliciclastics and Wyandot Formation chalk also in the Nova Scotia offshore (Eliuk and Wach 2010a).

A2.2 Differences Between Major Sediment Types and Carbonate Platform Morphologies

Before continuing with the investigation of mixed-sediment analogues and models, an important initial consideration is a summary of the characteristics of the major sediment end-member groups and a review of carbonate platform end-members terminology and their profiles. It is particularly relevant since the Scotian Shelf Mesozoic shows all four of the sediment groups as well as volcanogenic rocks. And the Abenaki Formation in the broad sense shows both the classic ramp and flat-topped platform end members with intermediates and small isolated buildups and, it will be argued, even atolls.

Since seismic profiles are a major part of the data set and profiles often are considered indicative of particular facies patterns and even sediment types, a short overview of these features and their controls is especially useful. Understanding the origin of geologic shapes seen on seismic may be difficult even when seemingly straight forward. The most attractive and 'obvious' carbonate play is an isolated buildup or 'reef' in the broad sense. But correct identification is not trivial. After noting failures by even the largest exploration companies, Burgess et al. (2013) suggested a matrix of confirmatory features to consider before drilling an isolated buildup. Perhaps one of the largest such failed 'isolated buildup' plays may have been the Schlee or "Great Stone" Dome in the Baltimore Canyon Trough offshore. Before drilling, the dome was interpreted as possibly an Abenaki analogue play or perhaps a huge anticline; after many wells it was found to be an igneous intrusion (Poag 1991).

James et al. (2010, slightly modified as indicated by italics in **Table A2.1**) summarizes some of the fundamental differences between terrigenous clastics and biochemical sediments (carbonate, evaporite and bioelemental sediment). Evaporites formed during the initial very restricted conditions producing salt of the Argo Formation then the overlying less restricted dolomite and anhydrite of the Iroquois Formation. By Abenaki 'time' there is no evidence of evaporites except traces of anhydrite cement and the fact that the gas in Deep Panuke is slightly sour (0.2% H₂S). This indicates the likelihood of thermochemical sulphate reduction of minor anhydrite by hydrocarbons to produce hydrogen sulphide. Since there is significant hydrothermal or deep burial dolomitization, the anhydrite likely came up from the underlying evaporites with

the dolomitizing fluids. Within and just above the Abenaki there are bioelemental minerals in the form of glauconite and red coated ironstones most obvious in the shelf interior at the Oneida to Mohican areas. The fact that there are large-scale and widespread mixed carbonate-siliciclastic associations gives rise to the subject of this thesis. The table does not equate carbonates with warm tropical to subtropical waters as was once the usual assumption prior to widespread temperate and cool-water carbonate studies. However, the presence of ooids, peloids, green algae and shallow-water hermatypic hexacorals and their reefs in the Abenaki does indicate a warm water temperature. Additionally the paleogeographic reconstructions also indicate a lower latitude setting making warm waters all the more likely, given the greenhouse climates and calcitic seawaters attributed to the Jurassic-Cretaceous.

An interesting morphological corollary between terrigenous clastic and carbonate sediments follows from the comparisons in **Table A2.1** particularly the effect of a hydraulic regime. The well-known carbonate profile distinctions of 'ramp' with gradual slope into the basin versus 'platform' with abrupt platform edge break in slope (whether rimmed or open see **Figure A2.2**) has only the ramp profile (and distally steepened ramp down to the continental shelf edge) as equivalents in the terrigenous realm since wave regime controls their profile. Ramp and platform profiles are common both over time and at the same time during Abenaki deposition. Unlike the platform profile of most of the Abenaki shelf complex, the carbonates of the basal Abenaki overlying the Mohican Formation and Misaine Member siliciclastics have ramp profiles. As well, ramp profiles are typical in the transition areas of the upper Abenaki-Sable Delta where siliciclastics interbed and fill the basin allowing progradation. This carbonate mirroring of the terrigenous clastic profile armours the underlying siliciclastics. Additionally, it seems to be associated with widespread development of oolitic facies due to the unprotected-open-wave setting on a broad shelf and to the likelihood of easy long-distance facies migration with small changes in relative sea level.

A spectrum of carbonate platform types and morphologies is shown by **Figure A2.2** (modified from Burgess et al. 2011). That full range occurs associated with the Abenaki or equivalent carbonates. Pomar (2001) applied a genetic approach to classifying carbonate platforms and considered grain size of sediment, place of production (implicitly productivity) and hydraulic energy as controls. In turn that biota producing the grains is controlled by light (euphotic if good and oligophotic if poorer at greater depth or turbidity) or independent of light and therefore depth independent. For instance, euphotic framework-producing organisms were said to create rimmed platforms. At the other extreme mud-dominated production no matter the photic setting were said

to create homoclinal ramps. In contrast, Williams et al. (2011, Burgess et al. 2011) observed that classification of carbonate platforms by depositional gradient with two extreme end-members did not reflect the great variety seen and suggested very different controlling factors than Pomar's (2001). They undertook 2D numerical forward model runs to investigate how sediment production, transport and other controls such as tectonic differential subsidence, antecedent topography, and relative sea level oscillation interact to determine platform geometry. The modelling seems to show that a critical factor producing profiles is the various rates of offshore sediment transport relative to rates of autochthonous production. To use their words,

These results suggest a continuum of platform types, ranging from transport-dominated, low gradient systems (ramps), to in-situ accumulation dominated systems (flat-topped platforms). A system may be transport dominated because of high-energy processes able to break down and transport even bound sediment, or because carbonate factories produce only sediment easily transportable even under low energy conditions. Breaks of slope in underlying topography and differential fault subsidence are a stronger control on platform geometry in in-situ accumulation dominated systems. Relative sea level oscillations tend to move the locus of sediment production laterally along any slope present on the platform, distributing sediment accumulation across the whole width of the platform, suppressing progradation and steepening, and so favouring development of low-gradient systems.

As early as Eliuk 1978 (see **Figure A1.1**), a variety of profiles were sketched showing ramp and flat-topped rimmed platform such as shown in **Figure A2.2**. Crude seismic lines indicated a rimmed margin and nearby reef passes or channels for the Abenaki platform. Somewhat better seismic showed ramp margins nearer the Sable Delta (Eliuk et al. 1986, see **Figure A1.3**). Many of the newer and better seismic lines through nearly all of the Abenaki wells in Kidston et al. (2005) are used in Chapter 4 Results as the key wells are discussed. Similarities and likely inheritance of ramp morphologies from siliciclastic regimes to overlying carbonates were discussed in the above. Another similarity between them can be inferred from the suggested controls important in the modelling exercise of Williams et al. (2011). The Abenaki carbonate ramps are generally oolitic with minor reefal contribution; such mobile sediment is likely to be more easily transported. Thus it fits one of their main criteria for low gradient or ramp system. Relative sea level oscillations were also seen to favour low gradient systems. The presence of deltaic infill and progradation with likely lateral delta lobe switching might well act like sea level oscillations that are then occupied by the carbonate regime of low gradient.

A2.3 Modern Reef and Oolite Distribution (and Some Large Low-Latitude Deltas)

The great majority of modern reefs formed from hermatypic corals and higher algae and occur in waters of the tropics and subtropics, typically where clear and shallow. Some exceptions in more turbid waters are potentially useful analogues. More generally, reefs usually of much smaller sizes can occur in temperate, cool even cold water and at considerable depths (James and Clarke 1997). World-wide distribution of warm-water reefs from Schlager (2005) are shown on **Figure A2.3** modified by the addition of deep, cool and cold water reefs (mainly from James 1997). Modern and relict oolites are also added but are much more limited in distribution. However when developed they may cover much larger areas than associated reefs. Some of the largest lower latitude deltas are shown with some significant anomalous features listed, including Canada's temperate Fraser delta remarkably with prodelta non-calcareous sponge reefs (Conway et al. 2004).

A brief survey of **modern oolite** occurrences is included in Opdyke and Wilkinson (1990) who made the following comment:

Among the modern areas of carbonate accumulation, only a few are significant examples of ooid generation. The Bahama Platform (e.g. Ball, 1967), Yucatan (Ward and Brady, 1973), southern Cuba (Daetwyler and Kidwell, 1959), Pedro Bank (Zans, 1958), Serrana Bank (Milliman, 1969), the Persian Gulf (e.g. Loreau and Purser, 1973), the Gulf of Suez (Sass et al., 1972), Lizard Island, Australia (Davies and Martin, 1976), and Shark Bay (Davies, 1970) are notable in this regard.

The few others mentioned were not considered to be forming ooids now. Flugel (2004, his Box 4.14) lists these and additional references including some in hypersaline and freshwater lakes. In a detailed study of current ooid formation in the Bahamian Archipelago, Duguid et al. (2011, their Fig.1) showed the following sites: (1) Lily Bank, (2) Double Breasted Cay, (3) Abaco Tidal Deltas, (4) Bimini, (5) Cat Cay, (6) Brown Cay, (7) Berry Islands, (8) Joulter's Shoal, (9) Schooner Keys, (10) Exuma Tidal Deltas, (11) Head of the Tongue of the Ocean, (12) Bight of Acklins, and (13) Caicos Platform. Along with the areas mentioned by Opdyke and Wilkinson (1990), these have been generalized on **Figure A2.3** and included with oolite formation in the Florida Keys (including early Holocene) as the largest area of modern oolite occurrence. Only one example of oolite is in the modern open ocean on the South Pacific Cooke Islands in a reef lagoon (Rankey and Reeder 2009). This single locality contrasts with as many as nine or more occurrences on/near Pacific seamounts in the Lower Cretaceous (Jenkyns and Strasser 1995) suggesting a significant difference between modern and Mesozoic sea water.

Relict Holocene ooids are also shown on Figure A2.3. They present the strange situation that oolites seem more widespread during the early Holocene transgression(s) than at present. This observation is actually in keeping with Wilkinson et al.'s (1985) somewhat surprising observation that greatest Phanerozoic oolite abundances correspond to neither highest nor lowest sea level stands but occur during transgression and regression (also see Section A2.6). Some occurrences are even near the large Amazon River and the Ganges delta in the greater Indian Ocean area. While likely not exhaustive the following occurrences were noted:

- 1. Near-modern pre- or early-Holocene, near Broome **northwest Australia** eroded from near shore dunes etc. produced in late Holocene 1-2m high stand sea level (3.5-4.5Ka bp) in tidal channels (Hearty et al 2006);
- 2. Relict Mg-calcite oolite during slow transgression (16.8Ka bp) Capricorn Channel at south end of Great Barrier Reef, east Australia (Marshall and Davies 1975, Yokoyama et al. 2006);
- 3. Northwest **Amazon Brazil French Guiana** in 100m low stand (16-21Kbp) hi-Mg calcite radial ooids in ?low energy but unlikely hypersaline (Milliman and Baretto 1975);
- 4. Off **west India** oolite in north (6.9-12.3Ka bp, 65-105m depth, Purnachandra et al. 2003), relict 300km submerged barrier reef system with late Pleistocene/early Holocene shoreline oolite at north end (Vora et al. 1996), and relict shallow calcareous oolite at 100m subsequently phosphatized by more recent upwelling currents (Nair 1968);
- 5. Off **east India** regressive oolitic beach barriers of last glacial sea level low (16.5-24.9Ka bp) (Nageswara Rao et al. 2005, Subba Rao 1964); and
- 6. Outer **Bengal shelf India Ocean** east side at 120-130m isobaths just east of major channel on shelf interpreted to be emplaced during regression (Wiedicke, Kudrass and Habscher 1999).

While hardly a carbonate platform, the presence of relict on or near major rivers or deltas such as the Amazon and Ganges-Brahmaputra shows that onlite can form near major rivers during transgression. It is intriguing that the only onlite occurring in Belize occurs as a bar just off the mouth of the Hondo River separating Yucatan, Mexico and Belize (Pers. Comm. Burr Silver, alerted in 2008 by John Harper).

A2.4 Analogues of Large Deltas by Carbonate Platforms Tabulated and Illustrated

There is a mixed system analogue that might be considered an excellent analogue for the Abenaki-Sable juxtaposition in the Arruda Subbasin of Portugal (Leinfelder 1997, see **Figure**

A2.3). Not surprisingly it is not a modern example but of the same age as the Abenaki, given the Late Jurassic high carbonate productivity (see Chapter 1). But its arid climate, rift setting and particularly much smaller size excludes it from the following review but is similar perhaps to the flanks of the modern Red Sea. The following is a short survey of more modern examples after our survey of modern reefs and onlite occurrences.

Even more so than shallow coral reefs, the presence of thick carbonate accumulations of ooids in close association with significant amounts of deltaic siliciclastics is highly anomalous, certainly for modern oceans and very rarely in the Phanerozoic record, possibly uniquely. Figure A2.3 illustrates this by including some major tropical deltas on a world map of reefs and oolites. Although shallow-water coral reefs are mainly absent; there are various examples of deeper water reefs including relict Holocene – mainly ahermatypic corals but also rarely sponges near modern deltas (See "anomalies" list in Figure A2.3 caption). Table A2.2 lists some of the few but better exceptions of reefs and significant amounts of carbonate near major large deltas. Deltaic shelves in tropical settings with high amounts of carbonates in the form of Halimeda (green algae) and larger benthic foraminifera mounds and/or coral patch reefs do have modern examples with the Mahakam Delta of Borneo being one of the best examples (Roberts and Sydow 1997, Wilson 2005, Saller et al. 2010). A variety of carbonate-producing organisms adopted various 'strategies' for coping with siliciclastic and volcaniclastic input and low light levels (Wilson and Lokier 2002). Pretkovic et al. (2016) recently described microbial domes and megaoncoids in the flanks and lower levels of Mahakam Miocene patch reefs - perhaps a fractal analogue to the Abenaki slope microbial 'mud'mounds, later called more generally, microbolites. Of great significance, it does illustrate the importance of oceanic currents in deflecting deltaic sediment and thereby aiding the growth of patch reefs (see **Figure A2.4** after Wilson 2005).

Another recently studied example of a large delta closely associated with a major carbonate reef tract is the Fly River Delta in the Gulf of Papua and the northern Great Barrier Reef (see Figure A2.5 modified from Eliuk and Wach 2010b from Pers. Comm. Andre Droxler 2010, Mixed carbonates-siliciclastics short course 2010 NOLA AAPG convention; Tcherepanov 2008, Tcherepanov et al. 2008). However the modern setting is one of a delta to offshore small carbonate banks, atolls and pinnacle reefs; so that is an example not of an adjacent large carbonate platform but rather a hermatopelago defined as a reefal island and atoll concentration. That area also has an adjacent drowned Miocene Platform buried by the Fly River Delta. But the Borabi carbonate platform was said to have drowned independently of and prior to the delta influx (Tcherepanov et al. 2010) due to global eustacy also involving the Maldives

Islands (Droxler 2010 AAPG NOLA short course). Significantly, like the Mahakam delta currents, the Coral Sea Current is sweeping deltaic fines away from the Great Barrier Reefs north end (Slingerland et al. 2008) and may once have aided Borabi shelf progradation northeastward over the Fly paleodelta. But there are few or no significant oolites so it is not a close analogue (pers. comm. 2010 Jeff Packard, Talisman Energy Inc.) These two areas along with the **Kuwaiti ramp** with oolite-isolated patch reefs near the Tigris-Euphrates Delta are the most interesting modern "near-analogues". Their main features are tabulated against the Abenaki and equivalent carbonates in the Baltimore Canyon Trough in Table A2.2. The modern northern Arabian-Persian Gulf is the closest example of a carbonate ramp in Kuwait with ooids and very shallow coral patch and fringing reefs offsetting the major Shatt al-Arab Delta of the Tigris-Euphrates-Karum Rivers (see Figure A2.6). The actual relationship is little studied and occurs in a major coastal industrial zone. But recently and surprisingly, a 28km² living coral reef in deeper turbid water at 7-20m was found off the delta in Iraq (Pohl et al. 2014). In giving yet more modern delta-associated reef examples, this coral reef discovery is like the 1990's unexpected discovery of siliceous sponge reefs off Canada's Fraser River prodelta (Conway et al. 2004, Eliuk 2010). The Gulf setting is an arid climate shallow foreland epeiric sea that is fundamentally different from the oceanic more humid setting of the Abenaki. In fact there is even an opinion, probably a minority one (Walken and Williams 1998), that the Persian Gulf is not even a true ramp, therefore a poor analogue for ramps since it has often been emergent with plentiful mixed siliciclastics in its disequilibrium Neogene history. Implicit in their suggestion is that the supposed carbonate ramp is simply "armouring" the previous siliciclastic profile; therefore the ramp profile is inherited. For the Abenaki bank and thinner carbonates associated with the Sable Delta, this reasoning could also be used to explain the ramp profile of the lowest Baccaro Member above the Misaine Member shale and of the Scatarie Member limestones above the Mohican Formation siliciclastics. Likewise the development of ramps and prograding ramps in the upper Abenaki is confined to areas adjacent to the Sable Delta (Eliuk 1978) and that could be taken as mainly armouring of prodeltaic fine clastic profiles.

The interesting argument by Droxler and Jorry (2013) that most of the world's modern barrier reefs originated above deglacially drowned siliciclastic shelf edges shows Pleistocene sea level fluctuations can make what is usually considered anomalous a common occurrence. Their examples included details on the first and second longest modern barrier reefs – Australian Great Barrier and Belize with a mention of Florida Keys and New Caledonia. As well, drowned barriers were shown for the Gulf of Papua and even a trend of approximately 20 small drowned reefs in the western Gulf of Mexico shelf edge off south Texas. While the applicability of glacial-scale

fluctuations to all of the geological record may be inappropriate, the importance of early transgressive periods for replacing clastics with carbonates is certainly obvious. In fact McNeill et al. (2004) gave more details on the interruption of the long-lived Mesozoic-Cenozoic south Florida carbonate province by a late Neogene siliciclastic influx that is again capped by carbonates in the Pleistocene. This is almost the opposite situation from the preceding delta analogues where a major carbonate province is interrupted by siliciclastics of fluvial if not deltaic origin along the axis of the Florida peninsula with karst involvement (Hine et al. 2009). This is not only a 'classic' analogue but also gives rise to cautionary insights in dealing with ancient mixed systems according to McNeill et al. (2004) and already discussed at the end of Section A2.1. But these examples are still not a thick carbonate platform beside a major delta. Still the Miocene carbonate platform just west of the Fly River Delta is the closest possibility particularly since it is shown to have even a progradational area adjacent the delta (Figure 4.5C after Droxler 2010 AAPG course). Probably all these analogues are more appropriate for the interbedded carbonates and siliciclastics ramp packages of tens to hundreds of metre scales relatively close to the Sable Delta on both southwest and more commonly northeast flanks.

A major control that may always remain speculative in ancient subsurface deposits is the effect of oceanic currents. They are very important in modern occurrences such as the reef tract off the Amazon (North Brazil Current, Moura et al. 2016), the Fly River Delta at the north end of the Great Barrier Reef (Coral Sea Current) and in the Mahakam Delta reefs of Borneo (Indonesian Through-flow Current). Nearshore currents are important for re-distributing siliciclastics from the small Burdekin Delta northward and out through a Great Barrier Reef channel near Cairns Australia resulting in basin floor mixed carbonates-siliciclastics (Francis et al. 2007). These currents direct river plumes and sweep sediments allowing for the growth of reefal and skeletal communities. This results in asymmetrical distribution of both the reefs and the types of mound or framebuilding organisms that make up the reefs. In the Abenaki a strong northeast directed current (paleo-Gulf Stream Current?) pushing river plumes and sediments northward could have helped maintain favourable carbonate productivity in the platform to the southwest of the Sable Delta both early during the GAP phase of the Sable-Abenaki and later during the southwest progradation of the enlarging Sable Delta. During that late phase of Abenaki-Sable association, there is a lateral progression from normal shallow-water platform sedimentation to a zone of condensed low sedimentation with marine redbeds, then the sponge reefs at the toe of the prodelta.

A2.5 Other 'Analogue' Considerations

- Baltimore Canyon Trough, Haynesville Shale Reservoir Paleogeography, Giant Rivers and 'Bad' Analogues, and Insight from a Modern Fractal Analogue

The only other wells drilled near the Late Jurassic carbonate margin occur in the Baltimore Canyon Trough (BCT; Meyer 1989, Prather1991, Eliuk and Prather 2005). Their lithofacies-seismic and a map of the deltas are shown as Figures A2.7 and A2.8 respectively and compared in Table A2.2. With a very similar lithostratigraphy and dating to the Scotian Basin Jurassic-Cretaceous, they even have had a similar formational nomenclature applied. Both areas also have an oolitic limestone capping the early Cretaceous deltas but of younger age in BCT. However the deposition of the three small BCT deltas post-dates the thick carbonate bank (Poag et al. 1990). Those prograding deltas may have contributed to the demise of the carbonates which have pinnacle reefs and ridges at the margin as they unsuccessfully attempted to keep up with Neocomian sea level rise. However unlike the Sable-Abenaki, the BCT deltas were not contemporaneous with the shallow-water platform but are in part the age of the overlying marly and sponge-rich argillaceous limestones similar to the Artimon Member. A graphic geometric model for the distal deep-water setting of sponge mound reefs arises from the relationship of the BCT sponge-bearing marls and shales capping the margin shallow-water carbonates and pinnacles as a mounded "mesa" seismic facies at the toe of prodeltaic clinoforms.

During the early phase (basal Kimmeridgian) of platform deposition there was a major linear progradation of the margin attributed to basin-filling siliciclastics (Meyer 1989). However the clinoforms below the BCT platform were never penetrated and they could well be mainly carbonates with minor siliciclastics which would be more expected by their linearity as compared to the point source deposition of siliciclastics (pers. comm. Paul Post 2005 based also on carbonate velocities used in seismic processing). The termination of the shallow-water carbonates is Berriasian in age (Ringer, in Meyer 1989 and in Eliuk and Prather 2005), about age equivalent to Weston et al.'s (2012) Near Base Cretaceous Unconformity (NBCU) at or above most Nova Scotian Abenaki sections. This makes the NBCU of greater than just regional significance. In both areas the exposure is followed by drowning of the carbonates. However younger carbonates off southwest Nova Scotia such as at Mohawk B-93, Bonnet P-23, Albatross B-13 and arguably Acadia K-62 (Eliuk 1978, Jansa 1993, MacLean and Wade 1993, Weston et al. 2012) and of course the continued carbonates of Florida-Bahamas show renewed and continued shallow carbonate deposition has occurred. In some ways the Baltimore Canyon relationship of the carbonates and deltas is less like the Abenaki-Sable and more analogous to the South American Amazon example with an abrupt termination discussed below, but orders of magnitude smaller. A

schematic block diagram shows the depositional setting for the Baltimore Canyon area from a comparative shale hydrocarbon reservoir study (Eoff 2013, **Figure A2.9A**, her Fig. 4).

In the introduction, a comparison was made with the Sable Delta and the Mississippi Delta with attention drawn to the fact that they are not contemporaries (Figure 2.1). The Mississippi drainage system is much younger and, as shown by the schematic stratigraphic charts, lacks any carbonate for the Cenozoic deltas just as is proper for any well-behaved major delta. But as shown for the mid Mesozoic and along the United States eastern seaboard of the gigaplatform, those deltas present were of generally small size confined to the inboard shoreline with carbonate on the outer banks of the broad shelves. Two examples in a volume about the Late Jurassic Haynesville gas shale and similar types of sediments are instructive in showing more closely this style of sedimentation (Eoff 2013, Cicero and Steinhoff 2013) for comparison to the much larger Sable Delta and the laterally adjacent Abenaki platform. Figure A2.9 from Eoff (2013, Fig.4) compares the setting and source rock potential of two Late Jurassic basins - Baltimore Canyon Trough (BCT) and the Gulf of Mexico Haynesville shale (GOMH) areas. Attention is drawn to the small size and nearshore location of the deltas with outboard carbonates. However the BCT is a more open shelf as compared to the GOMH and rapid carbonate and clastic sedimentation would further dilute potential organic material. In contrast, the GOMH had shelf edge highs of both basement and salt-origin that were capped by carbonates. These bathymetric barriers resulted in a restricted basin of low sedimentation rate that contained shales with multiple sources of organic nutrients. The result was a lack of source rock in the BCT but a self-sourced shale reservoir in the GOMH. Cicero and Steinhoff (2013) presented a more detailed picture of the Haynesville sedimentation with a series of maps going from dominantly carbonate to mainly shale deposition. The gross depositional environment map of Lower Haynesville as Figure A2.10 (Fig. 10 of Cicero and Steinhoff 2013) is a more detailed look at the Late Jurassic setting. As shown by the deposition shelf break more than 50 miles from the continental shelf break, the broad shelf had mixed lithologies resulting from complex bathymetry that fostered restricted-water areas conducive to source rock generation. A significant observation is that the small 'ancestral Mississippi River' outflow, which does not get beyond the continental shelf edge even in the shalier upper Haynesville, is separated from the carbonate areas by a bathymetric deep containing shales and aided by paleohighs such as the La Salle Arch. Only along the interpreted shoreline is there direct contact of sand-carbonate. The presence of evaporites in the nearshore behind the carbonate shelf may be indicative of why that delta was small.

Before leaving this Section which attempted to find modern or at least Neogene analogues with limited success, it is surprising and intriguing to learn very recently that the mouth of the largest river in the world – the Amazon – is underlain by a carbonate platform which may be the thickest Paleogene carbonate deposit in the world (see Figure A2.11A). And even more surprizing is the presence of a long narrow reef tract at the modern shelf edge (Moura et al. 2016). That reef tract is not a platform nor coral and the Amazon is not a delta but rather an estuarine system with a huge river plume (Figure A2.12). Before looking at the modern reef tract which gives interesting insights and analogues for the Abenaki sponge reefs relative to the Sable Delta, the relationship of the Paleogene carbonate platform and paleo-Amazon will be considered. Carozzi (1981) considered the Amapa Formation to be "the largest coralgal-foraminiferal platform of the geological record" with a composite thickness of over 4km. Being under the mouth of the world's largest river it appears to make the Abenaki less unique, even second rate. But is it a potential Abenaki analogue or could we be trying to solve our problem with someone else's unsolved problem?

The Amapa carbonates are dominated by large foraminifera and nodular red coralline algae with corals a minor component and oolite absent (the foram shoals might be considered a sedimentological onlite analogue). But more importantly, it was not really explained how the Amazon-Amapa mixed siliciclastic-carbonate relationship managed to occur since the siliciclastics were said to be confined for all the Paleogene to a restricted lagoon with the carbonates offshore. Given the modern size of the Amazon that seemed a bit of a stretch but the abrupt termination of the carbonates in the early Neogene (middle Miocene) pointed to another component in the puzzle. Subsequent studies on the Amazon drainage pattern (Latrubesse et al. 2010) and on the onset of the Amazon deep sea fan (Figueiredo et al. 2009) showed that in fact the Amazon for its early history was confined to interior drainage only. The present continental scale drainage into the Atlantic only starts in mid Miocene (see Figure A2.11B), which is the time of the abrupt termination of carbonates. At best the Amapa platform and the Amazon River are a grand-scale single-event reciprocal sedimentation. There is nothing contemporaneous between the major delta and the thick platform. It is a only a good example of nearshore-offshore mixing with a much smaller 'Amazon' of low sediment supply analogous in part to the modern Great Barrier Reef system (Francis et al. 2007). An interesting aside is that Carozzi (1981) showed reservoir development in the Amapa carbonates subdivided by age. Porosity was consistently poorer in the axis of the thickest sediment pile, perhaps indicating differential deep burial porosity occlusion due to the delta.

Moura et al. (2016) recently described an extensive reef tract at the edge of the wide (100-300 km) Brazil continental shelf in front of the mouth of the Amazon River as shown by Figure **A2.12** (modified from their Fig. 1). The modern Amazon River is not now a delta but is estuarine and generates a huge river plume of turbid water that is carried northwest generating a very large mud flat-chenier system continuing to the Orinoco River (Ginsburg 2005) and supplying sediment to a large deep sea fan. Speculatively the load of that fan may be aiding the depression of the northern sector's dead and eroding reefs. The strong North Brazil Current is said to be keeping the shelf edge relatively free of sediment and so preventing burial of the reef tract. However the reef tract is greatly under the influence of the river plume turbidity with that influence decreasing to the south. The added notes on Figure A2.12 emphasize the changes noted by Moura et al. (2016) in what they term 'marginal' reefs because they are not due to corals but rather red algae as crusts and mainly rhodolith beds. There are large amounts and great varieties of sponges which do not contribute carbonate sediment but populate both hard and soft surfaces. Other heterozoans are also present particularly bryozoans with barnacles and molluses. Corals do increase in the southern sector where turbidity and depth decreases but never become plentiful or diverse. Eventually on the extreme southeast the furthest north shallow-water and emergent coral reefs occur. Although the reef tract is not a platform and the Amazon is not a delta, the relationship of sponges and deepwater red algae to the increasing coral and even shallow-water coral reefs as turbidity decreases is the same pattern seen at the top of the Abenaki platform away from the Sable Delta. Unlike in the modern, the Late Jurassic seas had sponges that produced carbonate sediment prolifically.

Analogues help us imagine what some less known phenomena or setting might be like by comparison to a better known one. Many geological phenomena can be considered fractal in nature (Schlager 2004, 2005). Perhaps one final analogue – a fractal analogue - may help see into the mid Mesozoic off Nova Scotia (Eliuk and Wach 2010b). Clearly no argument for deltas-by-platforms is meant here but rather an intriguing similarity of terrigenous clastic-to-carbonate patterns. The situation off Nova Scotia in earliest Cretaceous (early Neocomian – Berriasian) and latest Jurassic can be seen as a smaller mimic of the present-day whole eastern North American continental shelf-slope. It could be considered as a fractal in space-time on a 1:10 scale (300km vs 3000km; 15MY vs 150MY). As shown in Figure A2.13, from north to south it goes from siliciclastics to carbonates. Off Nova Scotia the Sable Delta buries the carbonates but well to the south they continue growing similar to the Florida-Bahama modern carbonates replacing the siliciclastics of most of the North American continental shelf. Near the end of shallow-water carbonate sedimentation off Nova Scotia, there is an intervening area of diachronous deeper-water sponge-rich beds and condensed sediment with coated ironstones ("Fe-oolites"). This is analogous

to the likely greater depths of the 800m deep Blake Plateau off Georgia, USA with thin deepwater ooze-chalks (occasional *Lophelia* reefs, George 2004) and condensed sediments with phosphorite and manganese concretions (Mannheim et al. 1980, Sheridan and Enos, 1979). Possibly the north-flowing Gulf Stream that winnows and erodes the Blake Escarpment and Plateau had an early equivalent in the latest Jurassic that aided growth of the Abenaki platform by keeping Sable paleodelta clays-nutrients off the carbonates. This suspect current may also explain the margin profile of a distally-steepened ramp seaward of Oneida O-25 as well as O-25's abrupt Late Jurassic termination of Abenaki Formation limestone with a red coated ironstone ('iron oolite') cap.

A2.6 Two Simple Models for Testing – Delta-Lobe Switching and Delta-Loading Effects; And How Recent Salt Deformation Modelling Helps to Imagine Timing and Style that Potentially Influence the Abenaki-Sable

As outlined by Tipper (2003/2008), scientific modelling has the twin goals of understanding and prediction. A scientist makes a model to express a particular set of ideas that then can be worked with. That model may be physical, numerical, graphical, verbal or even visual. Tipper suggested two reasons for modelling, "Either it may be hoped that experimentation with the model will help in understanding the structure and function of the parent system, or it may be believed that the model can predict how that system will behave under specified input conditions." Ideally Tipper felt a good model will 'talk back' as it is tested, becoming closer and closer to being logically identical to its parent system. What is offered here is mostly "a start" to see if it helps us understand aspects of the Sable-Abenaki association.

Two simple models are outlined here, followed by a brief look at a more detailed recent numerical salt tectonic model study of the three primary large-scale structural regional styles, then local more complex variations. Some implications relevant to the Abenaki-Sable association are also included. Though very different; the two simple models can, and even may, be linked. The first is my adaptation of the **delta lobe switch transgressive-regressive model** (Blum and Roberts 2012 after Penland et al. 1988) of a repeating cycle of delta abandonment and reoccupation developed for the Mississippi Delta with a capping carbonate component added. Perhaps it does not quite qualify as a testable model. But at least it can be compared to the Abenaki-Sable situation where carbonates are found as a component of the prograding delta complex to see if it increases our understanding. The second is an earlier idea that was proposed to explain deltaic geometries and as a means of making bathymetric troughs around depositional loads of major deltas – the **delta load pendulum effect model** by Dailly (1975, 1976). Numerical

modelling tended to be 2D in the dip or shore-to-basin direction at the time, and even yet. Now however, a further examination could be done in 3D with new programs (pers. comm. Chris Beaumont and Sofie Gradmann; see Watts et al. 2009 Amazon study for an example). However Dailly's model can still be speculatively applied to the Sable-Abenaki to account for a deeper water separation of the two systems that might have existed as interpreted from seismic and other data reviewed in Chapter 4. The presence of horst and grabens of various dimensions (see Sections A1.03 and A1.10) might make loading effects locally variable as would the presence of thick salt. Furthermore, the bathymetric trough between delta and carbonate platform might have potential to migrate with delta growth. As well, prodeltaic-shale loading of the oceanic-scale deeper slope in front of the shelf could depress the outer shelf itself. Such a situation might cause progressive "drowning" of the carbonate platform already compromised by turbid and nutrientrich water resulting in condensed sedimentation in deeper water. Compensatory peripheral bulges might generate inner shelf highs and erosion. The two ideas or models can be linked by the delta load pendulum model being the origin of a depression followed by a delta lobe switching and local transgression. Distally the delta depocenter load creates a deep on its flank attracting a fluvial channel change that abandons the delta lobe. This mechanism is opposed to the usual avulsion concept of building river levees so high above overbank deltaic plains that they are breached and fluvial switching occurs proximally by a change in the upstream main river channel location.

The delta lobe switch T-R model of a full cycle (Figure A2.14, Blum and Roberts 2012 after Penland et al. 1988) shows an active delta abandoned and undergoing transgression due to lack of continued sediment supply, thus becoming a headland barrier system with interdistributary bays-cum-lagoons. This is followed by submergence and isolation of the barrier system with shoreline retreat. Finally there remains an offshore sand shoal. Before reoccupation of the area by a new delta lobe, my addition would have the offshore sand shoals evolve into sites of carbonate production, especially onlite since on former barrier and offshore bars there was likely higher wave energy. Given highly-carbonate-saturated warm seawaters, part of the transgressive trend would thus be the development of an ooid shoal followed by associated carbonate facies like backshoal peloid muds with shell accumulations, shoal-front reefs and distal-slope microbial deposits. Note that this scheme does not require eustatic sea level changes except perhaps a relative one generated by loading and sediment compaction. Neither a "transgressive sea level systems tract" for the back-stepping of siliciclastics and the creation of condensed carbonates, nor a "falling or low stand sea level systems tract" for replacement of carbonates by siliciclastics are required; just a large vigorous delta complex prone to delta lobe shifts. See the following model for the possible

mechanism the load from such a large delta might generate. This could also be the mechanism happening enough in the Cenozoic as to result in "delta-top platforms," one of Bosence's (2005) eight carbonate platform types. Or the mechanism may happen just once when the paleohigh deposited by a basin-filling delta is drowned and attracts carbonate sedimentation.

Dailly's (1975, 1976) delta pendulum model (Figure A2.15) was applied to the Niger, Mackenzie and Mississippi deltas. He cited Walcott's (1972) 2D gravity and flexural modelling of sedimentary basins at a continental-edge. As shown in Figure 4.15, the creation of lateral depressions may cause the depositional axis to swing to the lateral lows from time to time in a pendulum fashion. He suggested sedimentological implications of such alternating depositional shifts might be made more asymmetrical if there were preferred current directions so that fine versus coarse material was segregated. Keen and Beaumont (1990) showed 2D dip models for the Sable Subbasin and LaHave Platform off Nova Scotia. The presence of thick salt complicates the modelling further. Both Chris Beaumont and Sofie Gradmann (pers. comm.) thought that Dailly's development of crustal depression and a 'moat' zone was feasible. Beaumont commented that at least in a dip direction in Nova Scotia the sediment supply was quickly filling any depression created and the crustal depression might be very broad. Watts (1989) argued that lithospheric flexure due to prograding sediment loads could be a source of coastal offlap/onlap and downlap aside from or in addition to eustatic or other tectonic origins commonly cited in sequence stratigraphy. Just as Dailly suggested deltaic sedimentation consequences from his model, the effect of loading by a very large delta would also have consequences for carbonate sedimentation. For instance it potentially results in thickened sections with subsidence (see Figure A1.22) and as an isolating mechanism discussed above. But focussed modelling could be done to see if too much is expected of loading. Indeed modelling could be done on whether thick carbonate platform margins themselves might not generate their own lagoons by loading.

Recent 2D modelling (Albertz et al. 2010, Albertz and Beaumont 2010) characterized the three salt tectonic structural styles in the Scotian Basin by comparison of modern long seismic lines to both geometrically simple and then geometrically complex numerical models. Figure A2.16 shows the area and subdivisions of their study. All 2D sections showed significant flexure of the crust with increasing load. Since the shelf has three salt structural styles from north to south, a comparison of the depth to which the crust was depressed shows much greater depression in the middle under the Sable Delta. The regional change in north-to-south structural styles of Banquereau-Sable-LaHave areas was best modelled by a two stage sedimentation pattern. First Jurassic deltaic progradation occurred on the north and aggradation in the two southern areas then

Cretaceous progradation in the middle with continued aggradation in the south. No one has tried to model a line along strike but this most recent study, not surprising in being much more complex, showed significant almost syndepositional structural movement early including during the Late Jurassic (aided by using a J2 marker equivalent to Scatarie in their models). Their modelling accounts for the absence of salt structures southeast of the Banquereau Bank (SSA, SP IV, 3) by early salt flowage in a seaward direction moving over oceanic crust (with dissolution?). In contrast, the apparent absence of salt there had persuaded John Harper (CSPG talk November 2007 and pers. comm. 2008, 2016) that the Banquereau carbonates were on a foundered "African" basement rift block left behind when Morocco was separated from Nova Scotia. That foundered high was seen on proprietary seismic lines deeper in the section. He interpreted that the updip evaporites in the Abenaki sub-basin between the Sable and Orpheus sub-basins were the original intercontinental rift deposits rather than locating them east of the Banquereau Bank which was thought of as a later detachment from the African crust.

More relevant to the problem of the Abenaki-Sable association is the detailed modelling of Albertz and Beaumont (2010) that replicates some of the patterns seen in salt structures between the Abenaki and Sable sub-basin caused by the complicated basement structure (see Figure. A1.25). Their demonstration of early timing of salt structures means that paleohighs and barriers could be produced for Abenaki-age carbonate deposition and siliciclastic isolation. Of possible significance and demonstrating the Late Jurassic progradation is the movement of the reflective carbonates from the Middle Jurassic age Scatarie seaward edge to the top Jurassic Abenaki or MicMac carbonate shelf edge 30 or so kilometres seaward along a 200 km front as shown by seismic mapping (Wade and MacLean 1990, Fig. 5.25 and 5.28). Is it possible that the mixed carbonate-siliciclastic layering did not allow vertical salt tectonics and assisted the basinward movement then perhaps dissolution of salt to result in the unusual lack of salt piercement seaward of the SSA/SPIV/(3) sector of Figure A2.16 (Fig. 1 of Albertz et al. 2010).

A2.7 The Carbonate Side of the Equation of Reefs and Oolites versus Deltas

While considering what example or situation in the modern or near-modern world might help us understand how a thick carbonate platform and big delta co-existed closely for so long, we might pause to consider that maybe something affected carbonates themselves to make this possible. Was the Late Jurassic-earliest Cretaceous a time of greatly increased effectiveness in depositing calcium carbonate and creating reefs and platforms? The high number (Kiessling 2002) and much greater variety of reef types in the Late Jurassic as compared to the modern (Leinfelder

2001, Leinfelder et al 2002) as well as a great number of Phanerozoic oolite occurrences (Wilkinson et al. 1985) suggests the possibility is worth checking. This is shown on **Figure A2.17** – a comparison of Phanerozoic oolites and reefs along with relative sea levels based on older then newer data. The idea is not new that over geologic time there are global changes in climate, temperature and atmospheric-oceanographic chemistry, and not just by plate tectonic rearrangements. The fact that carbonates are sensitive indicators of those changes – indeed the main measurement – is also well known, whether directly precipitated or created by evolving organisms responding to these changes. Major reef types also appeared to alternate in abundance through time – 'true' or framebuilder reefs, skeletal reef mounds and mud mounds (James1984, James and Bourque 1992, see **Figure A2.17A - Bioherms**). Kiessling (2002) analyzed secular variations in the Phanerozoic reef ecosystems at a supersequence scale making the following observations. He concluded that large scale, reef attributes, and earth system parameters were not strongly correlated for reef abundance and diversity. But four largely independent factors were found to control much of reef development: evolution/recruitment of macrofauna (intrinsic), carbonate productivity/continental freeboard, nutrient level, and climate.

In the Late Jurassic the abundant presence of calcified sponges, both siliceous (lithistid) and coralline (stromatoporoid, chaetetid, rare sphinctozoan), and microsolenid corals - extinct or essentially absent as calcareous forms in the modern ocean- is one very great difference that indicates greater carbonate productivity potential (see Figure A2.17B - % reef builder plot). In fact Late Jurassic reefs are similar to Triassic and Paleozoic reefs in the high component of coralline sponges as opposed to their near absence after the earliest Cretaceous. Curiously like the Late Cretaceous, the Early Jurassic is low in coralline sponges but high in reefal bivalves. Some of these Late Jurassic sponges and corals, especially microsolenids (Insalaco 1996, Dupraz and Strasser 2002, Gill et al. 2004), were likely not as turbidity-and-nutrient averse as modern oligotrophic hermatypic corals and the stromatoporoids could exist in very warm waters (Leinfelder 1994, 2001, Leinfelder et al. 2005). This may be a significant factor in their productivity and ability to reside near siliciclastics. Carbonate production potential might also be assessed by the number and variety of carbonate morphologies and factories active at a given time and in a given area. Contemporaneous ramp and rimmed-to-open platform morphologies co-existed along with the Sable Delta.

If the subdivision of three Schlager's principal Phanerozoic carbonate factories (2003, 2005; see Figure A2.18X and Y) keyed mainly to depth and temperature is accepted, then all three would seem to be active in the greater Abenaki-Sable area. The 'M' factory (mud mound,

micrite-rich, mainly biotically-induced precipitation, mainly ?deeper water e.g. automicrite/thrombolitic/microbial 'mudstone', sponges) has widespread occurrence on the carbonate slope. The 'T' factory (tropical, topmost water, mainly autotrophic biotically-controlled precipitates e.g. corals, stromatoporoids, red and green algae) occurs near the shelf-edge with reefal-skeletal oolitic and abiotic deposits. The 'C' factory (cool-water, heterotrophic, biotically-controlled precipitates e.g. bryoderm/bryomol – bryozoans, echinoderms, mollusks) arguably applies to the lithistid-sponge-reef-mound-rich argillaceous carbonates in the uppermost Abenaki or in MicMac-Missisauga formations southwest of the Sable prodelta. The argument is that the sponge-rich beds have heterotrophic biota and are in somewhat deeper and certainly more turbid and likely nutrient-rich waters. They do not fit the 'T' nor 'M' factory classification. But given their setting probably they are not cool-water except perhaps due to greater depth.

Westphal et al. (2010) discussed this kind of problem, particularly in the potential for misinterpreting paleoclimates, when reviewing heterozoan carbonates in subtropical to tropical settings in the past and present. Like Westphal et al. (2010), Pomar and Hallock (2008) pointed out the oversimplification danger of just using temperature and depth parameters particularly when trying to assess the effect on the long-term oscillations of climate and ocean-atmosphere system on carbonate mineralogy. They presented an alternative set of carbonate factories (Figure **A2.16B**) for the Permian to Neogene with possible controls and complementary variables shown in a summary depiction that is included as Figure A2.18A-F. Whereas Schlager's (2005) factories were mainly depth and temperature controlled and had no secular Phanerozoic changes over time inferred, Pomar and Hallock (2008) considered additional geobiological variables including the effect of pelagic carbonate development and did show a progressive change in dominance for their three main factories. However when their factory changes over time are compared to Keissling's (2002, see Figure A2.17B) quantitative data, particularly for the Late Jurassic, they do not seem to be supported by the data on reef builders. Like the Abenaki itself all three of both Schlager's and Pomar and Hallock's carbonate factories are well developed with the 'T' and 'skeletal' most dominant. However the Abenaki as a whole, sometimes including significant sections near the margin, is carbonate mud prone but with many allochems and reefal framebuilders. Neither workers argued specifically for secular changes in carbonate productivity whether aragonitic or calcitic, but Riding and Liang did (2005, see Figure A2.19) as discussed below.

Although Phanerozoic reef crises have attracted study, particularly those associated with major extinction events as linked to earth system parameters such as climate and pCO₂-ocean acidification (Flugel and Kiessling 2002, Kiessling and Simpson 2011), the opposite, namely "reef

prosperity periods" when carbonates might better cope with siliciclastics is what we want to find and understand. Carbonate saturation and mineralogy are also known to have fluctuated over time (Sandberg 1983, Wilkinson et al 1985, Stanley and Hardie 1998, 1999, Pomar and Hallock 2008). What controlled these fluctuations is controversial. Even so, they resulted in variable seawater saturation and calcite-versus-aragonitic seas. These in turn influenced carbonate precipitation, especially abiotic and biotically-induced types. Carbonate saturation and mineralogy of ambient seawater may even have determined the initial mineralogy on the first occurrence of groups that biotically control their mineralogy, sometimes even in under-saturated waters (for instance, see Stanley and Hardie 1998, 1999; on microbes/biofilms -Webb 1996, Arp et al. 2001, Riding 2000 and Riding and Liang 2005a and b, Wright and Oren 2003; on aragonitic biota - Zhuralev and Wood 2010; on Cambrian start-up fauna - Porter 2007; on 'a mid-Mesozoic revolution' and nannofossils - Pomar and Hallock 2008, Ridgwell 2005). However, Schlager (2005) cautioned that "the science of long oscillations in Phanerozoic climate, sea level and carbonate chemistry show that, at present, the situation is heaven for a scientist writing proposals for funding and hell for a book author trying to extract the eternal truth of the matter." An example of modelling of carbonate seawater chemistry (Riding and Liang 2005) as compared to oolite occurrences is shown in Figure A2.19. Arguments are presented for a correlation and even control of carbonate production related to high calcite concentrations through the Phanerozoic even on bioticallycontrolled organisms as well as microbial or 'biotically-induced' organisms and non-skeletal precipitates. Since warmer waters are more easily carbonate over-saturated, it would have been interesting to know what effect modelling varying temperature would have had. Observe that the most plentiful ooids (Figure A2.19) do not occur at the highest carbonate saturations in the Mesozoic but rather during the transition intervals between high and low carbonate saturation. A two page future research note by Kiessling (2015) on 'Fuzzy seas' emphasized the likely importance of temperature and that calcite seas may in fact not be so exclusively calcitic. This is shown by the continued presence of aragonitic hexacorals. Physiology even in 'simple' organisms may overcome external seawater chemistry as obviously seen with shells in cold water.

Some of these global patterns, even with some of the contradictions, appear to show that the Late Jurassic was a particularly 'good' time for carbonates to compete with and survive near siliciclastics. Ignoring Schlager's warning, Mobil (now ExxonMobil) geologists claimed to have extracted that 'truth' and compiled charts of Phanerozoic carbonate trends (sea level, tectonics, climate, oolite data, dolomite, isotope-oceanographic, reef-organism, carbonate platform characteristics, biotic events) to develop themes for evaluation, comparison and prediction of carbonate reservoirs in their **Carbonate Analogs Through Time (CATT) hypothesis** (Markello

et al. 2008 admitting it is in part non-quantitative first approximations in a continuing work and citing their sources). Their CATT hypothesis states that "high-confidence, age-specific predictive models for carbonate systems and for reservoir occurrence, composition, stratal attributes, and reservoir properties can be developed by summing the ambient conditions of the carbonate processes and Earth process at any geologic age."

Those ambient conditions were presented by their 'equation': geologic age plus carbonate processes (biotic evolution, mineralogy) plus earth processes (tectonics, climate, eustacy, ocean circulation and chemistry) equal age-sensitive patterns or themes (occurrence and location, reef vs grainstones vs mudstones, platform types/profiles, stratal architecture, diagenetic potential). The two main deliverables of their project were Phanerozoic Carbonate Trends Chart and Global Atlas of Carbonate Fields (8325 fields) on paleogeographic maps (29 maps) of approximately "second order" time slices. Although Deep Panuke is not in their list of fields, one can go to their maps and chart and see what is predicted. Their Late Jurassic-earliest Cretaceous world geographic reconstruction and paleo-oceanographic interpretation for temperature and currents is shown in Figure A2.20. The Atlantic Ocean (Sea) is shown as small, warm and partly barred from the Gulf of Mexico (GOM) by a large isolated Cuba-Florida-Bahaman bank. As an example of the use of CATT, Markello et al. (2008, their Table 4) did a comparative analysis for two Late Jurassic reservoirs - the Arab and the Smackover formations. Using mainly their set of global maps as a data source and my own input in italics, Abenaki (Deep Panuke) was added to make **Table A2.3.** Others have made similar oceanographic maps and shared some of their data (Jim Harris of "Robertson-A CGG Co.", pers. comm.) GOM had seasonal rainfall and similarly large seasonal run-off with about an 8 month dry period but Nova Scotia (Abenaki-Sable) was less seasonal and the Atlantic sea surface salinity was elevated at 38°/00 (as compared to modern ocean water of 35°/oo or the shallow foreland Persian/Arabian Gulf of 37-40.5°/oo or the Great Bahama Bank of 36-46°/oo and summer temperature of ~28.5°C). A large delta and freshwater input is inferred as well from the juncture of Africa-South America. Some points follow that were added and do not seem to be compatible with Markello et al.'s (2008) characterization. The presence of significant Hith evaporites above the Arab carbonates and even within the Arab to subdivide and act as seals, indicates an arid setting. As well the setting might be considered epicratonic or epeiric, or at least a wide intrashelf basin which is more compatible with the sedimentation style (Murris 1980). Finally, though not a complaint about the intention of the hypothesis, deep burial or hydrothermal dolomitization as reservoir destroyers or producers can be the critical difference between reservoirs.

The power of a grand synthesizing concept such as CATT is 'organization,' to allow more appropriate and nuanced comparative sedimentology and reservoir characterization. Organization as seen in companies, armies and political parties is indeed powerful for good or bad, truth or falsehood. Like the Vail-Exxonian eustatic sea level charts that are part of CATT, this ambitious concept will attract both criticism and improper use. Sometimes both occur at the same time, as just shown in the above commentary on the Late Jurassic examples. But, like the picture on a jigsaw puzzle box, there is a vision of a final product to strive for even if all the pieces do not yet fit together...and maybe never will. In the following we will look at some pieces in that puzzle relevant to the Abenaki-Sable problem.

Whatever would favour high carbonate production should help carbonates 'compete' with siliciclastics. Most carbonate is created by calcareous organisms with the remainder from inorganic processes including organisms dependent on ambient carbonate saturation such as 'lower' metazoans (e.g. sponges) and bacteria. Despite the ExxonMobil CATT proposal and as already alluded to by Schlager's (2005) comment on 'eternal truth,' there is a lack of consensus on the degree and nature of climatic and oceanographic controls on carbonates over geologic time. If there is not yet consensus on controls then interpretation based on such parameters is not likely to be convincing. Simply using one feature – relative sea level - Figure A2.17 A versus B (also see comments in the figure caption) shows such a problem when sea level is compared to reef and oolite abundance. The histogram for oolites has not changed, but both data and definition for reefs have changed and is quantitative with types of reef builders recorded. The sea level curve is much more detailed with three high peaks in the Paleozoic instead of just one broad one. For the Paleozoic the oolite seem best developed during high sea levels along with the microbial reef mounds. Similarly the Paleozoic coral-stromatoporoid 'true' reefs have the two greatest abundance peaks in Silurian-Devonian and they occur during slightly lower phases in a long relatively high sea level period. In contrast the highest sea level in the Late Cretaceous is a bad time for reef and corals but a good time for rudistid bivalves. The older proposal (Eliuk 1986) is qualitative with reefs and mounds separated. A hint at quantities is shown by the depiction of the Devonian reefal maximum. As another changing factor, the climatically-based terms "icehouse/greenhouse" can be questioned when Early Jurassic-Toarcian (Korte and Hesselbo 2011, Silva 2014) and middle Jurassic-Callovian glacial or icehouse events (Dromart et al. 2003b) are postulated during a Greenhouse time. But at least those Jurassic events may explain the generally lower sea levels and local downward excursions as well as contemporaneous periods with ice-rafted debris globally (Veizer et al. 2000) during the start of a major sea level rise and change-over greenhouse period with calcitic sea-water. As well the mid-Jurassic is also the time of the coldest temperatures interpreted for the Mesozoic (Parrish and Soreghan 2013).

As just discussed, that figure A2.17 B may be useful in itself for comparison of some of the changes in carbonate components and mineralogy during the Phanerozoic, even if they or their proposed controls are contradictory. The Late Jurassic has a pattern indicating higher than average carbonate competency. The common presence of oolite nearby or with the modern marine occurrences of subtidal stromatolites (microbialites) at Shark Bay and on the Bahama Banks encourages the expectation that they may be quantitatively linked. And although we are looking for global patterns, similar to the saying "all politics is local" maybe "all geology is local" too. For instance, the Late Jurassic Smackover Formation of the northern Gulf of Mexico has aragonitic, calcitic and moldic ooids (Heydari and Moore 1994) due to greater salinities landward (aragonite) and lower salinities (calcite) seaward in keeping with the time of worldwide calcitic seas and greenhouse mode. The record of changing sea-water composition and ooid abundance for the Phanerozoic may help explain the anomalous high occurrence and presence of ooids even on siliciclastic shelves (Figure A2.17). There appear to be four major peaks in Phanerozoic oolite abundance and only the Late Jurassic-earliest Cretaceous peak seems to be mainly calcitic ooids, not aragonitic-high-Mg calcite ooids (Wilkinson et al. 1985). In the Late Jurassic both calcitic oolites and aragonitic coral reefs are in very great abundance as well as microbial-thromboliticautomicrite mounds.

This Section on speculative carbonate geochemistry and effects of secular changes in seawater types will end with one last open-ended thought that brings us back to carbonates by rivers. Rivers are prone to bicarbonate ions particularly if draining a carbonate terrain. For instance Canada's largest river by volume, the St. Lawrence carries hardly any suspended sediment but does carry 62M tonnes per year of dissolved solids (chemical analysis at Levis Quebec: anions in ppm/part-per-million = HCO₃ 84, SO₄ 20, NO₃ 0.4, cations in ppm = Ca 28, Mg 5.8, Na 8.0 (tidal effect?), K 1.1, Fe 0.02, SiO₂ 1.7). Modern coastal Belize with its offshore barrier reefs is a reasonable but not perfect modern analogue for the Abenaki. It lacks oolites although having a delta, muddy carbonate shelf and reefs. Actually, it nearly lacks oolite. For at the mouth of the Rio Hondo forming the border between Belize and Mexico (Quintana Roo) there are oolites. A tabular body of ooids occurs at that location in the shallow, variably-saline Chetamul Bay (pers. comm. Burr Silver and originally informed by John Harper as learned on one of Silver's carbonate field trips). Quintana Roo and Yucatan are composed of thick karstic carbonates with carbonate-saturated ground water (Perry et al 2009). Similar water (no analyses or

study known) is being delivered to the Belize nearshore shelf warm waters to form the oolite. In the mid Mesozoic the St. Lawrence and rivers draining its north shore would have been draining a large carbonate terrain as indicated by bedrock of the Quebec Lowlands and by outliers of Ordovician carbonates at Lac St. Jean and in the deep collapse breccias of a Triassic (240My) meteorite impact crater that is now flooded by the Manicouagan reservoir visible from space. Could those waters have once been carbonate-enriched and fed the Late Jurassic Sable Delta as figured previously to give yet another source for carbonates by a delta? See **Table A2.4** for a ranking of the world's largest coastal rivers and they don't always end in deltas.

A2.8 What Has Been Learned and What Can Be Applied?

To summarize, very large deltas in close juxtaposition to major thick carbonate platforms particularly if attached as a shelf to a land mass are a rarity, perhaps an extreme rarity, in both the modern and geologic record.

The possible **general principles or controls** on a mixed carbonate-siliciclastic system include: 1. reciprocal sedimentation

- 2. slow sedimentation with vigorous/adaptable calcareous organisms
- 3. ocean currents of appropriate strength and direction, and perhaps most significant
- 4. isolation and separation.

If scaling up is fractally reasonable; then perhaps these can also be applied to very thick carbonate platforms beside very large deltas. It could be argued that the carbonate platform and delta are not mixed systems but just close neighbours. However even the close juxtaposition of two such large systems is anomalous and rare, possibly unique. And places where there is interbedding on various scales shows that portions of the two systems do form a true mixed carbonate-siliciclastic system. From a study of the South Florida Neogene mixed carbonate-siliciclastics McNeill et al. (2004) listed themes and associated potential problems that must be considered no matter the scale including antecedent topographic templates, cryptic sequence boundaries, even cryptic petrophysical-geophysical characteristics and unconformities/hiatuses mistaken for siliciclastic 'smothering' of carbonates.

Analogues. Minor carbonate accumulations in dominantly siliciclastic settings are quite common e.g. small coral reefs or *Halimeda* banks in deltaic shelves e.g. Mahakam Delta of Borneo (Roberts and Sydow 1997, Wilson 2005, Wilson and Lokier 2002, Saller et al. 2010) and e.g. Gulf of Papua (Woolfe and Larcombe 1998) or nearshore paralic sandstones/shales or deeper

basinal/slope shales to marls in a dominantly carbonate province e.g. Australian Great Barrier Reef (Francis et al. 2007, Woolfe and Larcombe 1999). Recently however, the world's longest modern reef tract, the Australian Great Barrier Reef, has been the subject of a series of publications on its interaction during the Holocene-Cenozoic with major rivers of Papua-New Guinea in the Gulf of Papua (Tcherepanov et al. 2008a, b, 2010) that is complemented by a study on the controls over time of the carbonates in that part of the world (Davies et al. 1989). Both in the subsurface as gas-bearing atolls/pinnacle reefs and more distally from the base of the prodeltaic clinothems, fair sized coral reef complexes grow in front of the Fly River Delta. But these are not large platforms such as apparently occurred in the Miocene on the east side of the delta. The Late Jurassic gigaplatform (Poag 1991) along the North American Atlantic edge is the world's longest fossil reef tract (Keissling 2001, his Table 1), and it too has a major river input at its northeastern corner in the form of the Sable Island paleodelta as opposed to smaller groups of inshore deltas as in Baltimore Canyon Trough (Poag et al. 1990, also see Figure 2.1 and 1.2) or in the Gulf of Mexico (Eoff 2013, Cicero and Steinhoff 2013). As anticipated by Tcherepanov (2010), the Gulf of Papua (Great Barrier Reef) Holocene-Cenozoic mixed system provides an analogue for other ages and parts of the world. The Baltimore Canyon Trough can be used to show differences in sediments of similar ages and carbonate types but which have small shelf margin deltas that post-date the carbonates (Table A2.2; Poag et al. 1990; Eliuk and Prather 2005). In their Gulf of Mexico paleogeographic maps of the Late Jurassic Haynesville shale reservoir, an intrashelf basin low and paleo-highs of various origins with or without carbonates were shown as important for isolating the paleo-Mississippi River clastics from the carbonate shelf to the west. Thus these other occurrences will allow insights from analogy on what controls and circumstances may have allowed the co-existence of the delta and carbonates off Nova Scotia.

Perhaps one of the simplest controls that may have many origins is keeping a separation by depth and distance between the siliciclastic input and the carbonate sediments as in Walker et al.'s (1983) lower Paleozoic model derived from the southern Appalachians foreland siliciclastics separated by migrating basins from the cratonic carbonate shelves. It is worth noting that Walker et al.'s (1983) Paleozoic model is very similar to the modern Arabian/Persian Gulf foreland basin with the carbonates on the Arabian craton across from the siliciclastics of the Zagros mountain ranges of Iran. The point is that isolating the carbonates from the input of siliciclastics is the best way of allowing co-existence and not terminating or diluting the carbonates by siliciclastics. Oceanic currents pushing away the clays also may help clear carbonates of siliciclastics as in the Mahakam Delta and probably the Gulf of Papua. The non-analogue non-contemporaneous example of the thickest Paleogene carbonate platform under the mouth of the world's largest river,

the Amazon, cautions us to make sure that the two systems are correlative with support by biostratigraphy giving the same ages. But the very recent descriptions of non-coral red algal reef tract at the shelf margin is a good analogue but not for platforms by deltas. The gradient of changes depending on water depth and amount of river plume turbidity with high amounts of sponges and deeper-water red algal crusts and rhodoliths is an excellent 'look-alike' for the sponge-rich beds at the top of the Abenaki.

Juxtaposition of a thick carbonate platform and large 'continental-scale' delta is a very rare situation when there is no **obvious intervening low or bathymetric separation** to keep the siliciclastics and associated nutrients from inhibiting the slower-growing carbonates. Without that, carbonate growth would be inhibited due to increased nutrients and turbidity plus reduced salinity, oxygen and illumination as well as potential fouling, hard substrate loss and burial. Reciprocal sedimentation due to alternation in sediment supply spatially or temporally results in interbedded carbonates and siliciclastics vertically – not uncommon in the geological record. This situation is seen nearer the Sable Delta with its prograding ramp style and probably on the shelf northeast of Sable Island. But to the southwest there is an abrupt and long continued separation into thick clean carbonates versus the deltaic sediments to the northeast. Near the end of Abenaki deposition there is a pattern of delta depocenter to prodeltaic shales to distal deeper water sponge reefs that buries an apparently drowned carbonate platform with starved slow seafloor diagenesis indicated by coated ironstones ('iron oolites') and questionably Neptunian dykes. Then finally when far enough away there is continued growth as a shallow water carbonate platform. Ultimately we will see that too is drowned.

Some **simple models** were proposed for both these situations. The delta abandonment model with the addition of carbonate sedimentation in a ramp style on top of the delta-created paleohighs can be applied near and to the northeast of the Sable Delta. The model would generate a shoaling sequence of deltaic-prodelta terrigenous clastics then upward to interbedded higher-energy sediments like oolitic limestone and coarse siliciclastics like quartz sandstones where there is more limited accommodation space. There may be several means of generating or inheriting bathymetric separation. One conceptual model that actually is generated by the large delta itself is Dailly's (1976) delta pendulum model involving crustal flexure due to loading. That model requires better and modern modelling which should also account for the significant effect and contribution of thick salt. The importance and variety of effects due to salt tectonics were briefly looked at. Generation of salt highs that might act as isolated pedestals for small carbonate

platforms or walls that might bar and refocus terrigenous clastic sedimentation from carbonate would be an additional control to consider.

These analogues and general models give us insight to possible controls that allowed the Abenaki and Sable to co-exist. And going back to the opening quote by Chave (1967), "Rivers, not temperature, organisms or chemistry appear to control the distribution of carbonates." There would appear to be exceptions to his generalization. Sometimes, albeit rarely, temperature (a warmer Mesozoic perhaps), organisms (heterotroph sponges, microsolenid corals and microbes in turbid waters) and chemistry (calcitic seas allowing calcification of sponges, high carbonate saturations forming ooids) can nullify the killing effect of a big delta on carbonates. Indeed, sometimes the delta can deposit prodeltaic ramps and abandoned river-mouth bars that act as paleohighs to be 'carbonate-armoured' by oolite and reef following delta-lobe shifting. Speculatively, bicarbonate rich river waters might also aid carbonate-over-saturated waters to precipitate ooids. Although not easily apparent, since the delta and platform are juxtaposed on the same shore, isolation by several mechanisms is anticipated as the key factor that allowed the co-existence of this unusual sediment association.

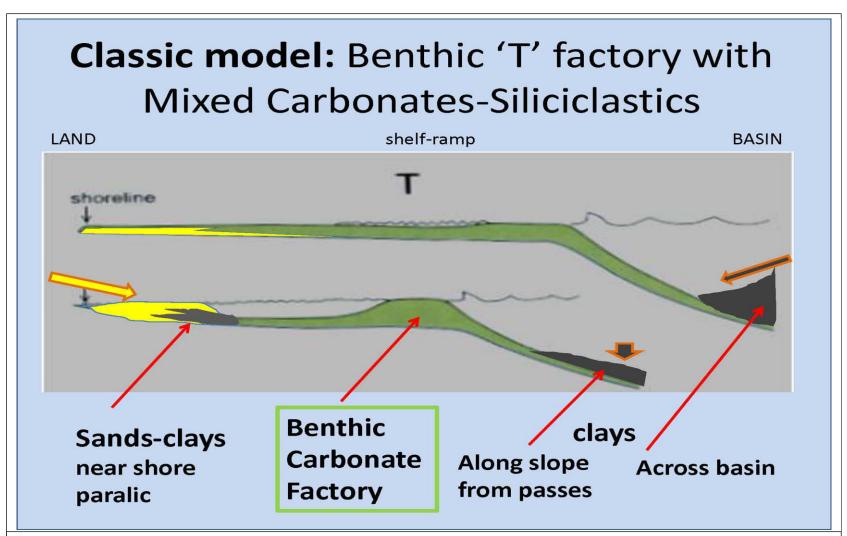


Figure A2.1 Classic or typical model for mixed carbonates-siliciclastics with clastic sources either nearshore on same-shelf (lower) versus acrossbasin (upper). For full and widespread interbedding then geographic, chronologic or climatic alternation may be required to give reciprocal sedimentation. Benthic "T" carbonate factory model modified from Schlager (2005) with addition of siliciclastic inputs. The modern Great Barrier Reef is not only the world's longest reef chain; it is also one of the best examples of the classic mixed system with nearshore siliciclastic and offshore carbonate accumulation (Well illustrated by Francis et al.'s 2007 Fig. 2 of the Great Barrier Reef showing nearshore paralic siliciclastics including small deltas and distant current-driven long-shore transport exiting through by-pass channels to deposit slope and basinal siliciclastics).

Table A2.1 Terrigenous clastic and biochemical sediment differences. N. James, A. Kendall and P. Pufahl 2010, italics = LSE modifications							
Provenance study possible	study possible "the sediments are born, not made" (quasi- in situ) Macro- & microfossils and Microbes						
TERRIGENOUS CLASTIC	Carbonate (Benthic)	Evaporite	Bioelemental				
Climate is no constraint Sediments occur worldwide	Most sediments occur in shallow marine environments Both cool and warm water but latter more prolific (reefal-oolitic)	Most sediments occur in shallow- water or mud-flat environments e.g. stromatolitic carbonate, gypsum-anhydrite, halite	Most sediments occur in middle to distal shelf environments e.g. iron deposits, phosphorites, siliceous-cherts, (coal, source rock)				
Sediments are both terrestrial and marine	Sediments are mostly marine (some lacustrine)	Sediments occur only in restricted (high salinity) terrestrial and marine environments	Sediments are mostly marine				
Grain-size reflects hydraulic energy of the environment (if grain-size available to sort)	Grain size reflects the size of skeletons and precipitated grains	Crystal size reflects nucleation and growth rate, or diagenetic alteration	Grain size reflects nucleation and growth rate within the water column or during authigenesis as well as hydraulic energy				
Mud indicates settling from suspension	Mud commonly indicates prolific growth of organisms that produce tiny crystals.	Fine carbonates/sulfates indicate rapid precipitation	Fine sediment indicates numerous nucleation sites and suspension settling				
Currents and waves form shallow-water sand bodies	Many sand bodies form by localized physicochemical or biological production of carbonate	Shallow-water sand bodies are rare	Currents and waves form shallow sand bodies by reworking and winnowing precipitated sediments				
Environmental changes are induced by widespread changes in hydraulic regime	Environmental change can be induced by localized buildup of carbonate, without change in hydraulic regime	Environmental change is induced by changes in basin dynamics	Environmental change can be induced by changes in physical oceanographic and hydraulic regime				
Sediments remain unconsolidated in the depositional environment	Sediments are commonly cemented on the seafloor	Sediments are commonly cemented or form crystal crusts in the depositional environment	Sediments can be cemented or unconsolidated on the seafloor				
Periodic exposure does not alter sediments (? may create glossifungites ichnofacies)	Periodic exposure results in intensive diagenesis	Periodic exposure results in growth of intrasediment evaporites or wholesale dissolution	Periodic exposure depends on deposit type and may or may not result in diagenesis				
Walther's Law applies to most deposits	Walther's Law applies to many, but not all, deposits	Walther's Law applies to few deposits	Walther's Law applies to most deposits				

Pelagic carbonates = chalks-oozes form deep water deposits by nano-microbiota 'rain'. GAPS in all settings likely greater than depositional record. Perhaps gaps are easier to see in biochemical deposits and arguably are a main contributing factor in evaporite and bioelemental sediments.

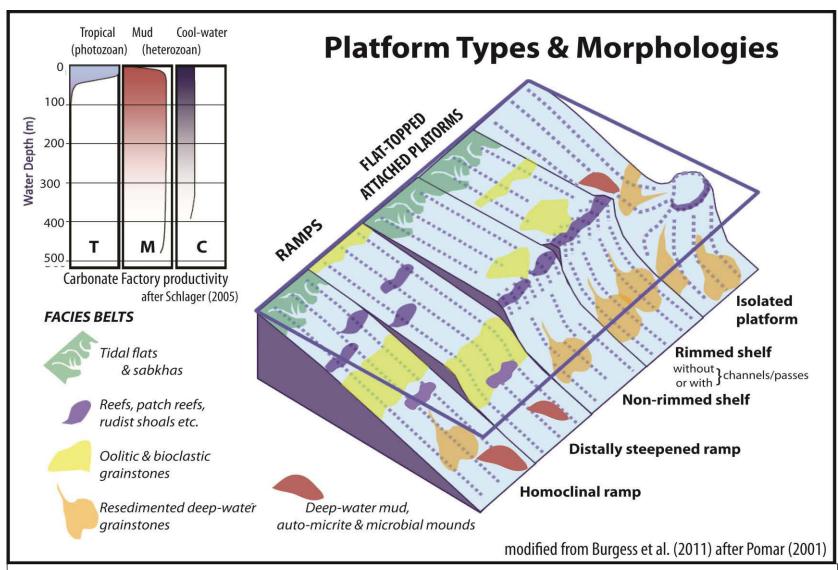


Figure A2.2 Carbonate platform types and morphologies (after Burgess 2011, also see Pomar 2011, Williams et al. 2011 for modelling of controls) show a continuum of types and profiles from ramps to rimmed flat-topped platforms. Basins with oceanic depths are less likely to show ramp profiles unless the basin is infilled at the margins as by siliciclastics. Whether carbonate or siliciclastic in origin, ramps tend to be distally steepened at continental shelf edges such as off Nova Scotia. The full range of morphologies occurs in the Abenaki or equivalent carbonates.

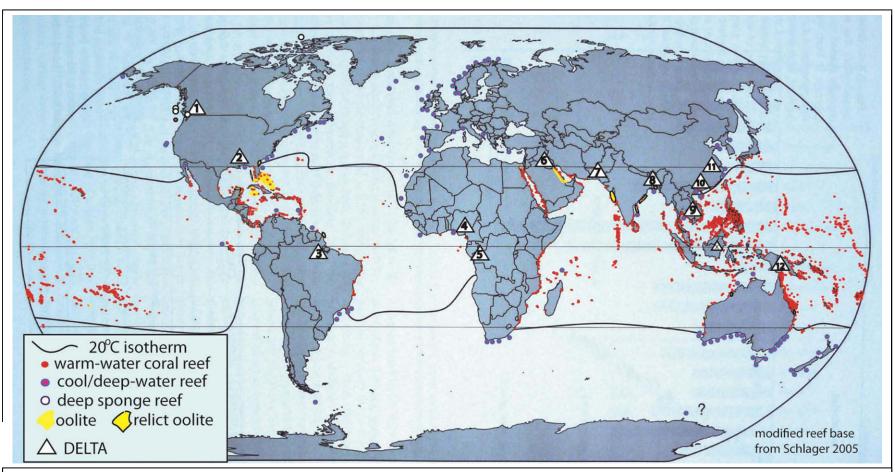


Figure A2.3A - Modern reef and oolite worldwide distribution and relation to surface sea-water temperatures limiting hermatypic corals. Some major deltas and associated 'anomalies' 1) Fraser prodelta sponge reefs, 2) Mississippi: absence of coral reefs, 3) Amazon (not a delta = estuarine): just described long narrow cryptic reef tract of rhodoliths-sponges-few corals; relict oolite on NW, 4) Niger: coral reefs absent except deep relict ahermatypic reefs on flanks, 5) Congo: coral reefs absent, 6) Shatt al-Arab-oolite in Kuwait just discovered coral reef in Iraq delta front, 7) Indus: reefs absent, 8) Ganges-Brahmaputra (Bengal Fan): reefs absent except deep type but relict oolite ridges, 9) Mekong: reefs absent, 10) Pearl/Zhujiang: reefs absent mud carried far south, 11) Yangtze/Changjiang: reefs absent mud carried far south, 12) Fly River: reefs absent except offshore pinnacles/atolls of Great Barrier Reef but Miocene platform closely adjacent, x) Mahakam of Borneo: small delta with associated patch and shelf-edge reefs. The modern ocean is a "transgressive to high-stand" system; deltas 2, 4, and 5 are shelf-margin. Yet 3, Amazon, the largest river is estuarine (with NW cheniers and big deep sea cone). Tidal in part= 3, 8, 10, x & 2.

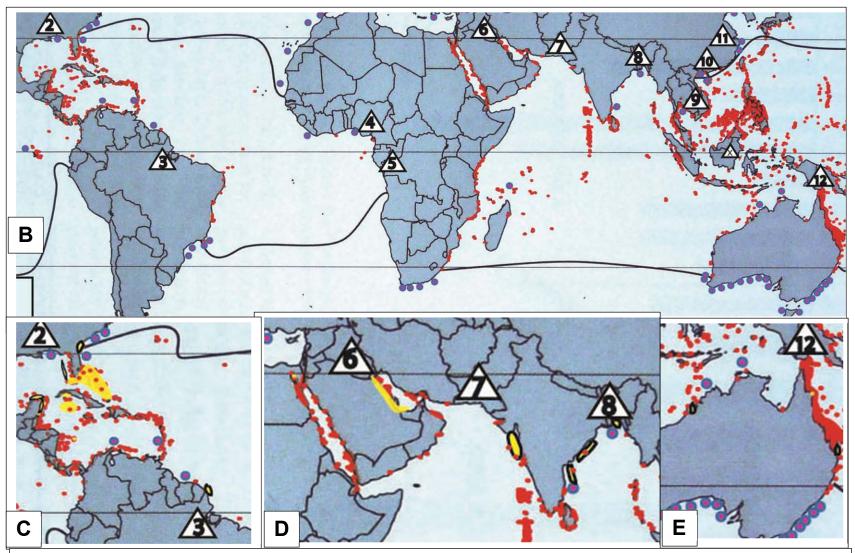


Figure A2.3B-E Modern Reef and Oolite Worldwide Distribution - enlargements to better show oolite occurrences: **B)** global low latitudes, note ooids even more confined within 20⁰ isotherm and mainly northern hemisphere, **C)** Central America-Caribbean, **D)** Middle East-India, **E)** Australia. See **Fig. 4.3A** for key and text for names and references on localities

EXAMPLES CONTROLS	Nova Scotia Shelf (NS) ABENAKI PLATORM - SABLE DELTA Late Jurassic-early Neocomian	Baltimore Canyon Trough, USA (BCT) 'ABENAKI EQUIVALENT' Late Jurassic-early Neocomian	Borneo (Indonesia) MAHAKAM DELTA Neogene (Miocene reef outcrops) to Recent (patch & shelf edge reefs)	Gulf of Papua FLY RIVER DELTA –N. GREAT BARRIER REEF Neogene (with Miocene platform) to Recent (distal atolls only)	Arabian-Persian Gulf - SHATT AL-ARAB (Tigris- Euphrates-Karun) DELTA- KUWAIT RAMP Holocene-Recent Oolite common; reefs rare.
LARGE DELTA simultaneous - siliciclastic input	YES—Sable paleo-delta eventually buries carbonates	NO – several small later deltas therefore NOT ANALOGUE; but bypass fan channels useful as pass analogue	NO — relatively small delta but in a petroleum -rich basin (part tidal) WELL STUDIED MIXED EXAMPLE	YES -Fly River drains high Papua-New Guinea mountain chain (part tidal)	YES – complicated by anthropogenic overprint of shoreline developments
SUBSIDENCE	Less than BCT	Greater than NS	Greater? (glacial effect)	Greater? (glacial effect)	Greater? (glacial effect)
PLATE TECTONIC DRIFT	North out of reef sub- tropic carbonate zone	North out of reefing but further south so delayed	North into reef zone of equatorial tropics??	North into reef zone of equatorial tropics	?North but within carbonate reef zone. Arab plate colliding with Zagros mountains
REGIONAL TECTONIC SETTING	Rifted blocks – passive margin. Thick salt affect delta (possible ponding slowed sediment supply periodically)	As left (NS) - Rifted blocks but regional clastic (?) wedge under carbonate margin. Thin salt	Complex convergent margin with small basin being in- filled by active delta	Rifted blocks later collision change from passive to active margin (great sediment influx)	Epeiric sea (300m or less depth) in nearly enclosed Mesopotamian Foreland Basin to mountain-building in Iran
EUSTACY	Important but not great fluctuations – mainly a rising trend (& base Cretaceous tectonics?)	Same as Nova Scotia and many events equivalent	Major glacially controlled global fluctuations of late Neogene	Major glacially controlled global fluctuations of late Neogene	Major glacially controlled global fluctuations of late Neogene
CLIMATE	Greenhouse time – equable subtropical humid	Greenhouse time – equable subtropical humid	Icehouse time. Humid equatorial Coral reefs & Halimeda mounds	Icehouse time – major variations but in tropics (humid to monsoonal)	Arid, subtropical – water salinities and temperatures elevated above open marine seas
Oceanography – CHEMISTRY – SEAWATER TYPES	Calcitic warm seas so high saturation (oolites & biotically induced carbonate = sponges mud mounds)	Calcitic warm seas so high saturation	Aragonitic-hi Mg more corals (lack lithified sponges, no oolite), fresher water (brackish) input Miocene flank microbialites	Aragonitic-hi Mg more corals (lack lithified sponges, less oolite), fresh input. Phosphates – Early & Mid Miocene	Slightly hypersaline (to 7% in restricted lagoons, evaporite production especially in sabhkas) Oolite formation common
Oceanography – WINDS & CURRENTS	Possible paleo-Gulf Stream with north flow	Possible paleo-Gulf Stream with north flow	Indonesian Through Flow Current south flow clears north delta lobes	East Australian Current with clockwise & north flow from Miocene	Shemal winds blow down axis to SE supply Aeolian quartz & carbonate. Flow counter-clock'
REFERENCES	Eliuk 1978, Eliuk and Wach 2008	Meyers 1989, Prather 1991 Eliuk & Prather 2005	Saller et al. 2010 Wilson 2005 Wilson & Lokier 2002 Pretkovic et al. 2016	Davies et al. 1989, Tcherepanov 2008, Tcherepanov et al. 2008	Evans 1995, Gischler & Lomondo 2005, Purser 1973 (but -Walkden & Williams 1998)

Table A2.2 Analogue Comparisons: Late Jurassic Abenaki (Nova Scotia) and Baltimore Canyon Trough (Delaware, USA) compared to some modern-Neogene mixed deltaic-carbonate platform analogues – Mahakam Delta (Borneo, Indonesia), Fly River Delta-Great Barrier Reef (Papua-New Guinea) and Shatt al-Arab Delta-Kuwait Ramp carbonates (Arabian-Persian Gulf). The modern Amazon is estuarine not deltaic but has a long non-coral reef tract in front at the shelf edge – see Figure 4.12.

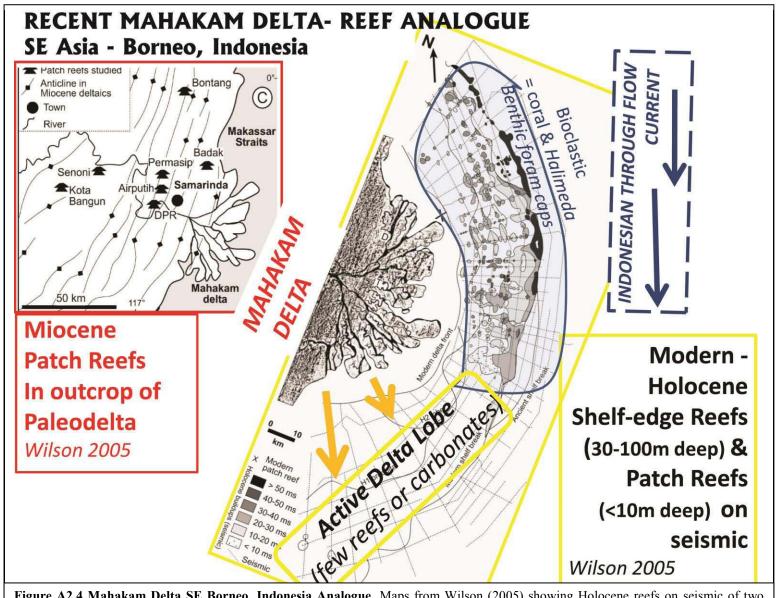


Figure A2.4 Mahakam Delta SE Borneo, Indonesia Analogue. Maps from Wilson (2005) showing Holocene reefs on seismic of two groups – patch reefs on shelf and shelf-edge reefs. Note the clearing effect of the Indonesian "Through Flow Current" favouring reefing on the abandoned NE lobes with reefs nearly absent on the active SW lobe that also is down current. Miocene outcrops of reef distribution seem to show the same asymmetric pattern giving evidence for a paleo-current.

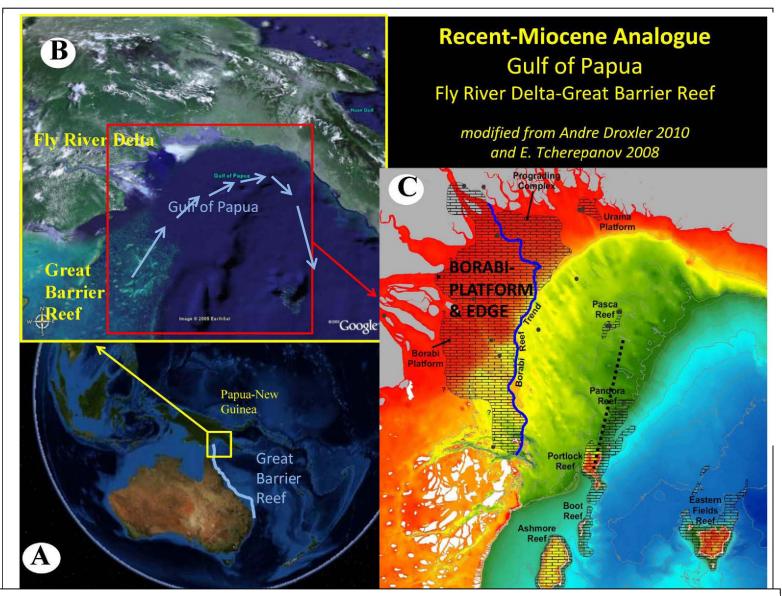


Figure A2.5 Fly River Delta-Gulf of Papua Recent-Neogene Analogue. A) Google world view of Australasia with Great Barrier Reef traced; blue, box shows B) Closer view of Gulf of Papua with coral reefs absent near Fly Delta but occur laterally and remnant in deep water with blue arrows added for path of Coral Sea Current (latter from Slingerland et al 2008); red box shows C) Recent and buried Miocene reef map beneath Fly River Delta. Note that reefs tend to re-establish above older reef trends (paleohighs). Ashmore to East Fields reefs 100 km. Maps B (modified) and C from Andre Droxler AAPG 2010 NOLA short course after his student Tcherepanov 2008 PhD studies and publications.

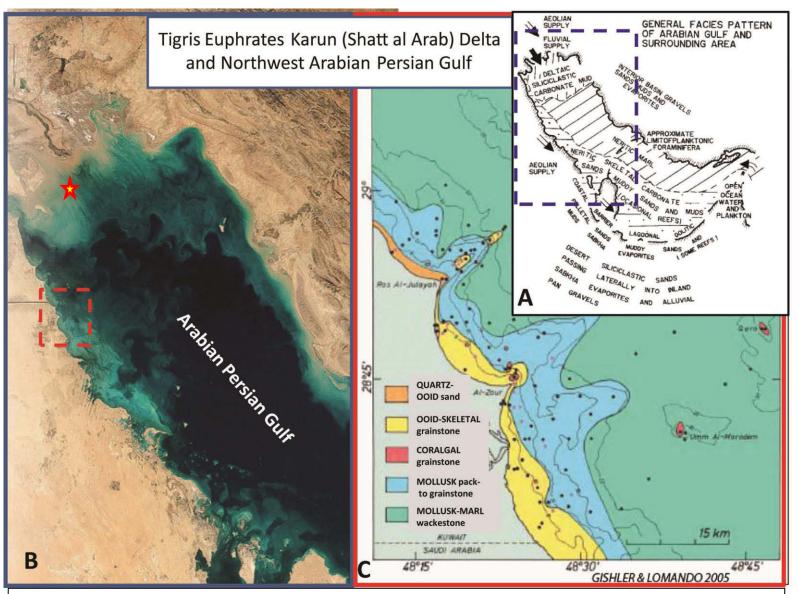


Figure A2.6 Arabian-Persian Gulf – Tigris-Euphrates Delta Recent analogue. A) general facies patterns (after Evans 1995) around Gulf with red outline indicating area of space photo next; B) Google space photo of northwest Gulf and Shatt al-Arab Delta area in Iraq and Iran with red outline of ramp facies off southeast Kuwait next, STAR = coral patch reef 7-20m depth (Pohl et al. 2014); C) depositional facies map of Kuwait ramp with offshore small reefs and near-shore oolitic facies becoming quartz-rich to north (after Gishler and Lomando 2005).

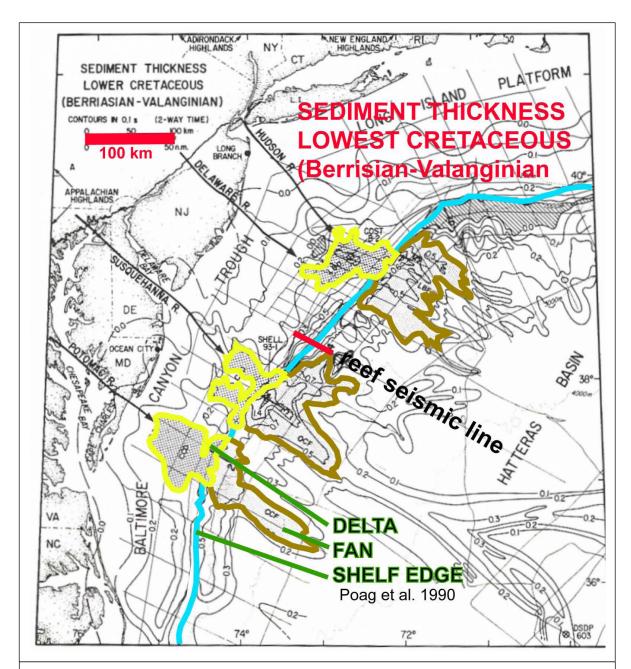


Figure A2.7 Sediment thickness and post-carbonate margin deltas Baltimore Canyon Trough (modified/colorized from Poag et al. 1990, Fig. 1). Three small deltas of Early Cretaceous age override the older Late Jurassic-early Neocomian carbonate shelf about mid-way along Poag's (1991) Jurassic gigaplatform. Reef seismic line crossing carbonate margin wells 0336 and 0337 with 0317 projected along margin from the NE is shown in lower left of **Fig. 2.4** (line is same as Prather 1991 Fig. 7 and Poag et al. 1990 Fig. 4). Likely earlier bypass channels at the delta locations may offer platform pass analogues.

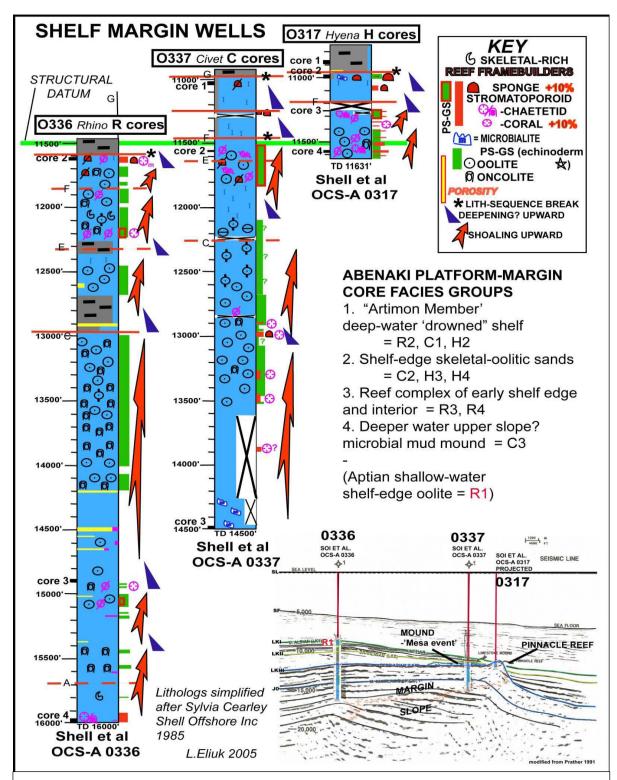


Figure A2.8 Baltimore Canyon Trough Jurassic carbonate margin wells (Eliuk and Prather 2005). Outside of the Nova Scotia Basin these are the only 3 wells that test the Late Jurassic carbonate margin. They show much more high energy onlitic and skeletal-rich sediments and less reef-framebuilders than Nova Scotian shelf-margin wells. This may result from their position slightly back of the margin and associated shallower-water depths.

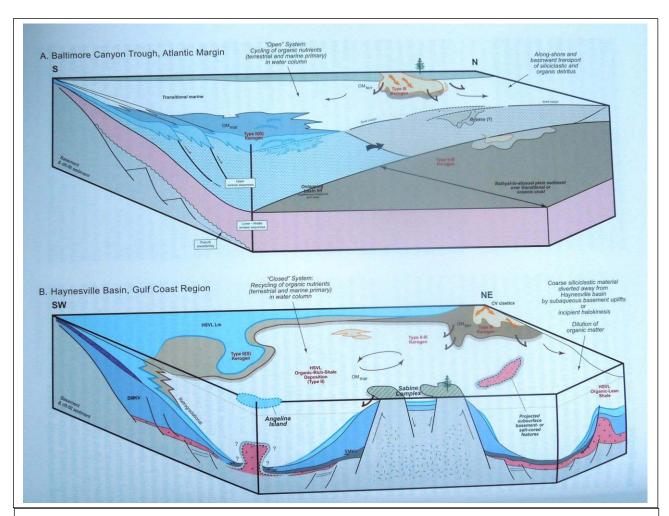


Figure A2.9 Contrast of Similar-aged Late Jurassic Atlantic Margin and Gulf of Mexico Potential Source-rock Basins (Eoff, 2013, Fig.4). Both areas are along the continental margin and both deltas are relatively small. A) Baltimore Canyon Trough is relatively open and carbonate-siliciclastic sediment supply is high so organics diluted and reworked-oxidized. b) Haynesville Basin, Gulf of Mexico is a broader shelf with various shelf edge highs restricting the intra-shelf basin so organics are not reworked with coarse clastic input deflected by highs and separated from carbonates by bathymetric deeps.

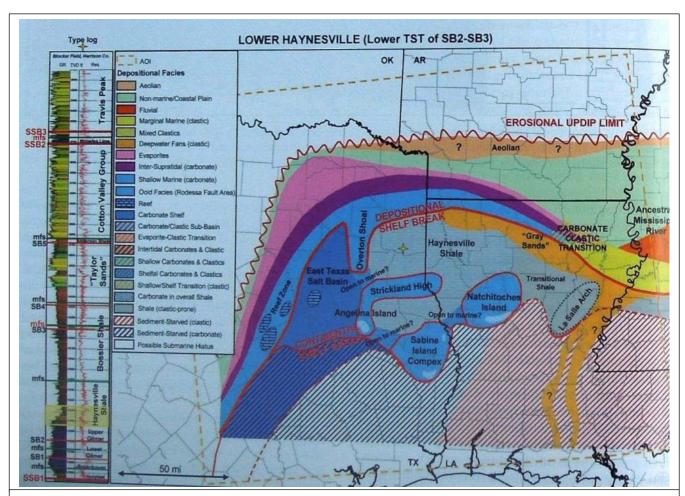


Figure A2.10 Lower Haynesville map detailing gross depositional environments of east Texas-Louisiana Haynesville basin (Cicero and Steinhoff 2013, Fig. 10). The continental shelf-edge paleohighs are sites of carbonate deposition but also restrict circulation favouring organic preservation in the intra-shelf basin. The fluvial input is deflected from the intra-shelf basin by another paleohigh resulting in less dilution of source-rock shale. The shale basin also provides a bathymetric deep and separation for the carbonate shelf from the deleterious effect of fluvial sediment input.

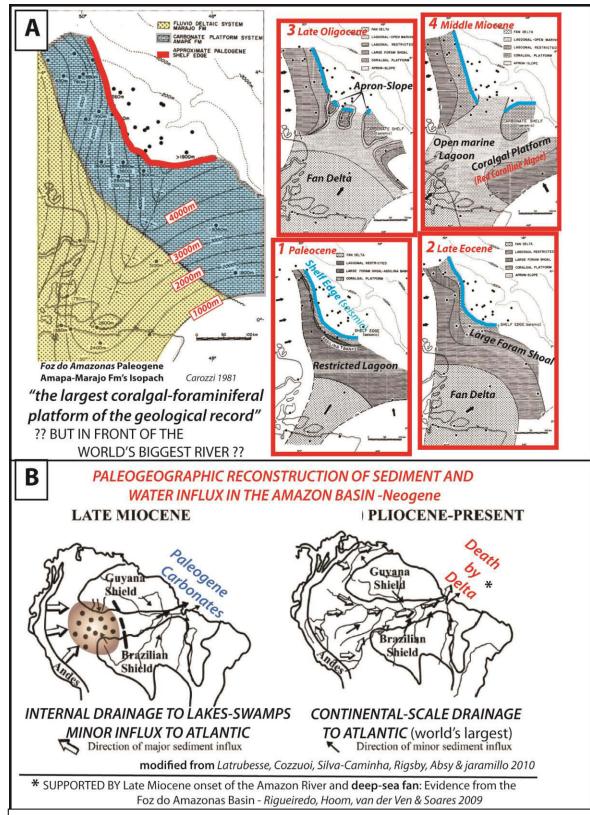


Figure A2.11 A) Paleogene carbonate shelf beneath the Mouth of the Amazon River. Isopach map of Paleogene carbonates and updip siliciclastics on left and age-based set of depositional facies maps for carbonate platform and up dip lagoon-fan delta on right (modified from Carozzi 1981). B) Change in Amazon drainage in Neogene – interior drainage in Paleogene prevented large amount of river sediment from reaching the Atlantic.

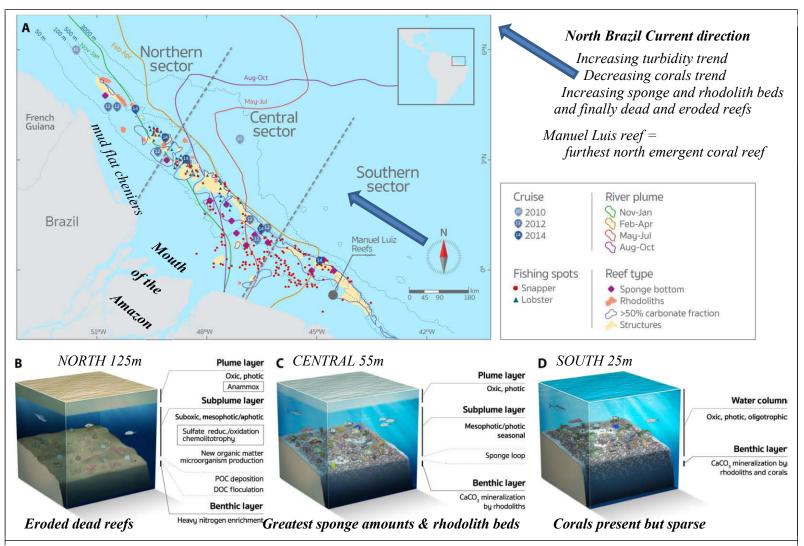


Figure A2.12 Marginal (red algal dominated non-coral) reef tract along Brazil continental shelf edge off Mouth of the Amazon. (Moura et al. 2016 Fig.1, *LSE modifications in italics)* **A) Map. B-D) schematic water columns** depicting varying turbidity effects and general bottom marginal reefs in 3 sectors. Modern Amazon River is estuarine in response to post-Pleistocene sea level rise but has huge river plumes supplying muds for cheniers on northwest shoreline and sediment for deep sea fan. The strong northwest flowing North Brazil Current deflects the river plume that with increasing depth gives a gradient of changes to the reef tract

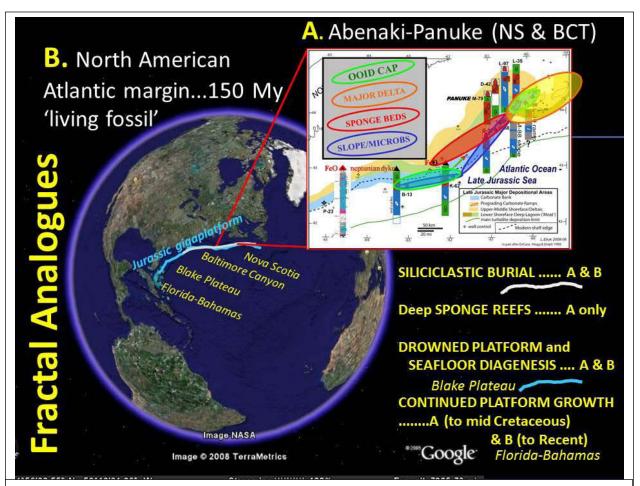


Figure A2.13 Fractal Analogue Comparisons over Space-time of a Siliciclastic-carbonate Largescale Association

- **A.** Abenaki-Sable (Latest Jurassic-early Neocomian) near end of carbonate sedimentation with Sable deltaic burial on northeast through deep sponge reefing on drowned platform with iron-ooid starved seafloor diagenesis to continued carbonate growth on southwest
- **B.** Modern North American Atlantic continental shelf with Late Jurassic gigaplatform (Poag 1991) from Grand Banks to Bahamas buried in siliciclastics as far south as Blake Plateau where it is drowned but thinly buried or exposed with seafloor diagenesis but still growing in the Florida-Bahamas as a 150 million year old 'living fossil'. (Modified from Eliuk 2010, Eliuk and Wach 2010b).

World figure from NASA-Google and Abenaki-Sable map from Eliuk and Wach 2010b.

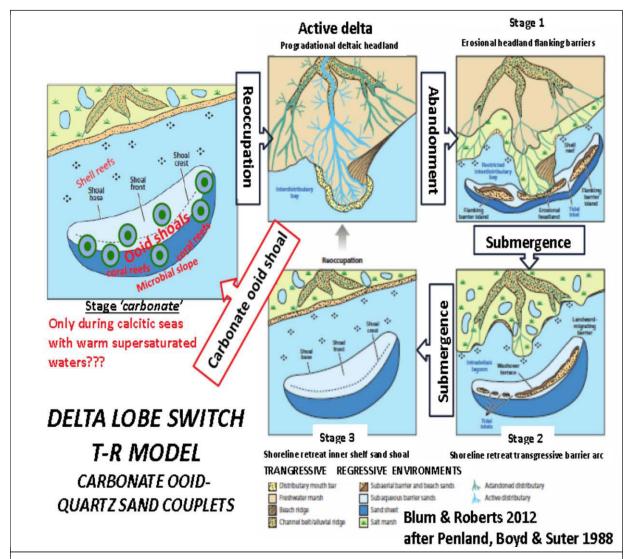


Figure A2.14 Delta lobe switching model with carbonates added (modified after Blum and Roberts 2012). This visual model of a cycle of changes in major delta environments as a consequence of abandonment then reoccupation of a delta lobe was developed to explain the patterns seen in the Mississippi Delta area. I have added a carbonate phase to the model. The development of offshore shoals with the absence of terrigenous clastic input seems a likely setting for shallow-water carbonates to develop given favourable seawater chemistry and climate. Wind or tidal wave energy associated with the exposed area would promote ooid development if carbonate saturation is high enough for precipitation.

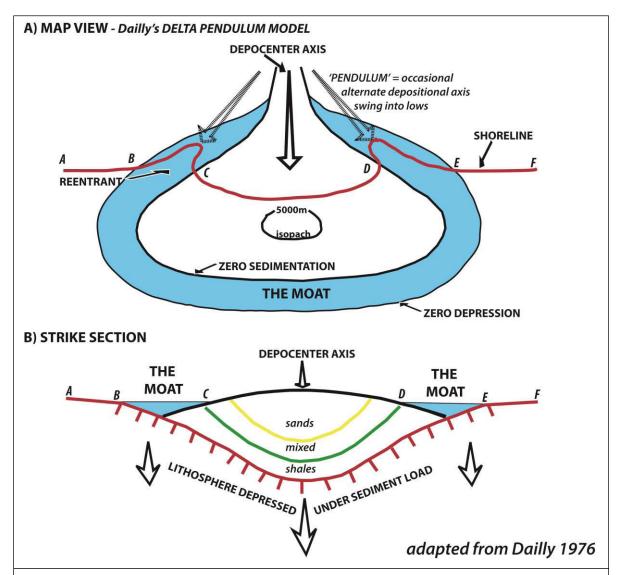
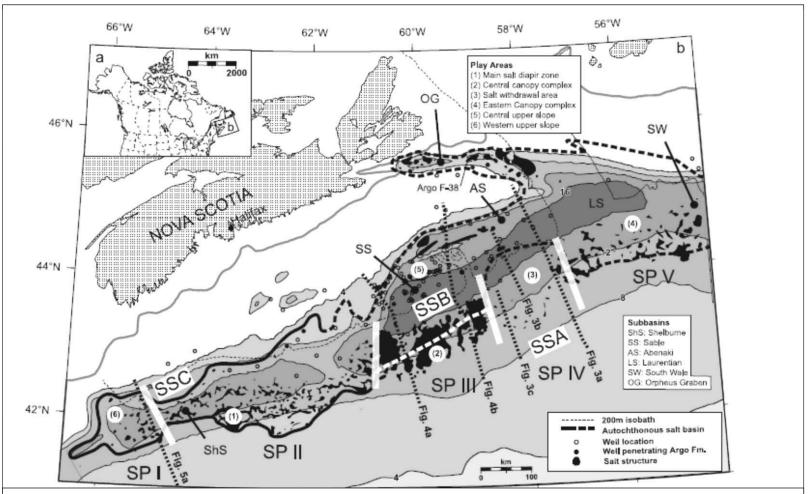


Figure A2.15 Delta-loading pendulum model of Dailly (1975, 1976). The load of a large delta depresses the lithosphere so that a "moat' or flexural bathymetric trough is created. This deep potentially attracts sedimentation so the depocentre axis swings to one or other flanks hence the 'pendulum'. Dailly modelled consequences of this for changes in siliciclastic sediment patterns over time.



Albertz et al. 2010 Figure 1 and caption. (a) Map of Canada showing location of regional map. (b) Regional map of Nova Scotia and the Scotian Basin in the offshore region showing various current subdivisions of the Scotian Basin. Modified after *Ings and Shimeld [2006]* (AAPG 2006 reprinted by permission of the AAPG whose permission is required for further use.) Techtonostratigraphic subprovinces and boundaries (white lines) after *Shimeld [2004*]. Salt play areas after *Kidston et al. [2007*]. SSA, region of structural style A; SSB, region of structural style B, SSC, region of structural style C

Figure A2.16 Nova Scotia offshore tectonostratigraphic subdivisions and salt distribution. (Fig. 1 of Albertz et al. 2010 with figure caption included). This aids locating features in the text discussion of their numerical modelling and its application. The three salt tectonic structural styles from northeast to southwest are the Banquereau area (SSA), Sable area (SSB) and LaHave platform (SSC). Note the shaded areas showing increasing Cenozoic-Mesozoic sediment fill thickness with greyer shading.

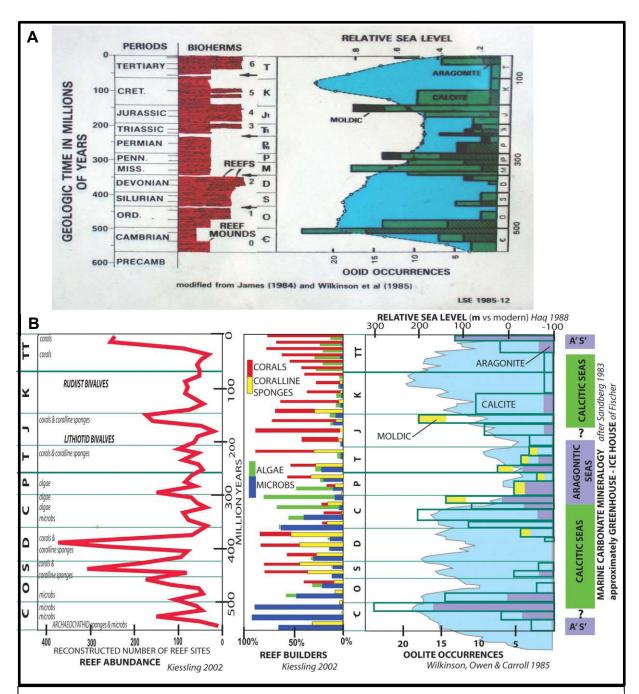


Figure A2.17 Reef abundance, reef builders, ooid abundance and mineralogy Phanerozoic comparison Comparisons show how generalizations change with new data and definitions. Specifically, high oolite abundance no longer corresponds to transition times between highest and lowest sea levels for the Paleozoic but only after. In both A and B, the Late Jurassic has very high abundance (and varieties) of reefs and oolites in calcitic seas of a world-wide greenhouse climate and rising relative seal level. Also reefs versus oolites vary inversely in the Paleozoic but directly in the Mesozoic-Recent even if the corals are aragonitic and the ooids calcitic.

A. Early version of variations over time of the qualitative true reef-reef mound abundance and oolite (Eliuk 1987 Fig.1 discussion of Wilkinson et al. 1985 with Vail 1977 sea levels much simpler than Haq 1988 curve) **B.** Comparison of reef sites, reef builders, oolite and sea levels but using more modern quantitative data on reefs and eustatic sea levels. The middle plots percentage-selected reef builders but with microbes-algae placed just left of corals-coralline sponges column to allow comparison. Note that the microbial reefs decrease with time and vary directly with the oolites both in abundance and mineralogy even in the Jurassic (also see Riding and Liang 2005a&b). Reef abundance peaks have been corrected for erosion. Sources cited

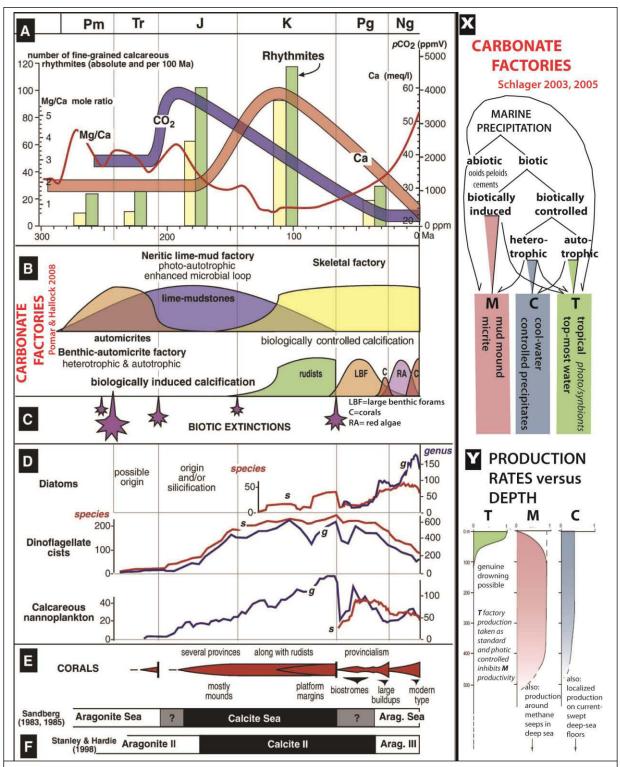
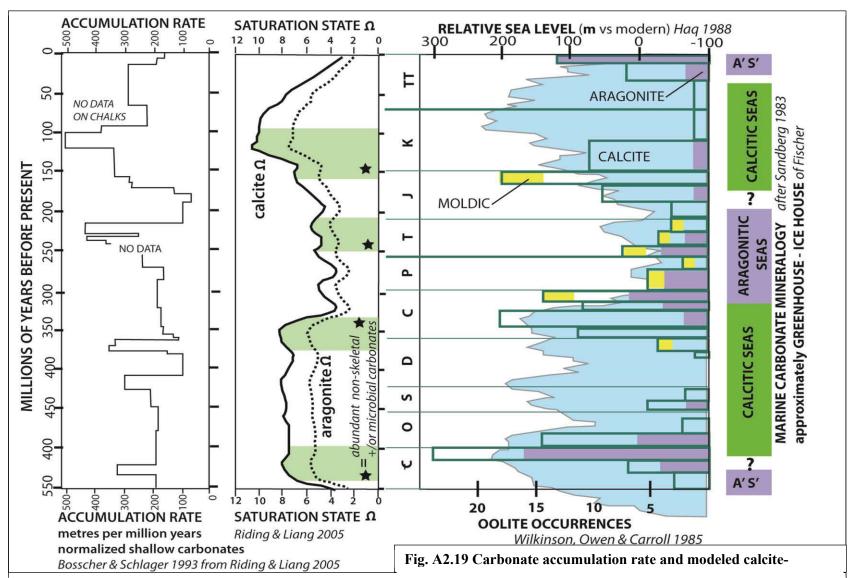


Figure A2.18 Carbonate factories compared and their controls – **Pomar and Hallock** (2008, their Fig. 9 **A-F**) and **Schlager** (2003, 2005 modified very slightly **X-Y**). **A:** Secular variation in the Mg/Ca ratio in seawater based on estimates of spreading rates and the effects of these rates on seawater chemistry according to Hardie's model (1996). Atmospheric CO₂ estimations smoothed average. Occurrence of fine-grained calcareous rhythmites (limestone–marl alternations and nodular limestone successions) normalized for five time spans. Smoothed average of secular variations in absolute Ca+ concentration in seawater. **B:** Changes on the predominant type of carbonate factories over the Mesozoic and Cenozoic. **C:** Major biotic extinctions. **D:** Eukaryotic phytoplankton diversity curves. **E:** Major cycles of scleractinian corals. **F:** Temporal distribution of non-skeletal carbonates according to and periods when seawater should have precipitated calcite or aragonite and high-Mg calcite. **X:** Schlager's (2003) carbonate factories with varied contributions from different abiotic and biotic sources. **Y:** Depth/photic and temperature controls of his factories.



aragonitic saturation state of Riding and Liang (2005b) versus oolite occurrences Wilkinson et al. (1985). The modelling considered estimated variations in pCO₂. pH, ionic Ca, SO₄ and CO₃ concentrations but held temperature constant at 15°C. Curiously greatest oolite occurrences seem to be at the inflection points of changing calcite saturation and seawater mineralogy types that also seem to be the times of changing major sea-level stands.

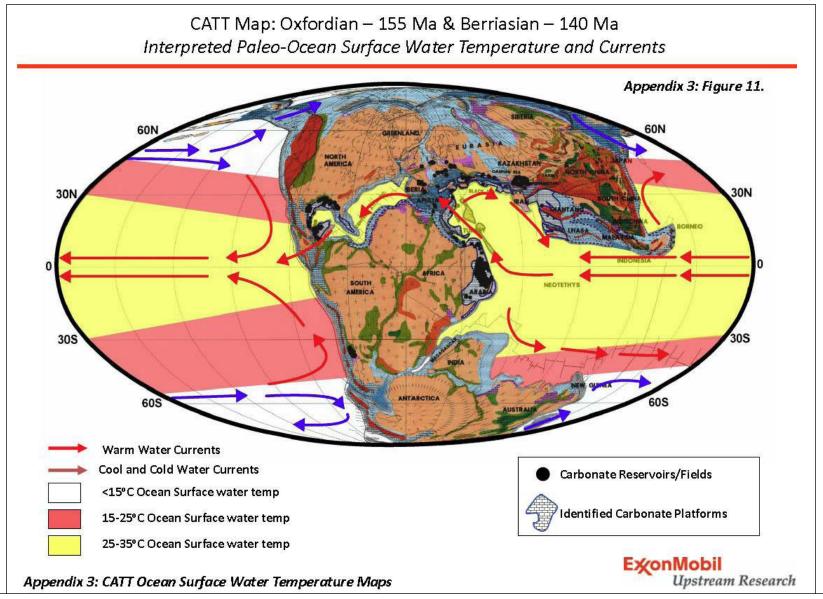


Figure A2.20 CATT Late Jurassic to earliest Cretaceous paleo-oceanography temperature and currents (Markello et al. 2008) – part of a global synthesis showing the high temperature inferred for the tropics and all of the semi-enclosed Atlantic-Gulf of Mexico seas.

Table A2.3 Late Jurassic comparisons modified after Markello et al. 2008. My addition of the Nova Scotia column and italicized words.

CHARACTERISTICS	ARABIA	GULF OF MEXICO	NOVA SCOTIA
Tectonics at deposition	passive margin	passive margin	passive margin
	(broad intrashelf basin)	(restricting arches)	17/42 V2377
Tectonic History	passive to collisional	still passive (deeper burial by delta)	still passive (deeper burial by delta)
Ocean circulation	open	restricted	open (but small sea)
Global climate	greenhouse	greenhouse	greenhouse
Paleo-latitude	equatorial	25°N	35°N
Regional air temperature	constantly hot	seasonally variable	seasonally variable
Regional climate	mostly humid (?Hith evap')	semi-arid (dolomite & evaporites)	humid (no evaporites, coals present)
Relative humidity	low	very low	moderate
Winds	onshore; west to east	offshore; NE to SW	? on and offshore SE to NW?
Wind strength	low (equatorial doldrums)	moderate?	moderate?
Ocean temperature	very high (35°c avg.)	not as high (30°C avg.)	Not as high? (25-30°C avg); salinity
			38% ₀ (Harris)
Tide level	macro	micro	micro
Storms	abundant	rare	common?
Overall ocean energy	high	low	moderate to high
Key reservoir facies	grainstones skeletal, ooids	grainstones/dolomudstones, ooids	reefs, skeletal grain/packstones
			(dolomitized LATE)
Reefs	stromatoporoid/coral	microbial mounds	coral-stromatoporoid reef complexes
	framestones (minor?)		microbial mounds on slope
			lithistid sponge reefs, argillaceous
Depositional mineralogy	calcite	aragonite (if restricted: also calcite)	calcite
Marine cements	rare/none	early/abundant	early/abundant
Early diagenesis	minor cementation	significant dissolution	some dissolution
	minor dolomitization	significant dolomitization	(very significant LATE dolomitization)
Dominant pore type	primary	moldic/dolomite	moldic, vuggy, intercrystalline-dolomite
Fractures	yes (foreland history)	maybe (passive margin history)	yes (slope loading by delta?)
Reservoir formation	Arab	Smackover	Abenaki

NAME (continent) Area Drainage Basin km² (Length) Discharge Sediment load dissolved some part of the par	Table A4.4 Large & Co.		man and Farnsw		
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Appendix A3. In Enclosures (Lithological Logs)

Appendix A4. Copyright Permission Letters
On following pages

2016-05-30

Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) 8th Floor TD Centre, 1791 Barrington Street Halifax, Nova Scotia B3J 3K9

Dear Mr. Carl Makrides, P.Geo

RE: copyright permission for use of several figures/enclosures from CNSOPB website and DVD reports:

I am preparing my PhD thesis for submission to the Faculty of Graduate Studies at Dalhousie University, Halifax, Nova Scotia, Canada. I am seeking your permission to include a number of figures (20) in the following website reports in the thesis:

CNSOPB. 2012. Call for Bids 2012 NS 12-1. Canada-Nova Scotia Offshore Petroleum Board website – NS 12-1 Parcels http://www.callforbids.cnsopb.ns.ca [various subsections on geology of the offered parcels]

Encana Corporation. 2006. Deep Panuke Offshore Gas Development Plan. Canada-Nova Scotia Offshore Petroleum Board, Halifax, Nova Scotia, v. 2, 313 p. [Document No: DMEN-X00-RP-RE-00-0003 Rev. 01U on the CNSOPB website].

Kidston, A.G., Brown, D.E., Smith, B.M. and Altheim, B. 2005. The Upper Jurassic Abenaki Formation offshore Nova Scotia: a seismic and geologic perspective. Canada-Nova Scotia Offshore Petroleum Board CD Publication, 168 p (on CNSOPB website).

We exchanged emails regarding this request May 20, 2016. Mr. David Brown of the CNSOPB is on my thesis committee and is familiar with my use of figures from the above reports. On the figures and/or their captions the sources have been properly cited and acknowledgement made of CNSOPB and the authors.

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Full publication details and a copy of this permission letter will be included in the thesis.

Yours sincerely,

Leslie Eliuk

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- b) for the material described above to be included in the copy of your thesis that is sent to the Library and Archives of Canada (formerly National Library of Canada) for reproduction and distribution.

Name: Carl Makrides Signature Title: Director, Resources - CNSOPB

Date: May 30, 2016

2016-05-30

Offshore Energy Research Association of Nova Scotia (OERA) Joseph Howe Building, Suite 1001 1690 Hollis Street Halifax, NS B3J 1V7

Dear Mr. Russell Dmytriw:

RE: copyright permission for use of several figures/enclosures from OERA website report:

I am preparing my PhD thesis for submission to the Faculty of Graduate Studies at Dalhousie University, Halifax, Nova Scotia, Canada. I am seeking your permission to include a number of figures or parts of figures (12) in the following website report in several chapters in the thesis:

Offshore Energy Technology Research Associates (OETR). 2011. Play Fairway Analysis, Chapter 9 – Late Jurassic Carbonate Play Fairway Analysis - Addendum to Play Fairway Analysis by BEICIP-FranLab (S. Doublet and co-workers), 104 p. Also Chapter 3-Stratigraphy, Chapter 5-Seismic interpretation 347 pages. http://www.oera,ca/Offshore-energy-research/geoscience/play-fairway-analysis/PFA-atlas

We have discussed and exchanged emails regarding this May 19-25, 2016 and you were sent examples of several of my figures making use of the PFA website figures. As you probably noticed citation to the original source and in some cases the principal researcher Dr. Stefan Doublet were on the figures and/or in the figure captions. I was involved in the PFA study as a contributor of geological data and interpretation in the Chapter 9 Carbonate Play carried out by Beicip-Franlab for the PFA Atlas.

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Full publication details and a copy of this permission letter will be included in the thesis.

Yours sincerely,

Signature:

Leslie Eliuk

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- b) for the material described above to be included in the copy of your thesis that is sent to the Library and Archives of Canada (formerly National Library of Canada) for reproduction and distribution.

Name: Stephen Dempsey

Title: Executive Director

Date: May 31, 2016

2016-05-31

SEG Society of Exploration Geophysicists 8801 S. Yale Ave., Suite 500 Tulsa OK 74137 USA

Dear Ms or Sir:

RE: copyright permission for use of several figures (7) from SEG *Interpretation*:

I am preparing my PhD thesis for submission to the Faculty of Graduate Studies at Dalhousie University, Halifax, Nova Scotia, Canada. I am seeking your permission to include a number of figures (7) from the following article in the thesis:

Qayyum, F., Catuneaunu, O. and Bouanga, C.E. 2015. Sequence stratigraphy of a mixed siliciclastic-carbonate setting, Scotian Shelf, Canada. Interpretation, v. 3, p. SN21-SN37

Over several years I have been in email correspondence with Dr. Farrukh Qayyum the lead author who is familiar with my use of figures from the above article. He has no problems with my using his figures in my thesis. On the figures and/or their captions the sources have been properly cited and acknowledgement made of the *Interpretation* journal and the authors.

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theses. I am also seeking your permission for the material described above to be reproduced

distributed by the LAC(NLC). Further details about the LAC(NLC) thesis program are available on the

LAC(NLC) website (<u>www.nlc-bnc.ca</u>).

Full publication details and a copy of this permission letter will be included in the thesis.

Yours sincerely,

Leslie Eliuk

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and Archives of Canada (formerly National Library of Canada) for reproduction and distribution.

Name: Ted Bakamjian Title: Associate: Associate Executive Director, Knowledge Management SEG

Date: July 8, 2016 (email) Signature:

See following email correspondence



Jul 18 (1 day ago)



Dear Mr. Eliuk,

Please accept my apologies for delay in response. I have signed the attached letter granting the permission you request.

The DOI-based permalink for the source article is the following:

http://dx.doi.org/10.1190/INT-2014-0129.1

This link takes those who click on it to official versions of the article.

I am quite impressed with your PhD effort at your age. Best of luck with your defense.

As a side note, I was in Halifax and other locales in Nova Scotia for a vacation about three weeks ago and thoroughly enjoyed it.

Sincerely,

Ted

Ted Bakamjian, IOM, CAE | Associate Executive Director, Knowledge Management +1.918.497.5506 direct

Society of Exploration Geophysicists (SEG)

8801 South Yale Avenue, Suite 500 Tulsa, OK 74137-3575 USA

No attachment accompanied this email and up to August 8, 2016 no reply to my request for an attachment

Encl	losure	e A3.1	Chevron-Pl	EX-She	II <u>A</u> C	CADIA	<u>A K-62 (</u> JABI	() _{i Inc}	L.Eliuk P.G	eol. 20	09-02	&10 (al:	so fro	m D.A.	Howar	d logs ar	nnota	ated by	LSE	1979 8	& CSS) & GS	C cto	as thir	n secti	ons					PAGE		
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						calcite c	crystals some pink hu	e tr mine	erlized pyrite, g	alena,	chalco	pyrite	_			brn (& lim	onite ye	el Fe g	ranule	es, LE-	Redder	ned ir	nocera	mid pr	sms tr							
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swc2784 >	2784		Poor TS plucked	a o ji ta		ЗP	ool-(M-C; crinoid n	ı ucleii) -p	pel	50	6		1?						5	1	2 ′	,		П	?		5D		•	n compact-	fitted grains	ShSstcave	9P
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	2814		CORE 1, 2	& 3						Г,						_																	
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	2829	LS dol	6/4	Wt-VLtGy	×	(TL	C-M	3-6	fair																			patches	XC calcite	spar			
	2832 2835	LS dol	6/4, chalky LST	\\/\t \/ tC\/		(TL	С-М																					tr pyrite					
>>>>		DOLIS	9/1 F-C poorTS	WI-VEIOY	l x	(TL	C-M-F & rextl LST C		tr??				1?						3	2									noids VC m	nicritized rin	ns		7P
2841	2841	LS dol	6/4, chalky LST	Wt-VLtGy	X	KTL	C-M																										
	2844 2847	LS dol	6/4, chalky LST	Wt-VI tGv	X	(TL	C-M																										
	2850	LO doi	0/4, chancy LOT	Wt VLtOy		\.	O-III																										
	2853	LS dol	7/3 chalky LS	Wt	×	KTL-PG	frag- (ghost ooid)			5		30																					
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>>>		DOLIS	7/3 dedolm??				F-C & rextl LST F-C																	ш				poor TS	patchy aliza	arin or dedo	olomite		8P
2872	2872 2875	LS dol	7/3 chalky LS	Wt	X	ctl-PG	(ghost ooid)																										
	2878	LS dol	7/3 chalky LS	Wt																													
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		LS dol	8/2 chalky LS	Wt-Buff		ı														2								7(1 0033)	minated ga	iciia: i yiit	c: (:DidCill	icixii illatcilai)	
>>>>		DOL-LS	6/4 poor TS pluc	(peloid-(ooid) & rextl	d			20	7								1				Ш			5						11P
2902	2902 2905	LS	float dolorhombs	LtGy - Buff		GP(W)	ooid (pel?)			40?	?10	10								2			1				5D 50	gy arg? (Dolite grain:	s w/ floating	g dolorhomb	S	
	2905	LS		LtGy	F	PS	ooid (pel?)			40	5			?	2					2	3		2				5D						
	2911																																
	2914	LS		LtGy	F	PGS	ooid - coated lithocl	asts		50		10			2												5D						
	2917 2920	LS	C ooids	LtGy	F	PGS	ooid - coated lithocl	I asts		50		10						?1		2 2	2						5D	loose on	d grains ?	Minor Mud	cmt?		
	2923																												J				

ſ	Α	В	С	D	G	Н		J	K	L	M N	0	P Q	R	S	T V	WX	Υ	Z A	A AB	AC AD	AE AI	F AH	Al A	J AK	(AL
	2926	LS	C ooids	LtGy	PGS	ooid - coated lithoclasts			50		10		3			2									5D	
>>>>	[2929]	LS	C-VC ooids VPTS			ooid - coated lithoclasts			45	15>>	15	?	?				2						4?	?		clasts peloidal?? Micritized 9P
2932	2932	LS	C ooids	LtGy	PGS	ooid - coated lithoclasts			50		10		3			2		2	3	3					5D	
		LS	C ooids	LtGy	PGS	ooid - coated lithoclasts			50		10							2	3						5D	
	2941		0 : - ! -	140	DOO						10					2		0								
		LS	C ooids	LtGy	PGS	ooid - coated lithoclasts			50		10					2		2						2	5D	
	2947		0 : - ! -	140	DOO	anid abalatal			40			_				2		0								
		LS	C ooids	LtGy	PGS	ooid - skeletal			40			2	2			2		2	3	·					5D	
	2953		0 : - ! -	1.40	DOO	anid abalatal			40							2		_	2 2							
	2956	LS	C ooids	LtGy	PGS	ooid - skeletal			40			2				2		2	2 3	5				3	5D	
2002	2959		Casida	L+NACV	PGS	ooid			40								2		-					-	ED	dark angold (lith coloot with migrany rite
2962missi		LS	C ooids	LtMdGy	PGS	ooid			40								2		2	•				5	5D	dark oncoid/lithoclast with micropyrite
	2965		Casida	LtMdGy	PGS	anid skalatal			FΟ			2	-			2			2 4	inocer	l Shime	nriem	.!!		ED	dark angold/w/ gold lithaglast
	2968 2971	LS	C ooids	LividGy	PGS	ooid - skeletal			50			2	5			2			2 4	inocer	aiiiu:	prisiri	II		5D	dark oncoid/ w/ ooid lithoclast
	2974	1.0	C ooids	LtMdGy	PGS	ooid			60										2	,					5D	ooids also dark
	2977	LS	C 00lus	LividGy	r G3	oolu			00										2	-					30	Oolus also dalk
	2980	LS	C ooids	LtMdGy	PGS	ooid			60											2					5D	
	2983	LS	Coolus	LividGy	r G3	oolu			00																30	
	2986	LS	C ooids	LtGy	WPGS	ooid-fragmental			30	10									3	inoc	I eramic	l 2 nrisi	me II		5D	
	2989		O OOIGS	LiOy	**1 00	Cold-Iraginieritai			30	10												r: prisi	II		35	
2992	2992	LS	TR VF DOL	LtGy	PWS	ooid-frg rd			20	15	15		4					2	3			12			5D	poor TS plucked spls - tr vf dol rhombs 4P
2552	2995		III VI DOL	LiOy		colu-iig iu			20	10	10		7									1.			I OD	poor 10 plucked spis ti vi doi monios
	2998	IS sh hk	C-F ooids	LtGy	PWS	ooid			30																5D	shale break stylolitic
	3001	LO SIT DI	0 1 00103	LiOy		COIG																			UD	Shale break stylohile
	3004	LS	C-F ooids	LtGy	WPS	ooid-bivalve-peloid			20	10								2	1:	5 2		1			5D	
	3007			,		оста потаго розота																-				
		LS	C ooids	LtGy	GPS	ooid-bivalve			50	5						2			10	0 2		1			5D	
	3013																									
		LS	C ooids	LtGy	WPS	ooid-peloid			30	10						2			10	0 1		1		3	5D	
SWC	3019																									
3022	3022	LS	vf-vC ooids tr dol ı	LtGy	GPS	ooid-skel 3	i i	interooid	50		2	1	3				3	1	2 6	5		2 milio	olid&bi	eria 1	5D	stylolites, gastropod mold; some thick bivalves - oyster?
	3025																									
	3028	LS	C ooids	LtGy	GPS	ooid-echinoid			60										2	2					5D	yellow calcite spar
	3031																									
	3034	LS	C ooids	LtGy	WPS	ooid-fragmental			40		10							10	2	2					5D	tr yellow and pink calcite cement
	3037																									
	3040	LS dol	C ooid dolorhomb	LtGy	PGS	ooid			70									3	2	2					5D	red-pink tinge/hue cf rhodochrosite-like??
	3043		7 0/00		00 41																١					
		DOLcalc	70/30	VLtGy	G?xtl	ooid			?15+				2?					2	2	inoce	ramid'	1			5D	tr green interXTL, red-pink tinge/hue cf rhodochrosite-like??
awa2052	3049	DOL 1 C	60/40 F-Cxtl	\/I +C\/	G?xtl	aaid			FΛ		2			1?			1	2	1 0 1	hiak			?		ED	rad pink tings/hus of rhadashrasita like??
swc3052	3052 3055	DOL LS	60/40 F-CXII	VLtGy	Grxu	ooid			50					17			1	2	1 21	ITICK					5D	red-pink tinge/hue cf rhodochrosite-like??
		DOLcalc	70/30	VLtGy	G?xtl	ooid			?15+		tr grape	Storie						2							5D	red-pink tinge/hue cf rhodochrosite-like??
	3061	DOLCAIC	70/00	VLICY	O . Ati	Cold			. 10. I																100	Tou print ungernae of mododinosite like:
		DOLcalc	65/35	VLtGy	G?xtl	ooid-skel			?15+			2				2		2	2		1	1			5D	red-pink tinge/hue cf rhodochrosite-like??
	3067	DOLOGIO	00/00	veloy	O . Ati	COIG ONO			 			-				-		1-1	-			•				Tod print ungernad of modeline into:
SWC		DOLcalc	60/40 calcsp	VLtGy	G?xtl	ooid			?15+				2	coate	d strom'			2	2					4	5D	red-pink tinge/hue cf rhodochrosite-like??
	3073			,										I	I I											
		DOLcalc	60/40 calcsp	VLtGy	G?xtl	ooid			?15+				2					2	2						5D	red-pink tinge/hue cf rhodochrosite-like??
	3079																									
3082	3082	DOL LS	65/35 calcsp	VLtGy	WG?xtl	ooid-frag vf-C			25		5 1		2					2	3						5D	AA M [c] xtl dolm anhedral dusty ctrs zoned 5P
	3085										tr grape	stone														
		DOLcalc	80/20 calcsp	VLtGy	G?xtl	ooid			?15+		5								2	2		1		3	5D	red stain in dolm shows ooid-frag outlines
	3091		7 0/00			L												\sqcup								
		DOLcalc	70/30	VLtGy	G?xtl	ooid			?15+		5		2									7			5D	red-pink tinge/hue cf rhodochrosite-like??
SWC	3097	DOLcalc	75/25	VLtGy	G2v4l	ooid			?15+		5								1						5D	red-pink tinge/hue cf rhodochrosite-like??
SVVC	3100	DOLCAIC	13/23	VLIGY	G?xtl	oolu			110+		3														שפ	rea-pink unge/hae of modocinosite-like ! !

	Α	В	С	D	G	Н	I	J	K	L	M N	0	Р	QR	RS	T	ГШ	v w	Х	ΥZ	' AA	ABA	CAD	AE A	AF A	Н	I AJ	AK	AL
SWC	3103 3106	DOLcalc	75/25	VLtGy	G?xtl	ooid			?25+											2	3			1				5D	
SVVC	3109																			2	3			1				טפ	
3112	3112 3115	LS DOL	60/40 vf-M ooid	VLtGy	GPFxtl	ooid-skel			30					4						2	3			1				5D	poor TS(= thin); M dolost & vf dolm rhombs in LS 6P
	3118	DOLcalc	70/30	VLtGy	G?xtl	ooid-frag-peloid			?15+	5+	5			2						2	2							5D	
	3121 3124	DOLcalc	65/35	VLtGy	CD2vtl	ooid superficial			?15+															1				5D	
	3127																												
	3130 3133	DOLcalc	60/40	VLtGy	GP?xtl	ooid superficial			?15+											2	2 1			2				5D	
	3136	DOLcalc	60/40	VLtGy	GP?xtl	ooid superficial			?15+							2	2			1	1		1?					5D	
3142	3139 3142	DOL LS	65/35 VF-VC	VLtGy	GP?xtl	ooid sup-frag			20	7	7 2			2		2	2		1	2								5D	more partially dolomitized LS or Calc DOLOS cloudy rhbs 6P
0142	3145													_															inore partially defermanced and date and a decided deady make
	3148 3151	DOLcalc	65/35	VLtGy	GP?xtl	ooid sup-frag			?15+		7+									2	3							5D	
	3154	DOL LS	50/50	VLtGy	GP?xtl	ooid sup-frag			?15+		7+					2	2											5D	
	3157 3160	DOL LS	50/50	VLtGy	GP?xtl	ooid sup-frag			?15+	3	7+									2	3							5D	
	3163																Ι.											-	
	3166 3169	LS dol	85/15	LtGyBn	WPS	frag-lithoclast				15	10)					1	?		1 1	2		2	1					stylolite
3172miss	3172	LS dol	9/1	LtGyBn	WPS	frag-lithoclast			5	15	10)								1									
	3175 3178	LS dol	9/1	LtGyBn	WPS	ooid			35	5											2	1						5D	
	3181												ш																
	3184 3187	LS dol	9/1	LtGyBn	WPS	ooid			25									2		1	1							5D	
	3190 3193	LS dol	9/1	LtGyBn	WPS	ooid-frag-oncoid			15		10									1							3		
		LS dol	9/1	LtGyBn	ws	fragmental					15					3	3				2								
3202	3199 3202	LS	minor dolm	LtGyBn	WpS	frag-skel-ooid			10	5	15	1		3		1	1					1					3		coated coral
3202	3205		minor doim								he	exactir		3													3		coated coral
	3208 3211	LS		LtGyBn	WS	fragmental-ooid			7	2	15			2					1	1	1			1					
	3214	LS		LtGyBn	ws	fragmental			5		15			1						2		1		1					
	3217 3220	LS		LtGyBn	ws	fragmental			5		15			2		1	1				2								
	3223																												
	3226 3229	LS		LtGyBn	ws	fragmental			5		15			2		1	1				2			1					
3232	3232	LS		LtGyBn	WmS	fragmental			5		15 1			3					1		1								?andhydrtie inclusions in ooid?? 6P
	3235 3238	LS		LtGyBn	ws	fragmental-ooid			20		15			4						2				1				5D	
	3241	1.6																											
	3244 3247	LS		LtGyBn	WPS	fragmental-ooid			25		20			6		2	2			1	2							5D 5	B
	3250 3253	LS		LtGyBn	WPS	fragmental-ooid			15		15					2	2							1					
	3256	LS		LtGyBn	WMS	fragmental					8 3										2						2		
	3259	LS		LtGyBn		frag-ooid-skel			35	5				2						2	2			1					
	3265																			_				'					
	3268 3271	LS		LtGyBn	ws	fragmental			5		15			2															
	3274	LS		LtGyBn	WPS	ooid-frag-oncoid			25		10 5			2		1	1				2						10	5D 5	E
	3277			I																			1						1

	Α	В	С	D	G	Н	I J	K	L	M N	0	P Q	R	S	Т	V W	Х	Y Z Z	AA AB	AC AI	DAE	AFI A	H AI	AJ	AK	AL AM AN AO AP AQ
	3280	LS		LtGyBn	WPS	fragmental-peloid		5	15	25		2							3							
	3283																									
	3286	LS		LtGyBn	WPS	frag-oncoid-skel		10		20		2			1				3		1			15	5E	
	3289																									
3292missi	3292	LS		LtGyBn	WPS	frag-oncoid-skel		10		20		2			1				3		1			15	5E	stylolite
	3295			I +CvDm	WD/C\C	anid from openid		25		15 5								1	2					40	ED EE	
	3298 3301	LS		LtGyBn	WP(G)S	ooid-frag-oncoid		35		15 5								1	3	1				10	5D 5E	
	3304	LS		LtGyBn	WMS	fragmental				8		1			1				2					2		
	3307			LiOyDii	*******	naginentai	Baccaro	Mbro	f Wa	do&Ma	cl as	an 1003	- 33	≀08m ~k	/ L c	ontact			_					_		
	3310	LS		LMGyBn	WFS	ooid-oncoid-frg	Daccard	15		10	I		- JJ			Jillaci			2					10	5E	
	3313					Ū																				
	3316	LS		LMGyBn	WFS	ooid-oncoid-frg		15	10	10		2							2					10	5E	
	3319																									
3322	3322	LS		LMGyBn	WFS	ooid-oncoid-frg		20	10	10		1?	1?				1	1	2				xx>	10	5D 5E	clotted ?microbial textures of oncoids??
	3325								40	40									•							
	3328 3331	LS		LMGyBn	WFS	ooid-oncoid-frg		20	10	10									2					10	5D 5E	
	3334	LS		LMGyBn	PWFS	Oncoid-ooid-skel		25	15	10 5		3						2 2?	9		1			10	5D 5E	
	3337			Livicybii		Oncola-cola-skei		20	10	10 3								2 2:	5						00 00	
	3340	LS		LMGyBn	PWFRS	Oncoid-ooid-skel		20	10	10 5		3						1 2?	5		1			20	5D 5E	
	3343			,																						
	3346	LS		LMGyBn	PWFRS	Oncoid-ooid-skel		20	10	10 5		3			3			1 2?	5		1			20	5D 5E	
	3349																									
3352	3352	LS	%s from ctgs	LMGyBn	PWFS	Oncoid-ooid-skel		20	10	20 5		3			3		1	1 2?	7		1			10	5D 5E	lithoclasts of ool etc; microbial clotted texture=oncoids? 8P
	3355			LMO D		0			40	00 5					40			4 00	-					40		
	3358 3361	LS		LMGyBn	PWFRS	Oncoid-ooid-skel		20	10	20 5		5			10			1 2?	7		1			10	5B 5E	
	3364	LS		LMGyBn	PFRS	Oncoid-ooid-skel		20	10	10 5		3			3			1 2?	5		1			20	5D 5E	
	3367			LIVICYDII	FIRS	Olicola-oola-skei		20	10	10 3					3			1 2:	3					20	JD JL	
	3370	LS		LMGyBn	PFRS	Oncoid-ooid-skel		20	10	10 5		3			3			1 2?	5					20	5D 5E	
	3373																								-	
	3376	LS		LMGyBn	PFRS	Oncoid-ooid-skel		20	10	10 5		3			3			1 2?	5					20	5D 5E	
	3379																									
3382	3382	00	ORE 4 81!m to 3400m	LMGyBn	PGFRS	Oncoid-ooid-skel		20	10	15 5		3			3				6					50	5D 5E	NOT REPRESNTATIVE OF CORE?? Small amt of ctgs 6p
	3385		nestone FS/RS	LMGyBn	PGFRS			20	10	15 5		6			3				6					40	5B	
skipped- in	3388 3391	on	colite-mollusc-	LMGyBn	PGFRS PGFRS	Oncoid-ooid-skel Oncoid-ooid-skel		20 20	10 10	15 5 15 5		3 3			3				6					50 40	5D 5E	
core zone	3394		id-peloid, thin coral bioeroded	LMGyBn LMGyBn	PGFRS	Oncoid-ooid-skel		20	10	15 5		3			7				6					50	5D 5E	
swc	3397		ef flat-backreef -	LMGyBn		ool-pel-mollusk		25	35	10		2			4			3 10		1	1			5	5D 5C	
	3400		oximal (lagoonal)	LMGyBn		ool-pel-mollusk		20	35	10		2			2			3 10			1			3	5D 5C	
	3403	Ľ.	· · · · ·																							
	3406	LS		LMGyBn	PGFS	pel-ool		15	50										8		1			5	5C	
	3409																									
	3412	LS		LMGyBn	PGFS	pel-ool-oncoid		15	50										8		1			10	5E 5C	
	3415	1.0		I MCvDs	DOEDO	and appoid from		25	10			4-							0		4			15	ED. ET	
3421	3418 3421	LS LS	poor small spl?	LMGyBn	PGFBS FWS	ool-oncoid-fram frambld-ooid-frg		25 8?	10 15	2		15			8 2		2		3		1			15 ??	5B 5E	small amt of ctgs M-WFS some VC spar/crinoid 5P
3421		LS	poor smail spr:	LMGyBn		oncoid-skel-coral		10		J		3			10		_		3		1			35	5B 5E	i i
	3427			Livicybii	1110	oncora onor corar		10																	02 02	
		LS		LMGyBn	FGPS	oncoid-skel		15	25	15		5						2 3	5		1			15	5E 5C	
	3433																									
		LS		LMGyBn	FWPS	ool-skel		10	5	10		3			1				5					8	5E	
	3439																									
		LS		LMGyBn	WPS	ool-skel		15	5	10		6			1				3	1 2						
	3445	1.0		I MCvPn	WDS	ool-skel		15	F	10						2			2	2						
	3448 3451	LS		LMGyBn	WPS	OUI-SKEI		10	5	10		4				2			2	2						
		LS		LMGyBn	WPS	ool-frag		15	5	10									2							
	J-10-			Livicybii	5	our mag		10	9										-							

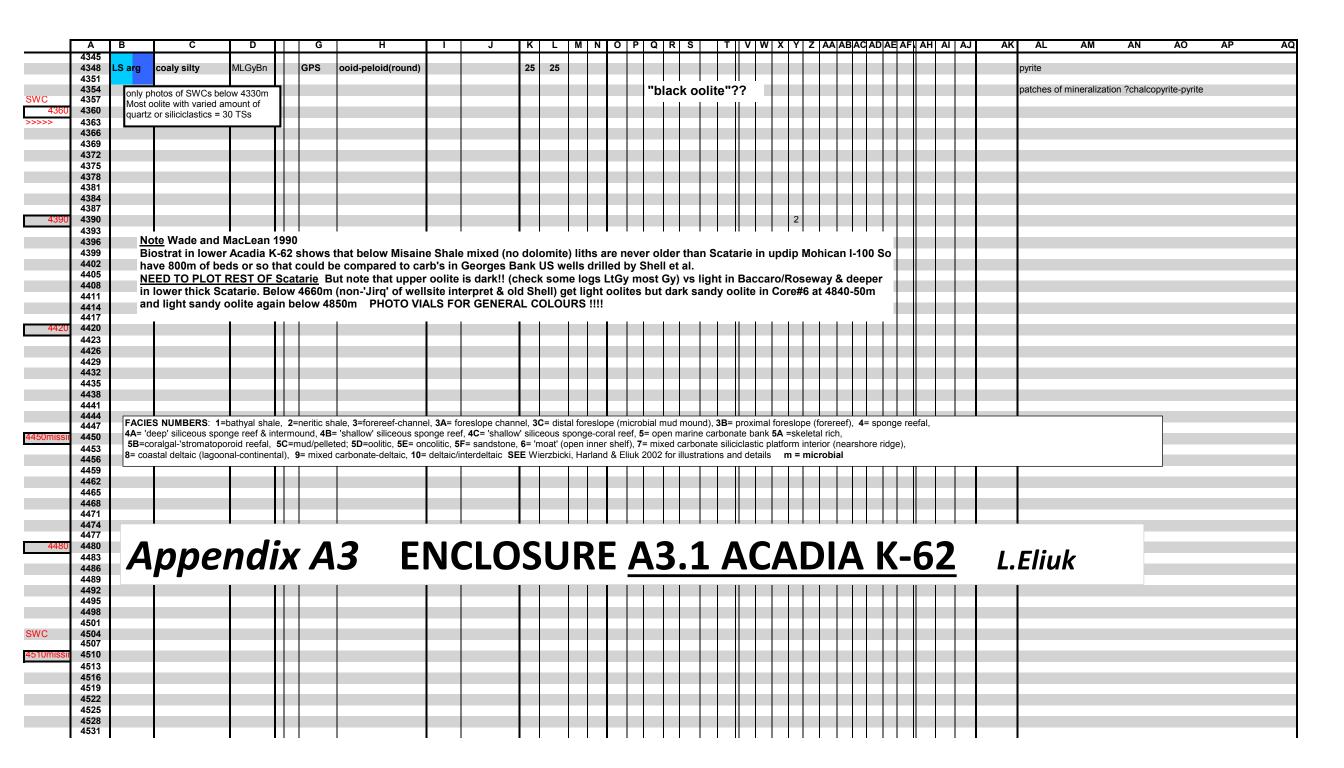
	Α	В	С	D	G	Н		J	K	L	M N	0	P Q	R S	T	V V	V X V	ΥZ	AA AB	AC AD	AE /	AFI AH	ΑI	ΑJ	AK	AL AM AN AO AP AQ
01110	3457								45	-	40															
SWC	3460 3463	LS		LMGyBn	WPS	ool-frag			15	5	10								2							
	3466	LS		LMGyBn	WPS	ool-frag			25	5	10														5D	
	3469																									
0.475		LS		LMGyBn		ool-frag			15	5	10				2				2							and and all added a distance of the side o
3475	3475 3478	LS	poor small spl?	LMGyBn	WpS WPS	frg-pel (clotted) ool-frag-oncoid			2? 15	10 5	10		2						3		1			7		small amt spls not too particle-fossil rich 5P
	3481			Livicybii	0	oor mag oncora			10	J	10													•		
	3484	LS		LMGyBn	WPS	ool-frag			15	5	10		2													
	3487			I MCvDn	WDO	ant not appoint			25	10	10		1						3 1					40	5D 5E	
	3490 3493	LS		LMGyBn	WPS	ool-pel-oncoid			25	10	10		2						3 1					10	an ac	
	3496	LS		LMGyBn	PFS	ooid-oncoid			30				2						4					15	5D 5E	
	3499			1.MO D					40	40	-								0 4					40		
	3502 3505	LS		LMGyBn	WFS	ool-pel-oncoid			10	10	5		2		2				3 1					10	5E	
	3508	LS		LMGyBn	WFS	peloid-frag				20			1											3	5C	
	3511																									
3517	3514 3517	LS LS dol	9/1 ?NOT REP?	LMGyBn	WFS WFS	frag-strom-oncoid frag-skel	3	intrafossil	5	10	15 15		10		1?		1		3 2 1						5B	5P
3317	3520	LS	OFF INOT KEP?	LMGyBn		frag-strom	3	ii ili ai OSSII	3	10	15		15		1 1				3		Ш				5B	or
	3523																									
	3526	LS		LMGyBn	WFBS	frag-strom					15		20		1										5B	
	3529 3532	LS		LMGyBn	WFBS	ool-strom-oncoid			15		10		10		2				4	1 1?				10	5B 5E	
3535	3535			0,		frg-pel-skel-strom			5	10	10			<2?	2				7		1		5?	5?	5B	9P
	3538	LS		LMGyBn	WFBS	oncoid-skel-frag			5		15		6		1				2					30	5B 5E	
SWC	3541 3544	LS		LMGyBn	PWFS	ooid-frag-oncoid			25	5	10								1					20	5D 5E	pyritic ooids
OVVO	3547			LIVICYDII	1 111 3	oolu-irag-oricolu			23	3	10								7					20	JD JL	pyritic collus
		LS	ooids F-C	LMGyBn	PGFS	ooid-frag-oncoid			35	5	10				2				3					20	5D 5E	
	3553			LMO: D=	DOEG				25	-	10				_				3					40	ED EE	
	3556 3559	LS		LMGyBn	PGFS	ooid-frag-oncoid			35	5	10				2				3					10	5D 5E	
		LS	F-C ooids	LMGyBn	PGFS	ooid-frag			50	5	10				1				2					2	5D	ooids in chalky matrix
	3565		F 0	1.MO D	D050						10															
	3568 3571	LS	F-C ooids	LMGyBn	PGFS	ooid-frag			50		10		2			1		1	2						5D	
	3574	LS		LMGyBn	PGFS	ooid-frag-oncoid			45	5	10		2		2				3					10	5D 5E	
	3577																									
	3580 3583	LS		LMGyBn	PFS	ooid-frag-strom			35	15			10		2					1				5	5D 5B	
	3586	LS		LMGyBn	PWFS	ooid-frag-strom			20		10 sp	icules 2	5			2			3						5D	
	3589					-															Ш					
3592	3592	LS	tr cr;t spg, microb	LMGyBn	PWFS	oncoid-frag-bivalve			5	3++	10	1	3	2?	?	1	2		10		1+ei	ncrust				see below 13P oid - thrombolite or in oncoids. Microxtl chert = sponge?zone
SWC	3595 3598	LS		LMGyBn	WFS	peloid-skel			5	20			5						3				IIN I	اک – د ا	ottea pei 5C	
	3601																									
		LS		LMGyBn	WFS	peloid-skel			5	20			3												5C	
	3607 3610	LS		LMGyBn	WFS	peloid-ooid-skel			10	20		2	3						3						5C	
	3613			LIVICYBII	1113	poloiu-oolu-skei				20			3												30	
	3616	LS		LMGyBn	WFS	oncoid-ooid-skel			15	5		1	2		5	5			2					15	5E	stylolites
	3619			I MOvDe	CDEBC		7	interportiol-	25						15				2 4	10	Ш				5D 5B	
3625		LS LS	<5%dol tr chert	LMGyBn	GPFBS WFS	ooid-coral-skel frg-skel-ooid?-micrb)	interparticle 3 tiny vugs Fr	35	8	10		6 3		15 2		2		3 1	1?	1		?	?	5D 5B	poor TS thin in part. Dolm-calc-filled hairline fractures 5P
5,20	3628	LS		LMGyBn		ooid-strom-bivalve		, . 55	15	_	5	2	8		1			1 1		2		2			5B	stylolites bivalves leached/spar some bored oysters
	3631		I	I								1														

Г	Α	В	С	D	G	Н	ı	J	K	L	М	N	O P	Q	R	S	T	۷	W X	ΥZ	' AA	ABAC	AD A	E AF	AH	Al A	J	AK	AL	AM	AN	AO	Al	•	AQ
	3634	LS		LMGyBn	ws	ooid-skel								3			1	1			2														
	3637																																		
	3640	LS		LMGyBn	WPF	ooid-skel-alga-onco	id I		20								3			2	4		1		7 re	d 1	0								
	3643 3646			LMGyBn	WPF	skel-oncoid-frag			2		5		2	2							8		1			1	0								
	3649	LS		LIVIGYDII	VVFF	Skei-oncolu-irag					5		2								0		1			- 1	U								
SWC	3652	LS		LMGyBn	W(P)	S skel-framebld			2		5			7			5	1			3		1			2	2	5B							
	3655			- 7	,																														
	3658	LS		LMGyBn		S frag-skel					10			1			1				3					3									
3661	3661	LS d	ol 9/1			frag-skel-microb	2?	micro vugs	8		15			3			1?		2	1	2		1	miliol	id				NB micro b	ored tiny	microbia	ıl/stromatol	ite		9P
	3664	LS		LMGyBn	W(P)	frag					8			2							3					1	0	5E							
	3667 3670	LS		LMGyBn	W/D)	S peloid-bivlave			3		15	2						1			10		1?						tr dolomite						
	3673	LS		LIVIGYDII	VV(F)	5 peroru-biviave			3		13	_						'			10		1 :						li dolomile						
	3676	LS		LMGyBn	W(P)	S peloid-oncoid			3	20		10									7		1?			1	0 5C	5E	tr pink & gre	een					
	3679					ľ																													
swc 3682	3682	LS		LMGyBn		S ooid-peloid-bivalve			15	10	5							2			10		1			5	5								
>>>>	3685		1.4.1	LMO D		pel-frg-microb-clast		tr intrafos	5			10?		2p	orou	IS		4	2VC		3		1? 2	2	1	10?		m	reworked p		clasts=cm	t early			10P
	3688 3691	LS	sl dolm	LMGyBn	W(P)	S ooid-frag			15	5	10							1			3		1?			3	3		pyritic ooids	3					
	3694	LS		LMGyBn	ws	ooid			15	2	5			2							2					3	2								
SWC	3697			LIVICYDII	110	oolu			13	2	5								m																
3700		LS 📕		LMGyBn	WMS	peloid				10											2														
>>>>>	3703	LS	tr dol Calcspar cm	nt	WPg	peloid-frg(microb)				25	15		?						1		3		11	?	1	15?		m	calcspar cn	nt interbd s	strom/mic	rob peloid la	yers		10P
		LS		LtGyBn	ws	frag-skel				20								3		2	2		1					m							
	3709			1.10 D	14/140	1 . 7 . 1				40	_										0		4												
	3712 3715	LS		LtGyBn	WMS	peloid				10	1										2		1												
	3718	LS		VLGyBn	WMS	peloid				10								5		1	1	1	1			? 2	,								
SWC	3721			120,2		poloiu																													
	3724	LS		VLGyBn	WMS	peloid				10								1				1	1												
	3727																																		
3730	3730	LS		VLGyBn	WMS	peloid				10													1			cisphe	eres				.00				
>>>>	3733 3736	LS LS	local calcsp blebs	VLGyBn	PMgS PMS	peloid (microB) peloid				40 25		2							1		1	1	2 1	1	1?	3		m	possible mi	cro subcm	it'?'?				6P
			CORE 5 3737m to 3753m	VLGyBn	FIVIS	peroru				25											'		1					m m							
			peloid WPS	VLGyBn																								m							
		LS	nterbeds microbial-	VLGyBn																								m							
	3748	LO	serpulid-sponge	VLGyBn																								m							
	3751		pafflestone	VLGyBn																								m							
	3754			VLGyBn																								m							
3760	3757 3760	LS	interbeds 7/3	Wt+lmBnG	v MW+	PS pel + ool-frg 8/2			10	15	10			1						1		1						m	lesser oolite	-oncoid fr	an PS in	nreater nelo	MS_M	S 3753.3	820m
>>>>	3763	LS	shelter calcspar	WUIIIIIII	MPS	peloid (microb)			10	20	10										1	'	1?			5		m m	icaaci UUIIII	Jilouu-II	ag i o iii	greater pero	1VIO-VV	0 01 00-0	10P
		LS	interbeds 7/3	Wt+lmBnG		PS pel + oncoid-frg-lith	oclast		10		10	7								1	2		1			-	0 5E	m	oids-oncoid						
	3769				1																														
	3772	LS	interbeds 7/3	Wt+lmBnG	y MW+	PS pel + oncoid-frg-lith	oclast		5	10	10	7									2		1			1	0 5E								
	3775			\A(I - I - D - D		20 1 1 1	ļ		10	00	40												4												
		LS	interbeds 6/4	wt+lmBnG	у /////// +	PS pel + ool-frg-oncoid	ı		10	20	10										1		1			1	0 5E	m							
	3781 3784	LS	interbeds 7/3	Wt+lmBnG	v MW+	PS pel+ oncoid-ool-frg			10	15	10									1			1			1	0 5E	m							
	3787		interpeds 775	WUIIIIIII	y 10100 T	per oncola-out-ing			10	13	10												'				JUE	111							
3790	3790	LS	interbeds 8/2	Wt+lmBnG	y <i>MW</i> +	PS pel + ool-frg			10	15	10										1														
>>>>	3793		poor TS thin midd	le	M-GS	pel-frag rd			5	20	10									1	2		?			2 5	5	m	rounded fra	g w occ sı	uperficial	coats, peloid	clasts/fr	ags (11P
		LS	s	Wt+lmBnG	y MW+	PS pel + ool-frg			15		10										1														
	3799		into the sile of	\^/+	84147	on all and from				-	7																								
		LS	interbeds 9/1	Wt+ImBnG	y //////// +	PS pel + ool-frg			7	7	7										1														
	3805 3808	LS	interbeds 9/1	Wt+lmBnG	v MW+	PS pel + ool-frg			7	7	7												3												
	0000		intorboad of 1		, I	,			•	•	'																								

	Α	В	С	D		G	Н		J	K	L	M	1 0	Р	Q	R S	LT.	۱ ا	v w	Х	ΥZ	ΑA	ABA	CAD	AE /	AF A	Н	I A	J	AK	AL	AM	AN	AO	AP	AQ
	3811			\A(1.1.5		MIALED	mal I aal fuu arresid			40	45	40											4							_						
	3814 3817	LS	interbeds 7/3	Wt+lmBn0	yز ا	WW+P5	pel + ool-frg-oncoid	l I		10	15	10										2	1	2				15	5 5E	m?						
3820		LS	interbeds 8/2	Wt+lmBn0	Gy	MW+PS	pel + ool-frg			10	15	10			1									1				5								
>>>>		LS	interbeds 8/2		Ш		pel + ool-skel			10	20	10			1			1				4		1	3		2	5 5		m						
		LS		VLGyBn		WPS	clast-ool-frg-skel			15		10 1	0 1		2			1			1	2		1		1	1				intraclasts, py some broken					
	3829 3832	LS		VLGyBn		(W)PS	ooid-frag			35												2		1	1						some broken		cropyrite			
	3835																																			
	3838	LS		M+VLGyB	n	PGS	ooid-frg-lithoclast			50		10 1	0					1				1									micropyrite					
	3841 3844	LS		M+VLGyB	n	PWS	ooid-frag			25		10						1						1												
	3847	LS		IVIT V LG Y L	Ì	FWS	ooiu-irag			23		10						1																		
3850	3850	LS		Wt+lmBn0	Gy		pel + ool-frg-clast			10	10	10 1												1												
>>>		LS	interbeds 8/2			MW+PS	pel-frg + ool-frg			10	20	10	1?s	spicul	е							1	1	?	1		1	ı		m	. (1 . PC .					8P
	3856 3859	LS arg		LtGy		WMS	peloid-ooid			8	8			POS	SIBLY	00ID								1							stylolitic					
		LS arg	interbeds 9/1	Wt+lmBn0	Gy G	MW+PS	pel + fragmental				10	15			ERBED									1												
	3865													CAV	/INGS?	???	[Ш																		
	3868 3871	LS arg		LtGyBn		MWS	peloid				10	5												1?							rare DkGy aro	g micaced	us pyritic a	rg LS chips		
	3874	LS		LtGyBn		ws	frag-peloid				10	20							1					1?												
SWC	3877																																			
3880		LS		LtGyBn			ooid-peloid			40	15	40												1?				2								400
>>>>		LS LS	interbeds 6/4	LtGyBn			peloid + ool-frg ooid-peloid			25 50	15 20	10			2				1	2			2	?	1			5	5D 5D		ooids vf-C so stylolitic ooid			all cmtd		10P
	3889			210,211			oolu pololu																								otyronae cora	g.a 00				
	3892	LS		LtGyBn		PGS	ooid-peloid	8	interparticle?	50	20											3	inoc	erami	id				5D	5C						
	3895 3898	LS	tr VF-F dolorhomb	I tGvRn		PGS	ooid-peloid			40	20											2	cor	ated				2	5D	5C						
	3901		tr VF-F dolorhomb			. 00	ooiu-peioiu			70	20											_	CUc	ileu						00						
		LS		LtGyBn		PS	ooid-peloid			30	10																		5D		stylolites, cald	cspar				
3910	3907 3910			LtGyBn		WPS	ooid-(peloid)			20	7																									
>>>>		LS LS	interbed-cave?	ЦСУБП			pel + ool-frg-pisoid			30	7 20	10						'		1	1	2	1	1?	1			5	5D							13P
		LS		LtGyBn			ooid-frag			10		10	POS	SIBI	Y OOII																stylolitic					
	3919	LS	interbeds 8/2	LtMBnGy		MIM/+DC	pel + ooid			15	10		INTE	RBE	DS =			2 1	?			2			10											
	3922 3925	LS	interpeds 6/2	LUVIBRIGY		WWTFS	per + ooid			15	10		CAV	INGS	???			<u> </u>	?						1 ?											
	3928	LS	interbeds 8/2	LtMBnGy		MW+PS	pel + ooid			15	10											1		1												
	3931											40																			-					***
	3934 3937	LS	encrusters	LtMBnGy		WFS	frag-frmbld(spg)					10	5		3							2		2				3			Tubiphytes er	ncrstg mic	rob encrsto	g spg; green	residue-cl	ay pyritic
3940		LS		LtMBnGy		W+PS	skel +ooid			20		3							2			6		2					5D		stylolitic					
>>>>		LS	interbed; tr VC cal	1	Ш		pel + ool-frg			35	10	5						Ш		1		2			1			3	5D		-					7P
	3946 3949	LS		LtMBnGy		PS	ooid			50														1?				2	5D		stylolitic grain	contact=	soln pressu	ire		
		LS		LtMBnGy		P+WS	ooid			40												3	1						5D		stylolitic					
	3955																														•					
		LS arg		LtMBnGy		WMS	(ooid)			10					2									1?							stylolitic					
	3961 3964	LS	interbeds 9/1	LtMBnGy		M+P	(pel-skel) +ooid			10	5		2		1				1		1 1			1		1	red?									
	3967			,			u,																				Ī									
3970		LS		LtMBnGy			(pel-skel) +ooid			15	5	40									1	2		1			1				stylolitic					
>>>>		LS LS	interbeds 8/2 interbeds 9/1	LtMBnGy			peloid + ool-frg (pel-skel) +ooid			10 10	20 5	10 5			L]]	U	_	1	1	1	?	1	2cor	nsortia 	1 5	5 5		5C	possible Litho stylolitic	ocodium-f	oram conso	лτιа		7P
	3979	_0					(poi-sitely roolu			.0	3				Р	POSSIB	LY OC	ID			'										Otylondo					
		ws	fracture spar	LtMBnGy		ws	pel-ool			5	3	2			2 11	NTERB	EDS :	•													stylolitic					
	3985		l									I	I	l		77			¦	1 1	1			l			ı	l	I							

ſ	Α	В	С	D	G	Н	I J K	L	M	N C) P	QI	R S	1	- V	W X	ΥZ	' AA	AB A	CAD	AE A	AH	Al	AJ	AK	AL AM AN AO AP AQ
	3988	LS	interbeds 9/1	LtMBnGy	M+PS	(pel-skel) +ooid	10	5	5									1		1?						
	3991																									
	3994	LS		LtBnGy	PS	ooid (pel)	50	5										2							5D	
	3997																									
4000		LS	1.1.1.1.2.00	LtBnGy	WPS	ooid (pel)	20											2	1	1?					5D	and the second section of the sectio
>>>	4003	LS	interbeds 8/2	L AD TO CO.		peloid + ool-frg	10	25		pel in						2	1	1		1?	1			2	5C	possible geopetal-cmt in cavity in pel PS 9P
	4006 4009	LS		LtBnGy	ws	frag-(skel)			7	2	2	1					1	2								
		LS		LtBnGy	MWS	(ool)	5													12						
	4015			Libridy	milio	(OOI)									1					1.						
	4018	LS		LtBnGy	WPS	ooid (frag)	12	4												1?						
	4021					3,																				
	4024	LS		LtBnGy	MWS	fragmental (ooid)	2		8								1		1							
	4027																									
4030	4030	LS		LtBnGy	MWS	(ooid)											1		1							
>>>>	4033	LS	interbeds 7/3			pel-micrb + ool-frg	15		10	2		_11_	_J			2	1?	2			2		5	2	m	
	4036	LS	interbeds 7/3	LtBnGy	M+PS	(pel-skel) +ooid	20	2				Y 00ID	·		1			1	1	1?	1				5D	^chipe radial & tiny broken ooids
	4039		interbode 7/2	I tDnCv	MIN/+DC	pel + ooid					INGS	DS =	- 4	1	?		1		2							broken et delitie enide
	4042 4045	LS	interbeds 7/3	LtBnGy	WWTFS	per + ooiu				CAV			,		?		1		2							broken-stylolitic ooids
	4048	LS		LtBnGy	ws	peloid												1	1	2						possible birdseye texture??
SWC	4051			Libridy	110	peroru													•							8P
	4054	LS	interbeds 9/1	LtBnGy	M+P	(pel) +ooid	7	2										1		1	1					stylolitic
	4057					" ,																				ľ
4060	4060	LS	interbeds 9/1	LtBnGy	M+P	(pel) +ooid	7	2										1	1	1	1					stylolitic
>>>2 TSs	4063	LS			WPS	pel-microb-frg	2	40	10	3 2	2									1	2		15	1	m	some forram-microb consortia?? Tr VC ooids-oncoids
	4066	LSslarg	argil LS	LtMBnGy	MWS			3									1	2	1	1						
	4069																									
		LS arg	argil LS	LtMBnGy	M(W)S										1					2						
	4075	1.0.011	orail I C	MdCv(Dn)	MWS			2	3								1			1				_		mioranywita
	4078 4081	LS SH	argil LS	MdGy(Bn)	INIVVS				3								1			1				5		micropyrite
SWC		LS SH	argil LS	MdGy(Bn)	MS													1		1						micropyrite
0110	4087	20 011	argii LO	Macy(BH)	INIO																					тисторупис
4090	4090	LS SH	argil LS	MdGy(Bn)	M+WS	(ooid bed/cave)	7										1	1		1						micropyrite
>>>>	4093	LS sltSH	LSstylolitic sltySH	, ,	WPgS	peloid-(ooid)	5	35	5					13	frg			2		2	2cons	ortia		2	m	
	4096	LS SH		MdGy(Bn)	MS												1?			1						micropyrite
	4099																									
	4102	LS SH	argil LS	MdGy(Bn)	M+WS	(oncoid bed/cave)							e S				1							5		micropyrite
	4105			MIO (D.)	14.14/0	(.1.1		_					x S											_		
	4108	LSsdySH	argil LS	MdGy(Bn)	M+WS	(skel-ool bed/cave)	5	2	4				ат 📗			5	2							3		micropyrite
	4111 4114	LS SH	argil LS	MdGy(Bn)	M+WS	(oncoid bed/cave)			4				m ic				1			1				5		micropyrite
	4117	LO 011	aigii Lo	Macy(BH)	101 : 003	(oncold bed/cave)			7				n o				'							٦		micropyrite
4120		LS SH	argil LS	MdGy(Bn)	MS								e n		1?					1						
>>>>	4123		5% calc arg vf qtz		MWS	(micro) peloid		15	3				t f e							1	1				m	7P
	4126		argil LS & SS beds		MS	, , , , , , , , , , , , , , , , , , ,				1	1		o n							1						
	4129												r t													
SWC	-	LS SH	argil LS	MdGy(Bn)	M+WS	(ooid bed/cave)	10						h							1						qtz nucleii in ooids
	4135												i 📙									<u> </u>				
		LSSHSS	argil sandy LS	MdGy(Bn)	MS			2?				1	g					1		1	1	10	alcisp	nere	?	
	4141											Ш,	n 📙													
	4144	LSSHSS	argil sandy LS	MdGy(Bn)	MS															1						
4150missir	4147 4150	SScalc	Fqtz Vcalc sl shly	I tGv	99 (E)	oolitic (pel?)	15											1		1						pyritic
413011118811	4150	Jocaic	I YEZ VEGIC SI SIIIY	LiGy	33 (F)	contic (perr)	15		NA:-	ol = c	, CL	ole M	one b		152											pyriuc
		SScalc	Fqtz V,calc V shly	LtGv	SS (F)	oolitic (pel?)	15		IVIIS	aine	; on	ale M	empe	<u> :r - 4</u>	153M											
	4159		,= :,:23.0 · 3111y	,-,		(, ,																				
		SScalc	Fqtz V,calc V shly	LtGy	SS (F)	oolitic (pel?)	15																			micropyritic
	4102	CCCCIC	i qız v,caic v siliy	LiGy	33 (F)	contic (perr)	15																			пісторупіїс

	Α	В	С	D	G	Н	I J	K	L	M N	0	P Q	R	S	Т	V W	X	ΥZ	AA	ABAC	AD	AE AI	F. AH	AI .	AJ	AK	AL AM AN AO AP	AQ
	4165																											
	4168	SScalc	Fqtz V,calc V shly	LtGy	SS (F)	oolitic (pel?)		15		TS notes	: larg	ge M-VC	ooids	do not h	have c	tz nucl	ei (frg	, ech	, crin)i	but sr	nall o	oids \	/F-			m	nicropyritic	
SWC	4171 4174	SScalc	Fqtz V,calc sl shly	I tCv	SS (F)	oolitic (pel?)		15		M may ar	nd bo	th occur	in calc	: VF-F e	equant	t angula	ar qtz	SS. S	Soln co	ontacts	sesp	w/ qtz	<u> </u>			m	nicropyritic	
3000	4174	Socarc	rqız v,caic si siliy	LiGy	33 (F)	oontic (per?)		15		ALSO NO	JIEC	oolds ab	ove the	4180 1	IS do	not hav	ve qtz	nucle	ell at a	II appa	arently	y!!				1111	пісторупіїс	
4180	4180	SScalc	Fqtz V,calc sl shly	LtGy	SS (F)	oolitic (pel?)		15																		m	nicropyritic	
>>>>	4183	SScalc	AA		SS(vf-F	oolitic W-GS		20	3	3							2	1	1			1			1		sandstone very calcareous to a limestone estimate 60/40	13P
SWC	4186	SScalc	Fqtz calc shly	LtGy	SS (F)	oolitic (pel?)		15																	3	m	nicropyritic	
	4189 4192	SScalc	Fgtz calc SHLY	LtGy	SS (F)																							
	4195	Socarc	ryiz caic Shlit	LiGy	33 (F)																							
	4198	SScalc	Fqtz calc SHLY	LtGy	SS (F)																							
	4201		·																									
	-	SH =dy	marly silty	LMGy-GyBn	SH			l ITS	notes	: similar	to abo	ove oolit	ic F atz	sandst	tone b	ut som	e biva	lve n	ucleii a	and ra	re cor	mplete	elv					
4210	4207 4210	SH sty	marly silty	LMGy-GyBn	SH					ized ooid:													,					
>>>>	4213	SScalc	interbeds w SH??	LiviGy-Gybii		oolitic W-GS		15	3	3					П		1		2			1				sa	sandstone very calcareous to a limestone estimate 70/30	18P
		SH sdy	marly silty	LMGy-GyBn	SH																							
	4219																											
		SH =dy	marly silty	LMGy-GyBn	SH																							
SWC	4225 4228	SH suy	marly silty	LMGy-GyBn	SH																							
SWC	4231	OII SU	illally Silty	LiviGy-Gybii	SII																							
		SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
>>>>>	-		calc interbeds?		MS				2																	m	nottled texture believe more carb than clay?: 8/2=SH-LS/SS	11P
4240	-	SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
SWC	4243 4246	SH	sl calc Tr LimeMS	MdCv	SH	carb specks																						
SWC	4246	эп	Si calc 11 Lillieivis	ividGy	эп	carb specks																						
		SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
	4255																											
		SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
	4261 4264	SH	sl calc Tr LimeMS	MdGv	SH	carb specks																						
	4267		Si cale 11 Limewo	Macy	On	си в эрсскэ																						
swc 4270	4270	SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
>>>		SH MARL	LS arg microbial		MS	microbial pel ARG		1	10micr	О											1 2	2cons	ortia	10		m	ninor qtz silt-vf in arg LS-calcSH Fe ooid???	9P
	4276 4279	SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
SWC		SH	sl calc Tr LimeMS	MdGv	SH	carb specks																						
00	4285	011	or care in Emiliano	Macy		ош в ороско																						
		SH	sl calc Tr LimeMS	MdGy	SH	carb specks																						
	4291																											
SWC	4294 4297	SH	sl calc Tr LimeMS	MdGy	SH	carb specks			0-	-4	N 4		400	F														
4300missii		LS Shly	MARL	LMGy	MS	marly			SC	atarie	wer	nber	- 429	5M														
	4303																											
		LS Shly	MARL	LMGy	MS	marly																						
	4309 4312	LS Shly	MARI	LMGy	MS	marly																						
	4315				IVIO	marly																						
	4318	LS Shly	MARL	LMGy	MS	marly																						
	4321 4324	IS	F-C grains	MLGyBn	G(P)S	ooid-peloid(round)		35	35																	m	nicrite-spar cement of dark ooid-peloids	
	4324		_			ooiu-peioiu(rouilu)																					monte spar cement of dark colu-pelolus	
4330	4330	LS	F-C grains	MLGyBn	G(P)S	ooid-peloid(round)		35 30	35		4.5																0.1.10	
>>>>	4333 4336		interbeds? F-Vcoc F-C grains	oids MLGyBn	GPS G(P)S	ooid (slty marl inter ooid-peloid(round)	beds?)	30 35	10 35		1?						3	2	2		1?	1			3	in	nterbeds or marl cave. Stylolitic contacts	13P
	4339		i -0 grains	IVILGYDII	G(F)S	ooia-peioia(rouria)																						
		LS	F-C grains	MLGyBn	G(P)S	ooid-peloid(round)		35	35																			



Enc	losur	<u>e A3.2</u> PE	X <u>Albat</u>	_		3 (JABK)	oTours	Consulting Inc	: L	.Eliul	k P.Ge	eol. 2	006-0	1 to ()3 (lo	g all s	ample	s exc	ept al	erna	ites a	at top	& bo	ttom)						& C	PAGE	
DEPTH (LITH	modifier I	COLOR	TEX	XTURE		POROS	ITY	ACC	ESS	ORIES					FOS	SILS		(enh	ance	d by	swc	data	<mark>if</mark> avai	lable	_			TYPI	k'78'88 k 2002	COMMENTS	
T=trip 0	DOL SH= SS=: SLT: arg= calc	imestone =dolomite shale sandstone ST=siltstone argillaceous -calcareous s sandy/qtz	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=w PS=pa GS=gr BS=bo (FS/RS FS=flo RS=ru	udstone 1 ackestone 3 ckstone 5 ainstone 7 pundstone 9 3=XC size) atstone 4 dstone 8 crystalline	%	modifier (Archie)	OOIDS	PELOIDS	PARTICLES LITHOCLASTS	SPONGES 14	WT SPONGES.	STROMATOPOROID. CI	CHAETETIDS BIG		MICROSOLENIDS HEXACORALS	BRYOZOANS	BRACHIOPODS	FCHINOIDS	GASTROPODS	BIVALVES	OSTRACODS	TUBIPHYTES etc	FORAMINIFERA	BORINGS HIGHER -green etc D	TGA STEEL ST		MICR	lugel'82&Wilson'75&Eliu Vierzbicki, Harland&Eliul	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen	
Α	В	С	D		G	Н	-	J	Κ	┖	М	N () P	Q	R	S	T	\ \	/ W	ΧY	/ Z	AA	AB A	CAD	AE /	AF.	M A	AI A	IJ ຶ	L -	AL	
Α	В	С	D		G	Н	ı	J	K	L	М	N () P	Q	R	S	Т	V	/ W	ΧY	/ Z	AA	АВ А	CAD	AE /	AF /	AH A	AI A	<u>u</u>	AK	AL AM AN AO AF	AC
2450																		Ш														
2455 T																																
	SHcalc	tr mical-qtz silt	MdGy									_																	_		10% Fe flakes in shale	
2465 2470	LSarg	SH-AA tr dolm	MdGytrRd		tr-2	inter xtl dolm f rhom	h																								tr porosity (10%?+) dolmM	
2475	Louig	S.T. C. G GOIII	wideyurid				Ĭ																								ctgs TS 2480m = red areas in ooids & cmts/geopeta	ls
2480	LS		Wt+Pk	7	GS	oolitic (F-VC)			70		1	tr										1	?	?		1	1?		5		tr C(VC) grapestone TS=some red areas in ooids &	
2485 T?																						rue	liet?								CASING 2483.5m	
	LS		Wt+Rd-Y	7	G(P)S	oolitic F-C(VC)			60		1	tr									1	14	17?						5	D	tr gastropod-foram (algal)nucleii reticulate pattern ?ru	dist 4F
2495	VDC	Casina Camant																													1000/	
2500 2505	VPS	Casing Cement																													+90% casing cement	
	LS		Wt(trY)	7 9	BFS	coral-stromatop	tr+		10+		20			15			5? 10	Ш				3	1		1				5	D 5B	20% casing cmt&Fe bits astrothizae	3F
2515 T			()					id GS 2511.5-				I GS v	w ope						red g	eope	tals?	??									CORE 2511-2517m (ooid GS some dolm cmt,dasyclad?	
2520 T	LS	ooids-F-M(VC)	Wt+Pk-Rd	7 4	G(F)S		17m		50		1	0		1?	·		1?	П	ΙĪ	Ť	?	2	1		?			5	i? 5	D	Fe bit	2F
2525						_																										
2530 2535	LS	ooids-F-M	Wt-VLGy	7 4	G-FS	ool-skel(FRG)			60		1	15		5			5			? 1	ı	5	2		1		2	1	0 5	D	tr VC spar calcite (=SPC)	
	LS	ooids-F-M	Wt-VLGy	7 4	GFS	ool-skel-lithoclast			50		2	20		1			5			1 2	,	5	2		2				5	D	red coral clasts!	
2545		coldo i Wi	W VEGy	1	0.0	COT CROT INTICORDE											Ĭ				-		_								Tod doral diadio.	
2550	LS	ooids-F-VC	Wt+PkRd	7 4	GFS	ooid-lithoclast(rd)		l l	40	10	1	red 15		3			1			3 2	2	5	2		?		2	2	2 5	D	tr dessiminated VL pale green	
2555					54m Rosev		012 but po	oor paleont used s	eismi																							
	LS		Wt(vlGy)	7 4	GFS	ooid-clast-strom			40	5	10 1	10 1	+	10-	٠		3			1 1	1 3	3	1		?		5		5	D 5B	yellow=?dolm cmt? Framebuilder clasts?	4F
2565 2570	LS	ooids f-VC	Wt(vlGy)	6 4	GPFS	ool-skl-strm-clast	3-5	Vug SPC-intx	35		1	10	.	15	5+	2	5	1 1		3	2	1	1		2		2		_	D 5B		2F
2575	LS	oolus I-VC	vvi(viGy)	0 4	GFT3	OUI-SKI-Sti III-Clast	3-3	vug SF C-IIIIX	33				'	10	J.	_		Н.		3	1	-	1				_			JD 35		21
	LS		Wt(vlGy)	6 4	GPFS	ool-skel-clast-frg	5	Vug SPC-intx	30		10 1	10		5	1	1	2			1	2	4+	1		1		2		5	D		
2585			()				_																									
	LS		Wt(vlGy)	7 4	GFS	ool-strom-calst	5-10	Vug -interxtl	25	5	10	5		2	:0		5+	-		2	2 ?1	5	2		1				5	D 5B	5-10% rextl spar calcite F-VC (coral?)	
2595																																
2600	LS		Wt(vIGy)	7 49	GBFS	strm-ool-skel-coral	10	M-C interxtl	20		10 1	10	1	30	1	1	10) [1 1	1	5	2+		1			2	2 5	B 5D	corals rextl/infilled	3F
2605																																
	LS	tr F qtz	Wt(vIGy)	7 49	GBFS	strom-frg-skel	5+	vug - interxtl	5	10	15 1	10	13	25		3	?2	+		2 ?	1 ?	5	2		1		2		5	В		4F
2615			14/1/ 10 1		050				4.	_	0.5	5					21															
2620 2625	LS		Wt(vlGy)	7 4	GFS	frg-strm-ool-skel	5+	vug - interxtl	15	5	25	5		10			2	<u> </u>				3	1		1				5	D 5B		
	LS		Wt(vlGy)	7 1	G(P)FS	strom-ool-pel-frg	tr-3	vug	15	15-	10	1	?	20			23			7	,	2	2		2				5	B 5D	pyrite M-VC SPC	
2635			vi(viOy)	, 4	3(1)13	oom-oor-per-ing	0	, ag		10-	10			20									_							<u> </u>	PJ.11.0 111 VO 01 0	
	LS		Wt(vlGy)	9 49	BF(G)S	strom-skel-frg	3-tr	vug	5	2	10	5	+ ?	30	103	1	5					5	1						5	В	stylolites corals in clast NB FvsC stromatoporoid str	
2645																															2665m=15% dk grey calc shale cuttin	
	LS		Wt(vIGy)	7 4	GFS	strom-ooid-frag	2-3	vug - IBC	20		20	5		25						3		3							5	B 5D	XC SPC similar to SH above Abk but casing se below so shouldn't be cave??	t 3F
2655		M C dalas sali	MH/s IO: ID		OFC	atuam aaid fusu	200	una Lintand	10		10			-			31			2										D		
	LS <u>/</u> LS <u>/</u>	M-C dolm xtls 3%DOLaa	Wt(vlGyB) Wt(vlGyB)	7 4	GFS G(W)FS	strom-ooid-frag ool-frg-strm-cor	<3? 2-3	vug + interxtl vug + interxtl	10		10 10	2	<u> </u>	10		strom	۱:۶: -like ۱ <u>۱</u>			2 1?		4	1		1	1	encr	ust 5			Csg Cmt Big chip of birdseye lime mudstone 15 % calc shale = cave??	4F 10F
	LS <u>/</u> LS	J /ODOLAA	Wt(vlGyb)			frg-skel-strm-coral		Vug + Interxti V-interxtl IBC		3	30 1	10		10		?	10			+ : 5+ ?	>	5 5	2		?1	`∥₁	?2	3			F-XC skeletal-fragments	2F

Α	В	С	D	G	Н	I	J	K	L N	I N	0	Р	Q	R	S	Т	V W	X Y	ΥZ	' AA	AB A	AC AD	AE /	AF, A	H AI	AJ	Α	
2675	LS	small ctgs	Wt+PkRd	6 4 GPFS	ooid-frg-skel(frbld)			20	5 20				6	<i>'</i>	?	5		5	1	7	2		1		3		5d 5	
2680	LS <u>/</u>	tr-2 dolm f-m rhomb	Wt+PkRd	7 4 GPFS	frg-skel-ooid	3+	IBC interxtl	10	2				8			2+		3?		4			1		enc		5D 5	
2685	LS	3-5 DOL	Wt	7 4 G(P)S	ooid-frg-skel(frbld)	tr-3		25	5 20	0			6	′	?	5		5	1	7	2		1	encru	st 5		5d 5	
2690	LS <u>/</u>	2-tr dolm rhombs	Wt+PkRd	7 4 GFS	ool-frg-strm-skel			20	1	5 10			20			2+		1	1	10			2				5B 5	ooids to VC yellow foram-stromatoporoid 3P
2695	LS <u>/</u>	tr dol Lg Ctgs	Wt+PkRY	6 GP(W)S	frg-pel-ool-skel(FB)			10	15 20	0 3	1		15		1	5		3	1 1	10			1+	1 1	?		5bd	(pure peloid GS,Oiid GS & mix skel) 10P
2700	LS <u>/</u>	dol tr	Wt+PkRd	7 4 GPFS	frg-skel-clast(coral)			5+	20	0 10	?		7+	_ <i>'</i>	?	9				5	2		2	1	•		5B	larg 9C-VC) pyrite crystal 3P
2705	LS		Wt+PkRY	6 GP(F)S	frg-pel-skel			3	15 20	0 3			3			3		3		3	?		2	7	•		5a	coarse stromatop may = meandroid coral 2P
2710	LS		Wt+PkRd	7 4 GFS	frg-strom-pel-skel	<3	M-F interxtl	5	10 2	5			15			?			2	4	1		1				5B	
2715	LS		Wt+PkRY	5 GPWS	frg-ool-skel-strom			15	7 20	0 2			10	1		2		4	2	5	1		1		1			d yellow-red ooid GS Beds strylolites 6P
2720	LS		Wt(PkRd)	6 GPS	frag-skel-ooid	<3	F interxtl		5+ 20	0 ro	und		8			1?		3	1	6	2		1				5AB	
2725	LS <u>/</u>	1-2 dol tr SPC	Wt(PkRdY	6+3 W+GPS	ool-pel-skel			20	20	0 5			5	2		2	1	2		5			1				5d 5	limonitic (yel) brch bryozoa, crinoid, shell WPS beds & qtz-rich shell WPS 6P
2730	LS		Wt	7 4 G(P)FS	ool-strm-frg-skel	3	IC interxtl	20	5 1				15+			?2+		5			3	?	2+	7	2		5D 5	oyster bivalves caclite fractures 4P
2735	LS	vf qtz SPC	Wt	7+3 G-WS	ool-frg-skel-strom			15	5 1	5 5			10?			1?		4			2		2	1	2+	1+	5b 5	d 4P
2740	LS <u>/</u>	2%dol rhomb	Wt	7 4 GPS	ooid-frag-skel	3+	F interxtl	15	1	5		16	3 +			?1+		3	-	7			1	1	•		5D 5A	
2745	LS <u>/</u>	2%dol rhomb	Wt	4+7 G+PWS	ool-pel+frg-skel	3+	intrafos & V	10	8 20	0 3			10	1		2		7	3 1	6	2		2			1?	5b 5	d stylolites 7P
2750	LS		Wt	6 4 PGFS	frg-strom-skel	5+	M-C interxtl	8	5 20	0 ro	und .		15			?1		3		5+			?				5B 5.	I A
2755	LS/DOL	8/2	Wt(vIGyB)	4+7 G+PWS	ooed + skel-frg			15	5 2	5 5			3					5 '	?	5+	2		2				5d	stylolites 4P
2760	LS/DOL	6/4?v.calc	Wt(vIGyB)	7 4 G(F)S	frg-ool-skel	5-10	Vug+intxtl M+	15	20				7+			2?		3	5	3			1?	1			5D 5A	B some FM SS grn skel?=cave? Olive grn calc dol? 3P
2765	LS/DOL	8/2 f qtzSS SPC	Wt(vIGyB)	6 GPS	frg-skel(crin)-pel			3	10 30	0			3	1+		1+		?8+ '			3?		2				5a	! Vf Glauc skel-rich qtz SS(stroms, shells) 6P
2770	LS/DOL	9/1 m-c SPC?	Wt-vIBGy	5 4 P(G)FS	frg-skel(-strm/ool)	5-10	Vug+intxtl M+	8+	20	-			8					2	2-		1			1 1		2	5A	B tr grn clayey SS? (cave) 2P
2775 T	LS <u>/</u>	3%DOL tr QTZ	Wt-vIBGy	5 P(F)S	pel-frg-skel	5	Vug+intxtl M+	5	25 25	5			3			2		3	2-	+ 7+	4		2	1 clar	n in co	oral	5c	FE filings & small ctgs (clam bored coral 2-x16) 5P
2780	LS	(ooid=F-VC)	Wt-vIBGy	6 PGS	pel-ooid-skel	3?	vug-spc		30 10	-			3+					1 :	2	4	1			1	?	1		A many loose free ooids!?
2785	LS <u>/</u>	5 DOL	Wt-vIBGy	PFGS	frg-ool-skel-pel-strom			15	10 20	0 10	3	1	10	2	2	5		3	2	6	2		2	2	2			red broken shells-stromatoporoies stylolites 7P
2790	LS	(ooid=F-VC)	Wt-(rd)	6 4 PGFS	ooid-skel-frg-clast	3-5	vug f-mSPC	25	5 10	0 10		1	5			?		2	2	?	 	_ I				3+	5CD 5A	B yel-clear M-C SPC=vug lining free ooids-disaggr tr pyrite 3P
2795	LS/DOL	8/2	Wt-(rd)	PGFS	frg-ool/skel-clast-strom	5-6	dol xtl V	15	5 1	5 10	1?		10			2		5	1 2	! '.S	pine t	base					5b 5	well reddened skel/stromatopoid clasts broken shells-crir 6P
2800	LS/DOL	9/1 f-c SPC?	Wt-vIBGy	7 4 GFS	ool-frg-strm-skel	5-10	vug+interxtl	40	10 20	0 5,	1,1	1	15			5?		2	УC	5							5D 5	3
2805	LS/DOL	8/2+	Wt	7 4 GFS	frg-skel(strm)pel	2-tr	V+interstl	8	12 20	0 10	1		15	2	1 2	5		5	3 2	başĕ	2		2	1 2	2		5d 5	DkGy ?milliporidium coral clasts f-m stl dol w porosity (x16) 9P
2810	LS	?DOL or SPC?	Wt-vIBGy	6 4 GPFS	frg-pel-strom	5-8	vug c-m SPC	5	20 20	0 5	2	5	15			1?		3	1 1	4	1		?				5C 5	tr intraclast-strom porosity 5P
2815	LS/DOL	7/3	Wt "	7 4 G(P)FS	frg-pel-skel(strm)	7+	interstl-dol	5+	20 2	5 10		1	9			2		6	1	5	1		1	7	•		5d 5	vug lining&interxtl dolm-porosity 6P
2820	LS/DOL	9/1 F xtl	Wt-vIBGy	6 4 GPFS	frg-pel-strom	5+	Vug c-vcSPC	2	20 20	0 10			10			2?		1	1	4							5C 5	tr XC dk gy round clast in pel-frgGS 3P
2825	LS		Wt "	6 4 GP(W)FS	frg-pel-skel-strm	tr-2	Vug c-vc SPC	2	20 30	0 5	2	3	10	1		3		2	2-	+ 5	2		2	II iliolid	1?	1	5c 5	coarse & fine celled stromatop (?spg or coral?) 4P
2830	LS		Wt-vIBGy	7 4 G(P)FS	frg-pel-skel-strm	tr	vub m-cSPC	3	20 30	0			10			5		2	1	4	1		2 "	IIIIOIIU			5C 5	rextl/leached corals strom=clasts REEF FLAT/SLOPE? (X40 foram)4p
2835	LS	small ctgs	Wt "	6 GPS	frg-pel-skel			2+	10 3	5 3			3	2		?		2		3	1		mi	liolid	2 ?		5a	micritezed&rounded frgs0dkel some green stain stylolites 3P
2840	LS	·	Wt-vIBGy	5 P(W)S	skel-frg-pel				15 20	0		2	2			1		3 2	2 2	5	1 1	1?	2	2	2		5.	A stringer F RD SS in lime MS/cmt (?scaphopod) (X16 foram) 3P
2845	LS	tr qtz (chalky)	Wt "	5 4 P(W)FS	frg-strm-pel skel				10 20	0			15	2		1?		2		3	1		1+		1+	1?	5b	loose VC ooids (?cave) 3P
2850	LS		Wt-vIBGy	3 4 WFS	strom-pel-frg				15 1	5 r	dund	1	15+					1 '	?	3	2 1	1?	1	2	2		5	stromatoporoid rextl or clear cmt
2855	LS	big ctgs	Wt - (")	7 49 GRBS	strom-frg-pel-skel	1-3	V-free SPC	5+	15 2	5 5	1		35+	? :	3	2?	?	3+ '	? 2	5	2 1	1?	2+	1	+ 5?		5b	several stromatoporoid types (7thumbholes, 5macros, x16) 31P
2860	LS	small cuttings	Wt-vIBGy	4 (G)PWS	frg-pel-skel	tr	vc SPC	2	15 20	of-m			3					2		2	1		1	1	?		5.	uniform 'chalky' white
2865	LS	·	Wt - (")	4 4 WPFS	frg-strom			3	5+ 1	5	1		20			?		2		3	1		1?	1	2		5b	chip qtz sandy LS 4P
2870	LS	1%vc-c cl SPC cm	Wt-vIBGy	6 GPS	frg-pel-skel			2	10 30	0		1	7			1?		5		4	2		1				5A	В
2875	LS		Wt - (")	2 4 MWFS	strom-frg-skel				5 10	0 2	3		20	1		1+		2	?	6	1	1+	1		1+		5b	
2880	LS	small cuttings	Wt-vIBGy	2 PWS	frg-pel (vf-f/m)				10 20	0			2					2		2							5ac	
2885	LS	small cuttings	Wt - (")	7+3 G+WS	frg +pel-skel(cor)				10 20	0 5			3+			10?		2?		2?	1		1		?		5b	2 lg chips = rextl coral + WS/PS interbeds 2P
2890	LS	small cuttings	Wt-vIBGy	3+7 G-WS	frg-pel-skel			3	20 20									3		2	1+		1	1	?		5C	
2895	LS	small cuttings	Wt - (")	7+34 G+WFS	frg-pel skel(strm)			5	10 20	0 3	1?		6			1		2	1	3+	1+ 1	1? ?	1	1	? 1-2	?	5abc	3P
2900	LS	small cuttings	Wt-vIBGy	2 WMS	frg-pel (f-vf)				10 1	5 2			1					1		1			1				5	
2905	LS	small ctgs chalky		2 MW(P)S	fragmental			?	5 1	gund			2			?		3		2			1				5	P
2910	LS <u>/</u>	3%vf dol rhomb	Wt-vIBGy	3 4 W(F)S	frg=pel-skel				15 1	5			7			1		2		3	1	1	2				5A	B 2P
2915	LS		WT	4 WPS	frg-pel-skel	tr	intra strom	2	10 1	5			4			1?		3		2 y	1		1				5ac	
2920	LS	1-tr vf dol brn	Wt-vIBGy	3 WS	frg-pel-skel	tr	sucrosic dol	3	10 1				1					1 2				1	2		2?		5A	tr-2% ool GS brn-dol or sphalerite oysters? (x16dol) 4P
2925 T	LS <u>/</u>	1% DOL 5%SPC	Wt - (")	5 4 PFS	frg-strom-cor-skel	1-2	V-ICD freeSP	3	3 20	0 3	1		10	1		10		3 '	? ?	7			1	1 1	? 2		5b	FE filings bivalve microquina!! Round lithoclasts (X16) 6P
2930	LS	tr vc SPC	Wt (pkrd)	5 P(G)S	pel-frg-skel				20 20				5			2		2+	1		1		1	2	?		5C 5	A stylolite tr micropeloid GS 2P
2935	LS	tr vc SPC	Wt - (")		frg-skel-pel			3?	10 30	0			6			3		2		5	2		1?				5abc	
2940	LS		Wt-vIBGy		frg-pel	tr-2	vug-tr m SPC		10 1	5	1		2			1?		?				1	1				5	
2945	LS _/_	tr-2% DOL	Wt "	6 4 (W)PGFS	frg-(pel-strm)-skel				8 1	5 5	2		8+			2?		2		5	2+	1	1+				5b	3P
2950	LS /	1%vf-f DOL tr G	Wt (pkrd)	3 W(P)S	frg-pel				10 1	5			1			1?		1?		2	2+		1	1.1	? ?		5	vf(f) scattered pk? dolm_rhombs 2P
2955	LS /	1-2% DOLpt chalk			strom-frg-skel-pel			1	10 3	5 2	5+		30+			?2+		3	1 1-	+ 5+	1	?	2+	1			5b	ribbed mm thick shell; sponge borings in coral (4-x16) 13P
	LS		Wt (PkRd)		pel-frg-skel				25 25				4+			?		5	?		2		3	7	•		5C 5	A 5% mica-LostCircMat (2X16 foram)5P
		•	1	II.	ı = !	•		, ,	ı		•		ļ	1	ı					•		1		11		1	•	. , , , ,

Α	В	С	D		G	Н	I	J I	ΚI	L N	1 N	0	Р	Q	R S	T	П,	/ W	ΧY	/ Z	AA	AB AC	AD AI	E AF	ΑН	Αl	AJ	AK	AL
2965	LS <u>/</u>	1-3% DOL	Wt (PkRd)	4	4 WPFS	frg-pel-skel(fmbd)			1	0 1		?		3+		5-	+		2		2		1					5ac	2P
2970	LS <u>/</u>	f DOL/SPC por?	Wt (PkRd)	1+5	M-P(G)S	Frag-pel (skel)	tr	vug? c SPC	1	0 20				?					2 ?	1	5+	1	1-	+				5	tr yellow SPC
2975	LS		Wt (PkRd)	4 4	WPFS	frag-strom-skel-pel			1	0 1				25	1	2	<u> </u>		1	3	5	1	1			1		5b	
2980	LS		Wt -(PkRd)	4 4	4 WPFS	frag-strom-skel	tr	vug? c SPC	!	5 3				20			- '	?	3		3	1	2	:	?	1		5B	rounded = branching stromatoporoid (or bryozoan??) 3P
2985	LS	v <color< td=""><td>₩t (PkRd)</td><td>4 4</td><td>4 WPFS</td><td>frag-strom-skel-pel</td><td></td><td></td><td>1</td><td>0 20</td><td></td><td></td><td></td><td>10</td><td></td><td></td><td></td><td></td><td></td><td>2</td><td>7</td><td>1</td><td>1</td><td>1</td><td></td><td>3?</td><td></td><td>5b</td><td></td></color<>	₩t (PkRd)	4 4	4 WPFS	frag-strom-skel-pel			1	0 20				10						2	7	1	1	1		3?		5b	
2990	LS+LSarg	8/2 tr qtz in red	Wt+PkRd	3	W(P)S	fragmental				5 2	5			3					5	1?	4	2	1 1	1	?			5A	red(yellow-tr) LS-more altered-clayey 2P
2995	LS		Wt+PkRd	5 89	9 PRBS	strom-skel-frg		14.5m		5 1	5	2+		25	2	5	5		3 ?	2	4	2 ?	2	2		2+		5b	5P
3000	LS	tr qtz in red	Wt+PkRd	4	WPS	frag-peloid		seway base	1	5 2	5			2+			1	+	3	1	3	3	1					5A	tr green xtl stylolites 2P
3005	LS		Wt+PkRd	8+	9 RBS	strom-cor-skel-pel-fi	-	Wade &	1	0 10	0	nd C		40	2	10	0 1	+	3	1	3	3	1			3?		5b	6P
3010	LS		Wt (PkRd)	7+3	G-WS	frg-pel (f)-skel	IVI	acLean 1993 ed seismic	2	0 2		ind C		2	1?		Ш			1		3	? 2	, 1	. ?			5C 5A	Tubiphytes? 4P
3015	LS		WT		4 GPFS	pel-strom-frg-skel	us	eu seisiilic	2 2	5 1		1		20	2?	1			2 ?	?	3	2	2	miloli	d	2+		5bc	rounded stylolites +3 types strom's 5P
	LS /	tr vf DOL	Wt (PkRd)		G-PS	frg-pel-skel(strom)				5 3				7	1				2	?		2	1			_	-	3?5C 5AB	2 21
3025	LS /	tr DOL	Wt	6 4	4 GPFS	frg-pel-strom-skel				5 2		3		15	2?	5	; II		3 2	? ?	5	2 1	1		1	3+		5b	rounded skel/fragments encrusting microbs 7P
	LS	502	Wt (PkRd)	4	(G)WPS	frg-pel-skel			Ť	5 1				3	2		, II		4 1	1		2	2	miloli	d '	0.			tr inocerimid clam?prisms
3035	LS /	tr DOL	Wt (Ficto)	6	GPS	frg-pel-skel(str)			2	0 1		1		5+		1			3	1	5	1	2			3+		5ac	4P
3040	LS <u>/</u> LS	li DOL	Wt (PkRd)	6	GPS	frg-pel-skel				5 3		' '	2.	J.	2	2	, II		3 1			3	2	, 1 1	٦.			3 ?5C 5A	Ti.
3045	LS		Wt (PkRd)		GPS	pel-frg-skel				5 2		1	2	5	-	1			2	1?		1	1? 3	miloli 31 l	d	end 5	rust	5abc m	4P
	LS LS	t- 000 t	` ,	6								'	2	1					3	1 !	3	2	11)		5			
3050		tr SPC m+	Wt	5	WPS	frg-pel-(skel)		VC ca				2		20			.		_	0.		4 4	0 0			22.		5ac	chalky?
3055	LS	SPC	Wt-vIBn	4 4	4 WPFS	strom-skel-frg-pel	4		-	2 10		3		20		2			2	2+		1 1	2 2			?3+		5b	10-20% mica LCM cave ooid-round clast GFS 6P
	LS		Wt (PkRd)		WPS	pel-frg-skel	tr?	vug-SPC		5 20		1		1		1.	?		2+		5	1	2			2?	-		tiny tubes/spheres?? Hairline calcite-fractures birdseyes 3P
	LS		Wt (PkRd)		W?S	AA? + strom	2+	V-SPCchalky		X X			1	10?															FE filings 60% mica LCM P
3070	LS <u>/</u>	tr vf DOL trG?	Wt (PkRd)		W(P)S	pel-frg				5 10		1		?					2	2	2+		11	?					gtr grn & brn xtls 80% MICA-LostCircMat!
3075	LS <u>/</u>		Wt (PkRd)	1+3	M+WS	peloid-microb				5 5									1	1	5	1	? 2	2		10+		5ac m	calcispheres?? Tiny tubules
3080	LS	v <colo< td=""><td>₩tVLB(Pk)</td><td></td><td>M+PGS</td><td>pel-frg</td><td></td><td></td><td></td><td>0 1</td><td></td><td>1?</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1?</td><td>1</td><td>2</td><td>1</td><td>2</td><td>2</td><td></td><td></td><td></td><td>3?5C</td><td>limonite stains stylolites Lithocodium? forams</td></colo<>	₩tVLB(Pk)		M+PGS	pel-frg				0 1		1?							1?	1	2	1	2	2				3?5C	limonite stains stylolites Lithocodium? forams
3085	LS	small ctgs trSPC	VLBn-Pk	1+5	M+PS	pel-frg-microb		micro	opel1	-		1		3+					1		2	1	1			15+		5c m	microbially encrusted stromatoporoids 2P
3090	LS	tr SPC m+	VLBn-Pk	1+3	M-WPS	pel-frg			1	5 10	0								1		2+	1	2	2		1?		3?5C	yellow stain stylolites birdseyes? 3P
3095	LS	tr SPC m+	VLBn-Wt(F	Pk] :	2 M+WS	peloid			1	0 5	5								2		2		1? 1					5c	
3100	LS		Wt+PkRd	1+3	M+WPS	frg-pel			1	5 2	5 tr		1	1					2	1	2+	1	2	2		2?		3?5C	yellow stain stylolites 3P
3105	LS	tr SPC	Wt+PkRd	1+4	M+WPS	frg-pel-skel			1	0 10	0 2			3+				1	1		2	1	? 2	2				5a	tr round lithoclast GS stylolites 3P
3110	LS _/_	2%vf-v DOL	Wt(PkRd)	2	MW(P)S	frg-pel	tr	V-SPCvf+interxt	: 1	0 1	5	1?		1		?	· -		2	?	3	1+	2	2				3?5	less yellow stain stylolite calcite blebs=birdseyes? 3P
3115	LS	5% SPC	Wt(PkRd)	3 4	4 WFS	frg-pel-skel			1	0 1	5	2+		1		1'	?		3		2	? ?	2	2		10?		m	stylolites 3P
3120	LS		Wt+Rd+Ýl	2	MW(P)S	frg-skel-pel	tr	V-SPCvf-f+inter	xtl 1	0 1	5 tr	1		1	1?	1			2	1?	2+		1					3?5	?sphlerite?=yellow xtl vf-f calcite stylolites-red lining 3P
3125	LS	2% SPC	Wt+Rd+Yl	3 4	4 WFS	frg-skel-frmbldr				5 20	0	1	1	5+	1?	2	?		3		2+	?	1			5+		5b m	possible rudist clam wall VS coral-like fabric stylolite 4P
3130	LS		Wt+Rd+Yl	2	MWS	frg-pel	tr-2	Vug-SPCm free		0 10				1			Ш		2	1	3	1	2	miloli	<u> </u>	3+?			stylolites
	LS /	Dol SPC sml ctgs		3 4	4 MFS	frg-skel-(microb?)								2		?	,		2		1?					5+		m	- 9
3140	LS	SPC more pinks		3 4	4 WFS	Frg-strom-pel-skel			1	0 1	5			11+	1?	2	?		2	2+	?5	1	-	1	?	2?		5B	stylolites red rextl+sparry+gastropods/bivalves/corals??
	LS	· · · · · · · · · · · · · · · · · · ·	WtBn+(Rd	2 4	4 MWFS	fra skal frahldr					5 2	2		5	3?				3	?	3	1	1		2		ed	5a m	stylolites minor round clast GSm-vc (x16,x25) 7P
3150	LS	peachDOL SPCm	Peach+Rd		MWS	fra (nol)		CYCLICITY		7 1		_		1		1 2	, II		2	2	2	1	1		_	7		5a	finer cuttings
	LS	?dol? +1%SPC	WtBn+Rd		4 MWFS	Constitution to		cles at top		5 10				5					1		2	2	1			?5+		m	stylolites 4P
	LS LS	14011 +1703FC	LB-Ph-Rd	1	MS			lownward so		3 5				3					2	1	2	1	1/1/	2		: 31			possibly leached crinoids? Hairline calcite fractures
	LS LS	3%SPC	LB-Ph-Rd	3	4 WFS		deepest	Cycle BUT within		5 10		2		10	1?	1	2		2	2	2	2	2-			?5+		5ba m	?Lithocodium? Sylolites 6P
	LS LS	3 /03F C	WtB-PkRd	3 '	MWS			Ice tends to		7 1				2	1?	'			3	1	4	1	2			: JT			stylolites 6P
		1 20/ SDC		2		J (/		downward						2	17	!			_			1	1			22		AC	,
	LS	1-2%SPC	WtB-PkRd	2	MWS	ing onto	- 2975>							2					2		2	1		-		2?			?Lithocodium? Sylolites 2P
	LS	tr CDC	WtB-PkRd	1	M(W)S	(frag)	3145>>		;	-				!					-		1	2				22			stylolites mottled red& Bn/Wt Small cuttings hairline
	LS	tr SPC	WtB-PkRd	1	MS	(Trag)	3275>>		icro 1	4 7									2			!	?			2?			calcite-filled
	LS	40/ 000	WtB-PkRd	1	M(W)S	(frag)	3375>>			5 7				1					2	1	1	1	1						mottled red& Bn/Wt Small cuttings fractues in
	LS	1%SPC	WtB(PkRd	1	MS	(pel-microb)	3495>>	3595uniform	m	5 Icro 5)			2							1	?	?			5?		m	many P
3200	LS		Wt(PkRd)	1	MS		o 3815	then Greys	١,	5 5	·						Ш		1		1	1	?	'					stylolites mottled red& Bn/Wt samples 2P
	LS	2-3%SPC	Wt(PkRd)	1	M(W)S	(peloid-microb?)				5 3									2		2					5?		m	2P
	LS <u>/</u>		Wt+PkYl	2	MWS		NOTE C			5 10				2		11	?		1		2	1 1?	1					5A	stylolites mottled 2P
	LS	1%SPC	Wt(PkRd)	1	M(W)S			LOURED		5 5									1?		2+		11	?		2			stylolites
3220	LS	tr vf DOL	Wt+PkYl	2	MWS			sually some		5 10				2		11	?		2	1	3	1+	11	?					stylolites? mottled
3225	LS <u>/</u>	+1%SPC	Wt(PkRd)	1	M(W)S			esent with	(6 5	5			1?					1		1	?	? 1			5		m	VF-tinytubules stylolites P
3230	LS		Wt+PkYl	2	MWS			oinks. Also	1	0 6				1					1			1?	1					3?5c	mottled
3235	LS	2%SPC	Wt(PkRd)	2	MWS	noloid (miorob2)	clear &	wnite r as noted	8	3	3						1	?	1		1		1	1		4?			very stylolitic P
	LS		Wt+PkYl	2	MWS	pel (frg)	Jaiu5µa	as noteu		0 5									2		2		1	1				3?5c	mottled
	LS	3%SPC v <color< td=""><td></td><td>2</td><td></td><td>peloid-microb?</td><td></td><td>all aplace from</td><td></td><td>0 3</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Ш</td><td></td><td>2</td><td></td><td>1</td><td>1</td><td>1</td><td>1</td><td></td><td></td><td></td><td>3?5c</td><td>P</td></color<>		2		peloid-microb?		all aplace from		0 3							Ш		2		1	1	1	1				3?5c	P
	LS /	f DOL scattered		1+5		pel - frg	munse	ell colors tray - ge 5-10YR8-7/2		0 20						2	2		2	1?	3+		2	tubule	s	2?			?brick/walnut? red material??LCM? Stylolite mottled SPC
	<u>-</u>		' "		1	li a	aveid	40 0-1011\0-1/Z	_ ~	- I - '	٠, ٠		ı	I	ı	1 1 -	- 11	1 1	- 1	1	1 ~ . [ı	1 12	·		1 1			otylonic motion of o

Α	В		С	D			G	Н	I	J K	L	M	/ N	0 P	Q	R	S 1	Г	v w	X Y	ΥZ	AA AB	AC A	D AE	ΑF	ΑН	Αl	AJ	AK	AL
3255	LS		+2%SPC	WtB-Pk	Rd 2		MWS	pel (skel-microb?)			15	5 5	5		3		7	?		3		1 1?		1			10	,	3?5c m	stylolites 2
3260	LS			WtB-Pk	Rd 1		MS	(pel+frg)			6	4	1		1					?		1? ?		1			?			stylolites w/ red st mottled red
3265	LS		2%SPC	WtB-Pk			M(F)S	(microb?)			7									7?		1 1		1			10		m	
3270	LS		v <color></color>	₩tB-Pk	Rd 1		M(W)S	(soft-pel)			8	5	5		1		1	ı		1	1	?1 1		1		1?				mottled red
3275	LS		3%SPC	WtLB(P		9	W(B?)S	microb-peloid			15	5								1?		3+ 1		1			20		3?5c m	stylolites 3
3280	LS		fSPCcmt ?DOL	WtB-Pk	Rd 1		MWS	micropeloid			15	3	3		1					1 1	?	2 1+		2			?		3?5C	?calcispheres/rod forams? Stylolites st tiny cal frc's (x16)5
	LS			WtB-Pk			WP(G)S	peloid-microbial			20)					solitary 1	?		1		1?		1			15+		3?5C	stylolites 2
	LS		10% SPC	WtB(Pk			M(B)S	wt?thromboidal?				5	5							1		2+ 1					15+			tiny cuttings microbial wt+cl calcite 3
	LS	#		WtB(Pk			M(B)S	microb?thromboid		clott	ed g		round				1	2				1					15+		m	microbialite stylolites
	LS	$\boldsymbol{\pi}$		WtB(Pk			M-PS	frg-pel (microb?)			10							:		1+?		1?		<i>t</i> ex	ktulari		5?			(stylolites) 2
		,	1%DOL 2% SPC (_	5				NBPEX T	Ss				1 1		101	.ca.a.					
	LS .			-			MWS	pel-frg			15						Tebbutt s			1?		2+		!			5+		3?5c m	stylolites 5
	LS			Pk-Org(P(G)S	pel-frg-thromb			35						cryptalga	ı		1		2		1			10			stylolite thrombolite=microbial clotted possible microbialii 3
	LS .		3%DOLv <color< td=""><td></td><td></td><td></td><td>M+WS</td><td>pel-frg (microb)</td><td></td><td></td><td>15</td><td></td><td></td><td></td><td></td><td></td><td>fabrics in</td><td></td><td></td><td>2</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td><td>5+</td><td></td><td></td><td>scattered VF dolomite rhombs stylolites 3</td></color<>				M+WS	pel-frg (microb)			15						fabrics in			2		1		1			5+			scattered VF dolomite rhombs stylolites 3
	LS		fine SPC	Pk-Org((Y) 1+		M+WS	pel-microb?-frg		mic	լ 15		-				100m thic	k		2	1	1		1			15?			possible microbialite
3325	LS .	_/_	1%DOL 1-2%SPC	Pk-Org((Y) 1+	+4	M+WPS	pel-microb-frg			15	10	0				sample			2		1 1	1	? 1			15+			possible microbialite stylolites scattered F dolm rhombs 4
3330	LS .	/	tr vfDol tr SPC	Wt +Rd	1+	+3	M+WS	pel-frg			20	10	0				intervals			1		2					5?	:	3?5C	
3335	LS		3%DOL 1-2%SPC	Wt +Rd	Yl 4	.	WPS	peloid-(microb)			30)				L			J	1		2 1	1	? 2			6?		375C	color banded scatterd clear dolm rhombs stylolites
3340	LS			Rd+Wt	4		WPS	pel-microb-frg			35	10	0							2	1	3		? 1			15+		375C m	possible microbialite stylolites mottled 4
3345	LS			Wt +Rd	YI 3		W(P)S	peloid-microb			20	5	5		1?					2		1?		1			20+			possible microbialite stylolites banded-red-orange-yel 2
3350	LS	1	tr VC DOLorSPC				M(P)S	pel-frg-(microb)			15		0							2		1		1			?5+			leached stylolite Mottle Wt+re-org
3355	LS		tr f DOL 1-2%SP0					pel-frg-microb			20	10	0		3+			-	?	3		1? ?		? 1+			10+		375C m	5
3360				RdOrg+	~		M(W)S	pel-frg			10-									1		12		1			?			some banded rd+Wt cmt - isopach cmt 2
3365	5	3		rtuoig.	**		111(11)0	per-rig			1.0	. 0								-		1 :						ì	7:00	Some banded to two one isopaon one
	F	>	F0/ CDC	D40	١٨/٠ ٥			mal for (mianah)			140						,,					2 1?		1				Ļ	2050	at delites
3370	LS	2	~5%SPC	RdOrg+	-vv 2		(P)WMS	pel-frg-(microb)			10	10	U				?1			2		2 1?		1			5?	·	5?5C m	stylolites 5
3375	C	ce	v <color:< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>١</td><td></td><td></td><td></td><td></td><td></td><td></td><td>. </td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>_ </td><td>إ</td><td></td><td></td></color:<>								١							.									_	إ		
3380	LS n	n	2%SPC	RdOrg+	W 2		(P)WMS	pel-frg-(skel-microb)			15	10	0 2		1		? 1	ш		1	?	2 1	?	? 1			5+		875C m	stylolites
3385	e	en																												
3390	LS t	S	+5%SPC	RdOrg+	W 2	:	(P)WMS	microb-pel-frg			10	10	0							2	1	4 1?	1	? 2			15+	3?	5CA m	stylolites mottled red+yel+Org-Pk+Wt SPC=clear
3395 T																														
3400	LS		1%SPC	WtB+Pk	KR (2	!	MWS	pel (frg)			10	7	7							1		2		1			2?	-	3?5C	stylolites
3405																														
3410	LS L		1%SPC	WtB+Pk	cRc 3	4	WFS	frg			5	10	0		3			Ш		2		2		1			?2+			10-20% mica-LCM stylolites
3415																														
3420	LS		1%SPC	VLBn+F	Rd 3		W(P)S	pel-microb (-frg)			10	5	5							3 1	?	1	1	2 1			10+	5?	3?5C m	tubular forams some laminites-stromatolites 4
3425			.,,,,,,				(- /-	,					roun	а																
	LS C	_	1%SPC	VLBn+F	3d 2		MW(P)S	microb-pel (frg)			15	5	5 3	u						12		2		1 1		?	15+		325C m	stylolites microstromatactis clotted peloid microfabric=thrombolite 4
3435	LS	3	17001 0	VEBILLI	`` -			mores per (ing)			1.0																	ì		atylonics microstromatacite ciotica pelola microtabile all'ombolite
	LS (3	5%SPC	VLBn+F	24 #		MWPS	poloid			10) 5	-							1		12		1 1			2+	- !	3?5C	stylolites
3445		٧	5763FC	VLDIITI	\u #		IVIVVES	pelolu			10	, 3	,							-		11		' '			21	ì	9:30	stylolites
		e e	= 400/ ODO	\							١.,																4			at talling MO to the NO his ODO On he and missely DO
	LS n	m	5-10%SPC	VLBn+F	Ka 1		M(WB)S	peloid-microb			10	3	5				IBPEX TS	30		1			?	1		?	15+		375C m	stylolites MS texture VS hi SPC=?sub cmt-microbBS 4
3455		e nt	v <color< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>١.,</td><td></td><td></td><td></td><td></td><td></td><td>ebbutt sa</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>_ </td><td></td><td></td><td></td></color<>								١.,						ebbutt sa										_			
	LS	,,,	5-10%SPC	VLBn+F	₹ d 1		M(W)S	peloid	tr??	open SPC	10)				C	ryptalgal			?		?		? 1		?	5+	?	3?5C	mica + LCM)walnut shells) 3
3465	3															fa	abrics in													
3470	LS		5-10%SPC	OgPk+F	₹d 1	9	M(B)S	microb (pel)	tr??	free SPC c-vc	8	3	3				00m thick			1		1	1	? 1	1		15+		3?5C m	"yel" MCxtl-dull LS ?MS? Geopetal in tube foram/tubiphytes calcispheres???
3475																	ample ntervals													
3480 T	LS		small cuttings	OgPk+F	₹ d 1		M(W)S	pel-frg (microb)			?10)+ 10	0				itoi vuio					1	2	?? 1			3?		3?5C	FE filings Geopetal in tube foram/tubiphytes 9
3485																														
3490	LS C	,	5%SPC	OgPk+V	Vt 2		MWS	pel (microb)			10	3	3							1		1	1	? 1			?5+		3?5C m	4
3495	LS S		v <color></color>																											
3500	LS	_	2%SPCf	RdOran	ne 2		MWS	peloid			10	5	5 2							1		2		? 2					3?5C	3
3505			27001 01	rtaoran	gc z		INITIO	perora			1.0	, ,	, -					-				-		: 2					3:30	, and the second
		n	20/ CDCf	DdOa (Λ/+ · · ·		M/\A/\C	(nol)			5.	- 3								21		1	12	2		?	2+			patches VLBn.Wt micropeloid PS 4
		en	3%SPCf	RdOg (\	VVI 1		M(W)S	(pei)			5+	- 3)							<i>!</i> I		1	1.7	4			2+			patches VLBn.Wt micropeloid PS 4
3515		_	00/ 000	D40 . "	A / 4		BANA/O	(m = 1)	4	······· ODO(·····	5+	F 5	. F	, .													20			
3520 T	LS "	ٽ <u> </u>	3%SPC	RdOg (\	vvt 2		MWS	(pel)	tr	vug-SPCfree	5+	- 5) 	1 1			1 1				1	1		1			2?			mottled 3
3525																														
	LS		3%SPC	RdOg (\	Wt 2		MWS	peloid (microb)			10	5		?]] ?	?		2?	1	2+	?	1			5+	1+	3?5C m	stylolites F-M pyrite 5
3535																														
3540	LS		3%SPC	RdOg+\	Wt 1		M(W)S	(microb-peloid)			5	3	3	1	1		7	?		1	1			1			5+		m	2

Α	В	С	D		G	Н	I J K	L	IMI- FI	1 0	P Q	R	S T	VW	/ X	ΥZ	AA A	AB AC	AD A	E AF A	H AI A	J A	K AL
3545																							
3550	LS	5%SPC	Rd+Wt	1	M(W)S	(microb-peloid)	tr Vug-SPCfree	5	5		1?				2	1	2	?1	1		5+	n	20% mica & LCM
3555																							
3560	LS	5%DOL 2%SPC	Wt+Rd	4	WPS	peloid (microb)	tr spc vug	25	15						2?		1	?	1		10?	3?5C n	stylolites red rombs=calcite 4P
3565																							
	LS	5%DOL 1%SPC	Wt+RdOg	1	M(W)S	(peloid) t	r+ vug-mcSPCcl	7	5						1?		1?		?	1	2?		stylolites
3575		10%DOL 3%SPC	D40=1M4		MINA	malaid (mianah)	nt Vive CDOfees	45.	_								10				1 - .	1	20
	LS S	10%DOL 3%SPC	RdOg+Wt	2	MWS	peloid (microb) t	r+ Vug-SPCfree	15+	5						1		1?	?	1		7+	3?5C n	3P
3585 3590	LS C /	2%DOL 1%SPC	RdOg+Wt	1	M(W)S			5	3						12		12		1	2	1?		atulalitas amall auttings
3595	ce	v <color></color>		1	IVI(VV)S			5	3			NE	BPEX TSs		1 !		17		1	?	17		stylolites small cuttings
3600	ı e m	2%SPC cmt	RdOg+Wt	1	M(W)S	(peloid)		5	3				bbutt saw		1?	?	2	12	1	2	2?		stylolites
3605	е	27031 C CITIL	ruog. wt		WI(VV)3	(pelolu)		5	J			fal	yptalgal brics in		1:	:		1 :			2:		stylolites
3610	LS nt	3%SPC cmt	RdOg+Wt	1	M(W)S	(peloid)		5	3				00m thick		1		1	1	1		3		stylolites 2P
3615	S	2,7,2,1,2,1,1,1			(/-	(parana)							mple										
	LS	2%SPC cmt	RdOg+Wt	2	WMS	peloid		10+	5 1	?		1	ervals		?		?	1	1		4?	3?5C	stylolites
3625																							, and the second
3630	LS 🖳	1%SPC cmt	RdOg+Wt	1	MS			4							?			1	1		1?		stylolites
3635																							
	LS	tr SPC	RdOg+Wt	2	MWS	peloid (microb)		10	5 5	+ 1+?			1				1	1?		1	5+	3?5C n	stylolites 3P
3645																							
3650	LS S	4%SPC cmt	RdOg+Wt	2	MWS	peloid-microb		15	5	?	2				?			1 2	1 1		15+	3?5C n	thrombolite-sub ?cmt_tubles conc inyel LS=SLOPE
3655	Р									ound													
3660	LS C	2%SPC cmt	RdOg+WtB	1	M(W)S			5	5 5	5 2?					1?		?		?	'	5+	? n	1 3% LCM mottled 1P
3665	ce																						
3670	LS m	5%SPC cmt	RdOg+WtB	2	MWS	microb (frg-pel)		7	8 2	2 1	3	1	?		1	1?	2	1?	? 1		10+?	n	mottled mottled
3675	nt	50/ ODO 1			1010	for and arterals		_	- I		40							40	4. 6		40.	0050	11 12 12 12 12 12 12 12 12 12 12 12 12 1
3680	LS III	5%SPC cmt	RdOg+WtB	2	MWS	frg-pel-microb		5	7 2	2 1?	1?				2		2	1?	1+ 2	<u> </u>	10+	3750 n	stylolites mottled ?Lithocodium tubular foram/microl (x16)3P
3685 3690	LS	3%SPC cmt	RdOg+WtB	2	MWS	(?frg-pel-microb?)		5?	5?						2		2		1		5?	3?5C	much Fe filings Mica&LCM+walnuts Small ctgs
3695 T	L3	3/63FC CIIIL	RuOg+WiB	_	IVIVVS	(ring-per-inicropr)		9:	J:						- 1						3:	J:50	much re mings wicaxeow wainuts offian cigs
3700	LS	3%SPC cmt	RdOg+WtB	3	ws	pel-microb		15+	5		1				1		12	1	2 1		10?	3?5C n	
3705		370GF G CITIC	ruog i vib	3	110	per-inierob		10.	J												10.	1	
3710	LS	3%SPC cmt	RdOg+WtB	1	M(P)S	pel-microb (frg)		10	5 5	?	1?				1?		1	1?	1		10?	3?5C n	stylolites 2P
3715	S	2,7,2,1,2,1,1,1			(. /-	(g)																	
3720	LS P	1-2%SPC cmt	RdOg+WtB	1	M(W)S	(frg-sft pel)		5	5					1	1?		1?	1?	1		3?		tr tiny tubes or ?calcispheres bryozoa 1P
3725	С																						
3730	LS ce	1-2%SPC cmt	RdGrn(Wt	2	MWS	(pel-frg-microb)		7	5		(1?)			2	1		2	1	1		5+	3?5C n	Rd/Yl/grn/Og/wt some bubiphytes-microb tubules 4P
3735 T	en																						
3740	LS ts	1-2%SPC cmt	RdPK(Wt)	2	MWS	microb(-pel-frg)		7	5	1					1		2	1 1?		1	10+	3?5C n	1 2P
3745												1 16	NBPEX TS										
3750	LS	4-5%SPC cmt	RdPK(Wt)	1 9	M(B)S	microb		3	2			I	Tebbutt sa	w L	2		1?	1?	1		15+	n	1 2P
3755		tr vf DOL 3%SPC	D (DIC(MA))		14(D) 0			vf					cryptalgal									0050	
0.00	LS	tr vr DOL 3%SPC	RdPK(Wt)	1	M(P)S	peloid		10	3				fabrics in 100m thick		1		?		1		2+	3?5C	
3765 3770		2%SPC cmt	RdPK(Wt)	1	MS	(peloid-soft)		vf 5+					sample		12				2	miliolid			?miliolid foram in yellow MS& uniserial foram (forams x16)2P
3775	L3	2 /03F G GIII	Kur K(VVI)	'	IVIO	(pelolu-solt)						l li	intervals		1 :								! Illillolid for all ill yellow wisk uniserial for all (Ioranis X10)2F
3780	LS		RdPK(Wt)	1	MS	(peloid-soft)		vf 5+							1		2		1		3+	? 3?5C	micro fracture-calcite filled stylolites
3785			rtai rt(vvt)			(poloid coit)																. 0.00	milities indicate calcite milities ctyromete
	LS	1-2%SPC cmt	RdPK(Wt)	1	M(W)S	peloid-microb		10	3						1		1	?	? 2	2	10?	3?5C n	stylolites (x16)3P
3795		. 2,00. 0 0			(,0	poteria illiotos		. •														1	(ATO)OI
	LS	1-2%SPC cmt	RdPK(Wt)	1	M(W)S	peloid (-microb)		5+	2		1				1			1	1		4+		1P
3805			` '		ì		@ Weston et al. 2012																
	LS	1-2%SPC cmt		1	MS		1 @ weston et al. 2012 111 Chpt 5 pl. 5-2-2								1		1		7		2?		1P
3815			CHANGE (I	ose re		noorly datad	above to Kim-Oxf &		ca	ve?						/C							
	LS	MAJOR COLOR 5%?arg small ct	LMGy+tan	1	MS	poorty dated	anove to killi-Oxi &		[1	0]					1	ĭ			?	·			50% cave or AA red interbeds Marly LS w/ black flecks 2P
3825													big/soli	tary?							cave?		
3830	LS	5%?arg	LMGy+tan	1	MS	(WFSskel-microb)		[10 9	ave? [1	0]			[1]	\parallel \parallel	[2]	1	1		1		caye?! (10?)		20% cave= skel WFS or interbeds (more fossiliferous than above) 4
•				- •	•	•	•				•					•		•				-	•

Α	В	С	D		G	Н	ı	J	K	LN	l _d N	0	Р	Q	RS	Т	V W	X	/ Z	AA AI	ВАС	AD A	E AF	AH	AI .	AJ	AK	
3835																												4p^ 5-10% cave= skel WFS or interbeds 3P
3840 3845	LS	5%?arg SPC	LMGy+tan	1	MS	(WS skel-microb)												[2]		1	1?	2		(5+?)			5-10% cave= skel WFS or interbeds 3P
3850	LS	arg	LMGy (rd)	1	MS	(MWSskel=cave)											2	[5]		[1]					(?)			10-20% cave/interbed -in marly LS xf lignitic flecks 1P
3855		arg	Liviey (ru)	i		(MYYCORCI cave)												[O]		r.1					(.)			11 25% Gavernierbed in many 25 x ngmao nooko
3860	LSarg	10% arg	LMGy (rd)	1	MS	(MWSskel=cave)														[1] 1		[1	1]		[?]			10% caave/interbeds 1P
3865 3870	LSarg	10% arg	LMGy (rd)		MS	(MWSskel=cave)						[4:2]	F-	1?]				[2]		[1] ?		1 [11		[5+]			10-20% cave/interbed fossils in cave carb banded subcr 5P
3875	Loary	10% arg	LiviGy (Iu)	1	IVIS	(IVIVV 35Kei-cave)						[1:]	L	1 :]				[2]		ין נין י	f	' L	'1		[3+]			10-20% cave/interbed Tossiis iii cave carb banded subci
	LSarg	10-20%arg = SH	LMGv (rd)	1	MS	(MWSskel=cave)					2							[1]		[1]		1	?		[+5]			10% cave 2P
3885																												TRIP
3890	LSarg	10+%arg	LMGy (rd)	1	MS	(MWSskel=cave)												[1]		[1]		?			[5+]			Fe filiings bad wood LSM? 40% cave 2P
3895 3900	LSarg	10+%arg	LMGy (rd)	1	MS	(MWSskel=cave)												[1]		[1]		[2] [4	11		[5+]			10-20% cave w. fossils-microbial 2P
3905	Loary	101 /baig	LIVIGY (IU)	1	IVIS	(IVIVVOSKEI-Cave)												[· J		ניו		r.llr	'1		[31]			10-20 % cave w. iossiis-iiiciobiai
3910	LSarg	10+%arg + SH	LMGy (rd)	1	MS	(MWSskel=cave)							[1?]				[1]		[1]			1		[5+]			10-20% cave w. fossils-microbial 2P
3915																												
3920	LSarg	10+%arg	LMGy (rd)	1	MS	(MWSskel=cave)												?		1			1					20-30% cave w. fossils
3925 3930 T	LSarg	10%arg	LMGy (rd)	1	MS	(MWSskel=cave)														1			1					10% cave 2P
3935	Louig	10 70419	Lividy (id)	1	IVIO	(WWOSKCI-cave)																						1070 cave
3940	LSarg	10%arg	LMGy (rd)	1	MS							[2]		[1]				[2]		[1]	[1]	[1]	1		[3+]			Fe filings 20% cave w fossils ?Planolites? 3P
3945																												
3950 3955	LSarg	10-20%arg + SH	LMGy (rd)	1	MS																							10+% cave micropyrite
3960	LSarg	10%arg + SH	LtDkGy	1	MS							[1]		[1]				[?]		[1]			1		[5+]			10-20% cave 2P
3965												,													. ,			
	SH+LSarg		LtDkGy	1	MS									[1]				[?]		[1]		1	?		[5+]			20+% cave
3975 3980	SHcalc	(+LSarg)	LADIO		MS								Η.	[4]				[0]		F41					rc . 1			20+% cave 1P
3980 3985	SHCAIC	(+LSarg)	LtDkGy	1	MS									[1]				[?]		[1]		1	<i>'</i>		[5+]			20+% cave 1P
	SHcalc	(+LSarg)	MdDkGy																			1	?					5-10% cave 2P
3995																												
4000	SHcalc	(+LSarg)	MdDkGy												\perp							1	?					5-10% cave
4005 4010 T	SHcalc	(+LSarg)	MdDkGy																									5-10% cave
4015	Cilcuic	(·Loury)	IVIdDROy																									0-10 /// Cave
	SHcalc	(+LSarg)	MdDkGy																			1	?					
4025																												
4030 4035	SHcalc	(+LSarg)	MdDkGy											[1]								1	?		[1]			5% cave w/ microbialite-stromatoporoids
	SHcalc	(+LSarg)	MdDkGy																			1	2					Fe filings in SH
4044	SHcalc	· •	MdDkGy																			1	?					g 911
TD		, ,,																										
Α	В	С			G	Н		J	K	L N	l N	0	Р	Q	R S	Т	v w	XΥ	/ Z			AD A	E AF	AH	ΑI	AJ	AK	AL AM AN AO AP AQ
	L	<u> </u>			L	Reference channel 3A-	لببا		<u>L.</u>			1				للبسل		<u> </u>								L		

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-'stromatoporoid reefal, 5C=mud/pelleted; 5D=oolitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details m = microbial

SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB .. NOT A PROBLEM JUST LOST CIRCULATION MATERIAL (and CAVE)

SEE G.E.Tebbutt 1985 PEX report Carbonate Petrographic Study Albatross B-13 in CNSOSPB files. NOTE - thin sections from cuttings over 100 m intervals Some SWC TS's

Appendix A3 ENCLOSURE A3.2 ALBATROSS B-13

L.Eliuk 2016

Lncl	osure	<u>A3.3</u> PEX <u>I</u>	<u>sonnet</u>		• •	ARK)	Inc	L.Eliuk P.G	_				(log a	alteri	nate s	sample	s until	first	ost	circulat	ion z	one)	20	14-11	logg	ed 3'	90-35	50m	28 4	More log	ging 20	14-11		PAGE			
DEPTH	LITH	modifier I	COLOR	TEXT		modifier	PORC	SITY		CESS mme							SSILS		(en	hanced	by S	WC d	lata if	avai	lable)				S TYPE IK'78'88 K 2002	COM	MENTS	3					
metres) T=trip	DOL= SH=si SS=sa SLTS arg=a calc=c	nestone dolomite hale andstone T=siltstone rgillaceous calcareous sandy/qtz	REVIATE	DUNHAM NUMBER ms-bs left fs&rs(bs) right	PS=pacl GS=grai BS=bou (FS/RS= FS=float RS=ruds	ckestone 3 kstone 5 instone 7 indstone 9 =XC size) tstone 4	%	modifier (Archie)	SGIOO	PELOIDS	PARTICLES	LITHOCLASTS	RA SBNOGS	- I	STROMATOPOROID- CHAFTETIDS O	_ ~	MICROSOLENIDS	BRYOZOANS	BRACHIOPODS	CRINOIDS	GASTROPODS	BIVALVES	SIRACODS	TUBIPHYTES etc	FORAMINIFERA BORINGS	een etc	Sstrombo-thrombolite	GIOSIA-S	STANDARD MICROFACIES Flugel'82&Wilson'75&Eliuk Wierzbicki, Harland&Eliuk		diager facies et cete some	netic te s-seque era P= long co	extures nce bre photos mments		e higher 10	6 & 40	
Α	В	С	D	ΤĽ	G	H		J	K							R S	T			XY								AJ		AL		_	ANI	10			
A 1750	В	С	D	++	G	Н		J	K	L	IVI	N	0	Р	Q F	R S	<u> </u>	V	W	ХҮ	Z /	AA A	BAC	AD	AE AI	- N AF	I AI	AJ	AK	AL	AN	Л	AN	AO	AP		—'
1755																																					
1760	SH	sl gtz silt-XF	(D)M Gy																											moderate	lv hard.	large ch	nips simi	lar Cave?			
1765			()			lower case																									, ,	J					
1770	SH calc	silt-VF qtz, lignitic	(L)MDkGy			m means less IPPER case liths																1								lignitic spe	ecks VF	& crea	m marl-L	S w shells	; glauconi	te? XF	
1775					u lai i U	I LIX Case IIIIIs																									.,						
1780	SH calc	tr XF qtz, lignitic	MdBnGy																											tr rust/side	erite pat	cnes,					
1785 1790	SH v calc	tr pyrite, v.calc	Md(D)BGy																					1						some lign	itic SH	Rusten	ots likel	v after nvri	te		
1795	orr v curo	a pyrito, viodio	ma(B)BOy																											oomo ngm	1110 01 1.	rtuot op	oto ilitor	y artor pyri			
1800	SH LS	8/2 LS red-lt org	MdGy+Rd																	1?		1?								SH cave b	oad=lv lo	g chip; l	S rusty	to crm col	or, calcsp	?fossils	s?
1805	SH LS	6/4 LS rd-crm;gla	MdGy+Rd-0	Crm									MLred	l-org	10R	4-5/6				4		1?								grn M grn							
1810		Fe Ool; trCrdqtz C				Fe ooid-F frag			15		10									1? 1										disaggreg							
1815		Fe Ool; trC-VCrdo				FeOoid (skel)			35		10			al				- 11		4		1							5Dred	disaggreg					S, M crino	id?	-
1820 1825		Fe Ool; trCrdqtz G tr rd & It Gn				FeOoid (skel)			65	IVI-V	15		regate	a	2	SO	me XC			6 1		5							5Dred	disaggreg Cu-"tourm							
1830	LS CIIL	li iu a il Gii	N8 VLGy N8 VLGy			frag-skel skel-frag					20		2spi	nee	3	1?		11 1	ranc	2		5			12				5A	ribbed (be			ille to C				
1835	LS	some blk frg, cht				skel-stom-frag					20		?		10 1			1?	•	2	1	5 ru	dist?		1				5B	micropyrit	, .		n LS; ??	rudist? ??	spg		1
1840	LS cht		N8 VLGy +		/PFS	skel(str-spg)-frg-cri	*ch	ık if spg+Clado			20		5*		5					6cht 3		2	1						5/4B	lots of Dk							
1845	LS cht		VI Gy (blk p			frag-skel (frambld)			1?		20				5	2?>				2		2			1				5A(b)	some blk	•						
1850	LS cht	9/1 blk M-C frag				frag-skel-(spg)				_	20		6		2	belen		1-bra	nch	3 2		2	1	1	1				4AB	tr Glaucor		•					1
1855	LS LS		LMBnGy			frag-clast(dk)-skel				5	20		6?		4 ba	by ?ba	culites	1	1?(3 4	1	3	1	1 1	1		1		5/4B-A	brach or correctly. Tr					ouboo.		1
1860 1865		blk frg/clast's arg; 1% gy cht	Lt(Bn)Gy LMdGy			frag rond frag-SKEL-dk	ooid		l 10dł	ļ.,	30		2?					8?	? ?	_	1	10 1	1 2	12	1				5A(b)	possible s		•				ttti_like	
1870	LS	blk frg/clast's	LM(Bn)Gy			frag-clast(dk)	l		l	ì	40		2:		?			0:	: :	1		10	1 2	1:	1				JA(D)	tr siderite/			2011301110	1 01 bi y020	a : spagne	itti iiko	
1875	LS	cave or interbeds		P	_	oolite M-C	5?	ooid voids?	35		20							2		1		2				?			5D	some qtz			ryo-shell	-frg WFS			
1880	LS	restl in pt; tr qtz ni	LTBnGy	P	GS	oolite M-C			50																				5D	tr silt 0VE				•			
1885	LS	cave or interbeds	,	V	V+PS	Frag & oolite			35		15		2?					1?	t	elemnit	е	2	1			?			5D								
1890	LS(arg)	? caving? Pyrite	L(M)BnGy	V	V+GPS	frag + oolite			25		10		?							1		1							5D	pyrite by f	rg/os; S	H, arg L	S & Fe	ooid etc lit	hs probabl	ly cave	;
1895	LS	BAD SH CAVE				frag + oolite			25		20		1									2							5D	not likely	represer	ntative					:
1900	LS(arg)	bad caving? Pyrite	L(M)BnGy	٧	V+GPS	frag + oolite			15		15																			SH, arg L	S & Fe o	ooid (en	nerald gi	n) etc liths	probably	cave	;
1905																																					
	DOL(LS)	bad Fe cave	Lt(B)Gy	2	(TL+ F	F-M dol +(strom)	tr	interxtl							5?cav	/e				1										dolm to ca	alc dolm	(euhed	Iral rhom	ibs F-M)			4
1915																																					
	DOLCAIC	bad cave	VL(B)Gy	X	TL	F-C euhedra	tr	interxtl																						ool, Fe Sh	n cave o	clear do	I rhombs	s w interxtl	wt calc		
1925 1930	LS dol	10%vf-f dol rhb+c	VI Gv		GS	oolitic M-VC	?	interooid=loose	50																				5D	bad cave;	Vf-F at-	z nuclei	iin nt∩	-VC disag	nrenated o	onide	
1935	LS GOI	15 /041 1 401 1110 1	, LOy			CONTROL MI- FO		intercold-loose	١																					Suu cave,	vii qu	_ 1146161	pt C	v C disay	g. egalea 0	Jiuo	
1940	LS dol?	bad cave	VL(B)Gy	W	+PGS	frag+ ooid			25		15									2		1							5d	ooids as 1	1860 = C	Cave or	just simi	ilar?			;
1945																																					
1950	LS dol?	F-M (C) ooids	VLGy	Р	GS	ooid (tr crin?PS)	tr	interXtl dol	50											2 3	·	1?							5D	possibly o	lolm = c	ave					4
1955	DOL cole	E(14.0)	M/T \ " C		_	last a mala la contra																										h t - !!					
1960	DOLcalc	F(M-C)	WT-VLGy	X	TL	interrhb calcsp	?++	loose rhombs	i	1	1	1	1		1	!		1					ı				1			LS chip b	ryozoa/c	cnaeteti	a				

Α	В	С	D	G	Н	I	J	K	L N	/I N	1 0	Р	QR	S	1	ΓΙν	W	Х	ΥZ	Z	AB	AC A	AD AE	AF	M	AI A	IJ	AK	AL	
1965	DOL colo	E M (O))A/T) " O		lasta milita																									6.7
1970 1975	DOLcalc	F-M (C)	WT-VLGy	XTL	interrhb calcsp	?++	loose rhombs																							3P
1980	LS	F(M) ooids	LtGy	PGS	ooid F(M) + pel?	??	ooid disaggr	45	5?									1?	2	1							5	D	disaggregate ooids darer and to C prolate	3P
1985					, , ,																								- 55 5	
1990	LS	F(M) ooids VF qtz	LtGy	PGS	ooid F(M)	??	ooid disaggr	60																			5	D	xf-vf qtz nucleii in F ooids	3P
1995 2000	1.6	cave of dol etc??	l tCv	PGS	ooid F-M(C)	?	tr disaggr	50										1	1								5			3P
2005	LO	cave or dor etc!!	LiGy	F 63	OOIG 1 -WI(C)		ti disaygi	30										'	1											JF
2010	LS	cave of dol etc??	LtGy	PGS	ooid F-M(C)	?	tr disaggr	50	5	5								1	1								5	D	stylolite ?leached echinoderm in dolocmt see photo?	4P
2015									_																					
2020 2025	LS		LtGy	PGS	ooid F-M(C)	?	tr disaggr	50	5																	·	1 5	U	stylolite?	3P
2030	LS	3% vf dolm rhb	LtGy	PGS	ooid F-M(C)	?	tr disaggr	50	5	5									1								5	D		2P
2035					· /																									
2040	LS		LtGy	PGS	ooid F-C(VC)	?	C ooid disagg	50	5	5																	1 5	D		2P
2045 2050	LS		LtGy	PGS	ooid F-C(VC)	?	C ooid disagg	50	5	5			11			1											1 <mark>5</mark>	D	similar to 1960 netlike colonial fossil	4P
2055			,	00	35.0.1 5(40)		S Sold disagg																						S 15 1000 Hounto colorina 10001	71
2060	LS	ooid F-C; pel=F	LtGy	PGS	ooid-peloid	2	interooid	50	1	5									1							1	1 5	D	some ooids/cmt darkened GypBlk; cave? VC qtz stylolite	6P
2065 0	18		Wt-VLGy	GPS	ooid C-VC			60	5										1	2							4 <mark>5</mark>		tr stylolite in grnish wt pyritic pel-ooid	3P
2075			VVI-VLOy	0.0	0010 0-40			00		,									1								_		ti stylonte in grinsii wt pyritic per-oold	Ji
2080	LS	minor M-VCcl qtz	Wt-VLGy	GPS	ooid (F) M-C (VC)			60	5	5			1						2 1	1 2			?				5	D	tr F-M dolorhombs	4P
2085		tu C M alalaukk	M/4 M/1 Co.	CDC	anid (F) M C															1										20
2090 2095	LS	tr F-M dolorhb	Wt-VLGy	GPS	ooid (F) M-C			50												1							3	D		3P
2100	LS		LtGy	GPS	ooid F- M (C)			40	5	5			1							1							1 5	D		3P
2105																											_			
2110 2115	LS DOL	TRIP CAVE		PG+X	TL ooid-frag			25	2	0																- 1	2 5	a	possibly all dolomite F-M cavings - bit-pipe rust	2P
2120	LS dol	10%dol F-C	LtGy-Wt	WPS	ooid-pel-frag	2	interxtl-vug	25	15 1	5																	5E)c	XC calcspar minor=vugs/fract??	2P
2125																														
2130	LS	VF-M ooid, Fpel	LtGy-Wt	WPS	ooid-pel-skel-frag			25	10 1	0			2					1	2	6	inc	ocer	amid				<u>50</u>)cA	stylolites. Thick shelled bivalves = inoceramid w/ prisms	5P
2135 2140	LS	some dk C frag	LtGy-Wt	wPS	ooid-frag-pel			40	10 1	0 1	1							2	1	1							1 5 E)c	ooids VF-M (C)	4P
2145		ound an omag	,		January Par										F ooids					-										
2150	LS		LSGy	wPS	ooid-frag-pel			25	10 1	5 3	3			erriciai ossible	coats (on		1	1	1	1?						<u>5</u> [<mark>)c</mark>	lg rd lithoclasts	5P
2155 2160	LS	cuttings tiny??	LtGy-crm	WPS	ooid-peloid?-frag			30	10 1	0			ritized					1		12	,						5 E)c	disaggregated ooids?? Or just tiny cuttings?	2P
2165		cuttings tiny : :	Lioy onn	W 0	ooia-peioia : -irag																								and aggregated colds: For just tilly cuttings:	
2170	LS	C dk rd frg	Lt(M)Gy	WPS	ooid-rd frag(dk)			20	2	0 1	1							1		2							(50	d)		3P
2175 2180	18	BAD CAVE	Lt(M)Gy	WPS	ooid-rd frag(dk)			2	2 2	,																			washout w/ wood for LOC lots of ooid GS cave sh	3P
2185		DAD OAVE	Lt(IVI)Oy		oola-ra rrag(ak)																								washout w/ wood for EOO lots of sold GO cave sil	Ji
	LS	BAD CAVE	Lt(M)Gy	WPS	ooid-rd frag(dk)			?	? ?	?																				3P
2195 2200	LS	F-M ooids	VLGy-Wt	WPS	oold frag			15	5 4	0																		(EA)		ΔD
2200		i -ivi oolus	v LGy-VV l	VVPS	ooid-frag			10	5 1																			(5d)		4P
2210	LS	small ctgs	VL(B)Gy	PGS	ooid-peloid-frg	??5	interooid disa	50	10 10)roun	nd								1?								5	D	ooids-round F-M frag disaggregated = porous? but not on lo	gs? 3 l
2215						005		50	40 43																				anida animal E O from dinamental anama and a	
2220 2225	LS	small ctgs	VL(B)Gy	PGS	ooid-peloid-frg	775	interooid disa	50	10 10	roun 	ıd																5	U	ooids-round F-C frag disaggregated = porous? but not on lo	js? 31
	LS		Lt(B)Gy	PGS	ooid-frg round			50	10	rc 1	1								2	1			1?				5	D	ooids-round F-C frag less disaggregated; F-M clear calcspa	ţ
2235																													anida mund E C francisco dia compania E Maria	
2240	LS dol	dol 10%	Lt(B)Gy	PGS	ooid-frg round			40	2	0	I					13	?		1					l II		1	5	D	ooids-round F-C frag less disaggregated; F-M clear calcspan	;

2200	В	С	D		G	Н	I	J	K	L	М	N C) P	Q R	R S	Т	٧	W	X Y Z	АА	AB	AC AD	AE AF	AH AI A	J AK	AL
2245 2250	DOL LS	6/4 F-M	Lt(B)Gy		XTL-pGS	ooid-frg XTL m-f	3	interxtl dolm	30		10								1	2	2				5d	ooids F-C; dol xtls F-M
2255																										
2260 2265	LS	small ctgs 2%dol	VLBnGy		PGS	ooid M-C disaggr	775	interooid disa	50		10														5D	ooids-round F-C frag disaggregated = porous? but not on logs? 3F
2270	LS	small ctgs	VLBnGy		PGS	ooid-rd frg-peloid	??	pt disaggreg	35	10	10	_							1		Ш		1		5D	ooids-round F-C frag & peloids disaggregated; stylolites 2P
2275 2280	LS	small ctgs	VLBnGy		wPgS	ooid-rd frg-peloid	??	pt disaggreg	25	10	15									2			1		5dc	ooids-round F-C frag & peloids disaggregated; stylolites 2P
2285 2290	LS	small ctgs	VLBnGy		wPgS	ooid-rd frg-peloid	22	pt disaggreg	25	10	15														5dc	ooids-round F-C frag & peloids disaggregated 3P
2295	20	oman otgo	VEBIIGY							10															Juc	oolds found if o mag a periods disaggregated
2300 2305	LS		VLBbGy		GpS	ooid M-C	??	pt disaggreg	60		10	1		1					1	2	1				5D	ooids-round F-C frag & peloids disaggregated 3P
2310	LS		VLBbGy		GPS	ooid-frg F-C peloid	??	pt disaggreg	45	10	10	2		1			1?			1					5D	4P
2315 2320	LS		VLBbGy		PGS	ooid-frag rd	??	pt disaggreg	40		25	2		1					1	3					5D	M-C frg-ooids, hairline microfractures calcspar filled stylolit 5P
2325																										
2330 2335	LS		VLBnGy		PGS	ooid-rd frg-peloid	??	disaggreg	25	10 2	20			1					2	4	1		1		5dc	F-C frg-ooids, vF-F peloids stylolite 5P
2340	LS	F-M	VLBnGy		WPGS	peloid-ooid-frg	??	disaggreg ooi	20	20	10						1?			1	П				5dc	tr M-C calcspar 3P
2345 2350	LS	F-M© ooids	VLBbGy		PGS	ooid-rd frg		disaggreg ooi	40	5	15									2					5D	3P
2355		omall etge	V/I PnCv							10	20								12						Edo	E Micaida 2D
2360 2365	LS	small ctgs	VLBnGy		PGS	ooid-rd frg-peloid	??	disaggreg	25	10 2	20								17						5dc	F-M ooids 2P
2370 2375	LS	small ctgs	Lt(B)Gy		WPS	rd frag-ooid?			10	4	10										Ш					darder due to md gy rounded F frags 1P
2380	LS		Lt(MdB)Gy		WPS	rd frag-ooid			15	4	10														(5d)	2P
2385 2390	LS	small ctgs	Lt(MdB)Gy		WPS	rd frag-ooid			15		10														(5d)	3P
2395	20	oman olgo																							(ou)	
2400 2405	LS		Lt(MdB)Gy		WPS	rd frag-peloid-ooid			10	10 2	25								4 1?							3Р
2410	LS	small ctgs	Lt(B)Gy		WpS	frag			5	5 2	25	I							1?		П					frag rounded darker F-M© 2P
2415 2420	LS	small ctgs	Lt(B)Gy		WpS	frag	1	interpart	5	5 2	25								1?							frag rounded darker F-M (C) recrystalllised in part 3P
2425					1440				10		20															
2430 2435	LS	SH & rsut trip cave	LI(B)Gy		WpS	frag-ooid			10	4	20															recrystalllised in part 3P
2440 2445	LS	VF-M ooids	Lt(B)Gy		GPS	ooid-frag			40	5	15						1		1	1					5D	4P
2450	LS	VF peloid	Lt(B)Gy		PgS	peloid-frag			5	40	15	3										1	l I 2 miliol	id	5C	M-VC gy frag stylolite 5P
2455 2460	LS	VF peloid	Lt(B)Gy		PWS	ooid-peloid-frag			20	20	10								1				1			F-M ooids M-C frags stylolites 4P
2465	20	VI peloid																								
2470 2475	LS	VF peloid	Lt(B)Gy		PGS	ooid-peloid-frag			35	25	10								2 1	1			1		5DC	F-Mgy ooids 3P
2480	LS	VF peloid	Lt(B)Gy		WPS	peloid-frag-ooid			10	25	10								1				1			F-Mgy ooids stylolites 4P
2485 2490	LS	VF peloid	Lt(B)Gy		wPGS	ooid-peloid-frag			30	20	10	2							2	1			1		5Dc	F-M ooids stylolites 6P
2495																										
2500 2505	LS		Lt(B)Gy		PGS	ooid-frag-peloid			30	20 2	20	2							1	1			1		5Dc	F-M ooids m-VC frag 4P
2510	LS	F-M frg dk + round	LGy+VLBgy	'	PWFS	frag-skel(frmbld)l-oo	oid		15	1	25	1		5	2?	1	1		2 1	3	1		1	2?	5BA	stylolites; mixed LS vI Bn skel-rich FWS & It Gy rd'd dk frag WPS 1
2515 2520	LS DOL	7/3	VLBnGy		PGS	frg-ooid-pel-skel	2	interdolm	20	10 2	Ord		?	2	1				1 1	1		1?	1	2		; euhedral It brn cl dolorhombs tr VC cl calcspar.F-M (C) ooid-frg
2525																										stylolites

Α	В	С	D	G	Н	ı	J	K	L	M	N	0 1	Q	R	S	Т	V W	/ X	ΥZ	AA	AB A	CAD	AE AI	FI AF	I AI	AJ	Al		
2530	LS dol	9/1	VLBnGy	WPS	frag-peloid-ooid			10	15	20			1?						1	5	1							tr hairline microfracturres=calcsp filled; micro birdseyes	
2535												COLO	D NO			•													
2540	LS	F-M	VLBnGy	MWPS	peloid-frag			2	20	10					6-7/2 on			1	1	2	1		1?				5c	stylolites	3P
2545		000/ -!!- f! DO	\		for a shall a shall			45	45	00		VLDIN								4								arional I O little and allower OLL (accord)	20
2550 2555	LS	20% dk frg ool PS	vLBnGy	WPS	frg-peloid-ooid			15	15	20	- 1		_			4		2		1			Ш.	II Solen	l onora	3		mixed LS liths w dk gy SH (=cave?)	3P
2555 2560	LS	10% dk frg ool PS	VI RnGv	wPgS	frg-pel-ooid-skel			10	15	25			2	1				1	1 1	3	1		1 '	II 1	opora I	3		stylolites; F-M-C frg ool	7P
2565		10 % uk iig ooi F S	VEBIIGY	wrgs	irg-per-ooiu-sker			10	13	23			-	ш					' '	3	-			1		3		stylolites, i -ivi-c ilg doi	/ -
2570	LS	tr M dolm	VLBnGy	WPGS	frg-pel skel-ooid	2?	C calcsp=vug	10	15	15			2					2	3	4			1	2		1		check Cladocoropsis; stylolites	9P
2575			TEEOy		ing per enter centr		o calcop rag		. •	. •			-															amphipora like no central canal??	•
2580	LS		VLBnGy	WPgS	frg-pel			5	20	15			1+					1		1	1?						5c	check Cladocoropsis; stylolites	5P
2585																													
2590	LS	tr dolm	aa+LGy	WPgS	frg-pel-ooid			10	15	15								1		1						2			2P
2595																													
2600	LS		aa+LGy	WPS	frag-ooid-pel			15	10	15								1		1								M calcsp in ?fractures	3P
2605																													
2610	LS		VLBnGy	WPGS	frag-ooid-pel			15	10	25rd										1									2P
2615		M C for	VI Da O	\A/ 0	fue a melei d	4	intended - 11	_	40	4.5																			45
2620	LS	M-C frg	VLBnGy	WpS	frag-peloid	tr	intrafossil	3	10	15rd										3			1			1		stylolites, t	4P
2625 2630	LS	F-M (C) rd elonga	VI BnCv	M+PGS	frag-pel	tr	fosisil mold		20	40										1			1			1	5c		4P
2635	LS	r-ivi (C) lu eloliga	VLBIIGy	WITEGS	irag-pei	u	iosisii iiioiu		20	40	26	65m=	15% (dk gre	v calc s	shale cu	ttings			'						L '	30		46
2640	ıs	? Qtz silt-VF grns	VI BnGv	MPS	frag-pel				10	35					Abenal		asing				1							F-VC rounded fragments	5P
2645		: QLZ SIIL VI GITIS	VEDITOY		irag-per				10	00	se	t belo	w so s	should	In't be c	ave??												1 VO Todrided Haginerits	O.
2650	LS	F-VC rd	VLBnGy	PGS	frag-pel			2	20	45								2?		2		1n	niliolid	?		1	5c		4P
2655																													
2660	LS	VF-M-VC rd frg	VLBnGy	PGS	frag-pel			4	15	40				1				1		1			1	1?s	solend	pora		tr VC calcspar; stylolites microperforate=alga?	6P
2665																													
2670	LS	F ooids superficial	VLBnGy	WPGS	frag-peloid-ooid	tr	ppt C pores	15	10	20								1		2									7P
2675																													
2680	LS	tr F dolm	VLBnGy	WPS	frag-			5	5	30																			2P
2685																													
2690	LS	tr F-M dolm	VLBnGy	MWPS	frag			3	6	30				1				1										some dark rd frags	3P
2695		E M (O.)	\/I D=O;	D00	fuers and resid			20		20										2									20
2700 2705	LS	F-M (C)	VLBnGy	PGS	frag rd-ooid			20		30	1															2			3P
2710	LS	15% ool	VLBnGy	MW+PS	pel-frg + ooid			15	10	20						1?		1		1								mushed coral=microenterolithic fabric? Stylolite	3P
2715		1070 001	VEBIICY	IIIIV I G	por ing + cond			.0																				That had been microsinered ability. Ctylonic	Ů.
2720	LS	VF-Fpel M-Cooid	VLBnGy	PGS	peloid-ooid-frg			20	20	10								1	1	3	1					2	5DC		6P
2725		·																											
2730	LS	dk frg.ooid	aa+ LtGy	MW+PGS	pel + ooid-frg			30	20	10										1							5DC		3P
2735																													
2740	LS	dk frg.ooid	aa+ LtGy	MW+PGS	pel + ooid-frg			30	20	10	2		3			1?			?	3	1	2n	niliolid	?			5DCA	VC calcspar XC fibrous shell inoceramid?	8P
2745																													
2750	LS	small ctgs	aa+ LtGy	MW+PGS	pel + ooid-frg	tr+	vc calc fract?	15	10	10			2							1				2?s	solend	porio	İ	smallis ctgs hard to see fabric	4P
2755		iner en ! O	001140:	WDs.	from soid			15	_	20		,								4	1						E A	at delites	
2760 2765	Lo	minor arg LS	aa+ LtGy	WPs	frag-ooid			15	Ð	20		2								1	1						5A	stylolites	
	LS	tr+ M dolm	LtBnGy	MWS	frag-peloid				8	15			2			1?		1			2 1							stylolites	3P
2775		u · IVI UOIIII	Libridy	.,,,,,,	nag-peroid				J	13			1			1 :					- '							Stylonico	Jľ
	LS DOL	7/3 dol M-VC	LtBnGy+Wt	FWPS	frag-skel	6	interxtl dolm	5	5	35			4			2		1		2	3 1		10	II :lam			5bA		6P
2785			,· · · · ·	1									Ť							_				<u> </u>					Ų.
	LS DOL	7/3 dol M-VC	LtBnGy+Wt	WPS	frag	4	interxtl dolm		5	40								1		1								stylolite = some arg LS	
2795			,							_																			
	LS dol	9/1 M-VC frag	LtBnGy+Wt	WPS	frag-pel-ooid	2	interxtl dolm	10	10	40	3	1								1						2		stylolite	6P
2805																													

Α	В	С	D	G	Н	ı	J	K	L	М	N	O P	QI	R :	S	T \	/ W	/ X	ΥZ	. AA	ABA	C AD	AE AF	- AH	AI A	J A	AL
2810			Wt VL Bn		(skel-frg)	5+	interxtl dolm		7		十		2+			1?			1	1	$\dagger \dagger$		\top	1			tr XC cl calcspar 4P
2815																							1				
2820	LS dol	9/1 M-VC frag	VLBnGy	FWPS	skel-frag-pel	2			15	35	2		2	1		1		1	1	5	1					5Ab	some thick XC shell 8P
2825																											
2830	LS	lost circ mat	VLBnGy	FWPS	ooid-frag-pel			20	10	20			1	1					1	2						5D	mica & wood lost circulation material 4P
2835																											
2840	DOL	lost circ mat	Wt	XTL	M-VC																						
2845					_																						
2850	DOL	lost circ mat	Wt	XTL	M-VC																						
2855	_																										
2860	wood	100% lost circ mat	erial																								
2865	DOI		10/4	VTI	14.1/0																						40
2870	DOL	lost circ mat	Wt	XTL	M-VC																						4P
2875 2880	DOL LS	9/1		XTL-FS	M-VC skel			3		3			2 !	5				1		1						5b	4P
2885	DOL L3	9/1		XIL-FS	IVI-VC SKEI			3		3			2 ;	3				-		'						30	45
	DOL	lost circ mat	Wt	XTL	M-VC																						minor LS frg PS
2895	DOL	iost circ mat	VVI	AIL.	INI-A C																						Illinoi Lo ilg Fo
2900	wood	100% lost circ mat	erial																								
2905	wood	100 % look on o mak	i i																								
2910	DOL	lost circ mat	Wt	XTL	M-VC																						mica
2915																											
2920	DOL	75% lost circ mat	Wt	XTL	M-VC																						wood & mica
2925	LOST	RCULATION																									
2930		I																									
2935																											
2940	L											NO.	r Loc	GGE	D BELO	W 291	0m ı	prior	to 200)9						1	
2945	L 0 S														gged to												
2950	S												TOF														
2955	Т														l60m;			olon	nite 352	24m							
2960	CI												cırcı omite		on 3650	-37001	n										
2965	R														on 3904	m to T	D.										
2970 2975	С														RE 4625			n									
2975	U												4336.														
2985	L L														2011, W												
2990	A TI														onian?-												
2995	0														endix lo above a												
3000	Ň											pick	s) wit	h da	olomite l	below	shale	e cal	lled Sc	atari	ie @ 3	525m	then	after o	leaner		
3005															led Iroq												
3010												@ 4	327m	1 (las	st below :	TD)				Ĭ			•		•		
3015															apter 9												
3020		L													3225m												
3025		0							1						ro) Top												
3030		T													n oolite												
3035															sts at 21						.,						
3040		C																									
3045												BAS	SED (ON S	SEISMIC	IN Ki	dstor	n et a	al. 2005	5 F A	\UL 1	г то	IRO	QU	OIS		
3050		R										AT	532	251	VI RATH	ER TH	IAN I	DOL	OMITIC	c sc	ATAR	IE SF	EMS N	/IORF			
3055 3060		Ŭ													LE WITH												
3065		Ľ													GE. MC												
3070		А																									
3075		Ţ																									
3080		0													- 1	П		1	т т		1 1			П	1 1		
3085																											
- 300																											

Α	В	С	l D I	1 1 (H		J	K	LT	M L.J.	M. I (O I P	QF	R I S	1 17	гПν	W	X Y Z	AAI	ABIAC	CAD	AEI AF I	АН	AI A.	Ał	(AL
3090		-	 				•		_	ual	IK .			Ť		 	Ť	+++	+ - 1							
3095		- EAC	IES NIIMBE	DS: 1-b	thyal shale, 2 =neritic sha	ale 3-for	rereef channe	1 34-	foros	slope (chan	nol 30	- diet	al force	slope (r	nicrobi	al mu	ıd mound	\ 3B-	provin	nal fo	reclone	/forer	oof) 4:	coonge	eefal
3100		L 4Δ=			e reef & intermound, 4B =																				- sponge i	eciai,
3105		O 5R=			oid reefal, 5C=mud/pellet																				ore ridge),	
3110					I-continental), 9= mixed																				0 //	
3115		'														П										
3120		CI																								
3125		R																								
3130		С																								
3135		U																								
3140		L L																								
3145		A TI																								
3150		0																								CSS log had nearly no oolites (Tubiphytes-calcispheres)
3155		O N																								PEX masterlog commonly had oolites peloids
3160																										FEX mastering commonly mad bontes perolus
3165 3170																										CUTTINGS MAINLY SMALL & CLEAN
								L,																		LOST CIRCULATION MATERIAL = LCM
3175 3180	CASING	POINT REGAIN	CIRCULATION	ON 3190i	n in Misaine (old GSC-l	ndustrv	pick)																			LCM = walnut shells, wood, biotitie, clear plastic
3185	3190 m				((,	p																			LOGGED EVEN #s USUALLY in white columns
3190		-																								LOGOLD LYLIN #3 GOODLL I III WIIILE COIGIIIIIS
3195	SH calc	calc	N6-5YR3																							lighter color=cmt/mud?? Tr recirc lst-dol smaill
3200	SH calc	caro	5YR3-N3																							ingritor color cirilamida : 11 recirc ist der sindin
3205	LSsdSH		5YR7-N6	PW	frag-sandy(MFang)					25		?														clean-sandy-frg LST interbeds
		prtly soft	4N-5N																							olean canay ng 201 molecus
	SH calc		4N-5N																							rusty spots = pipe?
	SH calc		4N-5N																							President President
3225	SH calc		4N-5N																							
3230	SH calc		4N-5N																							
3235	SH calc		4N-5N																							
3240		soft-disaggreg	4N-5N																							
3245	LS		LMdBnGy	M-G	S frag (ool, skel)			7		35		1							2	1	?					tr pyrite encrusted tubules in oncoid
3250	LS argL	S	LMdBnGy	M-G	PS oncoid, frg-skel			3		20								1	1		1	1		15		In part from above? @ gamma healied microfrac-calc
3255	LS		LMdBnGy	W-G	S ooid(M-C) frg			30		15	1	2						2	1		3				5D	Dk & Lt ooids W/Tubules = debris beds?
3260	LS		LMdBnGy	W-G				20		5rd			1		1	1					1			2	5D	
3265	LSar gSH		Md (Bn)Gy	W-P				10		15			7	,												strange colonial chain-link fossil=P
3270	LSar gSH		Md Gy	WS				5		15	_ :	2				2		1	?		1					more obviously argill LS
3275	<mark>LSar</mark> gSH		Md Gy	MPS																	1					black contaminant oily? Very small cuttings
3280	LSar gSH		Md Gy	MPS	frag-ooid VF-M			10		15	_ :	2												?		small black ool LCM
3285		poor sample																								bitumen clumps lots LCM
3290		poor sample	Lt(M)BnGy	MW	frag(rd)			3		15 2	2										1			?		XC calcsp+frac? bitumen clumps lots LCM
3295	AA?																									LCM
3300	LS		Lt(M)BnGy	M(V)S frag					10	- 2	2														very small cuttings
3305	as below	An alasainal -ilk	MDkO																							very small cuttings
3310	LSarg AA	tr dessim' silt	MDkGy N4	MS																						micropyrite, XF carb flecks very small
		noor oomala as	N/4	MS																						SH & LS ?caved LtBnGv Lg Rd ctgs bitum balling
	LS arg?	poor sample cave poor sample cave	N4	IVIS																	T or	ive WS				SH & LS ?caved LtBnGy Lg Rd ctgs bitum balling SH & LS ?caved LtBnGy
	AA LS ara2	poor sample cave poor sample cave	N4 N5	MW						5												ive WS		? 2		on a Lo ?caveu Libility
		poor sample cave		MPS							3 ,	2										146 449		2 ?		SH & LS ?caved LtBn: Tubiphytes conplex
	LS LS		MdLtBnGy		BS sponge-skel-frg			3	5	10 3 15	, i	∠ 1 1	1			1		1			2+	2		2 ? 3?		orra Lo ! caved Libri i dolpriytes complex
		poor sample cave		IVIPS	Bo sponge-skering			J	5	13	1	X				1		1				_		J!		LOST CIRC MAT lots LCM
3350			MdLtBnGy	WFS	skel-frag (Vf-C)				5	10 2	, (4				2		2			1	1		10 2		some rd black particles
	LS LS	u stylo-sii ptys	LTBnGy	WP				2	10	25		1						2 1			2	1		2		clean gamma 1 Wt DOL M XTL
	LS LS		LtBnGy		PS frag			_	10 5	20		1	Y	2		У		1 1			1	1		2		some frg rounded Tiny cuttings
3365			сынду	101.00	IIay				J	20		1	^	-		^		1			1	1		_		Tiny cuttings
3303	AA:	tiny ctgs		'																						Tilly cuttings

Α	В	С	D	G	Н	ı	J	K	L N	N N	V C) P	Q	R	S	Т	V	W	ΧY	ZA	A AB	AC	AD A	AE AI	AH	Al	AJ		AK	AL	A۱	И	AN		AO	Al	P	AQ
3445 I	LS arg?		MdBnGy	MS						5									1				1			2												Р
3370	LS	tiny ctgs	LtBnGy	?	pel-frg?			? 1)?															1								Tir	ny cutti	ings				Р
3375	AA?	tiny ctgs	LTBnGy																													Tir	ny cutti	ings				Р
3380 I	LS	tiny ctgs	LtBnGy	?MWPS	frag-pel?			1)? 1	5?				1										1								Tir	ny cutti	ings				P
3385 I	LS AA?	tiny ctgs	LTBnGy																													Tir	ny cutti	ings				Р
3390 I	LS	tiny ctgs	LtBnGy	?MWPS	frag-pel?			2? 1)? 1	5?													1	1		2?						Tir	ny cutti	ings				Р
3395 I	LS AA?	tiny ctgs	LTBnGy																													Tir	ny cutti	ings				P
3400	LS AA?		LtBnGy																																			P
3405 I	LS		LtMdBnGy	MPS	frag-pel-skel			1	0 1	5	3	3		1		1			1				2	1		5												Р
3410 I	LS AA?	•	LtMdBnGy	WPGS	rd frg- pel			2 1	0 2	5	2	2											1			2?			s	ome dk c	coated-c	ooid?						Р
3415 I	LS		LtMdBnGy	MW(P)S	rd frag (F-VC)				5 1	5	1												2			3?	2											P
3420 I	LS		LtMdBnGy	M-GS	pel-frag					5 2	2							-	1?		1		1	1		5?	2?											Р
3425	LS	1 M xtl wt dol	LtMdBnGy	MPGS	frag-pel-thromb?			1	5 2	0 5	5	1							1				4	1		15			c	lolm-frac?	?	mi	icropyri	ite				Р
3430	LS SH	marly & clean	Gy+LMBnGy	MS pws	fragskel-(thromb)					5		1				1			1		1		2	1		7	1?		>	(C clear g	reen m							Р
3435 I	<mark>LSar</mark> gSH		Gy+LMBnGy	WS-GS					1	5 3	3		1	?			1?		3	1						3												Р
3440	SH calc	marly	Gy-DkBnGy	MS															1				1?						t	r VC rd qt	z	V.s	small c	cutting	S			Р
3450	LSarg	marl	DkBnGy	M(W)S	frag				1	0								-	1?	1						2				nottled					cutting	3		Р
3455	LS	some marl	M(L)BnGy	PGS	ooid-rd frag (F-VC)			35	5 1	5 3	3									1							2	5D	c	oids dark	, mico	rpyrite			all cuttin			Р
3460	LS		M(L)BnGy	WPGS	ooid-rd frag (F-?C)			25		0																	2	5D			-	. ,			iny cuttii	_		Р
3465	SH L <mark>Sar</mark> g	marly	MDkBnGy	MWS	frag (F-M?)				1	0										?			1			1?			t	r pyriite								Р
	AA `	,	MDkBnGy		Frag-skel)F	1		m						1 1	1			2			3	2			Vt calcsp-	-frac? w	v/SHC?	tr pvr	ite bi	itumen i	n mud		Р
	LS (arg)		MLBnGy	WPS	frag				2	0	2	2											1	1														Р
3480 I	LS LSarg		MLBnGy	MWS	pel-frag			1 1		0																2			li	nterbeds								Р
3485	AA		-,																																			Р
3490	LSarg		MdBnGy	MWS	frag (round)			1	5														2			1			i	nterbeds								Р
		S as AA	MdGy																								1?											P
3500	LS		MdGy	GPS	ooid (-M-grey)			60	1	0																		5D	r	nicropyrite	e TR a	na C QT	ΤΖ	tinv	cutting	3		P
3505	LS	F qtz nucleii etc	MdGy		ooid (M-C)			50		0													1			2		5D		BnGy MS			-		cutting:			Р
	S SHcal	interbeds cave?	MdGy		ooid (M-C) frg			15		0													1			_		-		calcisphe					cutting			P
3515	SHcalc	cave Ool etc	MDkGy	0.00	, g						1												1							ош.о.орс					cutting:	3		P
	LS arg?	interbeds SH	Gy & BnGy	MWS	pel-frg(some blk)			1 1	0 1	0	1									1			1			3			s	ome VF p	neloid to	n PS			outg			P
	SH LS?	pink DOL 10%	Cy & Biley	MWS	frg			•	Ĭ.										1				1			2				ıtz silt mir								P
	DOL	VF-F xtl	N8 & R8	XTL	9																									/L grey (w		led with	nink to	thn re	ed inter	(TI AF	RUPTI	
	DOL	VF-F xtl	N8 & R8	XTL																										- gicy (w	,	OG WILII	piint to		00 1111017	L /\L	(01 1:	P
	DOL	VF-F xtl	N8 & R8	XTL																																		P
	DOL	VF-F xtl	N8-9	XTL																									l.	ess pink-r	ed.							D
	DOL	sl calc or cave	N8-9	XTL	EACIEC MUNICIPALITY	20. 4.				-1- ') A - 5-	un alc :	 		20-	istal f		- /:-		المنط		1\	25	L		•		£\ 4		f-1				P
3555	JUL	or care	140-0	AIL.	FACIES NUMBER 4A= 'deep' siliceou	13 : 1=0	oamyai snaie, 2	=neri	ıc sn -⊿⊿	ale, i	o=tore	ereet	-cnan	nei, i	A= f0	resiop	e cna	innel,	3U=0	iistai foi	resiop	oe (n	nicro	biai r	nua m	ound)), 3B :	= proxi	inai fi	oresiope ((IOreree	er), 4 = S	sponge	reetal	Ι,			
3560					5B=coralgal-'stron																											arshore	ridae)					
3565					8= coastal deltaic																									$\mathbf{m} = \mathbf{mic}$,u. 31 101 C	, iluge),	,				
3570					Codotal dollar	(.c. continontal),	J 11		Jul Di		30/10	, I	- 40				'			IGI IG			_002	. 51 1110		2110		Jano		J. 02.01							
3575																																						
3580		Λ		l:.,	12	, W I		C) [-	Λ	7		ľ	7		R I			T	Г	•	7	7												
3585		App	enn	IIX A	4.5 F	'IV	CLO			П		• /	4	5	.5	i t	31		IV	IVI			H	/_	1.	5			FI	iuk	20	16						
3590		'''										-	•	\leq						•		_	_			\leq		L .		MI	20.	- U						
	В		<u> </u>		i u		, , , , , , , , , , , , , , , , , , , 	V	-					В	-	-	11.77	14/	V V	7 4		A.C.	ADI 4	AE A	il Air	A.	Α.	-	ΑV	AI	A 8		ANI		40	A		AC
Α	В	L	ט ן	G	п	ı	J	K	'	VI I	v C	ץ י	Ų	ĸ	3	_ !	П 4	VV	A 1	ZA	A AB	AU	AU	A⊏ Al	N AH	AI	AJ		AK	AL	A۱	VI	AN		AO	Al		A

Enclo	sure	A3.4 Mobil-TI	ETCO-F	EX	СОН	IASSET L-97	III		Geo	Tou	rs Con	sultir	ng Ind	c L	.Eliuk	P.Ge	ol. S	equenc	e alte	rnativ	es cf.	PFA	2011	1 add	ed 201	4-11		1,89	PAGE	
DEPTH	LITH	modifier I	COLOR		TEXTU	JRE modifier	POR	OSITY	ACC	ESS	ORIES				FO	SSILS	S	(er	hance	d by S	SWC da	ata if	availa	able)				; TYPE <'78,81, k 02	COMMENTS	
(metres	H S O S L a	S=limestone ODL=dolomite H=shale S=sandstone LTST=siltstone rg=argillaceous alc=calcareous	ABBREVIATED or MUNSELL	UNHAM NUMBER left fs&rs(bs) right	WS= PS=p GS=p BS=t (FS/F FS=f	mudstone 1 wackestone 3 parainstone 7 poundstone 9 3S=XC size) loatstone 4 rudstone 8	%	modifier (Archie)	SOIDS	PELOIDS	ICLES ITHOCLASTS	FRA Sage	ES.	STROMATOPOROID C	HAETETIDS ILLEPORID	MICROSOLENID-	HEXACORAL	BRYOZOANS BRACHIOPODS	SIINOIDS	GASTROPODS	BIVALVES OSTRACODS	SERPULIDS	IPHYTES etc	NGS	HERES -green etc	STROMATOLITES BY THrombolites	ONCOIDS-PISOID	ANDARD MICROFACIES Ison'75, Flugel'82&Eliuk Vierzbicki, Harland&Eliuk	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera BBB =BADLY BIT BRUISE	
	G s	dy= sandy/qtz	,	sq-sw	XTL	=crystalline			O]	PARTICI	SPO	WT.	STRO	Ž PA	MICR	ίзн		8		TSO	i	TUB	BOR	CALCISE	STR		STAND, Wilson' , Wierz	some long comments may be SAMPLES = LIGHTER COL hidden & visible only on screer = RARE/ABSENT	OR &
Α	В	С	D		G	Н		J	K	L	M N	0	Р	Q	R S		Т	V W	X	ΥZ	AA AB	AC /	AD AI	E AF	E A	H AI	AJ	AK	AL	
3140	SH/SS	<u>'</u>	MGyCrm	Ш		F-M(XC) qtz																						2	glauconitic 1-2%	Р
3145	SH	slty-sdy(vf)	DkGy																1									2	1% glauconitic, 1% (micro)pyrite, tr lignite flakes	P
3150	SS/LS	7/3 F(M) qtz	LtBnGy	4	FS	frag-skel (sponge)				0	10+	6?		?						?	3		?	,				3?-4? 5F	biotite-glauconite	Р
3155 3160	SS LS/SH	calc VF-F qtz 6/4 sandy	VLtGy	3	(WS) PWS	(fragmental) F qtz frag-skel			2	5	5 30	2+					1	1	1	1	31 3		1			2?		5F 5A	glauconite pyrite rounded frags pyrite tr orange stain & green clay t	thumb'P
3165	SS/LS	6/4 sandy	MdGyBn	4	(PW)	frag-(skel) M qtz			· ·	2	10	1					'			'	2		'			?		5F	occ qtz granules, tr grn mica-glauconite, pi nk feldspar	ulullib P
3170	SS+SH		VLtGv	7	(1 00)	mag (oltor) in que					10										_					•		2-5F	M atz -well rd & srt	
3175	SS/LS	8/2 F-M qtz	LtGyBn	2	MW	calc qtz sst			1?			1						1	1		2							5F		Р
3180	SS-SLT	very Calc XF-F	LtGy					3187.5m		2																		5F	+1% pyrite	
3185	SH-SS	,	LtMdGy			very pyritic	-3157											1										2-5F	+3% pyritic	Р
3190	SH/SLT	6/4 very calc	MdGy			(frag?)		SIBLY ER &													2					1		2	<1/2% pyrite	
3195	LS(SH)) bad cave = SH	MdGy		M(W)	??		U cf. PFA						1	1?													2-5	+90% SH (+SS) cave?? Late Lg??	
3200	LS		LtBnGy	_	WS	frag-skel		onian UJ if		5	20	1?					1	1?			1 1		7			?		3-5A	manthlad anlar = 1 (Manual / I tDb Ou Orres	
3205 3210	LS LS	mottled argil?	LGy+Crm LGy+Crm		W(M)S WS	frag (VF-M) frag-skel	so th				20	1?		1	1 1	12			1		2	12	!	12				5? 5A	mottled color = L/Mgy+VLtPkGy-Crm. Few Fossils? tr micropyrite	Р
3215	LS	(argil)	LGy+Crm		WPS	frag-skel-strom'	unae	erlying seq r??? then			20	1		10	2	1 :			2		1	1:	1	1:		1		5B?3B	tr micropyrite, tra Cu green stain	P
3220	LS		LGy+Crm		W(P)S	frag-skel		ach closer			15			5	1 2				2+		1							5A?3B	tr micropyrite, tr orange stain	•
3225	LS	sl. Argil occ sl. argil Gy	LGy+Crm		W(P)S	frag-skel	to M				20	1+			1				1		1							5A?3B	tr micropyrite,	
3230	LS	sl. Argil calc	LGy+Crm		WPS	frag-skel		ls also			20 2	3	П	6	1?		1?		1		1		?	•		2		5AB?3		Р
3235	LS	sl. argil SH	LGy+Crm		WPS	frag-skel		in AB5 as 79 oolite			15 1	2		4	? ?			?	?	1	2		1			5		5A-3B?		Р
3240	LS	sl. Argil	MLGyBn		WPS	frag-skel-strom'		79 Oonte		?	15	3			2				1		1					2		5B-3B?		
3245	LS	sl. argil	MLGyBn		P(W)S		crob)			?	15 ?	2		-	6+		1		1		1		1			6+		5B-3BC?	tr/occ red microbial MS	_
3250 3255	LS	sl. Argil	MLGyBn		F(W)S FWPS	frag-skel	Ļ			2	20 10	2 10		•	3 ? 5	1	2?	1	1		1		1		?	6		5AB-3B	ND CCC log = CCT222	P 2P
3255	LS LS	(sandy?)	L(M)GyBn L(M)GyBn	4 4 5 4	FPS	strom-spg-frg-micro frag-skel	I			2	35 5	_		4	5 7			2	2 -	1	2 1		1 2	,		3		5A-3B?	NB - CSS log = SST??? Grainier tr micropyrite	28
3265	LS	argo; - shaly	LMGyBn	3 4	FWS	frag-skel-microb				1	20 5		1	3+	?			3+	5	'	5		2 2	- >		10?		3BC-5A	Possible Sequence Break w/ crinoids-bryozoa in arg lst	Р
3270	LS	tr DOL?	L(M)GyBn	3 4	FWS	frag-skel-strom'					20 3		1	10				?	3		2					5		5BA	tr pyrite	•
3275	LS	argill	L(M)GyBr	3 4	(F)WS	frag-skel					15	1		5				4	6		2		? 1			5		5A	tr micropyrite	Р
3280	LS	argill	MdBnGy		W(P)S	frag-skel				5	25	1	1?	5	1			6	5		1		? 1			5		5A	common micropyrite **	Р
3285	LS	argill	MLBnGy		WPS	frag-strom-skel					20	2		20	1			1	2+		2		1			5		5B	white ?stromatoporoid common	Р
3290	LS	sl argill	MLBnGy	3 4	FWS	frag-strom-skel-(mi	crob)				20	2		10 2	2+			1	2		2			1		7+		5B-3C?		
3295	LS	sl argil	MLBnGy	3 4	FWS	frag-strom-skel					25	2	1	10	1				1		1					5		5B-3B	tr pyrite	
3300	LS		L(M)GyBn	3	ws	frag-skel-(strom)					20	3		7	3 1			1	2		1		1			3		5AB		
3305	LS/SS	6/4 VF-F qtz	L(M)GyBn	3	ws	frag				5	15 3			3					1		2 1		?					5A	tr pyrite	
3310	LsSItDol		LMGyBn		WSxlt	peloid-frag	tr	vug-cmt?		10	10								1						1?-Br	n		3B	tr pyrite LtGy xtl(VF) (& siltstone)	
3315	LS(Dol	l) 8/2 & sltst-argil	LMBnGy		MWS	frag					10			2	1 ?						?		1					5A-3B?		
3320	LsDolSit		LMBnGy	_	WS	frag-skel					15		\sqcup	4			1?		3		2 1		?	<u>'</u>				5A-3B?	DOL = LtBn VF-F(M)	P
3325	DOL/L		Lgy+Bn		xtl FS?	skel		vug-cmt			5			5	?		1?		2		3		1					5A-3B?	MAJOR GAMMA BREAK = CLEAN BELOW	P
3330 3335	DOL(L: Dol/Ls	*	L(Bn)Gy		XTL xtlWFS	(FS skeletal)		3320m			10 5ro	Lind		5	1				1		1			12				? 5A	(tr pyrite) LS = Brn fossiliferous, tr C calcispar	P P
3340	LS/Dol		LtGy + Bn Lt(Gy)Bn		FMS	frag-skel skeletal	-3289 AB6L				10 310	und		3	•		2		2		2+		1	1 !	1?	3		5A		P
3345	LS/Dol	-	Lt(Gy)Bn		M(F)S	skeletal		vug-calcisp						2	1		1		-		1				12	3		5A-3BC		г
3350	LS/DOI		MdLtBn		M(F)S	skeletal (microb)	u r	vug-calcisp	1					2	1		1		1		1 1	2	1		1 ?	5+		5A-3BC	tr VC Calcispar	Р
1 3000	1		I.J.GELDIT	∎ . I I	(.)0		1	I	1	ı	I	•	1 1	- 1	Ι'	1 1		1 1	1 . 1	I I	ı . I ,	1 . 1	Ι,	1 1	1 1	1 2.	ı	157, 353	a. 13 Galolopai	

Α	В	С	D	Ш	G	Н	ı	J	K	L	M N	0	Р	Q	R	S	Т	VV	V X	Υ	ZΑ	AAE	AC A	AD AE AF	ΙE	ΑН	Al	AJ	AK	AL	
3355	LS		(v)L(B)Gy	1	M(W)S					8+	3			2+					1					1			3		5C-3C?	tr purite & C calc spar	Р
3360	LS		(v)L(B)Gy	2	MWS	peloid microb?				10				1			?		1				?	? 2			8		5C-3C	some clear cement in WS	P
3365	LS	tr DOL (VF-F)	(v)L(B)Gy	1	M(W)S	peloid (VF)				10				1	1	1								1 1			5+		5C-3C?		
3370	LS		(v)L(B)Gy		M(W)S	peloid (VF)				10						1							?	? 1	1?		5 +		5C-3C?	some clear cements	
3375	LS		(v)L(B)Gy		W(F)S	•				_~	3			2								1	?	2 2			10		5C-3C	minor peloid/microbe GS with cements	
3380	LS		(v)L(B)Gy		W(P)S	peloid-skel-(microb)			20		1							1		- 1	2 1	:	2 2		ш	8		5AC-3C	stylolite	
3385	LS	•	(v)L(B)Gy		WPS	peloid-strom		_ 3400m		20		1		10		1?						1 1		1 1			5		5BC-3C?		Р
3390	LS		(v)L(B)Gy		ws	peloid-skeletal		9.5m or		20				4		2			1			1 1	:	2 1			3		5C-3C?		
3395	LS		(v)L(B)Gy		ws	peloid-skeletal	?AB	5 ??			5	1		2+			?		2?		:	2	1	1			5		5C-3C	occasional peloid GS	P(2)
3400	LS		(v)L(B)Gy	2	MWS	(skeletal-peloid)	tr	vuy -VFcmt		5	5			3					1		? '	?	1	1					5A	stylolite	
3405	LS	microfrag	Lt Gy	4	PWS	pel-frg-skel				30	30			3+			1+	1	2		1	1	?	2 2			3		5AC-3C?	surprised - fossils not obvious above core	
3410	LS	CORE-no spl			RS	fracture-breccia	2%+	vugs			5? 30			5+		2	_	1		5	- 1	2	2	2+ 5			15		5B-3BC?	CORE 3407-3425m No cuttings hardgrounds & micr	obial textures
3415	LS/Dol	CORE-no spl			BS	Coral-microbial		CORE			5? 30			15		1		1		5		-		1 6			10		5B-3BC?	geopetals, pyrite common, WS-PS mtx w/ dolm	
3420	LS	CORE-no spl			BS	Coral-microbial		CORE RIPTION			5? 5	_		5	5	3		3			2 2			1 5			25		5B-3BC?	very large massive 7 branching corals in situ Hdgds of	
3425	LS	CORE-no spl		8	RS	Coral-microbial	DEGG	ttii Holt			5? 2	5 5		10	10	10	20					5	2	2+ 5			20		5B-3BC?	probable submarine cmt? Shelter covities	common
3430	LS/Dol	8/2 F xtl DOL	(V)LBnGy	6	RFS	Strom-skeletal				5	5	1		25	2	5	3		. 3			3	. 1 . :	2 1 1					5B	L-M Gy DOL vs VLBnGy LS	P
3435	LS		(V)LBnGy		PFS	Strom-skeletal	tr	M cl spar			7			30	1	6	5		3		:	3	1	1			3		5B		Р
3440	LS		(V)LBnGy		F(R)S	Strom-skel-microb								15	1	2	5		1			1		2 2 1			10			trace pyrite	
3445	LS		(V)LBnGy		FPS	Strom-skel-microb					5			15	2	2	2		2			1		1 1			10			trace pyrite	Р
3450	LS		(V)LBnGy		ws	microb-tubiphytes				5				3			3		1		-	1	1 1	0 2	1?		20		5A-3BC		Р
3455	LS		(V)LBnGy		FS	skel-Strom-microb				3		1		10	3	2			2	1		1 1		2 1			10		5B-3BC		Р
3460	LS	tr DOL	(V)LBnGy		FS	skeletal-(microb)	tr	vug-C spar		3				5	2		1		2			1		1 1			5+		5A-3C?		
3465	DOL		Lt Gy		XTL	(skel FS)		1D-vug ling						3			1							1					5A?		
3470	DOL	VF-F	Lt Gy		XTL			IAC3D						1	1		1		1				1	tr tr		ш	3+		5A?-3 <mark>C?</mark>		
3475	DOL/LS	8/2	Lt Gy		XTL	MS microbial	3%	vug-interstl						2			1		1	1		1		1			5+		3C?		
3480	LS		LtBnGy	3	MWPS	peloid-skel-microb				20	10			1?			1?		1	?		5 2	.	4 2			15		5AC-3C	thick wall tubiphytes (cl cmt - pel GS-geopetal)	P
3485	LS		LtBnGy	3	W(G)S	peloid-skel-microb				15 1	0	1		3		2	1?		2	1?	:	2 1	:	3 1			?15+		5AC-3C	(cl cmt - pel GS-geopetal)	Р
3490	LS		LtBnGy	3	W(G)S	peloid-skel-microb				15	5			4		1			2	1?		1 1	:	2 1			15to		5AC-3C	(cl cmt - pel GS-geopetal)	Р
3495	LS		LtBnGy	4	WPS	peloid-skel-microb				1 0	3	2		2					2			1 2		2 1			10		5AC-3C	(cl cmt - pel GS-geopetal)	Р
3500	LS		LtBnGy	4	WPS	peloid-skel-microb				15				3		1			2			2 1		1 1			10		5AC-3C	sty;lolites	
3505	LS		LtBnGy	2	MWS	microb-peloid				15					1				1			1 1		1 1			20+		5AC-3C	tr red brn mottle stylolites	(X16+10)2P
3510	LS		LtBnGy	2	MWS	microb-peloid				20		1 dl	k	1		1			2		:	2	1 :	2 1			20		5AC-3C	tr red brn mottle sty;lolites	
3515	LS		LtBnGy		MWS	microb-peloid				15				1		?			1			1		1 1			15		5AC-3C	tr C-VC clear calcspar stylolites	
3520	LS		LtBnGy		MWS	microb-peloid(skel)				15		2		1		?			2			1 1		2 1			15		5AC-3C		
3525	LS	tr pyrite	LtBnGy		MWS	microb-peloid				1 0				1	2				1			1		2 1			15		5AC-3C	peloids soft micro - size C clear calcspar	Р
3530	LS	tr pyrite	LtBnGy	3	W(P)S	microb-skel-peloid				15	5	2 dl	k	1		1the		1	1		:	2 1	:	2 1			20		5AC-3C	peloids soft micro - size	P
3535	LS		LtBnGy	3	ws	microb-peloid				10				2			1		1			1		2			20		5AC-3C	C clear calcspar	
3540	LS	tr pyrite	LtBnGy	2	MWS	microb(peloid skel)				9		1		2			1		1			1		2 1	Ш		15		5AC-3C		
3545	LS		LtBnGy	4	WPS	microb-peloid-skel				15	5	1		3			1	1	1			1 2		2 1	1		15		5AC-3C	C clear calcspar	Р
3550	LS/Dol	9/1	LtBnGy	2	WMS.	microb-skel-peloid	1%	vug spar		15	3			6		2	1		2			2		1 1			15		5ABC-3C	Minor dolomite = CSS overlogged??	Р
3555	LS	tr Dol?	LtBnGy	4	WPS	microb-skel-peloid	1-2%	vug spar		1 0	5	1		3		1	2	1	2			2 1		2 1			20		5AC-3C	some rd-brn stain Minor dolomite = CSS overlogg	ed 2P
3560	LS		LtBnGy	3	W(P)S	microb-skel-peloid				1 0	5	1?		5	1	2	1?		2		:			1 1	П		15+		5ABC-3C	Porosity-spar in shelter cavity AA?dol overlog	2P
3565	LS		LtBnGy	3	W(P)S	microb-skel-peloid				1 0	5			3			1?	1	3			2 1		1 1	Ш		15		5AC-3C	some rd-brn & orange stain	
3570	LS	tr pyrite	LtBnGy		WRS	microb-skel-peloid				20		4		1				1	2			2		1 1			20		5AC-3C	some rd-brn & orange stain stylolites & horsetai	s - P
3575	LS		LtGyBn			microb-skel-peloid				15		1		?					2			1		1 1			20		5AC-3C	some M-C red clear cement stylolites	
3580	LS		LtGyBn		WPS	microb-skel-peloid				15		1		2			1		2			1 1	I .	2 1	Ш		25		5AC-3C	red-brn stain stylolites	
3585	LS		LtGyBn		WPS	microb-skel-peloid				1 0		1	1	6		1	1		1			2 1		1 1			15			red & orange stain stylolites	Р
	LS		LtGyBn		WPS	microb-skel-peloid	Ab	5 3600m		1 0		2		4		1	1		1?			1 1		1 1	Ш		15+			red & orange stain stylolites	Р
3595	LS		LtGyBn		ws	microb-skel-peloid	- 3	569.5m or		1 0		1		2					1			1 ?		2 1			15			10% red & orange stai Some M-C cl calcsp NB CSS	dolm??
	LS		LtMdBn		WPS	microb-skel-peloid		4 ??			5	2		6			?		2			1 1		1 1	Ш		20			(?olivne color calc cmt)	
3605	LS		LtMdBn	5 4	FPS	microb-strom-skel						2+				1	1		3			2 1		2 1			15		5AB-3BC	(AA & oragne cmt) CSS = SS???	2P
3610		NO SAMPLE		Ш		LOST CIRCULATION			TSHE	ELLS	то Р	LUG	***TE		D GA	S TO S	URFA	CE AND) WA	TER	AT 3	600-	3620n	n	Ш					CSS log = no spls 3610-3625m	
3615			Lt Gy											5					2					1			10			m-VC cl calcsp corroded LS	3P (1X16)
3620	LS		VLBnGy	4	FS	strom-microb		IBC2D3			5	1		10			1		2			1 1		2 1	1?		15		5B-3C	intrastrom porosity	2P
3625	LS	cuttings tiny	VLBnGy	3	ws	strom-microb?	3%	ICD3 spar		?	?			1 0					1			1	:	2			10		5B-3C	VC clear calcispar = vugs	Р

Α	В	С	D	\Box	G	Н	l J	K	L	M N	0	P Q	R	S	Т	٧	W X	ΥZ	Z AA	AB AC	CADA	4E AF	- AE A	H AI A	J AK	AL	AM	AN	AO	AP	AQ
3630 L	LS		Lt(Bn)Gy	3 4 1	W(F)S	skel-(microb-frg)	Ab5 3600m			5		3			1		2	T	2	1	2	1	$\Pi \uparrow$	10	5A-3C <mark>?</mark>						Р
3635 L	LS	VF tr pyrite	LtBnGy	3 4 1	WFS	microb-pel-skel	-3569.5m or			5	1	2	١	1	3	1	2		2	1	1	1		15	5AC-3C	tr red stain,	green(zeoli	ite? stain)), calc cmt	in corals etc	Р
3640 L	LS	10% sandy = sl ar	LMBnGy	3 4 1	WFS	microb-strom	<u>'_</u>	J	2		1	1 1 (0	1	2		3		3	2	2 1	?		2 10	5B-3BC	green(zeolit	e?) stain		stylolite		(2)P
	LS		LtBnGy		ws	frag-microbial?	!%? vug-spar			1 0		3		1		?	2		1		1	1		1 0?	5A-3C?				photo of	2 br strom?	X16 P
		poor-small ctgs	Lt Gy		MWS	?microb-frag	'		- 1	1 0	1	2				П	3	\Box	1		?	1		1 0?	5A-3C <mark>?</mark>						
3655 L	LS		Lt(Bn)Gy	2	MWS	peloid-microb			10	2		1			1							1		1 0?	5A-3C?				Lost circ	material	
3660 L	LS		VL(Bn)Gy	3	ws	peloid-microbial			15		2	1			?		?		?	1		1		20	3C				Lost circ		
3665 L	LS	'sparry'	VL(Bn)Gy	2 1	MWS	peloid-microbial			10			1								1				20	3C						Р
3670 L	LS	major silty arg LS	Lt(Bn)Gy	2	MWS	peloid-microbial			10		1	2			1	1	1	1	1	1 ?	,	1		20	3C-5A?	<5% spar -	+ cementoc	cc (?geop	netals)	stylolite	Р
	LS		LtBnGy						10	5		1					1		1		1	1		20	3C	spar AA				stylolite	
	LS		LtBnGy		. ,	microb-skel-pel			8		1	5		1	?		1		1		1	1		20	3C-5A?	spar AA				stylolite	Р
3685 L	LS	common spar cmt	LtBnGy		٠,,				20	8		12-	+	1	1		2		1	1	?	1		25	3C-5B		ims on F pel	loids/frag	ments	stylolite	3P
3690 L			LtBnGy			microb-peloid				5		4					2		1	1		1		25	3C-5A?					stylolite	
	LS		LtBnGy		WFS	Strom-(microb)			5		1	15	5	1	2+		2		1		?	1		1 0?	3BC-5B					stylolite	Р
	LS		LtBnGy		W(F)S	skeletal-microb				5		8	-	1	1		2		1			1		1 0?	3BC-5B					stylolite	
			LtBnGy		WFS	microb-strom-pel			10	5		15	5		حجلي		1? 2		2	1	1	1		20	3C-5B			tr red stai	in		Р
		tr sparry (sandy)	LtBnGy		WFS	microb-skel-frag				7		7		1	2		2		1			2		15	3C-5AB						P
	_		LtBnGy		WFS	microb-pel-skel				3		6		1	1		1	1	1 3	1	1			1 0+	3C-5A	T					P
		•	LtBnGy		WFS	Strom-microb-pel				5	2	12		2	?		1		2		1	1		10	3C-5B						
		' '	LtBnGy		WFS	micr-skel-pel-frg				10	اش	5		2	1		2		2	1	1	1		15	3C-5A						
	LS		L(MB)Gv		WFS	skel(strom)microb	<u> </u>			1 0	3	7		2	1		1		2			1		1 0+	3C-5B?	•					
		sparry	L(MB)Gy		WFS	microb-skeletal			- 1	7	1	2		ائر	1	1	1		2	1	1	1		20	3C-5A	•	tr red/orang	ie stain			Р
	LS		L(MB)Gy		WFS	skeletal-microbial				7	1	3			1	1	2		3	1	2	1		10	3C-5A		tr red/orang				
			LtBnGv		WFS	Strom-microb-skel			_	5	2	10		1	2	1	2		3	1	?	1		10	3C		tr red/orang	•			Р
		sparry cmt	LtBnGy		W(P)FS	Strom-skel-microb			3	7	5	15		2	3	2	5		5		2	1 2		10	3BC-4C-5E	tr pyrite & o	ū	, o otani			P
	LS LS		Lt(Bn)Gy		W(P)FS	skeletal-microbial				3	1	7		1	1	1	3	_	3		1	1 1		15	3BC-4C-5E		tr red stain				P
			VLBnGy		WFS	skeletal-microbial				5	2	6			1		2	-	1		2	1		10?	3C-5AB		some spar &	& red stai	in		
			VLBnGy VLBnGy						5		2	4					2		3		1	1		15	3C-5AB	1	come spal	a rea sid			
	LS LS	•	VLBriGy			skeletal-microbial			3		2	4		?	2		2		2		1	1		15	3C-5A					etylolitor	Р
	LS LS		LtGyBn			skeletal-microbial			5?		4	2		2			1	_	2		1	1		20	3C-5A 3BC-5A-4E		tr red stain			stylolites stylolites	P
	LS LS		-		W(F)S MWS					ft	3	2		2			2		4		1	1		20						,	
	LS LS		VL(B)Gy VL(B)Gy		MWS	microbial-pelletal microbial-pelletal			1 0so		1	1	- 1				2	_	1	2	1	1		25	3C-5A 3C-5AC		tr red stain tr red stain			stylolites	
						•									-	+		4	+	1	++	1	##							stylolites	P
	LS LS		VL(B)Gy		MWS	microbial-pelletal	Ab4 3783m		15sof	IL .		2					1		2		1	1		20	3C-5A?	1	tr red stain				P
	_		VL(B)Gy		MWS	microbial-pelletal	-3752.5m or		15			1						4			1	1		20	3C 3C						20
			VL(B)Gy			microbial-pelletal	AB3U??	-	10		1	1 3					1		1			2		25						otulolita	2P
	LS		VL(B)Gy			microbial-pelletal	<u> </u>			5	1	1 3						4			3	4		15	3C-5A? 3C-5A					stylolite	2P
	LS		VL(B)Gy		MFS	microb-pel-skel	<u> </u>			5		1			2				2			1					200 M/ (2)	Noor - L	ioner	stylolite	Р
			VL(B)Gy		MWS	microbial-pelletal				8					1?		1	4	1		1	1		10	3C?		Occ M(C) c		лэраг	stylolite	
			VL(B)Gy		MW(P)S	microbial-pelletal	`			5		1			1		1		1		1	1		15	3C		cropeloid PS		CC	(to 1.10)	
			VL(B)Gy			microb-pel-skel-frg			-	1 0		4	`				1		1		1	1 1		10	3C	micritized ri	ims on M fra	ag-peloid	GS	(tr dol?)	Р
			VL(B)Gy		. ,	(microb?)pelletal	1		15										2			10		1 0?	3C				f= - 1	stylolite	
			VL(B)Gy		MWS	peloid-microbial			20			?	1				?		2		1 1	1?		15	3C	-00/ 1/E =	140		tr walnut		
			VL(B)Gy		MWS	peloid-microbial	`		15										1	1	1	1	1?	15	3C	<2% VF-F I	LIGY DOI		tr walnut		P
			VL(B)Gy			peloid-microbial			20			1			2				1		?	1	1?	10	3C	4	11 / 1		tr walnut		X16 P
			VL(B)Gy		٠,	pel-microb-(skel)	1		28			1		?	3?		_ 1		2	1	1 1	1		10	3C-5A?		Note-CSS 'I			al textures	
			VL(B)Gy		MWS	peloid-microbial		الكرابة	15			1			1?			4 إ	1	1	1 1	1		10	3C	(tiny tubiphy	vtes)	patches p	peloid GS		
			VL(B)Gy		MWS	peloid-microbial	·			5		_ 1							1	1 ?	? 1	1		10	3C						
		sparry + micropyri			MWS	peloid-microbial				1 0	1?	1			?		1		2	1	1	1	1?	15+	3C-5A?	The same of the sa					2P
			VL(B)Gy			peloid-microbial	'L	1	1 0		1	1							1	<u> </u>	1			1 0	3C			tr red stai	in		
	LS		VL(B)Gy		MWS	peloid-microbial			10		?	1							1	1	1	1		15	3C						
3880 L	LS	sparry	VL(B)Gy	2	MWS	peloid-microbial	'		10		1?								1	?	1	1		20	3C						
		sparry	VL(B)Gy			peloid-microbial			10			1?	?	1?			?		?		1 1	1+		20	3C						
3890 L			VL(B)Gy			peloid-microbial	'		9		?							T		1	1	1		15	3C						
			VL(B)Gy			peloid-microbial			15			2							1	1	1	1	1?	28	3C						Р
			VL(B)Gy			peloid-microbial	'		10		2	1			1			T	1	1	1	1		15	3C	??linear se	epta w. circle	es??	tr red sta	nin	X16 P
						ı İ	, I	•	. !	1	• !	1				11 1	1 1	ı	1 1				11 1	1 1		_					

Α	В	С	D	G	Н	ı	J	K L	. N	l N	0	P Q	R	S	T	V W	XY	Z A/	AB/	AC AE	AE A	\F\E	AH A	AI AJ	AK		AL	
		sparry	VL(B)Gy 2		peloid-microbial				0 3			1					?			1	1		1	5	3C		tr red stain stylolites	
	LS	sparry	VL(B)Gy 2			_			0 5			TF	₹.						1	_ 1	1			5	3C		geopetal, tr red stain,	_
	LS	tr pyrite spar	VL(B)Gy 2	MWS	peloid-microbial			1				1					1	1	1	?	1			5	3C		tr red & orange stain, tr-2% F qtz stylolites	
3920	LS	sparry	VL(B)Gy 1	M(W)	S peloid-microbial	1		1	0		1	?							1	?	1		1	0	3C		tr red & orange stain	
3925	LS	sparry	VL(B)Gy 2	MW(P)	s pel-microb-skel		U 3922m	1	5 5		1	3		1			1	1	1	?	1		2	20	3C		tr red & orange stain	Р
3930	LS	sparry	VL(B)Gy 1	4 MFS	peloid-microbial		91.5m or	1	5		2	4			?				1	1	1		1	5	3C		???????? NB no ooid GS as on CSS???3910-15	
3935	LS	tr arg + micropyrite	VL(B)Gy 1	4 MFS	peloid-microbial	AB3	3L ??	1	5		1	7						1	1	1	1		1	5	3C		(tr pyrite) tr stylolites	
3940	LS	sparry	VL(B)Gy 3	8 WRS	strom-pel-sklmicrb	3-4%	IB2CD2	1	0 1	5	3	20	1	1	1		2	1	1	?	1		1	0	5B-3B	C	calcispar = vug & intrafossil porosity	Р
3945	LS	sparry	VL(B)Gy 3	4 FW(P)	S str-skel-frg-pel-mic	1	vug spar	1	0 1	5	1	15	5	1						1	1		1	0	5B-3B	С	???????? NB no ooid GS as on CSS???3935-45	
3950	LS	sparry	VL(B)Gy 4	4 FWPS	S str-skel-frg-pel	3	IBC2D1	1	0 2	5		15	+				1	2	2	1	1			5	5B-3B		micritized F(M) fragments in GS-PS	
3955	LS	,,,	Lt(B)Gy 2	MWS					0 1 (1	1	1				2	1	1	1	1			5	3C		???????? NB no ooid GS as on CSS???3950-62	
3960	LS		Lt(B)Gy 2		S skel-frg-pel				0 1		1	5			1		2	2	1	1	1			5	3C		stylolites	Р
3965	LS		Lt(B)Gy 2		S frag-skel-microb			5			2	8			2		1	1? 1	1	1	1			0	3BC-5	В	-,,	2P
3970	LS	sparry	Lt(B)Gy 2	MWS				1 1			_	2					1	1		1	1		20		3C	_	1 chip of ooid GS! = Lt Crm	P
3975	LS	Sparry	Lt(B)Gy 2	MWS				1									2			1	1		20		3C		Tamp or cold Go: - Et Gilli	
3980	LS	sparry	LtMdGy 2		S microbial-(peloid)			;							2		1			1	1			0	3C			
3985	LS	sparry	LtMdGy 2		S peloid microbial			1	n		1	1			1		1			? 1	1			2	3C		tr red stain tr pyrite	Р
3990	LS	sparry	LtMdGy 2		S microbial-peloid			1				1			'		1	2		1 2	1		1		3C		a red clair a pyrite	
3995	LS	эрипу	LtMdGy 2		S peloid microbial			1									2			1	1			0	3C		tr pyrite	
4000	LS	sparry	LtMdGy 2		S microbial-peloid			1			2	1					1	2		1?			1		3C		tr red-brn stagin	Р
4005	LS	v.sparry	LtMdGy 2	MWS				1			_	1 5					1	1			1			0	3C-3A	I	u rea om staqui	r
4010	LS		LtMdGy 2	MWS				1				1 3					1	1	2	1	1	112	1		3C-3A	,	tr epidot grn stain some micritixed GS	P
4015	LS	sparry		MWS				1				1 1					2		1	1	1	- '	1 1		3C		· · · · · · · · · · · · · · · · · · ·	Г
		sparry	Lt(B)Gy 2		•	1.											4										<u> </u>	
4020	LS		LtBnGy 2	MWS			vug	1			1	3			40		1	2		1	1			0	3C	_	???????? NB no ooid GS as on CSS???4020-30	
4025	LS	sparry	LtGyBn 3	. ,	S strom-pel-frag		IBCD4		0 1	0	3	15		1	1?		2	2	1	1 2	1			i+	5B-4B-3		vug/intrafossil pores tr pyrite & ?clay	2P
4030	LS		LtGyBn 3	W(M)S		tr	vug?spar?		0 1	-	1	2					1	1		1	1		3	-	5A-3?			
4035	LS		LtGyBn 2		S peloid-fragmental				0 1			1					1	1	1	1	1			3	5C?-3			
4040	LS		LtMdGy 1	M(W)S				1				2					?			?	1				5C?-3		some spar	P
4045	LS		LtMdGy 1	M(W)S				<													1		2	2	5C?-3		lost circ mat - walnut shells	
4050	LS		LtMdGy 1	M(W)S	(peloid)			<												1	1				5C?-3		lost circ mat - walnut shells	P
4055	LS	tr sparry	Md(L)Gy 1	M(W)S				1												1	1			8	3C-5C			
4060	LS		Md(L)Gy 1	M(W)S	peloid (microb)			1													1				3C-5C	?		
4065	LS		Md(L)Gy 1	M(W)S	peloid (microb)			1	0										1	?	1		8	8	3C		stylolites	
4070	LS	sparry	Md(L)Gy 1	M(W)S	peloid (microb)			1	0												1		7	7	3C			Р
4075	LS		Md(L)Gy 1	M(W)S	peloid (microb)			1	0										?	1	1		1	0	3C		tr pyrite (tr red-brn stain)	Р
4080	LS		Md(L)Gy 1	M(W)S	peloid (microb)			1	0			1								? 1?	1			5	3C?-5C	?	tr red-brn stain (tr spar)	
4085	LS		Md(L)Gy 1	M(W)S	peloid			1	0												1		3	3	5C?		(tr spar)	
4090	LS	sparry	Md(L)Gy 1	M(W)S				1													1		5	i+	3C?-5C	?	tr micropyrite	
4095	LS		Md(L)Gy 1	M(W)S				1	0			1			1		• •			,	1		ŧ	5	5C?		stylolites	Р
4100	LS	sparry	Md(L)Gy 1	M(W)S				1				2									1		8		3C	I	tr micropyrite stylolites	
4105	LS		Md(L)Gy 1	M(W)S				1	0												1		3	3	5C?		stylolites	
4110	LS		Md(L)Gy 1	M(W)S	-			1				1+	+				1	1			1			5	5C?			Р
4115	LS		Md(L)Gy 1	M(W)S				1									1		1? If	1	1	1?		5	5C-3C	?	tr pyrite	
4120	LS		Md(L)Gy 1	M(W)S	•			1				?									1				5C?		tr spar	
4125	LS		Md(L)Gy 1	M(W)S	P			1:			1	(+)		?			1	?	1	1	1			0	3C		trspar	Р
4130	LS	sparry	Md(L)Gy #	MWS		Abai	? 4125m?	1			1	1						2	2 t	hir 1	1	+		0+	3C		stylolites	
4135	LS	sparry	Md(L)Gy 2		S strom-pel-micb-skel		4.5m or	10			3	1 15	5	1	1?		1	1	1		1	1?		5	3C	5B	- Stylolico	3P
4140	LS	opuny	Md(L)Gy 1		S peloid microbial		32 ??	1									'	'	1	1	1	2		5+	3C		???????? NB no ooid GS as on CSS???4140-50	OI .
4145	LS	sparry	Md(L)Gy 1	MWS	•		VFsp vugD	1							1?					1	1			20	3C		tr pyrite in geopetal/vugs stylolites	Р
4145	LS	ομαιτή		MWS	•			1							1 :				4		1				3C		ii pyrite iii geopetaii vugs stylolites	F
			Md(L)Gy 2		peloid microbial	1%	VFsp vugD												11	1	1							_
4155	LS		Md(L)Gy 1	MS	and and designates			5														1		2	3-5?			۲
4160	LS	sparry	Md(L)Gy 2		peloid (microb)			1	-			1		1			1 1		1	2	1	17	8	-	3C			
4165	LS	tr sparry	Md(L)Gy 1		S peloid (microb)			1				?		1						1	1	?		7	3C			
4170	LS		MdLtGy 1		S peloid (microb)			1									?			1	1		(-	3C?			_
4175	LS	tr sparry	MdLtGy 2	MWS	peloid microbial			10)+			1						1	?	1	1		1	0	3C		tr red-brn stain styloliites	Р

140 15 15 15 16 16 17 17 18 18 18 18 18 18	Α	В	С	D	G H	I J	K	L	M N	0	P Q	R	S	T	VV	V X Y	Z AA	AB/	AC AL	AE A	FIE	ΑН	Al AJ	AK	AL
499 58	4180	LS	spar	M(L)Gy 1				7			1							?	1	1					stylolites geopetals
1985 S. W. W. W. W. W. W. W. W. W. W. W. W. W.	4185	LS		M(L)Gy 1	M(W)S (peloid-microb)										1				1	1			6	3C?	
200 1.5	4190	LS	spar	M(L)Gy 1	M(W)S (peloid-microb)											?		?	1 1	1					P
268 S. S. S. S. S. S. S. S. S. S. S. S. S.	4195	LS		M(L)Gy 1	, , ,															1			3		small cuttings???
249 15 15 15 16 17 17 17 17 18 18 19 19 19 19 19 19	4200	LS	tr spar	M(L)Gy 1	MS (peloid)			-											?	1			3	3?	
425 15 Traper M.1.05 1 M.105 1 M.105 1 M.105 1 M.105 1 M.105 1 M.105	4205	LS	tr spar		M(W)S peloid-microb											2	?			1				3C	small cuttings???
222 L3 Spanny MLCO MLCO Memory MLCO				. , ,	1 1 1 1												?			1				3C	•
423 1.5 Survey Mil. Sp. Part Par	4215	LS	tr spar	M(L)Gy 1	M(W)S peloid-microb													?		1				3C	small cuttings??? tr micropyrite stylolites
423 1.5 Survey Mil. Sp. Part Par	4220	LS														1		1	?	1				3C	
424 1.8 Saparry MULSy Earny Saparry MULSy Earny MULSy Earn	4225	LS	sparry	M(L)Gy 4	(M)WPS peloid-microb			25			1			?		2	1?		1	1			15	3C	2P
		_	sparry			Ah2 4225m			5						1	2	-,	1	1 1	1					
Add S. Sparry MULCy 2 (evers) pel-sket-microby 0.5 2 2 3 7 1 2 2 1 1 1 1 1 1 1		LS							-	5							-								
A250 L.S. Samy C.M.O. A A A A A A A A A										2	3	1?		?	1	2	2	1	1 1	1					P
425 LS Sparry Chif(x) T Sparry		LS						-		1	2					1	1		2	1					
4265 LS	4250	LS		M(L)Gy 2	MWS peloid-microb				3							1	?		1	1					
A270 LS very sparny Ve		LS	sparry		M(W)S (peloid-microb)												1	1	? 1	1					Р
LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series LS Series		_	' '		, , , , ,			-											1	1	Ш				small cuttings???
A279 LS Samp CM/Gy Z MWS pelod-imicrob T Tee sign Temporary Tee sign Te		LS	very sparry 10%		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				-									1?	1	1					
A285 LS Sparry L(M/GV) LS Sparry L(M/GV) LS LS Sparry L(M/GV) LS LS LS LS LS LS LS L		_	very sparry				2		5 1					?		1		1	1		1?	?			
A259 LS Less sparr LMGy LAG	4275	LS	very sparry		MWS peloid-microb			10	7							2		1	1? 1	1	1		11		A stylolites
4295 LS respar MLGy Tapar (C) MLGy MLG			sparry							1?						?		?		1	?				
4290 LS trspar M.Coy 1 M.WS (peloid-microb) 5 3 1 1 1 1 1 1 1 1 1			•		. , ,	tr interxtl														1					
4306 LS tr spar MLGy tr spar										?								?		1	?				(,
4310 LS Fapar MLGy 1 MWS Geloid-microb 5 2 1 1 1 1 1 1 1 1 1		_			, , , , , , ,			5											1	1				3C	tr pyrite tr **Red Bn stain
4316 LS sparry MLG V Sparry MLG MWS MICTO Sparry MLG MWS			tr spar (C)	MLGy 1	, , , , ,					1									1	1					
430 LS Spany M.C.Q M.C.S M.S.S M		_	tr spar	MLGy 1	. , ,						1						?	1	?	1	1+			3C	
4325 LS LS LS LS LS LS LS L			·													\perp			1	[1]					
4330 LS LS LS LS LS LS LS L				-					2	1rd					1	1				1					
4336 LS 4340 LS 4344 LS 4345 LS 4440 LS 4345		less sparry	,												1				1						
A336 LS Sparry L(M)Gy																				1					pyrite small cuttings
4345 LS very sparry L(M)Cy 3 WS very sparry L(M)Cy 2 WS (peloid-microb 5 5 1 2 1 1 1 1 2 1 1 1				MLGy 1					1											1	Ш			3C	
4356 LS very sparry L(M)Gy 3 WS peloid-microb 10 15 7 1 1 1 1 1 2 1 1 1 2 1 3 3 4 3 4 3 4 4 4 4									_						- 1	?				1					
4355 LS		_	· ·	. , ,	•				~	2				1? Se	e later	1	1			1					more tragments-tossils & lighter pyrtie P
A355 LS									-							1			1						
4366 LS Sparry L(M)Gy 3 W(P)S Sparry LMGy 1 M(W)S Microb 3 3 W(P)S M(W)S Microb 3 W(P)S Microb 3 W(P)S M(W)S Microb 3 W(P)S M(W)S Microb 3 W(P)S			very sparry						15	?				1?		1	2	?	? 1	[1]					tr Rd Bn stain
4365 LS sparry LMGy 1 M(W)S microb Sayar LMGy 1 M(W)S microb Sayar LMGy Sayar LMGy Sayar LMGy Sayar Sayar LMGy Sayar Say		_			, , ,						1					2		1			?				1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
A370 LS									5 1+	2	1					1	1	1	2	1					,
4375 LS less spar blebs LNGy 1 M(W)S microb 3 2 2 2 1 11 3C 3C 3C 3C 3C 3C				-																1					some pale red bn chips MS
A380 LS tr spar fracture? LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 MWS frag (microb) 7tr Clear spar LMGy+Cm 2 MWS frag (microb) 7tr MYS frag (microb) 7tr Clear spar LMGy+Cm 2 MWS Frag (microb) 7tr Clear spar LMGy+Cm 2							3									?		?	1				3C		
4385 LS tr spar LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2 LMGy+Cm 2			•						2										_					3C	, , ,
A390 LS tr spar LMGy+Cm 2 MWS frag-skel 57 10 15 17 17 18 18 19 19 19 19 19 19		_				Otr. ol		3		3							2	2	2	11				30	, , , ,
A395 LS quite sparry LMGy(Rd) LMGy	_	•		, , ,	rtr clear spar				12									2 2							
4400 LS tr spar LMGy W+PS frag-skel tr dog tooth sp 5 15 2 1 1? 1 2 2 2 1 1 3 3 5A-3? red-orange stain 3P		_	·				E2		. •	1.	40	,			1	2	1	1	–	1			-		
4405 LS sl arg/clean 2/8 less arg Dk+Mgy 2 less arg Dk+Mgy 2 less arg Dk+Mgy 2 less arg L)+Mgy 2 less arg Misaine arg LS 4398.1m -4367.6 P 1 1 1 1 2 2 1 1 1 1 1 2 2 1 1 1 1 1 2 2 1 1 1 1 1 2 2 1 1 1 1 1 2 2 1 1 1 1 1 2 2 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					W+PS frag skol	tr dog tooth o									1	3		I	1	1					
4410 LS less arg (L)+Mgy 2 M-Ws fragmental frag-(skel)-peloid 4398.1m - 4367.6 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 7 1 1 1 7 1 1 1 7 1 1 1 7 1 1 7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 </td <td></td> <td></td> <td></td> <td>,</td> <td></td> <td>u dog tooth s</td> <td>μ</td> <td>Ü</td> <td></td> <td></td> <td>1 !</td> <td>+</td> <td></td> <td></td> <td>1</td> <td></td> <td>1</td> <td></td> <td><u> </u></td> <td>++</td> <td>+</td> <td></td> <td></td> <td></td> <td>ŭ</td>				,		u dog tooth s	μ	Ü			1 !	+			1		1		<u> </u>	++	+				ŭ
4415 LS sl arg/clean 1/9 DkMGy 2 MWS frag-(skel)-peloid fragmental PA420 LS arg /clean 4/6 Dk(M)Gy 2 MWS fragmental PA425 LS arg /clean 6/4 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy 1 M+DkGy			_		, ,									2	1		1	2	: 2						, , , , , , , , , , , , , , , , , , , ,
4420 LS arg/clean 4/6 Dk(M)Gy 2 MWS fragmental (fragmental) 5 15 2 2 1 ? 1 ? 1 ? 1 ? 1 ? ? 1 ? ? ? 1 ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?	_					4398.1m -4367.6	6		-	1	1 11				1	2	2	1	1 1	2	12		-		(-5)
4425 LSarg arg/clean 6/4 M+DkGy 1 M(W)S (fragmental) 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9<		_	-	-												1	,	1			111				1-5
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4730	LS	tr-3% calc spar	LM(B)Gy	3		fragmental	H		÷	5	20	Ť	\pm	1	-		. .	÷	1	- 7	3		1	7		5?	+	5	1	tr Rd Bn stain	tr micropyrite	Р
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4745	LS		LM(B)Gy			fragmental				5	25	1					1		1	1	1					5		5			Sh cave	P
4750	LS		LM(B)Gy			_	tr?	spar cmt		15		3		1?			2		2		1		1 1			5		5A	•	tr pyrite	3.1.33.13	P
4755	LS	Rd Bn to	L(M)BGy			frag-peloid (crinoid)		Spar Citi		10		ľ		' '			_		6	2	, i		1 1					5A	_	RdBn Sta	ain stylolites	P
4760	LS	sl argil	L(M)BGy		WPS	fragskel-(pel)					35rd								5 1	3								5A			c Shale ~5%	P
4765	LS/SH	argil 9/1	Dk(M)Gy			fragment-skeletal				5	15								5 2		· ·							5A	2	DKGy cal	C Shale ~5%	P
4770	LS/SH	argil 85/15	Dk(M)Gy		WS	frag-skel-(crinoid)					15								7 1		-		1					5A		puritio \/E	Eatz calo SST	г В
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4790	LS/SH	argil 9/1	DkGy		WPS	argil-frag-ooid?			10?	5	20								Ŭ				1 1				2blk			black coated graind	M-C,occVC +?phosphatic??	P
4795	SH/LS		DkGy		WMS	argil-fragmental					vf?	1							3	1			1 1			1		5-2			1.1.20	P 10
4800	LS		M(D)Gy			frag (?burrowed?)		00.0+			10+								-	1			1				l -	5		argil-dolm??	stylolites pyrite	P x16p
4805	LS		M(D)Gy			_		?DO*			30								2				· 1				5	5D		F-M(C) ooids		P -
4810	LS	F(M)	M(D)Gy			frag (round/ooid?)		?DO*	15		50									1			1					5D			tr micropyrite	Р
4815	LS	F-M sl arg	M(D)Gy			fragmental			5			5							1	2	2		1				2	5				Р
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4830	LS arg		L(M)BGy	4	WPS	frag-peloid			3	10	20								1	1	1	1?	2	2				5C		dolomitic LS		Р
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	DOL/LS		M(L)Bn			ooid-frag		IBC4	25	5	15																	5C			mite ?ooid LS(dolm) siderite?	2 p
4845	DOL/LS	3	M(L)Bn	4	PWS	peloid-ooid	1%	intraooid	10	25	10								1	1	1							5C		mtx = XF-VF(F)		Р
4850	DOL	argil	DkGy+Bn		M xtl	(frag WS?)					10																	5		DkGy argil doloMS 8	Md Bn xtl doloWS?-sandy? 3/	7ratio P
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DEPTH	LITH	modifier I	COLOR	TEXT	TURE	modifier	POROSITY	ACCI	ESSC	ORIES					FOSS	SILS	(6	enhan	ced by	/ S <mark>WC</mark>	C data	a if av	vailabl	,				K 78'88 K 2002	COMMENTS
(metres) T=trip	DOL: DOL: SH=5 O	imestone =dolomite shale sandstone ST=silistone argillaceous =calcareous = sandy/qtz	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=wa PS=pac GS=gra BS=bou (FS/RS FS=floa RS=rud		% modifier (Archie)	SGIOO	PELOIDS	PARTICLES	LIIHOCLASIS	SPONGES	STROMATOPOROID-	[m	PORID	MICROSOLENIDS HEXACORALS	BRYOZOANS	CRINOIDS	ECHINOIDS GASTROPODS	BIVALVES	OSTRACODS	TIIRIDHYTES of	FORAMINIFERA	BORINGS	STROMATOLITES	1 0	IDARD MICROFA	iugerszkwiison / skeliuk Wierzbicki, Harland&Eliuk	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
Α	В	С	D		G	Н	l J		_	М		0		R	S	Т			ΥZ] '	_ [AL
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3005	SS SH	8/2 F-VC qtz	VL+M Gy	(•	Mod sort, VC=WR					carb	clast	t	00/ -	ا	 isi	 :				dvster								siliceous SS, 1/2% pyritic SH, tr red chert tr glauconite 3P
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3025	SS LS	6/4 grz-lithic F-M	VL+M Gy VL+M Gy			WS'to calc SS	clean @ 3020			10	2	10%	<gv< td=""><td>pvriti</td><td>c mica</td><td>aceous</td><td></td><td></td><td></td><td>3+</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Fe bits pyritic to 1/2%</td></gv<>	pvriti	c mica	aceous				3+									Fe bits pyritic to 1/2%
3030	SScalc	VF-C qtz-lithic	VL+M Gy			very calc SS+arg		2		5	1		,			r brick r	ed SH	1		2									Fe Bits pyritic some arg to SS sdy SH 3p
3035	LSsdy	SH, F-M ooids	LMGyBn	6	G-PS	ool (qtz nucleii VF-F)	40		5						5.10101				3+							50)	Fe Bits. Coguinoid SH ~20% MGy SH (cave?)
3040	LSsdy	F-C ooids	LMGyBn			ool (qtz nucleii VF-F	,	60		5	^d 5					1		1?		2	2	20%	VF-F	ss		1	50)	Fe Bits 2P
3045	LS	VF-VC ooids	LMGyBn			ool-frg-(clast)	ĺ	65		18 ^{und}	¹ 5							2	1	30	oyster	r?			1+		50)	+1% micropyrite in frg + nucleii (less qtz) 4P
3050	SSLSSH	6/3/1 qtz VF-F	L+MbGy	5 I	PS	ool-sandy F-M		25		5	1							1	7	? 2					1?	2	50	5F	pyrite 4P
3055	SS LS	9/1 calc qtzVF-F(I	LtGy	7 (GS	ool -SS qtz		10		3	2							1?		2	1								Fe Bits pyritic 2P
3060	LS S <mark>S</mark>	6/4 VF-Mqtz calc	LMGyBn	7	GS	ool-SS qtz	gamma break-	35		5	2		13	?				1		3?					1	2+	5E)	vf qtz&skel nucleii. Pyriteµpyrite 3P
3065	SSLSSH	6/3/1 qtz F-M cald	LMGyBn	6	GPS	ool-SS qtz	above 3075	20		5										2	1						50	5F	quartz nucleii
3070 T	SSLSSH	6/3/1 qtz F-M cal	Gy Red?				CORE 3065.5-68									1		1	1	2	باحداد	ے ا			?				Fe Bits pyritic CORE 3065.5-68 SH cave 2% pyritic 3P
3075	SSLSSH	6/3/1 qtz VF-F	LMGyBn			ool-skel-qtz	all siliciclastics-	40			2	1	1			. 🖵 🌡	<u>∟</u> ⊥	_ 1			yster'	′	<u> </u>	_	?	1	5E		Fe Bits pyritic, qtz&skel nucleii bivalves=oysters? 2P
3080	LS	3%F qtz sdy	MLGyBn	6+1	GPS+MS	ool-skel & MWS	highly burrowed	50		5	3	3	1	2+		2		2	1?	2	?		?		1	2	5A	D	some MS/WS w ool GS & framebuilderg(x16- pyrite fibre bundles)8P
3085	LS sdy	sl arg 35%F-Mqtz				ool-qtz sdy-frg	"AB6 um" -	30		15	1							2+	1?	4			1				5E)	F-C ooids pyrite cubes & fibres AA 2P
3090	SS LS	5/5 VF-M qtz calc	- 3 - 3			frg-ool-qtz sdy		10		20			1?			1+		1			1		?			1			Fe Bits pyritic 2P
3095	LS	3%sdy, sl arg	LMGyBn			ool-frg-skel	3033 (3073)?	30		10	_					1?	3	2	2	2	1		1?			_	50		Fe Bits pyritic 2P
3100	LS	=/= :- - =/ \/	MLGyBn			ool-skel-frg	corr to G-67	35			3					2+		4	1	3+			?			5+		_	Fe Bits pyritic 3P
3105	SH LS	arg 5/5 ooids F(M				ool-frg-skel		30		10		1				2	2	5+	1	2	1		?				5A		F DkGy ooids Pyrite 3P
3110	LS	F-C ooids	DMGyBn			ool-skel-frg		50		10						4.		5+	1	5	1						5A		Fe Bits 2P
3115	LSsdy	qtz vf-f nucleii	M(L)GyBn			oolite (F-C)		65		5			13	!		1+		2		2						2	_		2P
3120	LS L Code	F-C ooids	M(L)GyBn			oolite (F-C)		70		10			1					3+	1 1	1 3						4+			Fe Bits 3P
3125	LSsdy LS	10% qtz	MdGy(B)			ool-frg (F-C+)		30 20				1	1					2		2			1				50		Fe Bits 3P Fe Bits pyrite 3P
3130		5 400/ -t-	MdGy(B)			ool-frg				20		1	'			40					40						5E	•	1 3
3135	LSsdy	5-10%qtz	MDGy(B)		W(P)S	frg-ool-(skel)		10	-	20			1			1?		2	1 1	1 2	1?								coated skeletal fragments pyrite 2P
3140	LS 55	8/2 qtz F(M)	(L)MBGy			frg-pel-ool(F)		10	10	20								2		2									Fe Bits pyrite 3P
3145	LS	0/0) /5 14	(L)MBGy			ool (F-C)		70			2+							1	1	2	1					1 2			3P
3150	SS LS	8/2 qtz VF-M	L+MdGy			ool (F-C)	ABC L 0447	15		3								2	1	1							50		Fe Bits quartz nucleii calcareous sl argil qtz SS 2P
3155	SHSSLS	4/3/3 qtz	MdGy			ool + sdy F-VC	AB6 L -3117	20		3	2							1		3			1			2	50		Fe Bits oyster SS to granule size well rounded 2P
3160	LSSSSH	5/3/2 SS f-c qtz	DMGyBn			ool	(3157)	45		5	2							1		3						1	50		pyrite
3165	SS L <mark>S</mark>	sdy 5/5 qtz VF-F	LMBGy			oolite sandy		25					1	1				1		2+							50		Fe Bits SH Dk Gy?)cave)
3170		5/4/1	LMBGy			oolite sandy		45		3		1						3		5							50	כ	Fe Bits omcero,od [ros,s & p'uwteres 3P
3175		F-C ooids	MdGyGn			oolite		70										1		2							50		Fe Bits small cuttings 2P
	LS		DMGyBn			ool-frg (oncoid)		50				1					1	2	1	1 4	1		? 1+			? 5	50		caved SS & SH?
3185	LS		MdGyBn			oolite & frag-skel(br	yoderm)			10							5	2		3								D	bryozoan-crinoid WX + ooid GS 3P
3190	LS		MdGyBn			ool-pel-frg			15								1		1 1				1				50		Fe Bits fissile red SH (?cav3?) 3P
3195	LS	2 LS liths	MdGyBn			pel-frg + oolite		40		10								2		3			1				50		FeBits stylolites micropyrite 3P
3200	LS		LMGyBn			pel-frg-(ool)		8+	20	15										3			1				50	3	Fe Bits stylolites 3P
3205	LS	tr spar calcite	LtMdBn			(pel-frg)		3		7 rc		1					1?	1		_	3	?	2		2	2			tr pyrite oysters minor ooid GS (cave?) 4P
3210	LS	VF-C(allochems)	LMBn			ool-frg-pel-skel			10		3		2					3	1	1 2	1	? 1	? 1		?		5A		5P
3215 T		TRIP mix liths	LMBnGy	2+7 !		ool-frg-(peloid)		25		15	und								1	1 2	1		1?				50)	TRIP mixed LS liths AA
3220	LS	mix liths	LMBnGy	2+/	MW-GS	oonte		20	3	20 10	JI IC							2		2							50		mixed liths SH cave 10-20% Rd&Gy

Α	В	С	D		G	Н	l	J	K	L	М	N () P (Q R	S	Т	۷۱	N X	Υ	Z AA	AB AC A	D AE AF	AH	Al	AJ	AK	AL Como P-21
3225	LS	Cave mix liths	LMBnGy	2+5	MW-PS	fragmental			5		25	1		1				3		2	?	?					mixed liths SH cave 20-30% Rd&Gy 2F
3230	LS	tr sandy (F)	(L)MBGy	2	MW(P)S	fraq (ool)			5	2	15		1	?		1?	?	2	1 1	1+ 3	1	? 1					mainly fragmental MWS 4F
3235	LS	2LS(5/5)MS+PS	(L)MBGy	1+5	M&PS	frag & ool-frg			25	5+	10		1	+				1	1?	2	_ I _ I ·	2 1				5D	2 LS liths tr pyrite
3240	LS	?poor small ctgs	(L)MBGy	2	WMS	fragmental			5	5	10							1?		2?							SS & SH cave tr pyrite
3245	LS	small ctgs	(L)MBGy	2	MW(P)S				2	10+ 1	0+					1		2		2							Fe Bits tr pyrite 21
3250	LS		(L)MBGy	2+6	MW+PS	frag-pel + ool-frg-skel			15	10	15		1	?		1?	1	3	2	4	1 ?	2 1					31
3255	LS SS	8/2 arg? Sml ctg			M+PGS	frag + ool (F_M)			35+		15							2		3+	1		Ĭ .	?	1	5D	Fe 2-3LSs-oolGS,MS,frgWS (sml grapestone) SS qtzVF 3I
3260	LS	3 3 3 3	MdGyBn	6	PGS	ool-frg (F-C+)	AB	5 -3213	60	-	10							2			me thiin	shells		-		5D	tiny ooid nucleii to M-VC ooid? Stylolitic (x16)2
3265	LS	F-C ooids	MdGyBn	4		frag-oolitic		53)????	20		30					1?	?	3	1	2	1 1	? 1+		2?		5D	stylolitic 3
3270	LS SS		LGy+MGyB	5	(M)PGS		(02)		45		10			1				3		4	2	2		2		5D	some VF qtz nucleii Variable range in ooid & concentration
3275	LS	(sl arg occ')	MdGyBn	1+5	M-PS	ool-frag	gamm	na breaks-	25			3		2		2		2		3	2		2	3+		5D	Fe Bits 31
3280	1.5		M(L)GyB	1+6	M+PGS	(pel)+ool-skel	32508	3270	35		-	2	1 2)+ 1		1	1	3	1	5	1	1	l .	1?		5D	mixed LS=oolGS, skelFWS, pelMWS tr pyrite 4
3285	LS	tr arg w/ crinoid	M(L)GyB		MS+PGS	(pel) + ool-frg			20		5+	_	' -					3	•	3	1 2	2		3		5D	mixed LS=oolGS, frgPWS, pelMWS, arg crinoid LS 3I
3290	1.5	•	M(L)GyB		WPS	ool-frg-pel			30		20							2		1? 2		1		1?		5D	stylolitic tr pyrite
3295	1.5	(ti dig)	M(L)GyB			pel/microb?-ool/frg/	l ekol		25		20						4	2+		1 3+	1 1	2 1		5?		5AD	stylolitic calcite-fill microfractures Pyrite Mixed LS's 3
3300	LS SS	9/1 F gtz-calc	LGy+MG		PGS	ool (frg)	I		65	5+	10					?	_	3		? 2	1 '	2			_	5D	Fe Bits minor peloid M-GS 4
3305	LS	tr sandy F	(L)MGyBr		W-GS	ool-frg-skel			40	-	15	1						2+	1	2+				enc 1	rust	5D	tr pyrite ??calcisphere?
3310	LS	u sanuy i	(L)MGyBr		WPS	ool-frg-skel					10 3	· }_				1?		2		3+	1	?		'	_	5 D	ti pyrite :: calciopricie: 41
3315	I S		(L)MGyBr		GPS	oolite (F-C)			60		10 3	, I				1 !		2		2	1	2			1	5D	
3320	1.8		(L)MGyBr		WP(G)S	Peloid-frag (ool)					10		1					2			2	1		2?		5C	tr pyrite some VF-F peloid GS Black?microb? 38
	LO	from F VC opide				• • •											2	2		2+	2		1	2!		30	· · ·
3325	LS LS	frag F-VC ooids	(L)MGyBr		WPS	frg-pel-ool			10 20	-	20 20			1		1?		2	2	2	1		'			5CD	Fe Bits
3330	LS	tr arg	(L)MGyBr		(W)PS WPS	frg-ool-pel							.	1		1.	1	2	2	3	1 .	, 1		4		5CD 5C	stylolitic tr pyrite Occasional pel GS 4F stylolites GS-ooid-grapestone tr pyrite 3F
3335	LS	tr arg	(L)MGyBr			frg-pel (ool)					20		1	1			1	2		-	1	(1		1			, , , , , , , , , , , , , , , , , , , ,
3340	LS	2 LS types	(L)MGyBr		M+PWS	Pel + Ool				-	10							2		2	1	1				5CD	stylolites tr micropyrite 2
3345	LS	2 LS types	(L)MGyBr		MP+PS	Pel + ool			25	-	10	1						1	1	4	1 ?	1			_	5D	stylolites 2F
3350	LS	tr arg	(L)MGyBr		M-PS	pel-frg-ool				-	20							1	1	5		. ?		1		5D	stylolites tr micropytrite
3355	LS	tr arg 2 LS liths	(L)MGyBr		M-PGS	pel+ool (VF-F)		na break-		. •	10					4.		1	1?	2		2 2		1		5D	Fe Bits=shot like balls(x16 P) stylolites tr qtz nucleii 3i
3360 T	LSSSSH	8/1/1 qtz VF-M	LGy+MBr			frg-pel-skel (ool)	3355	-3365		15+		_	1 .	1		1+		2	1		2	1 ?		1?			stylolites 6F
3365	LS	2-3LSs	(L)MGyBr		M-PS	frag-ool-pel					15			? 1				1+		3	0 4					5D	
3370	LS	2 LSs tr arg?	(L)MGyBr			Pel + ool-skel				-	10	- 1 2	2	1 1			1	2			2 1	1		5?		5D	Sh cave 7
3375	LS		(L)MGyBr		W-GS	ool-frg-skel AB4	-332	0 (3360)	25	-	15						1	2	?	? 3+	1	2		?		5D	50% Sh (SS) cave
3380	LS		DMGyBn	6	(W)PGS	ool-frg-skel				-	10		?			1?		2		4	1	1				5D	some allochem contact soln SH + glauc cave 4F
3385	LS		DMGyBn	5+1	PS+MS	pel(skel) + oolite				20		3	1	1		2+		2	1?	3+	1	1		?1		5CD	2 LSs (5/5)= oolite + peloid MS-Ps corals recrystallized 4
3390	LS	2 LSs 9/1	5YR3-4/1		PG+MPS	oolite + pel(skel)			50			2 2	2 1	?		1?		2	1?	3+	2+	1	1			5D	2 LSs (9/1) = oolite + peloid MS(PS) 5F
3395	LS	2 LSs 7/3	5YR3-4/1	6+2	PG+MWS	• • •			45		5	1				?1		2	?	3+	1	<u>1+</u>				5CD	2 LSs (7/3) = oolite + peloid MS(WS) tr pyrite in fossils
3400	LS	F-C ooids	DMBnGy	6	(W)PGS				65	-		2		2				4		4	1	1	3?			5D	31
3405	LS		DMBnGy	5	(W)PS	pel=ool-frg				-	15	1						5+		3	2				1	5CD	stylolites stylopackstone in crinoid etc. 4
3410	LS	argil	DMBnGy	4	WPS	frg-pel-ool			10		25	1				?		2		3		1	1?				stylolites micropyrite 2F
3415	LS arg?	SH 9/1	DMBnGy	6	PGS	frg-ool-pel-(skel)					25 ^r ou	na				1		3+	2	5	1	1				5CD	stylolites micropyrite 51
3420	LS	tr argil	DMBnGy	4	W-PS	frg-pel-ool-(skel)					20	1				2?		3			2 1?	1				5CD	stylolites micropyrite 3I
3425	LS	tr F qtz	DMBnGy		W-GS	ool-frg-pel-(skel)					20		:	2		1?		2	1	4	1	2			2	5CD	stylolites 5
3430	LS	(F-C+)	DMGyBn		W-GS	pel-ool-frg					10 ^{oui}	ıa						1		3+	1					5CD	tr micropyrite 3F
3435	LS		DMGyBn		MS+PGS	pel + ool-frg					10			1?			1	2		3+				1		5D	pyritic oyster shell 5F
3440	LS SS	9/1 F qtz SS	LGy+MGy		W-GS	ool(VF-M)-skel					5					1?		5	1	3	stor	1	1			5D	SH(SS) cave pyrite 5F
3445	LS arg	5%SS F-Mqtz	LGy+MGy		GP+MPS	oolite + pel(skel)					10					2?		2		5 ^O	Sici	?	1		2?	5CD	SH(SS) cave tr XC round QTZ 5F
3450	LS	tr SH?	DMGyBn	6	GPS	ool-frg (pel MS)			60	5?	15							2		2+		?	1			5D	2LSs = ool GS + peloid M-PS (minor) pyrite 3F
3455	LS	(tr SH w/ crinoids)			GPS	oolite (F-VC)			75								1	? 2	1	1 2+	1		1?		1?	5D	31
3460	LS	2 LSs ool=9/1=MS			GP+MS	oolite + pel MS			65	10								1		2+			1			5D	10% peloid M-GS Mainly oolite
3465	LS	trFqtz F-VCooids	DMGyBn	6		oolite (skel)			75	3								2		? 6	1	?				5D	micropyrite 38
3470	LS	F-C ooids	DMGyBn	7		oolite			75				fra	mehui	der cor	nnlev		2		3	1?		?		1	5D	21
3475	LS	2+LS liths SH?	DMGyBn	7+1		oolite + Peloid				15	5		1	? 1?	der cor	1?		2		3			1			5D	ooid GPS & peloid MS-PGS Minor F qtz 4F
3480	LS		DMGyBn		GPS	oolite (skel)			75						2?			2		4						5D	tr pyrite 38
3485	LS		DMGyBn			oolite(F-C)-skel			70		5							2	1	? 5	2					5D	tr pyrite 3I
3490	LS		DMGyBn		GPS	oolite(F-C)-(skel)			70			2						2		2	1		1?			5D	tr micropyrite 2F
	SS LS	6/4 calc F-Mqtz S			G(P)S	ool + VF-M SS			35		10							3		2 2	?					5D	oolite is VF-F quartz sandy
	LS		MdGyBn		GPS	oolite							0.1 = -					1	1	1 1		1	1			5D	31
3505			MdGyBn			oolite-frag-pel	gam	ma	70 35	10	10		?AB3	-347	2.5			2		2						5D	stylolites pyrite 21
•		•	. , .	1	1	j 3 i -	. –		• 1	ı	I			-				1 1		1 1	1 1	1 1	П	. !			1 ' ''

	В	C			9			J	ĸ		IVI IV							, , , ,	' -		17.2				. 7	70	AN	AL	Como P-	-21				
J		8/2 silty calc SH			PGS	oolite			60		5							2		2	1			17	7		5D		pyrite					
L	_S S <mark>S</mark>	8/2 F SS v.calc	LGy+MGy	/ 6	GPS	oolite-skel			60									4	1	3	1			1?	?	1?	5D	oolitic SS	pyrite					
L	_S		DMGyBn		G(P)S	oolite			70		5+							4	1 ?	2	1						5D							
L	.SsiltySH	?silty calc Sh?	DMGyBn	7	G(P)S	ool-frag(F-VCrd)			65		10							2			1	?					5D	tr VF qtz						
L	_S	2-3% Fqtz sandy			GPS	oolite(F-C)(skel)			70		2	2						3	2 1	3	1		1			5	5D	coral + ske	eletal nucle	eii py	rite in D	kGy ooli	te	
L	_S	1-3%F qtz SS	DMGyBn		GPS	oolite(F-C)(skel)			70									2		2	1						5D							
L	_S		DMGyBn	6	GPS	oolite(F-C)(skel)			65		5							2		2	1						5D			ppyrit	e			
ļ	В	С	D	Н	G	н		J	К	L	M N	0	P	Q R	S	Т	V	w x	ΥZ	Z A/	A AB A	C AD	AE A	FI AH	H AI	AJ	Ał	AL	AM	A	N	AO	AP	
٠.	CIES NI	IIMDEDQ: 1-h	athyal ch	ala	2-noriti	c shale, 3 =forereef-	chan	nol 2A-for	oclope	o ch	annal	3C-	- dicto	l foro	clono	mioro	hial r	aud m	ound	1/ 3	B - n	ovim	al for	oclor	no (fo	roroo	f\ 1-	cnongo ro	ofal					
5В	= 'deep' 8=coralg	gal-'stromatopor	oid reefal	inter I, 5 0	mound, =mud/p	4B = 'shallow' silice elleted; 5D =oolitic, ked carbonate-delta	ous sp 5E= c	ponge reef, oncolitic, 5F =	4C= ': = sand	'shal dsto	llow' si one, 6 =	licec 'mo	ous sp at' (op	onge oen in	-coral ner sh	reef, 5 elf), 7	5 = op '= mix	en ma ed car	rine or rbona	carb ate s	onate silicic	e ban astic	k 5A platf	=ske orm i	eletal interic	rich, r (ne			eiai,					
A: B	= 'deep' B=coralg coastal	gal-'stromatopor deltaic (lagoon WHOLE	roid reefal al-contine E CORES (a	inter I, 5 C ental) above	mound, =mud/po), 9 = mix = Jabk) #	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2	eous s 5E= c aic, 10	ponge reef, oncolitic, 5F =) = deltaic/int	4C= ': = sand terdelt	'shal dsto ltaic	llow' si one, 6= SEE \	liced 'mo Wier	ous sp at' (op	onge oen in	-coral ner sh	reef, 5 elf), 7	5 = op '= mix	en ma ed car	rine or rbona	carb ate s	onate silicic	e ban astic	k 5A platf	=ske orm i	eletal interic	rich, r (ne								
A: B	= 'deep' B=coralg coastal	gal-'stromatopor deltaic (lagoon WHOLE	roid reefal al-contine E CORES (a	inter I, 50 ental) above	mound, =mud/po), 9= mix = Jabk) #	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies	eous s 5E = c aic, 10 - 2955-	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3	4C= 's = sand terdelt 3 - 3065	'shal dsto ltaic 5.6-3	llow' si one, 6= SEE \	liced : 'mo Wier	ous speat' (op	onge oen in , Harl	-coral ner sh	reef, 5 elf), 7	5 = op '= mix	en ma ed car	rine or rbona	carb ate s	onate silicic	e ban astic	k 5A platf	=ske orm i	eletal interic	rich, r (ne			erai,					
A: 5B	= 'deep' B=coralg coastal Aben (Dunl	gal-'stromatopor deltaic (lagoon WHOLE naki Sequence ham & lith initia	roid reefal al-contine CORES (a s with Pe ls = M/W/	inter I, 50 ental) above Prcer /P/G/	mound, =mud/p;), 9= mix = Jabk) # htage lit!	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies	eous s 5E = c aic, 10 - 2955-	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone	4C= 's = sand terdelt 3 - 3065	'shal dsto Itaic 5.6-3 =shal	Illow' si one, 6= SEE \ B068.0m	lliced : 'mo Wier: T=sa	ous spoat' (opezbicki,	onge ben in , Harl	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic	carb ate s tions	oonate silicic s and	e ban astic deta	k 5A platfols	=ske orm i m =	eletal interio micro	rich, or (ne obial	arshor			AB7				
A: 5B	= 'deep' B=coralg coastal Aben (Duni VII (6	gal-'stromatopor deltaic (lagoon WHOLE naki Sequence ham & lith initia 50m) = 58% SS	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and	e ban astic detai	k 5A platfols	=ske orm i m =	eletal interio micro	rich, or (ne obial	earshor	e ridge),	T DEFINE A		ST			
A: 5B	= 'deep' B=coralg coastal Aben (Duni VII (6	gal-'stromatopor deltaic (lagoon WHOLE naki Sequence ham & lith initia 50m) = 58% SS	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and TOPS	e ban astic detai	k 5A platfols	=ske orm i m = D F-09 B7 ne	eletal interio micro AND I	or (ne obial	earshor OT HAVE	e ridge), OR CANNOT	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunl VII (6 SH/S	gal-'stromatopor deltaic (lagoon WHOLE naki Sequence ham & lith initia 50m) = 58% SS	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and TOPS	e ban astic detai	k 5A platfols	=ske orm i m = D F-09 B7 ne	eletal interio micro AND I	or (ne obial	earshor OT HAVE	or CANNOT	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunl VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS SST, 65% ooid F	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and TOPS	e ban astic detai	k 5A platfols	=ske orm i m = D F-09 B7 ne	eletal interio micro AND I	or (ne obial	earshor OT HAVE	or CANNOT	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunl VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS SST, 65% ooid F	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and TOPS	e ban astic detai	k 5A platfols	=ske orm i m = D F-09 B7 ne	eletal interio micro AND I	or (ne obial	earshor OT HAVE	or CANNOT	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunl VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS SST, 65% ooid F	roid reefal al-contine E CORES (a s with Pe ls = M/W/ T, 42% SI	inter I, 5C ental) above ercer /P/G/ H; VI	mound, =mud/p;), 9= mix = Jabk) # htage lith /B/F-mud	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1 - 2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS	eous s 5E= c aic, 10 - 2955- 1/boundard	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ': = sand terdelt 3 - 3065 ; SH= 26%	'shal dsto ltaic 55.6-3 =shal pelo	Illow' si one, 6= SEE \ 10088.0m	lliced 'mo Wier: T=sagmer	ous spoat' (operative)	onge pen in , Harl one)	-coral ner sh and &	reef, 5 elf), 7 Eliuk	5= op '= mix 2002	en ma ed car	rine orbonic strat	carb ate s tions	oonate silicic s and TOPS	e ban astic detai	k 5A platfols	=ske orm i m = D F-09 B7 ne	eletal interio micro AND I	or (ne obial	earshor OT HAVE	or CANNOT	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunk VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS 65T, 65% ooid F6 6 ooid PG	s with Pels = M/W/T, 42% SIPCG, 25% p	inter I, 50 ental) above Prcer /P/G/ H; VI peloi	mound, =mud/pe), 9= mix = Jabk) # mtage litl /B/F-mud I U (80m d-fragme	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1-2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS ent WM; V (150m) =	eous sp 5E= co aic, 10 - 2955- //bound ST. 69 = 83%	ponge reef, oncolitic, 5F =0= deltaic/int -2973.3m, #3 d/floatstone; % ooid PG, 6	4C= ':= sand terdelt 3 - 3065 3 - 3065 3 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065	'shal dsto ltaic 55.6-3 eshal pelo poid-	Illow' si one, 6= SEE \ SO68.0m Ille, SST oid-frag -peloid	T=sægmer	andsto	onge pen in , Harl one) I; VI V = (p	-coral ner sh and & - (115 art 30	reef, 5 elf), 7 Eliuk n) = 1 +m)	5= op '= mix 2002	en ma red car for illu	rine orbona strat	carb ate s stions	oonate silicic s and TOPS defn A tops =	RELAT	k 5A platfols IVE TC na ~A 3018r	= ske orm i m = D F-09 B7 ne m, AB6	eletal interior micro D AND I eed spo 6Up= 3	DO NC nges I	OT HAVE but just n, AB6Lo	OR CANNOT cant correlate = 3157, AB	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunk VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS 65T, 65% ooid F6 6 ooid PG	s with Pels = M/W/T, 42% SIPCG, 25% p	inter I, 50 ental) above Prcer /P/G/ H; VI peloi	mound, =mud/pe), 9= mix = Jabk) # mtage litl /B/F-mud I U (80m d-fragme	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1-2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS ent WM; V (150m) =	eous sp 5E= co aic, 10 - 2955- //bound ST. 69 = 83%	ponge reef, oncolitic, 5F =0= deltaic/int -2973.3m, #3 d/floatstone; % ooid PG, 6	4C= ':= sand terdelt 3 - 3065 3 - 3065 3 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065	'shal dsto ltaic 55.6-3 eshal pelo poid-	Illow' si one, 6= SEE \ SO68.0m Ille, SST oid-frag -peloid	T=sægmer	andsto	onge pen in , Harl one) I; VI V = (p	-coral ner sh and & - (115 art 30	reef, 5 elf), 7 Eliuk n) = 1 +m)	5= op '= mix 2002	en ma red car for illu	rine orbona strat	carb ate s stions	oonate silicic s and TOPS defn A tops =	RELAT	k 5A platfols IVE TC na ~A 3018r	= ske orm i m = D F-09 B7 ne m, AB6	eletal interior micro D AND I eed spo 6Up= 3	DO NC nges I	OT HAVE but just n, AB6Lo	OR CANNOT cant correlate = 3157, AB	「DEFINE A	AB6 iis L				
A: 5B	Aben (Dunk VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS 65T, 65% ooid F6 6 ooid PG	s with Pels = M/W/T, 42% SIPCG, 25% p	inter I, 50 ental) above Prcer /P/G/ H; VI peloi	mound, =mud/pe), 9= mix = Jabk) # mtage litl /B/F-mud I U (80m d-fragme	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1-2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS ent WM; V (150m) =	eous sp 5E= co aic, 10 - 2955- //boundersT. 69 = 83%	ponge reef, oncolitic, 5F =0= deltaic/int -2973.3m, #3 d/floatstone; % ooid PG, 6	4C= ':= sand terdelt 3 - 3065 3 - 3065 3 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065	'shal dsto ltaic 55.6-3 eshal pelo poid-	Illow' si one, 6= SEE \ SO68.0m Ille, SST oid-frag -peloid	T=sægmer	andsto	onge pen in , Harl one) I; VI V = (p	-coral ner sh and & - (115 art 30	reef, 5 elf), 7 Eliuk n) = 1 +m)	5= op '= mix 2002	en ma red car for illu	rine orbona strat	carb ate s stions	oonate silicic s and TOPS defn A tops =	RELAT	k 5A platfols IVE TC na ~A 3018r	= ske orm i m = D F-09 B7 ne m, AB6	eletal interior micro D AND I eed spo 6Up= 3	DO NC nges I	OT HAVE but just n, AB6Lo	OR CANNOT cant correlate = 3157, AB	「DEFINE A	AB6 iis L				
IA: 5B	Aben (Dunk VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS SST, 65% ooid F	s with Pels = M/W/T, 42% SIPCG, 25% p	inter I, 50 ental) above Prcer /P/G/ H; VI peloi	mound, =mud/pe), 9= mix = Jabk) # mtage litl /B/F-mud I U (80m d-fragme	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1-2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS ent WM; V (150m) =	eous sp 5E= co aic, 10 - 2955- //boundersT. 69 = 83%	ponge reef, oncolitic, 5F = 0 = deltaic/int -2973.3m, #3 d/floatstone; % ooid PG,	4C= ':= sand terdelt 3 - 3065 3 - 3065 3 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065	'shal dsto ltaic 55.6-3 eshal pelo poid-	Illow' si one, 6= SEE \ SO68.0m Ille, SST oid-frag -peloid	T=sægmer	andsto	onge pen in , Harl one) I; VI V = (p	-coral ner sh and & - (115 art 30	reef, 5 elf), 7 Eliuk n) = 1 +m)	5= op '= mix 2002	en ma red car for illu	rine orbona strat	carb ate s stions	oonate silicic s and TOPS defn A tops =	RELAT	k 5A platfols IVE TC na ~A 3018r	= ske orm i m = D F-09 B7 ne m, AB6	eletal interior micro D AND I eed spo 6Up= 3	DO NC nges I	OT HAVE but just n, AB6Lo	OR CANNOT cant correlate = 3157, AB	「DEFINE A	AB6 iis L				
IA: 5B	Aben (Dunk VII (6 SH/S	wHOLE maki Sequence ham & lith initia 60m) = 58% SS 65T, 65% ooid F6 6 ooid PG	s with Pels = M/W/T, 42% SIPCG, 25% p	inter I, 50 ental) above Prcer /P/G/ H; VI peloi	mound, =mud/pe), 9= mix = Jabk) # mtage litl /B/F-mud I U (80m d-fragme	4B= 'shallow' silice elleted; 5D=oolitic, ked carbonate-delta 1-2188.2-2206.5m#2 hofacies d/wacke/pack/grain.) = 6% SH, 12%SS ent WM; V (150m) =	eous sp 5E= co aic, 10 - 2955- //boundersT. 69 = 83%	ponge reef, oncolitic, 5F =0= deltaic/int -2973.3m, #3 d/floatstone; % ooid PG, 6	4C= ':= sand terdelt 3 - 3065 3 - 3065 3 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065 1 - 3065	'shal dsto ltaic 55.6-3 eshal pelo poid-	Illow' si one, 6= SEE \ SO68.0m Ille, SST oid-frag -peloid	T=sægmer	andsto	onge pen in , Harl one) I; VI V = (p	-coral ner sh and & - (115 art 30	reef, 5 elf), 7 Eliuk n) = 1 +m)	5= op '= mix 2002	en ma red car for illu	rine orbona strat	carb ate s stions	oonate silicic s and TOPS defn A tops =	RELAT	k 5A platfols IVE TC na ~A 3018r	= ske orm i m = D F-09 B7 ne m, AB6	eletal interior micro D AND I eed spo 6Up= 3	DO NC nges I	OT HAVE but just n, AB6Lo	OR CANNOT cant correlate = 3157, AB	「DEFINE A	AB6 iis L				

LIICIC	sure	A3.6	Shell DEMA	SCOL			tings ThinSections	(GSC/	Jansa)				ing Inc	L	.Eliuk	P.Ge	ol.exan	nined 20	009-06								_ <u>_</u> _ ∞ ~				PAG	3E		
	DEPTH	LITH	modifier I	COLOR	TEX	TURE	modifier	POROS	SITY	ACC	ESSC	RIES					SILS	(enhand	ced by	y S <mark>WC</mark>	data i	<mark>f</mark> availa	ible)			S TYP R/78'8 k 200	С	OMMENTS	1				
THIN SECTION GSC # and NTERVAL		DOL H SH=9 O SS=9 L SLTS arg= calc=	mestone =dolomite shale	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=wa PS=pac GS=gra BS=bou (FS/RS: FS=floa RS=rud	dstone 1 ckestone 3 kkstone 5 instone 7 indstone 9 =XC size) tstone 4 stone 8 rystalline	%	modifier (Archie)	SGIOO	PELOIDS	PARTICLES LITHOCLASTS	SBONGES A	.s	STROMATOPOROID-		MICROSOLENIDS	BRYOZOANS	BRACHIOPODS	ECHINOIDS	BIVALVES	OSTRACODS	TUBIPHYTES etc	BORINGS	HIGHER -green etc P	ONCOIDS-PISOID O	STANDARD MICROFACIES TYPE Fluge1'82&Wilson'75&Eliuk'78'88 Wierzbicki, Harland&Eliuk 2002		diager facies et cete some l	netic texto -sequenc era long comm		be		
	Α	В	С	D	ш	G	Н	T	J	К		M N						V									_	AL			•			
G-32	A 11040	В	С	D		G	Н		J	K	L	M N	0	Р	Q R	S	T	٧	w x	Υ	Z AA	AB A	ADA	E AF	AH	AI A	J A	K AL	. AN	1 4	AN	AO	AP	Α
3372 3308	11050 11060	SH&SIt	7/3 some VFqtz 5/5 VFqtz			colle 1161	ths represent base of ected cuttings samp 0 is sampled from 1 0 feet	ole <i>ie</i> .					1=sp	icule					2	1	1? 1 1 oy	1? /ster						shells	rextl & micri	itized rims	•			7
3373	111090	sltySH	5%vfSS				sh VC clasts														1?	1												5
3374 3375 3376 3377	11110 11120 11130 11140 11150	sitySH LSarg SLT+SH sitySH	tr sponge lst & SH cave? 6/4 XF-VFqtz tr glauconite		,	WSFS	spg ech skel pel				5		4 lith 25 3 1?	istid	& hexa	actinel	eid in S	SH	10 1 1		3	? 1	? 1 1 1	1		2'	? 4B	?FeDo	I cmt F rind	s?				13 8 3
\neg	11160				Ш																													
3310	11170 11180 11190	LSarg-SI	9/1			FSWS	Sponge-skel						20+						1	1	?	1 1	1	3			4B							1
3378	11200 11210 11220	LSarg	SHcave25% Chert	3%		FSWS	sponge pel?vf				10		35						?		2	r	ubecu 3			?	4B							
3379	11230 11240 11250	LSarg LS(arg)	CORE #1 -11228- SHcave85%	11251			sponge sponge						50+ 15		5 1		2 1=	oculini	d		1	2	4	2		3	4B	micros	solinids at	11240.'4T	S & 11246	.8'core		
3311	11260 11270	LS(arg)	cherty 5%		Ш	BFSWs	sponge-skel				5		60 se	evera	al types	8			1? 1		2		ubecu			??	4B	tr MS f	rg GS & sub	b cmts				1
3380	11280 11290 11300 11310	LSvarg	SH cave?75% che	ert purito		FSWS	sponge						15		en 2		ıg spon	ge	1?		1		1	ca	Icishpe	re	4B	ny rito r	eplacemen	+2				1.
3300	11310 11320 11330	Lovary	SH cave!15% che	rt pyrite	П	rawa	sponge	П					15					Н	11		1		H	1	1		40	pyrite i	еріасеттет	l f				
3381	11340 11350	LSvarg	Shcave?50% cher	t10%		FSWS	sponge						20						4		?	1	3	1			4B	some p	oyrite					
	11360										lithi	stid-he	xactine	llid-s	picule	s																		
3312	11370 11380 11390	SH&LS	?LScave? Cherty			FBS	sponge-stromtop	П					45		8				5	5	1	1	1	3	1 1	?&thro	om <mark>bolite 4</mark>	C some p	oyrite					
	11400										lithi	stid-he	xactine	llid-s	picule	s																		
	11410 11420		?LScave? Cherty				sponge-skel						15		2				1			r	1 :	lenelli										
3383?	11430 11440	LS				ws	frag-skel						3						1			3	2	3		?thron	nbolite	338	<mark>3 = 11433</mark> -	11443'				
3313= 11352- 11381'	11470	LSarg&S	FqtxSScave?			FSWS	sponge frg skel					15	15				1	?	5		1?	1	1	2	7	?thron	nb <mark>olite 4</mark>	B tr rd fro	g GS/PS; or	n possible	coarse sep	otate coral		
	11480	cltCU+l Cor	g 8/2cave? Vf-XFqtz	7		(MWS)	very qtz silty																1	1		1								

33524	Α	В	С	D	G	Н	1	J	K	LI	M N	0	Р	Q R	S	Т	VV	/ X	ΥZ	AA	ABA	CAD	AE AF	- AH	Al	AJ	AK	3074 = 11491-11501'	
33847	11500									1		Ť		1				Ħ										3304 - 11431-11501	
	11510																												
3385	11520	sitySH sitySH	minor F rd qtz		(MC)	ata condutr one						22						2	1				1 0		ooro				3P
3386 3387	11530 11540	LSarg SH	minor sdy LS 6/4 qtz silty Shcav	/e2	(WS) WMS	qtz sandy tr spg frag-skel		healed fractur	200		10	2? 2						1		1	1	1	2 1	alcish _l				hairline calcspar filled multi-fracs; some frg bored, tr pyrite	5P 6P
3388		LSarg SH	7/3 qtz silty Shcav	ve?	FWPS	frg-skel	filled	hairline fractu			20	2						2		1	1		2		?			encrusting consortia	8P
3389	11560		8/2 qtz silty Shcav		MWS	frg-skel		tr M-C dolospa				2						1		1	1 1				?			?oolitic Festone?? tr F qtz ssndy LS	13P
3309	11570	LS	Fqtz nucleii ooids		MW+P	frg-ske-pell + oolitic	1	interpeloid?	6	15	5	1				1?		2		2	1	1	1		?			10% qtz sandy F-M ooid PGS tr F calcspar veins	15P
	11580																											In cuttings 11570-75' ooid GS (PS) bed	
	11590																												
3390	11600	1.0	Fqtz SST ?cave		MWS	fun akal nal		hairling fractu		15	4	22				1?		1		2	1	1	1 1					andthered angiler F.M.Otz in early Tr.Facileoner and	440
3390	11610 11620	LS	rqiz 551 ?cave		IVIVVO	frg-skel-pel		hairline fractu	ies	15	4	2?				17		' '		3	1	1	1 1					scattered angilar F-M Qtz in carb. Tr Fcalcspar cmt	11P
	11630																												
3391	11640	LSDol	8/2 30%SHcave		FW+PGS	spg-cor-str+frg-clast	2	interxtl 1Af-m	5	15	3 15	10		8		10		4	2	2	1 1 1	1	1 2		3?		4C 5B	M-VC rd skel-rich clasts&coated grns.	
0001	11650					superficial ooids																						Boings in crinoids&framebuilders	
	11660																											·	
3314	11670	LS	5%dolm		FWPS	ech-skel-microb	tr	interxtl 1Af-m		10	20	3		5 1		?		10	3	2	1	1	1	2	10		5A m	peloid-microb-foram consortia	21P
	11680	BELOW	nitial scan of cutt	ings for micr	rosolonids (N=not seen) generally	v NOT	E more micorh	nial2 n	nicro	neloid		eortis	of ro	ofal fra	mowo	k than	in old	Cutti	nae a	nd off	on na	cketo	no or	oven	arai	netona t	extures vs wackestones	
	11000	BLLOW	I	1	l Usuleilius (y 1401	1	Jiai: I	IIICIO	pelolu	1	130111	1 01 16	Ciai iia	inewor	K tilali	111 010	Cuttii	iigs a	III OIL	en pe	LKSIO	11	CVCII	grai	istorie t	extures vs wackestories	
3392	11700 11710															N													
3382	11710															IN													
	11730																												
3393	11740															N													
	11750																												
	11760																												
3315	-	LS dol	9/1		BFWS	Strom-coral-skel-frg	Į.				15	1		25		2? 15	1?	6	1 1	4	1	1	1 1				5B	tr micropyrite, corals rextl	24P
البيبيا	11780																												
3394	11790													2		N													
	11800 11810																												
	11820																					Litho	l codiur	n m					
3395	11830	LS	15%Shcave		WFS	strom-skel					5	2		15 1		N 8	2	4	13	? 3	1 1		2 1				5B	VC calcspar isopachous	19P
			-11836-11861FEE	Ť												0													
3396	11850		70%SHcave													N													
	11860																												
	11870																												
3316	11880	LSDOL	6/4		BFPS	skel-frag-strom				8	15	1		10 2		N 5	1	2	2	3	1		1 1				5B		17P
	11890																												
	11900 11910																												
	11910																												
3397		LS DOL	30%SHcave													N													
	11940																												
	11950																												
3398	11960		30%SHcave													N													
	11970																												
3317	11980															N													
	11990 12000																												
	12000																												
	12010																												
3399	12030	LS	tr dol		FWPS	strom-coral				3	15			20 2		N 10	1	3		2	1	1	2				5B		14P
1300	12040																												
0.00	12050																												
3400	12060															N	2												
2040	12070		THOU TO 5: :: =																										
3318	12080	I	THICK TS ?MICR	OB-PELOID		1		1			l	1	1 1	ı	1 1	N			l		1		1	II			m	1	l

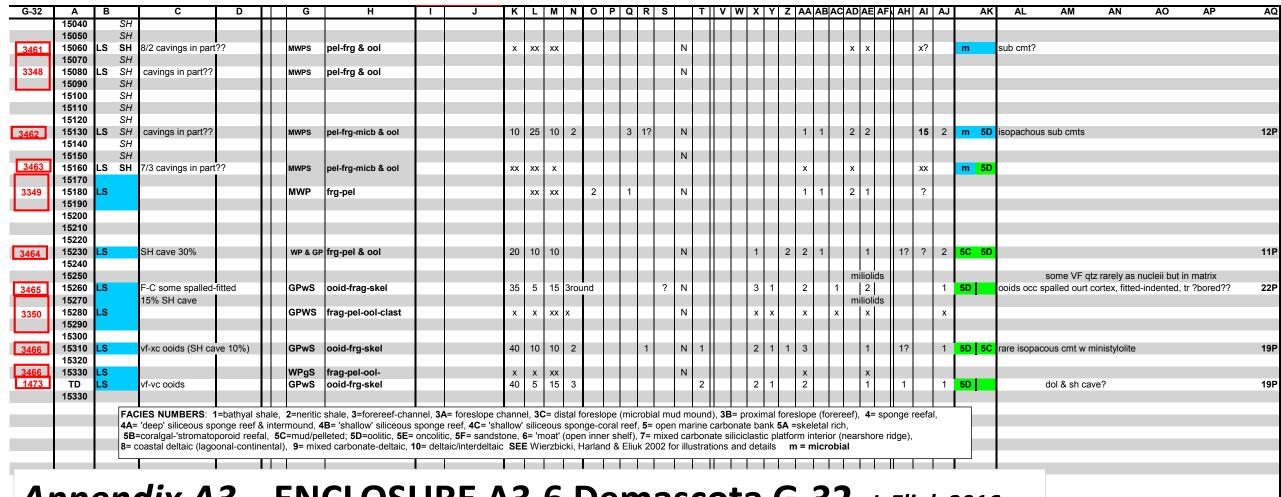
G-32	Α	В	С	D		G	Н	I J	K	L	M N	0	P	Q R	S	Т	Г∏	V W	/ X	ΥZ	AA	ABA	CAD	AE A	AH	Al	AJ	AK	AL
	12090 12100																												
	12110																												
	12120																												
3401	12130 12140		30%SHSScave													N													
	12140																												
3402	12160	LSdol	9/1			WPGS	frag-pel-skel			20 2	25	2		5		N 5	stylir	nid ro	s 1		4	1	1 1	2	?	3?		5C	14P
3319	12170 12180									Х						N													
3319	12190									^						IN													
	12200		NOTE 1978	E THAT	WITHIN	I A SAMPI G HAS AL	E OR SO																						
	12210 12220		FRAN	MEBUIL	DERS &	PELOIDS	main																						
3403	12230		differe	ence IS	OFTEN MOF	PS-GS (T RE CONS	S) VS WS			Х						N													
	12240		SH ca	ave COI	MMON 8	& high % ir	ORTIA n TS <i>ie</i> non-										Ш												
3404	12250 12260		seleti	ive colle	ction.					Х						N													
3404	12270									^						14													
3320	12280	LS	dol tr F			WPS	pel-frg-skelmicrob			25	15			3		N 2	2		5		3		1	1		107	?	m	
	12290 12300																												
	12310																												
	12320				ш							ш	\perp				Ш												
3405	12330 12340															N X	< -												
	12350																												
3406	12360															N X									1				
3321	12370 12380	LS				G+PFS	frg-pel & strom-skel			15 2	te rims	3	1	5		? 8	3	2	2		3	1 1	niliolid I	s, bis 3 1		3		5B	24P
	12390					01110	ng-per a stroni-sker				20								_										271
	12400																Ш												
	12410 12420																											5B M	
3407	12430	LS	poorTS, 30%Shca	ave, tr do	ol	PWFS	strom-skel-frg	INTRAFOSSIL PORG	3		15		2	20		N 5	5 2	X?	5		4	1 '	1 2	1		2			15P
	12440 12450																Ш											5B	
3408		LS(dol)	30%SHcave			FWPGS	Frg-strom-skel-ooid		5	10 2	20 5		1	5		1?? 5·	+		4	2 ?	6	1		2		??p	l eloid	5B	23P
	12470																												
3322	12480 12490	LS				BRWS	strom-frg-coral-skel		5		15	3	3	2?		1?? 1	0		3	2	3			2 1		2		5B	18P
	12500																												
	12510																												
3410	12520 12530															N													
3410	12540															14													
	12550																												
3409	12560 12570															N													
3323	12580															N	П												
	12590																												
	12600 12610																												
	12620																												
3411	12630															N													
	12640 12650																												
3412	12660		30-40%SHcave													N													
3324	12670																												

G-32	Α	В	С	D	G	Н	l J	K	L	M M	1 0	P	Q R	S	T	V W	X V	Y Z A	A AB	AC AD	AE	AFN AI	I A	I AJ	AK	AL	AM	AN	AO	AP	AQ
	12680	LS				S Pel-mic/consortia-s			20		2		0	N		2			2		2		15		5B						AQ 17P
3324	12690 12700					peloids, consortia s	troms																								
	12710		CORE #3 -12704-	12721FEET										0											5B						
	12720																				П										
	12730																														
3413	12740 12750	DOL	30-40%SHcave											N	X																
3414	12760	DOL	50%SHcave											N																	
	12770		00700110010																												
3325	12780	LSDOL	5/5		FWPS	Frbld-microb-skel-frg			5	10	3		7	N	7		3	2	2 1	1 1	1		15	?	5B						21P
	12790 12800					REEFAL																			5B						
	12810																														
	12820																														
3415	12830		30-40%SHcave											N																	
	12840 12850																														
3416	12860		30-40%SHcave											N																	
0410	12870																														
3326	12880	LSDOL												N																	
	12890 12900																														
	12910																														
	12920																														
3417	12930	DOL												N																	
	12940 12950																														
3418	12960	DOL	30%SHcave											N																	
	12970																														
3327	12980 12990	DOL												N																	
	13000																														
	13010																														
3419	13020	DOL												N																	
	13030 13040																														
3420		DOL LS												N																	
	13060																														
	13070 13080																														
3421	13090	DOL LS												N																	
3328	13100	DOL LS												N																	
	13110																														
	13120 13130																														
	13140																														
	13150		200/ 011																												
3422 3329	13160	DOI 18	30%SHcave 7/3 Cave?Ls						4	10 5	5 3		2	N N			3			1	2			5?		XC calcen	ar or crinoids				15P
3329	13180	DOL-L3	773 Cave!LS						4	10	, , ,		2	IN			3			'				3:		AC Calcopa	ai di cilildias				135
	13190																														
3423	13200	DOL 10	200/ 01 15																												
0420	13210 13220	DOL-LS	30%SHcave											N																	
3424	13230	DOL	30-40%Shcave&L	CM=WOOD/V	VALNUTS									N																	
	13240 13250																														
3330	13260	DOL												N																	
			-		•	i.	• •	•		,	•							' '				• • • • • • • • • • • • • • • • • • • •	•	•		•					•

G-32	Α	В	С	D	Τ	G	Н	ı	J	K	L N	1 N	0	Р	Q R	S	T	V W X	Y	Z	AA AB AC	AD A	AF	AH A	I AJ	Α	K .	AL	AM	AN	AO	AP	AQ
3330	13270 13280	DOL	CORE #4 -13273-	12205555				Ges	XTL DOL																								
	13290	DOL	CURE #4 -132/3	-13203FEE1				GS?	XIL DOL																								
3425	13300		30-40%Shcave														N		Ш														
	13310 13320																																
3426	13330		70%Shcave														N																
	13340																		П				ш	TH									
3331	13350 13360		MAINLY Icm = LC	ST CIRCUA	 TIC	 NM MATER	 RIAL = WOOD/WALNI	LITS									N							RO MI OI	3								
3331	13370		WAINET IOH - EC	I			IAL - WOOD/WALIN	I									14							1									
	13380																							TE S									
3427	13390 13400	DOL LS	30-40%Shcave&L	CM=WOOD	/WA	I NUTS					X X	(X					N	$ \cdot \cdot _{x}$															
0427	13410	502 20	1070011001001								Λ ,	` ` `					.,		·														
0.00	13420	LC(DOL)									V	,					N.																
3428	13430 13440	LS(DOL)									X						N							×									
	13450																																
3337	13460 13470	LS dol	50%LCM CK??							1	XX X	(N					XX		X	X X								
	13480	CHE	CKII																														
	13490																																
3429	13500 13510	LS dol	50%LCM							1	XX						N)	<								
	13520																																
3430	13530	LS	70%LCM								Х						N																
	13540 13550																																
3431	13560	LS (dol)	50%LCM								Х						N)	<								
3332	13570		500/ L OM			000					20 0						,								2								400
3332	13580 13590	LS	50%LCM			GPS	rd frg(fm)-peloid(vf)				20 2	U	1	2	2		N	1			1	1 1		5	7		roun	naea rewo	orkea mici	ritic-peloid fi	ags		19P
	13600																																
	13610 13620																																
3433		poorTS	50%LCM														N																
	13640																		П				ш										
3432	13650 13660	LS				GPS	peloid-rd frg-microb				XX		X?				N							×	7								
	13670						point in mg						7.1																				
3333	13680 13690	LS (dol)									Х)	X		N X?							X	?								
	13700																																
	13710																																
3434	13720 13730	IS				GPS				,	XX			,	X		N				X	X		X	X								
3434	13740					0.0				1	, , ,											, , , , , , , , , , , , , , , , , , ,		^	,								
	13750					ODC.					VV						, ,					V			V								
3435	13760 13770	LS				GPS				1	XX)	X		N ?				X	X		Х	^								
3334	13780	LS				GPWS	peloid-rd frg-microb)			45 1	0	1		5		N ?	1			1 1	2 2		1	0	m							20P
	13790 13800																																
	13810																																
	13820																																
3436	13830 13840	LS	Shcave														N																
	13840 13850																																
	13030																																

G-32	Α	В	C D		G	Н	I J	K	L	M N	0) P	QR	S	Т	VW	X	Y Z A	AABA	CAD	AE AF	AH	Al	AJ	AK	AL	AM	AN	AO	AP	AQ
3437	13860	LS		PW	S PE	ELOID MICROB			XX						N					Х			XX		m						
	13870 13880	LS	tr geopetal⊂ cmts	GP	WS pe	eloid-microb-rd frg			50				2		N 2		5		1	1	2		20		m						25P
	13890		a geopetalaced of the										_								_										20.
	13900										Ш																				
	13910 13920																														
		LS		PW	S PE	ELOID MICROB			XX		X	?	X?		N					Х	Х		XX		m						
	13940																														
		LS		PW	S				XX						N					Х	X		XX								
	13960 13970	ıs	tr isopach sub cmts	GP	WS no	el-microb-frag			40	10	1				N		1		1	1	3		20		m						15P
	13980		ii isopaon sub omis		PC	ci-inicrob-irag			40	10	1				14		1						20								101
	13990																														
	14000 14010																														
	14010																														
3440	14030		30%SH cave	GP	WS PE	ELOID MICROB			40	10	2				N		2		1	1	3		20		m						13P
	14040		tr isopach sub cmts																												
	14050 14060	LS	30%SH cave	GP	S PF	ELOID MICROB			XX						N					X	X		XX		m						
	14070	_0	00700110010						, ,																						
3338		LS	Dol cave	GP	WS pe	eloid-microb-skel			50	10 3	2		3		N 2		3	2	2 1	1	1		20		m	?sub cmt					18P
	14090 14100																														
	14110																														
	14120																														
3442	14130 14140	LS		WP	S pe	el-frg			XX	х	Х		х		N		X			х			Х		m?	?sub cmt					
	14140																														
3443	14160	LS		WP	S pe	el-microb			xx				x?		N					х	х		xx		m						
	14170																														
	14180 14190	LS		WP	GS pe	el-microb			XX				x? x?		N		Х			Х	X		XX		m						
	14200																														
	14210																														
3444	14220 14230	1 9	tr dol	WE	GS no	el-microb			35			1?			N 2		3	1 1	1 '	2 3	3		25	2	m	sub cmts,					21p
	14240	LU	ii doi		OO pe	er-microb			55			1:			IN Z				'	2 3	3		23			Sub Cirits,					210
	14250																														
3445	14260 14270	LS	tr dol	WP	GS pe	el-microb			XX		Х				N					Х	Х		XX		m						
	14270																														
	14290																														
	14300		tr dol	NA/E	~~ ~~	al miarah	tr colo voino		107						NI.						101		101		-						
3340	14310 14320	LS	li doi	WP	go pe	el-microb	tr calc veins		хх						N					Х	XX		XX		m						
3446	14330	LS	tr dol	WP	gS pe	el-microb			xx						N					х	х		хх		m						
	14340																														
	14350 14360	LS	tr dol	WP	aS pe	el-microb			XX	x			х		N x?					х	x		XX		m	sub cmts,					
	14370		a doi		go po	or milor ob			701						Α.								701			oub ornto,					
		LS	SH cave-poor TS	Wp	S pe	el-microb			xx						N		ш			х	х		xx		m						
	14390 14400	LS	CORE #5 -14400-14424FEE	I GS	&BS ck	kel & microb-stroma	atactid_nol		~~		×		v		Хх	$\ \cdot \ _{\star}$, ,	v v	\ \ \		XX	v	m	eub cmte	etromata	ctid_throm	olitic microb	al mud mound	Q.
	14410	LS	OOKE #0 -14400-14424FEE		GD3 SK	vei or illicion-stroma	atactiu-pei		XX	X	×		x			x x 408.7m	X :	x >	x x :	X X	^		AX	X	111	Sub Cills,	Suomala		oris bed (sha		u.
	14420																												,		
	14430 14440	I S	SH cave-poor TS	Wp	9	el-microb			vv						N								XX		m						
3448	17740	_0	011 0ave-pool 10	I lash	o lhe	CI-IIIICI OD	ļ	I !	XX	I	I	1	ı İ	i l	17	11 I	ı l	1 1	1 1	^	1^1	П	^^		m	I					

G-32	Α	В	С	D	1	G	Н	I J	K	L	М	N	0 P	Q	R S	S	Т	V W	Х	ΥZ	AA	ABAC	ADA	E AF	АН	AI AJ		AK	AL	AM	AN	AO	AP	AQ
	14450																																	
3449	14460 14470																																	
3342	14470	LS	tr dol			WPgS	pel-microb			XXX		х		,	?	N	N		X				X X			xx	m		sub cmts,					
5542	14490		30.			90	,			7.500																								
	14500																																	
	14510																																	
3450	14520 14530	1 9	tr dol			WPgS	pel-microb			xxx		х		x?		N	N.		x				XX			xx	m		sub cmts,					
3450	14540	LO	li doi			WFgS	per-microb			***		^		A:		,	4		^				^ ^	`		^^	""		sub cirits,					
	14550																																	
3451	14560	LS				WPgS	pel-microb			xx									х	х		х	хх	(xx	m		sub cmts,					
3343	14570						a alaid saisaah			40		<u></u>					1 40													:ht-				400
3343	14580 14590	LS				wPGS	peloid-microb			40		3				٨	N 1?		2			1 1	3 2	-		20	m		sopachous s	SID CMIS				19P
	14600																																	
	14610																																	
0.750	14620					D				00													linellid-											
3452	14630 14640	LS				wPGS	peloid-microb			30						N	N		1	1		1	2 2	2		15	m		sub cmts,					7P
3453	14650	LS				wPGS	peloid-microb			xx						N	N		X	Х			x x	x		xx	m		sub cmts,					
	14660																																	
3344		LS				WPgS	pel-skel-microb			25		5	1	6 1	1?	N	N 1?	1?	2		1	2	1 2	2		10	m							17P
	14680																																	
	14690 14700																																	
	14710																																	
	14720																																	
	14730	LS				WpS	pel-microb?			20						١	N					1	2 2	2	1	0?	m							
	14740 14750																																	
3455	14760	LS				WPgS	pel-microb			25						N	v I					1	2 1			15	m		sub cmts					
	14770					iii go	por miloros										Ì					·		'					Jub office					
	14780	LS				WPgS	pel-microb			xx						Ν	N					х	x x	c		xx	m		sub cmts					
	14790																																	
	14800 14810																																	
	14820																																	
3456	14830					WPgS	pel-microb			xx						N	٧		х		Х		х	(xx	m							
	14840		miissed TS samp	ling oolite a	at 11	1840 in cut	ttings																											
3457	14850 14860	I S	cavings in part??			WDs CS	pel-microb & ool		5	45		2				N					1	1	1	,		15			sopachous s	uh emte				11P
	14870	SH	cavings in part??			WF& GS	per-microb & our	14845-15160'	3	40		_				IN IN	1									13	m		sopaciious S	oub CIIIIS				118
3346	14880	LS SH	cavings in part??			WPgS	pel-microb	Shale with lst		xx	х	х				٨	٧				х		х	(xx	m		sopachous s	sub cmts				
	14890	SH						interbeds but in																										
	14900	SH						cuttings nearly lst																										
	14910 14920	SH SH						except as noted???															das	vclad') + cal	 cispher	e							
		LS SH	cavings in part??			WP&GWS	pel-microb & ool		5	40				1		N	٧		1		1	1	1 1		1		m		sopachous s	ub cmts				9P
	14940	SH																																
	14950	SH	7/0																															
	14960 14970	LS SH SH	7/3 cavings in part	77		WPS	pel-microb & ool	WHY shale	2	XX						Ν	V						X X	×		xx	m							
	14970	LS SH	cavings in part??			Wp&GWS	pel-microb & ool	missing in TS	1	xx						N	V						x x			xx	m							
	14990	SH	G: pen					sampling???																										
	15000	SH																																
	15010	SH																																
3460	15020 15030	SH IS SH	6/4 cavings in part	??		WPS	pel-(microb)			XX		Y				N	V .						X V			х	m							
0400	10000	_0 011	o, rouvings in part			**** 3	por-(illiorob)			^^		^				1	•						^ ^	`		^								



Appendix A3 ENCLOSURE A3.6 Demascota G-32 L.Eliuk 2016

Enclo	sure A3	3.7 EnCana-l	Maraud			ion <u>J-14 (</u> JABI	K) sec	Tours Con				iuk P.C	Geol. 2	006-04	to 05 a	and 2	007-0	08 infill	below	3300					TY PE 78'88	PAGE
DEPTH	LITH	modifier I	COLOR	רן ו	TEXTU	RE modifier	POR	OSITY	ACC	ESSO	RIES			FO	SSILS	s	(€	enhance	ed by S	SWC o	data if av	ailable)		E E	COMMENTS
(metres)		LS=limestone		따로		udstone 1	%					FRAN	/IEBUII	LDERS			È		Ø				,	AE o	28E	additional fossils/accessories
		DOL=dolomite		MB Sir(s	PS=pa	vackestone 3 ackstone 5		modifier		[O]	2		ام ا	[m] a !!			到 [8	<u> </u>	[일	S	8 -	MFERA	et c	-MICROBIAL - AV	8.5	diagenetic textures
		SH=shale SS=sandstone		(sq)s		rainstone 7 oundstone 9		(Archie)		PELOIDS	_ S		; [] 일	CHAETETIDS MILLEPORID	S	ALS	BRYOZOANS		피힘	BIVALVES	ջ[[[-MICROBIAL	MICR	facies-sequence breaks some long comments may be
		SLTST=siltstone	₩ ₩	HAM fs&rs		S=XC size)			တ္က	[필] [전	ПТНОС	Si I	<u> </u>			KACORA			ECHINOIDS GASTRO	اا≰ا	SERPI TUBIPHYTES	FORAMIN	HIGHER-green	₩ <u>₩</u>	STANDARD I	et cetera hidden & visible only on screen
	o	arg=argillaceous calc=calcareous	P BB F	E E	FS=flo	atstone 4			∥∺∥	عالثا		ĮŠ į	4 S	₽₽₽₽	SE SE	Ş.	BRYO		테이	إالا	影티의동			₽¥ S	82	SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND
		sdy= sandy/qtz		o å		dstone 8 crystalline				PARTICI		P. S	STROMATO	I 및	CROSC	ш		- 병	Ш		TSI IB		테뿔!!	را ا ي	uge	CHALKIER THAN ACTUAL =BBB
	Y			E					Ш	Ľ]	ш	STE		[발	1						ا ال] ""	
Α	В	С	D		G	Н		J	к	LI	и N	0	P Q	R S	2	T	V V	v x	ΥZ	AA A	BACA	AE A	F AH	AI A.	JAK	AL
3200	SSSHLS	7/2/1calcXF-F(XC	LMGy+B(R)		MWS	(skeletal) tr siderite/c	hert										1			3						It tan scaphopod&tiny cockle bivvalve(cave)glauc, Tr red-bn+slty SH 4P
3205		5/3/2AA	M(L)BGy		WPS	skel-frag -sandy				1	0	2		r pyrite			5	7		2	1 2	2			7-10	stylollitc contacts, bryoderrm w/ sponge&?nubeculinellids/lg tubiphyte (Tx16)6P
3210		6/3/1 AA	LMGy+B(R)		MWS	skel-frg	_		!		7		t r mic	ropyrit&	pyrite		3	3		2	1	1 1	1		5F-10	bored?bryozoan
3215	_	F-VC allochems	MGyBn		W-PGS	crinoid -skeletal-frg	tr It	green clay			0	2		1			5	20	3	2		3		1	6?	Only largish cuttings Common crinoid-frag-foram(T) GS. Pyrite &x16=6P)& 8P
3220 3225	_	AA inpart	MGyBn		M-PS	skeletal-fragmental	414				5	1?	1	1?	4		2	7	1	3	1 3	1		3? 1?	5A	tr green clay fill tr micropyrite 4P
3225	LS +arg LSargSH	tr It grn chert	MGyBn MGyBn		WPS WPFS	skel(spg-crin)-frag sponge-skeletal-frag		areen clav reen clav			5	8+ 25	1	2 2			2		3 ?		l? 3 2 1 3	2		5+	4Bc 4Bc	tr pyrite (X16=5P)& 7P CASING 3229.5M tr?sphinctozoan?sponge, micropyrite (x16=3P)9P
3235		8/2 cave??lg ctgs			FRWS	sponge-skeletal-frag	u n g	loon olay				70		1	1	11	_		2	1		1 1		2	4BC	tr lt green clay SH dkGy soft, pyritic Lt Grn (aaguamarine) ii 5P
3240		musch poorer SP				frag-skel?(sponge)				2		10						3		1				_	4B	 45% identifiable due to small lightened sheared poor ctg BBB BBB
3245		CEMENT +95%+3%			FWS?	microsolenid-skel-frg				5	-	2?			5?			5?	5	?cave	9		311	mm hole	to 3237n	t; 216mm to TD w/ 1 PDC bit = Reed DSX816M 3P
3250	LS	VPS=BBB	(L)MBn			fragmental (F-M)					5?									?	?				?4-5?	<5% identifiable=BBB, micropyrite, tr grn clay & bn chert/siderite BBB 2P
3255	LS		(L)MBn			sponge-skeletal-frag				10		20?						5?							4B	~5% ID tr grn clays, tr bn chert-siderite(dolmAA) BBB 3P
3260	LS		(L)MDBn		?WS	frag-skel				1		??						10?		?	21	? 2?		2? ?	3-5	~5%ID tr grn clay in LS aa, stylolites?, pyritized 'stick-fabric' BBB (2x16)5P
3265		9/1 XF-VFqtz	LMGyBn		W?PGS	frag-skel?				3	5?	6?	2?					4?		3?	1?	1?			3-4B	~7%ID minor silty qtz SS, tr grn clay BBB 3P
3270	LS	tr SSxf-vfAA	LMGyBn		??WS	frag?				1:	5?	?					00	5?	00	?				3?	3-4	<5%ID tr malachite grn clay BBB 2P
3275 3280	LS	\/am.iDaanCamanla	(L)MBn		WPS ?PS?	frag-skel-pel? crinoid-fragmental?					5? 5?	3?					2? 1??	4? 15?	2?	6?		?		4? 23	3-4	<5%ID BBB 3P <3%ID possible encrinite but terrible spls. tr pyrite & stylolites BBB 2P
3285	LS vps LSsdy?	VeryPoorSample arg SH&SS?cave	(L)MBn (L)MBn		?PS?	bryoderm-skeletal)?	4?				-	+// 15?	15?	152	?	12	?			3-4B	<3%ID possible encrinite but terrible spls, tr pyrite & stylolites common loose echinoid spines Lt grn clay infill BBB 3P
3290			DMGyBn		N+PGS	bryoderm- spong-fra	DGv	-Grn=glauc a	ara LS	1/	ori 5round		7				10	10		5+	1 11	1			4Bc	hexactiinellid+lithistid, V arg LS w fos'+glauc LS w rounded fos'frgs BB 6P
3295	LS-LSaig		DMGyBn			bryoderm-skel-frag	İ	J glade (l		5	3		2?		- 1	5		2	3	1	2			3-4	BB 4P
3300	LS	sl arg, (tr gy grn cl	DMGyBn			fragmental-skeletal					25	5	2				3+	5	?	2		1	. ?		3-4	?Favreinia?pellet (BB) (2x16) 7P
3305	LS	sl arg, tr VF Qtz	Md Gy Br	3 V	W(P)S	fragmental-skeletal				3 2	.0	5	1?			2	2	2?		1?	1	1 Pyrit	HO		5A	~20%ID tr pyrite, stylolites BB 3P
3310	LS	trVFqtzSS	LMGyBn		W(P)S	fragmental-skeletal					:0	5						3		2		?			4-5Af	~15%ID BBB 3P
3315	LS	+3%VF qtz SS	LMGyBn		M-PS	fragmental-skeletal					:0	2	2	2			1	2	3		1 1	1	sty	lolites	5A	~10-15 tr-1% C cl calcspar=infill shells? Tr pyrite tr lt grn clay fill BB 5P
3320	LS vps		(L)MGyBn		MWS?	fragmental				15	-	?	-	2?		10	^	2	_	2?		40		0	5A	5ID BBB
3325 3330	LS LS		LMGyBn		FWPS WPS?	stromatop-skel-frag stromtp-skel/frag					5 5?	1?	20	5		1?	2	2 2?	2	4?	2 2	1/		?	5B	20ID tr pyrite stylolites BB 4P 5-10%ID stylolites micropyrite BBB 3P
3335	LS		(L)MGyBn LMGyBn		MWS	frag (sekl)					5?	3	2?					2?		3	2 !	1 !	·	3	5B	5-10%ID stylolites Inicropyrite BBB 3P 5-10%ID stylolites BBB 1P
3340	LS		(L)MGyBn			skeletal-fragmental				15			7?	2?	5?			3?		2?		?			5Ab	~5%ID BBB 3P
3345	LS		LMGyBn		WPS	fragmental (skel)					10	2?						3	1	4		?		2? 0	5A	5-10%ID stylolites BBB 2P
3350	LS		(L)MGyBn	3 V	W(P)S	frag-skeletal-sponge				10		8	7?					3		3		?	stron	atolite?	5Ab	5-10%ID, tr pale grn clay infill BB 4P
3355	LS	tr VF qtz in LS	LMGyBn	4 V	WPS	fragmental-skeletal				15	5+	5	3			?		4	1	2		?		2	5A	5-10%ID stylolites tr Cu green clayey infill BBB 1P
3360	LS		(L)MGyBn		W(P)S	frag-skeletal-sponge	tr	intra fos IB			0	2	3	3?			3	3		1				3	5A	5% ID micropyrite tr pale grn caly infill BBB 3P
3365		2% VF qtz SS	LMGyBn		WPS	fragmental-skeletal					5	4		1?			2?	5	1	3		?			5A	5-10%ID stylolites tr pyrite BBB 2P
3370	LS		(L)MGyBn		PS	frag-skel-stromatop				20		3	10				4	0	2	4 1	12	1 ?	?	5?	5AB	5-10%ID tr pyrite malachite grn clay? + red stain, tr VC blocky cl SF BB 5P
3375 3380	LS LS-L{sits	8/2 gtz VPS	LMGyBn MLGyBn		N(P)S? ?WPS	fragmental (sekl) skel-frag				1		5?	2? 2? 2?				5	3?		72	1?				5AB 5A	5% ID cl c calcspar = infill? wt bryozoan in clay seam? BBB 1P ~3%ID BBB 3P
3385	LS-L: SITS	· ·	MLGyBn			skel-frag					5?	U!		3					2	, ,					5A	~3%ID tr lt grn clay infill with VF calcspar BBB 1P
3390		vps	M(L)Bn		WPS	fragmental-skeletal			2		5?		+5				?	7?		32		2enci	rust		5Ab	<3%ID micropyrite BBB 3P
3395	BBI		MGyBn			sponge-skel						20?	5					5			1?	1?		3??	4B	<2%ID mostly chalkified = spg-strom-crinoid ask med brn LS BBB 1P
			MGyBn		-	skel-frag??				?		7??					10?	? Microp	yrite		en	drust B	Raninell		4b	<2%ID BBBB 2P
3405		vps	MGyBn	_		skel-framebldr??				-	?		3 4	3		1?		3				? 2		5?	45B	~3%ID VPS but dark LS = skel-reefal? Honey cl calcsp BBB 1P
3410	LS		M(L)Bn			sponge-skel-frag?				10	0?	20?						6?		?				?	4B	<4% chip VC cl spar calcite BBB 4P
	_	vps but dk mottle				spg-skelfrg-pel				5 10		15	1?											3?	4B	~3%ID calcite filled veins??
3420	LS	time V/DO	(L)MGyBr			chaetetid-skel-frag					5	4	6	15+			_	5	2	4		1?		40	4-5B	~5% pyritic SH w/ shell frags=cave? micropyrite BBB 3P
3425		tiny VPS	(L)MGyBr			skel	I				?	3?	-				3	5	2 4	_	11	? 1		1?	4-5A	<3%ID micropyrite in grn clay infill (spg?) 40.0 (ID) Vorus prifting calculation and SUL grade grad (Sul like)
3430 3435		9/1 pyritic2%+ minor VF SST	MdGy(Bn) MdGy(Bn			frag-skel(crin-strom-s	sρg) ■			5 3		6	7+				2 15	8	2 1	5	2	?		3?	4-5BA 4-5A	40+%ID. Very pyritic calc+non-calc SH-gy to grn(Cu-like) 7P 50%ID tiny cuttings but not as bad bruising TR pyritic blk SH B 2P
3435		VF-XFqtz=60% MLGy	wiuGy(bf1	4 P		bryoderm-skel-frg skel(cri-bryoz)				4		3	7				1	3+		2	!			3:	4-3A	70%ID pyritic some pyritic grn-gy SH and some lime MS
3445			MdGy			tr crinoid PS	WO!	l site loa = 34	18.55			nottlad	CIV-14/4	to shah	, not c	11	i L	2							2	small cuttings B 2P
3450			RdGy+MG	ξv		tr shells pyritic	well	31 10 100 - 34	- 0-33	m dolc	mue. I	nomea	uv-wt	U SHAIN	IIOLS			1		2					2	3P
3455		calc, qtz silty	MdGy			pj						2?	micro	pyritic		2	2+?			Ħ					2	Marl-arg LS = bit bruised has bryozoa, tr spg. Tr micropyrite, silty B 2P
3460	SHcalcLS		DMBGy	4 V	WPS	skel-frag					5							1		3			solen	pporid?	2	4P
-		•	- •			•	-	•		•	•	- "	•			• • •	•		•				40.0 11		-	•

Α	В	С	D	G	Н	ı	J	K L	M	N	0 1	rQi	crBtpyrStic	Т	VW	V X	ΥZ	ZAA	AB AC A	D AE AF	AH	Al A	JAK	AL AM AN AO AP	AQ
3465	SH	calc, qtz silty	D(M)Gy		rhododerm nodules											1+	1+				1		2	100% ID LS rare nodules/thin beds w crinoids & echinoid spines	3P
3470	SHcalc LS	arg 8/2	DkMdGy	SH	crinoidal						1?					4		3					2	black fragments, micropyrite 10-20% calc F lignitic shards	2P
3475	SH+LS	aa & arg BBB	MdGy	3 WS?	Frag										1??	2?		?					2	SH as above LS = BBB mottled bookletted etc.	
3480	SHcalc+LS	Sarg	DkMdGy	x M-WPS	skel-frag				10		1	mic	ropyritic			2	2	1		1			2	LS is BBB no SH	3P
3485	SH	sl/non calc tr silt	Dk(MD)Gy	/																			2		
3490	SH	fissile	DkBnGy																				2		2P
3495	SH	sl/non calc tr silt	Dk(MD)Gy	/																			2	minor red-brown shale (sideritic?)	1P
3500	SH 😘	9/1silty-calc	DMGy														1	1					2	tr micropyrite	2P
3505	SH	sl/non calc tr silt	Dk(MD)Gy	/	5-10% red-brn SH (s	ideritic	:?)								1		1?						2		1P
3510	SH		DkBnGy												1								2	some swelling laminations	2P
3515	SH	sl/non-calc, tr silt	Dk(MD)Gy	/	tr rd-brn SH																		2		
	-	fissile	DkBnGy																				2	tr micropyrite	1P
	_		Dk(MD)Gy	/	tr rd-brn SH																		2		
		tr sdy-frag?	DkBnGy												1		1						2		2P
		silty, 9/1=SH/LS	DMBGY		<9% rd-bn SH silty										2	1?	1?						2	LS argil-chalkified & mottled,	1P
	SHsilty-ca		DMGy												3	2	1	1					2		3P
		, ,	MdDkGy												1?	1?		3					2		1P
		8/2 arg BBB	DMGy	2 MWS	skel-frag	mic	ropyritic	2	5			2?		\perp	1	2	1	1		1	4	1	2-3-5A		x16)3P
			Md Gy Br	1 M(W)S	skel?										1?	1?	2	3					5A?		1P
3560		poor spl	wt"LBGy	1 M(P)S	frg (rd)	1			15							3						1	5?	17	B 4P
3565		cl calcsp in MS	V LT Gy	2 MWS	frag(VF)			5				4			2							3?		, , ,	3B 1P
		poor spl	wt"LBGy	1 M(P)S	skel-frag-microb?				20			5?			-	2?		6				10? ?	3C-5	5%ID BBB (x	
	LS		VLGy	1 M(W)S				10							2			4				?			3B 1P
	LS	VF-F spar cmt 2%	wt"LBGy	1 M(P)S	peloid			15-										?	1	1		2?	3C-5C		BB 5P
	LS LS		wt"LGv	3 MPS 1 MS	peloid-frag (VF)			20	10							,		4	1	?		2?	3C-5C 3C?		3B 1P B 5P
	LS LS	15% MdBnfrg LS	,	1 M(W)S	frog(\/E\			3	10			2				2		3	1	1		2?	3C-5C		B 2P
		minor spar calc cn	"wt'LBGy	1 M(W)S	frag(VF) (skel-pel-microb?)			8			2	1	1	2		1		3	1			4	3C-5C		В 2P 8P
		tr micropyrite	"wt'VLGy	5 MGS	peloid (VF-F)			20								1	_	1	-		+ -	6?	3C5C		B 3P
	LS —	t spar VF cmt	wt VLGy wt''VLGy	1 MS	(peloid)			5	5						12	'		- 1		1		3?	3C3C		BB 4P
3615		VPS	VLGv	1 M(W)S	(micropeloids)			5	_						1:					12		J:	3C	5 701D DOOKINETS CONTINION	BBB
	LS	VI O	wt"VLGv	1 MS	(micropeloids)			3	"											1:			3?	3%ID dessiminated minor micropyrite tr styllolites BB	BB 3P
		2-3% Cl calcspar	LBnGy	1 MS	blebs clear spar			3				JF	avreina copre	olite)				1	12				3C	1,7 ,	3 4P
		some F-C spar cn		1 M(W)S				5			3+	12					1	1	1 .	1 1		8?	3C	+20%ID tr pyrite stylolites NB major hole washout??	
	LS	come i e opai on	VLBnGy	1 M(P)S	micropeloid			20			0.	1					-			1		•	3C-5C	,, ,	3B 2P
	LS		wt"VLGy	1 MS	micropeloid			4														2	3C?	.,,	BB 3P
					(noloid)															1		?		, ,,	
3645		tr micropyrite	VLBnGy	1 MS	(peloid)			6															3C-5C	, , , , ,	3B 1P
3650	LS	0:0/ 15 0	wt"VLGy	1 M(P)S	peloid	1		20			40-1						_	+	1	/ 1		3?	3C-5C	2%ID bookllets common stylolites tr micropyrite BBB (X	
		3+% cl F-C calcsp	LtBGy	1 MS				3?			Tispic	ules?	monaxon							encrus	sting		3C	25+%ID possibly tr micropyrite stylolites - rare argill ptgs in LS	
3660		SH ptg-blue-grn	wt"VLBGy	6 WPGS	· · · · ·			25	10			3		3		5			1	? 3		7?	3C	5%ID booklets tr micropyrite stylolites BBB (X	
		awful spl BBB	LBGy	1 M(P)S	peloid			15															3C5C		B 1P
		tr cl spar cmt	wt"VLBGy	2 MWS	peloid-skel(frambldr)			10				8	3?			2						5?	3C-5B		BB 4P
		awful spl BBB	LBGy	1 M(P)S	peloid			25															3C	· · · · · · · · · · · · · · · · · · ·	B 1P
	LS	VPS tr cl spar cmt		1 M(W)S	fragmenta ?			3?	10				1 1 1					3				?	3-5		BB 2P
3685	LS	?+!)% calcsp F-C	VLBGy	3 ?PMS	spg-crinoid? (not rep	??)		?			15?	very	poor spl=not	rep??		15?						?	?	<2%ID booklets (3-4 chips ID)	B 1P
3690	LS	VPS (10 chips!!)	wt"VLBG	2 MWS	stromatop-peloid?			5+				10?								1?			5B	<1%ID booklets tr F calcite spar cement VBBB (X	(16)3P
		BB mottled gy-wt		5 WPS	stromatop-skel-pel			7	5		5	15				3				1?		?	5B		BB 3P
	LS	cave=csg cmt+sh	wt"VLBGy	2 MWS	stromatoporid			?	5			12?	·		3	5+						3?	5B	5%ID booklets closeup photos bryozoa & stromatop BBB (2X	(16)7P
TD																									
Α	В	С	D	G	Н	l T	J	ΚL	M	N	0 1	Q	R S	T	VW	V X	ΥZ	ZAA	AB AC A	D AE AF	AH	AI A	JAK	AL AM AN AO AP	AQ

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reefal, 4C= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge reefal, 4A= 'deep' siliceous sponge

Appendix A3 ENCLOSURE <u>A3.7 Dominion J-14</u>

L.Eliuk 2016

Enclos	sure A3	3.8 EnCana-N	/larauder	Do			Inc	L.Eliuk P.				Rech	eck 2	007-0	8 lowe	er secti	ion	for fa	cies E	Basal	100m lik	ely C	AVINO	prob	olem		TYPE 778'88	PAGE
DEPTH	LITH	modifier I	COLOR		TEXTU	modifier F	PORO	SITY	ACCI	ESSORI	ES					SSILS		(e	nhanc	ed by	y S <mark>WC da</mark>	ita if a	vailab	le)			SE	COMMENTS
(metres)	T H O L O G Y	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone arg=argillaceous calc=calcareous sdy= sandy/qtz	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=v PS=p GS=g BS=b (FS/R FS=fle RS=re	nudstone 1 wackestone 3 ackstone 5 grainstone 7 ioundstone 9 IS=XC size) oatstone 4 udstone 8 c-crystalline	%	modifier (Archie)	SOIDS	PELOIDS PARTICLES	LITHOCLASTS	SPONGES SA	WT SPONGES' B	DS	<u>~</u>	MICROSOLENIDS	HEXACORALS	BRYOZOANS	CRINOIDS	ECHINOIDS	GASTROPODS BIVALVES OSTRACODS	SERPU	TUBIPHYTES etc	Si	HIGHER -green etc PP STROMATOLITE P	ONCOIDS-PISOID	STANDARD MICROFACI Flugel'82&Wilson'75&Eli	additional fossils/accessories diagenetic textures facies-sequence breaks some long comments may be et cetera some long comments may be hidden & visible only on screen SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB
Α	В	С	D		G	Н	_	J	K	L M	N	0	P	Q R	R S	1		V V	v x	Υ	Z AA AE	AC A	AD AE	AF	AH A	AI AJ	AK	AL
3200		no sample															\perp											
3205 3210 3215		no sample		NC sa	OTE DRILL mples and	LING BY SLIDING AND I was more used at top	ROT of ne	ATING - sli ew hole; "l	ding 「" = T	(=Turbo RIP (in	or n Dept	nud n th col	notor umn)	drillir	ng?) m	ay giv	e bo	etter				Н						
3220 3225		no sample		П										Т			I					П		П				
3230		no sample															I											
3235 3240 3245	LS arg	<10%shly	LMGyBn	4	4 WPFS	strom-spg-skel-frg				15		10	2 3	30		3		id2	7	1	2		1				4/5B3	minor (micro)pyrite stylolites-arg prtgs 7F
3250	LS arg	<5%shly tr C SP0	LMGyBn	3	4 WFS	strom-skel-frg				15		5	? 1	5	2	1	ty li h I	iiu !	4	1	3 ?		1	1			4/5B	tr micropyrite tr stylolites tr Glauc-grn clay infill 5F
3255 3260 3265	LS arg	<5%shly tr chert	LMGyBn	3	4 WFS	sponge-skel-frag				10		30	1 3	7 2	2 1				4		2		? 1	1			4(5)B	glauc-grn clay infill, tr micropyrite, tr milky chert & C spar calciffte 7F
3270 3275	LSsilty	3% qtz silt clear	L(MGy)Bn	6	PGS	echinoderm-bryozoa				15			1	2 1			I	15	25+	5	3	П	?	П			5AT <mark>3</mark>	50%ID tr micropyrite slope grainflow?? BB 4F
3280 3285	LS	tr G-grn clay	LMGyBn	5	P(G)S	frag-bryoderm				20		2	;	3			I	9	12	5	4 ?		?				5AT	csg cmt cave tr stylolites 5F
3290 3295	LS	tr grn clay	LMGyBn	4+	PWS	frag-skel(strom)				20		1		7 1		1?	41	2	5	1	3		1				5A	tr C spar calcite 4F
3300 3305	LS	tr arg - F sdy	L(MGy)Bn	3	4 WFS	strom-frag-skel				15		3	15	5+		?rex	?	2 1	? 3	1	4	Н	1	Ш		1	5B	tr pyrite, tr silty arg LS cave? minor woody? black frags 5F
3310 3315	LS 📉	~1% pyritic tr arg	LMGyBn	1	M(W)S	microbial?				3		1	- 2	2				1?	2		1	Н	1			5?	3C?	some wt zones/layers to rare cl calcspar 4F
3320 3325	LS	tr pyrite	LMGyBn	4	4 WFPS	skel-strom-frag				10		1	1	7	1	2 1	?	2	4	П	3 1?		1 1	1	red? 1? 5	?	5AB	wt zones/layers to rare cl calcspar, stylolites (thin arg partgs) 6F
3330 3335	LS	minor arg ptgs	LMGyBn	4	4 WFPS	chaet-skel-frag				15		2		7 1	5	1	?		3	Н	2		1		:	3	5B	41
3340 3345	LS	sl arg	LMGyBn	3	4 WFS	strom-skel-frag				10		?	1	0	?	3	3	1	2	П	2	Н				2	5B	%50 ID stylolites
3350 3355	LS	sl arg-lt grn clay	LMGyBn	3+	MWPS	frag-skel				5 15				2 2	2		\blacksquare	1	3		3		1	Н		3	5A	stylolites 41
3360 3365	LSarg	It grn clay	MGyBn	3	W(P)S	bryoderm-skel-frag				10			2	2 2	2			10	10	2?	5		1		2	?	5AT	stylolitic, minor pyritic 41
3370 3375	LS 📉	sl arg-grn clay	LMGyBn	3	W(P)S	skel-frag				15		5	1	2				2	4		3		2		1	?	5A	tr pyritic stylolites 31
3380 3385	LS 📉	sl arg tr SPC	(L)MGyBn	4	4 WPFS	strom-skel-frag				15		4	2	20 1					4		2		1				5B	stylolites 21
3390 3395 T	LS 📉	sl arg	(L)MGyBn	3	ws	frag (skel)				20			- 2	2				1	2		1		1					pyritic tr cl C SPC
	LS		LMGyBn	5	P(G)S	frag-skel(strm-spg)				35+	-	5		6					3		5		1	1			5Ab	50-40%ID tr micropyrite Ig inoceramid? fibres 2I
3410 3415	LS		LMGyBn	4	WP(G)	strom-frag-skel				20		2	20	0+				1	2		3 1?		1				5B	21
3420 3425	LS		LMGyBn	3	4 WFS	skel (spg-strm)frag				15		3	2	5		2	?		2		3		1		1	?	5Ab	50-60%ID
3430 3435	LS 📉	sl arg	MGyBn	3	4 WFS	skel(frmbldr)-frag				10		2		3 2	2			?	3		2		1	1			5A	21
	LS		MGyBn	3+6	WS+PGS	Bryoderm + round frag			rdu ?	inded M 35	I+VC	1?		1				3	5	?	3 ovs	ter?	1				5AT	tr styloites minor arg around bryozoa-crinoids occasionally 2F

3445	В	С	D		G	Н	ı	J	K	L	M I	1 0	Р	Q	RS	1 1	тΠ	v I w	Х	Y	Z AAABA	CAD	AE AF	АН	AI AJ	AK	AL
3450	LSarg	v.pyritic	MdBnGy	3+6		skel + frag (rd)					20	1	_	2			╁	1	2		1 1	+	1		2?	1	pyritic, 3P
3455		.,																									
3460	LS	sl arg	DMBnGy	4	WPS	frag-skel					25	4	1	2		1	?	3	3		2 4		1			5AT	gastropods leached/rextl 4P
3465																								CLC	SE TO	HORIZON	TAL DRILL PATH - SOUTH FOR ~950m @ 3325-3425m TVDSS
3470	LS		DMBnGy	5+	WPGS	frag-skel					35	1	1	1		1	?	1 1?	6		1 3		1			5AT	60%ID tr pyritic BB 4P
3475			D. (D. C																_								
3480	LS SI arg	dkgy+grn sh ptgs	DMBnGy	5+	WPGS	frag-skel(bryoderm)					35	1	2	2				3	7	1	1 2 1?		1			5AT	very pyritic & micropyritic esp in grn & dk shale ptgs 6P
3485	LS	al ara travritia	DMDaCv		WDC	alcal from					15	4	1	5			- 11	,	-				1		1?	FAT	(anaV46) 7D
3490 3495	LS	sl arg, tr pyritic	DMBnGy	4	WPS	skel-frag					15	4	1	э			- 11 -	_	-				1		17	5ATb	(spgX16) 7P
3500	LS	el ara tr pyritic	DMGyBn	4	WPS	ena etrom ekol fraa					15	20	1	9		3	2	1	5+		1 1		1			4C/5 <mark>B</mark>	micropyritic shale partings 5P
3505	Lo	sl arg, tr pyritic	DIVIGYBII	4	WF3	spg-strom-skel-frag					13		' '	9		,	у П	<u> </u>	31		4 1		'			40/3 <mark>B</mark>	micropyritic shale partings 5P
3510	LS	sl arg, tr pyritic	DMGyBn	3	W(P)S	skel(spg)-frag					15	6		2			- 11 -	2	3		2		1			5A	4P
3515 T		orang, a pyriae	J0, J		11(1)	ono.(opg) nag						Ů									_						
3520	LS sl arg	tr pyritic	DMBnGy	3	ws	skeletal-fragmental					10	2		3		1	?	1	3		2				1?	5A	3P
3525			. ,																								
3530	LS sl arg	tr pyritic	DMBnGy	3	ws	skeletal-fragmental					10	3		6				2	4		4		1			5A	65%ID BB 3P
3535		Sh-Marl on logs																									
3540	LS-SH	Sh-Marl on logs	DMBnGy	2	MWS	skeletal						2		1				1	3		1						micropyritic DkGy SH more fos arg LS (cave??) 4P
3545																											
3550	LS-sl arg	sl arg, micorpyrite	DMBnGy	2	MWS	skeletal (bryoz)					7	2		2				5	3		1		1+		2?	5AT	60%ID BB 5P
3555	I C al ara		1 M C D		14/50						_	٠,							_				4		00		40 F00/ ID
3560	LS-Si aig	gr clay-micropyrition	LMGyBn	3	4 WFS	stromatoporoid-skel					7	5		20				1	5		3 1 1		1		3?	5B	40-50%ID BB 5P
3565	LS		LMCvPn	20	4 WDES	atramatanaraid akal					5	3	2	30			- 11	2	2				2		5	5B	20-30%ID BBB 4P
3570 3575	LS		LMGyBn	39	4 WBFS	stromatoporoid-skel					5	3	2	30			- 11 '	_	4				4		5	90	20-30%ID BBB 4P
3580	LS	grn clay-silt	LMGyBn	2	4 MWFS	strom-skel-(frag)					7	6		15					4		1 3 1		1		5	5B	15-25%ID tr C spar calclite BBB 4P
3585		giri ciay siit	LIVICYBII		4 101001	Strom Sker (mag)					,	Ĭ							1								10 20/01D ti O spai calcine
3590	LS	micropyrite	LMGyBn	39	4 WBFS	strom-coral-skel					3	2		15	1	1	0	2	3		2		2 1		2	5B	10-20%ID tr C calcspar tr micropyritic grn clay BBB 4P
3595																											
3600	LS		LMGyBn	39	4 WBFS	stromatop-skel					7	1	3	40	1?	2	?	1	5		4		2		5	5B	10-20%ID ?encrusting forams-microbs? bivalve layers cmt? BBB 4P
3605																											
3610	LS		LMGyBn	3	4 WFS	stromatop-skel					5	2	3	20	3	2	?		4		4		1		5	5B	10-20%ID BBB 6P
3615																											
3620	LS	grn clay cave?	LMGyBn	3	4 WFS	strom-microb-skel					5		6	12		2	??		5		4		2		8+	5B	10-20%ID BBB (X16)5P
3625			LMO: Dr		. WEG	atus us alvalatal usianah					-			40	_										-		45.050/JD. O releases seeding like
3630	LS		LMGyBn	3	4 WFS	strom-skeletal-microb) (5			10	5		?		3		2		<u> </u>	I I	/	5B	15-25%ID C calcspar occasionally BBB 6P
3635											_	١.						droid					inella?	Lithoc	odium		5 450/ID
3640	LS		LMGyBn	39	8 WBRS	strom-skel-microb?					5	5	2	35		3	?	2	3		4		3		/	5B	5-15%ID BBB (2-foramX16) 6P
3645		00/ 6 1 1 / 11/0															_								_		5 450415 4 G 4 A A A A A A A A A A A A A A A A A
3650	LS	<2%xf dolm/sidrt?	LMGyBn	39	4 WFBS	strom-frmbl-skel-frg					10	2		20	5		ь	1	4		4+		2		5	5B	5-15%ID tr C calcspar tr grn clay-silt(cave?), tr pyrite BBB 6P
3655																											
3660	LS	tr dolm/sid?	LMGyBn	3	4 WFS	strom-skel-frag					10	2	4	9	5	2	2		4		4 1	?	2+		2	5B	5-15%ID tr C calcspar tr grn clay-silt(cave?), tr pyrite BBB 5P
3665																											
3670	LS		LMGyBn	3	4 WFS	frmbldr-skel-frg					15	4		4	3		- 11 '	4	4	1	3 2		1			5ATb	5.10%ID tr grn clay-silt(cave?), tr pyrite BBB 6P
3675	LS		I DCvD~		W/FOY	frog akol					15	4		6					2				1		2	EAL .	5.10%ID tr calcspar BBB 5P
3680	LS		LDGyBn	3	W(FG)	Sfrag-skel					15	4		6	ſ				3				1		3	5Ab	5.10%ID tr calcspar BBB 5P
3685			LMO: Dr			atus as alval					_	١,		40					-				,				40 000/ ID but small store
3690 3695	LS		LMGyBn	3	4 WFS	strom-skel					8	4		12					5		3		1		2	5B	10-20%ID but small ctgs BBB 3P
			I MOvDo		AMEC	atram akal(ang)					_	٦,		40			- 11	, ,	1				1		22	ED	E 450/ ID amail al unt colognar
3700 3705	LS		LMGyBn	3	4 WFS	strom-skel(spg)					5	7		10	4 ?		-	2 1	4		3 1 ?		1		2?	5B	5-15%ID-small cl+wt calcspar BBB 4P
3705	LS		LMGyBn	0	8 BRS	strom-skel						5	2	50		2?			5		5 1 ?	,	2		5+	5B	5-15%ID minor calcspar BBB 5P
3715	_5		LIVICYDII	9	סאס	Stroill-SKCI						1		30		2:			J		3 1 !		-		J.	7 5	o 10701D Hillion Calcopal DDD 3F
3713	LS		LMGyBn	9	6 BFRS	strom-skel(microb?)						3	3	25				3	5		3		2		7	5B	5-10%ID but small cuttings, minor calcspar BBB 3P
3725			5,5									ľ							Ĭ				_				2
	LS		LMGyBn	5	4 FPS	strom-skel-frag					10	5	1	15	2			2	4		5 1		2		5	5B	5-10%ID but small cuttings, minor calcspar BBB 4P
3735																											
3740	LS	tr SPC, tr pyrite	LMGyBn	3	4 FWS	strom-skel-frag					10	3		10	2				2		?		2		5	5B	10-15%ID-small ctgs BBB 3P
•				. !	į.		. !				1		1				11		1		1 1 1	1 1					•

3745	В	С	D		G	Н	I J	KI	_ M N	N O F	Q	R	S	TIV	WX	YZ	AABA	CAD	AE AF	AH A	I AJ	AK	AL	
	LS	tr F qtz, grgyclay	LMGyBn	5 4	4 PFS	frag-strom,-slel			20	4 2	15		3	2?			5		1	6	_	5B	10-20%ID tr calcspar, stylolite BBB	6P
3755		. 41			- DIA/EO		1		45		-		2 7				- 0						40.000/JD 4	45
3760 3765	LS	pyrite	LMGyBn	4 4	PWFS	strom-frag-skel(microso	ienia) 		15	5	20	3	? 7		4		5 2		1	4		5B	10-20%ID tr calcspar BBB	4P
	LS	Tr F qtz SS	LMGyBn	3 4	4 FWS	strom-skel-frag			10		25			2 2	5		3		2 1	6	6	5B	5-15%ID micropyrite Calcspar-cl+wt BBB	4P
3775												20												
3780 3785	LS		LMGyBn	9 8	RBS	stromatop-skeletal			5	2	60	2?		?	5				1	4		5B	5-10%ID Calcspar-cl BBB	4P
	LS		(L)MGyB	2	MWS	skel-(microb?)			4	2 3	6			?	2	1 1	?		1	5	5	5Ab	5%ID tr calcspar, minor stromatoporoids bored?	3P
3795					_(0)_0																		- 40//0	
3800 3805	LS	tr dolm xtl;s	LMGyBn	5 4	4 F(G)PS	frag-strom-skel			25	2	25	5+	2?	1	5)+		1	3	3	5B	5-10%ID tr C cl calcspar BBB	4 P
	LS	tr vf qtz grnais	LMGyBn	4 4	4 FWPS	strom-frag-skel			15	2	20	2		3+	2		4		2	5	5	5B	5-10%ID some Lt Gy Microb? MS BBB	4 P
3815																								
3820 3825	LS	tr micropyrite	LMGyBn	4 4	4 FWPS	strom-frag-skel			10	2	15				4		4		1	2	2	5B	5%ID BBB	2P
	LS		LMGyBn	5 8	RPS	Strom-skeletal (microb?)		5		40	3?			4		2		2	5-	+	5B	<5%ID BBB	2P
3835																								
3840 3845	LS	tr grn clay infill	LMGyBn	5 4	4 FPS	frag-strom-skel			20	2	15				4		2		2	3	?	5B	<5%ID-small cuttings tr C cl calcspar BBB	2P
	LS	vf rextl in part	LMGyBn	3 4	4 FWS	strom-skel			5		20	3	2?	.	4		2			?	,	5B	2-5%ID-small cutings BBB	2P
3855		·																					_	
3860 3865	LS		LMGyBn	3 4	4 FWPS	frag-skel-strom			25		10	5			4		3 2?		2	4	?	5B	5%ID-small cuttings tr C cl calcspar BBB	4P
	LS		LMGyBn	3 4	4 FWS	frag-skel-strom			15	2	10	7			2		4		1	5	5	5B	<5%ID-small cuttings tr C cl calcspar BBB	3P
3875																								
	LS	tr micropyrite	LMGyBn	5 8	RPS	stromatoporoid-skel				3	60	8			3		2 1		2 1	5-	+	5B	5%ID tr C cl calcspar BBB	4P
3885 3890	LS	tr micropyrite	LMGyBn	4	WPS	frag-strom-skel			20	2	15	1?		3	3		3 2		1	2	?	5B	5%ID-small cuttings tr C cl calcspar BBB	5P
3895																								
	LS		LMGyBn	5 4	4 FP(G)S	frag-skel(chaet-strom tr	 vug-free xt 	ls	25	2	15	10		3+	3		6		1	5	5	5B	5-10%ID minor C calcspar w tr dog tooth free ending = vug/pore BBB	6P
3905 3910	LS		LMGyBn	5 8	RPS	strom-skel(frmbldr)-frg	NOTE		15	3 4	40	2?		3+ 2	4		5		1	7		5B	5-10%ID tr C calcspar BBB	6P
3915							shale &													eı	ngrusti	ra		
	LS		LMGyBn	7 6	RPGS	strom-skel(frmbldr)-frg	arg LST minor		10	7 4	60	3?		3?	3		6 1 2	2	2 1	7	,	5B	5-10%ID tr C calcspar BBB	7P
3925 3930	LS		LMGyBn	5 4	4 FPS	strom-skel(frmbldr)-frg	seen as cavings		15	2 3	? 30				3		3		2+	4		5B	5%ID tr C calcspar BBB	4P
3935							Joavingo														ncrustii	g		
	LS		LMGyBn	4 4	4 FWPS	strom-skel-frag			10	3	20	3		3	3		3		2	6	6	5B	4-8%ID tr C calcspar BBB	4P
3945 3950	LS		LMGyBn	4 4	4 FWPS	strom-skel-spg-frag			20	10	15			? 2?	4		5 2		2 1	5	5	5B	4-8%ID tr C calcspar BBB	4P
3955	_		- 7			γ σ σ σ σ σ σ σ σ σ σ σ σ σ σ σ σ σ σ σ																	·	
3960	LS		LMGyBn	3 4	4 FWS	strom-skel-frg			10	5	12	3		3	2		2		1	2	?	5B	<5%ID-small cuttings tr C calcspar BBB	3P
3965 3970	LS		LMGyBn	5 6	FRPS	strom-chaet-skel-frg			15	3	35	10		5	3	2	4 1		2	5	5	5B/5AT	4-8%ID-small cuttings tr C calcspar BBB	4P
3975													styl	imid?										
	LS		LMGyBn	5 4	4 FPS	strom-skel-frag			15	2	20	3	2?	inid? 3	2		3		2			5B	<5%ID-small cuttings tr C calcspar BBB	3P
3985 3990	LS		LMGyBn	4 4	4 FPWS	strom-chaet-spg-skel				10	20	10		3 2?	3		2		2 1	4	l l	5B	<5%ID-small cuttings tr C calcspar BBB	3P
3995			20,2											J 2.									570.5 Silian sakangs a s saksopai	
	LS		LMGyBn	5 6	FRPS	strom-skel (frag)			10?	5	50			3	2		2	\perp	2	4		5B	<5%ID-v.small cuttings tr C calcspar BBB	4P
4005 4010	LS		LMGyBn	5 4	FP(G)S	frag-strom-skel			20	3	20	3			5		2		1	2	?	5B	2-4%ID tr C calcspar tgr pyrite arg spg lst BBB	2P
4015													stv	linid?										
	LS		LMGyBn	3 4	4 FWS	strom-chaet-frag-skel			10	3	15+	9	Sty	linid?	2		? 2	?	1 1	4	1	5B	2-4%ID tr micropyrite (x16 chaetetid-stromatoporoid-stylinid coral) BBB	4P
4025 4030	LS		LMGyBn	1+3 4	4 FW+M	strom-skel(frmbldr)			5	2	10	3		4	2		2		1	3'	?	5B	2-4%ID tr f-m calcite BBB	3P
4035	-																							
	LS		LMGyBn	5+ 4	FWPG:	frmbldr(strm-spg)-frg			20	5	8	3		3? 2?	3		3		1			5B	2-4%ID tr C SPC stylolites BBB	4P
4045																								

4055		В	С	D		G	Н	l I J I	ΚIL	MIN	I O F	Q	R	S	TIV	TWI X	ΥZ	AAA	BIAC	ADIAF	AF A	HA	I A.I	AK	AL
4050	LS		<u>-</u>	LMGyBn	5+ 4		Sfrag-skel-frmbldr		5		3	8		-	 	4	-	3		2	1 1	1	+-	5Ab	2-4%ID BBB 2F
4060	LS			LMGyBn			skel-frag			20	3	7			3	3	2	3		1	1 1	4		5ATb	5-15%ID-small cuttings BBB 4F
4065																									
4070	LS			LMGyBn	3 4	FWS	strom-slel-frag			10	5	20				5		3 1		2		2?	?	5B	5-15%ID-small cuttings BBB 4F
4075																									
4080	LS			LMGyBn	3 4	FWPS	strom-slel-frag			15 5	5 4	15	3+	5?	2	4		2		2		3		5B	5-15%ID-small cutting: skeletal lithoclasts BBB 4F
4085																						encru	stina		
4090	LS			(L)MGyBn	2+9 4	FBWM	spg/strom-microb-ske	el		5	10	15	2			3		1	2	2	1	15	sting	5B	5-15%ID BBB 5F
4095																						_			5 450(4D
4100	LS			LMGyBn	1+5 4	FPS+M	strom-frmbldr-skel			5	2	12	5		7 3	4		2	\perp	1	$\perp \perp$	5		5Bat	5-15%ID md-dk gy MS (shelter/infill??) BBB 4F
4105						EMBO	alanat atanan alan			1 -		40	40			3									5 400/ ID
4110	LS			LMGyBn	4 4	FWPS	chaet-strom-skel			5	2	10	13			3		3		2		4		5B	5-10%ID tr sucrosLS dk gy pyritic crinoidal arg LS-SH(30%cave?) BBB 5F
4115 4120	LS			LMC-D-	3 4	FWS	strom-skel			-	2	25			1 12	2 5		2		1		5		5B	5-10%ID BBB 4F
4125	LO			LMGyBn	3 4	FWS	Stroin-skei			3		25			1 /	1 3		-		- '		3		36	3-10%ID BBB 4F
4130	LS			LMGyBn	3 4	FWS	strom-skel			5	2	15	5			3		2		1	1	2		5B	4-8%ID tr calcspar BBB 4F
4135				LIVIGYBII	3 4	1 110	Stroin-skei					10	3											JD	4-0 /old ti calcapai
4140	LS			LMGyBn	3 4	FWS	strom-skel			7	5	15		3	2	3		3		1		4		5B	4-8%ID BBB 4F
4145				20,2			ou our outo																		
4150	LS			(L)MGyBn	4	PWS	frag-skel			35		7		4?		2		3 1		1?		2		5Ab	3-6%ID BBB 3F
4155 T				, , ,																					
4160	LS			LMGyBn	4 4	FPWS	skel/frmbldr-frag			15	2 5	7		2	2	2		3 1		1		3		5Ab	3-6%ID C calcspar SH-argLS cave booklets BBB 4F
4165																									
4170	LS			LMGyBn	4	PWS?	frag			25		2						3		1?	1 1				<2%ID-small cuttings booklets BBB 3F
4175														etv	inid										
4180	LS			LMGyBn	4 4	FPWS	skel/frmbldr-frag			20	3	6		01,	6 1?	? 3		2		2		3?	?	5Ab	2%ID-small cuttings stylolites booklets (X16=thin tubular form??)BBB 3F
4185																									
4190	LS			LMGyBn	4	PWS?	?frag-skel?			20?		7?				21	3	3				3?	?	5A	<2%ID-tiny cuttings echinoid spine in arg LS = cave? BBB 2F
4195																									
4200	LS	a	arg LS/SH cave	LMGyBn	4 4	FWPS?	strom-?frag-skel?			15	5?	20				2	2	5	1		1	3?	?	5B	<2%ID-small cuttings booklets BBB 2F
4205							06 1 10			0.5															20/17 (1)
4210	LS			LMGyBn	4	PWS?	?frag-skel?			35		5?				21		2				3?	'	5A	<<2%ID-tiny cuttings calcspar stylolites BBB F
4215						EMO	fra a alvalO			450	50														COOKID the continue of delites have later
4220 4225	LS			LMGyBn	3 4	FWS	frag-skel?			15?	5?	5?												5A	<2%ID-tiny cuttings stylolites booklets BBB F
4225	LS		+5%M-C calcspar	L MCvPn	4 4	EDWS	frag-strom-skel		5	30	3	10						2				27	,	5Ab	<<2%ID-tiny cuttings stylolites booklets BBB 2F
4235	LO		+5%IVI-C Calcspai	LIVIGYBN	4 4	FFWS	irag-strom-sker		3	30	3	10				4		-				2:		SAD	CC276ID-LITIY CULLITIES Stylotties DOOKlets BBB 2F
4240	LS		grn arg infill	LMGyBn	3 4	FWS2	frag-skel/frmbldr?			20?	5?	12?				5						3?	,	5Ab	<1%ID-tiny cuttings C calcspar BBB F
4245		_	sl arg+pyritic?cave		7	RFPS	chaet-stromatop-frg-p	nel l	15	5 15	1?	12			1?			4		1		27		5Ba	<22%ID-dark wrt BB cuttings Few chips argill rind w/ pyrite (??cave) BBB 3 F
4250	LS		5+% f-c calcspar	L(M)GyBn	6	PGS?	frag?-skel?	I I		35?		8?				43	,	4?						5Ab	<1%ID-tiny cuttings BBB F
4255			•	L(M)GyBn	7	FPGS	stromatop-frg-skel;	2?vug cl C spar	5	15		20	5			3		4 2	:	1		3		5Ba	<<2%ID-tiny cuttings BBB 4F
4260	LS	100	5+% f-c calcspar	'L(M)GyBn	5+		frag?-skel(strom)?			20?		10?				31		3?						5Ab	<1%ID-tiny cuttings BBB F
4265																									
4270	LS			L(M)GyBn	3+	MWPS	frag-(ske)l?			30?	3?					31		2?		1?					<1%ID-tiny cuttings stylolites tr C calcspar booklets 3BB 2 F
4275	ı	LS		L(M)GyBn			Chaet-skel-frg			20		6?	10		?	4		2		1				5Ba	<<2%ID-tiny cuttings tr C calcspar BBB 4F
4280	LS			L(M)GyBn	3+	MWPS	frag-(ske)l?			30?	5?	3?				41	· []	2?						5A	<2%ID-tiny cuttings stylolites tr C calcspar BBB 2 F
4285																									
	LS			LMGyBn	4	PWS	strom-skel-frag			15?	3?	15	2??			31	<u> </u>	3?		2 1				5B	2%ID-smalll cuttings stylolites booklets BBB 3F
4295						200	1.1/.1			450								00							4.00/ ID II II
	LS		110	L(M)GyBn	6	PGS	skel/strom-frag?	Chalky BBB cuttings	s =	15?		10		70	FO	6		3?	\perp	2	$\vdash \vdash$	2?		5Ab	1-2%ID-small cuttings Fe bits (=rusty) 4300 to 4340m BBB 2F
4305				L(M)GyBn	7	FPGS	stromatop-corai-skei	slightly darker mottle	od	10	3	30		7?	5?	3		3		2		4		5B	<2%ID-tiny cuttings BBB 3F
	LS		r vf-f?dolm rhomb		6	PGS	skel-frag? stromatop-chaet-skel	ı í ı	5	25?	2	5	10		22	3		3		1		3?		5A	1-2%ID-small cuttings 5%?calc vf qtz SS booklets BBB 3F <2%ID-tiny cuttings BBB 3F
4315 4320	L LS	LS		L(M)GyBn _{LMGyBn}	4	FWPS PWS	frag-sponge	i chip ve doim		10 20?	2 10	20 2?	10	3?	3?	4 3				1		2?		5B 4B/5A	<2%ID-tiny cuttings BBB 3F 1-2%ID-small cuttings booklets BBB 2F
4325	LS			LIVIGYBN	4	FVVO	nay-sponge			20 !	10	2!		31		3				1		2		4D/3A	1-2 701D-STHAIL CULLINGS DOUKIELS BBB ZF
	LS			I MCvPs	1 1	EDM6	strom-skel(chaet)-frag			20		20	7			3		3		1		3?	,	5B	2%ID SH/argLS cave booklets BBB 2F
4335	LS		LIKELY HIGH CA	LMGyBn VF CONTEN						20		20	-			3		3		1		3 !		30	2 7010 STI/AIYES CAVE DUUKIEIS BBB 21
	LS		_		3 4		strom-skel-frag			20	3?	20	2		2	2		3		1		?		5B	2%ID SH/argLS cave BBB 4F
4345	_0	1	LIKELY HIGH CA							20	31	20	ŕ												2701D OTTRAIGEO CAVE BBB 4F
	LS		r vf-f?dolm rhomb				frag-strom-skel(spg)			20	7	15		3		1		3		1	12	2		5B	2%ID SH/argLS cave BBB 3F
7000	_0	ι	a vi-i : doilli IIIOIIID	LIVIGYDII	5 4	113	mag-strom-sker(spg)			20		10		3	1 11	4		٧			1:1			00	2 / VID OI I/ AI YE COAVE DED 3F

365		В	С	D		G	Н	ı	J	K	L	M N	0	Р	Q R	S	Т	VV	V X	YZ	AAAI	B AC A	D AE	AF A	H AI	AJ	AK	AL						
355																																		
860	LS			LMGyBn	5		frag-strom-skel(micro		a)			15	2		12 3		8		3		3	?	2		3		5B	2-3%ID			LS cave			BBB
70	LS			LMGyBn	5		frag-strom-skel(spg)					15	5		10 3				2		3		1		4		5B	3-6%ID	tr micorp	oyrite :	SH/argLS	S cave VC calcs	oar	BBB
75			LIKELY HIGH C			_																												
80	LS	?	?sl arg = cave?	(L)MGyBn	3	4 FWS	frag-skel(spg)					10	8		4				3		6		2		3		5A/4 <mark>B</mark>	4-8%ID	micorpy	rite :	SH/argLS	S cave tr calcspa	r	BBB
85																																		
90	LS		tr VC calcspar	(L)MGyBn	4		frag-skel(frmbldr)					15	3		5	6?		Щ.			3		2		2		5Ab	3-6%ID	stylolites	3	SH/argLS	S cave		BBB
95			LIKELY HIGH C					MW	D tool brok	ce dow	n at 4	390m a	_	o gar	nma b	elow t	hat																	
100	LS		arg?? Cave??			4 FWS						15	2		3				2		3	\perp	1?		2?		5A	5-10%IC	(?cave?)	micropy	yrite			BBB
405		_	LIKELY HIGH C									_																						
110	LS	?	arg?? Cave??	(L)MGyBn	4	4 FWPS	frag-skel				- 12	25	2	2	4				2			1 1	? 1				5A	3-7%ID	(?cave?)					BBB
415						FIME									0.5	_			00				امام					0.00/10	(0 0)			011/2010		
420	LS			(L)MGyBn	4	4 FWPS	strom-skel-frag?				1	5?	2		25	5			2?				? 2		3		5B	3-6%ID	(?cave?)	tr micro	pyrite	SH/argLS cav	е	BBB
425 430				# J140 B		FWDO	stances alsol for a O					00	2		12 43	,							الملم				5B	0.00/ ID	(00)			011/2221 0 222	_	-
135	LS			(L)MGyBn	4	4 FWP5	strom-skel-frag?				1	0?	-		12 4				2				? 1				5B	2-3%ID	(?cave?)			SH/argLS cav	е	BBB
440		2	arg?? Cave??	(L)MCD-	2	ws	frog okol2					15			2				3				12					2 20/ ID	(?cave?)			CH/oral C agu	^	ввв
TD	LS	ſ	alg?? Cave??	(L)MGyBn	3	WS	frag-skel?					15			3				3		4		1 !					Z-3%ID	(!cave!)			SH/argLS cav	e 	DDD
	Ь	С	D			G H		+ -	K	+ - +	М	N O	Ь	Q	R S		-	W/S	/ ~	7 1	AABAG		EAE	<u> </u>	1 A I	ΛK	AL	AM	AN	AO		A	P AQ	7
_																													AIN	AU			- AQ	

Appendix A3 ENCLOSURE A3.8 Dominion J-14A L.Eliuk 2016

<u> 1Clc</u>	sure	<u> A3.9 SHELL</u>	PEX <u>K</u>		ok G-67 urs C	onsulti	ng Inc L.Eli	_			fron	E.Bo	goslows	ki (198	5) 2008-10 Eve	y 2nd sar	nple to b	be reche	ecked		ш _∞ ~.	PAGE
РТН	LITH	modifier I	COLOR	TEXTURE	modifier	PORC	SITY	ACC	ESSORI	ES			FOS	SSILS	(enhance	ed by S <mark>W</mark>	C data if	available	e)		TYPE <778'88 2002	COMMENTS
tres)	I DOL H SH=: O SS=:	imestone =dolomite shale sandstone	VIATED	RS: RS HIGH	mudstone 1 wackestone 3 packstone 5 grainstone 7 boundstone 9	%	modifier (Archie)		ൠ	CLASTS	FRAN	ROID-	DERS OTHER	ENIDS	BRYOZOANS BRACHIOPODS CRINOIDS	GASTROPODS	RPULIDS	PHYTES etc	ALG	DS-PISOID	ICROFACIES Son'75&Eliuk' arland&Eliuk	diagenetic textures
	O arg=	ST=siltstone rargillaceous =calcareous = sandy/qtz	ABBRE or MU	FS=	RS=XC size) floatstone 4 rudstone 8 =crystalline			SOIDO	PELC	ПТНО	SPONGE	STROMATOPO	CHAETETIDS MILLEPORID hydrozan-OTHER	MICROSOLENID	BRAC	GAS	OSTRACC	TUBIPHYTES	BORINGS HIGHER -gr	STROMATO	TANDARD M ugel'82&Wili Vierzbicki, Ha	facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
	В	С	D	G G	Н	Т	J	К	L M	N	0	PQ	R S	1	· v w x	Y Z AA	AB AC	AD AE	AF AH	Al AJ	ω ⊑ >	AL
	Sample	descriptions (mod	lified if carb	onate in EVI	N alternate spls) from	n Eric E	Bogoslowski's	Shel	II Canada	repo	rt to (CNOS	B and f	ossils-	dolomite from	CSS log	Depths	s are for	overlyir	ıg samp	le ie bas	se of retrieved cuttings
95	SH-SItst		5Y2+4/1																		9-10	2995.5SWC
0	Sitst-SH	· ,	5Y4/1+2/1																		10-9	2-3% carb mat, 2-0% mica tr-1% pyrite Hole slightly caved
5	SS-sitst		5Y7/1+4/1	SST -	M (F-C) qtz subrd	10	intergranular											KB:	37m		9-10	SS-20% kaolinitic, 10% calc cmt, 2% coal frg, poorly consol VPS
0	SS-sitst		5Y7/1+4/1		AA		poor K				OIL	BASE	D DRILL	NG MI	JD SO NO SHO	WS AND					10-9	and SLTST- 20% argil mat, 10% calc cmt, firm, 2% carb mat, tr m
5	SS-sitst	interbedded	5Y7/1+4/1		AA	10	intergranular				CAN	NOT I	JSE FOR	GEOC	HEM ANALYS						9-10	SS+SLTST
0 5	SS-sitst	interbedded	5Y7/1+4/1 5Y7/1+4/1		AA AA	10	poor K				(TH/	ANK Y	OU lan K	(ilgour)	1						10-9 9-10	SS+SLTST SS+SLTST
0	SS-sitst	interbedded interbedded	5Y7/1+4/1 5Y7/1+4/1		AA	10	intergranular poor K				Ь		_		п. г. г						10-9	3029.5SWC SS+SLTST
5	SS-sitst	interbedded	317/174/1		AA	10	intergranular								rosity estimates						9-10	SS+SLTST
0	SS	guartzose	5Y4/1	SST -	M (F-C) gtz subrd	10	intergrandian				W	nicn ai	e very or	otimisiti	c for carbonates						10-9	Hard , tr carb mat,
5	SS	guartzose	5Y4/1	0011	AA	10	intergr PrK														9-10	3043.5SWC AA
Ó	SH	quartzosc	5Y2/1		7.5	1	intergr i iit		based on	high	gamı	na = s	hale but	more s	st (AA) than bl	ack shale	in samp	ole			10-9	3046.2+46.75WC Firm, tr carb mat, possible silty st
5	SS	guartzose	5Y7/1	SST -	M (F-C) qtz subrd	5	10%on logs				Ĭ										9-10	SS-10%arg, 30% calc cmt, BUT mostly loose gtz grains
)	SS	gtzose & SH bed	N7-5Y2/1		M (F-VC)		on logs														10-9	very poorly represented
		11	5Y6/1?		M (VF-C) qtz subrd	10															9-10	10% arg, 20% calc cmt; VPS
5	SS SS	quartzose	310/19	331 -	M (VF-C) qt2 subra	10	intergr PrK aa											_			10-9	10% arg, 20% caic crit, VPS
0 5	SH	quartzose	5Y2/1		AA	10	aa								AB6 U -3038n	(3075m) 'A'				9-10	3072.5SWC firm. 1% carbonaceous mat. Tr mica
0	LS	30%cmt,	10YR3/2	6 GPS	ooid C(M-VC)			60	mı	ch S	S-SH o	cave o	interbed	Б	11 1 1 1						5D	I XFA3, ooids = quartz nuclei
5	LS	30%cmt, 9%arg	10YR3/2	6 GPS	ooid C(M-VC)	3	interxtl PrK	60													5D	17(17to, Goldo - qualtz fluoici
0	SH LS	silty 20%	5Y2/1	GSPS		1	intorxu i iit	30				1?			Sh on gamma.	1		1			10-9	3087SWC firm, tr C coal frgs, VF carb mat to 5%, tr mica
5	SS	guartzose	5Y7/1		M (F-C) qtz subrd	0-15	intergr						Oolds	mostly	F-Vf qtz nucleii						9-10	firm, 20% calc cmt,
)	SS	guartzose	5Y7/1		AA	15-0			oolitiic	let cav	/e 20°	ا % Tr V	I I Cnink ca	lesnar (omt Black coal c	I I nins 1-2%					10-9	3097.5SWC
5	SS-SH	interbedded	5Y7/1-2/1	SST -	M (M-C) qtz subrd	15	intergr		Johnne	locou	10 20		I I			1 1			_		9-10	SS-qtz, 20% calc cmt frim, 1% carb mat, tr pyrite Well sorted abd
)	SH-SS	interbedded	5Y2/1-7/1		% silty, (carb+mica)				some ooi	lstc	ave bu	ıt also	tr F ooids	in SS	г. (-	3077m (3	3114m)	'B'			10-9	3108SWC and SH 20% silty, firm carb mat 1%, mica 1%
,	SS-SH	interbedded	5Y7/1-2/1		AA	15	intergr GdK												_		9-10	
)	LS	to 7% arg	5Y4/1	6 GPS+	W ooids M (C-F)	3?	interxtl PrK	50			ΤT				? 1	1					5D	tr pyrite. Tr microSTL LS. Abundant soft chalky mat = dril
5	LS	to 7% arg	5Y4/1	6 GPS	ooids C (C-M)	3	I xfA3	60													5D	3125SWC tr pyrite. Tr microSTL LS. Abundant soft chalky mat =
)	LS	to 7% arg	5Y4/1	6 GPS		3?	interxtl PrK		cortex dk	vs m	tx liter	1	1		1	1		?			5D	tr pyrite. Tr microSTL LS. Abundant soft chalky mat = dril
5	LS	SH thin bed	5Y4/1	6 GPS	ooids C (C-M)	3	I xfA3	60													5D	tr pyrite. Tr microSTL LS. Abundant soft chalky mat = drilling artifa
0	SS LS	qtzose & SH bed	5Y7/1	SST- (M-F) subrd+ OOL	5?	intergr GdK	30	ctgs ma	inly oc	olite				?in Sh	2					10-9	10% calc cmt, 10% silica cmt, 5% argil mat, tr C coal frg, tr pyrite, well sorted,
5	SS		5Y7/1		AA	15	intergr GdK								possible	SH interb	eds loos	e qtz			9-10	10% calc cmt, 10% silica cmt, 5% argil mat, tr C coal frg, tr pyrite, well sorted,
0	SS ??	50% ool cave?	5Y7/1		AA	15	intergr GdK	30?0	cave?												10-9	10% calc cmt, 10% silica cmt, 5% argil mat, tr C coal frg, tr pyrite, well s
5 0	SS SH-SS	into abod de d	EV2/4 7/4	00.11	(C E) aubrel		interes Odl														9-10	CLL 200/ city firm to carbon met to reice and
U E	SH-SS SS-SH	interbedded	5Y3/1-7/1	55- M	(C-F) subrd	20	intergr GdK	0	ol cave 2	υ%?											10-9	SH- 30% silty, firm tr carbon mat tr mica and
5 D	SH-SS	silty mainly SS ctgs			AA AA	20	aa aa														9-10 10-9	SS-10% calc cmt, 10% silica cmt, 5% argil,
5	SS-SH				AA	20									AB6L -	3137m (3	3174m)	'C'			9-10	3171SWC
0	LS SH		5Y3/1	6 GPS	ooid M (C-M)	3?	interxtl PrK	60	40%	SS c	ave?					2				1	5D	I xfA3; 35% calc cmt, 5% argil, tr pyrite, Hard, minor mici
5	LS	211 211, 31, 10 01	10YR3/2	6 GPS	ooid C (C-VC)	3	interxtl PrK														5D	I xfA3; 30% calcareous cmt, 5% argil mat, tr pyrite, ooids=qtz nuc
0	LS		10YR3/2	6 GPS	ooid C (C-VC)	3?	interxtl PrK			S cav	e?					1 1					5D	I xfA3; 30% calcareous cmt, 5% argil mat, tr pyrite, ooids:
5	LS	tr DOLM	10YR3/2	6 GPS	ooid C (C-VC)	3	interxtl PrK		T	Ĭ									1?		5D	I xfA3; 30% calcareous cmt, 5% argil mat, tr pyrite, ooids=qtz nucl
0	LS	some SS cave	10YR3/2	6 GPS	ooid M-C (F-VC)	3?	interxtl PrK	60		rk ooi	ds in	iter mt	x			1					5D	3198SWC I xfA3; 30% calcareous cmt, 5% argil mat, tr p
	LS ?		5Y6/1	1 MS?(M-			I sIA3	5?							1?	1?					5	microcrystallin Mudstone w/ 5% ooids M(C-F)
	LS		5Y6/1	1 GS-WS				50													5D	microcrystallin Mudstone w/ 5% ooids M(C-F)

Α	В		IC	D		G	Н		J	K	LT	М	N	O F	Q	R	s		T II	V W	XIY	ZA	A AE	BAC	AD AE	AFI	AH A	AJ	AK	AL
3215	LS		argil 10%	5Y6/1	1	MS(M-G)	(ooid)	3?	I sIA3	5																			5	microcrystallin Mudstone w/ 5% ooids M(C-F)
3220	LS		a. g 1070	5Y6/1	1	WPS	ooid-frg-pel M(C-F)	3?	I sIA3		10	15			1?		mino	or chi	ps fr	om MS	to GS		2				1?	1	5	microcrystallin Mudstone w/ 5% ooids M(C-F)
3225	LS		tr DOLM	5Y6/1	3	WS	ooid M(C-F)	3	interxtl PrK	20																			5d	3225.5SWC xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=a
3230	LS			5Y6/1	3	P(W)S	peloid-frg-ooid F-M		interxtl PrK		40	15					minor	r chips	s fror	n MS to	GS				1?				5d	I xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=a
3235	LS			5Y6/1	3	ws′	ooid M(C-F)	3	interxtl PrK	20																			5d	I xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=atz nuclei
3240	LS			5Y6/1	3	ws	frag-pel F-M	3?	interxtl PrK	5 ′	10	15			2?							- -	1						5d	I xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=ε 1P
3245	LS			5Y6/1	3	WS	ooid M(C-F)	3	interxtl PrK	20																			5d	I xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=atz nuclei
3250	LS	SH	SH 3248-49 logs	5Y6/1	3	PGS	ooid M(C-F)	3?	interxtl PrK	50	5	5			1?			ofter	n dar	k ooids	in liter r	ntx							5d	I xfA3; 35% calc cmt, 5% argil mat, tr pyrite, ooids=ε 2P
3255	LS			5Y6/1	7	GS	ooid C(VC-M)	3	interxtl PrK	60																			5D	I xfA3; 35% calcar cmt, 5% argil mat, tr pyrite, ooids=qtz nuclei
3260	LS			5Y6/1	6	GPS	ooid C(VC-F)	3?	interxtl PrK	60	3	5				often	dark	ooids	s in li	ter mtx			1						5D	I xfA3; 35% calcar cmt, 5% argil mat, tr pyrite, ooids=qtz nuclei
3265	LS	SH	SH 3265-66 logs	5Y6/1	6	GPS	ooid C(VC-M)	3	interxtl PrK	60																			5D	I xfA3; 35% calcar cmt, 5% argil mat, tr pyrite, ooids=qtz nuclei
3270	LS			5Y6/1	6	WPS	frag-skel-ooid C(VC	3?	interxtl PrK	15	2	25		1	1?				1	?1	1	4	4				1?		5D	I xfA3; 35% calcar cmt, 5% argil mat, tr pyrite, ooids= 1P
3275	LS			5Y6/1	6	GPS	ooid C(VC-M)	3	interxtl PrK	60					1?												1?		5D	I xfA3; 35% calcar cmt, 5% argil mat, tr pyrite, ooids=qtz nuclei
3280	LS		20% argil logs	10YR3/2	1	GPS	ooid C(VC-F)	3	interxtl PrK	70 F	perh	aps o	cave b	out hig	ghly o	olitic			Щ					4					5d	I xfA3 Hard, 5% M ooids, 3P
3285	SS		guartzose	5Y7/1		SST-M(F-C) subrd	15	intergr GdK										A	B5 -32	51m (3	3288n	n)						5F	3285.5&87SWC VPS SST unconsolidated; logs= SST fining
3290	LS		15%gtzF SS cave	10YR5/2	7	GPS	ooid M(VC-M)	3		60									Т			1	1					1	5D	I xfA3 ooids = gtz nuclei 1P
3295	LS			10YR5/2	7	GS	ooid C(VC-M)	3	interxtl PrK	60																			5D	I xfA3 ooids = qtz nuclei
3300	LS			10YR5/2	7	GS	ooid C(VC-M)	3?	interxtl PrK	70											21		ı 3 tinv	V 0VS	ters?			1	5D	I xfA3 ooids = qtz nuclei 3P
3305	20		gtzose, 10% argil	5Y7/1			(VF-F) subrd	15	intergr GdK	7.0				trac	ce gla	LICOR	ito				: 1		, ann	, Jy3	.013:				5F	firm, 10% calcareous cmt, 3% carb mat, tr glauconite. Well sort-
	LS	CII	SH slty 3306-09	517/1 5Y4/1		331- VI	ì		•	25				_				. C4	- II		 	- 4	I C			 				
3310	LO	SH	3H Sity 3300-09	-	/	ſ	ooid M GS cave?	3	interxtl PrK	25		mi	xea s	IITY IVI	Gy S	H & I	minoi	rrqu	IZ 33	& sand	ay oon	e to a	rg La	cav	e r ma	inly			5D	3308SWC SH- 3306-09 5Y3/1, 10% silt, mica1% carb 49 1P
3315	LS		0.0.1.1.1.	5Y4/1	7	GS	ooid M(M-C)	3	interxtl PrK	70			_ I.		. ! .	I. I			_ [1]								, l		5D	I sxfA3, 25% calc cmt. 5% argil mat. Ooids=qtz nuclei
3320	LS		Qtz&skel nucleii	5Y4/1	7	GS	ooid C(M-VC)	3	interxtl PrK	70		so	me da	ark oo	ids in	liter	mtx	1 n	ucleii	·		4	2 oy	sters	?	1 r	ucleii		5D	I sxfA3, 25% calc cmt. 5% argil mat. Ooids=qtz nuclei 2P
3325	LS		to DOLMOO	5Y4/1	7	GS	ooid M(M-C)	3	interxtl PrK	70																			5D	I sxfA3, 25% calc cmt. 5% argil mat. Ooids=qtz nuclei
3330	LS	CII	tr DOLM??	5Y4/1 5Y4/1	7	PGS	ooid M(M-C)	3	interxtl PrK	50					1				1				1						5D	I sxfA3, 15% calc cmt. 5% argil mat & Fqtz SS. Ooids: 2P
3335	LS	SH	SH-silty 3333-35	-	/	GS WPS	ooid M(M-C)	3	interxtl PrK	70		10							2		2		,				12	2	5D 5d	3334.55WC Sh- 40% silty firm poorly rep in spls
3340	LS		10% argil	10YR3/2	3		ooid -frg (skel) C (C-	-IVI)	interxtl PrK	35		10							!		2	4	<u> </u>				17			I sIA3 chalky appearance = drillling artifact?
3345 3350	LS		10% argil	10YR3/2 10YR3/2	3	WS GPWS	ooid C (C-M)	3?	interxtl PrK interxtl PrK	20 40	3	10									12		1		1			2	5d	I slA3 chalky appearance = drillling artifact? I slA3 Hard, tr pyrite ooids = qtz nuclei tr cl VC calcspa 1P
3355	LS		10% argil	101R3/2 10YR3/2	0	GPS	ooid C(VC-M)-frg ooid C(VC-C)	3	interxtl PrK	60	3	10			12						1 !		1		1				5D 5D	I sIA3 Hard, tr pyrite ooids = qtz nuclei tr cl VC calcspa 1P 3350.5swc L liA3
3360	LS		10% argii	101R3/2 10YR3/2	0	WPS	ooid M(M-VC)-frg	3?	interxtl PrK		2	10			3						1	,	,						5D	L IiA3 2P
3365	LS		10% argil	101R3/2 10YR3/2	0	MWS	(ooid-M-C)		interxtl PrK	5?	_	10			3						1	4	_						5 5	L IIA3
3370	1.6		10 % argii	101R3/2 10YR3/2	2	MWS	frag M	3	IIILEIXII FIIX	5?		15											1						5	L liA3 bit bruised poorer spl = It color powdery/oily 1P
3375	1.6		10% argil	101R3/2	2	MWS	(ooid-M-C)	3	interxtl PrK	5?		13																	5	L liA3 bit bruised poorer spr – it color powder yrolly
3380	18		10 % argii	101R3/2 10YR3-5/2	2	MWPS	(ooid-C)	3?	interxtl PrK	8		30			2					2	1		1					1	5	L liA3 2P
3385	LS		10% argil	10YR3/2	2	MWS	(ooid-M-C)		interxtl PrK	5?		30			1-														5	L liA3
3390	LS		10 70 aigii	101R3/2 10YR3/2	2	MWPS	peloid F(ooid-C)	3	interxtl PrK		25	8			12						12				1				5	L liA3 bit bruised poorer spl = It color powdery/oily 2P
3395	LS		10% argil	101R3/2	2	MWS	(ooid-M-C)	3	interxtl PrK	5?	20				1 ' '						1:				'				5	L liA3
3400	LS		10 70 argii	10YR3/2	2	MWS	peloid F-frg	3?	interxtl PrK		15	10			5										1				5	3400.5&05SWC L liA3 2P
3405	LS	SH	SH 3404-3406	10YR3/2	2	MWS	(ooid-M-C)		interxtl PrK	5?	10	10			Ť														5	SH- not seen in spls
3410			95% LOST CIRC		_		(00.0 0)		IIICOIXEI IIC		- N	A	C	. h a	~~~	8 00		t-	700		an BET	+ 1 ()	M \A/a	1000	aballa	.2		_	5F	3408&10SWC 10% argi amt, 10% calc cmt, 3% c
3415				5Y7/1		SST-F	M-F) well sorted	15 in	tergr, PrK	120	or N	nua (uas s	iiow;	yas	ox CC	muen	isate	reco	overed (UII KFI	+ LUI	vi vva	mut	SHEHS	1 11		_	5F	3412&14.5&15SWC
3420			MSslty- 3414-15		3	WS	ooid-fos frag	3?	interxtl PrK	35		5? I	r foss	il fraq	ment	S	glau	uconit	te P	oor spl	3?	1	1 .		22-2				5d	SH/MS 40%silty w fossil frag tr, & glauconite, mica, carb' 1P
3425	LS	?	20% SH 20%SS c	10YR3/2	3	WPS	ooid (C)-frag	3	interxtl PrK	30		5?			1?		Ĭ			أني				4B4	-3378	m (34	115m)		5d	I liA3 Hard, tr pyrite, minor irregular fragments
3430	LS		10% argil	10YR3/2	3	ws	ooid (C)-frag	3?	interxtl PrK	30		5?		3 1	? 2					1?	1		1		1		1?		5d	I liA3 Hard, tr pyrite, minor irregular fragments 2P
3435	LS		10% argil	10YR3/2	3	WS	ooid (C; M-C)	3	interxtl PrK	20																			5d	I liA3 interbedded ooid PS (50%, 30% calc cmt) & Lime MS both 10%
3440	LS		J	10YR3/2	5- 1-	M+PS	ooid interbd skel	3?	interxtl PrK						2						1 1	2	2		?				5d	I liA3 interbedded ooid PS (50%, 30% calc cmt) & Lime I 2P
3445	LS		10% argil	10YR3/2	5- 1-	M+PS	ooid interbeds	3	interxtl PrK																				5d	I liA3 interbedded ooid PS (50%, 30% calc cmt) & Lime MS both 109
3450	LS			5Y6/1	7	GPS	ooid C(VC-M)	3?	interxtl PrK												1	1	1		1				5D	3450SWC I xfA3 Hard, 35% calc cmt, 5%argil, tr pyrite 1P
3455	LS			5Y6/1	7		ooid C(VC-M)	3	interxtl PrK																				5D	I xfA3 Hard, 35% calc cmt, 5%argil, tr pyrite
3460	LS			5Y6/1	7	GS	ooid C(VC-M)	3?	interxtl PrK						1	1									1?				5D	I xfA3 Hard, 35% calc cmt, 5%argil, tr pyrite 2P
3465	LS		10% argil	10YR3/2	6	GPS	ooid C(VC-M)	3	interxtl PrK	50																			5D	I xfA3 Hard, 20% calc cmt, 10% argil, tr pyrite
3470	LS		10% argil	10YR3/2	6	GPS	ooid C(VC-M)	3?		50					1				1		1		1		1			1	5D	I xfA3 Hard, 20% calc cmt, 10%argil, tr pyrite 3P
3475	LS		10% argil	10YR3/2	2	MWS	(ooid-C)	3	interxtl PrK																				5	I liA3 tr pyrite
3480	LS			10YR3/2	2	MWPS	pel-ooid -frg	3?	interxtl PrK	10 2	20	10									1		1		1				5	I liA3 tr pyrite 3P
3485	LS		10% argil	10YR3/2	7		ooid C(VC-M)	3	interxtl PrK	60																			5D	I xfA3 Hard, 30% calc cmt, tr pyrite
3490	LS			10YR3/2	7		ooid C(VC-F)		interxtl PrK	50	10	5	2				1?				2		1		1?		1?		5D	I xfA3 Hard, 30% calc cmt, tr pyrite 3P
-			-	- '		•		-	. '			•	•	•	•							•	•					•		

Α	В	С	D		G	Н		J	K	L	M I	N C) P	Q	R	S	Т	٧	W D	(Y	Z	AA /	AB AC	CAD	AE A	F A	AH /	ΔΙ	ĄJ [٩K	AL					$\neg \neg$
3495	LS	10% argil	10YR3/2	2	MWS	(ooid-C)	3	interxtl PrK	5?																					5	I liA3 Hard tr pyrite					
3500	LS	Ü	10YR3/2	2	MWPS	pel-ooid -frg			10	15	10								•	1		1 1	1?		1					5	3500SWC I liA3 Ha	d tr pyrite	е			2P
3505	LS	10% argil	10YR3/2	7	G(P)S	ooid C(VC-M)	3	interxtl PrK	60																					5D	I xfA3 Hard, 30% cald	cmt. tr p	vrite			
3510	LS	3	10YR3/2	7	` '	ooid-frag M(C-F)				2	20										?	1			?					5D	I xfA3 Hard, 30% cald					1P
3515	LS	10% argil	10YR3/2	3		ooid C (VC-M)	3		20																-					5d	I sIA3 Hard tr pyrite	, -	J			
3520	LS	10 / C d g	10YR3/2	3		ooid-frg-pel M (C-F)	-		35	10	10											1								5d	I slA3 Hard tr pyrite		cutti	ngs small		1P
3525	LS	10% argil	10YR3/2	3	W(P)S	ooid C (VC-M)	3	interxtl PrK																						5d	3525SWC I sIA3 Hard	tr nyrite	outu	igo orrian		
3530	LS	1070 argii	10YR3/2	3	W(P)S	frg-ooid M (VC-M)	•		10		15											3			1					5d	I slA3 Hard tr pyrite	прупис	cutti	ngs small		2P
3535	LS	10% argil	101R3/2	3	W(P)S	ooid C (VC-M)	3	interxtl PrK			13											9								5d	3535SWC I sIA3 Hard	tr pyrita	Cutti	ngs sman		21
3540	LS	10 % argii	101R3/2 10YR3/2	3		ooid CM (VC-M)	3		20		10		1						,	,		1								5d	I slA3 Hard tr pyrite	ii pyrite	outti	ngs small		1P
3340		TAL DEPTH 3540n		3	W(F)S	OOIG CIVI (VC-IVI)	3	IIILEIXII FIK	20		10		'						4	_		_							_	Ju	I SIAS Hard II pyrite		Cutti	ilys siriali		IF
	FULL IU	IAL DEPTH 3540N	n I			SideWall Core D	escri	ntions (blaste	n be	ot di	illed-	nos	sibly	not r	renre	senta	ative)	200	2-07				7													
2995.5	SH slty		LMBnGv			Gladwan Gold B	00011	ptiono (blact	1	ot ai	mea	POU	Jibiy	1100	Г	John	1		1												3 photos					
3029.5	SH Sity		DMGy																												•	loon om				
																															3photos black coals		اء مدياما		/ aa.ial	
	SH sity SH		(L)MGy																													x coaly fi	iakes, s	l.laminated,	(w ovoia m	ווו טעווו
	_	micromica	(L)MGy		00	alas Ob latada da																									3 photos					
	SS	F-M qtz clayey	?Lgy		SS	clay-Sh interbeds																									4 photos					
	SH	micromica	(L)MGy																												3 photos	0/ 04- 1/				
3087	SH	micromica	Lgy+Dgy																												4 photos Tr G?. Tr-2					
	SLTST sh	lly																													4 photos burrowed?					
3108	SH(slty)		LGy																												3 photos minor dark					
3125	SH?		MLGy																												3 photos ?powdery					
3171	SS	M-C qtz G?	VLGy				tr	intergranular																							4 photos mod-good	sor,t mod	l round,	some minor	rose qtz 8	grn gy
3198	LS sdy	10-20%qtz M-C fr			ws	quartz-fragment					15																				5photos					
3225.5	LS?-SS	VF(F) qtz calc																													4 photos 3 plugs ma					
3275	LS	M qtz nucleii			GS	ooid C-VC			60																						5-6photos VF clacite	ntx & silt-	-vf qtz.	Shattered b	/SWC gur	1
3285.5	SSw/SH	VF qtz	VL+MGy																												6-7photos SS w/ shall	silty thir	n parting	gs Micromic	a lignitic VF	swelli
3287	SH	soft, swelling	M Gy																												4photos trace micro	micaceou	us			
3308	SH		M Gy																												5photos sl. Qtz silty					
3334.5	SH? SS	SWC mixed liths																													4photos mud plyg v	/ shale/q	tz siltst/	sst(VF) con	ponenets	
3334.5	Shsity		DMGy																												4photos some conte	rted silts	t lamina	e - due to S	WC shot?	
3350.5	LSsdy	F-C rd qtz				quartz-fragment					35																				4photos					
3400.5	SH	calc soft if wet	DkGy		MS	(LMBn)																									5photos					
3405	SSsltst	VF-XF qtz pyritic																													4 photos well cemer	ted, 2%	vf pyriti	c blebs		
3408	SS	qtz VF-F	VLGy																												4 photos qtz clay cm	t mtx mo	stly dus	t lg qtz		
3410	LSsdy	2 liths-MS&PS	MBn&VLGy		MS+PS	PS qtz sandy					20																				6photos 2 liths sand	y LS &/o	r			
3412	LS sdy	10-20%xf-vf(F)qtz	LtGy		PS	skel-frag-sdy					20						brol	en sl	nells			5			1									Clay or dril		
3414.5	SH	XF lithic frg pyrite																													4photos some C-V0					
3415	SH	sitly burrow	DMGy																												4photos silt filled bu					t
3450	LS sdy	C(VC) ooid	L Bn		P(G)S	ooid, sandy f-vf																									5photos biggest pie	ce of met	tal from	SWC gun S	hattered S	WC
3500	SH+wSLT	XF-VFqtz laminae	DKGy			_																									4photos shattered b	y SWC				
3525	LS	"rough"stylolites	LtBn		MS(ws)																										4photos fractured n	,	burrow	w qtz silt: s	vlolites w/	black re
3535	LS	M-F size frg	LTGy+Bn			fragmental (rd)					60																				4photos fragments					
	В	С	Ď		G	Н	Т	J	K	L	M I	N C) P	Q	R	S	Т	٧	w >	(Y	Z.	AA A	AB AC	AD	AE A	FA	AH /	AI A	AJ	٩K	AL				•	
EACIE	. ALLIMET	DC: 4-both:-1-	hala 2	oritio -	bolo 2-f	ororoof channel 24	- for-										_	-	_	_	-	_	_	\rightarrow	_	_	_	_	_		-					
						orereef-channel, 3A:																			i), 4 :	= sp	onge	e ree	ıaı,							

Crestope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reef
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Appendix A3 ENCLOSURE A3.9 Kegeshook G-67 L.Eliuk 2016

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Enclos	ure A3	3.10 EnCana-S	Shell-Exx				CUTTING	S INFIL	L (gr	ey line	s)	s consu	Iltina In	c L.Eliu	k P.Geo	d.										7 7 PE 78'89 2002	PAGE		
DEPTH	S	LITH	modifier	COLOR		XTURE modifier	POROSITY	1	_	SSORIE	_			FOS			enhance	ed by S	SWC d	ata if av	ailable)				7	<u> </u>	COMMENTS		
(metres)	1	I LS=limeste	one	0	(©	MS=mudstone 1	%			ment bo		FRAME	BUILDE	RS				É	1		ĺ	п	ALG	AE [जा :	888	additional fossils/accessories		
	d	T DOL=dolo		TE N		WS=wackestone 3 PS=packstone 5		modifier		[O]	ᇤ	10.	ΙĪ		□	S	뭾	18	ш				[5]	tes S		lan 13	diagenetic textures	RADI V RIT RDI	IIISED
47.6	e W	H SH=shale SS=sands	tone	N N	₹ \$	GS=grainstone 7		(Archie)			Ы	l g		필용발	집[[[조]	I O V		श्र∣ह	<u> </u>	미리			gree	글를 [[<u>}</u> }	M Sign	facies-sequence breaks (BBB) - LIG	BADLY BIT BRI HTER COLOR THAN ACTUA	AND
KB	a	L SLTST=sil	tstone	BREVI	<u>σ</u>	BS=boundstone 9 (FS/RS=XC size)					일				렸川잉	Į į		GASTE	BN	SE SE	[표] [좌	l l l	<u>k</u>	P P P	3 9	S % S	et cetera CHALKIER =BBB	THAN ACTUAL	L
	1	O calc=calca	areous	B Z	as III	FS=floatstone 4 RS=rudstone 8			SGIOO	PARTICLES	5	NO 1	TROM,	[왕] 톡 ^호	2 X		쁴읡	퉨			ᄩ		틸	호텔 B	₹ !	12 % E	some long comments may be P = PI	LOTO	
	1	G sdy= sand	ly/qtz		·	XTL =crystalline			$\ \ $	Ĭ¥.	Г	g ,	II I		읡Ш		빋	Ψ.		Ö	ШI	M	=	TS	 	Mie Wie		ie=SWC info	
Α	С —	В	С	D	П	G H	1	J	К	L M	N	0 1	Q	R S	T	T V	w x	ΥZ	. AA	AB AC	AD A	E AF	AE AH	AI A	J	" -		s also in ctgs	
3225	0		VV ? Cave/ii	ntbd 10% LS	ST - ske	el WS & ooid PS w?	glauconite (gr	n-gy in corito	ces w c	qtz nucleii)								pyrit	ic					T				
3230	r	SS shly	XF-M calcar		Ш	qtz-lithic (carb	0,	nil? -shaly											ž	1 _		, L			2	(4?9)	1-2% pyritic XF(tr VC blebs), tr red SH, occ C-V0		Pfrosted 2P
3235	е	SS	VF-M	LMGy	CA	SING 3236.3M	5-10%?	intergranula												Į.	yritic					9 (2)	CASING 3236.3M Disaggregat		
3240		SH sity	-shlySLTST	DkBnGy		also SS as ab	ove; tr lime	WS w brn ?s	iderite			4								_			wood		2	(9?)	tr red SH, !% dessiminated micropytrite & occ vo	-	rags 2P
3245 3250		SH sity LS si arg	15% slty SH	Rd+MGy	l M	WS skel-frag?				10	+	tr 2	Abe	enaki 6 U	P = 324	6m <i>FA</i>	ULTEL	,		\vdash	1	2			+	2 3?	tr DkBn pyritic siderite?, tr C-VC calcspar	tiny BBB	
3255		LS sl arg	10 /0 Sity SIT	M(L)BGy 2		onei-ilay?				10		_		- 10 1 1					1.						H	3?	a Dabii pyride sidencer, ti G-vo calespai	BBB	F
3260		LS starg		M(L)BGY	ı Mı	W)S frag?skel				5		rex 1	tı/leach	ed?≢'calc	ite vein	w borir	igs & p	/rite	+ pr 2	isms	1	?	com	olexes		3?	tr VC calcspar, tr pyritic	BBB	3P (X16)
3265	1	LS sl arg		M(L)BGy 1		BS microbial-sp	onge-foram	consortium				15			1	3			2	2 2	3 5	5 3		10	4	A-C(3?)	micropyrite stylolitic	BBB	. (
3270		LS		M(L)Bn 2		WS fragmental				7			1									1	wood			3?	?Lithocodium/stromatopooroid?; tr pyrite	BBB	3P (X16)
3275		LS st arg		M(L)BGy 2	M-\			<u> </u>		7?		2?					1?					1	.,,,,,,			3?	micropyrite	BBB	
3280	2	LS sl arg	-t- F.\/F	M(L)Bn	,	V)S spong-skel	sponge B/F	₹ S		40		25 -10?				2			tr	2	2 3	3 1				4?	cuttings not representative wrt SWC	BBB ?calci:	sphere
3285 3290		LS	qtz F-VF SH partings	M(L)Bn 3 M(L)Bn 3	WS WS					10 10?		2						1loose	e spine							5-3? 3 (5)		BBB	2P
3295	3	LS	Orr partings	M(L)Bn 2		WS frag sponge-st	tromatop BS			6		25	15						e spin	9	3 2	2 5w/ c	clav-silt	7	4	B-5B		BBB	<u> </u>
3300		LS arg		DMBGy 9		B)S sponge-skel-	-frag			7		25		1		6	2		2						4	A(B)	G?=green calcaresous clay?	ВВ	2P
3305		LS arg		DMBGy 3	3 WS	frag-bryozoa	n-skel			20		5 1	+ 3?			10	2+		?		1.	+				2	Lithocodium? Foram	BB	bit Fe 2P
3310		SH (LS)	calc pyritic, tr	DMBGy	Ш	shale																				2	some soft in water	soft	Р
3315		LS arg SH	calc pyritic	DMBGy 2		WS F frag	I			15+ 8		3	2	4		16	4		2			ncrus	sting	3?		2(3)	pyrite	BB BB	5P(x16)
3320 3325		LS arg	shaly parting pyritic	DMBGy S		-MS sponge-bryoze -MS sponge-frag				10		20 :	2	1		16	1	2	1?		1	1		3?		4A 4-3?	pyritic pyritic	BB	5P(X10)
3330		LS arg	shalv parting	- 3	_	F)S fragmental			me			3					1		1						3	? (4)	sl pyritic	BB	•
3335		LS arg SH	J	D(M)BnG		F)S frag-sponge				20		12					2									(2)4 3	pyritic M-C	BB	
3340		LSarg/SH?	(washout py	,		P)S frag-skel				5 25		3				3	1		1						3	? (4)	LAG OFF?(= not shaly enough wrt log??) sl pyritic	BB	2P
3345		LS arg SH		D(M)BnG		P)S frag-skel				25		5	1 tr			2		loose	elspine	e						3?	^v^v^v^ pyritic		Р
3350 3355		LSarg/SH	5/5? argLS/cald	DkBnGy 3		F)S echinoderm				? 20		2				2	10	79030	СІЗРІПС	.5	1	1			5	A (3?)	LAG OFF?(= too shaly wrt log??) SH v.pyritic		2P(x16)
3360		LS arg	BBB	DMBGy (L) MdGy	₃ ws			+	- +	13?		- - <i>-</i>	benak	i 6 LO? =	3355m		_ 1	12	, – †		- ₁		+		Ŧ	<u>3-5</u> ?	pvritic	BBB	<u> </u>
3365		LS	tr SH	(L) MdGy 3	ws					15		1?	1?						frag	mont						5?	tr pyrite tr shale	BBB	
3370		LS	tr sity SH	LtMdGy 2	2 W-	MS fragmental?				6		fragm	ents						1	1?	1	1 _	l	20	Т	5?	tr pyrite	BBB	Р
3375		LS	sl arg	LtMdGy 2	2 M-V					10		1?		SWC4	microk	-chaete	tid BS i	n skele	etal W	PS w/ c	ta & do	ol 20%	anites i	n BS		5?		BBB	
3380	4	DOL/LS	8/2 dol por		₃ ws		- 5+	I/IIIBC2D3	tr XC	calcsp=vi		9-2	1 10	10		2	5 -1?	1? 2	5-1?		2 2	2 4		10		B (3B)		, dol=ok	3P
3385 3390	5	Dol LS LS/DOL	2/8 7/3	LtGy(MBr 3	4 FS		4	IBC2D2		10		1? sl	kelet-lit 7	noclast do	IORS	3	5 2	12	1?			1			5	A(3-5B)	d	lusty BB BB	2P
3390		LS/DOL	5/5	LtGyBn 3	4 F5		ay			15?		1?						11	17			1	1? Re	d	- 14	5?		lustv BB	2P
3400	6	LS	tr DOL & pyr g	LtMdBn 3	4 FW		matop'			10 5		7 -2	2 5-7	SWC#6 = s	ponge-	coral-sk	el dolo	F/BS 2	20% ca	lc fossi	S 2	2		8		5A-B 5B		BB	P
3405		LS/DOL	4/6	LtMdBn 2	M/\		1-2% n	ricropyrite		15		1							1	1	1	1				5?	pyritic shale partings		P
3410	7, 8	DOL/ IS	dolF-C 8/2	L(M)Bn 3	4 FW		tr	dol interxtl		10?		2	7 10-3	7	20		6-1	2	20		1	1		15-1	5	A(B)	yellow ?sphaelerite in M(C)DOL tr pyrite		3P(x16)
3415	9	DOL LS	9/1	L+MBGy 7		LGS F-M-C	3-7	IBC2D3		20		SWC#7 :	coral-	vt spg-cha	etmic	rob BS;	SWC	8 = st	romot	p-s <mark>kel</mark>	doloFS	S		4/		5? ?	VF-F vug lining in F-Cdolostone		Р
3420 3425	10	DOL DOL		Lt(Bn)Gy		TLRGS F-M-C anheo	5+9 4	IBC5D?+3		20	20		1	1 in LS	hips		6			At	enaki	5 = 34	05m	ا کے		5? ?	all DOL but 2 LS chips w framebuilders, tr micro	stylolites	Р
3425 3430	11 12,13	DOL DOL		L(M)Gy 7 VLGyBn 5		LGS F-IVI-C LFPS F-C anhedral vu		IBCD2+ IABC2D0-20	5?	10	8-53	7	102		22		10		5?							5? ? 5? ?	stylolites tr pyrite SWC = originally skel W-PS; heale	d fractures	D
3435		DOL DOL		M+LtGv 5	-	LPFS F-M-C	2-20	IABC2D0-20	J.	10			101				7	3	8					5	?	5A ?	ory.oos a pyrite ovvo – originally sker vv-r-s, fleate	bit F	e
3440	15	DOL DOL		LtGyBn 8		LPFS F-C	7+	vuggy XC o	alcsp	207	10?	3?	3?			I.I., I	7.	_	4?						Т	5? ?	TRIP=mixed liths&pipe scale	3.01	Р
3445	16	DOL DOL	dust VBBB		8 XT					25		SWU#	10116	DIValve-¢	ıın-ıragı	n a ciast	aoidigi	3	10							5? ?	VPS='dı	ust'/mud	
3450	17	DOL DOL		LtGyBn 3		LFWS SL/XF+ F	?	??VPSpI		25		2+ SW	C#17 =	bivalve-fr	ag dolo	F/W-PS	2		2-15						L	5A	3 1 3	ust'/mud	2P
3455 3465		DOL DOL	dust VBBB dust VBBB			TLxti Lxti		l					VV	SWC-TS	19 = ?fi	ramebui	ders-mi	icrobia	al cons	ortium	, heale	d fracts	3			5B? 5? ?		ust'/mud	
3465 3460		DOL DOL	uust vaaa	L&MGyB	XT		10?	IABC5+D5	2				202		202	,	5?							202	-	5/ /		ust'/mud /PS='dus	2P
13-33		_ J		Lawing	1 1^1	-	10:	I., 1500.50	.	ı	ı		201	1 1	201	11 1	ı l	- 1	1 1	ı	1 1	1 1	ı	207				. 5	4

Α		В	С	D		G	Н		J	K	L M	N	0	Р	Q R	S	T	٧	W X	. Y	Z	AA A	BAC	AD	AE A	AF AE	AH	AI A	J AK		AL
3470		DOL DOL		VLtGy		XTL	F-M(C)	7-15?	I?IIIB2C10E)+		5?	'						3'	?	1? 4	?mold	ls						5A?	?	tr XF pyrite 2P
3475	22	DOL DOL	mottled	Lt & DkGy	1	XTLMS	VF-M-C XTL	2-10	IbC5D0-5+			201	?																5A?	?	mottled - LtGy XTL & Dker doloMS P
3480		DOL	tr XC calcspa	MBn+LGy		XTL	F-C	10	IB2C5D2+																				5?	?	2P
3485	23	DOL DOL		VLtGyBn		XTL	F-C	5?			15	?		7?r	molds				5	SW	C#23	= crir	naid-1	frg-sk	el-str	om			5A?	?	tr stylolites in dolm
3490		DOL/LS	9/1	LMBn+LGy	1 3	M+WS	frag, F-C XTL	?5	IC3D+		10)			1?														5?	?	lime MS w 'birdseyes' & darker than dolm 2P
3495	24	LS/DOL	4/6	M(L)Gy		M+WS				1	5? 15	?	5+	7?r	molds			1?	1?	3 \$	WC#	24 = c	+ lob	lst=W	/PSFS	3??		8	5?		tr shale partings bit Fe
3500		LS/DOL	6/4	M(D)BGy	9 4	BS-FS	Strom-microb-	skel-frg		2	2? 15	5	1	5	15	3	3		1	1		2			1			15	5B		lag off (Lo/deeper wrt logs); stylinid corals, pyrite ii 6P
3505	25,26	LS/DOL	9/1	M(D)BGy	3 4	WFS	strom-frag				3 15	+ 15	2	1	15	micro	osolenio	1?	10	-2 1?	2 5	5-1? 2	2 S	WC s	ee be	low =	calcD	OL	5A-B?		tr grn clay = ?glauconite&siltsWC see below = DOL+ LST trip 4P
3510		LS arg		M(D)BGy	5 9	BS-F/PS	strom-skel-frag		tr		10		5?2?		20	2 2	4-3	9-3	4-	2	2	5у			1			5	5B		?lag off (Lo/deeper wrt logs) tr micropyrite 5P
3515	28	LS/DOL	8/2	M(D)BGy	9 4	BS_FS	strom-skel	-			2 10)	10-5	1	25 r	nicrosoler	nid 4-2		5-	2	5	6-2 1	1	2	2			15	5(A)B		SWC #26= skel-mollusk-sponge/microbial RGS 4P
3520		DOL (LS?)	lag off??	VLGy-wt		XTL	F-C + dolosp C(V	5-10	IBC2D3-7												A1	naki 4	4 0	-00	7				5		lag off (Lo/deeper wrt logs) VF pyrite, tr XC calci
3525	29	DOL DOL	lag off??	VLGy-wt			F-C + dolosp C(V	5-10	IBC2D3-7		SV/C =	: DOL	w/ fos	LST	cave - s	ee below					Abei	naki 4	4 = 3	523m					5?		lag off = !00% porous dolm AsBelow. Tr VF pyrite 2P
3530	30	DOL DOL		VLGy-wt			F-M(C) skel-cla	8	I/IIIBC5D3+			15?r	a 5?		5? SW	C#30 = sk	kel-clas	t FS S	WC ar	ticulat	ed cla	#10 = S	small r	mega	odont	s?	1	0?	5B flat	5A	tr XC calc SWC- articulated clam=small?megalodont 2P
3535	31,32	DOL DOL	tr calcFossils	VLGy-wt		XTLXTL	F-C	5-10	I/IIIBC5D3+												3?0	utline							5?		
3540	33,34,35	DOL DOL		LGy-N7/6		XTL	XTL F-M anhedra	3-8+	IBC1-14Dtr-4		SWC	= all [ODL bu	t #33 s	skel PW	S w/ HDG	GD- see				1	0?mol	lds						5?	·	occ clam fossomolds; wt card = crinoid + bivalves 2P
3545		DOL DOL	tr C calsp	Lt Gy		XTLXTL		10	IBC5+Dtr-4	1	0? 10		?																5?		M-C sadle dolm tr VF pyrite 2P
3550		DOL (LS?)		N7-8			VF-M vug (strom	15+	IBC2-5D10-20	1	0? 10		?																5?		lag off(Lo AA) v vuggy SWC toVC saddle dolocm & CTGS w 1 VC calc spar 2P
3555	39	LS/DOL	7/3	N7-8			strom-skel	5+	IC2D3		10)			30 SW	C = DOL	5		1			3			1			10	5B	5C	~5% calcspar Porosity = STL & intra strom stylolites
3560	40	LSdolmDOLcalc	9/1	VLGyBn			stromatop-sk	5?	IAB4?		10		1	3	35	?	5?mold	s 1	5	2		3 1	1	1	1	1	3r?	5	5B		SWC=dolmLS skel-lithoclast G-PS (crinoids, leached corals v 4P
3565	41	LS/DOL	9/1	VLGyBn :	9 8	R-BS	strom-frag	5	IB2C3		15	30	5		40 5		10	1	3	2	1	2	2				3?	5	5(A)B		w/ calcspar porosity intra stromatoporoid SWC = skel rd clast G/RS
3570	42	DOL/LSswc	7/3	VLtGyBn	ĺ	XTL	F-C (LS=BS/R	3-10	I/!!!BC5D+						20 7	3?	15		5		6	6 y ∣la	ag off	?(AA)		1	2r?		5B	1	SWC=LS w/10-30% dolo = strom-chaet BS&clam-coral-crinoid-skel RS 3P
3575	43	LS/DOL	5/5	VLtGyBn	9	XTL-BS	stromatoporo	3-10	I/!!!BC5D+	SWC	=porc	us DO	OL.		20														5B	?	
3580	44,45	DOL&LSdol		VLtGyBn	9	XTL-BS	F-C (LS=BS+F	7-15	I/IIIBC10D+								30		8	5		10			2en	crust>	? 7		5B		2SWC= Isastrea-coral BS& dolLS=por's bivalve-coral-crin-skel frg P(F)S 3P
3585	46	DOL/LSswc	8/2	VLtGyBn		XTL	F_C	7-15	I/IIIBC10D+	swc:	=porou	s DOI	L		??														5?		
3590	47	LS?DOL	8-4/2-6	VLtGyBn			F-C; strom-skel-f	tr-7	IABX5Dtr-2		5 15			2	15SWC	≠por DO	L 6	lag o	off?(A/	V		2 1	1		1			2?	5B		SWC(TS) - no sample left in vial 3P
3595	48	LS/DOL	9/1	VLtGyBn			pel-frag-skel	tr-15	cave??		10 20) 5			2		10		10	- 2	2-1	5-2 2	2	2	1			3	5B		SWC= Crin-coral-skel FS w/ skel-frg PS r dusty BB bit Fe 4P
3600		LS	w/ VC calcsp	VLtGyBn	9 4	B/FS	strom-coral-fr	rag			5	10	1	2	20 2?		10		1		1?	2 1	1		1	1			5B	1	4P
3605	49	LS		VLtGyBn	4	PWS	peloid-strom-	microb-frag	9		10 15	5			10		20 -2		3			2	2	5-1	1		1	0-15	5B	5C	SWC= coral-skel-frag RS w/ skel-frg PS r BB
3610		LS		L(M)BGy	4	P/WS	frag-skel-micro	b?			5 15	5	2		15		2					2 1	1		1			10	5B		3P
3615	50	LS		L(M)BGy			Coral-microb-				10)	2		7		50		2	2		2			2	5-1		20	5C	5B	?calcispheres? MTX = has grn clay w/ py BB stylolites 4P
3620		LS		LMBGy			strom-skel-mi				5 5				25		6								2			10	5B		3P
3625		LS		LMBGy	9 4	B/FS	strom-skel-mi	icrob			5 10)	2		35		3		1			2			1+			10	5B	5C	good spl 5P
3630			TD 3625.5n	n																											3P
A		R	C			G	н			К	l M	N	0	Б	Q R	s	+	V	wx	- V	7 /	A A	BAC	AD	AF /	\F AF	AH	ΔΙ Δ	J AK		AL.
		ь		-		G		<u> </u>	J	r\	_ 10	iN.	Ū	г	₩ K	٦	т.	٧	44 A	1'	۷ ۲	-A A	טאני	עא	AL /	- A	All	AI A	AN	`	AL .
	l 1=-	CIEC NUMBERS. 4																											1		

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-'stromatoporoid reefal, 5C=mud/pelleted; 5D=colitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details

	ENC	ANA-S	hell-E	xxon/Mo	bil Ma	rCoh l	D-41 Thin Sectio	n SWC List DOLO	MITE (mainly TS) W/ L	IMESTONE NOTES	(TS&SWCs)
mber		Depth	Thin Section	SWC vial co	Photos	тѕ		RW) 2003-11-14 Revised 2004-11 s (Archie porosity, crystal size etc.)	by Leslie Eliuk P.Geol	GeoTours Consulting Inc.	fossils from SWC only shown in red in cuttings liths above
1	#25a	3265.0m	25-3265.0	plug&lgchip	33	5+7	limestone	P.034 K0.04md	IA NVP		w/ qtz-VF-XF 10% stylolites Microbial-spongr-foram consortium BS w/ skel-bryozoa WS
2	#24a	3277.0m	24-3277.0	bgplug&lgchip	38	3+11	limestone	P. 02 9 K 0 .02md	IACtr intra-sponge		w/ qtz-VF-XF <5% sponge (2-3 &?microbial) BS-RS - Tubiphytes, bryozoa, serpulids, forams
3	#25b		25-3293.5		31	5+13	limestone	P. 01 K 0 .02md	IA NVP		sponge(coralline&lithistid)-microbial serpulid BS; cf Ellipsactinia or Actinostromaria
4	#23a			plug&3chips	36	4+12	limestone	P. 01 7 K<.01md	IA NVP		w/ 20%(dolm)-VF qtz-clay microbial-?chaetetid BS & bivalve-crinoid-stromP/WS bored
5	#22a	3385.0m	22-3385.0	plug&4frgs	18	3+6	DOLOMITE	P.108 K 17.4md	IAB2C4D4+	(VF)F-VC bimodal	tr calcite cement & remnant calcite = crinoid, bryozoa(intra-pores!), shell frag, lithoclast-skel rudstone
6	#21a	3399.0m	21-3399.0	4chips	22	7+9	DOLM & Lst fos.	P. 04 K 0 .02md	IAB2?C2 interskeletal	F-M©	calcareus20% = hexacoral clast/BS(bored) & skeletal (strom/spg, shell
7	#20a	3406.0m	20-3406.0	plug&3frgs	27	5+6	limestone	P.038 K0.01md	NVP? Along shale partings?		coral-wt sponge-microbial BS; coral rextl w wt sponge(Shuqraopsis?) microbialite, chaetetid
8	#19a	3408.0m	19-3408.0	full plug	19	4+7	DOLM (20%Lst)	P. 01 1 K 0 .02md	NVP		20% skel lst WS-FS = crinoids, bivalve, coralline sponge (stromatoporoids), chaetetid, bryozoa?
9	#18a	3413.5m	18-3413.5	brknplug&4frgs	16	3+6	DOLOMITE	P. 06 9 K 0 .2md	IAB2-3C3Dtr-1(+4)	F-C(VC)	wc= skel-frag-rd clast-crinoid GS; tr+ VF pyrite?
10	#17a	3418.0m	17-3418.0	plug&2frgs	14	3+6	DOLOMITE	P. 09 5 K 23 md	IAB2C6D2+Fr	C- <u>M</u> -F	an-euhedral in vugs fractures wc=C-VC rd platy skel or clasts GS (RS)
11	#16a	3421.5m	16-3421.5	plug in 3 pts	17	3+4	DOLOMITE	P.054 K0.45md	IAB1-2C4	M-C (Fpatches)	an-sub(eu)hedral wc=??
12	#15a	3426.5m	14-3426.5	ptplug&4frgs	12	3+8	DOLOMITE	NA	IABtrC2-3 (SWC=D10-20vugg	F-M (C)	wc= frag WS/PS w/ VC crinoid & ??microb stylolites
13	#14a	3430.0m			17	3+6	DOLOMITE	P. 02 4 K<.01md	IAB1C1-2Dtr	F & M bimodal	wc=skel-crinoid/echinoderm (tabular)-shell W/PS micritized rims
14	#13a	3434.0m	13-3434.0	1/2 plug	17	4+8	DOLOMITEvuggy	NA D vugs 20%?	IAB2C2Dtr (SWC=D10-20 v.vu	F & M/C bimodal	eu-anhe wc= snail/bivalve crin WS w/ VC rd clasts; vug>dri mud/SHC; M pyrite blebs
15	#12a	3438.0m	12-3438.0	2plug&2frgs	18	3+5	DOLOMITE	P. 05 6 K 0 .36md	IAB2C4	(F)M-C	sub/anh wc= skel-spg/strom-frag FS-W/PS
16	#11a	3445.0m	11-3445.0	frull plug	18	5+6	DOLOMITE	P. 02 2 K 0 .01md	IABCtr-1D1-2	M&C(VC) vug	anh wc= broken skel rd clast PS(GS)-RS; vugs =XC leached coral/strom
17	#10a	3450.0m	10-3450.0	smlplug&3frgs	13	6+11	DOLOMITE	P. 03 4 K 0 .02md	IAB2-3C1 (SWC=D10+ vugs)	(F)M-C(skel-crin)	pinpoint porosity filled dr'mud or SHC wc= platy shells=bivalves? FS ??healed fractures??
18	#09a	3454.0m	9-3454.0	lg plug&frg	16	4+7	DOLOMITE frct?	P. 014 K 0 .01md	IAB1(D edge?)	gradedF>C(VC-vug)	wc=single layer coral/strom? (or mottling); stylolites. NB bad stain or dedolm?
19	#08a	3457.0m	8-3457.0	plug in 3 pts	15	4+6	DOLOMITE	P. 02 5 K 0 .01md	IA & IAB1C1(-5)	F-M (C)	anhedra wc= ??? Single stromatoporoid-microbial consortium (massive-irreg'); tr healed fractures
20	#07a	3462.5m	7-3462.5	full plug&frg	26	4+6	DOLOMITE	P. 03 3 K<.01md	IAC1D2	F-M (C)	eu-anhedr wc= ?crinoid-fragment PS-WS (healed hairline fractures)
21	#06a	3467.5m	6-3467.5	ptplug&11frgs	15	4+5	DOLOMITE	P. 01 9 K NA	IABtrCtr-1	F-M bimodal mottle	subhedr.wc= skel/frag-gastropod FS-PS (or nothing but rext!??)
22	#05a	3475.0m	5-3475.0	1/2 plug	32	3+5	DOLOMITE	P. 09 1 K 0 .04md	IAB3C4 (SWC= D5?)	(F) M-C	subhedr.wc= ?? Frag-skel PS (or not??)
23	#04a	3481.0m	4-3481.0	1/2bknplug&2fr	16	4+7	DOLOMITEvuggy	NA vugsD=20%+?	IAB4C3 in F (C6D+20% vugs)	VF/F&C/VC bimodal	F=eu(sub)hedral w/ porosity, C= anhedral tite wc=crinoid-skel-frag P?FSw/cmt vug=strom?
24	#03a	3494.0m	3-3494.0		16	4+10	DOLOMITEVUGGY	NA vugsD=20%+?	IA&IABC3Dtr-3 (SWC=C10D20+)		anhedral wc= ??? Mottle M/WS; NB?cave (2 frags) LST- qtz-skel-echinoid-microbW/PS
25	#02a	3503.0m	2-3503.0	plate&7frgs	16	6+11	limestone	NA	nil		rd lithoclast-crinoid-shell frg-skeletal frag GS-RS ostracods, thin wall gastropods; tr VF-F quartz
26	#01a	3505.0m	1-3505.0	9 fragments	17	3+5	DOLOMITEcalcspar	NA	IA (?D edge)	F-C	eu/subhi 15% C-VC calc cmt (& SHC?) micro-stylolites wc= nil (I/III cmt'd? dol) skel MS/FS corals 2 types?solitary
27	#24b	3510.0m	24-3510.0	plug& 9 frgs	44	4+8	calc DOLM	P. 01 K 0 .02md	I-IIIbC2-10?		some blk SH ptgs; remnant LST = skel-bryozoa-shell frg spg/str FS(PS)
28	#23b			1plate&11frgs	30	5+12	LST (dolm?)	NA	NVP?		tubiphytes WS?=TS; sponge-microbial clast-crinoid-gastropod-micorsolenid?(bored) RS-GS
29	#22b			24small frgs	12	6+19	DOLM (Lst chips)	NA tite?or?vuggy	IABtr tite?SWC rubbly	M-C	rextl sponge/coral BS-TS
30	#21b			2 short plugs	29	4+6	DOLOMITE	P. 03 7 K 0 .03md	IAB1-2C1	F & C bimodal	an(sub)) wc= skel-bivalve-coral/strom FS small ?megalodont articulated bored peloids = HARDGROUND?
31			20-3532.0	shtplug,tplate	15	3+6	DOLOMITE	P. 04 2 K 0 .03md	IAB1C3+	F-C	anhedra crinoids; wc= F frag PS (or??sponge/strom BS?); line VF pyrite blebs
32	#19b			2plugs&4frgs	27	4+6	DOLOMITE frct	P.08 K0.81md	IAB1C4D3 frct	(VF)F-M(C)	parallel fthin wc= ?microbial/stromatoporoid? & skel frag-WS/PS
33	#18b	3536.0m		2bknplates&13t	39	3+4	DOL & LST	NA 2 liths -skel lst & dolm	IAB1C1-2	(VF) F (M)	wc= MS? - F frag W/PS? probable HARDGROUND = cracked lime W/PS above geopetal mud
34	#17b	3537.5m	17-3537.5		21	3+5	DOLOMITE	P.025 K0.01md	IABC2-3	F(M)	anhedra wc= ?MS mottled WS?
35	#16b	3539.5m		plug,plate&2frg	23	3+6	DOLOMITE	P. 07 1 K 0 .04md	IABC4D3 vugs	(F) M-C	anhedra vug edges only M xtl size(?) wc= F-M peloid-rrd clast GS-PS? Tubiphytes? coated leached bivalves
36	#15b			bknplug&13frg	15	4+5	DOLOMITEcalcspar	P. 02 2 K 0 .02md	IAB1C2 (SWC infilled vugs D1	\ / ·	anhedra single XC calcite spar pore fill; wc= peloid-frag-rd clast WS-PS
37		3547.0m		many rd frgs	14	4+8	DOLOMITEVUOGY	NA saddle dol cmt	IAB1C2-3Dtr-3 (SWC=D20+ v.		anhedra C-VC euhedral at D vug edges; wc= xtl pattern & ?frag rd clast-peloid WS-PS?
38	#13b	3550.0m		ptplug&7frgs	25	3+4	DOLOMITEVUGGY	P.239 K0.03md	IAB2C4-6D8+	F uniform-massive	subhedr porosity higher than TS wc= MS VF micropeloids W/PS uniform; saddle dol cmt
39	#12b	3553.0m		2bkn plugs sma	22	4+8	DOLM w XC calcsp	NA saddle dol cmt	IAB1C2D10	C-VC (XC calcite)	XC calcite crystal 50% vug fill & XF in rhombs; wc= XC xtl texture(or C rd clast PS)
40	#11b	3556.5m			36	5+10	LST (dolm40%)	P. 04 8 K 0 .04md	IABC4Dtr-1 interptcl-dolm lined		crinoids, leached hexacorals? w/ dol cmt in pores ?? bryozoa, shell foram Tubiphytes, str/spq
41	#10b	3562.0m		shtplug,plate&fi	25	3+12	LST (dolm15%)	P. 07 2 K 0 .61md	IAB2C4Dtr interptcl+micropore		Crinoids, rd∠ clasts RS rims dolm & some mtx
42	#09b		9-3568.0		29	6+15	LST (25%dol)	P. 06 3 K 0 .79md	IAB3C3Dtr interparticle	some dolm cmt in voids	chaetetid>stromatoporoid?-coral BS (boring or sponge/T/foram?) & skel RS crin, clam frg
43		3572.5m		3 smal frgs	11	3+7	DOLOMITE	P.147 K85.3md	I?IIIAB1C4D7+	M-C (VC)	wc= ?massive-mottled crystalline drill mud in D vugs
44	#07a		7-3575.5		19	3+9	limestone	P. 00 9 K 0 .00md	IA tight	2 (1-2)	massive recrystallized hexacoral BS = Isastrea VF cmt etc ,5% dolomite patch
45	#06b	3578.0m			32	4+6	limestone (5-10% dolm)	P.115 K1.19md	IA?B2C5+?inter/intraskeletal	some dolm cmt in voids	skeletal GS/FS & XC calcite cement; crinoid/echinoid; some ?microb encrust framebuilder
46	#05b			3lg frgs&2sml	13	3+7	DOLOMITEvuggy	NA	IABC4D6+	(F)M-C(VC)	wc= FS leached ?strom/coral? & fraq-skel W/PS; saddle dolm cmt
47	#04b	3587.0m			18	4+6	DOLOMITE	P. 06 9 K 0 .28md	IABC5D2 vuq	(F)M (C)	wc= peloid-frag-crinoid-skel PS (?M)
48	#03b		3-3593.0		33	5+10	LST (5-25%dol)	P. 04 8 K 0 .12md	IAB4?C1 interparticle?	(.) (3)	coral-bivalve-crinoid-skel/frag PS(GS) FS some ?microbial clast/fragment, strom,chaetetid
49		3604.0m		bknplug&11frg	38	5+9	limestone	P.016 K0.00md	IAB4?C1 interparticle?		hexacoral rextl w. borings & crinoid-skel/frag rd clast PS-RS/FS microbial clast foram ?Lithocodium?
50	#02b			thkplate&4frgs	26	5+10	limestone	P.013 K0.01md	IAB4?C1 interparticle?		hexacoral (?Thamnasteria) BS w sponge borings rextl ?

Appendix A3 ENCLOSURE A3.10 MarCoh D-41 L.Eliuk 2016

<u>En</u>	closu	<u>re A3.11a</u> EN	CANA <u>Ma</u>	rgare	<u>e F-70 (</u> JABK) d	uttir	ngs		GeoTo	urs C	onsul	ting In	c L.I	Eliuk P.	.Geol.										YPE 8.88		PAGE
DEPTH	LITH	modifier I	COLOR	TEXT	URE modifier	POR	OSITY	ACCE	SSORIE	S			F	OSSILS	3	(en	hance	ed by s	swc	data i	<mark>f</mark> availa	ble)			ES 1		COMMENTS
(metres)	T H S S a c	S=limestone OL=dolomite H=shale S=sandstone LTST=siltstone rg=argillaceous alc=calcareous idy= sandy/qtz	ABBREVIATE OF MUNSELL	Ws Rsus(ps) rigi S Rs Rs Rs Rs Rs Rs Rs	mudstone 1 awackestone 3 packstone 5 grainstone 7 boundstone 9 RS=XC size) floatstone 4 rudstone 8 =crystalline	%	modifier (Archie)	SGIOO	PELCIDS	LITHOCLASTS	RAM	STROMATOPOROID C	CHAETETIDS GA		HEXACORAL	BRACHIOPOD	CRINOIDS	GASTROPODS	BIVALVES	OSTRACODS SERPULIDS	Set	BORINGS	HIGHER -green etc P STROMATOLITES P		STANDARD MICROFACI		additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
A	В	С	D	G	Н	_	J	ΚI	_ M	N	O F	Q	R S	3	Т '	v w	Х	ΥZ	AA	AB A	AD A	E AF	AH /	AI A	J AK		AL
3140 3145 3150	SH+SS	5/5 VF(F)sl.calc	D-M GyB		ss=qtz w carbonaceo	ous			tr p	yrite ;	mino	r siderii	e=dk b	on (like l	ime M	IS)					Н				3-5F		ClayeySS+sitySH P SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB
3155	SH	silty, pyritic, soft	DkBnGy		??organic rich				2	% mic	ropyr	ite trsi	derite	Md Brwi	n]										2		disaggregates easily in water F
3160 3165	SH+SS	7/3 sltySh+calc S	D-M Gy		SS=VF-M rd qtz, cald	.					tr I	M-VC p	yrite												2-5F		Р
3170 3175	SS+SE	I 6/4 VF-F qtz SS	D+M Gv		SS=calc & pyritic																				2-5F		SS has F-M carbonaceous-liginitc fragments
3180					go dalo a pyllilo					Ţ																	- In our our our our our our our our our our
3185 3190	SH	sl silty, tr pyrite	Dk Gy							_ tı	sider	ite Md	Brwn N	/ISI											2		
3195	LS+SS	5/5 VF-M(VC) qtz	MdBnGy	WPS	sandy-frag-skel	ABE	NAKI VII	2	2 20	4	1					1	4	1	3	?	?	· I	•	1?	5A-5	F	pyritic shaly?? SS = glauconitic 2P
3200 3205	SS+SH	5/5 VF-F Qtz glau	D+LMGy		SS calc&glauc micac	eous											1								3-5F		silty SH; SS = lignitic qtz w/ DkGrn biotite-glauconitic mica
3210				144/D) O	from alcal (F.C)				20				1 - 1 4 -	Daniel M	<u>. </u>	14									2.54		
3215 3220	LS+SH	7/3 argLS/calcSH	D+LIVIGY	W(P)S	frag-skel (F-C)				20					Brwn M	5 1	(1)	3	·	2						3-5A		pyritic Calc SH & argill -sandy frag-skel LS P
3225 3230	LSarg	2-6% Lt Grn clay	L(M)GyBn	ws	fragmental (F-M)		nil? tr calcsp	ar	15		ABI	ENAK	I VI				2		1?						3?-5	?	tr pyritic Tr Clear Calcspar Very small ctgs = BB 25% P
3235	LS	1-2% Grn clay	LMGyBn	M-WS	fragmental				9								1		?		?				3?-5	?	tr pyritic Very small ctgs = BB 30%
3240 3245	LS	2-5% slty calc SH	l MRnGv	M-WS	fragmental (F-M)				? 8								1							?	3?-5	2	tr pyritic Very small ctgs = BB 30% P
3250		2 0 % sity calc of f																							00		
3255 3260	LSarg	green clay	MdBn	W-PS	sponge-skel-frag				7		15				7	?1	3	1	1	?	? 1			3	3?-4	<u> </u>	tr pyritic ??calcispheres? 3P
3265 3270	LS	sl arg	MdBn	WPS	sponge-fragmental	tr?	calcspar		15		9		1			1	2		?		?	1		1	3?-4	A	hexactinellid spg; tr free VC dogtooth calcspar BBB 2P (x16 of spg)
3275	LS	tr Grn SH	MdGyBn	M-WS	frag-skel	tr?	vug-shelter		5		3	?							1	?	?	?			3-5A		styloilites porosity on logs??= only cl spar ctgs BBB P
3280 3285	LS	tr Grn SH	MdGyBn	M-WS	frag (-skel)				3 5		?	2					2		2		?		1	2	3-5A		tr pyrite; tr clear calcspar 2P (x16)
3290																											
3295 3300	LS	tr Grn SH	MdGyBn	W-PS	stromatop-frag			į	5 10		?	17	7	?	?			1	2	1				?	3-5B	7	tr pyritic Clear-brwn spar = rextl coral?? BBB 2P
3305	LS		MdGyBn	W(P)S	skeletal-fragmental			į	5 15		3	3	7	?			?	1	2		?				3-4C	?	tr VC clear calcspar BBB
3310	1.0	are ab infill	MdGyBn	D/D/S	atrom and alcal fra				5 10		0	40	12		1?			1 ?	3	1 1			12		4C-3		tr pyritic BBB 3P
3315 3320	LS	grn sh infill	widGybii	F(B)3	strom-spg-skel-frg				10				1?		1.5		2	1 1	3			encrus	1? tint		46-3		tr pyritic BBB 3P
3325 3330	LS	+ grn SH seam	MdGyBn	FWS	skel-frag				12		3 ′	4	1		?	?	3		2	1 1	1			4	1 5A-4	C?	tr pyritic ribbed shell = pecten? brach? BBB 3P (x16)
3335	LS	poor sample	MdGyBn	ws	fragmental				7		?						2						2	2?	3?-5	?	v=ry poor sample very BBB
3340 3345	LS	+ Gy pyritic SH	DMBGy	ws	frag (microbial?)				? 5+		1	2					2		2		1	1?	Ę	5+	3C?-	5A	micropyritic P
1 00.0			220,	1	(ı	1	. ~	J	. 1	1 ~ 1	I	1 1	11	1	-	ı	~	ı	1 1,	1 !!	Ι,	1	100.	-, .	

Α	P	<u> </u>	<u> </u>	T F	6 1	н			I V		M I M		В	<u> </u>	ВΙС	1 1	T II	\/ \a	/ V I	V 1 -	A A	VDI V		ELAEU AL	LI AI	_ A -	IAK	I AL
A	В	0	D		G	п	'	J	К		IVI IV	0	Р	Q I	K S		'	V VV	^	1 2	AA			E AFN AI		AJ	AK	AL
3350		SWC#46-3450m				sponge-skel		nii			. rd	20					2		3			2	2 1		10		4A-3C?	
3355	LS	poor sample			MWS	fragmental				'	109	1		1					1?		1?						3?-5?	slightly pyritic very poor samples very BBB light
3360																												
3365	LS	poor sample				frag (microbial)				3	15	1		2			?				?		1		7		3?-5?	poor samples BBB P
3370		SWC#44-3466m		_		spg-strom-skel		000			1:			25			2			2 2	8	1	1 1		10		3C-4C	tr grn SH TS 10% VF qtx sandy
3375	LS sdy	SWC#43-3474m	(L)MBGy	l li	F/R-PS	skel-microb-ORAL		nil ?REW		א>ט	10) 1		2			50	1	2	3 2	5		2 2	3	10	2	5B-3C?	VF-F-silt qtz in matrix tr pyrite BBB P
3380								SURF	ACE !																			SWC43=coral w micritic rim bored
3385	LS	sl arg	(L)MBGy		M-PS	microbial-frag				1	20	3		2			2		1			1 1			15		3C-5A	tr micropyrite BBB 2P
3390																styli	nid											
3395	LS	sl arg; dolm 3%?	(L)MBGy		W-GS	Microb-skel-frag	tr-1	V-shelter		12	20	6					2		1		1		? ?	·	10		3C-4A?	??calcispheres? BBB 2P
3400																												
3405	LS	sl arg; dolm3%?	(L)MBGy		WPS	fragmental				?	30			1											?		3?-5?	very poor spl BBB P
3410	LS	SWC#42-3407m		1	P/F/BS	frag-microb-spg?	2	IAB1C1			15	15	1	0?			ocul	linid							15		3C?-4C	15
3415	LS?Dol	SWC#41-3413m	(L)MBGy	П	M-FS	microbial?spomge	3	1AB2-3Ctr				10			?	3	1						3	s I I I	10?	2	3C?-4AC?	15% F-M matrix dolom very poor spl BBB P
3420																												
3425	DOL/LS	SWC#40-3421m	LMBGy		XTL	VF-C+arg skel RS/WS	3	IC (+V)		1	5?	7		15		3?	7	1			5						4C-5B	8/2 dol/ls; tr pyrite(VF-F). Seems mostly DOL vs log?? Fract-dolm P
3430		SWC#39-3427.5m	-,			VF-F & M, VUGGY													3			A	BENA	KI V			3?-5?	# % remnant calcite-calcitic dolorhombs seen in thin section
3435		SWC#38-3431m	L(M)BGv			VF-C	5+	V dolospar																			3?-5?	+2% VC clear-wt calcspar
3440	LS/DOL	WC 3441-3465.4m					5-10																				3?-5?	Depth correction: 3434m core = 3441m in wellbore
3445	LS		•	П,	BS&GS	spgBS&skelG/RS	0 .0		RE		20 1	15				2	solite	ary	7	3	5	2	2 1	1	10		3A-4A	2.5m graded skeletal-clast debris flow in slope? sponge-;microbial F/WS
3450		SWC#37-3450m			XTL	framebuilder? FS	5-10	V PH	IOTOS		-0 1		4	52			•		15	_	5				10?		4C-5/3B	FS(RS) platy framebuilders (lighter and finer xtl size = bimodal xtlinity/porosity)
3455		SWC#36-3454.5m			XTL	vuggy & breccia	5-10	., & I	LOG				-	Ep lat	y				10		3				10:		4C-5/3B	vugs to 10cm with XC calcite infill very common; stylolites
		SWC#35-3460m			XTL	crinoid-strom-coral		OI.	ETCH			5		40			10		10		2			2	??		5B/3B	articulated echinoid/crinoid calyx = very low enery waters; stylolites
3460 3465	LS/DOL DOL	3VVC#35-3460III			XTL		5-10					5		02			202		5					2	11		5B/3B	XC calcspar in vugs for comparison P ctgs
		014/04/0004 0407								7			_	.0.			20 :							3				7.6 Salespai iii rage
3470	DOL	SWC#33&4-3467r				VF-C vs bimodal		IABCtr-1			_								30? ouncta	te							3A-5A	5-40% XC calcspar; micropyrite; stylolitic; crinoid-skeletal P?GS
3475	DOL/LS	SWC#31-3474m				10% lime M-WS		IABtr-2D2-5			5	1				Щ.							1 1 5				3?-5?	mostly st-LBGy DOL w/ occ MdGy 2P
3480		SWC#29-3479.5m				XTL-F-M&C-VC		IABC1-2Dtr				Dimc	dai xti	size	arter tr	ameb	ullaei	rs(tinei	_	itx (cc	arser			S?-frame		_		tr micropyrite, stylolites
3485	DOL/LS		SWC#28-3			10% lime M-WS	3-6												10?			1 2	WC-ble	DS MICTO	ppyrite, i	remn		n dol, stylolites; orig crinoid-skeletal WS
3490	DOL		LtBnGy		XTL	F-M C wt spar)	3-8	IAB1C1-3D																			3?-5?	tr F pyrite
3495		SWC#25-3493.5m				F-M(-C)		IABC1-2Dtr				sw			reccia/												3?-5?	5-10
3500		SWC#24-3497m	LtBnGy			F-C (XC calcspar)		IAB1C2-7D		2	20		SW	C-rd-	angula	r VC f	fragm	nenatal	FS								3?-5?	
3505		SWC#23-3506.5m	,		XTL	(F)M-C	10	V+IC (C&D	_														\perp				3?-5?	tr pyrite P
3510	DOL	SWC#22-3509m	LtBnGy		XTL	F-M	8	IABC2-5+D											5?	57)		SWC-	gastropo	d colun	nella	or crinoid v	ug; ghosts XC clasts & fossils, foram
3515		SWC#20-3514.5m	SWC#21-3	3513.	.5m	XTL F-M (C)	5-7	IAB2-3Ctr-3	3Dtr-7	/uggy	sv Sv	/C-mn	wide	ope	n fract	ure &	som	ne frac	t' wt	dolos	par c	mt'd					3?-5?	some LS cave or poor lagging
3520	DOL	SWC#19-3517m	LtGy		XTL	F-M (C & VC)	10+	IABC3D7+											10		10						3?-5?	originally probably crinoid wackestone
3525	DOL		SWC#18-3			XTL F-M-C	?5	V?calcspV0			10			2				riaform	1		1	?		? SV	NC- DC	Lfra	ctured? UV	IAB1C1-3Dtr-10? also LS=Frq WS w/ strom, crinoid, bivalve
3530	calcDOL	SWC#16-3529m	Lgy&MBG	y I	FS	coral-bivalve						5?		5	?		20 M	riaform						2	+5?		5B	
3535	LS	tr pyritic SH	LMBnGy		ws	fragmental		P dol cave		2	20 5	?		5?				?	1		?				5?		3C-5AC	tr-1% micropyrite BBB P
3540	LS	SWC#15-3538m	Md&L(B)G	y I	B/RS	chaetetid recrystalli	zed							7	'0												5B-3B?	zoned ?submarine cmts
3545	LS	poor sample	LMBnGy		WPS	fragmental?				? :	30																3?-5?	tr-?% F qtz porous DOL cave/interbeds? BBB P
3550			,																									
3555	LSsandv	SWC#14-3555m	L MBGy		B/RS?	chaetetid-microb?B	S-RS			? !	5?				0							3		3	15		5B-3B?	very poor ctgs tr frag GS BBB P
		SWC#13-3562.5m						IAB2C2-3D				NC =	oivalve	e mol	d, crinc	id? R	ound	led ske	letal fi	ragme	ntal F	P/GS?						VF-F pyrite esp near vug edges
		SWC#12-3565m						(C)D lining				Ť											1-10Dtr	r-1				tr-@%VC calcspar=D pore vugs;m tr grn pyritic Clay
3570		SWC#11-3571m				F-M (C-VC+vugs)		IAB2C2-10					<u> </u>										71 TODA	T			3?-5?	a (a), o . C calcopal o poro rago, in a giri pyritio Olay
3575		SWC#11-3571111						IAB2C5-9D		cture	122 de	lomit	e colo	or mo	ttled li	ght a	nd lig	ghter	—┞	ABI	:NA	<u> </u>					3?-5?	??trip = some LS cave inc chaetetid, stromatops, + MdBnGy argLS
	DOL					F-M		IAB2C3-9D			u :																3?-5?	tr pyrite; C IC pores
			VLtGy LtBnGv			VF-C(VC)		IAB2C4-8D		actur	ed?																3?-5?	u pyrite, O io poles
			LtBnGy MdBnCy					IAB3-6C6+		actur 	cu !																	tr micronyrito
3580 3595			MdBnGy			F-M-C F-VC		V/IC C&D																			3?-5? 3?-5?	tr micropyrite
1 3333	DOL	l l	VLtGy	 	AIL	1 -40	107	VIIC CAD	1 1	ı	I	I	1	ı	ı	1 1	Ш	l	1 1	ı	1 1	1	1 1	1 11	I	I	31-31	P

Α	В	С	D	G	Н	ı	J	K	L M	N	0	P	Q R	S	1	· /	/ W	Χľ	/ Z	AA A	ВАС	AD A	E AF	AH	Al A	AJ A	K	AL							
3600	DOL	SWC#7-3596m	LtBnGy	XTL	VF-C(VC)	7+	IABC3D2-4	??frac	tured																	3	?-5?	tr micropyr	ite near v	ugs					
3605	DOL	SWC#6-3601m	LtBnGy	XTL	(F)M-C	15	C&D				SI	VC -pl	aty fra	gmen	s =											3	?-5?	tr pyrite &	grn clay						
3610	DOL	SWC#5-3609m	LtBnGy			9	IAB2C5D2	V & IC	; ?frac	tured	?			Ĭ			T									3	?-5?								
3615	DOL		Wt-VLGyB	XTL	F-C	5+						\perp														3	?-5?	tr VF pyrite	:						Р
3620	DOL	SWC#4-3616m	LtBnGy	XTL	VF-F & M-C(VC)	9	IABC8Dtr ?f	racture	ed?			SW	:-bimc	dal xt	size -	finer	after	wt rep	laced	frame	builde	ers??				3	?-5?								
3625	DOL	SWC#3-3623m	VLBGy	XTL	F-C	10	IABC#Dtr-10)?	201	?		S	WC -g	hosts	M-VC	irregu	ılar									3	?-5?	tr Wt-clear	C-VC cal	cspar =	= vuggy	& Intercr	rystalline	pores	Р
3630																																			
3635	DOL	SWC#2-3631m	VLtGy-Wt	XTL	F-M-C	15+	V - C5D10																			3	?-5?	vuggy & In	tercrystall	line por	res				
3640	DOL	SWC#1-3636m	LtBnGy	XTL	F-M-C	15+	IABC3-5Dtr-	40 vuç	ggy																	3	?-5?	some bugs	=shell sh	ape					
3645	DOL		VLtGy	XTL	F-C	15-10	IAB3C7D5+							V = v	uggy	ooros	sitv	٦.								3	?-5?	vuggy & In	tercrystall	line por	res				Р
3650															ntercr																				
3655	DOL		VLtGy	XTL	F-C	10?	V C(&D)								poros	ity										3	?-5?	vuggy & so	me Interd	crystalli	ine pores	s (Wt cal	lcaareso	us chalk = M	UD?)
3660																																			
3665	DOL		Wt-VLGy	XTL	F-C(VC)	10?	V C&D																			3	?-5?	little IC por	es but fre	e M-C	XTL fac	es= vug	ду		Р
3670																																			
3675	_		VLBGy-Wt	XTL	M-VC	10?	V +(?IC)																			3	?-5?	little IC por	es but fre	e m-VC	C XTL fa	ices in C	C & D vu	gs	Р
3677TD																																			
Α	В	С	D	G	i H	I	J	K	L M	N	0	P (Q R	S	1	· \	/ W	X	/ Z	AA A	BAC	AD A	E AF	AH	Al A	AJ A	K	AL	AM	/	AN	AO		AP	AQ

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-'stromatoporoid reefal, 5C=mud/pelleted; 5D=oolitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details

Appendix A3 ENCLOSURE A3.11a Margaree F-70 cuttings L.Eliuk 2016

Enclo	sure	A3.11b	EnCana-Mur	phy <u>MA</u>	RGAREI	F-70 CORE #1	Not	e CORE	#1 DEPTHS	off from	wellbore	logs = :	3-7m hig	h - not a	djusted					
					TEVTUR	GeoTours Consulting Inc I	Eliuk P.G	eol 2004-		ted by initia	I logging not	es+depths	of Rick Wie	rzbicki 200	4-12-08 and LSE	notes/sketch 20	03-08	8'88, 002.	L	PAGE
DEPTH	SPL#	LITH	modifier I	COLOR	TEXTURI	modifier	POROSI	TY	ACCESSORIES =comment box		FOSS	SILS	shape	(enha	nced by S <mark>WC da</mark>	<mark>a if a</mark> vailable)		iuk7	L	COMMENTS
see pl for SF depth top do	L s-log	T H O L O G	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone arg=argillaceous calc=calcareous sdy= sandy/qtz	ABBREVIATE or MUNSELL DUNHAM NUMBER	MS=mud WS=wad PS=pacl GS=grail BS=bou (FS/RS= FS=float RS=ruds XTL =cr	estone 3 tone 5 stone 7 dstone 9 C size) tone 4 one 8	(modifier Archie)	PELCID PARTICLES	SPONGES WT SPONGES	STROMATOPOROJ CI CHAETETIDS SS MILLEPORID SS	MICROSOLENID	BRANCHING tabular-lamellar	BRACHIOPODS	ECHINOIDS GASTROPOD BIVALVE OSTRACOD	SERPULIDS TUBIPHYTES etc FORAMINIFERA BORING	HIGHER -green P STROMATOLITES D Thrombolites Thrombolites	STANDARD MICROFAC Flugel'82&Wilson'75&El Vierzbicki, Harland + E		additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
Α		В	С	D	G	H	1	J	K L M	N O P	Q R _{solita}	ary cor' T		v w	Y Z AA A	B AC AD AE AF	AH AI	AJ AK	_	AL
3434 3434.1 3434.2 3434.3 3434.4	1-1+2 1-3 1-4+5 1-5+6 1-7	LS arg SH LS arg do LS arg do LS arg do LS arg do	pyritic brach walls	DMBnGy 6 DM(B)Gy 7 DGyMBn 6 Dk BnGy 6	6 4 FS in G/F 7 4 FS in GS 6 4 FS in G/F 6 4 FS in G/F 6 4 FS in G/F 1 4 FS in W/P	microsolenid coral-skel sponge-skeletal sponge-echinoderm	2% in	nterxrl dol uggy nterxrl dol	30 40 30 40 30	10 20 5 5 8 5 7 10 10		1-2mm 1	Co	3 1 3 3	1 2 3 2 4 3 3 3 3 1	2 1 1 4 1 4 10 1 2 3 2	10	4b 4bc 4b 2 4	3? v 3? s	top 2cm SH cakc-LS v. argillaceous w microFS of bored bryozoa FD1 K-0.45md P- white sponge = Shuqriaopsis? (+ Gilletia??) framebuilders rextl-leached "DEEPER" some crinoid calyx wall frags + cm ossicles = Belemnites Montilivatia if solitary more likely Thecosmilia br' corals Stroms=rextl-do FD2 K-0.41md P-2.8%
3434.5 3434.6 3434.7 3434.8	1-7 1-8 1-9 1-9+10	LS arg do LS arg do LS arg do LS arg Do	9/1 to3%micropyrite 8/2 to3%micropyrite 8/2-6/4 pyritic	DMBnGy 4 Md GyBm DMBnGy 9 DMBnGy 5	4 4 FSin W/P 6 FRSin W 9 8 RBSinPV 5 8+9 RBSinPS	sponge-coral-strom-ske spg/microb-coral-crinoid microsolnd -spg/microb microsolnd -spg/microb			30 30 30 20	5 20 15 2 25 25	10	10 8 15 15		3 1	7 3 2 5 4 3 1 2 3	i I 2 6 1 2 2 2 4	dasyclads 2 10 20 20	4b m 4b m 4b m	3? 3c 2 3c 3c h	2 genera corals= Ig solitary+branched microsolenid MICROSOLE- NID CORAL RICH RICH
3434.9 3435 3435.1 3435.2 3435.3	1-12 1-13-16 1-17-19 1-18+19	LS dol SH LS arg DO LS arg DO	8/2 pyritic 9/1 stylolitic pyritic DL 7/3 7/3	(D)MBGy 5 DMBnGy 5 DMBnGy 5 DMBnGy 5	5 ++9 FBSin PS 5 9 B(F)S-PS 5 8+9 RBSin PS 5 9 B(F)S-PS 5 ++9 FBSin PS	sponge/microbial sponge/microbial			20 20 20 20 20	35 35 30 25 25	?? ['] tab	ulate?		3	3	2 4 10	25 25 20 30 25	4ab 4ba 4ab 4ba	3c 8 3c 8 3c ti	of microbial-sponge-microsolenid coral deeper slope reefing FD3 K-0.43md P-2.7% PON SLOPE? SH seam FD4 K-0.43md P-3.1% PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE? PON SLOPE?
3435.4 3435.5 3435.6 3435.7 3435.8	1-21+22 2-1+2	LS arg	oL 7/3 stylolitic pyritic stylolitic pyritic pyritic	DMBnGy 4 DMBnGy 4 DMBnGy 4 DMBnGy 4	5 9 B(F)S-PW 4 ++9 FBSin PV 4 9 B(F)S-PW 4 ++9 FBSin PV 9 BS seq	S sponge/microbial S sponge/microbial S sponge/microbial spg/microb>>microsolnd	2% si	cat intxtl	20 20 20 20 20 20	20 20 20 15 30		4 25	Co	2 2	5 2 2 2 2 2 3 2	1 1 1 1 1 2 1 1 1 1 1 2 2 2 5	20 15 20 15 15	4ba 4ab 4ba 4b <i>m</i>	3c s 3c s 3c s 3c ii	high 'depo' angle (20-40dg)due to later tectonics but mainly early in situ lithified stringer-like textures = microbia-'sponge crinoids to 2cm ossicles some crinoid ossicles to over 2cm size in situ succession dk spg>> spg-microbialite >up> bored tabular microsolenid
3435.9 3436 3436.1 3436.2 3436.3	2-2 2-2+3+5 2-5 2-5 2-6+7	LS arg do LS arg do LS arg do LS arg do LS arg do	8/2 stylolitic pyritic 8/2 stylolitic pyritic	DMBnGy 4 DMBnGy 4 DMBnGy 4 DMBnGy 4 DMBnGy 4	3 ++9 FS-BS-WS 4 4 FS(BS)W 4 4 FS(BS)W 4 4 FS(BS)W 4 4 FS(BS)W	S microsolenid-spg-microbi microsolenid-spg-microbi	al		15	15 10 10 10 7		25 15 15	Co Co Co Co		5 3 4	2	15 15 15 15 15	4b <i>m</i> 34b <i>m</i> 4b <i>m</i> 3	3c b	geopetals also above FD5 K-0.37md P-2.5% MICRO- branching+broken platey microsolenids MICRO- high 'depo' angle (20-40dg)due to later tectonics but mainly SOLENID early in situ lithified CORAL- microsolenids rextl to c-VC calcite SPONGE-
3436.4 3436.5 3436.6 3436.7	2-7 2-7 2-7+8+9 2-9	LS arg do LS arg LS arg LS arg do	9/1 horsetails stylolitic contact	DMBnGy DMBnGy DMBnGy DMBnGy	9 BS seq 9 BS seq 9+4 BS-FS 9+4 BS-FS+P	spg/microb>>microsolnd sponge-microbial spg/microb-microsolenid spg/microb-lithoclast+crii			20 25	15 30 15 5 10		25 10 10 3	Co	2 1	0 2	2 2 5 4 3 1 2 1 4 4 1	10 20 30 15	4b <i>m</i> 4b <i>m</i> 4b <i>m</i>	3c g 3c g 3c s 3c h	geopetals in situ succession spg-microbialite >> bored tabular microsolenid sharp stylolitic contact w encrinite below = cleaner+clast rich vs deeper encrinite high anble = biocmt clasts of microbialites w tubiphytes+serpulids
3436.8 3436.9 3437 3437.1 3437.2	2-10-12 2-12+13 2-13 2-13+14 2-14-16		horsetails stylolitic thick calcsp veins	DMBnGy 6 DMBnGy 6 DMBnGy 6 DMBnGy 6 DMBnGy 6	5 4 FS-PS PS-GS PS-GS PS-GS PS-GS	crinoid(M-XC)-clast-bryoz crinoid(F-M)-skel frag crinoid(F-M)-skel frag crinoid(F-M)-skel frag crinoid(F-M)-skel frag	oa 		25 25 25 25 25 25	5				1 2 3 2 3 2	5 5 1 3	2 1		3a 3a 3a 3a 3a 3a	C	very argillaceous encrinite to XC ossicles = break from below+ab(FD7 K-0.15md P-0.8%) occ VC crinoid ossicle but mainly finer grading down to coarser over decimeters grain flow = normal grading multi-flows FD8 K-0.04md P-0.5% SLOPE CHANNEL
	2-16 2-16 2-16+17 2-17+18	LS LS LS	VC-XC frgs	DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7	GS GS GS GS (FS)	crinoid(M-C)-skel frag crinoid-(M-C)skel frag crinoid(C-VC)-skel frag bryoderm-skel frg-clast			35 35 35 30 25 1	5		5			5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	2 1 2 1 2 1 2 1 2 1 1		3a 3a 3a 3a	s	rims often micritized, some isopachous cmt + rarely epitaxial CRINOIDAL some bryozoa encrusted by tubiphytes & most microsolenid clasts bored NORMAL
3437.7 3437.8 3437.9 3438 3438.1	2-18+3-1 3-1 3-2 3-3 3-3	LS do	VC-XC frgs VC-XC frgs F dol cmt F dol cmt F dol cmt	DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7	7 GS (FS) 7 6 GS-RFS 7 6 GS-FRS 7 4 GS-FS 7 4 GS-FS	bryoderm-skel frg-clast bryoderm-skel frg-clast crinoid-skel-lithoclast crinoid-skel-lithoclast crinoid-skel-lithoclast			25 1 20 2 20 2 35 1 35 1	25 20 5 0 3 0 3	5 5 3 2 3 2	5	solitary 1	8 1 2	5 5 3 5 20 5 3 20 5 2 20 5 2	2 1 1	3 4 3 3	2 3a 3a 2 3a 3a 3a		isopachous calcite cmt FD9 K-0.07md P-1.2% GRADED FLOW
3438.2 3438.3 3438.4 3438.5	3-3+4 3-5 3-5 3-5+6	LS LS LS	chilolita puritic	DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 7	7 6 GS-FRS 7 6 GS-FRS 7 6 GS-FRS 7 6 GS-FRS	crinoid-skel-lithoclast skel-lithoclast-crinoid skel-lithoclast-crinoid skel-lithoclast-crinoid			10 3 15 3 20 3 25 2	35 30 30 35 3 3	2 2	3 3		5 1 2 5 1 4	20 5 15 3 5			3a 3a 3a 3a	U	FD10 K-0.08md P- U*P 1/2 isopach M-C calcsp w lat dolm cmt & LO 1/2 clear blocky calc cmt v. pyritic
3438.6 3438.7 3438.8 3438.9 3439	3-9	LS do	F dol cmt larger lithoclasts	DMBnGy 7 DMBnGy 7 DMBnGy 7 DMBnGy 4	6 RFS-WPS	skel-lithoclast-crinoid skel-lithoclast-crinoid skel-lithoclast-crinoid lithoclast skel-coral			20 3 25 2 20 3 25 2 15 3	30 3 25 3 30 3 25 3 35 5 3	2 2 2 5 5	3 3 3 5 5	timy br	4 4 4	5 5 5 5 5 5 7 7	2		3a 3a 3a 3a 3a	r	dolm lined/cmt cm vertical vein/fracture rare submarine?cmt =Cf unslabbed core Late dolomite filled fractures =4 genera corals in clasts Reworked MWS+skel clasts
3439.2 3439.3 3439.4 3439.5	3-9+10 3-10 3-11 3-11 3-12-16	LS arg DO LS arg d LS arg d LS arg d	ol ol	DMBnGy 3 DMBnGy 3 DMBnGy 4 DMBnGy	WPS 9 BS	skel-frg-crinoid crinoid-microsolenid-skel crinoid-frag-skel sponge-microbial		NTERXTL?	15 3 10 10 15	3	5	1 15 3		5 : 3 : 2	15 3 5 10 3 20 3 25 3 2	1 1 1	30		3 to 3 to 3 c	basal debris flow larger clasts w framebuilders but muddier mtx transgressive crinoid-rich argillaceous LS upper surface Microsolenid bored then spg-microbial encrusted FD12 K-8.32md P-
3439.7	3-16-22 4-1 4-1 4-1to4	LS dol DO		DMBnGy 3 DMBnGy 3	2 9 BS+WMS 3 9 BS+WFS 3 9 BS+WFS 6 9 BS+WFS	spg-micrb+crinoid spg-microb + crin-skel spg-microb + crin-skel spg-microb + crin-skel coral-spg-microb+skel			5 10 5 10 5 10	10 15 3 15 3 20 5	2 2	3 3 1	B CO B CO	3 1	5	1 1 2 1 2 1 1 3 2 1 1 3 2 1 2 2 1 2 2 1 2 2 1 1 2 2 1 2 1	15 15 15 10	4b 4b 4b	3c C	FLOODING SURFACE clam-bored Thecosmilia w spg-microbial BS . Horsetails-stylolitic aroill concentrate FD13 K-0.78md P- possible encrusted cephalopod FD14 K-1.45md P- MICROSILENID

.2 4-8	LS DO	DMBnGy	3 9 BS+WFS	coral-sng-microb+ekel			10			20 5	1 1 1	5		2 40	4c.m	S POLICIAL TO BE THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF THE PART OF T
.3 4-8	DOL	F-M (C) ?bimodal xtl (L)DkGyE		coral-spg-microb+skel coral-strom?-skel+PSmtx	? 3-7%	vugs5%IBC2D0-10	15? 3?	10? OF	pen 1	10?		4	5	5?	70 111	DOLOMITE INTERVALS GENERALIZED & INTERPRETIVE BUT SEE NOTES BELOW FOR PARTICULAR FEATURES
.4	DOL	VVVV	x 4 V V V	V V V	٧	V V	v v	+	olm/	v		v	v	v		FD14A K-n/amd P-7.3%
.5	DOL	F-M (C) ?bimodal xtl (L)DkGyE			? 3-7%	vugs5%IBC2D0-11	15? 3?			10?		4	5	5?	\$	some vugs after several cm fossils and large crinoids w axial canal
.6	DOL	VVVV	x 4 V V V	V V V	V ===:	V V	V V	V p-	nt-	V		6 art	icualtéed whole ca		3	see unslabbed core photo of 2cm diameter crinoid calyx FD15 K-563md P-3.4%
.7	DOL DOL	F-M (C) ?bimodal xtl (L)DkGyE			? 3-7%	vugs5%IBC2D0-12	15? 3?	10? he		10? V 15	00	4	5	5?	-	above + below = low energy setting = reef debris on slope
i.8 i.9	DOL	V V V V V V F-M (C) ?bimodal xtl (L)DkGyE	x 4 V V V x 4 XTLdoloFS	V V V coral-strom?-skel+PSmtx	V 2 3-7%		v v 15? 3?		actu	V 15	CO		V ₅	5?	5b	small 1-2 cm branching ?corals insitu?? framebuilder/lithoclast FS-RS layer at inclined angle
1 4-24/25	DOL	VVVV V	x 4 V V V	V V V	V V	V V V	V V		s+ 1 igs 1	v		v	v I	I I V		FD16 K-96.5md P-3.2%
.1	DOL	F-M (C) ?bimodal xtl (L)DkGyE		coral-strom?-skel+PSmtx	? 3-7%	vugs5%IBC2D0-14	15? 3?	10?	· -	10?		4	5	5?	\$	SLO
.2	DOL	VVVV	x 4 V V V	V V V	V	VV	V V	V	١	V		V	V	V	5b 3	possible cemented crusts +/or framebuilders layers 💢WITH
.3 4-32+5-1		F-M (C) ?bimodal xtl	x 4 XTLdoloFS		? 1-5%	vugs2%IBC2D0-7	15? 3?	7?	1	7?		3	2	3?	5b	small <1cm branching ?corals insitu?? Indicated by FD17 K-0.53md P-1.2% BRIE
.4	DOL	VVVV	x 4 V V V	VVV	V	V V	V	V		V		l V	V		3	Leached open foosomoldic vugs
.5 .6	DOL DOL	F-M (C) ?bimodal xtl V V V V V V	x 4 XTLdoloFS	framebuilder-skel+PSmtx* V V V	? 1-5%	vugs2%IBC2D0-8	15? 3?	7?		7?		3	2	3?		ATIO
.7	DOL	F-M (C) ?bimodal xtl	x 4 V V V x 4 XTLdoloFS		v ? 1-5%		v v 15? 3?	7? 0	pen	v 7?		V 3	v 2	3?	5b	Small 1cm branching ?corals insitu?? (piece5-8+9)
.8	DOL	VVV occ' thru out pre-		V V V	V V	V V	v v	v +	,	,		l l v i	v ⁻			STAI SLO
.9	DOL	F-M (C) dolm stylolites	4 XTLdoloFS		? 1-5%	vugs2%IBC2D0-10	15? 3?			7?		3	2	3?		GEO (=HA
2 5-16	DOL	V V V V V V V V V V V V V V V V V V V	┰ ╻ ฝ ₄┃v v v	v v v	V	VV	V V	V Ci	alcs	V		V	V	v	\$	GRO
.1	DOL	F-M (C) ?bimodal xtl	x 4 XTLdoloFS		? 1-5%		15? 3?		mt-	7?		3	2	3?	\$	FD19 K-1.89md P-
2.2	DOL	VVVV	x 4 V V V	V V V	V = 0/	V V	V V		eale \	V		V	V	V V		10 10 10 10 10 10 10 10 10 10 10 10 10 1
2.3 2.4	DOL DOL	F-M (C) ?bimodal xtl V V V V V V V	x 4 XTLdoloFS x 4 V V V	framebuilder-skel+PSmtx* V V V	? 1-5%	vugs2%IBC2D0-12	15? 3?	7? d		7?		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	\ ²	3?	5b	Tabular framoshuildonus w horings
4 5	DOL	F-M (C) ?bimodal xtl	x 4 V V V x 4 XTLdoloFS		v ? 1-5%		v v 15? 3?		actu \	v 7?		3	v	3?	- JU	Tabular frameabuilderws w borings X?
2.6	DOL	V V V V V	x 4 V V V	V V V	v ,3	V V V	v v	v		v		v	v ⁻			ED00 K 44 44 D
.7	DOL	F-M (C) ?bimodal xtl	x 4 XTLdoloFS	framebuilder-skel+PSmtx	? 1-5%	vugs2%IBC2D0-14	15? 3?	7?	<u>ا</u> ا-	7?		3	2	3?		FD20 K-44.4md P-
1.8	DOL	v v v v	x 4 V V V	v v v	V	v v	V	V		v		V	V			<mark>ib</mark>
.9 5-30	DOL	F-M (C) ?bimodal xtl	x 4 XTLdoloFS				15? 3?	7?	1	7?		3	2	3?		<mark>b</mark>
3 <mark>6-1</mark>	DOL DOL	F-M (C) ?bimodal xtl MDBnGy V V V V V V V	x 4 XTLdolFRS	framebuilder-skel+PSmtx* V V V	? 1-7%	vugs5%IBC2D0-10	15? 2?	20	l.	, 15	CO CoSt	5	[,1] [[5		note occasional large crinoid ossicles thru out interval/box [FD21 K-0.58md P-0.9%]
5.2	DOL	F-M (C) ?bimodal xtl MDBnGy			v 1-7%	to +3cm V vugs5%IBC2D0-10	V V 15? 2?	20		15	CO CoSt	V 5	v	V 5		
.3	DOL	VVVV V	x 4 V V V	V V V	- V	to +3cm V	V V	v	Щ,	, 13	v v	l v	v'l l		5b	lamellar-tabular stromatoporoid layer X?
.4	DOL	F-M (C) ?bimodal xtl MDBnGy			? 1-7%	vugs5%IBC2D0-10	15? 2?	20	ppen	15	CO CoSt	5	1	5		bb A P
.5	DOL	v v v v v v i	x 4 V V V	V V V	V	to +3cm V	v v	v	saddl \	v	v v	V	V	v	5b 3	in situ upward enlarging strom? Head vertical in inclined beds
.6	DOL	F-M (C) ?bimodal xtl MDBnGy	x 4 XTLdolFRS		? 1-7%	vugs5%IBC2D0-10	15? 2?	20	9	15	CO CoSt	5	1	5	\$	(Pieces 6-10+11)
.7	DOL	VVVV	x 4 V V V	VVV	V	to +3cm V	V V		۱ /mlob	٧	V V	V _	V .		3	FD22 K-12.2md P-3.1%
i.8 i.9	DOL DOL	F-M (C) ?bimodal xtl MDBnGy V V V V V V	x 4 XTLdolFRS	framebuilder-skel+PSmtx*	? 1-7%	vugs5%IBC2D0-10 to +3cm V	15? 2?		calcs \	15	CO CoSt	5	1	5		
4 6-21	DOL	F-M (C) ?bimodal xtl MDBnGy			v 1-7%	vugs5%IBC2D0-10	15? 2?		cmt-	15	CO CoSt	V 5	v	^v 5		large inclined open dolm-lined linear vug/fracture FD23 K-501md P-7.3%
.1	DOL	VVVV V	x 4 V V V	V V V	- V	to +3cm V	V V	v ²	neale	, I 'S	v v		lv'l l			(pieces 6-19 to 22)
.2	DOL	F-M (C) ?bimodal xtl MDBnGy	x 4 XTLdolFRS		? 1-7%	vugs5%IBC2D0-10	15? 2?	20	ractu .	15	CO CoSt	5	1	5		(r-2-2-2-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-
.3	DOL	V V V V	x 4 V V V	V V V	V	to +3cm V	v v		es +	V	v v	V	V	v	3	FD23A K-n/amd P-
.4	DOL	F-M (C) ?bimodal xtl MDBnGy	x 4 XTLdolFRS		? 1-7%	vugs5%IBC2D0-10	15? 2?		/ugs	15	CO CoSt	5	1	5	3	<mark></mark>
.5 .6	DOL	V V V V V	x 4 V V V	V V V	V 70/	to +3cm V	V V	V		۱.,	VV	V _	V_			FD24 K-4.99md P-4.2%
.6 .7	DOL DOL	F-M (C) ?bimodal xtl MDBnGy V V V V V V V	x 4 XTLdolFRS	framebuilder-skel+PSmtx	? 1-7%	vugs5%IBC2D0-10 to +3cm V	15? 2?	20		15	CO CoSt	5	1	5	•	50 F 52 T X 1.55 M C 1.270
	DOL	F-M (C) ?bimodal xtl MDBnGv			2 1-7%	vugs5%IBC2D0-10	15? 2?	20		15	CO CoSt	v 5		^v 5	2	broken branching framebuilders & Ig crinoid ossicles
.9 6-46+7-1	DOL	VVVV V	x 4 V V V	V V V	- V	to +3cm V	V V	v	\ \	, I .	v v	l v i	lv'l l			(pieces 6-30-43)
5 7-3	DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS		tx 1-12%	vugs7%IBC3D0-15	15? 2?	15?	3	3? 25?	CoSt	5	3			pre-dolm stylolites & horsetails common
.1	DOL	VVVV V	x 4 V V V	v v v	V	to +8cm V	V V		open \	V	V V	V	V		\$	FD25 K-15.3md P-5.8%
2	DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS		tx 1-12%		15? 2?	15?		3? 25?	CoSt	5	3		3	<u></u>
3	DOL	V V V V V	X 4 V V V	V V V	V 1 100	to +8cm V	V V	-		V 25.2	V V		V ₂			FD26 K-2.55md P-0.8%
4 5	DOL DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS	coral-strom?-skel+PWSm V V V	V 1-12%	to +8cm V	15? 2? V		1-1/	3? 25?	CoSt	5	\sigma			th
6	DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS		tx 1-12%		15? 2?	152	calcs	v 3? 25?	CoSt	V 5				nearly fabric preserving dolm= stromatoporoid(microsolenid?)
7	DOL	V V V V V	x 4 V V V	V V V	V	to +8cm V	v	V	o- cmt-	/ [-0.]	v v	v	v			FD27 K-3.76md P-1.2%
8	DOL	F-C (+VC)	4 XTLdolFRS	coral-strom?-skel+PWSm	tx 1-12%		15? 2?		neale	3? 25?	CoSt	5	3	$\parallel \parallel \parallel \parallel \parallel$	3	B <mark>b</mark>
9 7-24	DOL	VVVV occ' thru out pr	- • • •	v v v	V	to +8cm V	V	V	۱ b	v	V V	V	V			<mark>ib</mark>
7-24	DOL	F-C (+VC) dolm stylolites	4 XTLdolFRS		tx 1-12%		15? 2?	15?	/ugs 3	3? 25?	CoSt	5	3			lb control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the con
1 2	DOL DOL	V V V V V V F-C (+VC) ?bimodal xtl	X 4 V V V	V V V coral-strom?-skel+PWSm	V 1 120/	to +8cm V	V V	V	fract	√ 3? 25?	V V	^V _	V ₂			FD28 K-2.21md P-4.4%
3	DOL	VVVV V	x 4 XTLdolFRS	V V V	V 1-12%	to +8cm V	15? 2? V			3? 25?	CoSt	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	v I I			th .
4	DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS		tx 1-12%	vugs7%IBC3D0-15	15? 2?	15?	1	3? 25?	CoSt	* 5	₃			e <mark>b</mark>
	DOL	VVVV	x 4 V V V	v v v	V	to +8cm V	v v	v		v		v	v l			B <mark>b</mark>
7-32	DOL	F-C (+VC) ?bimodal xtl	x 4 XTLdolFRS	coral-strom?-skel+PWSm	tx 1-12%	vugs7%IBC3D0-15	15? 2?	15?		3? 25?	CoSt	5	3		3	B <mark>b</mark>
8-1	DOL	F-M (C) ?bimodal xtl MDBnGy		branch coral?-skel		vugs5%IBC2D0-10	10?	10?		15?	CO	3	6			NOTE branching corals & bivalve fossomolds common FD29 K-6.6md P-7.0%
3	DOL	V V V V V	x 4 V V V	V V V		to +8cm V	V	V	pen \	٧ <u> </u>	VV	V	V		5b	compact delicate branching coral colony in situ w fossomoldic
9	DOL	F-M (C) ?bimodal xtl MDBnGy		branch coral?-skel		vugs5%IBC2D0-10	10?	10? +	oddl ,		CO]], 3	6			pores (pieces 8-2-4) FD30 K-7.37md P-5.9%
8-8a	DOL DOL	V V V V V V F-M (C) ?bimodal xtl MDBnGy	x 4 V V V x 4 XTLdolFS	V V V branch coral?-skel		to +8cm V vugs5%IBC2D0-10	V 10?		addl \	-	v v		v			100
1 2	DOL	V V V V V	x 4 V V V	V V V		to +8cm V	v V		olm/		v	_V	v" I I			lb
3	DOL	F-M (C) ?bimodal xtl MDBnGy		branch coral?-skel	1 .	vugs5%IBC2D0-10	10?		alcs	-	co	v 3	e			FD31 K-4.45md P-2.3%
.4	DOL	VVVV V	x 4 V V V	V V V		to +8cm V	v v	v p			v	v	v			1b
.5	DOL	F-M (C) ?bimodal xtl MDBnGy	x 4 XTLdolFS	branch coral?-skel		vugs5%IBC2D0-10	10?	10?	mt- eale	15?	СО	3	6			<mark>Bb</mark>
	DOL	v v v v v í	x 4 V V V	V V V	V	to +8cm V	V V	v d		<i>/</i>	v v	I I Iv I	lv I	1 1 11 1	5b 3	branching coral colony coarser small w leached pores VC
6 7	DOL	F-M (C) ?bimodal xtl MDBnGy		branch coral?-skel		vugs5%IBC2D0-10	10?	10?			CO	1 1 1 1	1 1 1 1			dolosp infilled (pieces 8-18+19)

		-				•						- 1								
3447.8 3447.9		DOL DOL	V V V V	V MDBnGy	x 4 V V V		V 0.00/	to +8cm V	O0-10 102	V	V +	V	V 453	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	V	V			31	FD32 K-1.07md P-3.4%
3447.9	8-23	DOL	F-M (C) ?bimodal xtl V V V V	WDBnGy V	x 4 XTLd		0-9% V	vugs5%IBC2I to +8cm V	JU-10 10?	v	10? (fra		15? CO	ال _{ال} ا	V 3	V			31	
3448.1	0-23	DOL	F-M (C) ?bimodal xtl	MDBnGv	x 4 XTLd		0-9%	vugs5%IBC2I	00-10 10?	•	10?	-/ V	15? CO	اا `اد	3	6			31	
3448.2		DOL	VVVV	V	x 4 V V		V	to +8cm V	V	V	v L	v	V	V	V	v			31	FD33 K-1.590md P-
3448.3		DOL	F-M (C) ?bimodal xtl	MDBnGy	x 4 XTLd	IFS branch coral?-skel	0-9%	vugs5%IBC2I	00-10 10?		10?		15? CO)	3	6			31	
3448.4		DOL	VVV	V	x 4 V V		V	to +8cm V	V	V	v	V	V	V	V	V			31	large disarticulated bivalves (8-30 to 33)
3448.5		DOL	F-M (C) ?bimodal xtl		x 4 XTLd		0-9%	vugs5%IBC2I	00-10 10?	.,	10?	.,	15? CO		3	6			31	FD34 K-16md P-3.0%
3448.6 3448.7	8-34+9-1	DOL DOL	V V V V F-M (C) ?bimodal xtl	V MDB ₂ Cv	x 4 V V V		V 0.20/	to +8cm V	00-4 20?	V	10?	V	453	V	V	V			31	FD34 K-16md P-3.0%
3448.8		DOL	V V V V	V	x 4 XILU		0-3% V	vugs2%IBC1I to +8cm V	50-4 20 f	V	v	v	151	CoSt CoSt	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	v			31	
3448.9		DOL	F-M (C) ?bimodal xtl	MDBnGy	x 4 XTLd		0-2%	vugs2%IBC1I	00-2 20?	ľ	10?	ľ	15?	CoSt	3	6			31	dolomite (collapse?) tectonic/diagenetic BRECCIAS in transition
3449	9-10?	ls DOL	brecciated	DMBnGy	x 4 XTLd			i i i gez / i i z			10?		10?	CoSt	6	2			5b 3b	
3449.1	9-9?+10	LS DOL	9/1 brecciated	MDBnGy	x 4 XTLd	IFS coral?-strom?-skel					10?		10?	1 1	3	2			5b 3b	
3449.2	9-11+12	LS DOL	9/1 brecciated	DMBnGy	x 4 XTLd						10?		10?		5	4			5b 3b	Preccias possible multi-/generations & some frag's crudely rounded?
3449.3	9-13	LS DOL	3/7 mtx=dolm	MDBnGy	9 4 xtl+B						20 15		10	CoSt	3 5	5 oyste	r 3		5b	(nc9.15) in situ? Chaetatid encrusted by strom all clam hored, above
3449.4 3449.5	9-13+14	LS DOL LS Is DOL	4/6 mtx=dolm 4/6-5/5 mtx=dolm	DMBnGy MDBnGy	9 4 xtl+B: 9 4 FBS-F		miara)		20	40	25 12 20 12	10			8 1	2	5		50 m	(pcs-13) in sita : Chaetetia encrustea by strom all claim borea above
3449.6	9-15+16 9-16+17		8/2-9/1	DMBnGy	6 8 RS-P				20	10	15 20 10 5		10 Co		7 2	2 oyşter	1 4	3	5b <i>m</i> 3b	microsolenid coral encrusted by sponge w/ scattered branches bryozoa -MICROSOLENID
3449.7	9-17+18		8/2-9/1	MDBnGy	6 6 RFS-F				20	15	5 15	10	5	´	10 2	5 oyster	1 3	10	5b <i>m</i>	rounded framebuilder clasts FD36 K-0.2md P-5%
3449.8	9-18+19		8/2	DMBnGy	6 6 RFS-F				20	15	5 15 3	10	5	1	10 2	4	2 3	8	5b <i>m</i>	AA ??megalodont valve?? OR DERIVED ON SLOPE
3449.9	9-19+20	LS DOL	8/2-7/3	MDBnGy	6 6 RFS-F	GS strom-chaet-coral-spg			20	15	5 15 5	10	5	1	10 2	8	2 3	10	5b <i>m</i>	AA possible megalodont single valve and rudist/dicerid fragment
3450	9-20		7/3	DMBnGy	6 6 RFS-F				20	15	5 15 3	10	5		7 7	4	2 3	8	5b <i>m</i>	
3450.1	9-20+21		8/2	MDBnGy	6 6 RFS-F	` '			20	5	7 10	40?	10?		3 2	2			5b <i>m</i>	partly rextl coral either microsolenid or long septa myriaform type
3450.2	9-21+22		8/2	DMBnGy MDBnGy	6 6 RFS-F				20	10		3/? 3	5		7 7	4	2 3		5b 3b	FD37 K-0.2md P-5%
3450.3 3450.4	9-22+23 9-24		. 8/2 . 8/2-7/3	MDBnGy DMBnGv	6 6 RFS-F				20	10	5 15 10? 5 15 10?	3/? 3	5		7 7	4	2 5		5b 3b 5b 3b	
3450.4	9-24	LS DOL		MDBnGy	6 6 RFS-F				20	10	5 15 10?		5	1 11	7 7	4	2 5		5b 3b	7
3450.6	9-24+10-1		9/1 red top to coral	DMBnGy	9 8 BRS-I		o)		20	8	10	- J	60		1 1	1	1 3	2	5b	large head coral (flower corallites) capped by rind chaetetid then spg-microb
3450.7	10-1+2		9/1-8/2	MDBnGy	9 8 BRS- I				20		8	45	Со	Co	2			6	5b	microsolenid talbular then stubby branches clam bored
3450.8	10-2+3	LS dol		DMBnGy	9 6 BRFS	PGxtl coral (spg/mic-strm)			20	8	7 8		40					5	5b	vertical head (LS) bored w/ spg/microb -strom-coral horizon to rt middle CORAL -
3450.9	10-3+4	LS dol	7/3	MDBnGy	9 8 BRS-I	Gxtl coral (spg/mic-strm)			20	8	9 5		40		2			5	5b	in succession of encrustations with clam borings 'biocmtst' FD38 K-0.49md P-7% STROMATOPOR
3451	10-4+5	LS dol	7/3	DMBnGy	6 6 RFS-F				20	15	5 20	5	25		2	3	1 2	7	5b	+3 different coral genera OID-
3451.1	10-5+6	LS dol	7/3	MDBnGy	6 6 RFS-F		icrob		20	15	5 20	5	25		2 2	3	1 2	7	5b	(OUIET_DEEDED
3451.2 3451.3	10-6+7 10-7	LS dol	7/3 7/3 microbreccias	DMBnGy MDBnGy	9 4 BS-FF 6 FRS-V				20	15	3 15 10	-	15 25		1 2	5 1	1 1	4	5b 40	in situ vase sponge(leit crusned) on biolitinied coral BS-bionaga ?? WATER BUT
3451.3	10-7	LS dol	7/3 microbreccias	DMBnGy	6 FRS-1				20	5	3 15 10		25		2 1 2	3 1	2	3	50 5h	tectonic fitted microbreccias at least 4 coral genera LESS THAN
3451.5	10-7-6-3	LS dol	7/3	MDBnGy	9 8 BS-R 3				15	10	10 25 5	5	5		2 2	3 1	1 5	10	5b	boundstone or biolithfication indicated by mtx + framework borings
3451.6	-10+11+12		11.0	DMBnGy	9 8 RFS-E				20	10	5 20 10	15	10		3 3	4	1 3	5	5b	layers of bored BS stabilizing framebuilder debris interbeds =likely NOT hi-energy
3451.7	-12+13+14	_	9/1 MTX muddier less o		9 8 BS-R				15	10	10 25 5	5	5		2 2	3	1 5	10	5b	FD39 K-1.6md P-6%
3451.8	10-14+15	LS dol	9/1	DMBnGy	9 6 RFS-	S coral-strom-chaet-ske			20	10	5 20 10	15	10		3 3	4	1 3	5	5b	
3451.9	10-15	LS dol	9/1	MDBnGy	9 6 BS +				15	10	10 25 5	5	50		2 2	3	1 5	2	5b	dm coral head in situ on ?hdgd/biolithified surface above muddy PS-skel F
3452	10-15+16	LS dol	9/1	DMBnGy	4 4 FS in				25		5 10			1	10 10	5	1 3	1	3b	enrolled strom nucleated on wt spg/strom-all bored
3452.1 3452.2	10-16+17 10-17	LS dol	9/1 7/3-6/4	MDBnGy DMBnGv	4 4 FS in 4 4 FS in				25		5 10 5 15				8 10	5	1 3	1	3b	FD40 K 0.20 and D C0/
3452.2		LS dol dol	6/4-4/6	MDBnGy	4 4 FS-W				25 25		5 20				8 10	7	1 3	1	30	some crinoids plates not ossicles FD40 K-0.38md P-6%
3452.4		Is DOL	3/7 F-C(VC)	M(L)Bgy	9 4 BFS->				20		3 20		20 Co)	<u> </u>		' '	-	3b	small branching coral bush in F_C dolomite
3452.5		DOL	pre-dolm stylolites	M(D)BGy	X 4 FS-P(ıl 2-10%	6 IBC0-5D0-15	M-VC 35	5	10	5?	St		15	3			3b	DOLOMITE INTERVALS GENERALIZED & INTERPRETIVE
3452.6		DOL	F-M/C (VC lines vugs)	M(L)Bgy	X 4 FS-W	Sxtl skeletal-frag-lithoclast	1-5%	vugs to dm		0 <cm< td=""><td>5</td><td></td><td></td><td></td><td>2 7</td><td></td><td></td><td></td><td>3b</td><td>BUT SEE NOTES BELOW FOR PARTICULAR FEATURES FORE</td></cm<>	5				2 7				3b	BUT SEE NOTES BELOW FOR PARTICULAR FEATURES FORE
3452.7]	DOL	saddle dolm cmt	M(D)BGy	X 4 FS-P(, i	1 2-10%	6 IBC0-5D0-16	M-VC 35	5	10 5?		St		15	3			3b	very big dm vug!! FD41 K-1.34md P-2%
3452.8	l	DOL	& C-VC wt calcspar	M(L)Bgy	X 4 FS-W			vugs to dm		0 <cm< td=""><td>5</td><td></td><td></td><td></td><td>2 7</td><td></td><td> </td><td></td><td>3b</td><td>SLOPE SLOPE</td></cm<>	5				2 7				3b	SLOPE SLOPE
3452.9	44.0	DOL	lines vugs + heals	M(D)BGy	X 4 FS-P(6 IBC0-5D0-15	M-VC 35	5	10	5?	St		15	3			3b	FD40 K 4 4md D 0 40/
3453 3453.1	11-9	DOL DOL	fractures	M(L)Bgy M(D)BGy	X 4 FS-W			vugs to dm	M-VC 35	0 <cm< td=""><td>5 10 5?</td><td></td><td>61</td><td></td><td>2 7 15</td><td></td><td> </td><td></td><td>3b</td><td>FD42 K-1.4md P-2.1% WITH</td></cm<>	5 10 5?		61		2 7 15				3b	FD42 K-1.4md P-2.1% WITH
3453.1 3453.2	l	DOL		M(D)BGy M(L)Bgy	X 4 FS-P(X 4 FS-W			6 IBC0-5D0-15 vugs to dm		5 0 <cm< td=""><td>5</td><td></td><td>151</td><td></td><td>2 15 </td><td>3</td><td>$\parallel \parallel \parallel \parallel$</td><td></td><td>3b</td><td>very big dm vugs with cm cements! RARER STABLE</td></cm<>	5		151		2 15	3	$\parallel \parallel \parallel \parallel$		3b	very big dm vugs with cm cements! RARER STABLE
3453.2	1	DOL		M(D)BGy	X 4 FS-P(6 IBC0-5D0-15	M-VC 35	5	10	5?	St		15	3			3b	STABLE
3453.4	l	DOL		M(L)Bgy	X 4 FS-W			vugs to dm		0 <cm< td=""><td>5</td><td>0.</td><td> </td><td></td><td>2 7 1</td><td> </td><td> </td><td></td><td>3h</td><td>FD43 K-4.32md P-3%</td></cm<>	5	0.			2 7 1				3h	FD43 K-4.32md P-3%
3453.5	1	DOL	occ thru out pre-	M(D)BGy	X 4 FS-P(6 IBC0-5D0-15	M-VC 35	5	10 5?		St		15	3			3b	big dm vug infill w/ XC wt dolm-calcite cements!! (=HARD-
3453.6	l	DOL	dolm stylolites	M(L)Bgy	X 4 FS-W	Sxtl skeletal-frag-lithoclast	1-5%	vugs to dm	25	0 <cm< td=""><td>5</td><td></td><td></td><td></td><td>2 7</td><td></td><td> </td><td></td><td>3b</td><td>GROUND?</td></cm<>	5				2 7				3b	GROUND?
3453.7	I	DOL		M(D)BGy	X 4 FS-P(d 2-10%	6 IBC0-5D0-15	M-VC 35	5	10	5?	St		15	3			3b	PRESERVE
3453.8	l	DOL		M(L)Bgy	X 4 FS-W			vugs to dm		0 <cm< td=""><td>5</td><td></td><td> </td><td></td><td>2 7</td><td></td><td> </td><td></td><td>3b</td><td>FD44 K-23.9md P-6.1%</td></cm<>	5				2 7				3b	FD44 K-23.9md P-6.1%
3453.9	44.25	DOL		M(D)BGy	X 4 FS-P(6 IBC0-5D0-15	M-VC 35	5	10 5?		St		15	3			3b	hig ++cm vugs with cm camentall
3454 3454.1	11-25	DOL DOL		M(L)Bgy M(D)BGy	X 4 FS-W X 4 FS-P(vugs to dm 6 IBC0-5D0-15	M-VC 35		10	5?	St		2 15	3			3b	big ++cm vugs with cm cements!! FD46 K-104md P-6.7% TED
3454.1	l	DOL		M(L)BGy	X 4 FS-P(6 IBC0-5D0-15	25	5 0 <cm< td=""><td>5</td><td>οr</td><td>Joi L</td><td></td><td>2 7</td><td>١</td><td> </td><td></td><td>3D 3h</td><td>CRINOID</td></cm<>	5	οr	Joi L		2 7	١			3D 3h	CRINOID
3454.3	1	DOL		M(D)BGy	X 4 FS-P(6 IBC0-5D0-15	M-VC 35	5	10 5?		St		15	3			3h	CALYXES
3454.4	ĺ	DOL		M(L)Bgy	X 4 FS-W			vugs to dm	25	0 <cm< td=""><td>5</td><td></td><td></td><td></td><td>2 7</td><td></td><td> </td><td></td><td>3b</td><td>OR OR</td></cm<>	5				2 7				3b	OR OR
3454.5	11-37-12-1	DOL		M(D)BGy	X 4 FS-P(G)xtl crinoid-strom?-skeleta	ıl 2-10%	6 IBC0-5D0-15	M-VC 35	5	10 5?		St		15	3	<u> </u>		3b	COLONIZA
3454.6		DOL	F-M/C (VC lines vugs)		X 4 FS-W			IBC0-4D0-8	30 25		?3				1 4				3b	TION)
3454.7	l	DOL	saddle dolm cmt	M(D)BGy	X 4 FS-PS			vugs to >cm		5	7? 2?	2?			7	3			3b	FD47 K-1.09md P-1.3%
3454.8		DOL	& C-VC wt calcspar	M(L)Bgy	X 4 FS-W			IBC0-4D0-8	30	_	?3				1 4				3b	⁷
3454.9	40.40	DOL	lines vugs + heals	M(D)BGy	X 4 FS-PS			vugs to >cm	25	5	7? 2?	2?			1 7 1	3			3b	
3455	12-10	DOL DOL	fractures	M(L)Bgy	X 4 FS-W			IBC0-4D0-8	30	5	?3 7? 2?	22			1 4 7				3b	<u></u>
3455.1 3455.2	l	DOL		M(D)BGy M(L)Bgy	X 4 FS-PS X 4 FS-W			vugs to >cm IBC0-4D0-8	25 25	5	7? 2? 7? 2?	2? 2?			'10	3			3b	FD48 K-51.7md P-6.1% articulated crinoid calyx indicates very quiet water deposition
3455.3		DOL	occ thru out pre-	M(D)BGy				6 vugs+interxtl	30	٦	?3	۲.			1 4 1				3b	2 & rapid burial
0-00.0	ı		ooc and out pre-	(<i>D</i> /DO)	L. 1 → 11 2 - L	Indinobalider-sker	12-11/	v rugo · interxti	1 1 30		1.0 1	l l	· II	1 111	1 1 71 1	1 1 1		1 1	30	o rapid buriar

K-8.93md P-5.3%
V 0.04 LB 0.09
K-8.24md P-2.6%
rved Y
-0.99md P-1.2%
0.991110 F-1.2 /6]
K-3.1md P-4.2%
[[
assil alang grouth lavers
ossil along growth lavers H BANDED (tr poro
MICROSOL EN
-4.17md P-3.5% ID CORAL
CAD DEEE
ttacts to doin mix
-1.77md P-5.8% REEF DEBRIS
piece 13-29 below OF SHALLOW
om?? STORM/WAVE
ant in corallites) AFFECTED
REEF
nant porosity
-2.11md P-5.3%
ita 0 Janah
te pores & leached
-2.11md P-5.3% ite pores & leach

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-coralline sponge reefal, 5C=mud/pelleted; 5D=colitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details NOTE-m=microsolenids main/only corals present

Appendix A3 ENCLOSURE A3.11b Margaree F-70 Core L.Eliuk 2016

	<u> </u>	ro 12 12	Cdn	<u> </u>	- F	I Dogo MA	BOILIE I	25	_															
	nciosu	re A3.12				I Paso <u>MA</u>	KQUIS I	•		ng In	10	L.Eli	uk F	P.Geol.	2005	-03 (2	004-11 re	log G	SC)	TOF	S RE	VISED cf	3.88 02	PFA DATING/SEISMIC 2014-11 PAGE
DEPTH	LITH	modifier I	COLOR	TEXT DUNH	TURE AM	modifier	POROSITY	ACCES	SOR	IES				FOSSI	LS		nhanced by	swc	data if	availa	ible)		CIES TYPE Eliuk'78'8 Eliuk2002	COMMENTS
(metres)		_S=limestone		ser ght	MS=r	mudstone 1 wackestone 3	%				FRA	MEBI	JILDI	ERS		BRYOZOANS		J				ALGAE	≪	additional fossils/accessories
		OOL=dolomite BH=shale	VIATED	UME S) ri	PS=p	packstone 5 grainstone 7	modifier	Sulo	ا ا	ပည		SIII a		<u> </u>	P			ãII⊢ la	_ ဗျ	g li		etc etc	MICROF Vilson'75 ,Harland	diagenetic textures facins-sequence breaks BBB = BAD BIT BRUISE
	o	SS=sandstone SLTST=siltstone	INSE	AM N &rs(t	BS=b	ooundstone 9	(Archie)	II III 	삥	AS					8	ANS E		E		ESe		FE ET ST ST ST ST ST ST ST ST ST ST ST ST ST	MIC Vilso i,Har	facies-sequence breaks et cetera BBB = BAD BIT BRUISE due to hi-speed PDF bits -
	_ [arg=argillaceous	ABBRE or MU	DUNHAM I IS left fs&rs(FS=fl	RS=XC size) loatstone 4		SOIDO	PARTICI		P P P		딍	MILLEPORID hydrozan-OTHER	HEXACORALS	BRYOZOANS	RINOIDS ECHINOIDS	BIVALVES	OSTRACODS SERPULII	TUBIPHYTE	NGS II	IIGHER -gre	STANDARD I Flugel'82&W Wierzbiciki,	some long comments may be colored/bleached & striated or
		calc=calcareous sdy= sandy/qtz	[¥ °	고 호		udstone 8 =crystalline				15	Og	₩ A		hydro	[皇 			"∐ ፟ቑ [TSO S		[S	STROM thror	AND gel'8	hidden & visible only on scree 'laminated'
	Y			E		, and the second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second			Ш	H		WT SPONGE		֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓		Ш	ĽН					ਡੀ ਇੰ _ਹ ੀ	s	L-35 ctgs mainly good except
Α	В	С	D		∫ [™] G	н	l J	К	. м	N	0	P		R S −	т	v v	XY	ZAA	АВ АС	AD A	EAF	AH AI A	J An	AL from 385/4000 to 4200/4400m
3325	SS	VF-F QTZ	LtGy			carbonaceous				Р	FA C	hap									300 ^^		5f-9-10	P=PHOTOS 2P
3330	SS+Sh SS+Sh	8/2 VF-F, quartz	LtGy			pyritic				se	quen	ce t	ops	in gree	n			1?				_	5f-9-10 5f-9-10	NB-red-brn non-calc ctgs=cmt?walnut?3330-80m 2P
3335 3340		AA VF-M calc gtz	LGy & Gy			micropyrite commo								1				2			-		51-9-10	
	LS	5%SS	LMBn	7	GS	Ooid F-M		75	ARE	NAP	(I-R	(CC)	AKO	at 3341	ım			1?					5d	qtz nucleii vf-f 4P
3350	LS	5%SS	LMBn	7	GS	Ooid (skel)		60	10		1	1						3	1			5	5d(e)	nucleii=skel&qtz 5P
3355 3360	LS/Sh	5%SS? F-C 5/5?	DdCv	6	P-GS M-WS	ooid-skel		50	1.5		10-	11	?	1?	2			5	-				15d	1P of reddish Sh P
3365	SS/Sh	6/4 F-M gtz	RdGy LtGy	2	IVI-VV3	sandy-ooid-frag LtGy		10	13	1	AB-	5 ?	335	5				2	MR	RS6	3355		5 5f	?red calcite cement
3370	SS/LS	7/3 F-C qtz	LGy&Bn	5	(PS)	frag (skel-ooid)		10	15					2?	1			3					5(d)	cakcareous qtz SS P
3375	SS/LS	7/3 F-C qtz	LGy&Bn		(PS)	frag (skel-ooid)		10	15									5					5(ad)	SS Well rd-subang F-C qtz Tr carbonac & pyrite 2P
3380 3385	LS/SS LS-sdy	5/5 10%SS	LtBGy LtBGy		G(P)S G-PS	frag-skel-ooid ooid-frag-skel sandy		15 20	25 25			1	?			1		5	2				5ad 5da	Calc'SS-VF-F; Sandy LS; chip of glauconite. Wood LCM?
3390	LS-sdy	+20%SSqtzF-C	LtBnGy		G-PS	ooid-frag-skel sandy		20	25				: 2 11	? 1?		1	1 1	1	_				5da 5da	gtz nucleii & SS stringers Tr pyrite P
3395	SS/LS	6/4 sandy	LtBnGy	5	(PS)	frag-skel (ooid)		10								1	1?	7	2	1	?		5a(d)	qtz SS F-M© Tr pyritic fossils
3400	LS		LtBnGy		P-WS	frag-skel		5	30								2	3	1		1		5a	
3405	LS LS		LtBnGy		P-WS	frag-skel-sponge? ooid M-C			0 30		5	1?	1 1		SB6	3408	2 1	2	1		1	3 2	5abc?	algal-sponge textures Micritized VF-F grains. Bigge 2P
3410 3415	LS LS		LtBnGy LtBnGy		G-PS G-PS	ooid-stromatoporoid	1	70 50	10			1	5 13	?		1?	-	5			1		5d+5b	some qtz nucleii P (fine & normal) 2P
3420	LS		LtBnGy	6	G-PS	ooid-peloid-skel		50 2	0 10r	d					1?	1		3	1				5d	Massive white bryozoan in fragmental GS 2P (1-X16)
3425	LS	small ooids	Lt Bn		W-PS	ooid-peloid-frag				10							3	5	2			3		2P
3430 3435	LS LS	F-M ooids	LGyBn LGyBn		(G)PS G-PS	ooid-peloid ooid (frag-algal)		40 °	10	10 5								1				1 1	5d(e) 5d(e)	P (X16) slight BBB
3440	LS		LGyBn		G-PS	ooid-peloid		50 2		5			1	1?				1	1?			2	(-)	P
3445	LS		LGyBn		G-PS	ooid-peloid			0	2		•	1										5d	P
3450 3455	LS LS	F allochems	LMGyBn LMGyBn		G-PS	ooid-peloid-clast skel-frag-peloid		20 2 15 1	0 15 5 10		2			1?		2	1 1	5 2	1	1		5	5de 5acd	enongo eniculros
3460	SS/LS	9/1 VF-F qtz	LtGy		vv-คอ frag (m			13 1	10							_			'				5f	sponge spiculres Tr micropyrite well sorted
3465	ss	VF-F qtz	LtGy		5 (shaley (calc)												2					5f	Tr pyrite Fracture?=calcspr fill well sorted P
3470	ss	F-M (C) qtz trVC	LtGy			10% LS-Wackestone									MR	S5 34	70						5f	coarser & poorer sorted P
3475	SS+SH	& pyritic sdy SH	Lt(M)GY			F-M (C) 5%ooids		5 cave	?														5f	Tr green caly fleck of glauconite??
3480	SSshly	F(M) qtz	LtGy	1	ме	shaley												Зу					5f	Mainly well sorted & subrounded qtz VF-F. Tr pyrite nodules
3485 3490	SS/LS LS sdv	7/3 LS-mudst sandy&shaly	LtGy LBnGy			30% VLtGy LS fragmental			10									1	12				5f 5(f)	
	LS shiv			3	W(P)S	fragmental-ooid	?????	15	30				ı	AB-4 ? 3	495			1					5(1) 5(1)	
3500	LS/SS	8/2 or less	LMGy	4	W-PS	frag-skel-sandy		1	30		2	1	1		1	2	1	2	1?	- 1	2		5(f)	Superficial ooids Bryozoa in argil LS P
3505	SS	VF-Fqtz 10%LS	LtGy														1	2y				10	5f	white clay matrix & clacite cmt Bivalves = oysters P
	SS/LS LS	7/3 shaley?VF-Fo sandy (shaly?)	L&IVIBGy		P-WS	sandy frag (ooid)		5 10	25								12	3y				1?	5f 5(df)	Some dark green shale = glauconite? Some grey Shale stylolitic Some MdGy SHALE chips
		sandy	Lt Bn			fragmental-skeletal		8	35	5			3		1	2	2 1	10	1		1		5a(d)	bivavlves include oysters 2P
	LS	shaly??		4	P-WS	frag-skel		5	20		1?		2	SB5 35	23	1		7					5a	stromatoporoids recryst (or BBB) shaly?? LS
3530	LS	ooids F-M+	LtGyBn	6	P-GS	frag-ooid-skel	chalky BB	10	30	10			3		1		1 2	9			2		5a(d)	ВВВ

A	В	С	D		G H I J	J	K	LN	N N	0	P Q	R	S	Т	VWX	(Y)	Z AA A	BAC	AD AE A	F AH	I AI	AJ	AK	AL	AM	AN		AO	AP	AQ
3535	LS	ooids M-C	LtGyBn 6	F	P-GS ooid-skel-frag		35	1	10		7			2		1	1 1	1	1	1			5dab							7P
3540	LS	oids F-M (C)	LtGyBn 6	F	P-GS ooid-stromatop-skel		25	1	10		15	5		1		1 1	? 3	1					5b+5d	dusty'						2P
3545	LS		LtGyBn 5	F	P(W)S frag-skel-ooid		10	2	20		18	;		1		1	8	2	1 1				5b(d)							2P
3550	LS		5	F	PS strom-skel (ooid)		9	3	30		15	1 1	?	1			2 3	?	1 1				5b(d)	stylolites						4P
3555	LS		5	F	P(W)S frag-skel (ooid)		9	2	20	1	8	2	1	1	1		1						5b(d)	Tr green cla	ay infill					Р
3560	LS	ooids (F) M-C	LtGyBn 6		P-GS ooid		65				1				1?	1 1	2						5d	carbonate nu	cleii in o	oids				Р
3565	LS	ooids F-M (tr SS)	6	_	P-GS ooid-frag tr V-vf s	spar	45	1	10	1							1						5d	minor VF-F SS	ST					Р
3570	LS	(LtBnGy 5		PS-FS frg-ooid-strom-skel		15		20		10	1		1		7	2						5b(d)							P
3575	LS		LtBnGy 3		WS-FS skel-frag-ooid		10		10	5	8			1		,	2 3						5b(d)							Р
3580	LS		LtBnGy 5		PS-RS stromatoporoid-frag		5		20	1	30			2	13	,	2 2	2					5b(u)	dusty'						D
3585	LS		LtBnGy 4		P-WS frag-skel		1		30		5			1			3	_					5a	BB - dusty/cha	ılkv					•
3590	LS		LMBnGy 4		P-WS stromatoporoid-frag				20	12	15			1			2		1				5h	Minor dk Bn	•	aamonta	al skolo	otal M/S	=0	
	LS		-	_			15		10	2	9		?	1		1	4	2	1	1			5D Eb	WIIIOI UK BIT	p,yritic ira	aymema	ai-skeie	elai VV S-	-3	P??
3595		id- t- VO	LMBnGy 4		W-PS skel-frag (stromtop)-ooid								′	1		1	1	2	1	1			50	£#=4 ==:4 OC	T- 00/	1	-IO :t	£!!	:4	P//
3600	LS	ooids to VC	LtBnGy 6	_	G-PS ooid-frag-stromatop 1-2 intrafo		40		10		10		4	2!			4		4 4				5d+5b	fitted ooid GS	5 11-2%	leached	a? intra	iossii po	osity	
3605	LS	V= 14	LtBnGy 4		P-WS frag-strom'-ooid		10		35		15		1				1		1 1		40		5b(d)							
3610	LS	VF-M+	LtBnGy 5		P(W)S frag-skel-stromatop		5	5 2	25 1	3	15			1		1	Зу	1	1		1?		50	-	lolites					3P
3615	LS		LtBnGy 5		P(F)S stromatoporoid-skel			2		2	15		1	6	1wt	1	3		1				5b		lolites					Р.
3620	LS		LtBnGy 4	_	P-WS stromatoporoid-frag			_	15		35			1					3		5		5b	stromatoporoi	a encrus	sted by r	microb-	-toram co	nsortia <i>L</i>	.itnocodium?
3625	LS		LtBnGy 3		G&WS ooid & frag-skel-pel		20	10 1	15		5		?	2		1	3		1				5ad							P
3630	LS		LtBnGy 4		N-PS frag-skel			5 2	25	1?	2?	2	!?	2			5	1	1		1?		5a	360	35-55+ h	nave <u>larc</u>	<u>ge</u> cuttii	ngs??!!		
3635	LS	M-C allochems	LtBnGy 5	4 F	P-FS frag-skel (stromatop)		2	5 3	30		10)				3 1	5	2	2		2		5ab	chip with gre	y branch	ning stro	matopo	oroid		
3640	LS	M-C allochems	LtBnGy 5	4 F	P-FS frag-skel-oncoid			2	20 10	2	3			1			1	1	1		2	10	5a							2P
3645	LS	F-C allochems	LtBnGy 5	F	P(G)S peloid-frag-skel		5	20 2	20 5		5	5	2				1 2	1	2				5ac							P
3650	LS		LMBnGy 4	. F	P-WS fragmental-skeletal		1	5 2	20		2	2			1white		1 2		1				5	sty	lolites					
3655	LS		L-MGy		ooid & skel-frag (strom')		50	1	10	2	7		1	2				1	1				5d+5b	P GLAUCC	ONITE - 3	3645-55	on we	elisite lo	Í	р
3660	LS		LtBnGy 7	4	G&FS ooid & skel-frag-strom'		40	1	10	1	10		1	5	AB3up?	365	0 3	1	2	0D4	2050	J	5d+5b	sty	lolites					3P
3665	LS		LtBnGy 5	4 F	P-FS strom-frag-skel (ooid)		10	2	20 10		20			5		2	8	1	1	SB4	3658		5b(d)							Р
3670	LS																													
3675			LtBnGy 6	F	P-GS ooid-frag-skel/stromatop		30	2	25 5	1	10	1	?	2		1	5		3		1?		5bd	sty	lolites					
3680	LS		LtBnGy 6 LtBnGy 4		P-GS ooid-frag-skel/stromatop P-WS frag-stromatop-skel		30		25 5 20 5	1 2	10 15	1 1	?	2		1	5	1	3		1?		5bd 5b	sty some round	lolites					9P
	LS LS	M-C allochems		F			30	2		2	15	1	?	2		3	5 2 1	1	3		1?		5bd 5b 5a	some round	lolites lolites ar	round so	ome fos	ssils		9P
3685		M-C allochems	LtBnGy 4	F	P-WS frag-stromatop-skel		30	3	20 5	1 2		1	? 2	4		3	5 2 1	1	3 1		1?		5b	some round		round so	ome fos	ssils		9P
3685 3690	LS LS LS	M-C allochems	LtBnGy 4 LtBnGy 4 LtBnGy 4 LtBnGy 5	. F F 4 F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag		30	3	20 5 30 5 0 5 15 5	1 2	15 5 1? 10	1	? 2	2 4		3	5 2 1	1	3 1		1?		5b	some round sty	lolites ar	omatopo	oroids 'r	rounded'		9P ?
3685 3690 3695	LS LS LS		LtBnGy 4 LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5	. F F G 4 F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag stromatoporoid-frag			1 1	20 5 30 5 0 5 15 5	1 2	15 5 1?	1	? 2 1 1 1	2 4		3	5 2 1	1	3				5b	some round sty	dolites ar some stro	omatopo	oroids 'r ER & s	rounded'	B!?	9P ?
3685 3690 3695 3700	LS LS LS LS	minor ooid GS	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4	. F F F 4 F F 4 F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag stromatoporoid-frag fragmental-skeletal-ooid		15	3 1 1 1	20 5 30 5 0 5 15 5 15	1 2	15 5 1? 10 10 8	5 1 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	? 2 1 1 7 ?	4 2		1	1 3 1	1	3 1 1 1 1 1 1	?	1?		5b	some rouni sty lithoclasts & s ?? stylolites ??	dolites are some stro P!!MUCH P!!MUCH	omatopo I LIGHTI I LIGHTI	oroids 'r ER & s ER & s	rounded' some`BE some`BB	B!? B!?	
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3685 3690 3695 3700 3705 3710	LS LS LS LS LS LS	minor ooid GS	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 3 VLGy 4	F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag strom-frag fragmental-skeletal-ooid F-W Skel-strom-frag frag-skel-(clast)			2 3 1 1 1 2 1 5	20 5 30 5 0 5 15 5 15 20 15 20 5+	1 2	15 5 1? 10 10 8 10	1 1 1 1 1 1	1 1 ?	2 4 4 2 2 1	2	1 2 1 2	1 3 1 1 2	? 1 1	1 1 1 ? 1 1 1 1		1?		5b 5a 5b 5b 5ab 5b 5b	some round sty lithoclasts & s ?? stylolites ?? ??	dolites ar come stro P!!MUCH P!!MUCH P!!MUCH	omatopo I LIGHTI I LIGHTI I LIGHTI I LIGHTI	oroids 'r ER & s ER & s ER & s	rounded' some`BE some`BB some`BB some`BB	B!? B!? B!? 3F B!?	
3685 3690 3695 3700 3705 3710 3715	LS LS LS LS LS LS LS LS	minor ooid GS	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 3 VLGy 4 VLGy 5	F F F F F F F F F F F F F F F F F F F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag strom-frag fragmental-skeletal-ooid Skel-strom-frag frag-skel-(clast) frag-skel		15	2 3 1 1 1 2 5 2 5 3	20 5 80 5 0 5 15 5 15 20 15 20 5+	1 1 1	15 5 1? 10 10 8	1 1 1 1 1 1	? 2 1 1 ? 1 1 ?	2 4 4 2 2 1 1	2 2 2	1 3 3 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 3 1 2 3 3 3	? 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1?		5b 5a 5b 5b 5ab 5b 5b 5b	some round sty lithoclasts & s ?? stylolites ?? ?? ??	dolites are some stro P!!MUCH P!!MUCH P!!MUCH P!!MUCH	omatopo I LIGHTI I LIGHTI I LIGHTI I LIGHTI	oroids 'r ER & s ER & s ER & s ER & s	rounded' some`BB some`BB some`BB	B!? B!? B!? 3F B!? B!?	
3685 3690 3695 3700 3705 3710 3715 3720	LS LS LS LS LS LS LS LS	minor ooid GS tr grn clay	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 4 VLGy 5 VLGy 5 VLGy 5	F F F F F F F F F F F F F F F F F F F	P-WS frag-stromatop-skel fragmental-skeletal fragmental p-WS stromatoporoid-frag strom-frag fragmental-skeletal-ooid p-WS skel-strom-frag frag-skel-(clast) frag-skel p-WS frag-skel p-WS frag-skel p-WS frag-skel-peloid		15	1 1 1 1 5 2 5 3 10	20 5 30 5 0 5 15 5 15 20 15 20 5+ 35 30	1 1	15 5 1? 10 10 8 10 7 4 1 3		1 1 ?	2 4 2 2 1 1		1 3 1 2 1 2 1 3 3 1 1	1 3 1 1 2 3 2	? 1 1 1 1 1 1 1 1 1	3 1 1 1 1 1 1 1		1?		5b 5a 5b 5b 5ab 5b 5b	some round sty lithoclasts & s ?? stylolites ?? ?? ?? ?? ??	dolites are some stro P!!MUCH P!!MUCH P!!MUCH P!!MUCH P!!MUCH	omatopo I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT	oroids 'r ER & s ER & s ER & s ER & s ER & s	rounded' some`BB some`BB some`BB some`BB	B!? B!? B!? 3F B!? B!?	
3685 3690 3695 3700 3705 3710 3715 3720 3725	LS LS LS LS LS LS LS LS LS LS LS	minor ooid GS	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 3 VLGy 4 VLGy 5 VLGy 5 LtBnGy 5	F 4 F 6 4 F 6 6 4 F 6 6 6 6 F 6 6 6 6 6	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag strom-frag fragmental-skeletal-ooid skel-strom-frag frag-skel-(clast) frag-skel frag-skel-peloid frag-skel-strom-clast		15	5 2 5 3 10 3 3 2 2	20 5 30 5 0 5 15 5 15 20 15 20 5+ 35 30 15 20 15	1 1	15 5 1? 10 10 8 10 7 4 1 3		1 1 ?	2 4 2 2 1 1	2 2 1wt	1 3 1 2 1 2 1 3 1 1 1 1 1 1 1 1 1 1 1 1	1 3 1 1 2	? 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3 1 1 1 7 1 1 1 1 2 1		1?		5b 5a 5b 5b 5ab 5b 5b 5b	some round sty lithoclasts & s ?? stylolites ?? ?? ??	dolites are some stro P!!MUCH P!!MUCH P!!MUCH P!!MUCH P!!MUCH	omatopo I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT	oroids 'r ER & s ER & s ER & s ER & s ER & s	rounded' some`BB some`BB some`BB some`BB	B!? B!? B!? 3F B!? B!?	
3685 3690 3695 3700 3705 3710 3715 3720 3725 3730	LS LS LS LS LS LS LS LS LS LS LS LS LS	minor ooid GS tr grn clay	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 3 VLGy 5 VLGy 5 VLGy 5 LtBnGy 5 LtBnGy 5	F F F F F F F F F F F F F F F F F F F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag stromatoporoid-frag fragmental-skeletal-ooid fragmental-skeletal-ooid fragmental-skeletal-ooid frag-skel-(clast) frag-skel frag-skel frag-skel-peloid frag-skel-strom-clast stromatop-skel-frag 1 vug-ca		15	5 2 5 3 10 3 2 5 2 2	20 5 30 5 0 5 15 5 15 20 15 20 5+ 35 30 20 15	1 1	15 5 1? 10 10 8 10 7 4 1 3 10 20		1 1 ?	2 4 2 2 1 1		1	1 3 1 1 2 3 2	? 1 1 1 1 1 1 1 1 1 1 2	3 1 1 1 7 1 1 1 1 2 1 1 1		1?		5b 5a 5b 5b 5ab 5b 5b 5b	some round sty lithoclasts & s ?? stylolites ?? ?? ?? ?? ?? Tr greenish f	ome stro	omatopo I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT I LIGHT tal GS.	proids 'r ER & s ER & s ER & s ER & s ER & s ER & s ER & s	rounded' some`BE some`BB some`BB some`BB some`BB some`BB	BI? BI? 3F BI? 3F BI? BI? eams	(duplicates) P P P
3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735	LS LS LS LS LS LS LS LS LS LS LS LS LS L	minor ooid GS tr grn clay	LtBnGy 4 LtBnGy 4 LtBnGy 5 VLtGy 5 VLtGy 4 VLGy 3 VLGy 4 VLGy 5 VLGy 5 LtBnGy 5 LtBnGy 5 LtBnGy 4	F F F F F F F F F F F F F F F F F F F	P-WS frag-stromatop-skel fragmental-skeletal fragmental stromatoporoid-frag stromatoporoid-frag fragmental-skeletal-ooid fragmental-skeletal-ooid fragmental-skeletal-ooid frag-skel-(clast) frag-skel frag-skel frag-skel-peloid frag-skel-strom-clast stromatop-skel-frag 1 vug-cap-ws frag-strom		15	5 2 5 3 10 3 5 2 1 1	20 5 30 5 0 5 15 5 15 20 15 20 5+ 35 30 20 15	1 1	155 5 17 100 100 8 100 7 4 1 3 10 20		1 1 ?	2 4 2 2 1 1 1		1	1 3 1 1 2 3 2	? 1 1 1 1 1 1 1 2 2 2 12 12 1	3 1 1 1 7 1 1 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1?		5b 5a 5b 5b 5ab 5b 5b 5b	some rouni sty lithoclasts & s ?? stylolites ?? ?? ?? Tr greenish f BBB =Bad B High speed	dolites are strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the strong of the stro	omatopo I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI I LIGHTI	proids 'r' ER & s ER & s ER & s ER & s ER & s ER & s Styloliti	rounded' some BB some BB some BB some BB some BB some BB some BB some BB some BB	BI? BI? SIP SIP SIP SIP SIP SIP SIP SIP SIP SIP	P (duplicates)
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Α	В	С	D		G	Н	I J		M N	0	P Q	R	S	Т	V W	/ X	ΥZ	AA A	BACA	D AE A	F. Al	I AI AJ	AK	AL	AM	AN	AO	AP	AC
	LS		LMBGy	5	P(G)S	frag-strom-skel	tr V-calcsp		20	2	10		4	3		1	3	5	1	1		21	5b	stylolites					P
	LS		LMBGy	5 9	P-BS	strom-skel-frag	tr V -calcsp		0 5		1 25		1	5	1wt			3				31	5b						P
	LS		LMBGy		P(B)S	frag-strom-skel	tr C-VC calcsp		20	3	1 15	1?	1	2		1 1	1?	5	1 1	3	1	4?	5b						F
	LS		LMBGy		P-WS	Frag-Skel	tr-4 vug-calcspC		30 !	5 3	6			1		1	10	3		1			5b	r	mud adhere	es tightly			
	LS	11200.1	LMBGy		P(B)S	frag-strom-skel	4.4		30	6	20	1	1	5	1?	1	1?	5	4	1	4	00	5b						_
	LS LS	tr qtz siltst	LMBGy		PS	frag-skel	tr-1 vug-calcsp	?	25	3	10		2	2		2	2	5	1	1	1	2?	50	noor campl	o-TDID in	DDE hit	SH cave &	metal+paint	F
	LS LS	Poor spl -trip	MdGy		PS M/M/S	frag-skel ???			7		2	,				1		1?		1			E			PDF DIL	BB	песатрани	F
	LS LS	sl arg (tr SH) BBB-chalky	VLGy		M(W)S M-WS	(frag) fragmenatal? F-VF		3	8		3			2		1		1?	12	1		1?	5 5a		nicropyrite		BBB-chal	kv	
3845	18	BBB-chalky	VLGy		WS	fragmental		2? 10	12		3					2	+ '	2	1	1	_	1:	5a				BBB-chal	•	4F
	LS	BBB-chalky	VLGy		W(P)	fragmenatal (skel)			15		6					1		2	1				5a(b)				BBB-chal	,	P-P-tray3
	LS	BBB-chalky	VLGy		ws	frag-stromatop?)?		10?							_					5	9	stylolites	BBB-chal		Only ID str	
	LS	BBB-chalky	VLGv		ws	fragmenatal (skel))?		1						ı	1		1			5		•	BBB-chal	•	, ·	-
	LS	BBB-chalky	VLGy		ws	fragmenatal (skel))?		2)					1	2	1	1			5			BBB-chal	,		
	LS	DDD onancy	VLGv		ws	gc.i.a.a. (e.te.))?		3	3		2?				_					5		, i j i i i i i i i i i i i i i i i i i	555 ca.	,		P
	LS	tr styol'SH-pyrite	LBGy		P-WS	frag-skel-stromatop-	peloid		25	1?	10					2		2	1	1			5b4b?	r	nore norma	al chips w	some BBB		P
3880 I	LS	, ,,	LBGy		W-PS	frag-peloid-skel			20	1	7	1	2			1		1	1	2	1	5	5abc3c?	microbial-th		•	less BBB	microborin	P
3885 I	LS		LBGy		W(P)S		p)	20	10	3?	8?		1						1	2		10	3c4b	consortia=	stromatop-	microb	less BBB		2F
3890 I	LS	tr styol'SH-pyrite	LBGy			peloid (algal-microb)			10	2	5			1 1	?	1			1	1?		10?	3c4c	S	stylolitic co	ral=solitar	y??	less BBB	P
3895 I	LS	C-XC calcspar	LBGy	1	M(P?)	peloid-microb		20 51	?	1	2	2								1?		20	3c	5	stylolitic			lessBBB	P
3900 I	LS		LMBGy	4	W-P(G)	peloid-skel-(microb)		35		2	10	1?		1		1			1	2		7	5b4c3c	S	stylolitic			less BBB	4P
3905 I	LS		LBGy	3	W(P)S	Peloid-skel-microb	tr-1 free calcsp	20		3	5?									1		10	3c-5		stylolitic			lessBBB	3P
	LS		LBGy	4	W-PS	Peloid-stromatop-mi	crob	15		3	15	2				1?		1	2 1	4	1	10	3c4b5b	8	stylolitic			less BBB	3P
3915 I	LS	AB-3lo ? 3910	LBGy	6	P-GS	Pel-frag-strom-skel	tr calcsp	5 35 3	15	3	10		1	5	s	1		1	3 1	3		5	5bc4c?		stylolitic			(low BB)	3P
	LS		LBGy	5	P(G)S	peloid-frag-skel	tr tr calcsp	5 25	10		7		1	2		1	1		2 1	2		5	5bc4c		stylolitic			(low BB)	
	LS		L(M)BGY	4	W-PS	Pel-frag-skel	tr	_	10	1	3	3		2	В	1		3	2	1		3?	5ac-3c?	S	stylolitic				
	LS		L(M)BGY			Peloid-frag-microb	1-2 vug XCspar		15	2	6	1		1	3			1	1 1	3		15	3c4c5b	S	stylolitic				4P
	LS		L(M)BGY		P(W)S	frag-peloid-stromato	-	-	15	1	10		2		?	3		1	1 1	2		6	5b4b3c						2P
	LS		L(M)BGY		P-GS	frag-skel-stromatop			30 !	5 2	10		1	5	3	3		5	1	1			5b-4c?						P
	LS		VLGy		P(F)S	frag-skel	2-4 vug-calcsp		20		7		2	1	9	1		3	1	1			5b-4c?	pyrite (mind				BBB	
	LS		VLGy		BS-PS	stromatop-(coral)-fra			15	3	20			7	2	1		5	1	2	1		5b	Caved glaud	conite & ooi	d GS			8P duplic
	LS LS		VLGy		PS WC	frag-skel	3 vug-calcsp		25 20	2	6		1	1	1	2		2	1 1	1		3	5ab4c	stylolitic	t delitie	in at MC		BB	6P
			VLGy		P-WS	frag-skel		3 4	20	1	. 0				T	'		2	. '	4			5a			just MS		ВВ	01
	LS		VLGy		MS	microbial?				1spic	ules							1	?			??	3c?		-	just MS			_
	LS	A . A	VLGy		MS	?microbial	tr M-C sprcalc			10				00				44	0 4 0	. 4		??	3c?		stylolitic)	C	01		P
	LS LS	AsAbove	VLGy		M-WS	microbial?		1 1		1?				2?				11	? 12	+ 1		10	3c	S	stylolitic	tiny boring	gs?burrows	?	11P 2P
	LS LS	tr clear calcspar	VLGy VLGy		M-WS WS	microbial strom-microbial		3		1	10			E					1 1	2 1		15	3bc			von dorac	chino		2P 5P
	LS LS	5% cl calcspar	VLGy		M-GS	microbial-peloid		15		22	2		1?	1					1 12	1 1		20	3c			very large	criips		4P
	LS LS	chalky	VLGy		M-GS	microbial-peloid		15		1									1 1	1 1		15	3c	chalkified s	o %s helo	w are esti	imates	BBB	45
	LS	onanty	VLGy		M-WS	microbial-peloid														1		10	3c	Januaria	2 700 DOIO	4.5 631		BBB	P
	LS		VLGy		M-WS	microbial								1						1		10	3c	S	stylolitic			BBB	P
	LS	calcspar	VLGy		M-PS	micribial-peloidal		10		1	2				1				2 1	1 1		20	3c		,			BBB	P
	LS		VLGy		M-WS	microbial		5											1			10	3c					BBB	P
	LS		VLGy		M-GS	micribial-peloidal		10?		1	3	3						2	1	1		15	3c					BBB	P
	LS		VLGy		M-PS	micribial-peloidal		10														15	3c					BBB	
4030 I	LS		VLGy	4	M-PS	micribial-peloidal		10			5	5		1					1	1		15?	3c					BBB	P
4035 I	LS		VLGy	4	M-PS	micribial-peloidal		10			2	2						2				15	3c					BBB	P
	LS		VLGy		M-PS	micribial-peloidal		10			4								1	1 1		15	3c					BBB	P
	LS		VLGy		M-PS	micribial-peloidal		10			3	3							1	2		15	3c					BBB	P
	LS		VLGy		M-PS	micribial-peloidal		10			5?											15	3c					BBB	P
	LS		VLGy		M-PS	micribial-peloidal		10		6	5	5		2								15	3c					BBB	2P
	LS		VLGy		FMPS	micribial-peloidal		10?		5?	4+			5?		2		2у		1		15	3c					BBB	10F
	LS		VLGy VI. Over		M-PS	micribial-peloidal		10?		40	1?								1	1		15	3c	-4. 4. Pri				BBB	
4070 I	LS		VLGy		M(P)	micribial-peloidal		10?	l	17	2	1	I	1	I	2		3		1	II	15	5-3c	stylolitic				BBB	3P

Α	В	3	С	D		G	Н	I	J	K	L N	1 N	0	Р	QF	R S	Т	V	W	Х	Z	AA /	AB AC	AD	AE AF	AH	Al AJ	AK	AL	AM		AN	AO	AP		AQ
	LS			VLGy	4	M-PS	micribial-peloidal				10																15	3c						BE		
	LS			VLGy	1	M(P)	microbial				5			-	?		2?										15	3c						BE		Р
	LS			VLGy	1	M(P)	microbial				5		1/	2	? 2?	?											15	3c						BE	3B	Р
	LS			VLGy	1	M(P)	microbial			5	5?					2	2?					2					15?	3c	stylolitic	bit caus				BBB		2P
	LS			VLGy	1	M(P)	microbial				5?		2		2								1				15?	3c		Estima	te %'s s	ince BE	3B	BBB		Р
	LS			VLGy	1	M(P)	microbial	tr	V=sprcalc	_	5?									2	2						15?	3c						BBB		
	LS			VLGy	1	M(P)	microbial				5?			2	?												15?	3c		stylolite			BBB -rea	illy bad		Р
	LS			VLGy	1	M(P)	microbial				5?																15?	3c					BBB			
	LS			VLGy	1	M(P)	microbial				5?																15?	3c					BBB -rea	illy bad		Р
	LS			VLGy	1	M(P)	microbial	tr-3	IBCtr-5%		5?																15?	3c					BBB			
	LS		BBB=??	Lt(B)Gy	1	M(W)S					5?		3												40		??	5-3					BBB -rea			P
	LS		F clear spar cmt?	Lt(B)Gy	3	W(G)S		?)			20?											1	1?		1?		??	5c-3c?						BBB		P
	LS		555	Lt(B)Gy	3		peloid				20?		3														?	3c?-5c						BBB		. Р
	LS		BBB	Lt(B)Gy	1	M?	peloid??				??				_								?		?		?	3c?		texture?	"?			BBB -re	ally bac	
	LS		to a Constant Cha	Lt(B)Gy	4	W-P	peloid-skeletal?			1	15?			3	?								1?		1?	10	?	3c?-5c						BBB		P
	LS		tr micropytite	Lt(B)Gy	2	M-WS	•	O,			15		3							40				-	1?	1?	15	3c		. (1 . 12 .				BBB		Р
	LS			Lt(B)Gy	1	M(W)S			□ M		7		40		-				1	1?		1	1?	1	1?		5	3c?	oomo fr	stylolite		loopor		BBB		
	LS			Lt(B)Gy	2		peloid(?stromatop)	ır	F-M calcsp		10	2	1?		5								10 4	4	4			3-4	Some ii	ee termina	ating car	icspai		BBB		Р
	LS		0	Lt(B)Gy	2		peloid-fragmental			_	10 1	0			1							1	? 1	1	1		?	3-5						BBB		
	LS		C calcspar	LtGy	1		peloid??		0.6	t		1	1		1								1?		1?		400	5-3	000001//	ıa linina C	· aalaan	~-		BBB		
_	LS		t=1/0 ==l====	LtGy	4		peloid-?microbial	Tr	C free spar		15		1?		2							1	?	1	1		10? 5?	3c	Some vu	ug-lining C	•	ai		BBB		Р
	LS		tr VC calspar	LtGy	2		Peloid	40	0		9	2 0			2	1	40							1	1		5?	5c-3c	l40 .	stylolite				BBB		
	LS LS			LtGy	3	W(P)S		1?	vug-C spar	1	15	3 2	40		3	1	1?	44		4				1	1			5ac		w/ geopeta		-1-!		BBB		- 25
				LtGy	3	W-PS		?tr	•		15	5	1?		2		10	TWt		1	10	2	1	2	1			5ac?	Subcrnt?	w/ geopeta	als //C	aicispn	eres	BB BB		3P
	LS LS			LtGy	5		peloid-skeletal?	Tr 2	M-C calcsp		10 2	0	1?		2		1? 1?			3	1?	2	ı	4	1		2	5ac? 5a(b)	porocity	(= \((1)\)(\)	i-0\ 0 i	atorfoosi	il (C nizo)	BB		P
	LS			LtGy	5	-	frag-skel-peloid	4	Csp&foss				11		2 42	,				1		1	2	1	2	+-		` '	porosity	/= vug(D s	12e) & 11	iteriossi	i (C Size)	BB		ᅼ
	LS		10%+ M-C+spar	LtGy	5	P(G)S		tr	interfos		5 2				3 1 2	1	2? 1?			1		2	4	1	4			5a 5a						BB		3P
	LS		10%+ IVI-C+Spar	LtGy	5	P(G)S		tr	interfos&sp		2		2		8	1	1 ?			3	1?	7	2		2		3	5ab						BB		3P
	LS			LtGy LtGy	4		frag-skel-stromatop fragmental-skeletal				2				2		1?			2	1 !	2	2		1		3	5ab						DD		
	LS			LtGy	4	PS	fragmental-(skel)	3-6	IABC2D2-3		3 3	-		2	?		1?			1		3	1	2	1 1	1	3?	5a 5a	VC ud	spar & cle	or M.C.	oper M	ioritizyod	rimo		BB P
	LS			LtGy	5	P(G)S		4 Q	IABC2D2-3	2) 4				?	2	1?			1		2	1	2	1	•	10?	5ab-3c <mark>?</mark>	_	ozoan? W		•				DD F
	LS	dol	tr wt DOL CMT	LtGy	5	P(G)S		6	IB2CD5	9	2 4	-		3	2		11			1			1	3	1		101	5h		ozoan: w		•		105511		8P
	LS	uoi	ti Wt DOL OM1	LtGy	5	P(G)S	_	1-2	fossomold		5 3				3		1?			1		3	2	1	2			5a	(1 OI þ	Jorosity W	corar se	pia mon	u)	ВВ		OI
	LS		poor spl-BBB	LtGy	1	P-WS		tr-1	10330111010			0 ?			3 ?1		1:			1		2		· '				5		tr pyrite				BBB		
_	LS		poor spl-BBB	Lt(MB)Gy	4		peloid-fragmental	tr			15 1				J : 1					12		2	1 2	3	1		1?	5a-3c?	Spar in I	MS? Or pe		n GS		BBB		Р
00	LS		poor spl-BBB	Lt(MB)Gy	2		(frag-skel)	tr			-	5			7	2?				12		1	2		1		1.	5ab?	Ораг III I	wio: Oi po	,ioia/iraç	g 00		BBB		3P
	LS		poor spr BBB	Lt(MB)Gy	2		Microb-skeletal				3	6	2		3	3?				1		1	1		•	12rc	10?	3c5ab		stylolite	9			BBB		P
	LS		BBB-tr dolm	Lt(MB)Gy	2 1		Smicrob-peloid	3	IABC3D			5	1			0:				1			1 1	3	1	1	15?	3c	pores i	n tubules		erfrag h	it>'hookle			P
	LS		BB ti doilli	Lt(MB)Gy	1		peloid				9					1?								1				5c?	P01001	tubuloo			2501110	BBB	P-th	umbho
	LS		55	L(M)BGy	1 4	` '	skeletal (-microb)				5					1?	2	2 1?		1		1	1	1	1		10?	3c?						BBB		Р
	LS		v.bad=BBB	L(M)BGy	1		(peloid-fragmental)	tr	vug-Vcspar			5 1rd				?												5(c?)	XC free	e-dogtooth	ı spar			BBB ve	rv bad	
	LS			L(M)BGy	4		peloid-skel-microb		vug & IC1			5 1			2		?1			1			1	4	3		10?	3c5ac?		heres Nu	•	nellids			BB	Р
	LS			L(M)BGy	2		peloid-microb		-g		10				2		1?							2	1		15?	3c		calcis?				less BB		
	LS		BBB	L(M)BGy	1	MS	P				5													1	1		5	3c?						BBB		
	LS			L(M)BGy	4	M-PS	pel-frg-microb-skel	tr	vug-Ing sp		20 1	5 1	2				1?					1	1	2	1		15?	3c-5c						BBB		P
	LS		BB	L(M)BGy	2	MW(P			الم حق		10 2	-						1							1			5c?	mottled					BBB		
	LS		BBB	L(M)BGy	1		peloid				7											1	?	1?	1			5(c?)	,					BBB		
	LS		BBB	L(M)BGy	3 4	W-FS		tr	interstl		5 1	0			6		1	2 2										5(b)						BBB	P -th	umbho
	LS			L(M)BGy	4		pel-frag-stromatop	tr			15 1	0	1		10 1?	>		2		1		1?	1	1	1		5	5bc-3c?						BBB		Р
	LS			L(M)BGy	3	ws	peloid-microb					5			2	1						1	1		1		10	3c-5c						BBB		Р
	LS			L(M)BGy	1 4	M-FS	stromatop-sponge						10		10					1			1	1?	1		3	5b-4b		?calcis	pheres		stylolites	BBB		Р
4335	LS		tr grn clay	L(M)BGy		P(G)S		2-3	IBC2-interxt	11	25 1	0	2			1?		2		2	1	2	1 1?	1		1rec	i	5ac		?calcis				BBB		2P
	LS			L(M)BGy			frag-pel-lithoclast	4	vug+interxtl		22 3	0 10		1	?						1	1	1?	1				5c						BBB		Р
				, , – -)	1 1	, - , -	J	1	1 .2	1 1	1	1 .	1 !	Ι.	ı	1 1	1 1	11 1	· 1	ı	1	1 1	1	1 1	ı	11	1 1									

Α	В	С	D		G	Н	1	J	K	L N		0	P Q	! R	S	Τ	٧	W X	ΥZ	Z AA	AB	AC AE	D AE AF	ι АН	AI A	AJ /	\K	AL		AM	AN	AO	AP	AQ
4345	LS	1	L(M)BGy			frag-peloid-stromato		ВС		15 2			1	0								1	1 1 1			5	bc4b						BBB	P
4350	LS	tr pyrite	LBGy			frag-peloid-skeletal					20 5	5	- -	2	4	1		3		_	1	1	1 1			_	bc4b		mic	rosolenid	coral re	eddened	BBB	Р
4355	LS	DDD	LBGy			peloid-chaetetid-ske	ei-trg				10	3		8 20				1		2	1	1? 1	1 1				bc4bc						BBB	Р
4360	LS	BBB tr. grp. olov				fragmental (peloid) frag-peloid-microb				15 2	15	1	3					2			1	1 1	1		10	2 2							very BBB BBB	D
4365 4370	L3 9	tr grn clay BBB	LtGy LtGy			frag-pel-skel				10? 15		1 '	12					1			' '	1 1	1 2		10 3		b-5c ia-c	'hooklet	te' caus	sed by bit			BBB	F
4375	16	555	L(B)GY			microbialite				6) !	12	12					- '				- '	1 2		10?		bc-	DOORIEL	is caus	seu by bit	L		BBB	
4380	LS LS		L(B)GY			microblante microb-peloid				10		2	1:							1	2	12	2		10		c-5c	more	microh	oial than v	velleite's	s 'reefal'	BBB	
4385	LS	BBB			M(W)S	•				9											1		1		2?		i(c)	111010	11110101	nai trair v	Wonorto t	o rooiai	BBB	
4390	LS	555	L(B)GY			peloid (microb?)				9		1?				1?				4	1		1		6		i-3(c)		ovst	ter fragme	ent		BBB	
4395	LS	BBB	L(B)GY			fragmenatal (-coral)				6 1	15	1?				7				1	2	1	1		6		i(b)		-,-				BBB	
4400	LS		L(B)GY			peloid-fragmental				10 1	10						SE	32? 4	400		1		1				i(c)						BBB	
4405	LS	BBB	L(B)GY	6	P-GS	peloid-fragmental				30 3	30 ?		1?				1				1	1?	2				c-5ac						BBB	Р
4410	LS	tr grn clay	L(B)GY	6		frag-skel-microb			?	5 3	35 2	2 1	6	1		5	1?	2		1 5	2	2	2 1		15	3	c-5a						BBB	2P
4415	LS		L(B)GY	3 4	WP+FS	frag-skel-microb-str	omatop)		5 2	20 2	2 2	10	0 2	?	6					3		2	3	15	3	bc-5b							2P
4420	LS		L(B)GY	4		frag-skel-strom-chaet		r-Fspc		5 2	20			9 9		2		1	11	? 5	5	3 1	1 3		5	(3bc)5 <mark>b</mark>	2 chips -	red L	S				3P
4425	LS		L(B)GY		W-GS	frag-peloid-skel-cora	al tı	r-IBC		15 2	25			3		10	2	1		3	1	1 1	1 1	?	3	5	ib						BB	2P
4430	LS	tr grn clay	L(B)GY	3 8	W-RS	frag-skel-stromatop	(-coral)			5 1	15		10		?	7	2wt	1		1 5	1		1		5	5	ib		styl	olites			BB	3P
4435	LS	BBB	L(B)GY	4	W-PS	frag-skel-(stromator	o)			3 1	10		8?			1?	5			3	1		1		2?	5	ia(b)						BBB	
-	LS		L(B)GY		. ,	ooid-frag-skel			20	5 1	0 5	5	2?			3	2?			3	1	1	1 1	1	6	5 5	ad	mottled	mic	ritized an	d round	ed		P
4445	LS	BB	. ,			rd frag-ooid-clast-m	icrob?		10		30 10)	:	5	-2? 4	1125			111	? 2	1		1	2	10		ad						BB	Р
4450	LS	tr pyrite BBB	` '	5 4		Frag-sponge-skel			5		30 7	7 10		5		+433				1 3	1?	1	1 1	1		-	b-5b						BBB	Р
4455	LS		. ,			frag-strom-spg-skel		r				5 10	2			1?	2	3		5	3	2 1	1	1	2	5 4	c-5b							7P (X16)
4460	LS		L(MB)GY			frag-stromatop-cora					20	5	2		?	10	2	2	111	? 5	2 '	1? 2	2 2		10	5	ib							3P
4465	LS		L(MB)GY			frag-stromatop-skel-ooid			10			7?	1			3	3	3		5	2	1?	<u>, </u>	0.	10		c-5bd		•					4P
4470	LS		L(MB)GY			strom-coral-microb-frag-			1	5	10 5	5 7		0 2* 2'		10	1	3	?	5	2	1 3	3 2	2^	15 (?	- /	b4c(3c)			lcispher				4P (X16)
4475	LS	<u> </u>	L(MB)GY			fragmental-skeletal			2	2	10		10	0 3 3				2?		2	2	1	1 1	21	-	2 5		tr pyrite	(X	16 - rea a	aigae oi	r hydrozo:	ans)	3P
4480	LS LS	Cu ara SH	L(MB)GY			frag-skeletal-(stroma			3		10 3	0		<i>I</i> 3	1	1		2 !		· 1	1	1	1 1	f 1	5		iab Ic-5ab		naa	r comple				muddior
4485 4490	L3 1 8	Cu grn SH Sh aa BBB	LMGy LtGy			frag-skel-(sponge) fragmental-microbia					15	3 8	12	5	'	2		2		2	' '	2 1	1 1		15?	_	C-5ab		poo	r sample			BBB	muddier
4495	18	tr grn clay	LtGy			skel-strom-microb		r-ICD		5 1	10	1	1:	5 3		2?	2			; 3	1	1 3	3 1	21	10		c-5b	SH ptgs	NVI	P vs logs	•	stylolite		cuttings 2P
4500	LS LS	BBB			P-FS	sponge-stromatop-f		100		2 1	10	15	1			٤:	4			8	1	1 1	1 1	: 1	3		c-5b	or r pigs	1441	vs logs	2	Stylolite	S Dubbly:	P
4505	IS	000	LtBGv			oral-skel-oncoid-fra			2	5+ 1	0 5	5	2 5	-	?	15	2	3		7	1	2 2	2		-		be		tubi	ılar foram	ns thick	tuhinhyte	s (VS mainly thi	2P
4510	LS		LtBGy		P-FS	frag-stromatop-skel	_	,	_		15 5	5 5	1			2	_	2		3		1 12	1		10		b-3c		tubt	alai lolail	io unon	tabipityto	o (vo manny un	 P
4515	LS	tr qtz sand	LtBGy		P-FS	stromatop-frag-skel					10 2	2 5	1	-	1	1 4		1		3	1	2	2 1		15	_	b-3c							2P
4520	LS	tr M-C pyrtie	LtBGy		B-PS	strom-oncoid-bryoz-skel				3 1	10 3	3 1	2			3	10	3		4	1	1	1 1			15 5	b4c							2P
4525	LS		L(M)BGy		B-RS	stromatop-chaetetid		,			5	2	2			2				5	,		1		1	_	b-4c?							
4530	LS		L(M)BGy		B-RS	chaetetid-stromatop					5		2	5 35		3							1		5	5	b-4c?	6P(rando	om ph	otos fran	nebuild	ers so ple	entiful)	
4535	LS	tr pyrite	L(M)BGy	9	B-RS	chaetetid-stromatop	o-skel					5	2	0 30		5				1		1	1 2		3	5	b-4c?	,				•		5P
4540	LS		L(M)BGy	5 4	P-FS	stromatop-frag-(cora	al)			5 1	15 5	5 4	2	5 5		8		4		2	1		1		5	5	ib							4P
4545	LS		L(M)BGy	5 4	P-FS	strom-chaet-skel-oo	id-frag		15	1	10	2	1:	5 10		3		1		2	3	1 2	2 2 ?1	1?	3	5	bd4c		sma	all cell cha	aetetid	ooids =	superficial	4P
4550	LS	grn clay	L(M)BGy	6 4	P(G)FS	frag-stromatop-chae	et-micro	ob		5 2	26 5	5 5	1:	5 10		8	2			1	1	1 2	2 1		15	5	b4c3 <mark>c?</mark>		mix	BS & fra	g GS &	clasts mic	robial MS	2P
TD-4552																													som	ne red sta	ained ch	aetetids		
	estim	ate 4700-480	<u>0m abo</u>	ut N	<u>/lisain</u>	<u>ne Shale top (fr</u>	rom s	<u>eismic</u>	<u>in k</u>	<u>(idst</u>	<u>on e</u>	t al.	2000	<u>6se</u>	<u>ction</u>	<u>ı thi</u>	cke	<u> 1ed :</u>	= <u>ov</u> e	er sa	alt?	? q	rowth	<u>faul</u>	ting/	<u>loa</u>	ding??	?						
		FACIES NUMBER	RS: 1=bath	nval s	hale. 2	=neritic shale, 3= fore	ereef-ch	annel. 3A=	fores	ope ch	annel	. 3C=	distal f	oreslope	e (micro	obial ı	mud n	nound)	. 3B=	proxin	nal fo	resloc	pe (forer	eef). 4 :	= spond	ae re	efal.							
						ound, 4B= 'shallow' s																			-1		/							
		5B=coralgal-'stror	natoporoid'	' reefa	al, 5C =n	mud/pelleted; 5D=oolit	tic, 5E =	oncolitic, 5	F= sa	andstor	ne, 6=	'moat	t' (open	inner sl	nelf), 7 :	'= mix	ed ca	bonate	e silicio	classti	ic plat	tform i	interior (nearsh	ore rido	ge),								
		8= coastal deltaic	(lagoonal-c	contin	nental),	9= mixed carbonate-	deltaic,	10 = deltaic	/inter	deltaic.	SEE	E: Wie	erzbicki	, Harlan	d & Eliu	uk 20	02 for	illustra	itions a	and de	etails													
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	/\}	, pc//	ЛІЛ			F14,	L				` _	. <u>"</u>	77	7 0 - 44			V I (иΙ	<u> </u>	М	13					L.	LIIU	n ZU	, 10	' _				
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DEPTH L			COLOR	TE	XTURE		PORC				RIES	П			OSSIL	П		enhanced								18 ,	COMMENTS		
(metres)	LS=limest		2	其	MS=m	nudstone 1	%				2	FRAN	IEBUII	DERS			ľ	3	SO					LGAE		18.74 17.74 18.74	additional fossils/a	accessories	
Ţ	DOL=dolo SH=shale		ABBREVIATED or MUNSELL DUNHAM NUMBI	s) riç	PS=pa	vackestone 3 ackstone 5		modifier			LAS:		ES.	S	<u>د</u> ا		_ 6					FORAMINIFER	-	, <u> </u>	니 등	ACIE KEIE	diagenetic textures		
c	SS=sands		REVIATIONSE	rs(b		rainstone 7 oundstone 9		(Archie)		ã ŀ	ᇑᅝ		뙮[띖	<u> </u> ₽	ᄬᆙ	K	SCOANS		TROP(N S	3 ş	ျှုပ္ပ		ROF and8	facies-sequence b	reak BBB = BAD BIT BRUIS	SE
L	SLTST=si arg=argilla	aceous	MA H	ft fs8		S=XC size) patstone 4			<u> </u>	삤	텔텔	GES	ATO ATO	CHAETETIDS	<u>ا</u> ا	HEXACORA		CRINOIDS	GASTROPO	TRACODS	뛞뉡	FORAN	<u> </u>	E E		Tark	et cetera	due to hi-speed PDF b	
C	calc=calca sdy= sand			bs le	RS=ru	idstone 8			8		PARTICLES	NO.	WT SPO	 †	hydrozan-OTHER MICROSOLENID	\models	BRYOZOANS	8		OSTR	TUBIPHYTES	2	₹∭ #	\ <u>A</u>	No.	ARD 75,F icki,I	some long comments may hidden & visible only on scr	~ · · · · · · · · · · · · · · · · · · ·	
Y	<i>(</i>			-s L	\hat{1}	drystalline						s l	ST		호 일						트		SHE SHE	N 등 학		Son' erzb		striated or 'laminated'	
				П	Ч			V=vug												Ш				S		Z × ×		L-35A ctgs mainly goo except from 3615-3960	
Α	В	С	D	П	G	н		J	к	L	M N	0	PQ	R S	,	7	v v	v x y	ZΑ	A AB A	C AL) AF A	FLA	H AI	AJ	AK	AL P = photo	to TD	
3995	_	no sample	_	Н				J																		,	7. <u> </u>		
3400		nosample		Н		AB-6	up 3	396 = 339	4 8m	1 TV								d from						10m					
3405 3410		no sample no sample	ASING 3			7150	I I	000 - 000	7.011		~	ba	sinwa	rd to NI	E abo	out +4	00m	at TD o	of 410	5m (3	3970	m TV	D)						
-	Ssity		MGyBn 1		IS(GS	+ 10% ooidGS			10																	(5d)	quatz and carb' nucleii Cas	sing CEMENT	2P
3420 L	∟S (slty)	& 10%silty/arg	MGyBn 6	G	-PS	ooid F-VC			60		3		2?			1		1 1		5 2	1?	1				5d	stylolites superficial ooids	·	2P
			L-MGyB 5			peloid-frag-ooid			10	20	20 1		3			2	lwt	2		5 1		1		1		5cd	XF-VF micropeloids		3P
	_S _S	tr XC calcspar	LtGyBn 6 LtGyBn 7			ooid F-VC ooid F-C	tr	XCspar/frc?	70 70							1		1	3	3 1			1	? 1		5d 5d	qtz&carb nucleii (metal shard some red ooid GS F(M)	s)	3P
			LtGyBn 6			ooid-frag-rd clast-p	l eloid			10 2	20rd 10rd								-	<u>-</u> 1 1		1?		1?		5cd	roounded allochems, some MS	S lithoclasts stylolites	F
3445 L	_S		LtGyBn 7	C	SS	ooid-stromatoporoi			70		5		10	2	2			2	3	3 1		1	4	dasycla	3	5bd	2Pclose of dasyclad grn alga		7P
	_S		LtGyBn 4			frag-skel-ooid			20		30 5rd		8			1	1	2+ 1		5 1	1	1		2		5abd	possible trip- paint,	Fe, SS cave? (from what	2P
3455 L 3460 S	LS SS/LS		LtGyBn 5			frag-skel-ooid			15		40 3		3					2 2		3 2	1	1				<mark>5ad</mark> 5a	20/ my mitig. I. Omy mitigand a manage	sian in humaua00	P
3465	SS/SH	7/3 calc qtzVF-F 6/4 calc qtzVF-F	LtGy 3 Md(B)Gy	ľ	V(F)S	frag-skel			3	2	10		1					5	4	-	2	1				5f	2% pyritic + ?pyritized orgar lignitic specks, SS partly pyrit		P
	SS		Md(B)Gy	П			5?	intergranula	r										1 2	2						5f	mod-poor sorting, cmt = calc	*	ritic?
3475 S	SS		LtGy			minor skeleltal LS		J		2									2	2 ?						5f	occasional rounded quartz gra	anules	Р
3480 S			LtGy	Ц						3									1	?						5f	tr pink C-VC feldspar? Sili		ent _
the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the s			LtGy			f glauconite? frag-skel-(ooid-stro			8		15? 20		8			4		6 3		?						5f	1-2% glauconite? = F grained POOR SAMPLE - SLURRY	It green	P
3490 L	_S/SS SS(SH)		LtGyBn 5 MdGy	F		POOR SAMPLE	matop)	0	5	20		٥			4		6 3	,	9		1				5abf	POUR SAIVIPLE - SLURRY		
	/ -	arg/silty	MdBn 3	v		fragmental-skeletal				3	15	1	2		1?	•		2		3 1 ′	1? 1?	3 1	?			5a	?calcispheres		2P
3505 S	SH/LS	6/4	3	V		silty-fragmental					10								2	2				1		5	oysters? sideraite??	POOR SAMPLE	
		qtz VF-M	L(M)Gy	ш		quartz grains -F-																				5f	well rounded. Tr pyrite in VC p		
		qtz F aa 9/1 qtz F aa	L(M)Gy LB&Lgy 1		1(W)S	quartz grains -F-					5							12	1	2 1		1		3		5f	Tr micropyrite in VC patches 1-3% micropyrite in Bn tran		P
3525 S		7/2/1 F aa	LDOLLGY 1			fragmental					10							•		: 1				3		5f	POOR SAMPLE - SLURRY	Sidoetit iiitie ivio	
			Dk&LtGy			ooid [shaly SS]			10			\B-6	o 35	32 = 35	<u> 19.1</u>	m TV	D_									5f	POOR SAMPLE shale dark	Tr glauconite	
	S (SH)		1			frag-ooid (-peloid)			15			2					2wt	2	1? 3	? 2	1th	k 2				5ad	cephalopod?? Pyritic SH fro	m above or lag off?	P
	_S		LGyBn 5		` '	peloid-skeletal-(frag	,,				5 1		6					1	4	1 2		2		3	1?	5ac			2P
	_S		LGyBn 3		` '	peloid-thrombolitc=	micro	bial		15			2?						100		1 1?	2		5		5c	stylolitic	Email and allifer and do C	
	_S _S	skel & ooid=7/3	LGyBn 6			ooid strom-skel & ooid(F	-C)		70 20	7	10		20		2			1	1? 2	2 1	10	1 2 1	2	5	2	5d 5bd	fossils leached & cmted. Some SS cave stylolites	titted stylolitic oolds.Cart	11P
3560 L	S	SKEI & UUIU-1/3	LGyBn 7 LGyBn 5			frag-skel-peloid	0)		20		30		3		2		l Iwt	5		1 2	1 2	1	:	5		500 5a	55 cave stylolites	spls "muddy'-acidized	117
	_S		LGyBn 5		` '	frag-skel				-	40 1		2				2wt	6	1 5	5 2	2	2				5a	stylolitic	spls "muddy'-acidized	5P
3570 L			LGyBn 5			frg-skel-strom-microb	Tr	free calcsp	5+	10			10				wrt	3			1	1		10		5b(c)	stylolitic SS cave	spls "muddy'-acidized	P
	_S		LGyBn 3			frag-skel-peloid				10 15		5	4					2 3	2			1		7		5ab(c)	,	spls "muddy'-acidized	
3580 L	_S		LGyBn 3	V	V(P)S	frag-skel-peloid				15	15	5 2	3						3	3		1				5ac	stylolitic	spls "muddy'-acidized	
			LGyBn 3			fragmental-peloidal				10	10		1 1				10	1	2	2 1		1				5c		spls "muddy'-acidized	
			LGyBn 3			fragamental-skeleta fragmental-skeletal			5	5	15 25 1	2	3				1?	1			12				1	5a	stylolitic	spls "muddy'-acidized spls "muddy'-acidized	20
3600 L	_S		LGyBn 5 LGyBn 5			rragmentai-skeietai ooid-frag-skel			40		15 1	1	3			2		2 2		2 1	1 ?	1			1	5a <mark>5d</mark>	stylolitic	spls "muddy'-acidized	3P 2P
3605 L	.S		LGyBn 5			frg-pel-ooid-(skel)	tr	V-calcsp fill	20	15	35 und		1					3		1 2		1		2?		5cd	superficial ooids=miciritized	spls "muddy'-acidized	3P

Α	В		С	D	П	G	Н	Ι	J	K	L N	N	0	P Q	R	S	T	V	W X	Υ	Z A	AB	AC AI	AE AI	F\ AH	I AI	AJ Ak		AL A	AM A	N AO	AP	AQ
3610	LS			LGyBn	5	P(G)S	Peloid-frag-ooid			10	25 1	5		2					2		2	1		1	ii -		5c			spls "	muddy'-acidize	d	Р
3615	LS			LtGyBn	6	P-GS	ooid-peloid-skel-frg	Ī		30	15 1	5		2	2 4				6	?1	3	3 1	1?	1			5a	cd	P of crinoid,cha	etetid,superf	icial ooids =mi	critized BBB:	3P-x16
3620	LS				5	P(G)S	ooid-frg-pel-skel	tr	V-Cdogtoot	20	10 2	0	3	9			1?		5	2	3	3 1	1?	1			5b	d	stylc	litic	В	В	
3625	LS				5	PS	frag-skel			5	5 3)	2	5					1 2		3	1	1	1			5a		,		В	В	
3630	LS				3	W(P)S	Frag-skel-peloid	tr	V-C calcsp		15 1	5			1?				3		2	2 2		3 1		2	5a	С	stylc	litic			
3635	LS						6 frag-skel	tr	V M-Cspar		30	?		5?					?		?		2	2 1					(NO SAMPLÉ a	t ElPaso) ?d	calcispheres?		
3640	LS		white=BBB	VLBn	4	W-PS	frag-ooid?-skel			20	5 1	5			3 5				4		3	3 1		1			5a	d	ooids superficia	I micritized 8	k chalky. Wt M	C blky CMT	BBB
3645	LS		veryBBB+ to 3900	j	2	M-WS	frag-skel				1	0	1?						1		2	2 2	2+	2		5?	5a		spar in MS		•	BBB	
3650	LS		10%argLS-MBn	L(M)Bn	3 !	9 W(BP)	S frag-skel-(strom?)			1?	5 2	0	1?		1?				2	1	2		2	2 1		2?	5a		clasts of stroma	toporoids?	better sa	mple?	Р
3655	LS			VLBn	2		fragmental (peloid)			-1-1	5 1	0			1				1		?			1 1			5		wt & clear C-VC	calcspar =	subcmt??	BBB	
3660	LS		very BBB	VLBn	1		S Microbial? (frag)		superfi	ciai 2	5	5										1?		2		?10+	3(0	:)	In MS Mstl spar	=cavity only	4-5 chips ID'd	very BBB	
3665	LS		VF calcspar	LtBnGv	1	MS	microbial?				2	2										2		1		?20+	3c	_	Calcspar = fract	tures or subr	narine cmt?? s	tylolites	BBB P
3670	LS		VF calcspar	VLBnGv	2	MWS	peloid (F-M)-microb	ial			15	5										2		1		?15+	3c	5c)	?calcisphere:	s? Stylolite	s tr M-C calc	cı BBB	
	LS		F+ calcspar	VLBnGv	4		Sfrag-stromatop (cor				5 2	5		17	7		?7					1?		1		5?	?5				clasts? styloli		Р
3680	LS		VF calcspar	VLBnGv	2 4		s microbial?-(stromat	•							1?			(?)		1?		2		1		?10+		(b)3	•		f 'booklets' >>>		Р
3685	LS		VF calcspar	VLBnGy	1	MS`	microbial?	1			10 ^{mic}	0														10?	3c		hardgd? stylc		cisphere	BBB	7P
	LS		VF calcspar	VLBnGy	2		S peloid-microbial				20								1?			3		1 1		?10+	3-		stylc		-	BBB	
	LS		VF calcspar	VLBnGy	1	M-FS					5		3?		1 15							1?		1 1?		+10?	3с		,		borings?	BBB	
	LS		VF-F calcspar	VLBnGy	1	MS	microbial (spar)				3soft															?20+	3с		,		"booklets" = F		
	LS		· · · · · · · · · · · · · · · · · · ·	VLBnGy	1	MS	microbial (spar)				5											1		1		?20+	3c		G,	"book		BBB	
	LS		F calcspar	VLBnGy	1	MS	microbial (spar)				3		1?													30?	3с		- also example			BBB	Р
	LS		F calcspar	VLBnGy	2	MWS	` ' '				20				3											+15?		-5c	alco oxampio		samples	BBB	
-	LS		very BBB	VLBnGy	1	MS	(?microbial?)				2													21		2	?3		only	3 chips ID'd	campico	veryBBB	
	LS		very BBB	VLBnGy	1	MS?	(?microbial?)				_															?	?3		-	good chips		veryBBB	
-	LS		M calcspar	VLBnGy	3		peloid-frag-(microb)	,			55 2	n									1	1		1		?10?		(5c)			ts about F-M	BBB	
	LS		ivi odloopal	VLBnGy	3	M-PS			vug-Mspar		?50													11		?10?		(5c)		ips one loos		BBB	
	LS		VF clear spar	VLBnGy	1		S microbial?		vag mopai		.00		3*									12		1		?10?	3c		VF clear spot	•	•	BBB	Р
	LS		very BBB	,	1	MS	(?microbial?)						2?									1 :		11		?10?	3c			chips only	3picule3	veryBBB	
	LS		very BBB	VEDITO	1	M(P)S					20?		Z :													?10?		(5c)	stylc			veryBBB	
	LS		?argil? very BBB	mottled V	/ 1	MS?	???																			??	?3		P of BBB w/ Dk		surface	veryBBB	Р
	LS		very BBB		11.	4 FS	frg-stromatop?-cora	al?		5?	5 2	5		10)		10				1	1		1			5b			J -		veryBBB	P
	LS		very BBB	` ' '	1 4	4 M-FS			0)	•		5		20-	-											?10+		4b3c	5 chips ID'd - 2	stromatopor	oids	veryBBB	
	LS		very BBB		/ 	4 G-FS		1	,		40															15+	3c		calcispheres		0.00	veryBBB	Р
3775	LS		very BBB	` ' '	114	4 M-FS					5			10+	fine?									1		25+		4b	·		very'dus		Р
3780	LS		?argil? awfulBB	` ' '	2	M-WS	, ,				20				l										_	??	3-	_	stylolites		,	y' veryBBB	
3785	LS(SI	H)	?argil? very BBB			??	??									wasl	hed out	sha	ly cark	o's o	r ma	rls?	?				?		dark stain/strea	k on ctas		v' veryBBB	
3790	LS(SI		?argil? very BBB	mottled LM	1	MS?										Chec	ck agai	nst v	vellsite	e lith	log						?		dark stain/strea	-	very'dus		
3795	LS(SI		?argil? very BBB	mottled Dkr	. 2	MWS					?														4		?		micropyrite		oad ctgs BBBB		Р
3800	LS(SI		?argil? very BBB	mottled LM	3		? frag-clast				5 4	0 20)														?			ips ID'd only	•	veryBBB	
3805	LS	,	. a.g 10., 222	mottled LM			frag-sponge-chaetetid				3	-	15?	52	20?	45		_			21	1		1			4b		micropyrite			vervBBB	2P
	LS			mottled ML	3	W-PS		iae			10 2	ol	10		10	AB-	5 380	4 = ;	3696.9	IVE	?1	?1		?!			4b		morobyillo			veryBBB	
	LS		tr qtz silt VPS	LtGyBn	2		? fragmental				20		1.3								22	>							tr py	rite		veryBBB	
	LS		VPS BBB	LtGyBn	2		Frag(F-M)-microbial	1?			1											2				10?	3с			e - pyritic cal	: SH	veryBBB	
	LS		VI C BBB	LtGyBn	1 4	4 M-FS						5	2?		17		2				3	3				15?	5c		tr pyrite styloli		Cave -SH	BBB	Р
	LS		VPS BBB	,	3	M-PS	U ,	l			20 2				.,						3	3 1		2			5c		a pyrito otylon		hips ID'd	veryBBB	
	LS		VPS BBB	,	1	MS?	(microbial?)				2											1				??	3c		tr clear yellow		•	veryBBB	
	LS		V1 0 000	LtGyBn	1		S peloid-(microb?)				10mic	ro			32				5			2		2		10?	3-		?calcisphe		(. Wood)	BBB	P
	LS		VPS BBB		1	MS	parota (microbi)				2								J			1	12	1		??	3c			chips ID's		veryBBB	
	LS		spar VPS BBB	,	1		peloid-frag(F)-micro	h?			20 1	0										'		12		???		-5с		s of F calcsp	nar	veryBBB	
	LS		VPS BBB	,	4	FS?	chaetetid-stromator		1			_		10	10													4b			matop & chaet		
	LS		spar VPS BBB	,	1	MSxtl	•]																			2		,	arry ctgs	matop a oriaet	veryBBB	
	LS			LtGyBn	2	MWSx		tr+	vug-spar																		2		2 sparry ctgs &		r	veryBBB	D
0000			Spai 11 0 000	2109011	ľ				.ug opai																		Ι.		_ opany olgs t	w spa		10. you	

Α	В	С	D	TI	G	Н	I	J	K	L	M N	0	Р	Q R	S	T	V	W X	(Y	Z AA	AB AC	CADA	AE AI	F A	I AI	AJ	AK	AL AM AN	AO	AP	AQ
3870	LS	spar VPS BBB	LtGyBn	5	P(G)	peloid-fragment	tr+	vug&interxtl	5	30	30							1?	?		1?		1				5c-3c	chip of peloid PS, 1-2 spar, fr	ag? GS-PS	veryBBB	P-x16
3875	LS	VPS BBB	MLGy	3		S fragmental				5	15																3-5			veryBBB	
3880	LS	spar VPS BBB		П	??	?? (Spar F-VF)																1	?1				?	1 or so chips only "booklets	s"	veryBBB	
3885	LS	darker BB	MdGy	3	WS?	fragmental? VPS =	very p	oor sample		7	??																?	darker chalky		veryBBB	
3890	LS	VPS BBB	mottled	5	PS	fragmentatl-peloid((F-M)	· ·		20	30	1?						13	?		1?	1 1	1?				5c3?	1-3 chips tr pyrite & grn S	H	veryBBB	
3895	LS	VPS BBB	mottled	2	M-WS	peloid (F)	Ì			15		15	spicule	es									1				5c3?	stylolitic 4 chips	tr VC calcspa	veryBBB	
3900	LS	cave?-SH&ooidLS	LMGyB	3	W-PS	peloid-frag(F-M)			(!0?)	20	20 2	2	1 r	rd clas	st				1	1 3	1		2 ′	1			5c3?	stylolitic CaveA? of SH, S	S(F), Ooid GS,	ВВ	Р
3905	LS	some frag GS	LBn	1	M(W)	S peloid (F-M)				20											1		1				5c3?	tr pyrite-VF 'booklets'		BB	Р
3910	LS	· ·	LBn	3	MP(G	S peloid-fragmental*I	F-M)			35	15							1?	1	1?	1		1		3?		3c	micropyite stylolites			Р
3915	LS		LBn	2		Speloid-microb?				15		3?											1		10?		3c	micropyite stylolites		BBB	8P
3920	LS	spar	LBn	2		microbial-peloid	tr?	calcsp-frct		15	5	1									1		1		20)	3c	thrombolitic w/ spar (subma	rine cmt?)	BBB	4P
3925	LS	? sl.arqil spar	L(M)Bn	3		peloid-frag-microb				20	10	2	2			^				2	1 1	1 1	2 1?	?	10		3c	thrombolitic aa slightly darl		BBB	Р
3930	LS	? sl.argil	L(M)Bn	2	M-WS					10					Sha	aly?=					12	3	1		?10		3c	stylolitic slightly darker ??S			
3935	LS (SH?)	glaucSS	M(D)BGv	4	W-PS		-frag				10	5	5		1	muddy				2	1	3	1		20+		3c	thrombolitic stylolitic tr G		,	Р
3940	LSarg (SH)	Argil? Tr pyrite	M(D)BGy	3	M-PS	•	l			35	10				I .	tgs					1		•		52		3c?	3935 MAJOR DARKER CHG	•	red)	BBB .
3945	Lsarg	argill?	M(D)BGy	2	M-WS		nge			25		10) .	< </td <td>393</td> <td>0-60m</td> <td></td> <td>2</td> <td></td> <td></td> <td>1</td> <td>12</td> <td>1 '</td> <td>1</td> <td>18</td> <td>5</td> <td>3c 4B</td> <td>stylolites ?calcispheres?</td> <td>,</td> <td>,</td> <td>BBB P</td>	393	0-60m		2			1	12	1 '	1	18	5	3c 4B	stylolites ?calcispheres?	,	,	BBB P
3950	LS/SH	w? DGySH+sitlst	M(D)BGy	2 4		S peloid-sponge-frag	_				10		10			v		ļ.	1		1	1.	1 21	1	15?		3c 4B	Stylolites : calcispheres:	viioropyrito : gie	BBB	2P
3955			M-Dk Gy	_ 7	??	? Marl?					. 0		10		L			2			'		1 : 1		131		2	lag off? cf wellsite log?? MUE	DV SI LIDDV	VPS	21
3960			M-Dk Gy		??	? Marl?		AB-4 396	30 = 3	3839	.4m T	VD						l i									2	lag off? 5m cf we		_	<i>y</i>
3965		muddy slurry tr spar	LGyBn		M-FS	_		IC2Dtr		45	101	1 40	1 2			21	214	112)	2	2	1 1	2		10?		4ac3c			(BB)	1 2P
3970	LS LS	li Spai	LGyBn	2 4		Speloid-skel-microb		IC2DII		25	5	1 2	4			f 1	3wt 1wt	1 ?	1	4	3	' '	2		101			,			2P
	LS LS		,	2		′ •		fract'spar		20	5	3	_	2			ΙWί		1	4	3 10	2	2		10+		3c 3c	some peloid GS stylolit		(BB)	
3975 3980	LS LS		LGyBn	4	P-WS	Speloid-skel-microb		iraci spar		20 30+	-			4		12			1		2 1?	! 2	3		10+		3c 3c	some peloid GS stylolit	Pip a sum	pleS to TD for t not GSCs?!	
	LS		LGyBn	4	_		١				5		5	-1		17					1		4		-			stylolit	, ,	11101 0003::	·2P
3985	LS		LGyBn	3	M-PS	1		fractispar		20	15 2	2 3	3								2	1	1		10+		3c	sponge spicules? stylolite			
3990	LS		LGyBn	1	٠,	peloid-microb-frag		l ,		20	10	3	3 2	27			?1+	40 40	1	1	3	1	2		20		3C	stylolites microp	yrite		2P
3995	LS		LGyBn	1		peloid-microb-skel		•		20	10	3	3	9				1? 1?	'	1?	2	1	1		10	-	3c(4 <mark>b)</mark>				
4000	LS	spar	LGyBn	4		s frag(Mang)-peloid-i	microb)			25 3	3 2	2								1	1	1		10	יו	3c	?calcispheres? stylolites			2P
4005	LS		LGyBn	4		frag-strom-peloid					25			20				1?	?	5	1		1				4b5b				Р
4010	LS		LGyBn	3		frag-stromatop-ske	el				20 2		2	10		2			1	3	1	1	1			-	4c5b	micritized			2P
4015	LS	tr spar	LGyBn	1 4		S frag-sponge-skel		vug-spar		-	20	15	5 1	6			1?	_ ·	1 2	2	2 1	1 1	1		3	-	4b	stylolites			2P
4020	LS		LGyBn			frag-stromatop-ske	_		3	-	20	5	1	22		?2	1wt	_ 2	2	1 5	1		1		2	2 1?	4c5b				3P
4025	LS	w/styloSh-grn+red	LGyBn			Frg-strom-spg-skel					20	10	2	22				;	3	4	1		1				4b5b	stylolites shaly residue=gre	en&red & spar		2P
4030	LS	tr grn slty clay	LGyBn	4 4	WPF	Frg-strom-spg-skel	ı			3	20	10)	25 2?				- 2	2	2	2 ?1	1	1		5	5	4b5b	minor red			3P
4035	LS		LGyBn	4 4	WPF	Frg-strom-spg-pel-	skel			10	20	17	3	20		3?	1	- ;	3	3	1	2	1 1?	?	3	3	4c5b	red stylolites w/ tr pyrite			4P
4040	LS	spar	LGyBn	2 4	MWF	S frag-stromatop	tr?	vut?spar		5	10	2	2	9		1			1	2 5	1		1		5?		5b/4c	llinear spar = shells leached	I & cemented?	?	Р
4045	LS	grnSH=cave? Spar	LGyBn	3 4	W(P)F	S stromatop-skel-frag	g				10	3	3	25	3	2		1	1	3	3	1	1		2	2	4c5b	stylolites w/ VF pyrite ti	white VC spar	calcite	Р
4050	LS	tr grn clay	LGyBn	4 6	WP-R	stromatop-skel-frag	g			5	10 3	3 5	5	35 3?				1?	?	2	1	1	1		2?		4b5b				2P
4055	LS	tr grn clay	LGyBn	3	W(PF)\$ stromatop-skel-fra	ıg			2	10	2	2 1	10		3?		- 2	2	3	2	2	1		3?		4c5b	micropyrite tr red in fossils	& corals		Р
4060	LS	fracture? VC spar	LGyBn	5	•	Sfrag-stromatop-ske	Ÿ	vug spar		5	35			20		2?					2	3	3				5b	stromatoporoids r			2P
4065	LS	VC calcspar	LGyBn	4		S stromatop-fragmen				5	15 5	5 1		20					1	2	2 3	3	1		2?		4b5b	stylolites micropyrite		slight BB	Р
4070	LS		LBnGy	4 4		stromatop-frag-mic		kel		5	10	1		15					3	2	1	1	1		12	2	4b5b	1%-tr micropyrite		slight BB	Р
4075	LS		LBnGy			F stromatop-frag-ske				5	25	1		10	3	4		1	2	2	2		1		5	5	4c5b	stylolites		slight BB F	>
4080	LS		LBnGv	5		frag-pel-skel-micro		matop			20			10					1	4	2 2	2 2 5	5?	?rd	1 10	o	5b	Ps of algal-foram GS/BS? Cl	nip Tr C-VC ca		3P-x16
4085	LS		LBnGv	3 4		Ffrag-skel(stromate				5	15	2	2 2	3?>>>	>5		2wt		1	2	1		1	?		-	4b5b	stylolites - tr grn c	•		Р
4090	LS		LBnGy	3		Sfrag-stromatop-ske				-	20			15	3	5				1 2	2 ?1	1 2			1		5b		,	ВВ	2P
4095	LS		LBnGy	4		frag-microb-stroma					25	3	3	10					3	2		3	1 1?	>	15?	-	4b5b				2P
4100	LS		LBnGy	4 9		R frg-microb-pel-stro		al	1		20			10+	1?	10			-	2	1	2	1		20+		5b	stylolites dark o	reen clast/foss	il in carb chi	2P
4105	LS		LBnGy	4 9	BSaa					5	15			10	5+	1? 10			3	1	1	2	2 12	?	201		5b	geopetal-& strom-milleporids			
A	В	С	D		G	H	1	,I	К	-	M N	0	Р	QR		T	V	w	V	Z AA	AΒΙΔΩ	CADIA	λΕ ΔΙ	FΙΔΙ			AK	AL AM AN	AO	AP	ΔΩ
_^		3			Ĕ		÷			_		Ť	H	٠ ١١	Ť			- ^	+	_ ^^	1374	-,,	/1		+~	1~0	7	All All	70		7.4
= 3	1105m 970m VD	4A= 'deep' siliceou 5B=coralgal-'stron	ıs sponge ı natoporoid	reef 8 I reefa	k interral, 5C	2=neritic shale, 3=forer nound, 4B= 'shallow' si =mud/pelleted; 5D=ooli 9= mixed carbonate-o	iliceous itic, 5E :	s sponge ree = oncolitic, 5	ef, 4C =	· sha ndsto	llow' si	iceou 'moa	s spo t' (ope	nge-coi n inner	al reef, shelf),	, 5 = open 7 = mixe	n mari d carb	ne car onate	rbona silici	te bank clastic	c 5A =s	skeleta	al rich	۱,	·	•	eefal,				
				H																					1	1					
Α	В	С	D	tt	G	Н	1	J	К	L	M N	0	Р	Q R	S	T	V	w x	Y	Z AA	AB AC	CAD	AE AI	F A	I AI	AJ	AK	AL AM AN	AO	AP	AQ
																								- 11	_						

Appendix A3 ENCLOSURE A3.13 Marquis L-35A L.Eliuk 2016

Enclo	sur	e A3.	14 PCP-MU	RPHY	Μι	ısquodoboit E-23	on	sulting Inc	L.E	liuk P.Geo	l. Initi	al 1/2	logge	d 2001	1-11&12 a	at Calgary	and 2	nd 1/2	in 2005	-09 at C	NSOPE	3 (total	6 days	work)			TYPE 78'88	PAGE
DEPTH	LITH		modifier I	COLOR		TEXTURE modifier	ROS	ITY	ACCI	ESSORIES					FOSS	ILS	((enha	anced b	oy S <mark>W</mark>	C data	ı if ava	ilable))			Si 'A	COMMENTS
(metres)	 T H O L O G Y	LS=limest DOL=dolc SH=shale SS=sands SLTST=si arg=argilla calc=calc sdy= sand	entite stone Itstone aceous areous	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	MS=mudstone 1 WS=wackestone 3 PS=packstone 5 GS=grainstone 7 BS=boundstone 9 (FS/RS=XC size) FS=floatstone 4 RS=rudstone 8 XTL =crystalline	%	modifier (Archie)	SOIDO	PELOIDS PARTICLES LITHOCI ASTS		ONGES.	STROMATOPOROID	CHAETETIDS		MICROSOLENID HEXACORAL	BRYOZOANS	BRACHIOPODS	ECHINOIDS	GASTROPODS	OSTRACODS	TUBIPHYTES etc	FORAMINIFERA	HIGHER -green etc P	STROMATOLITES P	턵	STANDARD MICROFACII Flugel'82&Wilson'75&Elii	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera P = photo (FeP) = iron filings photo SAMPLES BIT BRUISED (BB) - LIGHTER COLOR THAN ACTUAL and rarely chalky =BB - indicates worse than
Α	В		С	D	П	G H	-	J	K	L M	V C) P	Q	R	S	Т	٧	W .	ΧY	Z AA	ABA	C AD	AE AI	FI AH	Al	AJ	AK	AL avg
3340 3345	SH s	lty	20% silty 10% VF-F atz SS	. , ,		silty Shale silty pyritic Shale	Ab 7	7? 3350					L							Tr	Tr		Tr Tr			1	2	Tr C rounded quartz grains pyritiic to +1%. Siderite??
3350 3355	SH s	y & LS	pyrite&glauconite	DK Gy		silty pyritic Shale Ls=MS-WS peloid				G pyritic	dark c	<u>ireen</u>	n glau 	conite	e pellets	∐WASI 	HOUT	ТО	3376m	BELC	OW CA	ASING	AT 3	360.5ı	m		2 2?	tr C rounded atz sand and VF qtz SS. CTGS=dusty&sma tr glauconite, pyrite, stylolitic limestone P
3360	LS		<5% VF qtz SS	N6-7		?FS skeleital-fragmental?	Tr			Tr 10		1				1 1			?	1	?		1		00		5	Tr turquoise Grn clay. Tr pyrite. CTGS = dusty small. Bf P
3365 3370SWC	LS LS			N7-6 N7	3 4	WS frag-skel-(peloid) ?FS (BB - sl. chalky)				10 20 5	2'	? ?				1? 10			1			1	1? 1		2?		(4)5 <mark>5b d</mark> eep	sl cherty, rd brn lr FA?siderite tr G tr pyrite BB Tr pyrite. Tr grn clay infill. CTGS small dusty. BB P
3375	LS p	oor spl(S	SS+SH+cmt)			FS spg-skel-frag	Ab	6u 3375		15	20					2?			2						5+		4b	Cavings =Trip(SS+SH) CSG CMT tr glauconite
3380 3385SWC	LS LS		?quartz clay?	N5 N5-5YR5/	3 4	FS/WS sponge (skeletal?) FS-WS microb-frag-spg-(T?)				1 10	10	-	2		1	tr?			2			1 ?	1		5 15?		4	blue-whity chert. Tr grn clay infill. BB & Fe scale (FEP) P cement 30% tr M-C qtz rd SS(cave?) (Fe P)
3390	LS			N6-7		fragmental(skeletal?)				20	1		1						?			1					5	BB. Fe Scale bit and pipe steel>>>> (Fe P)
3395 3400	LS LS		F glauconite 1% sl. argillaceous	L(M)BGy		F-WS strom?-frag FS skelelal(sponge?)				25 5	5′ 10		10					?	2	2		1 1	1		15		<mark>5b</mark> 4	Cement 10-20%, F glauconite-1%, tr milky chert (Fe P) 2P VC crinoid w/grn. Tr grn clay. DEEPER? (Fe P) P
3405		sl arg		L(M)BGy		WFS sponge-frag				10+	20		2						1	?	1	? 1			3		4 4b (c)	tr gren caly & internal galuconite So,e RED sponge 3P
3410	LS		(glauconite?)	L(M)BGy		FS/PS skkeletal-fragmental				15	5		?		?				1	?	1	?	1 1				5a	Dk grn caly infill. Sl.Pyritic. (Striated BB) (Fe P) P
3415 3420	LS s	arg	tr glaux Tr F calcspar&dol	L(M)BGy		FS sponge-skel-frag FS? Skel-frag (?microbial)				2 10	2 !		5			1			2			?	1		2?		<mark>4b(a</mark>) 4/5a	chips of paaint = TRIP glauc in spg's tr pyrite 3P Tr grn clay & pyrite. Small septate coral Microbail layers
3425	LS s	i?a <mark>rg</mark>		L(M)BGy	3 4	FWS sponge-skel-frag				15	10		_			·			3	1		Ė	1		3?		4b(5)	
3430 3435	LS	l?a <mark>rg</mark>		L(M)BGy L(M)BGy		Fs(ws) Fragmental (microbia MSWS (skel-frag)	l?)			1 10	5	2	?		1							?	1		10?		4/5?	Tr turquoise grn clay
3440	LS	i.u <mark>ig</mark>		L(M)BGy		FS(W-G) skeletal-fragmental				2 20	1		3				1		2			1	1	?			-ло: 5а	Tr turquoise grn clay. Patches fragmental PS-GS (F-M)
3445	LS			L(M)BGy		FS sponge-skeletal					5	5	4						1	2		?	2		5?		4b 5 (3)	(still cement cavings)
3450 3455	LS s	sl a <mark>rg</mark>		N4-5(YR) N4-5(YR)		FS skeletal FSWS bryoderm + skel				2 5	3	3 1	3			1?	5		5	2 ?	1		1 1	das	yclad		5a (4)5	bryodemr tragngressive break?? (cmt cave) 2P
3460	LS			N4-5(YR)	3 4	F(ws) Sponge-fragmental				10	15	5	5			• •				1	1		1				4b	BB
3465		arg arg		N4-5(YR)		FSWS skel(echinod-spg)-frg	tr-2%	vugs-spc do	gtootl		5	2+	+ 3	2	coarse		1+	3	3+ 2		1		1		1		<mark>4b(5</mark> /3)	spine/calcisphere?/OSTRACOD tr laminate P
3470 3475	LS	sl a <mark>rq</mark>	Tr M qtz SS tr grn clay (G)	N4-5(YR) N4-5(YR)		FS fragmental (Skeletal) FS(PS) frag-strom-skel				10 20+	3	3	1 10	1	1?see	photo			3 1	3					2		5 4/5b	Some VC calcspar BB P BB
3475	LS	, arg	Tr VF-F calcgtz SS	, ,		F/WS fragmental				20+	1	3	?	'		1				Ι.				clam			4/30 5	Tr pinkish white cement
3485		sl a <mark>rg</mark>	tgr grn clay	- ()		FWS frag-strom				20	2	2	8							3	oring		1		2		5(b)	boring clam in stgromatoporoid 2P (TH=x16)
3490	LS		Tr VF-F calcqtz SS	N4-5(YR)		F/WS fragmental (Tr pel GS	5)			2 15	1		1						1		1				1		5	Some spar cmt = GS?
3495 3500	LS s	arg arg		N4-5		(F)WS frag-skel F/W(P)s fragmental (Skeletal)				25 2 10	1	2	2 3			2			1	2	?	1					5	BB p
3505	LS			1 14-0		WPS strom-skel-frag				15	1	1	10	(dklo	ow)	+1?	encru 1?	ıst	2	3	2	?	1		3+		5b	BB P
3510	LS			N4-5	4	W(P)S Frag (pel-skel				3 15	1		2						1	?							5	Minor Md grn clay infill
	LS		Tr glavas = it =	NA E		frag-sponge-skel				15	7	2					?		3	3		1	2		5+		<mark>4b 5</mark> (3)	
3520 3525	LS s	sl arg	Tr glauconite tr G + grn clay	N4-5		W(P)S Fragmental (pelletal) W(P)S frag-skel				5 15 5 20	2	: 4	. 2				2+		4		2				3+		5 (3)5?	Minor Md grn clay infill
3530	LS		Tr gy pyritic clay	N4-5	6	P(G)S Frag-Pel-Stromatop		6 L3530		20 20	1		10		?		?		2		1		?		1	1?	5b	Grain-supported. Micropyrite. Tr XC clear Calcspar P
3535	LS		tr-1%Fqtz SS	NA E			3+?	vugs C+D		15 35-M	5 2		5						2 1	3	2		1		3+		5(3)	f quartzs grains float in LS
3540 3545	LS LS		Tr grn gy clay tr VF qtz burrows?	N4-5		WS Fragmental (pellet) W(P)S frag (skel)				5 15 ? 20	1		5+						1	?					2		5 5	BB P BBB
3550	LS			L(M)BGy	6	P(G)S fragmental (ooid GS)	Tr	vug-XC spa	10	7 50	1		2		micro	oyrite	1		3	1	1		2		1?		5ad	2P

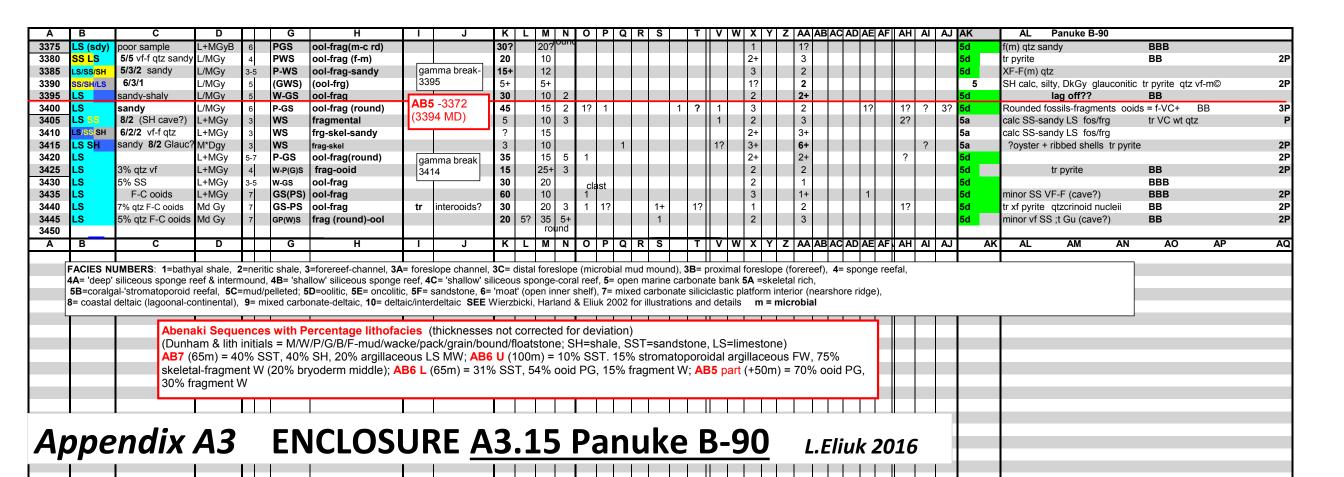
Α	В	С	D		G H	П	J	K	L	M N	0	Р	Q	₹ S	Т	V	W	(Y .	Z AAABA	CADAEA	F AH	Al	AJ	AK	AL
3555	LS	F(M) rounded frg	=N6(YR)	6	P/GS fragmental-(clast-ooi	d)		10?	5	50 5	1		2				?	?	1 1					5ad	See photo contrast of BB(bit bruise) vs 'nor Rel' BB
3560	LS	Tr M xtl DOLM	N5-6(YR)	6 4	F-P/GS frag-skel (ool-peloid)	ĺ		10	10	30	3	1	3	Tr	5		1	1		1				5b	Tr grn clay & sucrosic F-M dolm. Micropyrite Dark cave? P
3565	LS	BBB	N7mdB	5	PS fragmental(-skel)			3	5	25	2		3				2	2	1			?		5	sample light due to BBB
3570	LS		N5-6(YR)	4	W-PS fragmental (skeletal)				5	25	1		3	tr		2	2	2		1 11				5a	interbeds dk crinoid-bryozoan LS = 'breaks' Dark cave?
3575	LS	tr grn clay (G)		4 4	F-WPS strom-skel-frag					20	2	4	15	3			2		1	2 2		5		5b	much less BB = dark fossiliferous samples; micorforq 2P
3580	LS		N5-6(YR)	4	w(P)s frag-skel (peloid GS)	Tr	vug -F spar			30	2		3	7		1	1		1111	1-1-1				5a	1 chip pink LS. Minor grn peloid/frag's. Tr gy Pyritic clay Dark cave?
3585	LS sl a <mark>rg</mark>	tr micorpyrite	110 0(111)	3 4	FWS strom-frag		rag . opa.		-	25	1	7	-	+			2	> =	χίνster	? 1		3		5ab	tr pyritic XF-microXTL
3590	LS	. ,	N7	6	P(G)S fragmental (skeletal)	Ab 5	3590			40	1		1					2 2	1 1	1 1 1 1	1			5a	?SHC stained stylolites? Tr pyritic grn arg infill
3595	LS (sl arg)	bleach=BBB		3	WS Frag (skel)					20?	1		1+				1		12		clam?	52		5	BBB
3600	LS (Si aig)		N6-7(YR)	4	W-PS fragmental-skeletal					20	2			2 1			- '		111		I	3:		5 5b	(first chaetetid seen in cuttings)
			NO-7 (1 K)	4	,			20?				4		2 1		1	2		00	1 1 ' 1 '	71			50	`
3605	LS	F-M round (to XC)	NC(VD)	اما	P-GS fragmental-ooid	т.				30 5+		1	2	,		1	2+		2 ?		[] [1			50 50/b	some quartz nucleii in ooids 2P
3610	LS		N6(YR)	6	P-GS fragmental-skeletal	11	interskeleta		-	40 5			-	3		1	1		1 2			22	?	5a(b)	in photo see bit bruise "booklet" 2P microbial-foram encrusters BBB 2P
3615	LS	tr arg LS	NO(V(D)	5 4	FPS frag-skel (ooid GS)			10		35	١,		10	1		1			1 ?	? 1		2?	•	5b(d)	
3620	LS		N6(YR)	6	P-GS fragmental-pelletal				-	30 2					1		1		?					5a -	inaginismo (i)iii o i i olioto II i
3625	LS			6	P(G)S frag-peloid					35 5			1				2	+	2 1	1		?	?1	5a	stylolites
3630	LS		N5(-6)	6	P-GS fragment-pellet (ooid)	<u> </u>		5		30 1	٠.		2				1	1	2	1				5a	Tr micropyrite {no dol? VS log}. Stylolitic P
3635	LS		N6 (BB)	5	PS frag (peloid)			?	10				2				1	1	1					5a	BB
3640	LS		N5	4 4	(F)WPS frag-skel-stromatopro	Tr	vug calcsp			25	2			3 2	2		_ 1	1 ?	2 1	1			?1	5b	Tr micropyrite. ?calcisphere? 2P-Ig
3645	LS	F-C(VC)		6	GPS fragmental-ooid			20		30 5			2			1	1	1 1	1	1				5ad	CHECK FOR POROSITY of logs AND WASHOUT BB
3650	LS		N5(YR)	5	(F)w-GS fragmental-skeletal	Tr	vug calcsp			20+	1		2	1				1	1 1				1	5a	Browner? But still grey. Rare M-c calcspar. BB
3655	LS		LTBnGy	4	PWS frag-skel					20 3	1		2			1	1	1	2			1?	1	5a	BB
3660	LS		N5(YR)	5	F-w(G)s fragmental-skeletal	2	IC2 interske	el		15	?		2	2		1	4	1 1	1 1	1			1	5a	stylolitic BB
3665	LS		MLBnGy	7 4	FP+GS frag-skel + ooid			15		20	1		3		1	1	2	+	1 2	1		5	2	(3)5ad	stylolitic
3670	LS		N5(YR)		F-WS fragmental-skeletal			3		15	1		2	1			1	1	1 1 1					5a	Minor small M ooid G/PS & C Frag GS BB P
3675	LS		(,	3 4	(F)WS frag-skel					20 2	1		2 enci	ust	1		2	2 12		1 1		2		5	BB occasional 'booklets"
3680	LS		N5(YR)	6	PS/GS ooid-fragmental		?chalky	30		30	1			1			1	1	1	1 1 1		_	3	5d	F-M ooids BB -chalky P
3685	LS sI a <mark>rg</mark>		110(111)	3 1	FWS frag-clast-skel	tr-1	chalky M	?		30 10) 1		5		11	,				1 1		1	-	5A	1 In colds
3690	LS		N5(YR)	6	PS/GS ooid-frag-stromatop		vug calcsp			20	1	2	15	1	2		2						2	5bd	stylolitic less BB 2P
3695	LS		Bn+Gy		PFS(GS) frag-skel-stromatopro		calcspar	20		20	2	1	10		3		1		1	1 1		2		5bu	Common calcspar cmt = GS(FS) ex corals =/or bivalves etc.
3700	The second second		N4-YR		F(W)S sponge-frag-skeletal					15 1	17		2	1			- 1 '	;		1 1 2			10		Large cuttings so more photos. Stylolitic, sl shaly 3P
	LS	J				Q IIII	Crobiai Crust	45						?	2			1	2 1	4 2 2	,	22	4	_	
3705	LS		Bn+Gy		FPS+GS strom-frg-skel + ooid			15		15	5		15 1	1	2	3	2	<u>.</u>		1 2 ?	·	2?	7	5b	3
3710	LS		N4-5		F(W)PS fragmental-skeletal					25	5		00	1			1	1	1	enc	rust		•	4/5	Stylolitic, sl shaly
3715	LS		N4-5		FWS frag-skel	Ab	4 3715			20	2		3?			1		!	2	2		1		5a	BB 3P
3720	LS	,	N7	4	FSxtl? chalky = ?frag		chalky			?? - F-M	2						1			1 1				5?	dusty& chalky BBB=Badly Bit Bruised (all spls liti P
3725	LS	chalky-bleached		5 4	FSPS strom-frag-skel	6	IBC5D			25 M	3		20		2		2	2	3	1 1		?		(4c)5b	stellate coral calices inter & intrafossil (strom) porosity stylolitic
3730	LS	,	N7-6	6 4	F-P/GS fragmental (skeletal)		IBC6D2	?		50_ F(M)			1		?		1	1	1					5?	leached? BB-chalky P
3735	LS	tr grn clay BB		6 4	F-PGS skel-frag-strom	8	IBC6D2	ıameı	ntal	50 ^{F(M)}	2		10		?		2		2			?		5b	inter/intrafossil porosity BB
3740	LS	0 , ,	N7-6	4 4	F-W/PS fragmental-skeletal		IBC4C	gille		35	1		5+	?	?		2	_	1	1 1 1				5a	Tr VF dolm??
3745	LS	chalky BBB		4	wpsxtl frag (skel?) XTL	??				35?	1		3+		?		1	1	1					5a	poor sample = BBB w/ 'booklets'
3750	LS	chalky-70-80%	N7	6	P-GS Frag-peloid (-skel)	3	IBC3	1?		25	1		2	?	1 1			1	1 1	?				5a	Intracoral septa porosity w/ cmt BBB-chalky P
3755	LS			7 4	FP-GS frag-skel-oncoid?	2+	IBC2+	2+		25			1		3	1	1	1	3 1	2		10	10	(3)5a	intrafossil porosity 2P
3760	LS		N7 -(YR)	6	P-GS fragmental-ooid	1	ICD (cmt)	15		25			3	?			1	1	1 1	? 1				5d	minor C-VC calcspar + vugs infilled BB chalky P
3765	LS	F-M particles		5	P(G)S frag-skel	tr	vug-sparca	?	5	35			2		11)	1	1	3 1	1				(3)5a	
3770	LS		N6-7(YR)		F-P/GS fragmental (skeletal)	2.5	IC2D	5	5	40			1	1			2	2	1 1	1				5a(d <mark>)</mark>	C-VC clear & white calcspar = vugs. Fragments rounded P
3775	LS			6	P/GS fragmental (Skeletal)	5+	IC5D	2	4	50		1	2		11	>	1	1	1			2		5a	
3780	LS		N6-7(YR)	6	P-GS fragmental-ooid (skel		IBC4D	10		40 ?			2				1	1	1 1					5d	Tr red calcite cement Small cuttings BB
3785SWC	LS	F(M) fragments	ì		FP/GS framebldr-skel-frag		IBC4D2		5+	40	1		6?	1 ?	51	1	2	2	2 1	1 1		2		5(b)	interparticl-vuggy leached porosity 2P
3790			N6-7(YR)		GS fragmental-ooid	5	IBC4D	30	5	30 5			1		1				1 1	1				5d	Tr green clay infil BB P
3795SWC			` '		FPWS fragmental-skeletal	3+	ICD2+	2		20+			3?		31		1	1	1 1					5a	
	LS		N6-7(YR)		P-GS ooid-fragmental		IBC4	50		10 10	1						1	1	1	?	1			5d	dasyclad algae in ooids chalky BB P
3805SWC			ML(B)Gy	7	GS ooid (skelletal)	tr?		60		2			3				1	1	3 1	1		2+		5d	2P
	LS		N5-6 YR	7	G(P)S ooid-skeletal (frmbldr	37	IBC2?	20	5	20			6	1	2			1		1	1 1			5d	dasyclad algae in ooids chalky BB P
	LS	F(M)ooid, tr Glau?		6	G-PS ooid-skel-frag (ooidG			20	5		1		2			1?	9		1	1 1				5d(a)	D
3820	LS		N5-6 YR		P-GS fragmental-ooid (skel		TR	15		35	1	1	2		?		7	2	1 2					5d(a)	stylolites P
	LAST SAMPL		. 10 0 111	Ĭ	. 23 magnioritai oola (skei	<u> </u>							_						1 - 1 -					J.,	2 P -3365
יוו	LAUI SAIVIPL	3010																							[2: 0000]

		SIDEWALL C	ORE SAMPLES																																		
3369	SW	LS			9 4	BS/FS	microsolenid coral										30								3	0			5k)	Deeper (m	icrosolenio	d) coral re	eef margi	n (upper?	?FR or de	rived BR-FF
3383.	5SW	LS			9	BS	sponge-microbialite						20	5	1			1		1	1		3			5	30)	4		sponge-mi	crobialite o	crusts in o	deeper re	ef		
3784	SW	LS	C-VC ooids	%Y(YR)5/	7 4	F-GS	Ooid-mollusk	10	IAB1C7D2	30	15	5 3							2	3	15	7	2	:	2	clionic	1	144	50	t	shallow oo	id shoal (d	or derived	l? More d	istal to re	eef margin	-lo framebu
3793	SW	LS		5YR5/1	7 8	(R)GS	coated skeletal	4	IBC3Dtr		15	coat	ed		15			2	3	2	1 3	7	1	1		1	dasyc	iau clad?	5k	od	shelf marg	in proxima	ıl skeletal	-reefal sa	nds (?re	ef flat-upp	er foreslope
3803	SW	LS	F-C matrix	5YR2-3/1	6 6	F-G/PS	bivalve-skeletal-frag		NVP		35	5			2?			2	1	6		15	1	1	1	1	uasy	Jiau :	58	1	Deeper? dista	al shelf sand	s (slglty qui	eter, distal f	rom reef si	nce less fran	mebuilders & fi
-	١	В	С	D		G	Н	ı	J	K	L M	l N	0	Р	Q	R S		T	VV	N X	ΥZ	AA A	AB AC	CAD	AE A	F A	ΗА	I A	J Al	K	AL	AM	A٨		40	AP	AQ
																														YPE 8'88							
DE	· T. I	ITU	man alifia a	COLOD	1		and a different	l DOG	NTV	400		150	_				CCII	,	1.			CIACO	data	:£ =	ما ما ماند	<u> </u>			-	78.	COM	MENTO	_				
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(met	res)	LS=limes	tone		bs)		mudstone 1 wackestone 3	%					FRA	MEB	UILDI	ERS	_			51			L	,	œ	AL	GAE			Β̈Ξ							
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	н	SH=shale SS=sands			₹ F		grainstone 7		(Archie)	-	<u> </u>			비엛	의 (世	빌줌늝		l∦l II		ાહિ	जा≚।	I≨l⊦	미값		I	Jr.		0	: 1	5 5		diagenet	ic textur	es			
	o	SLTST=s			AM Jet		coundstone 9 RS=XC size)			တ		ı∣ğl	liii l	비웨	입 꽃					اڠ ااڎ			ACOD SERPUI	≩	٦⊪	2 2	텒	ΙĮΫ		≥≅		facies-se	equence	breaks			
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	G	suy- san	Jy/qtz			XTL:	=crystalline			Ш	<u> </u>		S		S		MICROSOLENI	ᆂᅵ		F	H		Υ	\square	Ľ	_الا	STI			≱ 8	hidden & v	isible only	on scree	n			
-	\ Y	В	С	D		G	Н	Т	J	K	L M	N	0	Р	Q	R S	_	T	۷۷	N X	ΥZ	AA A	AB AC	CAD	AE A	F. A	H A	I A	J Al	oπ	AL						
	FΔCII	S NUMBERS	: 1=hathval shale	2=neritic	shal	e 3=for	rereef-channel, 3A= fo	resio	ne channel	C= die	stal for	eslone	(mic	rohia	mud	mound	1) 3R=	nrovi	mal fo	reslo	ne (forei	reef)	4= s	nona	e ree	fal 4	Δ= 'd	een'	silice	ים פווס	onge reef &	intermou	nd 4R = '	shallow' s	iliceous	sponge	
			siliceous sponge-c		Jilai	c, o-ioi	ereer-criarille, JA- II	71 0210	pe onanner, .	Jo- uk	olai 1011	colobe	THIL	i UDIA	muu	mount	1), JD-	PIONI								aı, 🕶	n- u	CCD :	31110	JUUD OI	יטוועכ וככו ט	HILCHIIOU	11u, 4D -	JIIanuw 3	mocous	apoinge [

Appendix A3 ENCLOSURE A3.14 Musquodoboit E-23 L.Eliuk 2016

(nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details

<u>En</u>	closur	<u>e A3.15</u> SF	ELL P	anu	ıke B-	90 (JABK)			Ge	oTou	rs Co	onsu	ulting	Inc	L.E	iliuk P.	Geol.	2006-	03			КВ	22.3	m dev	iated	1?		00 01	F	PAGE	
DEPTH	LITH	modifier I	COLOR	TE	XTURE	modifier	POROS	SITY	ACC	ESSO	RIES	3				FOSS	SILS	(enha	nced	by S <mark>W</mark>	C data	<mark>a if</mark> ava	ailable)				TYPE (78'88	COMMENTS		
(metres) T=trip	T DOL= H SH=si O SS=sa L SLTS arg=a Calc=0	mestone dolomite hale andstone T=siltstone rgillaceous calcareous sandy/qtz	REVIATE	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=v PS=pa GS=g BS=bo (FS/R FS=flo RS=ru	audstone 1 vackestone 3 ackstone 5 rainstone 7 sundstone 9 S=XC size) vatstone 4 dstone 8 crystalline	%	modifier (Archie)	SGIOO	PELOIDS	PARTICLES LITHOGI ASTS	מראסוס	SPONGES	STROMATOPOROID-	CHAETETIDS T	ORID OTHER	MICROSOLENIDS HEXACORALS	BRYOZOANS	BRACHIOPODS		GASTROPODS BIVALVES	OSTRACODS	SERPULIDS TUBIPHYTES etc	FORAMINIFERA BORINGS	HIGHER -green etc	STROMATOLITES B	ONCOIDS-PISOID	s tandard microfacies lugel'82&Wilson'75&Eliul Vierzbicki, Harland&Eliuk	additional fossils/acce diagenetic textures facies-sequence break et cetera some long comments m hidden & visible only on	ay be	
Α	В	С	D		T G	Н	ı	J	К	L	М	N	0 1	PQ	R		Т	V	w x	Y	Z A/	A AB	AC AD	AE AF	AH	Al	AJ	o _L >	AL		
Α	В	С	D		G	Н	ı	J	K	L	M	N	0 I	P Q	R	S	Т	V	w x	Υ	Z A/	A AB	AC AD	AE AF	AH	Al	ΑJ	AK	AL AM AN	AO AP	AQ
3155 3160 3165 3170								na info- v		7 -310 91 MI																			BBB = Bad Bit Bruise Eg-sa streaked, softened, thinned e OIL BASED DRILLING MUD =	etc. in drilling	
3175							shaly	above			_	_									Į,	orokei	n-roun	ded							
3180	Shelty	soft; 10%BBLS cave? 80% SH cave/lag?			adr. LC	tr argLS& shells					3									4	2							2	soft SH in part, micaceous sl, tr XC-		2P 2P
3185 3190		6/4 sdyLS(cave?)			say LS	tr & Fe siderite Sscalc VF-Fgtz	AB7	-3139 ?												1	1							10 2-10	v.calc, glauc siltst-vfSS + 5%VC-XC tr loose VC qtz grains. SH soft(pt c		2P
3195	SH	15%sdy LS (cave?			traces	FcalcSS-sdyLS		-3139 ? 1 1 MD) ?												1	17	>						2	ti loose ve qiz grains. Si i soli(pi e	ave:), glauc iii 33	
3200	SS LSsdy	·	Dgy+MBG	1	M(W)S	(skel-frag)	(310	i iviD) !			3									2	2							9	VF-F(M)qtz in LS SH soft tr VC qtz	loose	Р
3205	-		M(L) Gy	3	?sdyW								"rus	sty' rid	laes													9	Possilby major silt to SH& cave?		Р
3210	SHsdy	si9lty soft glauc	D-MGy			fossiliferous						Т	2	rty 110	1900				2	1	3		1+					2	XF-F qtz in soft siltst-SH glauc		Р
3215		sdy, glauconite	D-MGy			v.calc, vf-f qtz		na break -													1?	?						10	tr red stain by qtz in calc matrix, py	rite	2P
3220		5/5 & glac SH	M+LGyB	2	MWS	skel (frag)		above 3223	Щ		4								2	⊦ 1	? 5			?				9	pyrite		2P
3225	LS SSarg		MLBnGy	4	WPS	skel (bryoderm)-frag		B6 U -3201			10		2	1?	'				7	2	7		1?	2				5-9	tr milky-clear chert	(2P
3230	LS sdy?	5%qtz f-granule ro	L(M)GyBn	3 4	4 FWS	skel-stromtp-frg	(3	3223 MD)	ш		10		2	10				1	3		13	3		1?		2?		5b	1% pyrite sf-mcubes, tr Glauconite	(cave?) (BB)	3P
3235	LS	1-3% sdy qtz&shly	. , ,	3 4	4 FWS	skel(strom)-frag	_				10 20		1	7+					5	2	1?			1				<mark>5b-3</mark> a 5	stylolitic loose 2.5mm echinoid spine Tr M-0	Covrite BBB	20
3240 3245	LO I S	tr sdy Fqtz	L(M)GyBn L(M)GyBn	3	W(F)S WS	frag (skel) fragmental					20			1?						1	3			1				5 5	•	BBB poor samples	3P
3250	L3 1 S	li Suy Fqiz	L(M)GyBn	3	MWS	fragmental					0+		1?	1 1					2		2				1?	3	2+	5		BBB poor samples	
3255	LS sdy	5%qtz SS vf-f	L(M)GyBn	3 ,	4 FWS	skel(strom)-frag					-		1	8+	1		2	1?	4	1?	5	12		1?		3	2+	5b		BBB	4P
3260		5% qtz SS aa	LMGyBn	3	ws	frg-skel(bryoderm)					15			2?			_	6	5		3						2.	5a-3a?	0 1 0	3BB	2P
3265	LS sdy	aa	LMGyBn	3	ws	skel(bryoderm)-frg					12	roun 2	nd					3	8		27	>					2	5a-3a?		veryBBB	
3270	LS SS	9/1 SSvf-fqtz	L+MG _V B	3 4	4 FWS	skel(bryoderm)-frg					10	- 1		1?				10	3		2+						_	5a-3a?			(2-x16)5P
3275	LS/SS/SH	4/4/2 (vf-f)	D+L+MGy	3	WS?	frg-(skel)-sandy	gan	nma break -			10	1						?	3-	+	2							5		3B	P
3280	LS S <mark>S</mark>	7/3 vf qtz	L+MGyB	3	ws	frg-sekl-(sdy)	328	30-3285	3	2	20	Т		2					6		3			1?				5f	M-C rounded fragments (tr glauco	nite in soft SH-cave?)	2P
3285	LS SS	9/1 SSvf-fqtz	L+MGyB	3	ws		36 L -3	3262		2	25+							1+	5-	+ ?	3							5	M-C rounded fragments	,	
3290	LS		MGyB	3	ws			D) old LE	2		15								3		2?							5	small cutting	s BB ??	
3295	LS		MGyB	3	ws	frag-(skel)		- / OIG EE			15		1	2+			1?	1?	2		2			1?		1?	1?	5(b)	Cave?/lag? ~20% SH soft dk gy		
3300	LS S	7/3 vf-f qtz	LGy-MGyE	3	ws	frag-skel					15		1?	3					2		2+			1		1		5abf	tr micropyrite (in SS)		2P
3305	LS		MdGyBn	3	ws	frag-skel						5		2			1?		2		3		1?	1				5a	encrusters = oncoids?		P
3310	LS		MdGyBn	3	(P)WS	frag-skel(broken)					-	?	1			Q	olitary?	?	3		6	1						5a		3B	
3315	LS		MdGyBn	3	(P)WS	frg-skel(stromtp)						5?	1	5			1	1?	3	-	3	?						5a	,	BBB	Р
3320	LS	tr sdy	MdGyBn	3	W(P)S	frag-clast?						10							5	-	5	?				2?		5a		3B	
3325	LS	,	MdGyBn	3	W(P)S	frag-(skel)		ma break	2		30		1 -		000		1		3		2+	- ?			?			5a	pink chip		2P
		calc 8/2	MGyB-Dgy	4	WPŚ	frag-skel	- 332	5-3330	3			3		6 L -		U		?	4	?	5+	1?		?	?			5a	calc SH bed broken shells & rou		
3335	LS		MdGyBn	6	PGS	frag(rd)-ool			15		35		(33	30 M	ID)				1		1	1		?				5d	tr micropyrite in Qtz skel frags coat	ed	
			L(M)GyB	3	ws	frag-sandy			3		20		\top						1		2							5		3B	2P
		•	L&MGyB	6	PGS	ool-frag-skel	AB5 -		45		10			2+				4	3	?	2			1	1?	1?		5d	?Lithocodium brnaching bryozoa		2P
		10% vf-m qtz	LMGyBn	3	(P)WS	frag-sandy	(3352	2 MD)				3							1	?	2							5	,	3B	l atau
	LS SS	6/4 sdy vf-f qtz	m L I MOUD	3	WS	frag-sandy(vf-m qtz	Corbe	ett pick?				?		1?					1	?	2							5-9	3	BB poor samples small	ctgs
3360	SS LS	5/5 vf qtz	L+MGyB	3	ws	frag (skel)		gamma info	?		10				1			2	1	2	2+							5-9	, ,	BBB	Р
	LS S <mark>S</mark> LS S	6/4 sdy vf qtz 7/3 f qtz poor spl	L+MGyB	7	GS WGS	ool-frag	-	ratty shaly	35 20		15 10								2	?	2+ 2							5d 5d		3B 3B	В
1 3370		4.2 poor spr	LINGYD	5	WGS	ool-frg	I L	, ,	20	l	10	ı	ı		l	1 1	ı	II I	4	1 1	2	1 1	1	1 1	11	1		Ju	oolus-qız Hudicii	,,	Р



	E	nclosure	A3.16 PanC	anadia		PCP) Panuke F-09					Geo	Tours	s Co	onsulting l	nc	L.E	liuk F	.Geol.	Revi	sed-In	fillec	1 2005	-03		TYPE 78'88 2002	PAGE
swc	DEPTH	LITH	modifier I	COLOR	DUNH	TURE modifier	POROSITY	ACCE	SSOI	RIES	П			FOSSILS			(enhand	ed by S	WC dat	a if avai	lable)				CIES FIEK	COMMENTS
	(metres)	I LS=limestor T DOL=dolom H SH=shale SS=sandsto SLTST=silts arg=argillacc calc=calcare sdy=sandy of	ne ite ne etotone eous	ABBREVIATED or MUNSELL	DUNHAM NUMBER left*=ms-bs right=fs&rs(bs)	MS=mudstone 1 WS=wackestone 3 PS=packstone 5 GS=grainstone 7 BS=boundstone 9 (FS/RS=XC size) FS=floatstone 4 RS=rudstone 8 XTL =crystalline 1 XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL = XTL	% modifier (Archie)	SOIDO	PELOIDS	LITHOCLASTS		WT SPONGES' ME STROMATOPOROID	ETIDS	RS SOIN	HEXACORAL	BRYOZOANS	BRACHIOPODS	ECHINOIDS	(ES	SERPULIDS TI IRIDHYTES of	FORAMINIFERA	BORINGS HIGHER -green etc P	STROMATOLITES BY	ONCOIDS - PISOIDS	STANDARD MICROFA Flugel'82&Wilson'75&I Wierzbicki, Harland & I	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen P = photo additional fossils/accessories SAMPLES BADLY BIT BRUISED (BBB) Lighter color and chalkier than actual
	Α	В	С	D	*	G H	I J	K		M N			R	S	Т	V	w x	ΥZ	Z AA A	AB AC A	DAE	AF AI	I AI	AJ	,,,,	AL
) (60m	diff). 3700mMD=3560mTVD (1	40m diff): 3530 t d						_			1 1						H	-1 -1 -	Ť		
	3150 3155 3160 3165 3170 3175 3180	SHsity SH(sity) SHsity SH(sity) SHsity SH(sity) SHsity SH(sity) SHsity	20%slt (& SS vf-C) aa & 10%SSvf-m aa sl calc			VV ?cave ? VV +5%qtz C-VC loose 2%qtz C-VC loose AA sand <5% AA sand <5% (C-VC loose AA sand tr +2% noncalc sand 5% AA sand tr	? disaggreg					KB :	39.9												2 2 2 2 2 2 2 2	POOR SMALL SAMPLES TO 3250m tr pyrite P BB micromicaceous. Tr M-VCqtz grains loose L Gy'slime' = drilling mud contaminant? ??fracture w/ C qtz cmt(VC) xtls tr micropyrite & mica ?qtz SS-SLTST Lgy non-calc (not on log??)
	3185 3190	SH(silty) SHslty	aa ?glauconite	DMBGy DMBGy		AA sand tr AA sand tr																			2 2	pyrite encased in C Quartz? Tr XF grn clay=glauconite?
	3195 3200	SH(silty) SHslty	10%slty	DMBGy DMBGy		AA sand tr AA sand M-C ~5%													NP 7	3199m	- 244) T\/F	닉		2 2	soft-flocculant when wet. Powdery samples some red in quartz sandstone; slightly pyritic
	3205 3210	SH(silty) SHslty	slight-noncalc aa	DMBGy DMBGy		AA sand tr - 1%							A						1	3199m	= 3140	<u>JM TVL</u>			2	some red quartz; trace siderite - DkBn
	3215 3220 3225	SH	tr C qtz pyritic; tr LS chalky argil	DMBGy DMBGy L+DMBGy		IS tr AA sand tr							VE?	cleaner cave??		logs	=								2-3? 2-3?	<5% Lgy chalky LS tr lime MS P BB? 10-15% LGy chalky LS
	3230	SH/LS	6/4 ?glauconite	(D)MBGy	1 N	IS AA sd							Ш												2	BB (LS 40-50%)
	3235 3240	LS/SH LS	6/4 chalky BB	MBGy L(MB)GY		IS? tr C+ qtz	? chalky BB				?		-	7											2-3? 2-3	SH = micromicaceous LS chalky BBB BB carbonate tr grn mica/glauconite in siltstone
	3245	LS/SH	7/3 chalky BB	L(MB)GY		IS?					silic	ified							B 6m	D 3246	m - 2	100m T	VD	ı	2-3?	calc SH + argil LS BB-dusty spls
	3250 3255	LS DOL?/(SH)/LS	chalky BB 6/4 SH=cave??	L(M)Gy Bn+l(M)G		I-WS skeletal Shslty-cave ?tiny cuttings	? chalky BB				1			SH + d	Irill c	mt?	= cave		7 7	3240	111 - 3	102111 1			2-3 2-3?	BBB blue chert; silicified sponge? (calc)Fe?DOL=M Bn XF dolo?MS? OR additive?? next 100m
1-1	3260 3265	LS LS(slty)/DOL	chalky BB 8/2(calc)	L(M)Bgy L(M)Bgy	3 V	VS sponge-frag	? chalky BB chalkyBBB			5? 5?	? ?7	1					? 3	1	2	1 ?	1 ?				2-3 3-4a	BB "DOL" = possibly siderite ^ P BBB very bad = white chalky SWC give ID ^
	3270	LS	, ,	LMBGy		-WS sponge	,		Ľ		10						1					2 ^{phola}			3-4	BB ^ P
1-2	3275 3280	LS(sity)/DOL LS (?DOL)	8/2(calc)	L(M)Bgy LMBGy	3 4 F	V(P)S spg-crinoid-frag -WS sponge fragmental	chalkyBBB chalky BB			1	?7 10	?				?	3 2		1	1 1	1	20.0			3-4a 3-4a	BBB tr grn caly or Glaconite SWC=IDs BB glauconite? = green clay P
1-3	3285 3290 3295	LS(sity)/DOL LS/SH/S SH/LS/S /DOL	7/3 (Sh-noncalc) 4/4/1/1	L(M)Bgy DBGy DBGy	6 (0	V(P)S frag (crinoid) mixed liths (ooid etc) WS) mixed liths (ooid etc)	chalkyBBB	gtz n 10	ucleii ¹	5? superfic	cal ¹ ool	d G/PS	3			1	1	1	1?		?				3-4a 3-5	BB SWC(silty SH) does not match clean gamma log??? 50% LS (cave?) 10% siderite? - Bn
1-4	3300	SS/SHslty/carb	6/2/2	DBGy	ĺĺv	F-F ss shelly					1					1	?		5+	2		m	icritic cr ?		5-5f 2-5f	XF pyrite 1% pyrite. Micaceous?. Minor siderite? =very argillaceous. MS
1-5	3305 3310	LSarg/DOL SLT/LS	7/3 7/3 argLS	DBGy DB+Bgy		IS? IS argLS & calcSH		3 ? e									?		tr 1					١	5? 2-3	drill cmt? CHECK if H2S Gas scavenging = P Tr red chert. Slightly pyritic blackened rusty scale P
1-6	3315 3320	?DOL?SS-SLTS		MBn M(Lgy)B	1 ?	MSxtl IS argillaceous	tr pp IAB										-			1?	2				5f 3-5	XF pyrite to 1% A 2P (x16) minor very pyritic calcareous VF-F SS and pyrite in shale
	3325	SLT-LS/?DOL	5/5	MBn	2 ?	MWS frag			5	5+				microsole	nid		F 2					clionid			5f	Fe?DOL=M Bn XF dolo?MS? AA ^ 2P (x16)
2-1 2-2	3330 3335	LSarg/SS SS/calcLSsity//	6/4 argillaceous DOL	D(M)GyB LMBGy		IS argLS & SS qtz VF-VF	tr pp IAB				5+	2	1	5+		1	2	1		1		phala			<mark>3-5b</mark> 5f	pyritic "DOL" = possibly siderite ^ BB
2-3	3340	LS/SH/DOL	mixed sdyLS	MBGy	3 V	VS frag-spg (BB or It LS)			5 1	10	10?		2	1 1?	1		2		1	1	1	pholac 1	Crus 1	st	5?-4 <mark>b?</mark>	BB white chalky limestone. TRIP? -mixed/caved liths
		LS/SH LS	6/4 (BB)	MBGy M(L)GyB		VPS ooid-frag V-PS. fragmental	NVP	10+	5 2	20 5							1		2	1					5d 3-5	BB
	3355	LS/SH?	9/1 V poor spl	M(L)GyB	4 V	VPS? fragmental?			2	5?								A		3355m		275m?	ΓVD	Щ	5	poor spl. Pyritic
2-4	3360 3365	LS/SH/S	80/15/5 sltySH 80/15/5 sltySH	MBGy MBGy		P+GS frag-ooids-peloid G+PS ooid-frag	NVP NVP	25 20		20			1	Brn I	4? M?	1	?		2	1 1	1	1			5da 5d	tr pyrite. Bn & VL(BB)LS, 15 % silty shale, 5% SS poor sample
	3370	LSsdy	(SH cave?)	LMGyB	7 G	SS ooid F-M qtz	INVP	65		10	1			Dill I			1		1						5d	. quartz nuclei ~20% P
2-5	3375 3380		qts nucleii BB less Sandy	LMGyB LM(B)Gy		ooid M-C ooid-frag M-C		65 50		10	1	?			?				1						5d 5d	BB trace very C quartz and quartz siltstone
	3385	LS(SH)	BBB	LM(B)Gy	7 G	SS? ooid-frag	chalky BB	30++		10					10										5d	BBB
	3390 3395	LS LS/SH?	(BBB) BBB	LMBGy LMBGy	7 G	G-PS ooid- frag-lithoclast ooid?-frg?	chalky BB chalky BB	30 5+?	5	20 10 5?	?				1?		?		1						5d	BBB tr XF-VF qtz SS BBB pyrite?
	3400 3405	LS LS/SH	15% qtz nuclei 9/1+ qtz nucleii	LMBGy LMBGy		G(P)S ooid M-C(VC) GS +?? ooid (+!0%)-frag	BB chalky	55 10?		5 1	?	?					2? 2?		3		?				5d 5d?	BB (+20% white) BB tr pyrite
2-6	3410	LS/SH ??	poor ctg seeSWC	LMBGy	3 V	VS? frag-skel(microsoleni			1	15	2+	ľ		5+			1		? 5 2+	1 1	2	1			5ab	BB poor samples TR VF SS & Sh (cave?) (tr ooids) poor sample
	3415	LS/SH	8/2	LMBGy	3 V	VS? fragmental		5?	2	20							5		2+		4				5a	poor ourripie

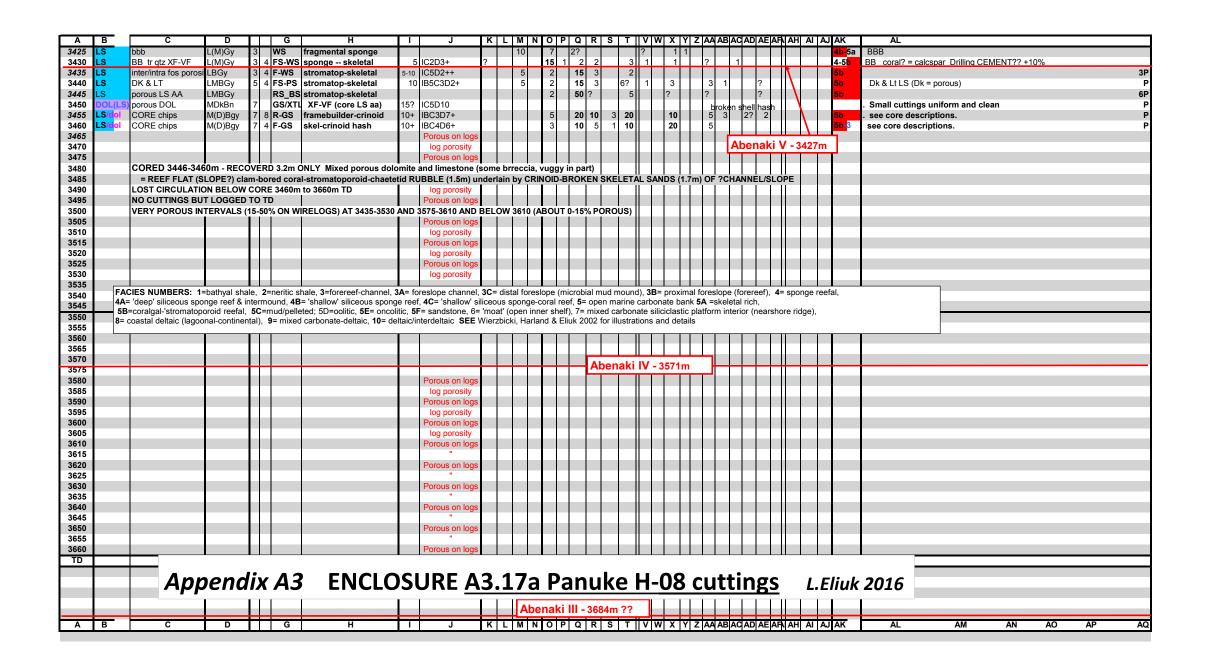
	Α	В	С	D *	<u>'</u> G	Н	I	J	K	L M	N	0	P Q	Q R	S	Т	V	W	ΧY	Z	АА А	AB AC	ΑD	E AF	АН	AI A	AJ A	ΔK	AL
	3420	LS/SH	70/30? Tr sltst	LMBGy 3	WS?	fragmental		NVP?	1	9	1	_						_										5	v. poor sample - small cuttings
	3425	LSsilty	BB	LMBGy 7	g GS	ooid			60				AB 5	5 - 34:	26m = 333	2m T∖	/D		3		2 _{ovs}	ster	?					5d	BB pyritic
2-7	3430	LSsandy	poor sample	LBGy 7	GS	ooid ooid VF-C		NVP?	35 60	10)	1						_ 4	2 2		2				1			5d 5d	BBB (not much qtz) loose ooids occasionally
	3435 3440	LSsilty LS/SH	85/15 DGy calc	LBGy 7 L+MGy 4	GS W/PS	ooid-frag F-VC		NVP	15	20) 2							1	2		5		1 '	,				ou 5d	BB, tr Qtz, It jade grn chert; "mother of Pearl"=bivalve
	3445	LSargil + SH	corre Dey care	L+MGy 4	WPS?	frag-ooid BB			10	20		2?						- -	1 2		2+							ida	ss, a que, ajudo giri enert, medier en euro
2-8	3450	LS (?DOL)	7% SH AA	LBGy 6	G(P)S	ooid (M-VC)-skel	?	chalky BB	35			2	1	1 1		1		1	?		4				1 ^{da}	syclad		ida	BB eg. 50% wt chalky SWC= skel FS in ooid GS
	3455	LS	qtz nucleii F BB	LBGY 6	G(P)S	ooid F-VC		,	60												3							5d	BB tr F qtz SS P
	3460	LS	poor sample small	LBGy 3	WS?	fragmental?		NVP		10																		5	BB very poor sample - small cuttings (C)
	3465	LS	BBB VPS	LBGy 3	WS?	fragmental??				10																		_	BBB
	3470	LS	poor sample small	LMBGy 3	WS?	fragmental?-clasts		NVP	1	10		1?									1							5	BBB chalky white
2-9	3475 3480	LS LSdol	BBB VPS	LMBGy 4 MBGy 6	WPS?	ooid?frag? BBB ooid M-VC +spg BS		chalky NVP	10? 45	10	· 1	8+		1	2		2	١.	1 1		2			,		₃crus		5d dba	BBB BB SWC (spg-microb) doesn't fit well ooid liths
2-9	3485	LS BBB		LMBGy 6	G(P)S'			chalky	50?		1?		inds-m	nicritize	ed				` '		_					3		5d	BB stylolite
	3490	LS	sl dolm	MBGy 3	WS(G)	frag (ooid GS)		oriality	15	5 20											?	1		1				5d	trace C quartz
	3495	LS	BB	LMBGy 6	GPS?	ooid (microb)			15+				?	?					?		?			?		2+		5d	BB P
	3500	LS	mixture	L(M)BGy 4	P(W)S	peloid-frag (ooidGS)			10	20 20) 5		?	?							?			?			5	id?	BB superficial ooids/micrite coat thin
	3505	LS (SH cave)	BBB	L(M)BGy 7	+3 ?G-WS				20	10																		5d	BBB small cuttings
	3510	LS	poor-chalky	L(B)Gy 6	G-PS	peloid-frag (ooidGS)	?	chalky	15	20 25	5					wh	nite		_		?			1				5d	BBB small cuttings AA Fitted allochems F-M
0.40	3515	LS/DOL trSS	6/4 dker'MS'	M(L)GyB 7	+1 G+MS	ooid+doloMS	tr-3	xtl-microvu	35	grape	stone					?1	1	2	2		2							ida	porosity in doloMS=MBn; L BGy ooid-VC-C
2-10 2-11	3520 3525	LS	5%SS vf-fqtz G	L(M)BGy 7 LBGy 7	GS	ooid F-C ooid F-C(VC)			50 70		1	1	1			se	pta	1	3		2	1		7		1		5d 5d	very few qtz nucleii. Stylolites trace pyrite P
2-11	3530	SScalc Scalc	07000 VI-IQIZ G	M(B)Gy	GS	VF-F qtz SS subang			15	cave?	5					1 :			1		1	1						ou d-5f	RUSTY from metal filings off bit due to qtz
2-12	3535	SScalc	vf-f (C) qtz	L-LGy		VF-F qtz SS subang					Ĭ																	5f	1.2.2.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1
2-13+14	3540	SS/LSarg (tr S		M(LB)Gy 3	(WS)	(frg) VF-F(C) qtz SS			3	10)	7+	1	1 1	74			1	?			1		1			5	f 4c	very rusty = quartz hard on bit SWC has framebuilders
	3545	LS/SH/S	6/3/1 vf-f	M(LB)Gy 6	G-PWS	ooid-frag			20		5						1	- -	1		3+			1	?1	?	5	ida	pyrite 5% cavings clasts etc.
2-15	3550	LSsandy	25% VF-C qtz	MGyB 7	gs GS	ooid M-VC qtz-rich			75 ⁰	tz nuclei			2	2					1		5				asvd	ad		5d	. Rusty P
	3555	LSsandy	20%vf-C qtz	MGyB 7	GS	ooid F-M+C			70 60	nucleii 10	2		1				1		2		3+?							ida	(micro)pyrite small cuttings
	3560 3565	LS/SS LS/SS(sl arg)	8/2 F-CqtzSS	MBGy 7 MBGy 6	GS GS-PS	frag-ooid M-VC ooid (skel) frag			60	10		1		3 1	1	4		2	1 1		2							daf ida	pyritic DkGy ooids P
	3570	LS	6/2 pyrite	LGvB 7	GS-FS	ooid skeletal			65	10	'	1	1			2	1	ļ.	1			AD.	4 0	569m =	044		5	ida ida	pyllic DkGy colds
2-16	3575	LS		6	G-PS				70			1				2			1	1	2	AD 4	+ - 3	569m =	= 3449	em .	1	5d	stylolite
	3580	LS	VF-C allochems	MLGyB 6	G-PS	ooid-frag-peloid			30	10 20		oloot			1			- 1	2		2			1				ida	
	3585	LS	F-M-C	MLGyB 6	G+PS	ooid-frag			35	20		Clast						•	?		1	1					5	d(c)	some qtz nucleii stylolite
	3590	LS	M-C allochems	M(L)GyB 4	W(P)S	fragmenatl-peloid			5	15 20											?	1		2				5c	. Р
	3595	LS	VF-M allochems	M(L)GyB 6	G+PW				5									'	?		1	1						5c	fragments rounded stylolite
0.47	3600	LS	F-C allochems	M(L)GyB 4	P-WS	fragmenatl-peloid			45	15 25									,	1	1	1	?	1	40			ac	-t-1-11-1
2-17	3605 3610	LS	2%dolomite	M(L)GyB 6 M(L)GyB 4	(G) PS W-PS	frag-ooid-clast frag-peloid M		2.010	15	10 30			1			2		- 1 :	2		1			1	1?		2	5d	stylolites
	3615	LS	F-M©	LGyBn 6	PGS	frg(rd)-ooid-peloid		?vug	15							ľ			'	1	2			1			5	d (c)	rounded micrite - superficial ooid tr 2P
	3620	LS	1%dol (F-XC alloch	LBGy 7	4 F-GS	ooids-frag-pisoid			30	5 20	١ .	1						- 1	6		3			1		1?		iad	stylolitic. Grounded allochems poor sorting
	3625	LS	(M(L)GyB 7	GS GS	ooid-frg F-C			60		5							- 2	2		3 ^b kn	ו			1 ^{da}	syclad		ida	single rim MDST=lithoclasts?? Bivalve rextl
	3630	LS	F-XC allochems	M(L)GyB 7	4 (F)-GS	ooid (clast)			60		5							- ;	3	1	1			1			5	5d	
2-18	3635	LS	E#4370	M(L)GyB 7	4 F-GS	ooid F-C)VC)			70		10	1?				1	1	4	4 2	1	2			1				ad	tr qtz pyritic nucleii
	3640	LS	F/M-VC	MGyB 7	4 F-GPS	ooid-frag-lithoclast			30	20			4						5		1			1	da	syclad		ida	al all france france and a like another annual authors and a
2-19	3645 3650	LS LS	F-M 2%dol (M-VC alloch	MGYBn 6	GPWS G-PS	ooid-frag F-M(C) ooid-fragmental			25 20	25 20			1	, da	ark			1	?		1			1	1			5d 5d	shell frags free = scale-like pattern small cuttings dry-P
2-19	3655	LSdol	- 7000 (IVI- V C allOCI	MOyb 6	PWS	frag-ooid F-M			15	25		1					1	1	+		2			1				5d	
	3660	LS	2%dolm F-C	LBGy 7	GS	ooid-fragmental			50	10						1			1		2							5d	. Fitted/cemented. Some 100% F-M dolomite F-M
2-21	3665	LSdol (SWC)		MBGy 5	4 PS(FS				25	15			<5	5?		3		;	3	1	2	1		pho	ads	2?		d(ab)	micropyrite stylolite
	3670	LS	3%dol M-VC alloch	LBGy 6	P-GS	ooid -fragmental			30	5 30			?	?				1			1			1				5d	solid hydrocarbon? Stylolitic
	3675	LS	3%dol	LBGy 6	P-GS	ooid-frag			50	5 10								1	?		1		1	1				5d	small cuttings stylolites
0.00	3680	LS/DOL	6/4?	L(M)GyB 6	P-GS	ooid & XTL dol F-M				5				2				_ ·	1		1							5d	CI calcsp (C-VC) in dolm Increased secondary rust.
2-22	3685 3690	LS/DOL LS/DOL	8/2 ctgs?(SWC=d 9/1			ooid + xtl DOL f-m	4?	intrxtl IC1D	1 40 60	5 20	5		113	!					1		2			1				5d 5d	+tr calcsp (C-VC) dol SWC does not ctgs LS?? dry-P
	3690 3695	LS/DOL	9/1	LMBGy 7 LMBGy 6	GS G GPS	ooid F-VC ooid-frg F-M	fr	vug Ccalcsp		5 25									2		1							5d 5d	small grapestone
	3700	LS/DOL	8/2 F-M calc	L(M)GyB 7	GS GS	ooid M-C & M DOL		- ag couloop	40	15									1		3		1					5d	BB slightly pyrite in fossils. Dolomite calcareous
	3705	LS/SS		L(M)GyB 6	(G)PWS		2	vug-C1D1	20				2	2 1		?			?		2	1				2		ida	P
	3710	LS/SS	9/1 XF-Fqtz	L(M)BGy 7	gs GS	ooid M			50	10) [AD					1		1		1	1						5d	Darker brown More rust
	3715	LS		6	GPS	ooid F-M	tr-2	intxtlBC	50		2		_		n = 3564m	TVD										2+		5d	micropyrite
	3720	LS	F-XC allochems	L(M)BGy 7	GS	ooid M (C)	L.	NVP	60			?	1 1	1		1		_ .	1		1				red			ida	tr qtz
2-23	3725	LS	tr vf SS	L(M)BGy 6	G(P)S	ooid F-M (C)	4	interooid	65+								1		1	1+	2+							5d	(x16)2P
	3730 3735	LS LS	vf E allochomo	L(M)BGy 6	G/PS	ooid-frag F-C frag-ooid (skel)			50 10				2	2 1?		?		- 13	2		1			1		2		ida i(d)	tr sparcalc stylolite
	3735 3740	LS	vf-F allochems 3% DOL porous	L(M)BGy 4 M-LGyB 7	WPS GS	ooid M-C (XC)	tr	I/IIIBC	50	5 28			1 1	7		!					2		2	1		2		ida ida	tr sparcaic stylolite tr qtz nucleii P
	3745	LS	3% DOL porous	M-LGyB 6	GPS	ooid F_C	Li Li	,,,,,,,	50	_			2+	+	(?1)						2	1						5d	Γ Υ <u>α πασίοι</u> Γ
	3750	LS/SS	85/15 VF-F, tr DOL		ws	fragmental				15				10	(?1) dark					1	2	1		1				5a	rusty due to metal filings
2-24	3755	LS	swc=DOL	M(L)BGy 6	GPS	ooid-?peloid F	•			20 10											1	1						5d	SWC=DOL but cuttings = LS?>>VF-F ooid/peloid(rims) fitted P
		LS		M(L)Gy 2	M-WS	fragmental-peloid				5 10)										?			·				5	rust stylolitic
-				-	•		•				•	٠	•	•	•	•		•	•			•				•			•

	Α	В	С	D	<u>*</u> G	Н	I J	K'	ביין	M N	1 0	Р	Q	R S	Т	٧	W	ΧY	ZA	AA AB	AC AD	AΕ	AF, A	Н	I AJ	AK	AL
	3765	LS		M(L)Gy	2 M-WS		tr intrxtl BC		15	25										3 1+		1+		2+		5c	micritized rim? Pyrite 'fool's gold' style (dry) 2
	3770	LS		MBGy	2 M-WS	fragmental	tr vug?xtl	1	2	15						П		?		1		?				5	rust tr ooids
	3775	LS		MBGy	2 M-WS	fragmental	tr vug-clac	sp	5	15 3	3									2 1		1?				5	
	3780	LS		L(MB)Gy	2 M-WS	fragmental				15				? ?						2		?		1	?	5	
	3785	LS		L(MB)Gy	3 4 WFS	skel(strom)-frag			10	30			8+	1?					5	5y 2		1?				5b	bivalve=mother of pearl shellstylolite
	3790	LS		LM(B)Gy	3 2 W(M)					20 2	2									2		?		1	? 1?	5a	
	3795	LS		L(MB)Gy	4 WPS	frag-peloid			20	30+								1	1 5	5+		1?				5c	
2-25	3800	LS		M-LBGy	5 PS	fragmental (f-vc)				50 3	3					ш						?			2	5	rust
	3805	LS/DOL ?	5/5	L(MB)Gy	xtl-1		? interxtl			?+																5	small cuttings
	3810	LS ?		M-LBGy	4 W/PS		l I		5	30			3	_		ш				2 1					1	5a	
	3815	LS DOL oth of well	8/2-9/1	M-LBGy	4 W/PS	fragmental	interxtl	3		30 5	5 1	1		2	1		2	!+ 2	1 :	2		1			1	5a	very rusty (cave?) small cuttings
	Total dep	oti oi weii		4A= 'de 5B=cor	ep' siliceou ralgal-'stror	RS: 1=bathyal shale, 2=neus sponge reef & intermou matoporoid reefal, 5C=mu (lagoonal-continental), 9=	nd, 4B = 'shallov d/pelleted; 5D =	' siliced oolitic, 5	ous sp E= or	onge re	ef, 4C = 5F= sa	= 'shal indstoi	llow' s ne, 6 =	iliceous spo · 'moat' (ope	nge-co en inne	ral ree	ef, 5= f), 7= r	open m nixed c	narine arbon	carbo	nate ba ciclasti	nk 5/ c pla	A =ske	letal	rich,		
			Panuke F-09	SIDE V	VALL C	ORE SUMMARY																					
SWC#	Α	В	С		E F G		I J	К	L	M N	0	Р	Q	R S	Т	l v	w	ΧY	ZA	AA AB	AC AD	AE	AF A	НА	I AJ	AK	AL AM AN AO AP A
												TT						1 1		i	Ħ		ij				
1-1	3265	LS	SWC-3264	D(B)Gy	5 8 B/RS	spong in crinoid P/W	S				30	5	2				? 1	0 3			? 2					4a-3b	stylolites; 5% quartz silt
1-2	3275	LS	SWC-3275	DBGy	5 4 F-PS	sponge in crinoid PS					30					?		0		4 2	1	1	5 prol	ad		4a-3	
1-3	3285	SHslty	SWC-3283	DBGy		crinoid silty shale	atz nucle	i super	ficial	nid G/P	S 3?		?			1		0 3		2		?				2-3	doesn't match clean log??
1-4	3300	SHslty	SWC-3298-V	DBGy		clayeyQTz & sitst										2		?		2			r	nicriti	c crus	2	
1-5	3310	SS calc	SWC-3308-V	DBGy		very shelly SS													1	15	5					2-3	
1-6	3315	SS-SLTST	SWC-3312	DBGy		burrowed silt/sandst								microso		Ш										2	
2-1	3330	SLT/LS	SWC-3328-V	D(M)BGy	9 BS	coralsponge					20	5		1 2	0	3		5 3			1	1	5			5b-4c	microsolenid coral; sponges micritic, siltstone calcareous
2-2	3335	SScalc	SWC-3333	N6		calcareous Qtz VF-F										ш										2-5	
2-3	3340	LSdol	SWC-3338 - ^	MGy-BGy	9 BS	sponge-chaetetid					40			6 2 _{Brn}	M?			5				_	2	2	2	4b	pyritic three sponge types. 30% ferroan dolomite
2-4	3360	SS/LS	SWC-3360- ^	5YR 3/1	3 4 F-WS	skel & SSqtzM calc	tr pp BC							1 ?	15	2	1	2		5 1	2	<<<	NUCL	EIĻ		5d	LS 5-20% sandy, LS cement colored zoned in alizarin stain
2-5	3375	LSsdy	SWC-3373	5YR4/1	7 GS	ooid M-C qtz nuclei		50						microsole	nid	3		5					phol	ad		5d	
2-6	3410	SH/LS	SWC-3410- ^	5YR3/1	9 8 R(B)S	Microsolenid-sponge	NVP				10			5			- :	2		2 1	3		5	~~ t	5	5b-4c	microsolenid coral ?30% silty SH
2-7	3430	LSsdv	SWC-3427- ^	5YR4/1	7 GS	ooid M-C gtz-rich	tr ? In cmt	60			1							7 5		7 .				asyc		5d	30% F-M quartz nuclei. Fossils only as nucleii
2-8	3450	Lsdol	SWC-3450- ^	5YR3-4/1	7 4 F-GS	skel in ooid GS	NVP	50			5		2	1 .	2	2		1 1		⊤ øyst 15 l	ers		- 11		lad	5da	pyrite contact pressure solution 1% dolomite
2-9	3480	LSdol	SWC-3477- ^	N3-5YR3	BS		2 IB1-2	50			40		-micri	iżed		5		3 2		5			phola	1d 1	crusts	4a	mtx dol(30%) rextlzd LS Fracture Consortia-spg/micrite crusts
2-10	3520	LSuoi	SWC-3419-V	5YR3/1	6 G-FS	sponge/crusts skel in ooid GS	2 151-2	١.,			2	3			2	³		0 2		٦		:	5	1	5	4a 5d	ilitx doi(30%) rextiza ES Fracture Consortia-spg/micrite crusts
2-10	3520 3525	LS	SWC-3419-V SWC-3521	5YR3/1 5YR3-4/1	6 G-FS 7 GS	ooid C-VC		50 60	g	apeston	e Z	3			2			0		7 3						5d	some leach/cmt bivalves/corals? Uncompact+early cmt?
2-11	3525 3535	SScalc	SWC-3521 SWC-3534	DMBGy	/ GS	VF-F qtz SS	2 \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	60									1	0		, 3						4f	calcareous to non calcareous (vuggy? =minor porosity)
2-12		SS	SWC-3536- ^				2 vuggy' NVP			50	% cavi	ngs dla	asts	tc						1						3-5	calcareous to non calcareous (vuggy? – milior porosity)
	3540			N5-6		F-M qtz SS														1							
2-14	3540	LSdol	SWC-3539 ^^	5YR2/1	9 BS	spg-microsolenid	2? IAB2		z nuc	eii	20		2	2 2		Ш	?				3					5b-4c	microsolenid corals 10%Fdolm xtls, 5%arg reddened
2-15	3550	LS	SWC-3549 ^^	10YR3/2	7 GS	C ooid (10%qtz)	2? IAB2	65			1?			3	2	2		15 10		5						5d	1-2% pyritic (oolitic shoal near margin - open marine)
2-16	3575	LS	SWC-3571	N7-5YR5	7 4 F-G		2? IAB2	40			2				7			2	2	7						5d	Rextlzd (cmt) corals and mollusks. Stylolitic
2-17	3605	LS	SWC-3604	5YR3-4/2	5 4 F-PS	lithoclast >frg-skel	2? IAB2		30	3										5			_ 1		5	5c	clasts=oncoids? thromboids? Very stylolitic
2-18	3635	LS	SWC-3633	5YR3-4/1	7 GS	C ooid	NVP	70			1?				3	2	1	0 5	- 1	6		1		NUC	LEII	5d	tr qtz -pyritic nucleii; NO macrobiota. Well cemented
2-19	3650	LS	SWC3651-V	5YR4/1	7 4 F-GS	ooid-skel-lithoclast	6 IB1C5+	35		1	0 2			dark		_		5	10 1		1			1		5d	~5% dolomite cmt. Clasts = grapestone & bivalves
2-20	3655	LSdol	SWC-3655	5YR4/1	5 4 F-PS	bivalve-skeletal	NVP									5		5		10	2	_	_			5a	10-15% Dk dol +10%XC fossils = 5% oysters & 5% thin bivalves.
	3665	LSdol	SWC-3657- ^	10YR4/2	4 4 F-PW		5 IB2C3	10					30		15			0	2	3 2			3	ie		5b	+10%dolm XF (C-VC in borings). Micrite rims =superficial ooids
2-21		DOL	SWC-3685	N5-6	5 4 F-PS	skel F-M originally	4 I/IIIB3D1									Ш		?	1	1				ed		5	sl.calcareous DOL F-M. Early stylolites
2-22	3685					ooid M-C	12 IB2C10	60						1	1			2	3	5		1		1		5d	<10% Fqtz. Inter ooid porosity. Some stylolites
2-22 2-23	3725	LS	SWC-3724	10YR5/2	7 GS								_	-	-			_ _		-						_	6 0 10 150/ 17 1/5 6
2-22			SWC-3724 SWC 3751 SWC=3798-V	10YR5/2 5YR5/1 5YR3/1	7 GS 4 FSxtl 5 4 F-PS	skel? F-M/C dol skel-crinoid-coated g	7 I/IIIB2C5	Dtr		15			2		2			5 2 0 6		5						5a 5ab	feroan? 10-15% spar calcite VF-f 7% DOL F-M Common stylolites/horsetails Microfractured.

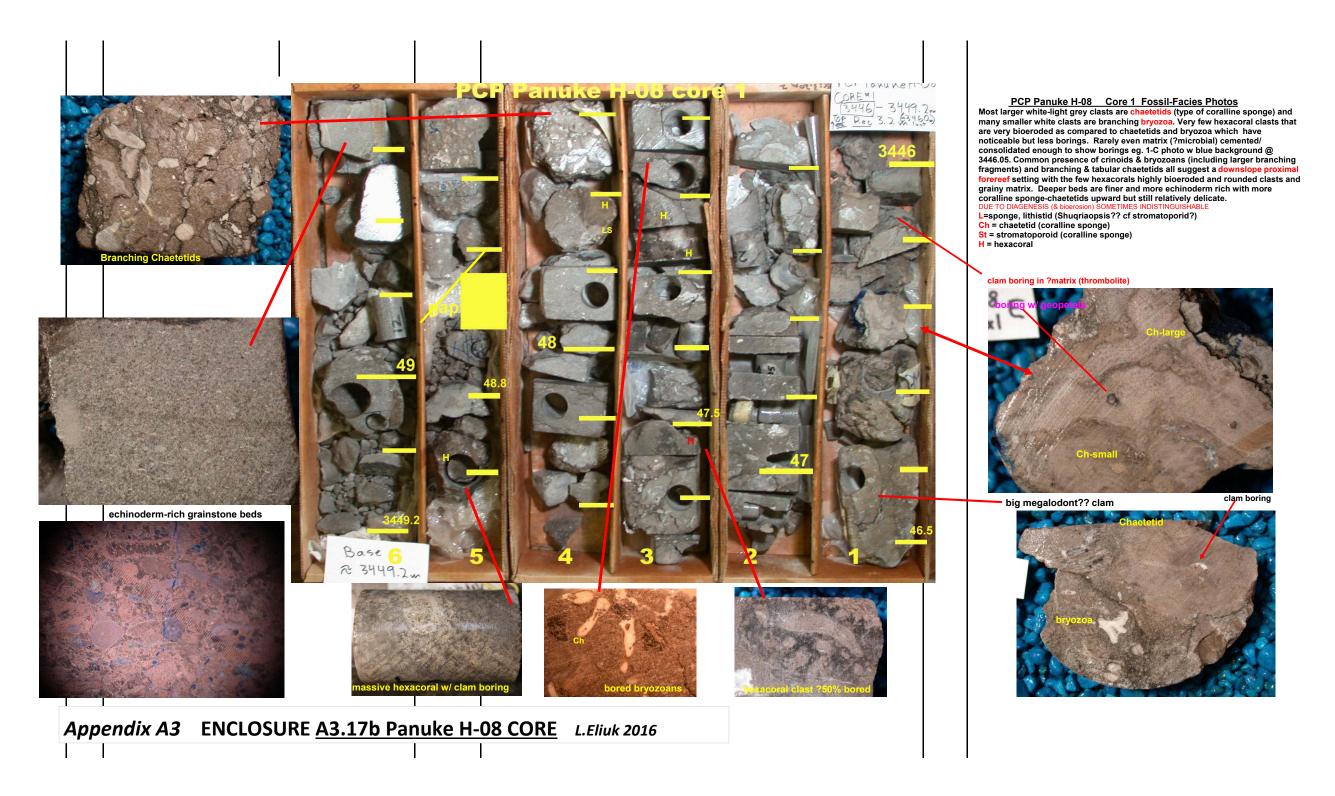
VII (45m) = 44% silty SH, 56% argillaceous lime M; VI U (110m) = 5% SH, 20% SST. 31% sponge W(P), 14% ooid-fragment P, 20% argillaceous MW; VI L (70m) = 7% coral, PW, 71% ooid PG, 22 % fragment W; V = (145m) 10% SST; 73% ooid PG, 17% fragment W; IV = (140m) 82% ooid PG, 14% ooid-fragment W 4% dolomite; III partial (+105) stromatoporoid WF, 38% ooid PG, 14% fragment PW, 33% fragment WM, 5% dolomite. Note the original tops unchanged from 2001 and the old pie diagrams are good approximations but are based on every second sample using more detailed Excel calculations aided by sidewall cores. The above have been calculated more generally and similarly to Panuke B-90 and Como P-21 using every sample from an 2005 infill of the older logging.

Appendix A3 ENCLOSURE A3.16 Panuke F-09 L.Eliuk 2016

	E	nclosure A3.1	<u>a</u> PanCa	ana		PCP) <u>Panuke H-0</u>	<u>cu</u>	ttings	Geo	Tou	rs C	onsu	lting	Inc	L.Eli	uk P.	Geol.			Infill	l fina	1 200	4-11			Ş	78'88	PAGE
EPTH	штн	modifier I	COLOR		TEXTU DUNHAM	Mmodifier	POF				RIES		Ī		FOS	SILS	(er	nhanc	ed by	SW	C da	ta if a	vailat	ole)			CIES I	COMMENTS
metres)	H SH O SS L arg cal	=limestone bL=dolomite l=shale =sandstone TST=silistone j=argillaceous lc=calcareous y= sandy/qtz	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	(FS/F FS=fI RS=r	mudstone 1 wackestone 3 acackstone 5 grainstone 7 \$\sisin \text{S} = \text{X} \text{Cize} \text{loatstone} 4 udstone 8 =crystalline	%	modifier				Г	STROMATOPOROI TO		MILLEPORID AND Hydrozan-	HEXACORAL	BRYOZOAN	CRINOIDS	ECHINOIDS GASTROPODS	BIVALVES	OSTRACOD	TUBIPHYTES	FORAMINIFERA	BORINGS HIGHER -green	STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROMATOLITE STROM	ONCOIDS-PISOID	STANDARD MICROFA Flugel'82&Wilson'75&	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen P = pnoto
Α	В	С	D		G	Н	ı	J I	L	. M	N	0	PC	R	S	Т	v w	Х	ΥZ	AA A	ΑВА	CAD	AE A	AFA A	H AI	AJ A	λK	AL
3205 3210 3215	SH? SH SH SH SH (S	tr silty tr silty tr silty tr silty tr silty tr silty st silty	5YR2-3/1 M-DBGy 5YR2/1 M-DBGy 5YR2/1			slightly darker	?																				2 2 2 2 2	trays 3200-50 & 3250-90 'all mud" Very poor & dirty samples small cuttings-VF-M trace micropyrite & blk SH? pyrite SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB
3225	SH/LS	v. calc(10-20%)	N4-5	1	MS??	?arg LS?				+	Abe	nal	ci V	II -	3224n	n	7—			H	+			#		_	2	RR-Chalky
3235 3240 3245	SH/L <mark>S LS/S</mark> H LS/SLT LS/SH	75/25 LGy chalky 5/5 LGy chalky 9/1 5/5 tr C dolm tr G	N3/1 N3-5/1 N3-5/1 N3-5/1	1 1 1	MS? MS? MS? MS?	(5YR3/1) arg LS	?	chalky?													?		?	ı			2 2 2 2	BBB chalky limestone? BBB pyrite BB (?log out? Silty zone) tr C wt dolomite w/ micropyirite thumbhole P
3255 3260	SH/LS SH SH Sh (LS)	9/1 calc (LS?)	N3-4/1 N3-5/1 %YR2/1	E SA	W NO C	ASING CEMENT??																		ı			2 2 2 2	BBB xf pyrite BBB BBB calcareous
3270 3275	LS/SS		N5-6			chalky?	<3%	xtl-IIIBC							Н									I	Н		2 2-3	BBB P veryvery BBB = dust size
3280	LS/SH	5/5 tr SS	N5-6																					Ш			2-3	P
		7/3 VF-F SS 65/35 calc VF SS	5YR4/5 N7-YR4		XTL	XF-VF	-30/	xtl IIIBC A	en	aki	VI	- 329	16m		1											(5) 5 2-3	xf dolomite (?siderirte) sandy to VC frounded good sample but small cuttings
3295	SS	sl calc VF-F(M)	N7-11X4 N7		^1L	SS- VF-F(M)rd	\J /0		T	T	Ü	1	T	Т													9	larger sand grians rounded F
3300	LS/DUL	90/10 aa cave?	N5-6	3	WS?	sponge-frag	?			12		15		+			2	2		?	7	?	1	#			4ab-3	BB tubular foram?
3305	LS	argilaceous		3	ws	fragmental-sponge				10		8						1		?			1				4ab	P
	LS	silty (cave?)	L(B)Gy	3	WS?	sponge-frag	?			6		10						5?		1	1		•	ш		- 4	4ab-3	BB ~1%micropyrite
3315 3320	LS LSarg	argoll tr silty	L(B)Gy L(B)Gv	3	WS FS-WS	fragmental skel-frag	2			15		3? 6	1	2	1		1 white	2	1	1	2		?				4-3 b-5b	BBB BB chalky P
3325	LSary LS(<mark>DOL</mark>	95/5	L(B)Gy	3	WS	fragmental (sponge)	1			15		6		4			1	1		2	1						ab	DD Clidiky P
	LS/DOL	9/1 F DOL	L(B)Gy	3	ws	fragmental	+2?	disagg F-VF dol		15		5		2				?		2				П			b-5b	BB chalky. Tiny cuttings
3335	LS	lighter color tr SSvf	L(B)Gy	3	ws	fragmental				20		3	2	:				2		1							b- <mark>5</mark>	BB chalky
	LS	BB = bit bruised	VL(B)Gy	4	W-PS	frag (?bkn skel)		chalky		25		1						1?		5	?			Ш			5a	?BBB chalky broken fossils fragments??
	LS LS	minor an alov	VL(B)Gy LM(B)Gy	3	WS F-WS	fragmental	tr?	vug=VC calcspar	2	15		2 mi	ritic,	3			12	?		1			?		crust	t	a(b) b-5b	BBB P tiny cuttings Px16
3355 3355	LS LS/DOL	minor gn clay 7/3	LM(B)Gy LGy+Bn	3 4	WS	frag-skel (sponge) fragmental			4	15		5	2				1 /			1							5	LS=white-Lt gray; DOL= Md Brown (MUDSTONE?)
3360	LS/DOL	7/3 Bn VF	LM(B)Gy	3	ws	frag (skel-sponge)			2	20)	4		1						1	1	ı		П		4	-3?	BB? Some sponge? texture in dolomite. Tiny cuttings
3365	LS/DOL		Gy + Bn	4	WPS(MS				3	30		1	1							1							5	LS=white-Lt gray; DOL= Md Brown (MUDSTONE?) BBB
3370	LS/DOL	9/1	LM BGy	2	M-WS	fragmental				10		1						1		1				Ш			3?	BB
	LS LS	<5% DOL BB = bit bruised	LM BGy L(B)Gv	3	W-MS W-MS	fragmental (chalky)		v. chalky	1	10		1	1					1									5 3-5?	BBB BBB?
	LS LS	DD - DIL DI UISEU	VLGy	2	W-MS	(fragmental)		v. chalky		5?			?					?									?	BBB
	LS	BB 2%VCcalcspar	L(B)Gy	3	ws	fragmental (chalky)		v. chalky	2			1	1			?		1						П			<mark>3-5</mark> ?	BBB? p
	LS	BBB	L(B)Gy	2	WMS	(fragmental)		v. chalky		5		?		2													5?	BBB mislabel?P
	LS	BB	L(MB)Gy	3 4	FS-WS			v. chalky		10)	3		1 ?		1				?				Ш			b-3?	BB
	LS	BBB DD. tr.alay	L(MB)Gy	3	WS	fragmental		v. chalky		15		3	?	2				2		٦							b- <mark>5?</mark>	PD purite
	LS LS	BB tr clay BBB	L(MB)Gy L(MB)Gy	3	WS WS	fragmental -skeletal? fragmentlal-skeletal		v. chalky		10		2		3		2		1		?				Ш			- <mark>5b</mark> a	BB pyrite BBB
	LS	BB	L(M)Gy	3	WS?	fragmental -skeletal?				10		2	2		1			1								1		BB pyrite



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1-F,G	ni angle stylolites horsetails-stylolitic horsetails-stylolitic 8/2 dolm dessimin' htervals sampled tid-rich BEDS	MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 7 LMBGY 6 LMBGY 7	6 4 FS 6 8+9 (B) (B) 6 8+9 (B) 6 8+9 (B) 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 6 4 FS 6 6 6 6 4 FS 6 6 6 6 4 FS 6 6 6 6 4 FS 6 6 6 6 4 FS 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	GPS skeletal (small br strom/chailings) GPS bivalve-skel-frag RS-GPS chaetetid (altered) RS-GPS chaetetid-stromatoporoid? RS-GPS chaetetid-skeletal GPS bryozoa-skel-chaetetid GPS skeletal (bryozoa-crinoid) GPS coal(rextl-bioeroded) GPS chaetetid-bryozoa(coral) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	ae 10? inter ?11 ?11 ?22 10? 15 intra- ?	r+intra skel	50 50 50 40 40 50 65 70 70 50		10 10 10 10 35 20 30 5 20 30		X X?	3		megalodor 20	nt?				
146.5 1-G,2-A	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB (MLGyB	6 8+9 (B) 6 8+9 (B) 6 8+9 (B) 6 6 6 FR 6 4 FS 6 4 FS	RS-GPS chaetetid (altered) RS-GPS chaetetid-stromatoporoid' RS-GPS chaetetid-stromatoporoid' RS-GPS chaetetid-skeletal GPS bryozoa-skel-chaetetid GPS skeletal GPS coral(rextl-bioeroded) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	10? ?? ?12 zzz 10? 15 intra- ?	a-chaetetid	50 40 40 50 65 70 70 50 70		35 20 30 5 20 30		х х?	3	4	20	1 1			5b-4c grai	FD02 K-2110md P-14.8%
146.6 2-B	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 LMBGy 6 LMBGy 7 LMBGy 7 LMBGy 7	6 8+9 (B) 6 8+9 (B) 6 6 FR 6 4 FS 6 4 FS	RS-GPS chaetetid-stromatoporoid? RS-GPS chaetetid(bioeroded)-bryos S-GPS chaetetid-skeletal Bryozoa-skel-chaetetid GPS skeletal S skeletal GPS chaetetid (bryozoa-crinoid) GPS coaf(rextl-bioeroded) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	97	a-chaetetid	40 40 50 65 70 70 50 70		20 30 5 20 30		X X?	40						514	iny lg clm to 10cm insitu??
146.7 2-B,C,D	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLGyB (6 MLG)) (6 MLGyB (6 MLGyB (6 MLG)) (6 MLGyB (6 MLGyB (6 MLG)) (6 MLGyB (6 MLG)) (6 MLGyB (6 MLG)) (6 MLGyB (6 MLG)) (6 MLGyB (6 MLG)) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG) (6 MLG	6 B+9 (B) 6 6 FR 6 4 FS 6 4 FS	RS-GPS chaetetid(bioeroded)-bryo S-GPS chaetetid-skeletal GPS bryozoa-skel-chaetetid GPS skeletal S skeletal (bryozoa-crinoid) GPS chaetetid (small-branch) GPS chaetetid-bryozoa(coral) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	10? 15 intra- ?	a-chaetetid	40 50 65 70 70 50		5 20 30		x	40						4c-5b 3	<mark>6</mark>
46.8 2-D,E LS 44.9 2-E,F,3-A LS 47.1 3-A,B LS hi angl 47.2 3-B,C, LS 47.4 3-C,D,E LS horset 47.4 3-C,D,E LS horset 47.5 3-F,G LS 47.6 3-G,4-A LS dol 8/2 dc 47.7 4-A,B LS 18 decimeter interval UPPER Chaetetid-ric 47.8 4-B,C LS 47.9 4-C,D LS minor 48.1 4-E,F LS dol 9/1dol 48.2 5-A LS dol 48.3 5-B,C LS 48.4 5-C LS 48.5 5-C,D LS 48.6 5-D,6-A LS dol minor 48.7 6-A,B LS 48.8 6-B,C LS 48.9 6-C LS 48.9 6-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C LS 48.9 1-C	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 6 LMBGy 6 LMBGy 6 LMBGy 7	6 6 FR 6 4 FS 6 4 FS GP 6 4 FS 6 5 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 4 FS 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	GPS chaetetid-skeletal GPS bryozoa-skel-chaetetid GPS skeletal S skeletal (bryozoa-crinoid) GPS coral(rextl-bioeroded) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	15 intra- ?	a-chaetetid	50 65 70 70 50		30							3	5?	5b-4c grai	FD03 K-3.62md P-8.5%
46.9 2-E LS 447 2-E,F,3-A LS 447 1-3-A,B LS hi angl 47.2 3-B,C, LS horset 47.3 3-C,D,E LS horset 47.5 3-F,G LS 47.6 3-G,4-A LS 47.7 4-A,B LS 18 decimeter interval UPPER Chaetetid-ric 47.8 4-B,C LS 47.9 4-C,D LS minor: 47.8 4-B,C LS minor: 48.1 4-E,F LS minor: 48.2 5-A LS dol 9/1dol 48.3 5-B,C LS horset 48.4 5-C LS 48.4 5-C LS 48.5 5-C,D LS 48.6 5-D,6-A LS 48.7 6-A,B LS 48.9 6-B LS 48.9 6-C LS 48.9 1-C LS 49.1 C-D LS 49.1 C-D LS 49.1 C-D LS 49.2 LOST CORE TO 3460m 49.3 1 COST CORE TO 3460m 49.3 1 COST CORE TO 3460m 49.4 49.5 49.6 49.7 49.8 49.9 FACIES NUMBERS: 1=bath; 48.8 49.9 FACIES NUMBERS: 1=bath; 48.9 6-C LS 49.1 C-D LS 49.1 C-D LS 49.1 C-D LS 49.2 LOST CORE TO 3460m 49.3 1 COST CORE TO 3460m 49.3 1 COST CORE TO 3460m 49.4 49.5 49.7 49.8	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	MLGyB (MLGyB MLGyB (MLGyB (MLGyB (MLGyB (MLG)) MLGyB (MLGyB (MLGyB (MLG)) MLGyB (MLGyB (MLGyB (MLG)) MLGyB (MLGyB (MLG)) MLGyB (MLGyB (MLG)) MLGyB (MLG) MLGyB (MLG)) MLGyB (MLG) MLGyB (MLG) MLGyB (MLG)) MLGyB (MLG) MLGyB (MLG) MLGyB (MLG)) MLGyB (MLG) MLGyB (MLG) MLG) MLGyB (MLG) MLGyB (MLG) MLG) MLGyB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG) MLGYB (MLG) MLG (MLG) MLG (MLG) MLG) M	6 4 FS 6 4 FS 6 GP 6 4 FS 6 4 FS	GPS bryozoa-skel-chaetetid GPS skeletal S skeletal (bryozoa-crinoid) GPS coral(rextl-bioeroded) GPS chaetetid (small-branch) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	? 	a-cnaetetid	65 70 70 50 70					10	-			5		4c-5b 3	2 300 K 8/02 Miles
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A7.1 3-A,B	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	MLGyB 6 LMBGy 6 LMBGy 6 LMBGy 6 MLGyB 6 ' LMBGy 6 MLGyB 6 LMBGy 7 LMBGy 7	6 GP 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS	S skeletal (bryozoa-crinoid) GPS coral(rextl-bioeroded) GPS chaetetid (small-branch) GPS chaetetid (small-branching GPS chaetetid (small-branching GPS chaetetid (small-branching	g)		70 50 70		3 3		^	7	5	٥	4 1	4		5b-4c grai	iny FD04 K-320md P-8.7%
47.2 3-B,C, LS horset 47.3 3-C, LS horset 47.4 3-C,DE LS horset 47.5 3-F,G LS 47.6 3-G,4-A LS dol 8/2 dc 47.7 4-A,B LS 18 decimeter interval UPPER Chaetetid-ric 47.8 4-B,C LS minor: 44.8 4-B,C LS minor: 48.1 4-E,F LS minor: 48.2 5-A LS dol 9/1dol 48.3 5-B,C LS horset 48.4 5-C LS horset 48.5 5-C,D LS 48.6 5-D,6-A LS dolm in 48.7 6-A,B LS 48.8 6-B LS 48.9 6-B,C LS TS ech 48.9 6-C LS 49.1 6-D' LS 49.1 C-D' LS 49.2 LOST CORE TO 3460m 49.3 LOST CORE TO 3460m 49.4 32 LOST CORE TO 3460m 49.4 32 LOST CORE TO 3460m 49.5 49.6 49.7 49.8 49.7 49.7 49.8 49.9 FACIES NUMBERS: 1=bath; 48.8 49.9 40-coraljane sponge 58-coralgal-coralline spong	norsetails-stylolitic norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	LMBGy MLGyB LMBGy MLGyB LMBGy MLGyB MLGyB MLGyB C LMBGy MLGyB C LMBGy T	6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS 6 4 FS	GPS coral(rextl-bioeroded) GPS chaetetid (small-branch) GPS chaetetid-bryozoa(coral) GPS chaetetid (small-branching GPS chaetetid (small-branching	g)		70		5		rladt	5	5		3 1			4c-5b 3	b
47.4 3-C,D,E LS horset 47.5 3-F,G LS S dot 47.6 3-G,4-A LS dot 47.7 4-A,B LS dot 47.7 4-A,B LS dot 47.9 4-C,D LS minor: 48.4 4-D,E LS minor: 48.4 4-D,E LS minor: 48.2 5-A LS dot 48.3 5-B.C LS horset 48.4 5-C LS horset 48.5 5-C,D LS horset 48.6 5-D,6-A LS dotminit 48.7 6-A,B LS S S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-B,C LS S-	norsetails-stylolitic 8/2 dolm dessimin' ntervals sampled tid-rich BEDS	LMBGy 6 MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 7	6 4 FS 6 4 FS 6 4 FS 6 4 FS 7 Haetetid	GPS chaetetid-bryozoa(coral) GPS chaetetid (small-branching GPS chaetetid (small-branching	ıg)				5		30	5	3 6	etid-stromato		15		5b-4c grai	iny large (10 cm) highly (50%) bioeroded coral clast, even bryozoa bored FD05 K-21.4md P-14.5%
147.5 3-F,G	8/2 dolm dessimin' ntervals sampled tid-rich BEDS	MLGyB 6 LMBGy 6 MLGyB 6 LMBGy 7	6 4 FS 6 4 FS 6 4 FS haetetid	GPS chaetetid (small-branching chaetetid (small-branching	ıg)		65		15		, x	5	3					4c-5b 3	DUS K-21.4IIIU F-14.5%
147.6 4-A,B LS dol 8/2 dol 4/4.7 18 decimeter interval UPPER Chaetetid-ric 18/4.8 4-B,C LS minor : 18/4.8 4-B,C LS minor : 18/4.8 4-B,C LS minor : 18/4.8 4-B,C LS minor : 18/4.8 5-C,D LS minor : 18/4.8 5-C,D LS dol 5-D,6-A LS dol minor : 18/4.8 6-B LS dol 18/4.8 6-B LS dol 18/4.8 6-B LS dol 18/4.8 6-C LS dol 18/4.8 6-D LS dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol 18/4.8 dol	ntervals sampled tid-rich BEDS	LMBGy 6 MLGyB 6 LMBGy 7	6 4 FS 6 4 FS haetetid	GPS chaetetid (small-branching	ıg)			round	clast 10		chaist	10	3			3		5b-4c grai	FD06 K-79.7md P-15.1%
147.7	ntervals sampled tid-rich BEDS	MLGyB 6	6 4 FS				60		5 15		XX	3	5			2		4c-5b 3	•
18 decimeter interval UPPER Chaetetid-ric UPPER Chaetetid-ric 147.8 4-B,C LS minor: 448.4 4-D,E LS minor: 448.2 5-A LS dol 9/1dol 48.3 5-B,C LS horset 148.4 5-C,D LS horset 148.5 5-C,D LS horset 148.6 5-D,6-A LS dolm in 148.7 6-A,B LS 448.8 6-B LS 448.8 6-B LS 449.1 6-D' LS LOST CORE TO 3460m 149.1 6-D' LS 149.1 49.1 6-D' LS 149.1 49.1 6-D' LS 149.1	tid-rich BEDS	LMBGy 7	haetetid	Gra Chaetetiu-Coran spg clast			60 60	5	15 15	clast	20 XX	3	3					5b-4c grad 4c-5b 3	bb massive uniform coral clast encrusted by sponge (Shuqraiopsis?) FD07 K-0.74md P-12.5%
47.8 4-B,C 47.9 4-C,D LS minor: 448.4 4-D,E LS minor: 48.1 4-E,F LS minor: 48.2 5-A LS dol 9/1dol 48.3 5-B.C LS 48.5 5-C,D LS 48.6 5-C,D LS 48.6 5-D,6-A LS 6-B LS 6-B LS 6-B LS 6-B LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C LS 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C 6-C C				(stromatoporoid) Floatstone - skelet	tal formunantal	I CC DC	950	5	93 348	+ + +	57	66	48	28	7 3	45	5	40-00	Inassive dillioni colai dast enclusied by sponge (ondifialopsis:)
47.9 4-C,D LS minor: 448 4-D,E LS minor: 448 4-D,E LS minor: 48.1 4-E,F LS minor: 48.2 5-A LS dol 9/1dol 48.3 5-B,C LS horset 48.4 5-C,D LS 48.6 5-D,6-A LS 48.7 6-A,B LS 48.8 6-B LS 48.9 6-B,C LS 49.1 6-D' LS 49.1 LOST CORE TO 3460m 49.3 LOST CORE TO 3460m 49.3 TOTAL AVERAGE PI 49.5 49.6 49.7 49.8 49.9 58-coralgal-coralline spong 58-coralgal-coralline spong 58-coralgal-coralline spong	minor etylolitic		7 /50	· ,	tai-iraginentai	11 03-F3	53%		5% 19%		3%	4%	3%	1.5		3%			
448.4 4-E,F LS minor: minor: minor: minor: minor: minor: 48.1 4-E,F LS dol 9/1dol 48.3 5-B.C LS horset: 48.5 5-C,D LS 48.6 6-B LS 6-B LS 6-B LS 6-B LS 6-B LS 6-B LS 6-C LS 15-D LOST CORE TO 3460m 10.0 10.0 10.0 10.0 10.0 10.0 10.0 10)-G(P)S skeletal-fragmental	intraskele	etal	75	encrusted	clast 3			2	5 2+	3				3c (5a)	
	minor stylolitic	LMBGy 7		s)-G(P)S skeletal-fragmental s)-G(P)S skeletal-fragmental	microporo	rosity	75 75		3			2	5+ 2 6 2+	2 4	1			3c (5a) 3c (5a)	FD08 K-1.73md P-11.4%
48.2 5-Å LS dol 9/1dol 48.3 5-B.C LS horset 48.5 5-C,D LS 48.6 5-D,6-Å LS dolm in 48.7 6-A,B LS 48.8 6-B LS 48.9 6-B,C LS TS ech 49.1 6-D' LS 49.2 LOST CORE TO 3460m 49.3 LOST CORE TO 3460m 49.4 149.5 49.6 150 150 150 150 150 150 150 150 150 150	minor stylolitic	MLGyB 7		i)-G(P)S skeletal-fragmental	amount		75		3			2	5+ 3	2 1	1		3	3c (5a) 3c (5a)	
148.3 5-B.C LS horset 148.4 5-C,D LS horset 148.5 5-C,D LS dolm in 148.6 6-A,B LS dolm in 148.8 6-B LS TS ech 148.9 6-C LS TS ech 149.1 6-D' LS 149.1 LOST CORE TO 3460m 149.3 LOST CORE TO 3460m 149.4 32 decimeter interval 149.5 149.6 TOTAL AVERAGE PI 149.7 149.8 149.9 15B=coralgal-coralline spong 15B=coralgal-coralline spong 15B=coralgal-coralline spong	9/1dolm in burrow	LMBGy 7		G(P)S branch spg/strom-skeletal	1		50	5?=	= 102		x	1	3+ 2+				3	5b-4c grai	skeletal-fragmental grains F-M-C FD09 K-0.08md P-7.7%
148.5 5-C,D LS 148.6 5-D,6-A LS 148.6 5-B, LS 148.8 6-B LS 148.9 6-B,C LS 149.1 6-D' LS 149.1 6-D' LS 149.2 LOST CORE TO 3460m 149.3 LOST CORE TO 3460m 149.4 149.5 150 150 150 150 150 150 150 150 150 15		MLGyB 7		G(P)S branch stromataop-skeleta			50		15		x	1	3+ 2+					4c-5b 3	
Mas.6 5-D,6-A LS dolm in	horsetails-stylolitic	LMBGy 7		-G(P)S stromatoporoid-skeletal			50		15		x	1	3+ 2+				?	5b-4c grai	<mark>ny</mark>
148.7 6-A,B		MLGyB 7		(BS)-GS hexacoral (massive)-spon	nge		10	15			75		3+ 2+		1 1	2		4c-5b 3	multigeneration massive clam-bored hexacoral (Isastrea??) encrusted by lithistid?-stromatonoroid sr
148.8 6-B	dolm in TS to 60%	LMBGy 7	7 G(I				50						10 10	1 15 3	1 1			3c (5a)	oriented small (C-VC) shell-echinderm fragments TS FD10 K-0.02md F FD11 K-0.08md P-8.9%
148.9 6-B,C		MLGyB 7	7 G(I				50 50						10 10	1	1 1			3c (5a) 3c (5a)	skel GS all cemented 2TS 3448.6
449 6-C	TS echinod-bivalve from		7 G(I				50						10 10	1	1 1			3c (5a)	increase in echinodermal material FD12 K-0.21md P-4.0%
149.1 6-D' LS LS L99.2 LOST CORE TO 3460m L99.3 LOST CORE TO 3460m L99.4 L99.5 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L99.6 L	13 echinou-bivaive ing	LMBGy 7	7 G(I				50						10 10	15 3	1 1			3c (5a)	Increase in echinodernia material
49.3 LOST CORE TO 3460m 49.4 49.5 32 decimeter interval 49.6 49.7 49.8 49.9 FACIES NUMBERS: 1=bathy 4A= 'deep' siliceous sponge 58=coralgal-coralline spong		MLGyB 7	7 G(I				50						10 25	15	1 1			3c (5a)	some layers above suggestion of cross-bedding
49.4 49.5 49.6 49.7 49.8 49.9 49.7 49.8 49.9 48-1 49-2 49-3 48-2 49-9 58-coralgal-coralline sponge																			
49.5 49.6 49.7 49.8 49.9 150 FACIES NUMBERS: 1=bath; 4A= 'deep' siliceous sponge 58=coralgal-coralline spong	tomale compled		+		-		1710	20 5	5 140 350	+ + + .	122	77	140 106	4 70 7	14 11	44			
49.6 49.7 49.8 49.9 4A= 'deep' siliceous sponge 5B=coralgal-coralline spong		ES (small skeleta	al materi	al underestimated)			55%	<1%	4% 11%		132 4%	2%	4% 3%	2%	<1%	1%	ا ا		
49.8 49.9 FACIES NUMBERS: 1=bathy 4A= 'deep' siliceous sponge 5B=coralgal-coralline spong				nodermal-skeletal-fragmental GS (PS	8)			1 "1					1,0		1 1				
49.9 450 FACIES NUMBERS: 1=bathy 4A= 'deep' siliceous sponge 5B=coralgal-coralline spong			1 1	T T T T T T T T T T T T T T T T T T T	-,														
450 4A= 'deep' siliceous sponge 5B=coralgal-coralline spong													Щ			Ш			
5B=coralgal-coralline spong												= spor	nge reefal,						
				olitic, 5E= oncolitic, 5F= sandsto								rshore	ridae).						
	onal-continental),	l), 9= mixed ca	arbonat	e-deltaic, 10= deltaic/interdeltaic	SEE Wierzb	oicki, Harland &	Eliuk 2002	for illustra	ations and	details NOTE	-m=microsoler	ids ma	in/only corals	s present ch =	chaetetid i	mainly/c	only		
1 1	J														T	П			
- - - - - - - - - - 		+	++		+ +		+	++	+ + -	+++	 	-	++	+++	+++	\dashv	+		
PTH SPL# LITH mod		COLOR		modifier	DROSITY			11	FOSSI	ILS	shape_	(en	hanced by SV	VC data if avail	able)	T			COMMENTS
etres) LS=I	modifier I	K	ŝ	MS=mudstone 1	%			FRAME	BUILDERS			<u>.</u>				AL	GAE		
H SH=	LS=limestone	MBE 18	Šrs(t	WS=wackestone 3 PS=packstone 5		nodifier	ا مو ا⊡		SQ	ॏ॒ ॾॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗॗ		୍ଲ ହ୍ଲା	l sa l	┐┢╗┃┃≝	f R		S .		additional fossils/accessories
	LS=limestone DOL=dolomite SH=shale		# fs	GS=grainstone 7 BS=boundstone 9	(Arc	chie)	Pas ELO	S S	og Se				S O		되불	힐	lites		diagenetic textures
L arg=	LS=limestone DOL=dolomite SH=shale SS=sandstone		9	(FS/RS=XC size)				S S S	ATO		ar-li	Z X	JO H	SE SE	ZA H		Mbo IDS-		facies-sequence breaks et cetera
	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone arg=argillaceous	3BREVIA D	8			8	A & E	ğ M	HAE	GE GE	[[[[[[]			STR RILL		쁴뱮			some long comments may be
, , ,	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone	ABBREVIA D DUNHAM NU	sq-sw	FS=floatstone 4					ST C	[*] ½ ½ 1		_			E	Ē	F S		hidden & visible only on screen
АВ	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone arg=argillaceous calc=calcareous	ABBREVIA	sq-su				L M N	N O P	Q R	S	7	V W	XY	Z AA AB A	C AD AE	AF AH	AI A	J AK	AL
1 1	LS=limestone DOL=dolomite SH=shale SS=sandstone SLTST=siltstone arg=argillaceous calc=calcareous	D ABBREVIA	SQ-SE G	FS=floatstone 4 RS=rudstone 8	1	J K													

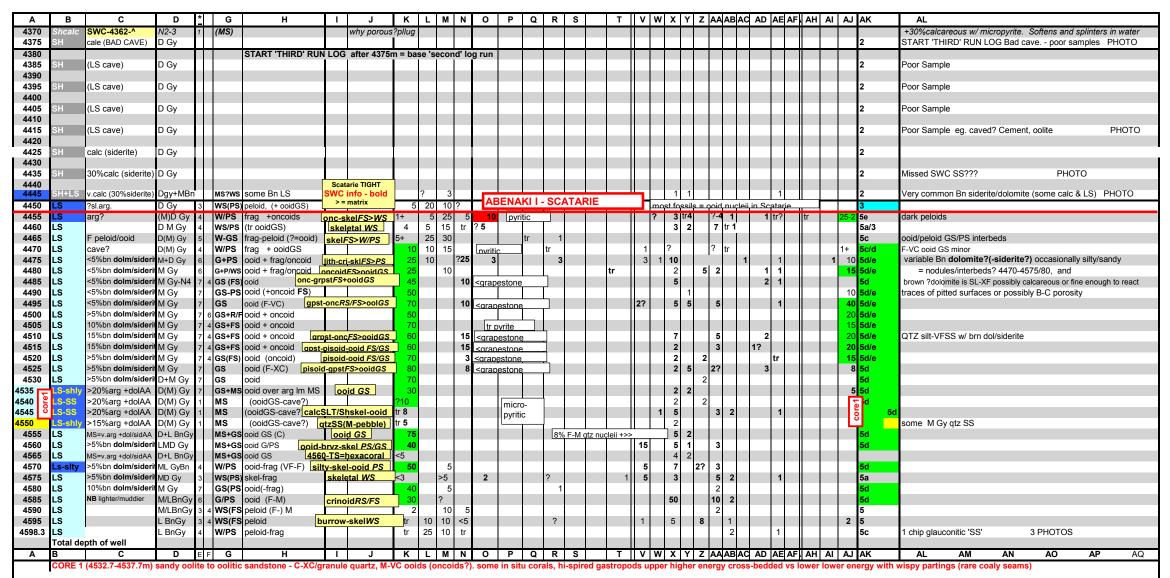


Enc	losure	A3.18 PanC	anadian	(P	CP) Panuke M-79				Ge	oTours	Cons	ulting	Inc I	L.Eliuk	P.Geo	ol.						St					8,88	PAGE
DEPTH	LITH	modifier I	COLOR	I	modifier	PORC	OSITY	ACCESS	ORIES					FOSS	SILS		(е	nhanc	ed by	/ S <mark>WC</mark>	data if	availa	able)			- 1	liuk'7	COMMENTS
(metres)	H SH O SS L arg	=limestone JL=dolomite =shale =sandstone TST=siltstone =argillaceous c=calcareous y=sandy	ABBREVIATED or MUNSELL DUNHAM NUMBER	left*=ms-bs righ=tfs&rs(bs)	MS=mudstone	%	modifier (Archie)	OOIDS	PARTICLES		WT SPONGES'	STROMATOPOROID	CHAETETIDS	MILLEPORID hydrozan-OTHER	MICROSOLENIDS	HEXACORAL	BRYOZOANS	CRINOIDS	ECHINOIDS	BIVALVES	OSTRACODS SERPULIDS	TUBIPHYTES etc	FORAMINIFERA BORINGS	HIGHER -green etc P	STROMATOLITES THE ONCOIDS - PISOIDS	STANDARD MICBORAL	Flugel'82&Wilson'75&E	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
Α	В	С	D <u>*</u>		G H	ı	J	K L	M	N C) P	Q	R	S		Т	V W	/ X	Y		AB AC	AD	AE AF	Ц Ц	_	J A	ιK	AL
3195 3200 3205 3210 3215 3220	LS	arg+10% ipped sample larg10%,tr qtzSS arg+10%	L Bn ?? 9	4 F			chalky? chalky?	?	10	5	3'		2?	LIGH		COLO	Y BIT			(BBB)		x?	ABEN	IAKI	VII	4		minor pyrite, tr Org Bn staining, tr Gn clay BBB minor bright Gn clay, trVF-FqtzSS BBB minor Gn&Blk clay BBB
3225 3230	LS	arg+10%	L Bn ?? 9	8 F	S-BS sponge-	?	chalky				30 5								2+							4		BBB
3235 3240 3245	LSw/SS				VS sponge-					5												x?						SS-silty-clayey&<10%calcareous, (LS cave??in part)
3250	LS&SS	arg-sltyVFcalc SS	M Gy 2	N	IS-WS sponge-	AKI V				1	5									П			2+			4		50/50 LS/SS - liths as above tr Gn clay/stain
3255 3260	LS	?arg<10%	M(L?) Gy 9	8 F	S(BS) sponge-	?	chalky?			3	5								2+			3?	2+			4		Tubiphytes ?encrusting form BB
3265 3270	LS	silty-arg	M L Gy ? 1	N	AS .						2-	+																??sample -casing cement. Tr Gn clay, sl pyrite. BB
3275 3280	LS	sl arg	ML? Gy 4	v	vs-ps				5+	1		22	22					2+	2+	22	1+					4		cement caving, Encrusted bivalve?
3285 3290	LS	or arg	M(L)GyBr 6		SS-PS sponge-chaetetid/stro	maton	oroid ES	x?		5? 2		12	2 122					2+	2+				2+					foraminiferal encruster. Tr pyrite
3295		<100/ ptga CHalty				Inatop	01010113	A:				12	12:					21	21				21					
3300 3305	LS	<10%ptgs- SH slty			vs-ps sponge-stromatop'					2		10	<u>'</u>										2+					Partings-sity calc SH. Dk encrusting foram?on stromtp
3310 3315	LS	~7% SH sltyDGy	ML GyBn 5	P	PS(BS) sponge-					4	2-	+ 2+	3+									2+				4		spicules. Chaetetid?or encruster
3320 3325	LS		L Gy&Bn 5	P	S(BS) sponge-	?	chalky?			2	1	3+											2+			4		more soft white bit bruise/heated ?rock BB
3330	LS	~3%clayey LS	L(M)?BGy з	٧	vs sponge				5+	10	3-	+ tr														4		
3335 3340	LS	ptgs-DGy pyrt SH	LM BnGy 3	v	vs sponge (+peloidWS//	MS)		5-	+	10	2-	+ 2?	3+										2+			4		
3345 3350	LS	10%sltyshlypyr LS	LMGyBn 4	v	vs-ps SWC=sponge BS/RS	darke	r=DBnGy			20	+ 2·	+ 5		2+									3+=tub	ular		4		SWC darker! Sponge,wt sponge,stromatoporid,hydrozoan respectivel
3355		VF-Fqtzcalc SS									2-																	
3360 3365	LS&SS	VF-FQLZCalc33	MLGy&Br 3	4 V	VS-FS		tight		5+		2.	+	2+			AB	ENA	(I VI	LO	ᅪ								50/50 LS/SS -sity,sl shly&25%calc
3370 3375	LS	trVFqtz in LS	M(Bn)Gy 3	۷	VS peloid			15	5	3-	+											2+				4		tr cl,VC calcspar, tr micropyrite
3380 3385	LS	'mottled'>>	M Gy 3 V color cha		vs						3-	+ 2+				?				3?	2+					I		
3390 3395 3400 3405	LS skipped LS>SS		DM Bn N8&5Y5/15 (D)M Bn 5	4 F		alve- ti	r vug interpt IB	40		1: clio		5+ 2?				? 30 tr				#	2+		2+ 3+		10?	4		microbial-peloid(VF) crusts w/ micropyrite, Tr clay-sltst. corals & bivalves rextl/d(C-VC) bored by clionid sponges nearly calc SS XF-M (subrounded)
3410 3415	LS	15%slty-VFsdy	DMBn 3	٧	vs								5+			2+												coral=C calcspar w/ septa Cave?= LGy & Bn LS
3420 3425	LS&SS LS	SSVFqtz LSsltysdy	M D Bn 3 D(Bn)Gy 4		SWC=Sdy Skeletal PS SWC=Cor-Stromtop-S			30	10	1		7+	3 5+		15deen	per wate	1	2	2	5	1 2	1? 1?	2	1	0coats		/5b	SS= L Gy, VF qtz, tr C-angular,pyritic LS to 50% VF-F qtz SWC Microsolena coral, microbial coats on XC frambuilders-stromatoporoid-Burguni
3430 3435	LS&SS LS	sdy, sl.dol sl sdy 5% SS aa	M(Bn)Gy 3 LMBnGy 5	٧	vs s(ws) frag-stromatop-skel			5-	10+	4		2?				1?		L	5		2		1?		3	5	a a	SS sityVF-M qtz,caic, LMGy

Α	В	С	D i	*	G	н	ı	J	K	L M	N	0	P Q	R	s st	ylolites-	horset	ails Y	ZΑ	AAB	AC A	D AE	AF A	H AI	AJ AK	AL
3440	LS&SS	sl.sandy LS	M BnGy	4	WS PS	SWC= Skel-rich VF S	S(FS	3')		2	2	10	10	2-				4	3 !	_	1	1 2rol		1 1	4/5ab	SWC SS VFqtz,40% M-VCskeletal frags, Cm oncoid
3445	LS	trSS trDOLXF-M	M DBnGy	4	WS PS	SWC=2LSs>BS/GS	tr	IB	3+	10		5	10	3-				4	5oy	ster			3clionid	10		SWC bored microbial?stromatop BS on F-M skel-frag GS
3450	LS	stylolitic clay	D BnGv	5	PS(WS)	SWC=Cor-Spg-Cri BS/RS	tr	ICD shelter				30 sı	ıbmar? (cmt	15		3+	15 2+	5+			2	ADEA	IAKLY	4	SWC BS mcrosolenid&articulated crinoid =deep/quiet water, thin-walled gast
3455	LS	20% SS calcFqtz-rd	M BnGy	6	PS GS	SWCskel-lithoclast-su	up'ooid	d GS	15		15	2+	15			10	2+	3+	3	+	tr mic	ropyri	ADEI	IAKI V	5b/d	SWC ooids=superficial Corals/bivalves rextl=cl calcspar. Allochems C
3460	LS	dol15%&5%VFsdy	M BnGy	3	ws	SWC crusts-skeletal	FS					?	3 2	2				3	3					15?	5a	also SWC Dark encruster(microbial/sponge?restl)
3465	LS	M-VC allochems	M GyBn			ooid-lithoclast			60		20		3+	st	ylolitic, tr pyri	te&clav			3+ 5	5		2			5d	M-VC ooids/lithoclasts poorly sorted, some qtz nucleii ??does this sa
3470	LS	F-Mpeloids&ooids	M BnGy	-		SWCstromatop-chaet			5	20 20		2+	15	10				10					2+		5c/b	also some DGy peloids. SWC 7%VF-Fdolospar Chaetetid bored w/ dc
3475	LS		LM(Bn)Gy			SWCstromatop-skel-				10		2+		0 3+	_	10			4	+ 2	2+ 2		:	2	5b	SWC M-VCallochems, MS mtx, grn algae(<i>Clypeina</i>), gastropods tiny
3480	LS		LMGy :			TSsponge-chaetetidR				15 10		10	3+			tr	?	5	5	+ 2+			rolled		4/5b	
3485		5%XF-Fsndy&dol	MDBnGy :			SWCchaet-sponge-st							2+ 10			tr	1+ _{st}	olites	2+		1+		2pholac		4/5b	SWC mtx MS=microbial?/hdgd=bored by pholad clam w/VF-F sdy dol
3490		40%arg-slty LS	LMBnGy	-		SWCoyster-stromator	4			10 10		5	8?	'	8?		2+[00]	1011100	1	0	_	2encrus			5a/b	
3495	LS	10%dolomitic	LMBnGy :			SWCmassive coral		IB in dol		5+	3				_	10?	_	3+		2+			2clionid		5b	massive colonisal coral-rextl bored by clionid sponge
3500	LSw/SS	v.calcXF-Fqtz LS sdy	M BnGy			SWCskeletal FS-BS SWCskeletal FS	tr	intraskel				2+	2+			8	5+	3+ 5+		oyster			2pholac	2+	5b	SWCoyster-bryozoa-coral-chaetetid-milliporidFS/BS. Boring by clams SWCoyster?bivalve-coral-crinoidFs. 7%VF=Fdolospar
3505 3510	LS LS	tr calc qtz sltst 5-15%dol	DMBnGy : M GyBn :			2SWCsponge-skel-co	ral DS	 S/ES	10	10			2+ 20 2+ 20	5- 5-		??	3+	10 5	0	1+	2 2	+ 1			5ab 5a/b	SWCsponge/strom-crinoid-coral-skeletal FS/PS
3515		min dol,F-Cparticle	LDBnGy			SWCcoral BS/FS		interxtl dol	10	20 20		3+	5+	_	-	15	J+	10 5+ 5+		1+	1+	2+	2phola	do	5a/b 5b	F-Cpeloid-particle-skelGS/PS-XFcemented. SWC massive coral BS/F:
3515	LS LS	tr sitst-FSS,tr dol	L?DBnGy			SWCcoralBS		vug&intxtl do	ol.	10		1+	5+		,	25	12	3+			3+ 2	?	2phola		5b	BB lightened
3525	LS	0.1.01 . 00, 00.	MDBnGy			SWCstrom-skel FS		IB1Dtr		- 10			2+ 30			tr	• •	5+ 2	oyster	+	1+ 1		1		5b	SWCstromatoporoid-sponge-oyster?-crinoidFS
3530	LS	F-Mpeloids&ooids	M BnGy			peloid-ooid-skeletal	tr	vug	20	20			15	2			1		_			2		chara?	-	allochems rounded (Cave?? FqtzSS, cal pyritic SH)
3535		5% dolomitic	M GyBn			SWCchaetstromBS	7	IB2C5	2+	10	10		15	1		tr		3 5+	5	+	2+		I	S.IGI G :	5b	inter-mtx&leached/intraframebuilder pores PHOTO
3540		tr C-VC dol	M BnGy			SWCchaetIFS)PS-GS	tr	IBC	20	20			1+				??	5+	3+		2+	1+	2+			poor spi BB
3545		2-15% dolomitic	L?MBnGy			2SWCskelGS&FS	0-4	IC3D1			10	:	2+ 20	5-	+	7+	5+ 2-	+ 3 4+	8	+ 's	vloPS'	1+	3clionid		5a/b	SWCs at right poor spl BB -50% bleached light SWCs skeletalG
3550		20%Fdolomitic	L?MBnGy		MS?PS								5+			5?						$\neg \cap$				poor spl BB PHOTO
3555			MDBn&wt?			SWC coral-clam-'spg			S/RS	25	10	5+	5			25			5	+					5a/b	poor spl BB
3560		F-Cxtl 0-70%calc	MGvBn		WS PS	COMP AND AND AND A		IB1C2D0-3					5+	_		57		BENA	KI IV	┺	2	+				
		VF-VC calc0-25%	LMGyBn 4			3SWCdol+strmR/BS	6	IB2C0-3D0					10	_		5+					2				5a/b	BASE OF 'FIRST' ABENAKI LOG RUN
		F-M trVCcalcsp	LMBnGy			?PS?	8	IB4C3D1	'Seco	nd Run	' CUT	TINGS =	mainly e	every	second 5m s	ample a	ıt odd ı	numbers	(white	back	ground	d)				mottled (tr pyrite-cave?)
3575 3580	DOL-LS LS		L Gy		XTL		2	interxtl dol	SWC			s) = supp	lementa	I data	italicized and		y in gr	ay backg	round.	·QU	DIES.	=ınterr	red dep	oth		tr red-org stain Poor spl& small ctgs BB+white/gy
3580 3585		10% DOL(?siderite tr DOL	L(B)Gy			fragmental fragmental				35			1	2		?septa				?						poor spl-BB/wt. Siderite M Bn&porous PHOTO BB Tr F qtz in LS
3590	LS LS	li DOL	L(B)Gy L(M)BGy			skeletal-fragmental	tr	intraskel		35		1	2			?		,		1 1		1			5a	poor spl-BB/wt. PHOTO
3595	LS	tr DOL	L(M)BGy			fragmental	·	IIIII askei		20		•		1				1 1				'			Ja	BB
3600	LS	10%VF-M qtz	L(M)BGy			frag-peloid(F)-qtz			7	20 30		1						1	2	1					5c/a	ovsters? Some F-M rounded Qtz in LS
3605		20% qtz	L(M)BGy			frag-oolitic-qtz	1		15	25				2			?	1 1							5d/a	stylolitic qtz nucleii in some ooids PHOTO
3610		20%Bn Dol	LMGyBn !			fragmental-skeletal			3			1	5	7		2pyritic										gtz nucleii in some ooids
3615	LS-DOL	45/55-20%qtz sdy	M Bn	7	ws?gs	sandy(Fqtz)			50				1	1		?1		1						2	5d	SWC-3613 = ooid(F-VC)GS w/ 20%qtz nucleii
3620	LS-DOL	40/60 VF; tr sdy	M Bn	3	WS-GS	sandy-oolitic			15				2	3											5d	
3625	_	Dol<10%	L(M)BGy	8	PS-BS	stromatop-coral				2	2	1	1 30	5		10		?			•	? 1			5 b	BB or cave of chalky st LS PHOTO
3630		SWC-3629	N4-5			F qtz, dolm cmt	4	IAB5											3	3						
		F-M; 20%LS	LM BnGy			?PS-GS?	3	IB2CtrDtr						1			?								5	
3640	_	SWC-3639	5Y4-5/1			skel-lithoclast	8	1AB6C2				3?	5			1?	1?	3					2	0	5a	
		F-C <5%calc	VL Bn-Wt		XTL	?PS-GS?	12	IB3C8D3																		cuttings large; tr XF pyrite
	<i>DOL</i> DOL	SWC - 3647	5YR5/1			M(F-C)an-euhedral	4	IAB4Dtr																		outtings lorge
3655 3660	DOL	F-C 10%calc	VL Bn-Wt		AIL	?PS-GS?	8	IB2C4D2			1 1		1	1				1 1	1 1	-1						cuttings large
	DOL	F-C tr calc	VL Bn-Wt		XTL	?PS-GS?	10	IB2C7D1			1 1			1			1	1 1	1 1.	1 I						cuttings large; BB = minor wt chalky
		SWC-3669	5YR5/1			M an-euhedral	5	1AB1C2Dtr-	4									3shape	? 3	mold						Saturde, DD Timor We oriding
		F-C tr calc	VL Bn-Wt		XTL		10	IB2C7D1										Jonapa		T						cuttings large PHOTO
3680		SWC - 3674-^	5Y5-6/1			framebuilder-skel	4	IAB2C1D1					3 5	5		5	2	2 2	1 3	3						
3685	DOL(Ls)	XF-VF; LS=20%	M Bn	5	xtl-PS?	(VF-F fragmental)			2	30			1							?						cuttings small; porous dolm cave
3690																										
3695	LS(DoI)	Dol=20%	L(M)GyB	4	WS-PS	skeletal-fragmental	tr	Ls-IC1		20		1		3		1		2	'	? 1				?	5a	porous dolm cave
3700																										
3705	LS	tr Dol	LMGyBn	5	PS(+BS	skeletal-chaet-frag	Al	BENAKI III		25		1	7	1:				5 1	1	2					5ab	mottled
3710			L (MA) C. E.		DO/E 2:	abal ataunt 1 12	_			-						_ [
	LS	CWC 2746	L(M)GyB			skel-stromtp-chaet-frag		//UDFOFF?		20				20		2		3		1 1					5a/b	
		SWC-3716	5YR6-7/1			coral (strom?)		I/IIIB5C5D2		10 10			10			65									5b	some rad calor dolm w/ DC parasiti
	LS(DoI) LSdol	Dol=20%-porous? SWC-'3724'-^	L Bn : 5Y(YR)5/1			peloid-frag frag-skel (-ooid clasts	tr 6	IABC5D1-2	5	10 10	10	1	2	2		3		5	6	s					50	some red color dolm w/ BC porosity
	LSaoi LS	3770-3124	5 Y (Y R) 5/1 L Bn			frag-skel (-00ld clasts	1 0	IADUSD 1-2	5	5 25			5	3		3		5		2					5a	some peloid-frag GS
			L DII	7	·V3-F3	ii ag-skei			3	3 25			3							,						Some perolu-riag Go
3740 3745	LS	(20%DOL-cave)	LBn		ws?	frag-skel				3 0)			1				1 2	?	1					5a	BB-chalky, Wt (&Bn dol = cave ?trip) Tr-leached fill-bivalve. PHOTO-X

Α	В	С	D	*	G	Н	-	J	K L	M	N	0	Р	Q	R S	3	T	V	V X	Y	Z AA	AB A	AD.	AE A	F. Al	_			AL
3750	LS	SWC-'3743'-^	5Y(YR)4/1	5 4		sponge-chaetetid						35			25?					3	? 3?	2				7?t		bolitic 4	horsetails w/ red hue. 5-10% wt dolomite
3755	LS		L(M)Bn	3 4	WS(FS)	skel-frag	tr	inter/vugLS		15				5	3		2	1			1							5a	Bn dolm cave
3760																													
3765	LS		LBn	3 4	WS(FS)	skel-frag	tr	C-vug	5	10				10	5		3				?			1				5ab	BB-wt Bn dolm cave
3770																													
3775	LS		L(M)Bn	4		skel-frag			5 1	10				7	7		1		1	ΙΙ.	1 1			1				5a	Bn dolm cave
3780	LS	SWC-'3771'-^	5YR2/1	7 3		spg-chaet (ooid-frg-sl-			20	20		15	5		10					₋				2p	oholad	d		5d/a	pyritic, some red patches
3785	LS	?chalky?	VLGy-Wt	5	?PS?	frag	tr			25		1		3			?	1			tr pyrit			?					BBB-?wt/chalky (tr org' chips) Bn dolm cave
3790	LS	SWC-'3786'	5YR5/1	7		frag-ooid(superficial	3+	IABC2D1	15?	35							2		2	3	3 4	1?						5d/a	allochems(F-M/C)-superficial coats or micrite rims
3795	LS	+50%chalky	LBn-Wt?	3 9	WS(BS)	skel (framebuilders)		II-chalky?		5		1		15	15 3	,	?							1				5b	BBB-chalky&Wt 3795-3865m similar chalkified/leached/bleached
800																													
3805	LS	+50%chalky	VLBn	3 4	WS(FS)	strom?frag	3?	II-ICD2	5	7				10	10		?				1			1				5b	stylolitic BBB-chalky&Wt PHOTO (thumbhole)
8810																													
815	LS	+50%chalky	VLBn	3 4	WS(FS)	strom-frag	4?	II-IC2D2	?	10				10	5						1							5b	BBB-chalky&Wt
8820	LS	SWC-'3820'	5Y(YR)4/	1	GS/RS	ooid-skel+lithoclast		not apparer	35		25gr	apesto	ne	2	2		4		2	2 4	1 5	1						5d/a	C_VC ooids; lithoclasts = grapestone + rounded to angular occ stromatoliti
825	LS	+50%chalky	VLBn	3 4	WS(FS)	chaet-skel-frag(F)	2?		?	10		•		5	10													5b	BBB-chalky&Wt PHOTO
830					<u> </u>	J. /																							
3835	LS	+50%chalky	VLBn	3 4	WS(FS)	strom-skel-frag	5?	II-ICD2		10				10	5		1											5b	BBB-chalky&Wt
8840	LS	SWC-'3837'	5Y5-6/1	5 4		coral-skel(M-C)	14?		a.mold&nur					3			20	2			5 3			1				5b	stylolite=hi-relief
845	LS	chalky-30%	VLBn	5 Q		strom-chaet-frag	7	IAB2C5D	,o.uapui	1 10					15		2	_			1							5b/a	BBB-chalky&Wt PHOTO
850		37 anty 30 /0	V L DII	و ا	. 5(55)	on on dot-may		(52005		1.0																		J. J. J. J. J. J. J. J. J. J. J. J. J. J	555 S.M.Mydrit 111010
855	LS	+50%chalky	VLBn	4	W/PS	frag-strom	2	(II) ICD		20				15			1				1					1		5b	BBB-chalky&Wt. Bn Dol CAVE(10%). Tr Gn clay
860	LS	SWC-'3852'-^	5Y-YR3/1	5 4		strom + skel-ooid		tight	25	20		2	3	25			5				7	2	1	2.	nhi 2	1 1cla	l eet	5b/a	PS= fitted GS?& horsetails Strom bored by pholad clams, thrombo
865	LS	+50%chalky	VLBn	3 4	WS?	skel (frag)	tr	_	20	5		2	3		6		1				2	2	,	21	Ji 10 Z	ICI	iol .	56/a	BBB-chalky&Wt
	LS	SWC-'6862'-^		3			4?	` '	ſ	20					40		1		3		7	0 4	10	1				5ab	•
8870			5Y-YR6/1	5 4		chaet + skel-frag	4?	II/IADCtr	? ?	20				7	40		3		3		1	2 1	1?	1				5aD	tr pyrite; stylolites
8875	LS	chalky-15%	L(M)BGy	3 4	WS(FS)		(0)		7 7			- 10	- 40	2					_		1			1				5	
880	LS	SWC-'3884'-v	N2-5Y2/1	5 5		sponge-skel-frag(M-X	(C)	tight		10		10	10					5 3			#	1	1	1				4-5ab	clayey; some frags pyrite-coated~4%. Deeper shelf transgression
885	LS	sl argillaceous	M(Bn)Gy	3		lithoclast-frag-spg				20	25	7						1white	Э	micro	pyrite			1	Ш				stylolitic, micropyrite(1%). Tr VF SS. Some red clasts. PHOTO
890	LS	SWC-'3886'	5YR2/1	6 9		stromatop-milleporid		tight						60	? 2	0		?						10	Ophola	ad			just below seq?break=initial deepening? Strom=Dehonella?
3895	LS	+50%chalky	VLGy-Wt	3 4	W/FS	skel-frag(VF)				10		1		6	1													5a	BBB?-bleach/leach. 3895-3935m similar 'cycle' to 3795-3865 also
3900																													
3905	LS	+50%chalky	VLGy-Wt	3	ws	frag	?	II? ID	3(F-M)	10				1					1				?	1				5	BBB?-bleach/leach. Tr C-VC clear calcspar
3910	LS	SWC-'3913'-v	5YR7&4/1	4 6		coral-skel	3	IABCD2	5								35		5	4	1 7			2				5b	some superficial ooids/micrite rims
3915	LS	+50%chalky	VLGy-Wt	4		frag(f) (peloid-skel)	3	(II) ICD	3?	15				6	1							1to		1				5a	BBB?-bleach/leach. Tr C-VC clear calcspar
3920	LS	SWC-'3916'	5YR6/1	9 8	BS(RS)		1	IC1 intracha	et					10	80													5b	Chaetetopsis or Ptychochaetetes; strom=Dehornella? 1-3% dolom
3925	LS	+50%chalky	VLGy-Wt	3	ws	frag	?	II? ID	tr	15							?					1		1				5	
3930																													
3935	LS		LBnGy	2	W/MS	frag			1	8				?							1							5	darker, pyritic, stylolitic
3940	LS	SWC-'3934'-^	5YR4-5/1	9 8	BS(RS	hexacoral		tight?									85		1	1	2			8	3			5b	nearly all reticulated/tabulated hexacoral except skeletal WS infill of
3945	LS	chalky'	VLGy-Wt	4		skel-frag	3?	II - ICD		20			1	5	3				?		1	1		1				5a	BBB-'chalk'. Micritized particles
3950	LS	SWC-'3944'-^	5YR7-Y6/1	7 8		coral-oyster-skel	5	!AB2C2D		8		7		8?			30		5	1 7	7 #	2		5r	oholad	d		5b	C-XC skeletal frags - some micritized, bleached and leached. Poros
3955	LS	+50%chalky	VLBn(Wt)	2	W(MS)	frag	?	II -ICD		5				1			1		?			_		?	П	-		5	BB - wt chalk/bleach. Stylolitic
3960	LS	SWC-'3956'	5YR5/1	7		ooid ((M-C)	3	IAB2C1	70	Ľ	3gra	peston	e				3				5							5d	well rounded & sorted, some superficial. Compact-fitted w/ contact grain s
3965	LS	+50%chalky	VLBn(Wt)	1	MS?	((5)	tr	ID			Jg, a	- 001011	-				-				2 2		1						BB - wt chalk/bleach.
3970		- 50 /00 lainty						.5							ABEN.	AKI III	LO												TO THE CHARLES FOR COLUMN 1
3975	LS	+50%chalky	VLBn(Wt)	4	WS(P2)	stromatop-frag(F)	tr	ID		10	2			12	5		2						1	1		one	9	5h	BB - wt chalk/bleach. VC clear calcspar
3980		- 50 /00 laiky	V(VVL)		## 3 (F ?)	on omatop-may(i)		10		10					3											Jile		J.,	25 W. Shally Dicach. VO Glear Galcapar
3985	LS	chalky<30%	VLBn(Wt)	6	P&GS	skel/frag & ooid(F-M)	tr	(II) ID?	20	10				5	1								1	1				5a/d	BB (CAVE - Bn dolm) PHOTO
3990		Griainy > 30 /0	V LDH(VVI)	°	rado	ancimay & UUIU(F-IVI)	CI CI	(11) 10!	20	10				J														Jaru	DD (OAVE - DIT QUIIII) FROTO
3990 3995	LS	chalky 50%	VLBn(Wt)		W&PS	frag & ooid	tr	(II) ID?	10	6				4			4				4			1				5a/d	BBB? Tr pyrite
	LO	Charky 50%	VLDII(VVI)	4	WAPS	irag & ooid	ιr	יטו (וו)	10	0											- '			'				5a/u	DDD? IT pyrite
1000		200/ 1 11 / //	15 (1)																									_	DD 444 HH 444 A D 4570
005	LS	30%chalky/mottle	LBn(wt)	6	P/GS	ooid(F-M) - frag			50	20											3			?				5d	BB st 'chalk"-mottled. Some superficial ooids. 2 PHOTOS
010																													
015	LS	chalky 50%	LBn(wt)	5	WS(GS)	skel-frag-ooid			15	15		1		?	1		1				1						1	5d	BBB Stylolitic
1020																													
025	LS	+50%chalky	VLBn-Wt	4	WS-PS	frag-skel-ooid			10	20		1		1	3		1							1				5d	BBB Some ooid GS
030	LS	SWC-'4024'-^	10YR5&2			coral-skel-frag(F-M)	2	IAB1Ctr		20							35		4		8	2	1	1 3p	oholad	d		5b	hexacorals recrystallized in part and bored
	LS	chalky-30%	L(M)BGy			skel-strom-frag			2	10		?		15	5						?		1					5b	BB Tr dark ooid GS (Dolm cave)
040	LS		5Y-YR4/1			chaetetid		tight		أ					90													5a	single chip Ptychochaetetes with intergrown ?stromatoporoid (?Der
045	LS		L(M)BGy		ws	frag (F-M)		3		12				1			?				?		1					5	4045-4105m tr "SHC" blackstylolitic stain
	LS	SWC-'4050'	5YR(Y)2-3		WS	tubiphytes-skeletal		tight		1 2		3-frac						5	2	1?	2		15					3/6	10.0 1.00m tr Orio bidokotylolido dtaliri
	LS							ugni		12		3-frag	1	5	1			3	2	1:	2		2						BBB chalky
	ILO	chalky	VLBn-Wt	3	449	skel-frag				1 12	1 1		1	0	1 1	1	1	1 1		1 1		1	1 .	1 1	- 11	1	1	5	DDD CHAINY

Α	В	С	D	*	G	Н	I	J	K	L	M	N	0	Р	Q	R	S	Т	V	/ X	Υ	Z A	A AB AC	AD	AE AF	АН	AI A	AJ AK	(AL
4060											\Box																			
4065	LS	(sl argillaceous)	MBnGy	3	ws	frag-skel					10						?		2	5	1			2				5		BBB gives friable chips
4070																														
4075	LS		M(L)Bgy	3	ws	frag(F)					20				?					?	?	?						5		BB?
4080		al all DD	V // D - (VA/V)	J						40	40														_					DDD stall Ottobic To 10 selector
4085	LS	chalky=BB	VLBn(Wt)	2		peloid-frag(VF-F)		4: 1-4		10	12		?					1				10 4	2		?			5c		BBB-chalky Stylolitic. Tr wt C calcspar
4090	LS	SWC-'4090'	5Y4/1 VLBn(Wt)	5 4		coral-skeletal (F-M/C)	tr?	tight			15							15			1	10 #	3					<u>5b</u>		DDD(AA) Missa dad faar (aak sannas) DC CC 1/227 F alaas salas
4095 4100	LS	chalky=BB	VLDII(VVI)	14	MS(WS)	ıray	urr	יטו										ſ										٦		BBB(AA). Minor dark frag (salt+pepper) PS-GS. Vug?-F clear calcs
4105	LS	chalky=BB	VLBn(Wt)	1	Me/De/	skel-frag(VF-F)	tr	ICD			15		?		2	5		6				2			1		2	50	/b	BB(AA) (M Bn dolm cave). Vug?-F clear calcspar PHOTO
4110	LO	Clarky-DD	VLBH(VVI)	14	W3(P3)	Skei-ilag(VF-F)	u	ICD			15		f		_	5		0				,			-			Jai	/ U	BB(AA) (IVI BIT COIIII Cave). Vug!-F clear calcspar FHOTO
4115	1 9	chalky=BB	VLBn(Wt)	V 2	ws	frag (VF-F)					10				3	2							1					5		BB(AA) (M Bn dolm cave)
	LS	SWC-'4113'				coral + skel-ooid(M-C	·)	tight	60		10				5?			15				5 8	-		ΔB	ENI	KI II			DD(AA) (IVI DIT GOITT CAVE)
1125		chalky=BB	VL-LBn			strom-skel-frag		II)IB1C1D3+	00		15				20	7		8		7	-	7	-		7 4	CINA	Arxi II	5al	/h	BB(AA) VC calcspar PHOTO
1130	LS	SWC-'4121'-^	5Y4/1			coral-chaet+skel-frag		II/IAB8C7Dtr			15					10		25		5		9	2	3enc	rusting			5h		chalky, inter-&intraskeletal porosity. Hexacorals recrystallized 7 obvious
	LS	chalky=BB	VL-LBn	3 4		skel-?frag		(II) IB2D1			10		1		10	2		?		0		3		2	?			5h		BBB(AA) (M Bn dolm - cave?)
	LS	SWC-'4137'	5Y4/1	9 8		coral-chaetetid		tiaht			10				25	_		50				7	3		5ph	ll nolad+	clionid			WS mtx-boring infil
145	LS	chalky=BB	VL-LBn			strom-skel		? IBCD2			10		?		25	10		3		1		1 1	_		1				/b	BB. Seems porosity under-represented
150	LS	SWC-'4144'-^	5Y6/1			coralchaet+skel		I(II)AB3C5D	3							15	4	50			3	8			5cli	onids		5b		porosity=intra-chaet, interskel,but(chalky-fill)
155		chalky=BB	VL-LBGy			Skel?frag		(II) ICD			5?				5		2?	1			1	2			0011]		5		BBB Stylolitic Dk Bn LS = milliporids??
160	LS	SWC-'4158'				chaet-coral +skelPS		IAB3C7								40		30				8	2 1					5a		chaetetids encrust corals
165	LS	less chalky=BB	LBnGy			strom-skel-frag		IBCD			10?		2	1	20	3		?	1	1		1	1	?	1			5al		less BB Tr superficial ooid GS
170	LS	SWC-'4167'	5Y3/1			coral + skelRS-WS		tight							?	?		40				? ?	?					5h		two liths = coral FS-MS & lithoclast-skel F/RS-WS separated by pyriti
175	LS	less chalky=BB				skel-frag-lithoclast		ICD3+	2		10	10			7	5				1					1			1 5a		less BB Some ooid GS. Tr clear M-VC calcspar
180	LS	SWC-'4177'	10YR7-6/1			hexacoral		ICD15+								5?laye	er	90							5ph	olad/i	vorms	5b		single massive colonial coral recrystl & leached = Ig mold/vug (unmeasured)
185	LS	less chalky=BB	L(M)BGy			frag (skel)	tr				30				2	?			1					1	1		?crust	s 5		stylolitic
190	LS	SWC-'4186'				rd'd skel'lithoclast		tight				45				8		8	3	5			2	1	1					clasts of sediments and skel frag. Common stylolites w/ pyrite
195	LS	(BB-sl chalky)	L(M)BGy				1+	(II) IBC			10?		1		5	3							1		1		?crust	s 5a		BB - minor chalk. Tr pyrite
200	LS	SWC-'4194'-^	5Y6/1			chael-coral-skel	10	IC6D4							5	20		15		4		5 80	yster					5b.		porosity = inter- & intraskeletal
205	LS	more BB-chalky	L(M)BGy			strom-frag	tr	ID			10				20					?			ĺ		1		?crust	s 5a		•
210	LS	SWC-'4211'-v	5Y5+6/1	9	BS	coral-chaet-strom	7?	I(II)B2C5Dtr							20?	25		35					5	5	5 3ph	olad		5b.	o/a	consortium of framebuilders (+serpulid-foram-?tubipytes encruster) se
1215	LS	+50%chalky=BB	VLBn(Wt)	3 4	4 WS(FS)	strom-skel	2	IC2			3				15	1		1		1				1				5b		BBB-chalky. Stylolitic
1220	LS	SWC-'4217'	5Y4-5/1	9	'BS'	chaetetid	2?	CtrD2								75	??	2						2	2encrus	ster		5b	,	?Ptychochaetetes or cf rextl Milleporidium of Ellis
1225	LS	+50%chalky=BB	VLBn(Wt)	3 4	4 W/FS	?strom-chaet?	4	(II) IC3D							17	10							?					5b		BBB-chalky.
1230	LS	SWC-'4227'	5YR6-7/1	7	GS	frag-skel-clast (F-VC)	5	IB1C4+	5?		35	10				5		5			4	3 6	;	1	1			5a	(b)	skeletal fragments - some micritized (superficial ooids?). Tr VC dolos
1235	LS	+50%chalky=BB	VLBn(Wt)	3 4	4 FS(WS)	skel	3+	ICD2+					1		7	?				1		1	? ?	1				5		BBB-chalky.
1240	LS	SWC-'4233'-^	5Y-YR6-7/	7	GS	fragmental-lithoclast	tr	tight-vug			45	15										8-	rextl					5		Tr VC dolospar & pyrite
1245	LS	It & dk mottled	M Gy	5	PS	ooid(F) (peloid)			50	12												1	1					5d		much less BB. (wt cave?)/ Occ' M-C It oolite PHOTO
4250																														
4255	LS	It & dk mottled	M(D)Gy	4	P/WS	ooid-peloid			30	10					mic	ropyri	te					?	2		1			1 5d		micropyrite 1%?. Some VC-XC ooid-oncoid
1260																														
265	LS		DM Gy	4		peloid-frag		•	?	10?	10?											1	1					5c		BB-darker
270	,	SWC-'4267'	N2-5YR2/1	12		burrowed															2-sm	nall	1	2	2-tubul	es		3/		mottled = burrowed/churned
275	LS		DM Gy	4		ooid-frag-micr/oncoid			10	5?	10									1		_ 1	?		1		?	10 5d	_	micropyrite in micro-oncoid/ooids PHOTO
1280	LS	SWC-'4279'	5YR3/1	9		coral-stromatolit	6	!AB2C4Dtr										45				5 5			5ph	olad	15	5b		complex consortium of bored branching?hexacoralencrusted woth tubiphyte
1285	LS		M Gy	4	WS(PS)	frag-peloid?		1	r	15	17					1				1		1						5с	:	BB =bit bruise
1290			DM 0		DC/CC	1			pro-			46																		2022
1295	LS		DM Gy	6	PS(GS	ooid (VF-VC)			50			10										1						4 5d		poorly sorted ooid-microoncoid PHOTO
1300			DM C			0.14/5.1/6																								AA Waxaa adda adda aadda a
305	LS	mottled	DM Gy	6		Ooid (F-VC)		tiabt	70												2		0 1					6 <mark>5d</mark>		AA with more ooids and oncoids PHOTO
310	Ls(arg)	SWC-'4306'	N2	9		coral (Micorsolena?)		tight	70								65			2	2	2-	d 1					50		skeletal WS mtx. Horsetails. 1-2% XF-VFdolomite (chert?)
	LS	mottled	DM Gy	6	GS(PS)	Ooid (F-VC)			70																			3 <mark>5d</mark>		AA
320		al anali ar 101 d	D= 1140			O+:4 (E VO)			F 0																					000/ Da dalas/aidadia 04//E00/05-31/
325		sl argil -mottled	Bn+MGy	4		Ooid (F-XC)			50	4000																		8 <mark>5d</mark>		20% Bn dolm/siderite CAVE?? (?ooid cave?) 2PHOTOs(10&16X)
330		SKIP?-4328	D Cv:		_	terpreted to be missi	ing - s	ee above at	SWC'4	4306 '	_	_	М	ISAIN	ΙE				 			4	\vdash							had said save
	LS(SH)	argill (cave?)	D Gy	1	MS	ooid cave?			(20?)					. 37 111														2		bad ooid cave
340	CLI// C)	4000/ male (114 - 11	D C:		(840)																									To assista
		<20%calc (siderite		1	(MS)	ananan niat							-						lingulid	"			11 1					2		Tr pyrite PHOTO
350		SWC-4343-^ 35%calc(10%sid'?	N2-3	3		sponge-rich							75							1		2						4		+10%calcareous(dolm?) <2% micromicaceous and pyritic. Silt in spo
1355	SH	55%caic(10%sid"?	D GY	1	(MS)															1								2		Bn siderite in shale (10%) Oolite cave
4360 4365	CH .	200/ pala (aidarita)	D Cv		(MC)																							2		<10% aiderite. Tr migrapyrite
ანმ	SH	30%calc (siderite)	D GA	Γ^{1}	(MS)]	1	I			- 1	I			l		I	ļ	II I		l	ı	1	1		II .		12		<10% siderite Tr micropyrite



FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 4= sponge reefal, 5= open marine carbonate bank, 5a =skeletal ricn, 5b=coralgal-'stromatoporoid reefal, 5c=mud/pelleted; 5d=oolitic, 5e= oncolitic, 6= 'moat' (open inner shelf), 7= nearshore ridge, 8 = lagoonal-continetal, 9= mixed carbonate-deltaic, 10 = deltaic/interdeltaic

En	oloou	ro 2 10 De	n C o r		ion (PCP) Panuk	_	M 70 A															7 YPE	
_					TEXTU						Cor	sulti					l. Inf						ES TYI	PAGE
DEPTH			COLOR	~ ^	DUNHAM	modifier	POF	ROSITY	ACC SOR		Н	FDAM		OSSILS	S	(e	nhanced	l by <mark>SW</mark>	/C dat	a if ava		<i>'</i>		COMMENTS
(metres)		mestone dolomite	ш	ABEF s(bs		udstone 1 vackestone 3	70	modifier			H	FRAIN	_BOIL	DEKS	2			Sac	IDS		Ιâ	LGAE	의 중 _統	additional fossils/accessories diagenetic textures
	H SH=sl	hale andstone	ABBREVIATE D	15g J	PS=pa	ackstone 5		(Archie)	ļ	_,	¥	To	[월][문	L I I I		N N		OPC	입고	티티		a E E		facies-sequence breaks
	O SLTS	T=siltstone	₩ ₀	AM	BS=bc	rainstone 7 pundstone 9		, ,	တ္က			8 8	6 E	8 E 5		티헤		STR	SER.	¥ M¥	Š	1 P P P P P P P P P P P P P P P P P P P		et cetera
		rgillaceous calcareous	ABB	E isq	(FS/RS	S=XC size) patstone 4			SOIDS	齓闦	訠	Š Š	본미참	MILLEP drozan-	الإواالة الإواالة	RA BRY		A I	SIR		ВЩ	S NA MO	<u>8</u> 2	some long comments may be
		sandy/qtz silty/tz		JQ š	RS=ru	dstone 8			ᅃ	PELOI	H	2 S	<u> </u>	d d d	종 流	∐"			$^{\circ}$	F	1"	STROW	STAN	hidden & visible only on screen
	Y Sity -	Siity/tZ		left	XTL =	crystalline			Ш			^	l⊵ ⊩	∦ - 6∥:	=		_					ž "	σ <u>=</u>	D
_		_	_					-				_												P = photo(s); (th) = thumbhole photo; x16 = times 16 instead of usual 10X enlargemen
A	В	C	D		G	Н	<u> </u>	J	K			ОР										AH AI A	JJAK	AL
		VII 3197m		N OF V		ARLY HORIZONTAL ie. I	MD/T		3500/	3435, 3	600/3	3462. 3	700/34	172, 393	4/3490.	LATE	ERAL 50	00m IN	65m \	VERTIC	AL			INFILL LOGGED Jan 2005 LSE
	LS arg	metal scale	DM GyB	2	M(W)S	VF-SL xtl md/wkst		NVP		1	ш	1?			1?		1	?					3? ?	. Darker= arg LS (calc dolm) Tr pyrite CEMENT P
3215 3220	LS (a <mark>rg)</mark> LS(a <mark>rg)</mark>		cropytite LM BGy	3	ws ws	fragmental				5 ^{micro}	oel	2?	6 3				1	1					3?? ?	CEMENT /50% magnet removed drilling iron G = glauconite micropyrite SOME SAMPLES BIT BRUISED (BB) - P(th)
3225	LS(alg)	1% gn clay	LM BGy	3 4	WFS	skel (spg/strom?) skel-framebuilder (spg/	I stron	n)		10		5 micrit			1 .			4	1 '	1		2	4/5b	pyrite, white chert LIGHTER COLOR AND CHALKIER THAN 3P
3230	LS	tr gn clay	L(M)BGy	3 4	FS/WS	stromatoporoid (spg)]				П	micrit	10	? n	n-small	cell	1		1	1			5b	BB micropyrite ACTUAL =BB P
3235	LS		M BGy	3 4	FS/WS	stromatp-sponge-skel	tr	Cdog tooth = vug]	10		10	15				2	2	1	1 ?		3+	4bc-5b	C calcspar; pyrite; ? Calcispheres? ?sub cmt? 3P
3240		(<10LS) slty10%	M Gy									1						1	1	?			2?	+1% pyritic & gn flecks (glauc?) trace
	SHcalc-sl	ty G? 7/3 AA	Mgy		we	from (on on mo 2)				E 10		1	1					2		1 1		micri	tic sponge	P P P P P P P P P P P P P P P P P P P
3250 3255	LS/SH LS	7/3 AA	M BGy LMBGy	3 4	WS FWS	frag (sponge?) stromatop-spge-skel-fr	n	AB VI up		5 10		10	10		2		1	1	1	2	1	+5?	3-4b 4bc-5b	deeper sponge-stromatoporoid-microsolenid coral reef ABENAKI VI up 3248m P
3260	LS		L(M)BGv	3	ws	skeletal-pelletal	Ĭ			10 5		10 micritio	1	1	_		1	1	1 ?	1		1	3-4b	micropyrite P
3265	LS	tr grn clay	L(M)BGy	3 4	WFS	stromtp-skel-frg				15+		5+	10		sol	itary	2+	2	1	?		5?	4c-5b	tr-minor clear + milky chert (replaces stromatoporoids?)
3270	LS	tr white chert	LM BGy	3	ws	fragmental			1			1	1			1		1	1		1		3? ?	tr siltstone & pyritic grn clay LS
3275	LS	10/ 11/	LMBGy	3 4	W(F)S	skel (strom)						1	5				3	1				1	4-5	tr white/clear chert 2P
3280 3285	LS LS	1% white chert !% wt chert	LM BGy LMBGy	3	WS WFS	frg (skel-pel) sponge-skel-frag				6 10 15		15	6	12	1	2	2	2	1	2		1?	3-4	micropyrite, 1% white milky chert tr-<1% white chert in stromatoporoids etc.
3290	LS	1% white chert	LM GyB	3 4	FS/WS	spong-frag (peloid GS)	tr			5		12	0	1 1	1	f	2	1	1	12 1		crusts/spor	nge <mark>4bc</mark>	micropyrite, 1% white milky chert
3295	LS	170 WHILE GHELL	LMBGy	3 4	FWS	stromtp-skel-frg				10		3	8+	1? 2	!+ 1		2	2	il.			2	5b-4c	2P
3300		40%SS qtzF-C calc	LM Bgy	8	PS-GS	sandy-frag-skel			5	5 25		3	2			4	5	1		1			3-5a	BB pyrite 3300mMD = 3265m TVD?? P
3305	LS	sl arg-silty	LMBGy	> >	WPS+GS	frg-skel-bryozoa + oolit	е		20	20 38	unde	d.	5			10	3	2				1? 2	3 flood+	MIXED LITHS: Bryoz LS=sl arg/sdy. Oolitic LS=GS M-C ooids. Big Chip of skel (2=x16)5P
3310	LS LS sdy	gn = glauc?? <10% SS; G?	LM BGy	4	WS-PS	fragmental (M-C+)			?			⁴ 1	-		1?	1	3	4				1 0 4	3-5a + 3?-5a+d	BB pyritic SH 1%, stylolites MIXED LITHS as above. Oolitic LS=GS M-C oolds. Tr pyrite 3P
3315 3320	LS sdy	<10% SS xf-f/m	LMBGy LM BGv	3	PFS+GS WS	Frag-skel + oolitic frag (skel)			20	25 20	3	2	5	1 2		1	3 1	1				1 2 1	3-5a	pyritic SH 1%
3325	LS	pyrite Glauconite	LMBGy	5 4	FPS	stromtp-skel-frag				-	١.	2 2	15		1	1	2	1 2		1		2	4bc-5b	pyrite a& glauconitic clay sl. Sdy
3330	LS	,	LM BGy	4 4	FS/WS	(PS) frag-skel(stromtp)				20 20	unde 2	^d 1	7 1	? 2			1 1	∤ii-spi	red	1	1?		3?5b	tr grn = glauconite??
3335	LS	pyrite Glauconite	LMBGy	3 4	WFS	skel (stromtp-spg-bry)-	frag			20	2	3 3	7		çalo	7 spar?	2 1	1		1		2	5ab	G=glauconite = green mineral
3340 3345	LS	tr VC cl calcspar	LM BGy	3	WS	fragmental	4		_	20	ш	1	4 1	1	??``	799	1	1 1					3?5b	tr pyrite 3340mMD = 3300m TVD??
3345	LS LS		LMBGy (L)MBGv	3+	W(G)S WS	Frag-skel + oolitic frag (skel)	tr	vug-dogtooth cal	С	15 15		micrit	5 c 5 re;	xtizd			1	2				1	5ab 3-4b	BB P
3355	LS		(L)MBGy	3+	W(P)S	frag-skel				30	5	1	2			1	1 1	1 2	?	?		1+		micropyrite VC white vein? calcite
3360	LS	(tr SLTST)	(L)MBGy	4 4	FS/WS	(PS)frag-skel-strom				25		1	micrit	ic	septa	a-spar 1	1	1		1? 1		1+ cgusts	3?4c <mark>5b</mark>	Р
3365	LS		MBGy	3 4	FWS	skel-frag				20		5	5	1	?		5 1	1		1			3b	stylolitic (clay concentrations) crinoid ossicles to 1.5MM
3370	LS	pyritic vf SS	(L)MBGy	3 4	FS/WS	skel-frag				12	ш	1?	3 7	?	1		1 1	1		1			? 3-4a	micropyrite
3375 3380	LS/SS LS	8/2 (SS-Fqtz +)	(L)MBGy (L)MBGv	3 4	WFS FS/WS	skel (stromtp) frag strom-skel-frag				15		12	5		2		2	1	1	1			5a 4 <mark>3?5b</mark>	tr pyrite 2P
		sl arg pyritic	(L)MBGy	3 4	WFS	skel (spg-stromtp) frag		AB VIIIo2		15	3	6 1	5		?		1	? 2	1	1	1?	5	3?4c-5b	pyritic when argillaceous LS ABENAKI VI Io ?3280m
3390	LS(arg-slt		(L)MBGy	3	ws	fragmental		AB VI Io?	-	15	ľ	1	1			1	3		•	1		1	? 3? ?	2%? Pyrite. Seems grayer less fossils
3395	LS	(pyritic)	(L)MBGy	2	W(M)S	fragmental				15+		2	1	1?				1	1				3?-5 ?	tr white calcspar
3400	LS?		M(L)BGy	3	ws	fragmental				10	ш	1	1				1		?	2 1			3? ?	Seems grayer less fossils 3400mMD = 3351m TVD??
3405 3410	LS LS		M(L)BGy M(L)BGy	3 4	W(F)S WS	fragmental				1 15		2	2		5	1	1 1	2	1	1 1		2 crust	3?-5 ? 3?5a ?	puritio tr CU
3410	LS LS		M(L)BGy M(L)BGy	3 4	WFS	frag (skel) frag-skel(stromtp)				1 15		3	6		J	1	1	1		1 (3?5a ? 3?-5 ?	pyritic tr SH P tr green clay tr pyrite BB
3420	LS	tr qtz-XF-VF	M(L)BGy	3	ws	bryozoan-skeletal				2 5		1	3	?	1?	10	5	1		1		crusts 2 crust crust	ts 3-5a	tr pyrite & arg LS micropyrite
3425	LS		M(L)BGy	3 4	WFS	frag-stromtp-skel				5+ 15		2 1	8+	?	?		1	3		1			s 4c-5b?	2P
3430	LS	tr qtz-XF-VF	M(L)BGy	4	P-WS	peloid-frag (skel)	tr	vug?=spar		22 10		1	2 1	1		2		1				2?	3?5c	tr pyrite & arg LS micropyrite P
3435 3440	LS LS	to ata VE VE	M(L)BGy	_	P-WS	frag-skel-peloid				10 20 10 40		1	5					3	1	1		2?	3?5	?Lithocodium?
	LS LS	tr qtz-XF-VF	M(L)BGy LMBGy	3	P(W)S WS	frag-peloid frag-skel				10 40		1	52	' ,	2	(1	1	2			2?	3?-5 <mark>c?</mark> 3?-5a	stylolitic mottled light brown and gray BBB P
0110										3 20			١٠.١		.									555

Α	В	С	D	* G	Н	I J	К	L N	1 N	ОР	Q F	s	Т	v	w x i	/ Z A	AABA	C AD AE	AF A	AH AI	I AJ	J AK	AL
3450 I	.S ((tr SS VF-F)	M(L)BGy	3 (P)WS	frag-skel	tr-1 IBC -SHC		20	0	1	1 1	?		+		1	++			-		3?	tr XC calcsapr (=vug?) BB P
	s	(MGyB	3 ws	frag			20	0	1 ?	3	1?		1	2	2	2	1				3?5a?	BB + small P
		SS 65/30/5	M(L)BGy	4 W-PS	frag (skel)	?			5	1	? 1	1	?		1	1	1					3-5a	leached/infilled fossils= bivalves&corals? DOL VF xtl MBn P
			M(L)BGy	3 WS	frag (peloid)				? 25		1 1				1	2	y 1					3?5a?	SS= VF-Fqtz clayey-calc BB 2P
3470 I	_S t	tr sandy & tr DOL	M(L)BGy	4 W-PS	frag (skel)			3	5	1	?	4	?	Ш	1	П	П			St.	rusts	3-5a	
3475 I	_S t	tr silty	M(L)BGy	WFS	strom-spg-frag		1	5 30	0	5+ 3	15	?	?		3	6	1 1	1 2 1+		C	crusts	4c-5b?	single ooid!! Micropyrite ?Lithocodium? 3473mMD = 3400m TVD?? 3P
3480 I	_S t	tr gn slty clay&DOL	M(L)BGy	5 PS(GS)	frag-skel			4	5	3	1 1			1	1	? 1		? 2		3	านธเธ	3? ?	P
3485 I	_S t	tr silty	M(L)BGy	5 4 PFS	stromtp-spg-skel-frag			?3	30	10	20 ?	?		1?	3	2	1 1	? 1		5		4bc-5	3P
			M(L)BGy	7 GS	frag-stromatop-skel	AB V	?	3 4		1 1	10		?		3	5	5					5b	rounded frag's and clasts (BB) ABENAKI V 3425mTVD=3484mMD@PCP P
	_S		M(L)BGy	5 4 PFS	stromtp-spg-skel-frag			?3	80	7 ? 7	15			2	3	4	1	1	1			4bc-5	white stromatoporoids bored 3P
	_S		M(L)BGy	8 P-GS	frag-skel(spg-chaet)			6 30			1 6	?	1	2	3	1 4	?			?		5b-(4c)	(BB) P
			M(L)BGy	5 4 PFS	frag-skel(stromtp-spg)			30		5 ?	7	?	1		3	3		1 1		çr	rust	4c-5b?	10%dolomitic LS w/ 10-20% SS 3P
			M(L)BGy	3+7 W+GS	frag (skel)	tr CD spar		3	-	1		?	2		4	2	? ?	1		1		3?5a ?	tr clay (BB) P
	S(arg)		M(L)BGy	4 W(P)S	frag-stromtp-skel	deviated	1	2		2	15+	?			1?	2	? ?	1 1		2	crust	5b-4c?	2P
			M(L)BGy	3 W(P)S	frag (GS)	"near V"		2		0	0	?	40		1	1 1		1		3		3? ?	trace pyrite and green clay (infill) 3520mMD = 3425m TVD???
	S(arg)		M(L)BGy		(frag) + skel-microbial	ileai v		25	0 0	3 7	3		1?		3 2	2 4		1 1	?	6	rust	3? ?	3P
	_S(arg) _S(arg)	tr DOL, 2% clay	M(L)BGy	3 4 FS-WS	frag-sponge			3	-		2+ 1	2		1	3	1 1 2	1	2		3		3-4 3?-4bc?	pyritic 1 to 2 % green and gray clay ?Lithocodium? 3P
	_S(arg) _S	+1% clay	M(L)BGv		sponge+frag) frag-peloid (GS)			10 20		10	1	2		2	3 1	1 1 1	2 /	2		_1C	crust	37-40C7	?Lithocodium? 3P (BB) pyritic tr-1% green and gray clay P
	_S(arg)	1-2% dolm	MBGy	3 WS	fragmental			20	-	3	1			3+	5	† 1	+ 2	1				3-4-5?	micropyrite Arg beds rich in bryozoa 2P
	_S(arg)	tr clay, tr SSqtz F	M(L)BGy	3 WS(GS)	fragmental					4	1 1					1	1	1 1				3-4-5?	tr green and gray clay
		micropyrite	MLBGy) frag-skel		2		-	3+	2 1	?		3-	3	1 2	1	2 1				3 flood	tr glauc VF qtz SS 3P
		M-VC ooids	LMBGy	7 4 G+FS	ooid + frag-skel		50		5	1 1	2		2	1		1	1	1 1				5d	trace pyrite and green clay BREAK = deeper/over/shallower P
		M-VC oolds	MLBGy		oolite+(frag-skel PWS)		60		5		2 1		? '	11.1	3 1	1 4	1		1	2	3	5d	tr F dolm (+SS) stylolites 2P
		<2% DOL C wt	LMBGy	7 4 FS+GS	frag-skel + ooid		33	20		1	7	1	. 3			1	?	1		1		5d+b	(BB) tr green clay infill. (F)M-C(VC) ooids
		1%C-VC calcsp	LMBGy	7 4 F+GS	strom-skel-frg + ool		20	20			15 2	1	?		2 1	1 2						5b+d	2P
		<1% DOL wt	LMBGy	5 4 FS/PS			15	30		2	3 4		?	1	1	1						5da	tr reddish cement P
3585 I	_S		LMBGy	6 4 FPS+GS	frg-skel-strom + ool		10+	20	0	2	10 3	2	1?	1	2 3	? 3	3	1			5+	- 5b	stromatoporoid-skeletal-fragments coated = oncoidal?? in part 2P
3590 I	_S ·	<2% DOL xtl Bn	L(M)Bgy	5 P(W)S	frg-skel (tr peloid GS)		4	5 30	0		3 1			1	1	1 1 2	: 1	1				5a	(BB) tr reddish cement
3595 I	_S		L(M)Bgy	5 P(W)S	frag-skel(stromtop)		5	20	0	1	7 1	3+	2	1	2	2	2		2			5ab	3P
3600 I	_S	<1% DOL F-M	L(M)Bgy	4 P/WS	frag (skel)	tr vugs?spar	2	2		1?	2 1	1?	1		1	1						5a	(BB) pyrite (black LS w/ chaetetid? - very pyritic) Porosity - tr interstl DOL
	_S		L(M)Bgy	4 WPS	frag-skel(stromtop)		2				6	3+			1	2	:		1			5a(b)	2P
	_S	<2% DOL	L(M)Bgy	6 P-GS	fragooid (peloid)	tr? SHC?			_	? 1	1	1	?	1	1 1	1 1	1	?				5d/a	. Pyritic SHC?
	_S		L(M)Bgy	5 4 PFS	frag-skel-stromtp-millep		5		5	2	10 1	10	?	2	3	3	3	?				5b	2P
	_St	tr gn clay	L(M)Bgy	5 P(W)S	frag-chaetetid	deviated	2	3		_	1 1	0 1	4	1.7	_	. ? 1	?	<u> ?</u>				5b	. St <u>vlo</u> liti <u>c fractu</u> re? Mi <u>cropyrite Tr grn (glauc</u> ?) & dk gn pyritic clay
		tr F dolm	LMBGy	4 4 PWFS	frag-skel-strom	"far V"		4 2		2 1	10 2	:	?		2	2	?	1		3 Cru	ust	5b	micropyrite dark&light stromatoporoids 3P
	_S t	tr gn clay, tr DOL	LM BGy	3 WS	fragmental			1 20	-		_		•			1				71-	-1-	5	M(D)Bn >> 2-DOL << wt F xtl porous?
	_S(dol) _S/DOL	<5%dolm	L(M)Bgy	3 4 WFS	frag-skel	to DOI internet		4 20		3 1	5		?		2	1				- FK	rusts	5a-4c?	tr pyrite 3P
			M(L)BGy M(L)BGy	3 4 WFS	frag-sponge (skel)	tr DOLinterxtl			_	. •	2			1	1?	1 2	1 1	1 2	2	10)	40	2 DOLs -M(D) BnXF-SL & wt F xtl w/ tr porosity
		9/1 AA	M(L)BGy M(L)BGy	3 W(P)S 4 WS	fragmental	tr vug + interxtl			5 2	1	3				3	1 3)	1 2	ſ	1		5a	tr pyrite BB 4P micropyritic BBB (nondescript and dirty)
	_S/DUL		M(L)BGy M(L)BGy	4 WS	frag (5% peloid PS) fragmental			5 2		1	2				1	2	+	1 2		- '		5	micropyritic BBB (nondescript and dirty) BB cuttings small and dusty 2P
3660	_S/SH	9/1 <2% DOL	L(M)Gv	4 W-PS	fragmental			41							1	3.	2	,				3?5 ?	SH - D Gy pyritic, non-slightly calcareous BBB P
			L(M)BGy	3 WS	fragmental			30	0	1	2					1		2				5	(pyritic SH-argLS = CAVE??) BBB
	_S	o , odoli i	L(MB)Gy	4 W-PS	fragmental-peloid			10 49		1	-				2	1	1			gr	rusts	3-5	tr bright gn clay; stylolitic (BB)
	s	tr dolm	L(MB)Gy	3 WS	fragmental				0	1	3 1		?		2	3	1	1		1		3-5a ?	tr pyrite 3P
		<2% DOL M-C wt	L(MB)Gy	4 W-PS	fragmental (peloid)				Ğ-C						1	?				įρ	crust	3-5	trace micropyrite (BB)
		tr dolm	L(MB)Gy	4 WPS	fragmental			5 3	-	2	1				1+	1						3-5? ?	tr pyrite 2P
		50/50	L(MB)Gy	3 WS/xtl	fragmental VF-M(C)	2 BCinterxtl		20							?			1		1		3-5	(tr SHC in DOL) Tr XF pyrite
	OOLcalc		VL(MB)Gy	XTL	(VF)F-M(C)	6+ I/III B2C2+D2		?)													?	M-VC calcspar
3700	_S/DOL	<1/9	L(MB)Gy	XTL	(VF)F-M(C)	7 I/IIIB2C2D3									?							?	2-3% XC cl-wt calcspar (=vugs) LS = pyritic
3705	_S/DOL	1/9	VL(MB)Gy	XTL	(VF)F-M(C)	5 vug=calcspar																?	C-VCspar (clear+white) calcite = fracture/vug lining. As in LS stylolites common
3710 I	_S/D <mark>OL</mark>	5/5 trSS vf	L(MB)Gy	4 W/PS	frag + XTL F-M(C)	4 I/IIIBCD2		1 30					?			1						3-5? <mark>?</mark>	P
	_S/DOL	4/6	L(MB)Gy	WFS	frag-skel			25		1 1	3 2	2			1	1	oveter					4bc?-5	minor SH = cave? Pyritic P
	_S/DOL	9/1	L(MB)Gy	5 P(G)S	frag (M-VC) XTL-M-C	tr vugs?		2 40			3 1	?	?		1	f	7,396,					3-5	vugs? or large voids - XC clear calcspar
		<8%dolm arg	L(MB)Gy	4 WPS	fragmental (skeletal)			3		2+	?				?	3	3			2		?3-5? ?	sl argillaceous BBB P
		9/1	L(MB)Gy	5 P(G)S	frag (M-C) XTL-M-C	tr interxtl		4		?	?	?			1	1						?3-5 ?	micropyrite
			L(MB)Gy	PS P(C)C	fragmental-skeletal	tr vug?		4			3	1?			2	1 1.	+					?3-5? ?	P
		5% DOL	L(MB)Gy	5 P(G)S	fragmental			50	-	1	2 1				1	1		?				3-5	~5% partial dolomite in limestone - F euhedral
	_S/DOL S	7/3	L(MB)Gy	4 PWS 5 PS	fragmental (akaletal)	2 1/1/00		40	5	1	3 1	12			3	1		1				?3-5? ?	Pure VC close calconer = 40% partial DOL in LS. E cubodral
	S(DOL)	90/10 tr SS F <9%dolm	L(MB)Gy L(MB)Gy	5 4 PFS	fragmental (skeletal) frag-skel(stromtp)	3 vugs tr-1 intrafossil		30		1	1 3	1 2			2	1	1	2 1		1-1		3-5a ?3-5b ?	vugs VC clear calcspar ~10% partial DOL in LS - F euhedral BB small cuttings
0,00	- (- - -)	-0 /000111	L(IVID)Gy	٠ ا - ا - ا	mag-skei(stronntp)	u 1 IIIu ai 055ii		30	E VC						2		1 1	. '		141		. 3-05	gv

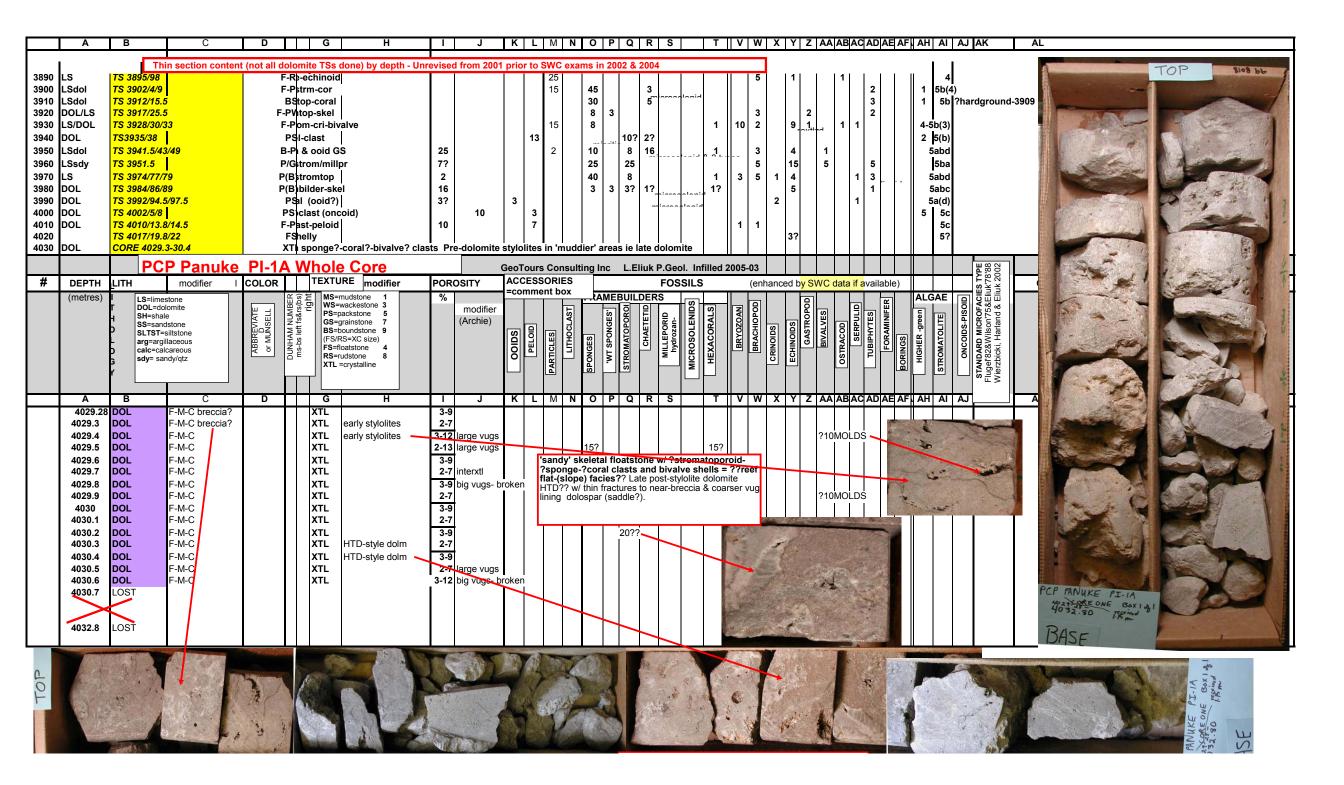
Α	В	С	D '	*	G	Н	I	J	K	L M	Ň	ОР	QF	S	Т	٧	w x	ΥZ	AAAB	AC AD	ΑE	AF AI	H AI A	AJ AK	AL
3760	LS(DOL)	<10%DOL aa	L(MB)Gy 5	5 F	P(G)S	frag-chaet-skel	6	LS+DOL		50		1	1 8		?	ĦТ	1		1					(3)5b	porosity intrafossil (leached) and vuq lined spar (minor DOL intextl)
3765	LS(DOL)	<9%dolm	L(MB)Gy 3			Chaet-strom-skel(ool)			5	?	und		8 10	0	2	1	2		3		1		1? grust	(3)5b	tr qtz nucleii in ooids ~5% 3765mMD = 3475m TVD?? 2P
3770	LS(DOL)	<10%DOL F(M) xtl	L(MB)Gy 5			frag-chaet-skel (GS)	4	LS-vugs?		5 38	una		2 1		?	Ш	1		1				grust	(3)5b	. Stylolitic, Lt & Dk chaetetids, large vug?=clear XC calcprism = thin blade-like
3775	LS/DOL		M(L)BGy 5		FS-PS	frag-stromtp-skel		interxtl	1	20		2	10 3	?	?	1	2	2			1			(3)5b	micropyritic Tr pyritic SH w/ bryozoa ?Lithocodium?
3780			M(L)BGy 5			frag-skel (peloid GS)		I/IIIBC4(D)		7 30		1	5 3		1		1		?		1?			(3)5b	. ~10% DOL(arg)- DGy F euhedral rhomb, Also DOL VLGy M-C XTL Tr pyritic SH shale P
3785	LS/DOL		M(L)BGy			frag-skel (ooid GS)		I/IIIBC4(D)	3+	30		12	7 2							1	1			(3)5b	micropyrite 2P
3790	LS/DOL	4/6 F(M)xtl dol	L(M)BGy 5	5 4 F		frag-skel (peloid GS)		I/IIIBC4(D)		4 30		2	2 1		2		1		1		•			(3)5a	trace pyritic
3795	LS/DOL		L(M)BGy 3			fragmental		?vuq?		20			1		?		?		1					3-5	DOL calc w/ frag+fossils LS BB pyritic 2P
3800	LS/DOL	4/6 tr grn clay	L(M)BGy			frag-skel F-M xtl		I/IIIBC3(D)		4 20			2 ?	1	2				pyste	r		1		3-5 ?	DOL-often calcareous. ?Bivalve bored (tiny).
3805	LS/DOL	4/6	L(M)BGy 3			fragmental		interXTL		20			2	?			12		1	2				3-5	tr micropyrite BB P
3810	DOL		ML BGv			XF-M-C (XC calcsp)		interXTL		20		1	-				1		3	- 1 - 1				5?	mix of LM BGy & wt & mottled DOL
3815	(Is)DOL	<10%LS as fossils	LBGy			XF-M-C (XC calcsp)	-	interXTL				1	2						J					5?	??crinoidal LS tr XF pyrite dusty 2P
3820	(Is)DOL	<5%LS gn clay	L(M)BGy		XTL	F-M(C) 1%XC calcsp		I/III BC(D)					1											5?	~1% XC calcspar, tr pvrite XF-VF
3825	(Is)DOL	<5%LS gn clay	L(M)BGy			F-M(C) 1%XC calcsp		I/III BC(D) vugs?					1		12									5:	tr-1% pyrite XF. Tr calcspar C+ stylolitic
	(LS)DOL	~5%LS dol Bn			XTL	F-M(C) 1%XC calcsp			<i>:</i>				-		1 1									51	
3830 3835	(Is)DOL		L(M)BGy L(M)Gy		XTL	F-M(C) 1%XC calcsp		I/IIIB2C3(D) I/IIIC3-4D2+				2	2+						12 1	1			1-2	5?	tr pyrite XF-VF (pyrite=where DOL is darker locally but just traces) tr pyrite XF-VF stylolitic 2P
3835	DOL	Notes girday	L(M)Gy L Gy-Wt		XTL	F-M(C) less calcsp		I/IIIC3-4D2+ I/III B2C3(D)				?	2+						1 ! 1				1-2	5? 52	tr pyrite XF-VF stylolitic 2P
3845	DOL	-20/ LC						I.IIIB2C4D+																5?	
3845	DOL	<2% LS	L Gy-Wt		XTL XTL	F-M(C) less calcsp (F) M-C		vuggy vuggy>	بار با	orXTI														5? 5?	tr pyrite XF-VF stylolitic
3855	DOL	tr-2%LS	L Gy			(F) M-C		vuggy vuggy - I/IIIBC3D5+	1111	CIAIL														5?	tr pyrite XF-VF
	_		L Gy																					5? 52	mior C-VC calcspar samples slightly dusty
3860	DOL	tr sphalerite	L Gy		XTL	(F) M-C		I/IIIBC2D8+		_			^			ш								٥.	tr pyrite XF-VF P&PdryX40
3865	DOL		L Gy		XTL	(F) M-C	_	I/IIIBC3D5+		?			?											5?	tr pyrite XF-VF 2P
3870	DOL	tr sphalerite	L Gy		XTL	(F) M-C		I/IIIBC2D8+								ш								5?	tr pyrite XF-VF PdryX40
3875	DOL	tr LS	L Gy			(F) M-C	_	I/IIIBC3D5+		2			1		1									5?	tr pyrite XF-VF CAVE= tr arg LS-shaly LS 2P
3880	DOL		L Gy		XTL	(F) M-C		I/IIIBC2D8+								ш								5?	tr pyrite XF-VF
3885	DOL		L Gy			(F) M-C	-	I/IIIBC2D8+																5?	tr pyrite XF-VF
3890	DOL		L Gy		XTL	(F) M-C	10?	I/IIIBC2D8+								ш								5?	tr pyrite XF-VF
3895	DOL	tr LS	L Gy			(F) M-C		I/IIIBC2D8+					1											5?	tr pyrite XF-VF Minor med grey Fd dolm 2P
3900	DOL		L Gy			(F) M-C	10?	I/IIIBC2D8+			\perp					ш			\perp					5?	tr pyrite XF-VF
3905	DOL	tr LS	L Gy			(F) M-C		I/IIIB2C6D3+																5?	tr pyrite XF-VF
3910	DOL		L Gy		XTL	(F) M-C	12	IIIB5C5D2+	inter	XTL >>	vugg	у				ш			\perp					5?	tr pyrite XF-VF ??curved dolomite faces Pdry
3915	DOL		L Gy			(F) M-C		IIIB5C5D2+																5?	tr pyrite XF-VF minor greyer finer(F-VF) XTL dolm dry P
3920	DOL		L Gy		XTL	(F) M-C		(I)IIIB6C5D5+								Ш								5?	tr pyrite XF-VF P & P-X16
3925	DOL	tr LS	L Gy			(F) M-C		(I)IIIB6C5D5+												1?				5?	tr pyrite XF-VF LS = MS-WS w/ ostracods + micropyrite = CAVE?
3930	DOL		L Gy		XTL	(F) M-C		(I)IIIB6C5D3+								Ш		Ш						5?	tr pyrite XF-VF
3934TD	DOL		L Gy)	XTL	(F) M-C	15	(I)IIIB6C5D3+																5?	stylolitic tr pyrite XF-VF P&PdryX16
											$oldsymbol{\perp}oldsymbol{\perp}$							$oxed{oxed}$							
Α	В	С	D		G	Н	ı	J	K	LM	N	0 P	QF	S	T	V	WX	ΥZ	AAAB	AC AD	AE	AF A	H AI A	AJ AK	AL AM AN AO AP AQ
			Р	CP I	Panuk	<u>ce M-79A</u>			Geol	Tours	Cons	sultin	g Ind	: L.	Eliuk	P.Ge	eol.	Inf	ill 20	05-01				3'88	PAGE
DEPTH	LITН	modifier I	COLOR	T	TEXTUR	RE modifier	POR	OSITY	ACCI		П		F	OSSIL	S	ПТ	(enhan	nced by	SWC	<mark>dat</mark> a if a	availa	able)		S 7.3	COMMENTS
(metres	I Is-lir	mestone		ps)		udstone 1	%		SORI	ES	F	RAME	BUIL	DERS			"	S		S	ξ	ALG	iAE		additional fossils/accessories
	T DOL=	dolomite		S.		ackestone 3 ckstone 5		modifier			E		2 8	 [တ	<u>S</u>	SQ	8	(0)	ايرا	刨	-	្រែស		diagenetic textures
	H SH=s		EVIATE D M NI IMB	1 sg	GS=gra	ainstone 7		(Archie)		_	<u> </u>	o lo	发내를	± □	틸	<u> </u>	ĕ L		삣삤	ᆲш		ສ ∥ a	55		facies-sequence breaks
		andstone T=siltstone		gr		undstone 9			တ			ŭ	린	8 E	שַׁוַּשַּ	ĭ	[호[일	I웨티	∣≰∥∦	览 호	Ź	Pe III		₩	et cetera
	L arg=a	argillaceous	ABBI	. Sc.		i=XC size)					間間	₹ §	뒫비똣	MILLEP(ICROSOLENIDA HEXACORALS	BRYOZOANS	X S	≱ ∦	퉨빏	" 뜲	힏		A M	8 문 월	some long comments may be
		calcareous	ءً السكا	발	RS=ruc	dstone 8			∥ŏ⊩	비티		ارة الله الم	າໄຊ	물일	ଥ∥≴		ᄪᆝᇙᆝ	ᇜ		2		削貨	윤품	\$ A B B	hidden & visible only on screen
	G say=	sandy/qtz		#	XTL =c	rystalline				절		ΙĮ	ĔII	₽ğ	일∥뽀			HI		$-\square$		ַבּוּ וַ ∟	եր		INFILL LOCCED Law 2005, LOC
	'											- _	"	Ή.				ГШ			\square			[<u>.</u> s ≘	P = photo(s) INFILL LOGGED Jan 2005 LSE
Α	В	С	D ,	┯╄	G	Н		J	к	L M	N	ОР	Q R	s	Т	l v	wx	Y 7	ΔΔΔΡ	AC AD	AF A	AF A	H AI	AJ AK	AL
			_					Ţ		_ 200		- •	- I .			11.	/		- 7 T		·			/	· -

FACIES NUMBERS: 1=bathyal shale, 2=neritic shale, 3=forereef-channel, 3A= foreslope channel, 3C= distal foreslope (microbial mud mound), 3B= proximal foreslope (forereef), 4= sponge reefal, 4A= 'deep' siliceous sponge reef & intermound, 4B= 'shallow' siliceous sponge reef, 4C= 'shallow' siliceous sponge-coral reef, 5= open marine carbonate bank 5A =skeletal rich, 5B=coralgal-'stromatoporoid reefal, 5C=mud/pelleted; 5D=oolitic, 5E= oncolitic, 5F= sandstone, 6= 'moat' (open inner shelf), 7= mixed carbonate siliciclastic platform interior (nearshore ridge), 8= coastal deltaic (lagoonal-continental), 9= mixed carbonate-deltaic, 10= deltaic/interdeltaic SEE Wierzbicki, Harland & Eliuk 2002 for illustrations and details

Enc	osure	A3.20	PanCanac	lian (F		Р) Р а	nuke PI-1	۹ (J	-99)	GeoTou	ırs Con	sulting	Inc	L.Eliuk	P.Ged	ol. Infille	ed 200	5-03							23 8 E	PAGE
#	DEPTH	<u>L</u> ITH	modifier I	COLOR		DUNHA		POR	OSITY		SSORIE	-			FOS	SILS		(enhanc	ed by	SWC da	<mark>ta if a</mark> vai	lable)			S TYPE K'78'88 K 2002	COMMENTS
	(metres)	I LS=limes DOL=dol SH=shale SS=sand SLTST=s arg=argill calc=calc sdy= san	omite e stone siltstone laceous careous	ABBREVIATED or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS= PS=; GS=; BS=! (FS/F FS=f RS=:	mudstone 1 wackestone 3 anackstone 5 grainstone 7 ooundstone 9 3S=XC size) loatstone 4 rudstone 8 =crystalline	%	modifier (Archie)	SGIOO	PARTICLES			STROMATOPOROID C		MICROSOLENIDS	BRYOZOANS	BRACHIOPODS	ECHINOIDS	BIVALVES	SERPULIDS TUBIPHYTES etc	FORAMINIFERA BORINGS	HIGHER-green etc P P P P P P P P P P P P P P P P P P P	١١٥	STANDARD MICROFACIES Flugel'82&Wilson'75&Eliuk' Wierzbicki, Harland & Eliuk	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen P = photo P = photo
swc	Α	В	С	D		G	Н	ı	J	К	L M	N C	P	QR	S		г v	wx	Y	Z AA A	BAC AD	AE AF	AH AI	AJ	1	P = pnoto (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB
		EXAMINE	ED UNEVEN NUM	BERS (EN	D IN	'5 in 200)1) SINCE SOME EVI	EN NU	MBERS PF							EN ALL									<u> </u>	
					IED T	O BE IN	PLACE = MORE PH	otos	. DOLO	IITE CC	DRE TAI	KEN AT	TD -	4029.3-4	030.4	m Many	sampl	es oil-bas	ed mu	d coating	=floccul	ate				3 photos of dry trays for color - 3605 - 4030m TD
			NON-SL.CALC	Dk Gy																					2	VF ligniticf flakes minor silty LS=thin bed P
		SH SH/LS	NON-SL.CALC	DGy(Bn) Md(B)Gy		MS?	shale soft					?											2		2-3	tr mica (lignite?) & qtz slt P chalkified BB
	3610 3615	LSarg	7/3 (SH cave?)	MGy		MS	(micropeloid PS tr)	2	chalky BB	1	Λŧ			AB 7	3611n	n = 3173ı	mTVD		Н						2-3	BBB thromboid? P Tr pyrite P
	3620			Md(B)Gy		MS	(IIIICI Operolu F 3 tl)		chalky BB		3														2-3	BBB shaly micropyrite patches Tr LGrnGy clay; lignitic flakes
	3625		(SH cave?)	MGy	1	MS	(PS aa)	?	chalky BB		tr														2-3	BBB grn clay ?= glauconinte?
	3630		(SH cave?)	Md(B)Gy	1	MS			chalky BB		3?									1					2-3	BBB
	3635	LSarg	(SH cave?)	MGy	1	MS		?	chalky BB											1					2-3	BBB grn clay ?= glauconinte?
	3640	LS arg	(SH cave?)	Md(B)Gy	1	MS			chalky BB																2-3	BBB P
	3645		SH cakc	MGy	1	MS	soft	?	chalky BB																2-3	BBB grn clay ?= glauconinte?
			5/5		1	MS			chalky BB		2							si 2?	mall						2-3	BBB 9sheared into booklets)
	3655		(SH cave?)	D+MGy	1	MS	soft	?	chalky BB					B6-up 3	661m	= 3223m	TVD	2?							2-3	BBB
	3660	•	Sh+tr Fqtz		2	M(W)S			chalky BB		5+		<u> </u>	Do-up o	001111	- 322311	IIVD								2-3	BBB tr M (C) atx grains in LS
	3665		(SH cave?)	DMBGy	1	MS	soft	?	chalky BB									?		1		?			2-3	BBB tr grn clay
	3670	_	dry-chalk cover		1	MS			chalky BB		5														2-3	BBB tr C qtz grains rounded lignitic sttreaks
	3675	LSarg	(SH cave?)	DMBGy	1	MS	soft	?	chalky BB																2-3	BBB ??LAG OF SAMPLES OFF???
	3680	LS	(D) (O) () (O) (T)	MBGy	1	MS		<u> </u>												2y?	1	1			3-5	BBB small tubiphyttes Common micropyrite
	3685 3690	LS LS	(Dk SH) "CMT"	MBGy LMBGy	2	M-WS WS	fragmental CEMEN fragmental	T 50%			8? ? 10	?						1		1	1	1			3-5 3-5	VPS small cuttings 50% cement casing/drilling VPS tr chert - VLGy Minor drilling CMT
	3695	LS	CMT	LMBGy	1	M(W)S	(skeletal fragmental				7	2						1		1		1 1			3-5	(VPS) small cuttings 50% cement csg/drill P
	3700	LS(arg)	CMT	LMBGy	3	WS	frag (skel)	') 			5 15+	2-						1		2 1	1				3-5	tr blue-Gy chert = sponge
	3705	LS	(cmt)	LMBGy	2	M-WS	skeletal fragmental				8	2						1		1 1					3-5	BB small cuttings tr pyrite
	3710	LS(arg)	(cmt)	LMBGy	3	ws	frag (skel)			2	2+ 8	?						4		2	•				3-5	poor spl/BB ?bivalve tube = scaphopod?
	3715	LS	tr SSqtzVF	MBGy			skeletal fragmental				7	4		3				?		?					3- 5 (ab)	BB small cuttings tr pyrite P
	3720	LS	tr SSqtzVF calc	MBGy		WS	skeletal fragmental				? 10	?	•	1?	?			3		2		1			3-5(a)	BB tr VF pyrite P
	3725	LS	<5%SSqtzVF	L(M)BGy		ws	skeletal fragmental	?	chalky BB		8	4		?						?					3-4/5	ВВ
	3730	LS(arg)	(cmt)	L(M)BGy		ws	frag (skel)		,		10	?	•	1				2		2					3-5	BBB
	3735		BB	LMBGy		ws	fragmental				3 7	?		2				?							3-5	ввв
	3740	LS(arg)		LMBGy		ws	frag (skel)				10	1	?	1			1	2		2		1	?		3-5	BBB ?Lithocodium? Micropyrite shaly stylolitic
	3745	LS		L(M)BGy		ws	skeletal fragmental				8	2		?				1							3-4/5	BBB tr grn clay cement = ?trip?
	3750	LS(arg)		L(M)BGy		ws	Frag-Skel				3 10	4		2				1		2		?			3-4/5	BB-poor spl P
	3755	LS		MLBGy	3	W(M)S	fragmental				7	2		?						1					3-4/5	BB
	3760	LS	1%pyriticSH fos'	MLBGy	3 4	WFS	skel(spg)-frag				2 8	5	_	2 1			1-	+ 2+		1+ 1		1+	2+		3-4b <mark>/5b</mark>	BB tr (1) VC qt grain rounded 2P
		LS		MLBGy	2		fragmental (skeleta	?	chalky BB		4 8	4						1							3-4	BB Minor DGy pyritic arg LS - calc SH
		_	pyrite patches		3 4		frag (peloid)		, 55			1		1?			1	2+		2+		1			3-4/5	BB-poor spl??
		LS	p).ito patorios	MLBGy			fragmental	?	chalky BB		8 20 15	2													3-4	BB tr pyrite & white calcspar
			tr pyritic SH	MLBGy			frag (skel)				20	1	? AE	36-lo 377	5m ?=	=3339mT	V 1			1?		?			3-5a	BB
			Tr DOL & SSqtzV				fragmental-skeletal	-spond	ge		20 10	12		2	?		1	1		1					4b	BB tr pyrite & clay CUTTINGS LARGE P
			XFpyrite tr DOL	L(M)BGy			microb-spg-frg-stro				15	12		10			çalçsp	2+		2 1	? ?	1 2	15	5	4b/5b	tr pyrite & clay CUTTINGS LARGE 4P
	3795		tr DOL	L(M)BGy			skel-frag-peloid(pel				15 5 10	4		?		,	çalcsp	ar 1		1 1	1				5-4	tr pyrite & clay CUTTINGS LARGE
			micropyrite	L(M)BGy			skel-peloid-frag			1	0 10	3-	+	3+		1	?	4		5	2	1	5		5a	BB tr glauconite in SH CUTTINGS LARGE 4P
	3805	LS		L(M)BGy	9 8	B/RS	Spg-chaet-?coral-st	trom i	P/GSmtx		20	15	5 5	20 10		?> (6 ?	3		1 1	1 1?				5b(4)	BIG CHIPS P(5)
		LS (+SH)		L(M)BGy	7+3	G+MW	frag-skel(+strom)				5 30 30	3'		5			? 2	3		4+ 2	2	1	3		5 b	BBB MIXED LITHS ? CUTTINGS LARGE 5P
		LS		L(M)Bgy	4	W/PS	skeletal-fragmental				30	1		1 ?		1		2		1 1	1	1			5a	BB SAMPLES BADLY BIT BRUISED

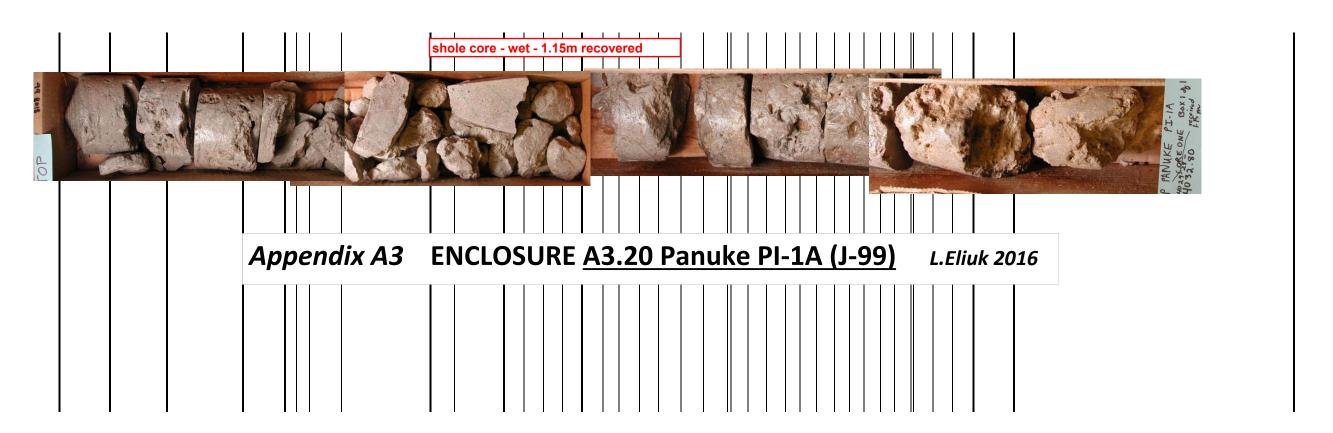
SWC	Α	В	С	D		G	Н	ı	J	K	L M	l N	0	P Q	R	S		T	V	W	Υ	ZA	A AB	AC AD	AE A	F AH	ΑI	AJ	AK	AL (BBB) - LIGHTER COLOR AND	
	3820	LS(arg)+SH	gngy micropyrite	L(M)BGy	5	WPS	skel-frag	2?V	tr C calcspa	2?	15	5	?	1 2				1	1?		1	2	2		1	?	2		5a(b)	ooids or blk rim miciritze	
	3825	LS(arg)		L(M)Bgy	4	W/PS	fragmental-skeletal		Open vug?		20		6	1 6				1	1		1	1	1						5b(4)	<u> </u>	Р & Р
	3830	LS(arg)		LMBGy	5 4	4 FWPS	-1-5(tr	vug-XC calc	sp	15		10 micri	, 3	rextlzd		3	rev	1? 11zd ₂		5	2-	+ 1	?	?	1	5+		5 b	BB 1% micropyrite; tr Dk pyritic glauconitic SH	6P
	3835	LS		L(M)Bgy	5 4	4 F-PS	frag-framebuilder				15			tic 3	2		1	'?^	2			1			1	1			5b	BB some big chips	P(3)
	3840	Lsarg-slty		LMBGy	5 4	4 FPS	spg-skel-frg				10		10	2			1			4	4	2	2		1				5b	qtz silty/SH tr chert/dol in SPG tr pyrite	2P
	3845	LS	<5%DOL, tr SSVF		5 4	4 P-FS	chaet-skel-frag				10	nn I		_	10		_				³ lg	1			1				5b		Р & Р
	3850	LSarg	silty	MLBGy	7 #		frg+Spg-coral?-skel			2?			-	5 6?			5	?5+		1	0	3	3 1		1		10 _cr	usts	5b (4c)	BB pyritic (some lg flat chips = cave?) tr grn clay	7P
	3855	LS (arg)	< 5% DOL F	L(M)Bgy	4	W/PS	skeletal?-fragmenta	11			10		2	2 2	_			<u>6m =3</u>			_				-		_		5		2 & P
	3860 3865	LS (arg <mark>)</mark> LS		LMBGy L(M)Bgy	9 4	FBS R-PS	Spg-coral-skel; frag-bivalve-skeleta	_	ah allar		15		10 .	3 3!	? 3	2!	10	!	+8	!		2 4	yster	s			3		F	BBB some lg chi9ps xf pyrite Minor pyritic SH(+ grn)	5P
	3870	LS	bryozoaSH=cave	L(M)BGy	5	WPS	fragmental (bryozoa		chalky		35		1						10		2 1		1				1	1	5a	BBB some big chips cave? BBB micropyritic calc SH/argLS = cave?	P
	3875	LS	DiyOZOaSi i-Cave	LGy	2	4 F-WS	skeletal-fragmental		chalkv		15		1	1					10	4	_ 1	1 2	' 1	1	2		1	4	52	BB some big chips with bivalves as above = cave?	
	3880	LS/DOL	5/5? BBB	LGy	3 .	xtl/WS			IC3D2intxtl	15	15			3?	,					2	2	1		-	1		'		5a 5 (5d)	V BBB fossiliferous pyritic SH = cave	D
	3885	LS	3/3: 000	VLGv	3 4	4 F-WS	sponge? (skeletal?		chalky	13	10		7+	2?							-								4-3	BBB six or so large chips	•
	3890	LS	<5% dol	MLGy	3 4	4 (F)WS		Ė	onanty		20	?		5							1	2	? 1		?		2?		5 (3)	V BBB only 5 md-lg chips identifieable	Р
45	3895	LS/DOL	9/1 F & vug	VLGý	4	P-WS	skeletal-fragmental	?	chalky/vug		15		1	1				?1_	П., П	L L .	1-:1-0		1						5a ´	BBB six or so large chips	Р
44	3900	LS	v BBB			?	? Frag?				?1	0						5? ^{re}	±\$tı =\$	spar ca	icite?									V BBB no ggo cuttings	
43,42	3905	LS		L Gy	5	W+GS	frag=coral-skel	?	chalky		15			6		1?	10			′	?	1		1	2	n	ad		5b(3)	BB micropyrite some big chips	Р& Р
41	3910	LS/DOL	6/4	l Gy	9 4	4 BRS	coral-strom-red alga	5+	interxtl-vug		10		5?	10		5*	10	40			1	3	3			?5*			5b	BB myriaform rextl corals red algae VS milliporid	5P
40	3915	LS		L Gy	6	4 F-P/GS	strom-chaet-skel-frg	tr	vug		20		3	1 10		?		5 .	AL+I	6		2	2						5b	many big chips traced pyrite Cu grn clay	P(5)
39,38	3920	LS/DOL	9/1 M-C calcspan		7 !	9 B+GS	1.0	2+	spar=bug?		30		10	20				?10	3		3		2 1		1				5b	some big chips sl arg partings (?cave) Frg-skel GS	3P
37,31	3925	LS/DOL	6/4 F-C	LBGy	6	P+GS	frag-skel XTL	5	IC2D2		35	5	3	3				1			1	5	5		1				5b(3)		Р & Р
29,30	3930	LS	?? VBBB			???	? Strom? BBB							2?									rextlz	d						V BBB no good cuttings	
28,27	3935	DOL/LS	6/4 F-C, 1% SH	LGyB	9 8	8 B/RS	stromtp-skel XTL	7+	IB&IIICD5		5		2	10	_			1			1		rextlz	<u> </u>			1		5b	BB ?SHC in vugs & interxtls tr-2% pyritic shale	Р & Р
26	3940	DOL/LS	7/3	LGyBn	9 8	8 BRS	stromtp-skel XTL	7	IC+IC3D3+		5		?5	25	nicritic		3	?2			1	11	?			1	3	.oto	5b	PPT porosity in stroms & interxtl DOL-vug	4P
24,25	3945	DOL/LS	5/5	LGyB	9 8	8 B/RS	framebuildersXTL	6	I/IIIC3D3				?	6	nicritic	10?		6				1					3 ^{cn}	ısts	5b	(BB) micropyrite in framebuilders	Р& Р
23	3950	LS/DOL	8/2	LGyBn	7 8	BRPS	coral-strom-frg-skel	Ī	tr interxtl		30	ו	5	15	3		5			2	2	3	3		1 2	<u>'</u> +	3?		5b	micropyrite Ig chips	8P
22	3955	LS/DOL	75/25	L(M)GyB	9 8	8 B/RS	framebuilder-skelet	5	I/IIIC2D3		5 10),	5	15	10	?	5	10 t	ybes	1	?	2	2	1	1	1			5b	many big chips traced pyrite in stromtps/corals	P(5)
	3960	LS/DOL	8/2 (tr arg)	L(M)GyB	7 8	BRGS	frmblder-skel-frg	tr-2	?vug Ing		15	5 5	5	15	8 6		10	15	1	1	2	3	3 1		1		2?		5b	many big chips pyritic	8P
	3965	LS/DOL	9/1 F trSSqtzM	L(M)GyB	7 .	4 F-GS	frg-coral-strom-skel	i		00	20)	2	10	3			10			2		1	1	1				5b	Lots big cuttings Some very calcareous pyritic shale	ъ & Р
	3970	LS (dol)	<10% dolm	L(M)GyB	5 8	BRPS	microsolenid-strm-s	skel-fi	ra	GS 5	15	+ 3	5	5 20	2	?	30	5			3	4	?	1	2+	3	5		5b	, , ,	
21	3975	LS	<5%DOL F-M	L(M)BGy		4 F-PS	framebuilder-skelet		Ĭ		10		3	5 10				6	1			1 2	2	1		2 dioni			5 b	trace pyritic shale stylolites?	
20,19	3980	LS/DOL	6/4	L(M)GyB	5 4	4 FPS	strom-frag-microb	3+	interxtl-vug		15	5	5	3 25	5			5		4	1	2	2 2	2 1	1+		10		5b	BBB Lithocodium 2-2.5m	4P
18	3985	LS/DOL	85/15 tr SH+SS	L(M)BGy	5 4	4 F-PS	coral-frmbldr-skel				5			1 6	5		10		1	1	2	2	1		1	1 1 ^r	ed		5b	tr pyritic shale with crinoids/bryozoan VF-F calc dolom	P(4)
17,16	3990	LS/DOL	6/4 (lo 1/2=dol)	L(M)GyB	5	4 F-PS	frag-strom	3+	I/IIICD2+		35	5	5	8			5		2		3	2	?		1				5ab	dustyBBB (lo 1/2 lg cuttings) 2-2.5m	4P
15,14	3995	DOL/LS	9/1	VLBGy		XT L.	(VF)M(C)	3+	I/IIICD2+					1	1_		1				1 🔽	1							5a	Tr crinoidal shale	Ρ.
13	4000	DOL (LS)	9/1?	VLBGy		XTL	(microb-frg)	_	I/IIIBC5D3+		5			1 ?		AB4	3991	m =35	50mT					?			5	?			y+2P
12,36	4005	DOL (Is)	LS<10% dkr	VLBGy		XT L.	F-C & coral BS	10+	I/IIIC4D7+					?				3			1	1			1	1			5b/a		° & Р
11,10	4010	DOL (Is)	LS<10% dkr	VLBGy		XTL	F-M(C)	_	I/IIIC4D7+					3	2			1				2	У								y+2P
9,35	4015	DOL (Is)	LS<10%	VLBGy		XT L.	F-C & skel-pelGS		I/IIIC5D5?		2				1			2	1										5(b)		-3dry
34,7		DOL (LS)	LS<5% dkr	VLBGy		XTL	F-C	15+	I/IIIB2C7D8+	+				1 2	1			1	1								1			(silty arg LS w bryozoa = CAVE?) 2-2.5m	2P
6,33,5	4025	DOL	LS<2% mbGy	VLBGy		XT L.	F-C (skel GS)		I/IIIC5D5-10					_				_												Vuggy = euhedral DOL in vugs v. common	P
4,3,32	4030	DOL	LS<3% MBn pyriti	VLBGy		XTL	F-C	-	I/IIIB3C5D10)				2+		1		?								1	1			tr C clear spar calcite 2-2.5m 3dr	y+2P
2,1		DOL 20. 42m		VLBGy		XT L.		10-15	I/IIIC5D5-10																						Р
	TD at 40	30.43M																													
1 1					44		(arg) MS	<u> </u>						_											1	_					
	A	В	С	D	Щ	G	H	L	J	K	L M	l N	0	P Q	! R	S		Т	٧	W >	(Y	ZA	A AB	AC AD	AE A	F AH	ΑI	AJ	AK	AL	
		SIDEWALL	CORE DESCRIPTI	ONS ON F	FOLL •	OWING	PAGE										l	I	II I				T			I	1 1				
		l F	ACIES NUMBERS	: 1 =bathv	ı∎ /al sh	ale 2 =n	eritic shale, 3=forereef	f-chan	nel 3A= fore	slope	chann	el 3C:	= distal	fores	lone (n	nicroh	nial m	nud mo	ound)	3B= n	roxim	al fores	slone	(forere	ef) 4 :	= spon	ie ree	fal			
							ind, 4B = 'shallow' silice																			opon	,0100	,			
			5B=coraİgal-'stroma	atoporoid r	reefa	l, 5C =mι	ud/pelleted; 5D=oolitic,	5E=	oncolitic, 5F=	sands	stone,	6= 'mo	at' (op	en inn	er she	elf), 7 =	= mixe	ed car	bonat	e silicio	clastic	platfor				re ridg	e),				
		8	= coastal deltaic (la	agoonal-co	ontine	ental), 9 =	mixed carbonate-delt	aic, 1 0	0= deltaic/inte	rdeltai	ic SE I	E Wier	zbicki,	Harla	nd & E	liuk 2	2002 f	for illus	stratio	ns and	detai	ils				_					

		SIDEWAL	L CORE-TH	IN SECT	ΓΙΟΝ	I DES	CRIPTIONS SU	JMM	IARY P				1-1A		Comp	oiled	fror	n L.E	liuk,	J.W	/eisse	nber	ger	& R.	Wier			REVISED from SWC	by L.Eliuk 2004-12 &	2005-02
swc	DEPTHL	LITH	modifier I	COLOR		TEXTU	JRE modifier	POR	OSITY	ACCESS =comme					FOSS	SILS		(en	hanced	by S	WC data	a if ava	ailable)			TYPE 78'88 2002	COMMENTS		
	(metres) ^I T T H O L O G Y	LS=limes DOL=dolc SH=shale SS=sand: SLTST=s arg=argill calc=calc sdy= san	omite estone iltstone aceous eareous	ABBREVIATE D or MUNSELL	DUNHAM NUMBER ms-bs left fs&rs(bs)	WS=1 PS=p GS=0 BS=b (FS/F FS=fl RS=r	mudstone 1 wackestone 3 parainstone 5 grainstone 7 poundstone 9 \$3=XC size) loatstone 4 udstone 8 =crystalline	%	modifier (Archie)	OOIDS	PARTICLES	HOCLAST	SPONGE SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WITH SPONGES WIT	STROMATOPOROI C	CHAETETID SO MILLEPORID SO hydrozan-OTHER	HEXACORAL	HEARCORAL	BRYOZOAN	CRINOIDS	GASTROPOD	BIVALVES	SERPULIDS TUBIPHYTES	11 Z II	BORINGS HIGHER -green P	STROMATOLITE P	ONCOIDS-PISOID	STANDARD MICROFACIES Flugel'82&Wilson'75&Elluk'7 Wierzbicki, Harland & Eliuk	SEE WRITTEN REPO DESCRIPTIONS OF V PHOTOS by LSE see earlier PanCdn E	cessories diagenetic ience breaks et cetera RTS FOR MORE REC WHOLE SWCs AND TH xcel for TS only interp	ENT & COMPLETE HIN SECTIONS WITH pretation
#	Α	В	С	D		G	Н	Т	J	K L	М	N	O P	Q	R S		Т	v w	ΧY	ΥZ	AA AE	AC A	DAE	AF A	H AI			o riolocomporger	J.W.'s FACIES	R.W.'s FACIES
45 44 43 42 41 40 39	3895 3898 3902 3904 3909 3912 3915.5	Lsdolarg DOL/LS LSdol		MLBGy MDBGy M+LBGy MBGy	6 4 5 4 5 4 9 9 8 6 6	B/RS B/RS W-FS BS F(B)S FSgps	framebuilder cor'spg-bivalve-clas	nicrob -micro al cropyr	ob?	10 5? lground??	_	2	20 20R 20 5 5	R R 5 5 35 15	10?	50	3J JR	3 1 2 2wt	7 R 1 J 2 2 2 5 J 5 5	J 2 5 1	J 3 10y 3 5	11	? 3 1 2 2 2 ? 1 1 1	5 2 2	a cisp	ter 3 here	4c5b(3c 4c5b(3c 5a 3c? 5b(4c,3c 5b 5ab (3c?	† 	thin sections"J" reef flat PS prox fore reef PS foreslope PS prox? foreslope PS reef BS reef BS prox? Foreslope PS	whole SWC's"R" prox fore reef skelPS proximal fore reef reef-prox FR corRS forereef strm PS FR or infill W/PS prox FR pl-skPS reef-backrf cr-spBS
38 37	3917.5 3925.3	LS+calcDOL LS/DOL	75/25	L+MBGy M(D)BGy			coral(rextl)-stromate spg(varied)-skel(bro	•		R			10J	15	25		5JR BRJ	1?	J J	_	3J 2 2v 3			3	1		5a 5b	sphinctozoan spg	near reef PS reef	prox FR pelGS forereef cor-spPS
31	3925.5	DOLcalc	10120	LBGy		W/PS	skeletal?frag			, K	15		100	13		3: 3	1110	1 !			2y 3	2		3			5	Just granules???	AA dolomite	SS lo-stnd exp surf
30	3928		80/20	M(L)Bgy			Spg(strom?)-skeleta	al (bro	ken)					15R			J	2	J20 3	3	J8y				dasvel		5(b)	calcispheres	foreslope	forereef sk-strFS
29 28	3930 3933		60/40 F-M-(VC)	MBGy LBGy		P(B)S XTL	skel-frag-sponge? ?frg-skel PS??	6	I/IIBC3D3			3	30?	1			J	2	5J 3	3	J9 2	1? 1	J2	2	dasycl		5a4bc3c 5a(3c?)		?distal foreslope PS prox Frslp PS	SS lo-stnd exp surf
27	3935		F-M-C sub/ashedr				?frg-skel PS??		vug+interxtl					0	20?		J										5a(3b?)		prox FS to reef? PS	DOL??
26	3938		85/15 F-M(C)	MBGy			strom?-skel(cri)-			R	2	5?rd		15R	15??	;	3?		20	J				g	reen?		(3bc?)5l		mld foreslope PS	forereef pl-skl-strPS
25 24	3941.5 3943	LSdol LS	7/3 30%qtz nucleii	MBGy M(D)BGy		BR-PS GS	strom(chaet?)-skel coral-strom-ooid (st	l MADS	2)	3 R J70		-	R5?	30 R15	20?	15 .	J JR	2	5 J	-	J8 5 1	2	1	1			5b(d)3b 5bd	Chaetetopsis?	prox foreslope PS ooid shoal-near off	prox? FR skl-plPS distal FR c-sp-stBS
23	3949	LS	30%qtz Hucieli	M(L)BGy		BS	corals		intrafos	370 R		ļ	101	KIS			J50	2)	3 1		'		5?		5bu 5b		?reef/near reef rextl	distal FR c-sp-stb3
22	3951.5	LSsdy	30%qtzF-M	MBGy	6	FBPS	chaetetid-skel			7?			5		45		J		5J 3		J10	5		5			5b/4c-5f		mid-upFS-channel?	prox FR str-chaetPS
21	3974		7%dolm trQTZ	M(L)BGy		RS	coral-strom?-skel			5		5		25?	15??		R25	2	8 3	3 3	10			3R	50		5b (3c?1		D (0) . D (1)	FR bored coral
20 19	3977 3979.2	LS LSdolm	15%dolm F-VF	M(D)BGy M(D)BGy		BRS FPS	single hexacoral coral-frg-skel-echin	l oid			15		rextlzo	ij,geoj 5?	petal in bor	ings 8	30?	3	10 8		Lith	ocodiu	ım _{.12}	J5 2			5b 5b (3c?)	Thamnasteria? microsolenid (rextl)	Reef?! Rextl shoal-near shoal PS	reef str-corBS forereef skIWS
18	3984		F-XC LSpatches	MLBGy	-	B=PS	chaet-skel(coral/alg				10				25 8?	-	?5J	?	5		10		02	2 5	?			t ?coral or alga?	reef-near reef PS	forereef cor-tb-bryPS
17	3986	DOL	VF-M-VC bimodal			PS?	micrite/rim-skel?	tr	IABCD0-2								J?										5-3b		??dolo W/PS	DOL??
16 15 <mark>a</mark>	3989 3992		F/M-V/XC bimoda F-M anhedral	L(B)Gy L(B)Gy		PS MS?	peloid or uniform peloidPO	3	1BC0-2D2- micropor	5 50 30?							J				5??						5c 5c??		reef-near rf doloPS near reef doloPS	DOL?? DOL??
15 b	3992		F-VC	L(B)Gy		PS ?	skeletal (broken)		1(III)B5C8D								3										5			DOL??
14	3994.5	DOL	F-VC anhedral	L(B)Gy	П	PS?	skel?	17	1(III)B5C3D	8+ J									10?								?5a-3	?(5a-3b)?	reefshoal GS	forereef DOL
13	3997.5		F-VC	L(B)Gy	5	PWS	clast-ooid skel			10?		10 o	only 4 o	hips	in SWC		J		J5?	5			2?			450	5acd		reefshoal-upFS PS	DOL??
12 11	4002A 4002B	DOL DOL	F-XC anhedral F-M (LSvf-f)	L(B)Gy L(B)Gy	5		peloid-clast/oncoid'	25 4+	1BC5+D20 1C2+D2+	30	1	?10 15															5c-3c 5c-3c		reefshoal-upFS PS reefshoal-upFS PS	DOL?? DOL??
10	4008		M-C uniform	L(B)Gy L(B)Gy			peloid-frg(small)	3+	1ABC3+Dtr	?30+		10					J		2 2	2							5c-3c		reef-near rf doloPS	DOL??
9	4010		F-VC bimodal	L(B)Gy			rd lithoclast-peloid	-	1AB3C3+	30		20					J		J3 2	2							5c(a)		up foreslp_doloPS	DOL??
9	4013.8		M-C uniform	VL(B)Gy				3-6	1B2+C0-3								JR										?		up foreslp_doloPS	forereef-reef DOL
35 34	4014.5 4017		F-VC	L(B)Gy		EGO	abally	6	1BC3-5DTF 1B10C3D5-												?						? 5-3? 5a?	fractured?shattered	up foreslp? doloPS	forereef calcDOL
7	4017		F-VC eu/anhedral F-VC	L(B)Gy L(B)Gy	4	FS?	shelly		IC5D2-6+	JR							J		J		9!						5a ?		reef shoal GS upFS near shoal GS	FR? calcDOL up FR Pel-skl doloGS
6			F-VC bimodal	L(B)Gy		FS?	shelly	6	IBC3D2-5	J.C							JR				J5?						5a?		upFS near shoal GS	
33			F-VC bimodal	L(B)Gy					1B2C6D3+								J		J								?	fractured??	breccia near shoal	
5	4024		F-VC	L(B)Gy			fabria daction the		1BC2-8+D2								J				J						?	autlines 2 - 5 - 11 -		calcDOL??
3	4027 4029 <mark>A</mark>		XF-SL + F-C vf-VC	L(B)Gy L(B)Gy			fabric destructive		1C2D5=frac 1c2d3+SHC										J		5? 5?						?	outlines 2 shells ghosts?shells F/RS	m-upFS doloPWS up FrSlp doloPS	DOL?? reefal DOL cor
32	4029B		F-VC anhedral	L(B)Gy				5	1BC2D3?																		?	fractured	m-upFS doloPS	DOL??
2	4032	DOL	F-VCanhedral	L(B)Gy				<15%	1BC5+D10-	-																	?		m-upFS doloPS	DOL??
7	4034 A	DOL B	F-M LSvf-f	L(B)Gy	+	G	Н	1	?? J	K L	M	N	0 P		R e		5 mi	rosole V W		/ 7	AA AE	AC A	DAE	ΔELA	н м	ΔΙ	ΔK	I iny rubble AL	by-pas channels:	forerref? DOL/skiws
	^		U	נ		3		_ '	J	^	IVI	14	~ r	×	. 3	1	• 11	- 1	1 ^ 1 '	۔ ا ۔		ᄭᆨᄉᄓ		~ A		70	~11	I ~-		





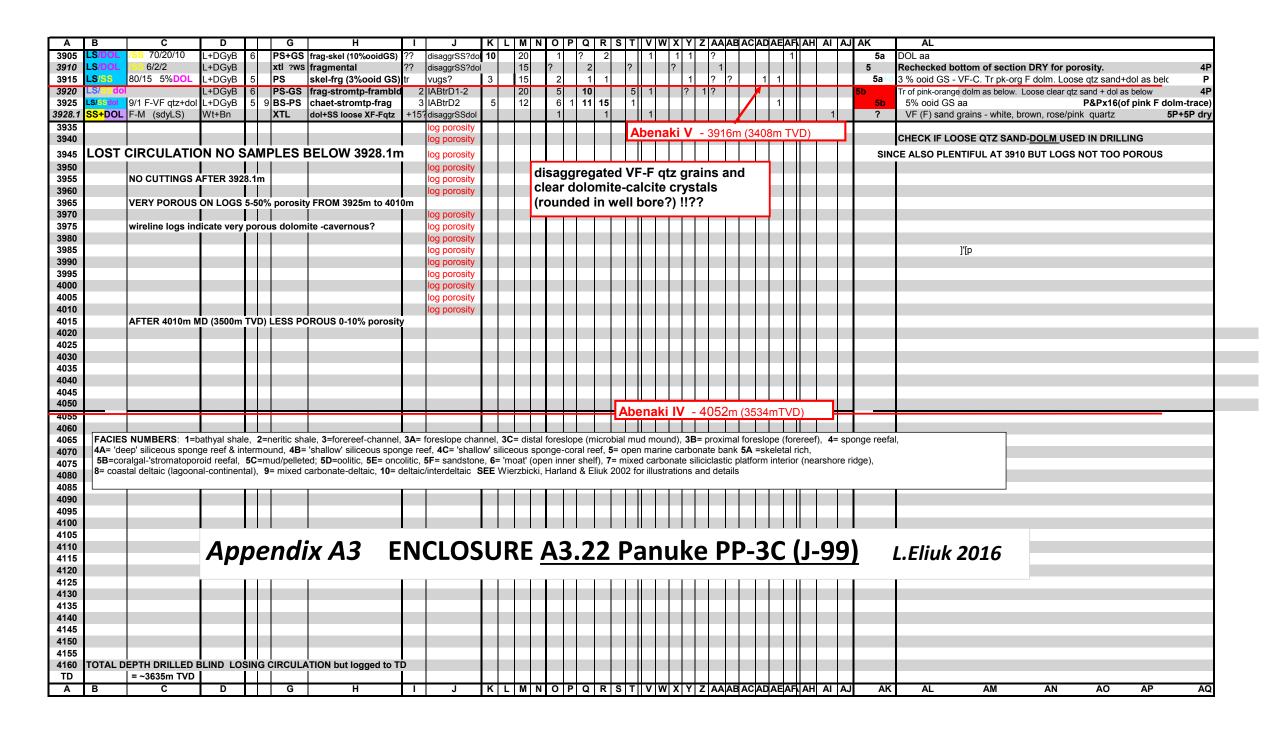




Enc	losure	A3.21 PanCa	nadian	(PC		nuke P1-1B (J-9	99)	GeoTours	Cons	ultina	Inc	L.E	liuk P	.Geol	I. Revi	sed F	INAL	2004	I-12-1:	5								TYPE 78'88 2002	PAGE
DEDTI		madifier I	COLOR		TEXTURE DUNHAM		200		ACCE	SSOR	IES	Ī			FOSS						10 4	-4- :6		labla)				ACIES T Eliuk'78 Eliuk 2	
DEPTH (metres) H O L O G Y	SH=sh SS=sa SLTS1 arg=ar calc=o	dolomite	ABBREVIATE D COLOR	DUNHAM NUMBER eft=*ms-bs right=fs&rs(bs)	MS=mudst WS=wacke PS=packst GS=grains BS=bound (FS/RS=X/FS=floatste RS=rudsto XTL =cryst	tone 1 estone 3 tone 5 tone 5 tone 7 tstone 9 C size) one 4 noe 8	ROS %	modifier (Archie)	SOIDS	PARTICLES		RAME .M.1 SPONGES.	STROMATOPOROIDS.	ETETIDS.		HEXACORALS.	BRYOZOANS	BRACHIOPODS	ECHINOIDS.	GASTROPODS. 60	OSTRACODS	SERPULIDS	TUBIPHYTES etc	BORINGS	HIGHER -green etc	STROMATOLITES THROMBOLITES	ONCOIDS-PISOIDS,,	STANDARD MICROFACI Flugel'82&Wilson'75&Eli Wierzbicki,Harland & Eli	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
												L				_									լեր				P = photos
Α	В	С	D	*	G	Н	-	J	ΚL	. М	N C) F	Q	R	S	Т	٧	w x	Υ	Z A	AAB	AC	AD A	AE AF	AE AH	Al .	AJ	AK	AL
3600 3605 3610		no sample no sample no sample			7 - 36	11m = 3174mTVD																							SAMPLES BADLY BIT BRUISED (BBB) - LIGHTER COLOR AND CHALKIER THAN ACTUAL =BBB
3615 3620		no sample no sample			77 00	11111-017-41111-01	_	V	Vell w	hin-st	ocke	d aw	av fro	m ori	iginal l	_	_	e at 36	_	_	_	_	cal ir	n Abe	naki e	ea .	٦		
3625 3630 3635		no sample no sample no sample						3600mMD = degrees off	3160 vertica	m TVI al towa	O (44 ards t	0m o	liff) ar ie sou	nd 40 uth-so	000mN	1D = 3 ast (10	3345 68 ძე	m TV grees)	D (65 near	5m d TD.									
3640		no sample						$\overline{}$			т	\top				П					\top						_		
3645 3650		no sample no sample																											
3655		no sample																											
3660		no sample				0004 0000 Th		_		П																			
3665		no sample			b 6U - 3	3661m = 3223mTV	טי																						
3670 3675 3680	CEMENT CEMENT CEMENT	no sample																											drilling/casing cement F
3685 3690	LS	gn clay & tr chert	D(M)Bgy	6	G+PS	sponge-fragmental				30	1	0						1		? 1	1	?	١.	1		crus 5?	sts	4-5	F-C allochems with XF-VF cement. Tr micropyrite
3695			D(M)Bgy			sponge-fragmental				30	(2	1	1		1	2	:	3	3 1		1+	1		5		4b	3F
3700	LS	tr gn clay	D(M)Bgy		F-W/PS	frag-skeletal-peloid			1 1	0 20	- 3	3	5		3?		1	1			1					•		5a	. Tr micropyrite
3705 3710	LS LS	tr pyrite tr G	D(M)Bgy D(M)Bgy	4	WPS W(P)S	frag-skeletal fragmental-sponge-skelet	ol.			15	1	3	4				1	1		۱,	. ?			1		3		4 4-5b	small cuttings tr VC Bn calcspar pyrite
3715		pyritic tr G - SS & SH	D(M)Bgy	6 2	G-PS-FS	sponge-stromatop-frag	aı			20	8	-	ic 5				1			3.	+			1		5+		4-5b 4ab	clams=oysters black silicified sponge 38
3770	LS	pyriac a d - oo a or i	D(M)Bgy	4	W/PS	(GS) frag-skel				30	- 6	micri 1	?			3	1 '	1			1		?			5+ spor	nge	crusts 4	Gams-bysters black smalled sponge
3725	LS		D(M)Bgy		W/PS	sponge-stromatop-frag			2	2 25	1		tic 5				1	21112		1			•	?		2		4b	2F
3730 3735	LS LS	tr silty shale tr silty shale pyritic	D(M)Bgy D(M)Bgy		F-P/WS F-P/WS	Spg-stromtp-skel-frg sponge-stromtp-frag				10	1		10		5 ?1		ġr	own 1		1	1			1		2		4b-5b 4b	(BB) crinoid-bryozoan shaley beds micropyrite C spar
3740	LS	tr VF-FSS & pyrSH	MGyB		F-PS	Frag-spong-stromtp				20	1		10		5			1		1	?							4-5b	pyrite stylolites XC calcspar
3745	LS		MGyB		P/GS FS	stromtp-spg-frg-microb?				15				-	? 1		1	1		1		2	2	1 1		7		4c-5b	71
3750	LS	tr pyritic slty SH	MGyB		F-P/WS	Spong-Millprd-skel	tr	vug		5	1		5		10?	?		_		1	1 1	2	1 :	2		2		4-5b	stylolites pyrite cuttings larger
3755 3760	LS LS	pyritic tr M-Cqtz & calcSH	MGyB MGyB		F-P/WS F-WS	stromtp-spg-skel-chaet-frg skeletal-fragmental	y			10	8	3 5	15		?	3	2	2		1	1	2	1	1		3		5b 4-5b	tiny stylinid-type coral 5F (BB) stylolites pyrite Drilling cement (cave?)
3765	LS		MGyB	3 4	F-WS	stromtp-frag-skel-microb				15			8					2		1	l 1 ovste	:		?		8	o to	5b	small cuttings
3770	LS		MGyB	5 4	F-PS	spongskel-frag				10	1	m ici	itic 5	1				1		5	ovste	rs	?	1		grus 5	รเร	4-5b	pyrite F
3775	LS	G? Large cuttings!?	MGyB	3 4	F-MWS	microbial-sponge-(frag/pe	eloid)		5	5 10	8	3 micr	itic 2					1? 1			1		1			25	usts	4ab-3	tr vf eandy eilty LST
3780	LS	tr grn clay pyritic	MBGy		WS	skel-frag-sponge		Ab6L		10			3	3			1	1	1	? 1	?							4-5b	Ab6L - 3780m ? = 3332mTVD?
3785 3790	LS LS	tr grn clay pyritic some F cl cement	MBGy		WS P(C)S	Microb-skel(spg)-frg			2	2 10			1 2				2	1		2	2			1		15+		<mark>4ab-</mark> 3 4-5a	big bryozoal 3F
3790 3795	LS arg		MBGy MBGy		P(G)S WS	fragmental-(skel) fragmental-(skel)				20		3	2				2		1	1				1		4+		4-5a 5	pyrite small cuttings
3800	LS alg	tr DOL F	MBGy		WS	skeletal-fragmental				10		3	1 2		3?		1		1							5		4-5b	(BB) small cuttings
3805	LS		MBGy	-	WS FS	strom-frag-skel				15		2	2 10				1	1	1					1		2		5b	BB small cuttings
3810	LS	tr clear calc cmt	MBGy		WS?	fragmental				10		1			?											1		5	BB small cuttings BB small cuttings SS top AB 5 =
3815	LS		MBGy	3	ws	fragmental-skeletal				10		3	2 2				2	1	l							1		5	BB small cuttings SS top AB 5 =

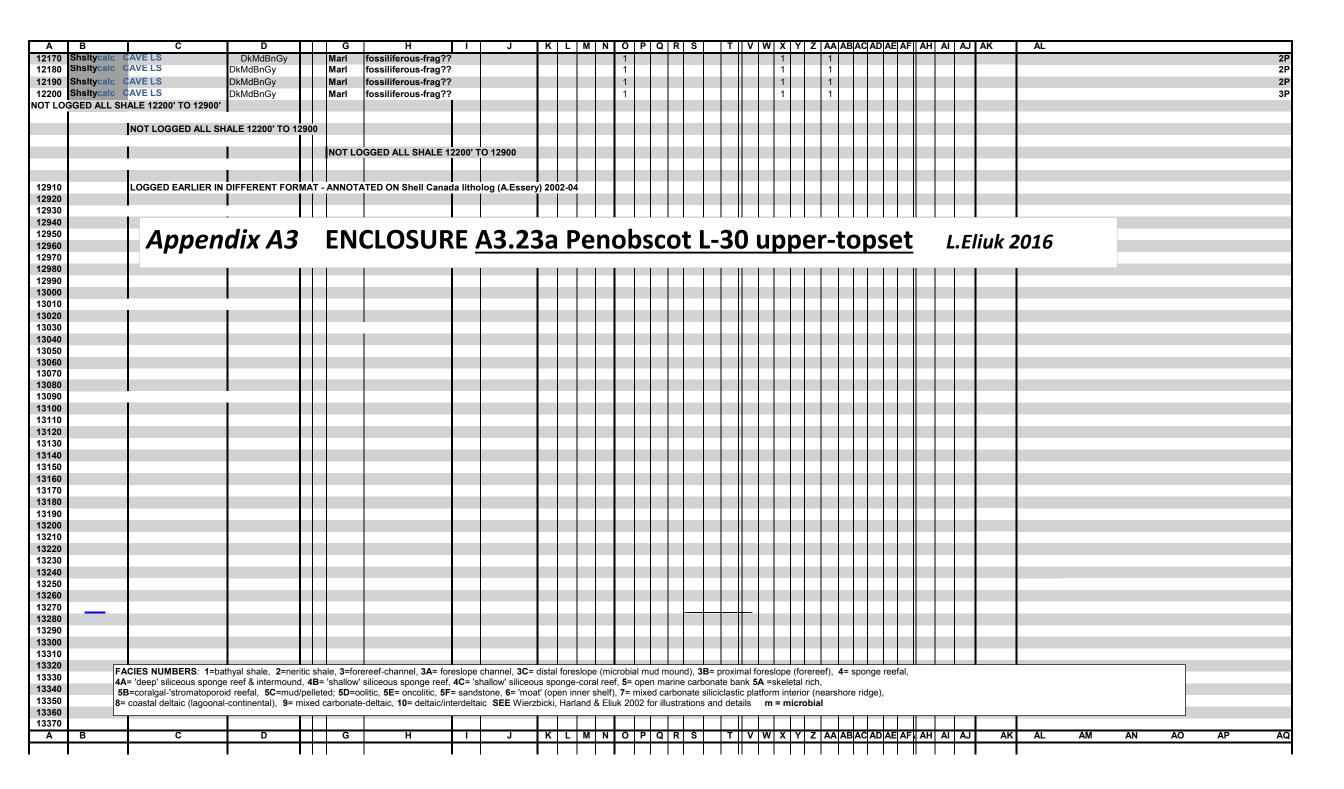
Α	В	С	D	*	G	Н	П	J	Κ	LM	N C) P	0	R	S	IT II	V	w x	ΥZ	ΑΑ ΑΙ	ВАС	ADA	AE AF	AE AH	AI A.I	AK	AL 3322.2m ????
3820	LS		MBGy	3	WS?	fragmental	H		+	10		Ŧ.	1	+ +	1	+	-+	+	╅	- 7 "	+	H	77	7		5	small cuttings
3825	1.6		MBGy	3	WS	fragmental-spong/skel				10		5 2	2 1		- 1		1						2		2	4b	BB 2P
	10	to one starr	,	2	_			vf mig	itized	2 0		4	2 1				١,			4			1		2		DD ZF
	LS	tr gn clay	M(L)Bgy	3	WS	fragmental?				2 8		1		1			2			_						5	
3835	LS		M(L)Bgy	3	WS	fragmental				15		2	1				?	?		?						4(3)-5	poor cuttings +30% cement cavings
3840	LS		M(L)Bgy	3	WS	fragmental				5 15		1		1	?				-		1		1			5	pyrite P
	LS arg	SH pyritic	M(L)Bgy	4	WPS	frag-skel(bryoz)				5 30		2 3	3				4	2	2	2 ′	1	?	?		3	3-4-5	BB oyster frag w/ qtz ooid = CAVE?
3850	LS		M(L)Bgy	4	W/PS	fragmental-skeletal		chalky?		5 20		1		1?	?	2				1			1			5	pyrite P
3855	LS-SH	8/2 v.pyritic	M(L)Bgy	4	WPS	frg-bryoderm-sponge				15		5 2	2 3		'	1	6	6	2	2 ′	1		1		?	4ab-3	tr oncoid? Tr glauconite in gy SH_pvritic (1st photo not select!) 2P
3860	LS	2%pyrSH tr gn clay	M(L)Bgy	4	W/PS	fragmental peloid		A1.5	1	10 20		5		?				1					1			5-4	Some peloid grainstone Ab5 - 3861m = 3415mTVD P
3865	LS	2% pyritic SH	M(L)Bgy	4	WPS	frag-bryozoan-skel(strom	tp)	Ab5	1?	20		2 4	4 6+			T	10	1	1						1	5-3	tr clear M-C calcspar P
3870	LS	2%pyrSH tr gn clay	M(L)Bgy	5	PS	fragmental-skeletal			2	30		2	?	1			3	3		1 1	1				1 ^{crust}	4-5a	Some M-VC ooid grainstones P
3875	LS	tr-2% DOLM F-M	LMBrn	4	PWS (gs)	(ooidGS) skel-strom-frq			8	20		5	10				3	1	5						2 1	5b (5d)	<10%M-C ooid GS w/ ?oncoid-rounded clasts 2P
3880	LS		L-MBGy	3	ws	fragmental			1	3 20					1?	2		1		1						5a-b	BB micropyrite P
	LS	2% C wt dolosp &5% calcsp	L-MBGy	4	PWS (gs)	frg-strom-skel (ooid GS)			10	25		2	7	1		1				1 .	1	1 2	22		2	5bd	?calcispheres? Tr G BB 10% ooid (superficial M-C GS patch M D (Px40) 4P
3890	LS	5%DOL F-M	L(M)Bgy	4	W/PS	fragmental-(skel-pel)	tr	interxtl	.0	5 20		1	1	1		1	1	1		1 .	1		1			5a	(BB)
3895	LS	5%DOL F-M	L(M)Bgy	4	WPS			IIICIAU	7_	20			15	1	1 1	e '		1		1			1		1:	5h	BB tr glauconite? 2P
	LS LS		. ,	4		stromtp-skel-frg (ooidGS)		intend CHC2	12	5 15		1	15		17	اا را				1 2			1	d	lasyclad	50	•
3900		DOLaa tr SSqtzvf	L(M)Bgy	3	WS	fragmental-(skeletal)		interxtl SHC?	1?	0 10		1			1.7	!		11	2	1 ?				1		5a	BB 5% porosity in dolomite P
	LS/DOL	2/8	L(M)Bgy	3	WS	fragmental (skeletal)	tr	tr interxtl		15		1	3			1		1		1					2		BB
3910	LS/DOL	6/4 VF-M	L(M)Bgy	3	WSxtI	fragmental		I/IIICD dol		1 20		1	1	1?				\perp								5	5% porosity and dolomite
3915	LS/DOL	1/9	L(M)Bgy	4	WPS	fragmental (skeletal)		interxtl dol		30		1 ?	2			?										5	BBB small cuttings
3920	LS/DOL	7/3 VF-M	LGyB	4	P/WS	fragmental XT L.	3	LSvug+interxtl		1 30				2				1		1			1	1?		5a	Stylolites P
3925	LS/DOL	8/2	L(M)Bgy	4	PWS?	fragmental (skeletal?)		& tr I S nn		20+			10?	1				2		2						5b?	BBB tiny cuttings minor dol+calc veinlets-fractures stylolitic
3930	LS/DOL	5/5	L(M)Bgy	5 4	F-PS	stromtp-frag-skel	6	& tr LS pp I/IIIBC3D2+		1 10	?	1	10	5 '	?	poro	us	1		1 1	1		1			5b	P
3935	DOL/LS	85/15	LGyBrn		XTL	VF-M xtI	6	I/IIIBC3D3						1?		1?		1									minor C clear calcspar P
	DOL	<10% LS	L(Gy)Bn		XT L.	VF M.	7	I/IIIBC3D4																			P
	DOL	<10% LS	L(Gy)Bn		XTL	VF-M(C)sub+anhedral		I(III)BC2D1+																			small cuttings tr XF pyrite dry&wet 2P
3950	LS	<5% DOL	L(M)Bgy	6	P-GS	frag-skel-(ooid Gs)		I(III)BOZBT	5	2 25		1	5	2	1			1		1 4	1					5h.a	micropyrite P
	LS/DOL	8/2 lighter color tr SS	LBGv	5 1	PS-FS	frag-stromtp-skel	1 2	D vugs	J	20			_	1?		1				1					1	5b-a	tr VF pyrite DOL F-C XTL w/ tr porosity tr-2% stz SS
3960	LS/DOL	9/1	,	4	P/WS	fragmental-chaetetid		interxtl dol		20	2			10	4	<u> </u>		2		, ,	1	2				5b	Stylolitic pyritic shale with crinoids SEQ' BREAK??
	LS/DOL		L(M)Bgy	4			1	interxti doi		20	- 1	10			- 1	1 .		2		!	1	!				50	, ,,
		9/1 tr SS	L(M)Bgy	6	G/PS	frag-stromtp-skel				40		1?	10			1		1		. 2	2				1	5b	tr argil stylolite pyritic tr 2% vf qtz SS calc 3P
3970	LS	<5% DOL, trSS F	L(M)Bgy	3	WS	fragmental-(skeletal)				15		1	1?			\perp	1	?		1 1	l					5b-a	
	LS	~5% DOL	L(M)Bgy	5 4	PS-FS	frag-stromtp (ooid GS)			25	25	5?	? 2	2 15			1		2	2	3 ?			1		2 1	5bd	2P
3980	LS	5% DOL tr SSqtzC-M	L(M)Bgy	5	W/P+GS	frag (ooid-skel GS)	tr	interxtl	10	20		5	?	1				?		2			1			4- <mark>5</mark> ad	(BB) ooids quartz centered.
3985	LS	tr qtz SS aa	L(M)Bgy		WPS	frg-stromtp (tr ooid GS)			3	20		2	20	1	1	3 1	+	3	1							5b	P
3990	LS/DOL	9/1 trSSqtzM	L(M)Bgy	5	W/P+GS	frag-chaet (ooid GS)	1-2	interxtl	6	25		3	1	10		1	1	1	1	3 ?			1	1		5b	Micropyrite ooid grainstone & bivalve wackestone strom w/ astrothizae P
3995	LS/DOL	9/1	L Gy+Bn	5 4	PS-FS	stromtp-spg-skel-frag	3	interxtl			1	10	20	2		1		3	2	2	1		3 . 3		3 2?	5b	lig LS ctgs & smaller dolm ctgs - 1cm chip = stromatop w. boring partly dc 8PI
4000	DOL/LS	8/2 Ab4	VLGv	4	xtl FS	milleprd-chaet	5	I/IIICD4+				1	1	3	3		1			?			1 191	n olavit		5	Large chips of limestone fossils Abd 2005m = 2540m TVD P. & P.
	DOL/LS	8/2 - darker	LGy+B		xtl FS	stromtp-skel		IB2C2D1+				3	15	1		3			1	1	1		1			5b	Large chips of limestone fossils tr XF pyrite Ab4 - 3995m = 3540mTVD P. & P. 4P
	DOL/LS	9/1, tr pyr SH	VLGy	4	xtl FS	sponge-stromtp ??	4	I/IIICD3+				2 .	1 2			1			1	1	1		1			5b	Tr pyrite Large chips of limestone fossils
		LS ~5% MBn	VLGyB+B		XTL			I/IIIC5D5+				_	2				?										C clear saddle dolm cement 4P
	DOL (LO)	<5%LS	VLGyB+B VLGyB		XTL	F-VC	15					1	1	1													tr pyrite an-euhedral rhombs P
	DOL	<3% LS fossils	VLGyB		XTL	F-C(VC)		!/!!!B2C7D4+				1	1					1		1							
			,																	- 1							1,
	DOL	<3%LS (cave?)	VLGyB		XTL	F-VC	7	I/IIIC3D4						1		1 11											tr pyrite an-euhedral rhombs
	DOL		VLGyB		XTL	F-C(VC)																					tr pyrite an-euhedral rhombs tr clear C calcspar
	DOL	<3%LS (cave?)	VLGyB		XTL	F-VC	7	I/IIIC3D4										1	1								tr pyrite an-euhedral rhombs
	DOL	<1%LS (cave?)	VLGyB		XTL	F-VC		I/IIIB2C7D4					1														tr pyrite an-euhedral rhombs VC-XC clear-wt saddle dolm wet + dry 2P
	DOL	<1%LS (cave?)	VLGyB		XTL	F-VC	10	I/IIIB2C4D3+																			tr pyrite an-euhedral rhombs (Px16) 4P
TD 4046.3m																											
Α	В	С	D		G	Н	ı	J	K	L M	N C) P	Q	R	S	T	V	W X	ΥZ	AA AI	ВАС	AD A	AE AF	AF AH	Al AJ	AK	AL AM AN AO AP AQ
		EACIES NUMBER	DQ: 1-hath	val ob	ale 2-norit	ic shale, 3=forereef-chanr	nel 2	A = foresions ab	annol	30- 4	lietal f	oreolo	ne /~	nicrob	ial m	d marr	24) 3	R= provi	mal fo	racion	ne /fc	rerec	f) 4-	enone	e reofol		
						, 4B= 'shallow' siliceous sp																	.,, 4-	spung	ic recidi	,	
						pelleted; 5D=oolitic, 5E= o																	arsho	re rida	e)		
						ixed carbonate-deltaic, 10																oi (116	ا ا ا د ا د	riug	○ <i>)</i> ,		
		o ocasiai acitale	\.agoona=0	J. 10116	,, 5-111	our boriato-doitaio, 10	acı		J_L		I	·aiiai		an Z	JUE 10		J. 10110	. and 46	Land								

	Enclos	<u>ure A3.22</u> Pa	nCanad	lian		Panuke PP-3C	(J-	99)	_			ulting	g Ind	С	L.Eliuk P.G	eol.	Infil	l-final 2	004-11			TYPE 78'88		PAGE
DEPTH	LITH	modifier I	COLOR		DUNHAM		POF	ROSITY		SSORI				ı	FOSSILS (e	nhanc	ed by	SWC da	ata if avai	ilable)		-ACIES		COMMENTS
(metres)	T DOL: H SH=S O SS=S L arg=a O calc=	mestone =dolomite shale sandstone ST=siltstone arcalcareous sandy/qtz	ABBREVIATE D	DUNHAM NUMBER ms-bs left fs&rs(bs) right	WS=w PS=pa GS=gi BS=bo (FS/R: FS=flo RS=ru	audstone 1 acackestone 3 rainstone 7 rainstone 9 S=XC size) atattone 4 ddstone 8 crystalline	%	modifier (Archie)	Sdioo	M PARTICLE	SPONGES	- WT SPONGES	STROMATOPOROI	CHAETETID		CRI	GASTROPOD	OST	DT.	BORINGS HIGHER-green	STROMATOLI	STANDARD MICROF		additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen P = photo AL
Aber	aki VII	- 3663m (318	2mTVD)			red depths - highly d			700MD	= 3210	TVD	(390	m d	iff) a	and 4125 M	D = 36	00 T	VD (525	diff)				er ma	arkers in vials,
		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	,				,,,,,,	J = 2			Ť	of I	_ T		1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			Ė				<u> </u>		- tray 3700-3740 Small dusty cuttings
3705	SH/LS SH SH	85/15 dusty BBB <5%LS	D(B)Gy D(B)Gy D(B)Gy		FS/WS	Sponge (85% SH)			Н		20				Ш	?	П	?	?	Ш		2	2	LS - MBn (15%) SAMPLES BIT BRUISED (BB) - LIGHTER P COLOR AND CHALKIER THAN ACTUAL;
3715	SH	dusty BBB	D(B)Gy			Δb	ona	ki VI - 37	14m (2226m	TVE	<u> </u>	_									2		SAMPLES OFTEN VERY SMALL MAKING ID DIFFICULT
	SH SH/LS	<10%LS 8/2 arg LS	D(B)Gy			LAD	CIIA	KI VI - 31	14111 (1 1	TVL		_									2 + 3	2	
-	SH/LS	7/3 tr chert	D(B)Gy D(B)Gy	3	ws	?frag-skel?				15	5											2 &		tr blue-cream chert
	SH/LS	5/5 calc/arg	D(B)Gy	2	WS-MS					?	2											2 &		tr micropyrite OCC' TRACES OF PINK orange DOLM IN WHOLE SECTION
3740	LSarg	& SH 10%	D(B)Gy	3	ws	frag-sponge?				10	7?		?			1							4?	. Small cuttings
3745 3750	LS/DOL LS/DOL	7/3 6/4 cl F-M calcite	DBGy DMBGy	3	4 FS-WS	Stromatop-skel skel-frag?	??	Log??	2	5	4		10	\perp	1	11		1 1		Щ.	$\perp \perp$	4-5	4-5a	
3755	LS/DOL	6/4 CI F-IVI CAICILE	DMBGy	3	WS	?frag-skel?		interxtl-B]] 3	10	2		?	chec	k if DOL = s	iderite	??? L	ikeliest r	nd-dk xf t	brwn do	olomite			3745 >> 40% casing? Cement Question porosity on logs orange ?chert Small cuttings = IDs difficult DOL aa
3760	LS/DOL	8/2 F gtz sandy		3	ws	frag-skel (sandy)	1	IIIICIXII-D		3 10	2	1+	1+		?			-						3755+60 >> 20% casing cement 2P
3765	LS/DOL	85/15?	LM(B)Gy	3	ws	skel (sponge)					6		2		?				1	?	calcisphe	rez	4	
3770	LS	tr G/chlort tr cher	LM(B)Gy	4	WPS	atromtp-skel-frg				5 15	3		6		1? 1	? ?)	2 1			5	5b-	3	tr green mineral=G? Pyritic fossils 2P
	LS		LM(B)Gy	3	4 F-WS	skel-framebuilders				2 6	4		8	3	4	?		1 1	1		?		5b	copper ('Cu') grn pyritic caly Pyrite
3780	LS	tr G/chlorite	LM(B)Gy	3	4 F-WS	skel-framebuilders				5 7	5 20	icritic	10		2	?		2+	2		5? crusts	5b	(=1.)	tr G (x16)3P
	LS LS	tr C tr obst tr ody	LM(B)Gy	5	4 F(P)S	spong-stromtp-skel				5 25	5	1 1	10		2	1		1	1 ? 1		5?	4b 5b(4)		Cu gm & blue cement (?silicified) tr G 4P
	LS LS	tr G tr chrt tr sdy	LM(B)Gy	5	4 F(P)S 4 F(P)S	stromtp-skel-frag stromtp-spong-skel				2 5	10		15	1	microso	leŋid		1 1	pyritized		2	5D(4)	,	Cu gn tr Tr pyrite
	LS	gtz silty/sdy	LM(B)Gy	3	4 FWS	stromtp-skel-coral?			1 1	5	1.0		13	1				1 1				5b	JD	P
	LS	7% SS qtz VF-F	LM(B)Gy	5	4 F(P)S	stromtp-spong-skel				5	10	miçriti	15	1	5?	1		6	1 1		1		5b	Cu gn tr Tr pyrite P
3810	LS		LM(B)Gy	1	4 FMS	stromtp-spong				5	11		9		1?	2						5b		P
	LS	5% SS qtz VF-F	. , ,	5	4 F(P)S		1?	interxtl-B		5	10			3	4	2		2	1		1		5b	
	LS	.50/ 00 : 1/5 =	LM(B)Gy	5	4 FPS	stromtp-skel-frag				10	5			2	2 1	2		2			?	5b		4P
	LS LS	<5% SSqtzVF-F tr G tr micropytin		9	4 F(B)S 4 F(B)S	stromtp-skel-frag stromtp-spg-skel-frg				? 10 3 10	5 10		20 15	1	1 1? 1	1		10 3 1	1		5	Sh	5b	. Tr white chert. Stylolites
	LS	<5% SSqtzVF-F		9	4 F(B)S	stromtp-spg-skel-ing				5 10	10			6	3 ? 2			1 1			3	30	5b	. Large (+small) chaetetid cells VS bryozoans
	LS	570 CCQIE VI I	LM(B)Gy	5	4 FPS	spong-skel-frag				15	10		9		? ?			?	1			5b		2
	LS	<5% SSqtzF	LM(B)Gy	5	4 F(P)S	spong-chaet-stromtp	,			2 4	10		7	6	2?	?	·	1	?				5b	P.
	LS	tr G	LM(B)Gy	9	8 BRS-PS	stromatoporoid-skel			?	2 5	5	:	30		microsol	119		?	1			5b		3P
3855	LS	TINY CUTTINGS			?	???	tr	interxtl-B			?		?									1	5?	very small cuttings
3860	LS	TINY CUTTINGS			?	?? Mottled				10	١,		٦.			X	11,					5?	4/51-	P
3865 3870	LS/DOL	8/2 VF Bn DOL 5/5 VF Bn DOL	MLBGy MLBGv	4	xtl WS	frag-skel(spg-strmtp)		1+	5 10 10	3		5	2	1?	4		·	1			5ah	4/50	minor SSqtzVF-F (cave?)
	DOL/LS	7/3 AA	DMBn	3		sponge-skel	tr?	interstl	1 1	10	10		5	1		1			2 1			Jab	4/5b	P.
	DOL/LS	7/3 AA	DMBn			skel-frag-(pel-ooid)			6	5 10 .	5, 5		7		1 ?	?		2 1	1			5ba	., 5.5	tr F round gtz dolm mainly XF/MS but tr IIIAF-M 3P
3885	LS/DOL	/SS 7/2/1	DMBn	9		chaet-stromtp-skel	tr?	interstl		5 3	no 6		9	12	? ?			1					5b	~10% SSqtzVF-F
	LS/DOL	<mark>/SS</mark> 6/3/1	DMBn	.	4 FS xtl	skel-frag			3	4 10	3	3	5		1?	3			1		2	5a(b))	2P
3895	LS/DOL	/SS 50/35/15	L+DGyB	5		skel-frag-ooid	?		7	10	5	5	2	2	1	2	2							F-M qtz SS, ooids M-C, micropyrite
3900	LS/DOL	/SS 6/3/1	L+DGyB	5	XTL-PS	skel-frag-(ooid)			5?55	10	3	8	4		2	1		1	1			5bd		VF-F coated/oolitic SS 4P



Enc	losure A	3.23a PetroCa	nada <u>Penc</u>			set	GeoTours				.El <u>iu</u> k	P.Ged	ol. Upp	per tops	et be	ds re	logge	ed 2011	-11					2 8 8	PAGE	
DEPTH	LITH	modifier I	COLOR	TEXTURI	modifier	POR	OSITY	ACCE:					F	FOSSIL	s	(€	enhan	nced by S	SWC da	<mark>ta if</mark> av	ailable)			3 TYPE K'78'88 K 2002	COMMENTS	
(feet) T=trip	LS=limesto DOL=doloi SH=shale SS=sands SLTST=sil arg=argilla calc=calca sdy= sand	mite tone Itstone aceous areous	ABBREVIATED or MUNSELL	HAM NUMBERs left fs&rs(bs) right left fs&rs(bs) right left fs&rs(bs) right left left fs&rs(bs) right left left left left left left left lef	S=mudstone 1 S=wackestone 3 S=yackstone 5 S=grainstone 7 S=boundstone 9 S/RS=XC size) I=floatstone 4 S=rudstone 8 L =crystalline	%	modifier (Archie)	SGIOO	PARTICLES	ASTS	SPONGES SPONGES	WT SPONGES' BY STROMATOPOROID- C	CHAETETIDS D MILLEPORID B	hydrozan-OTHER © MICROSOLENIDS	HEXACORALS	BRYOZOANS	CRINOIDS	ECHINOIDS GASTROPODS	BIVALVES OSTRACODS	SERPULIDS TUBIPHYTES etc	FORAMINIFERA	een etc	STROMATOLITES THEOMBOLITES THEO	STANDARD MICROFACIES lugel'82&Wilson'75&Eliu Wierzbicki, Harland&Eliul	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen	
Α	В	С	D		Н	I	J	К				PQ											Al AJ	J 00 LL /	AL	
A 44400	В	C	D	G	i H		J	K	L M	N	0	P Q	R	S	Т	V V	N X	YZ	AA AB	AC AI) AE AI	AH	Al AJ	AF	K AL AM AN AO AP A	AQ
11100 11110		NOTE depth is at base of cuttings 10' interval	CAVINGS C	QUITE BA	D WHEN COMP	ARED	TO																			
11120		or outlings to intorval	LITHOLOGI	C CHAN	GES ON WIRELIN	E LO	GS: EVEN																		Logging began 2011-11-24 to 2012-12-06	
11130					SHALE INTERVAL		,																		amended about 2012-02-04 plot XL	
11140 11150			CARDONA	1 L 11 V 1 O 3	JIIALL IIVI LIVVAL																					
11160	SS-SLT/SH 7	I 7/3 noncalc	VLGy-Mgy(Bn)	ss	sub ang Rd VF-F		NVP disag												1+					5f	tr shelly LS md brn minor black coal/lignite = cave?	2P
11170	SH-SS	5/5?	MdGy-VLGy		SS AA finer & siltst																			5f	sh= silty & sdy, tr loose ang qtz granules 2mm,	2P
	LS-Ca <mark>lcSS</mark>	SH&SS = cave-lag	Md GyBn		sd skel-frg-oncoid				10							1	?	1?	6		1		5?			3P
	LS sdy? LS sdy?	SH&SS = cave-lag	MdGyBn MdLtBn(Gy)	?WS					10°			2	-		12		1		5					5ab	,	1P 3P
	LS suy? LS	FM superficial ooids	Md(Bn)Gy		VG) ooid-skel-frg			45	10			3	4		1 !	1	1		4 1		1		3	5d		2P
	LS	FM(C) ooids	MdLtBn(Gy)	GPS				35	20			2	1.1			1?	1		2				3	(5d)		3P
11230	LS XX	V Bad SH cave	LtBn	PS	Frg-bivalve (cave?	?)		10?	30)									10						bad SH cave	1P
	LS XX	V Bad SH cave		PGS				40?	20)														5d		1P
	no spl	Core #1 LS			+FS ooid-skel			25					10		3									5bd	see core photos & description	
	no spl LS	Core#1 LS f-M-C ooids	:t <dgu&bn< td=""><td>PGS</td><td>FFS ooid_skel</td><td></td><td></td><td>70 70</td><td></td><td></td><td></td><td>!</td><td></td><td></td><td></td><td></td><td></td><td>7</td><td>1</td><td></td><td>1</td><td>7</td><td></td><td>5d 5d</td><td>ooid shoal w chaetetids+belemnites oids often dk gy vs paler mtx</td><td>3P</td></dgu&bn<>	PGS	FFS ooid_skel			70 70				!						7	1		1	7		5d 5d	ooid shoal w chaetetids+belemnites oids often dk gy vs paler mtx	3P
	LS	Fsof t& M-C ooids	LtMd Bn		PS ooid-frg (soft?)			45	15	5		? 3						1	2 1	1	2	1	1	5d		8P
11290	LS	clear bn spar=coral?	MdLtBn(Gy)	FBR	S strom-coral-chaet	etid		5	10)		3 20	6+		7?		2		4		1 1			5b	lots clear brn spar= srrom&chaet&cor? Malachite stain 10	0P
	LS-SH	8/2Sh DkGy (LS cave?)	MdGy& MdBn		FWS ooid + skel-strom			15	10			1 10	-			2	3		5		1			5b(d)		6P
	SS sdyLS	7/3 also Sh Coal	LtGy (rusty)	SSvi	F-M sdy fos LS (FWS)			3	8			5	1		1?	1			3			1?	1	5a		4P
11320 11330	SS SS	F-VC LS cave ool+skel M-C qttz	VLt Gy	SS F	sub ang-rd if C			2?				1							3					5f 5f		3P 2P
	SS	F-C qtz	V LtGy	SS F								1												5f		2P
	SS	F-C (VC) qtz	VLt Gy	SS F								1ei	ncrust					1	1-inoce	ramids	?			5f		3P
11360	SS		VLtGy	SS F	-c																			5f		3P
11370	SS		LtGy (rusty)	SS F																				5f		2P
11380	<mark>SS Sh</mark>	8/2 trXC qrz cmt=Frc?	LtGy+MdGy		-C & Sh gy																			5f		2P
11390	SS Sh	7/3	LtGy+MdGy		-C & Sh gy																			5f		3P
11400	SS Sh	6/4 LS coal cave?	LtGy+MdGy		-C & Sh gy							2	2								1 enc	rust?		5f	F	4P
11410	SS Sh LS SS ShLS	5/3/2 XC sil Frc fill 4/4/2?? F-VCdk ooids	VLtGy	SS F				2				2	1		1				1					5f 5f	,, 55 5	5P 5P
11420	SH SS	5/5?	Lt Gy Bn & MdGy MdGy & LtGy		SS tr skel LS	və I		4				1												OT .		3P
	LS-logs	arg LS bad cave Sh-SS		FPS	skel frg				15	5		2	2		2				2							3P
	LS	small ctgs & cave	MLtGyBn	WPS				15	15			1?							1					(5d)		4P
11460		ooids VF-C	LtGyBn	G+PS	ood			70				1?						1	3		1	1		5d	no? Qtz nucleii? Prolate F-M 1-2 layer cortices	3P
11470			ML Gy+LtBn	GPS				60	10	10rd			2						3			1?	1	5d		5P
11480 11490		sparse M ooids M-C ooids	MLGyBn LMBn&Mgy	FWPS GPS				10 70	15 5			7 5 1 2	1?		2						1	2?		5abd 5d		7P
11500		F-M(C) ooids +F peloids		GPS	ooid ooid-peloid				20 5			1 2	2						2 3 1			?		5d	dark & light oolite all light oolite F=M(C) tr pyrite	4P 6P
11510		peloid vf-m, ooidF-M	LtBn	PGW			tr SHC?	15 2				3 3			?				3 1		1	?	1	5ad		7P
11520	LS	ooid F-M(C) rd Frg	LtBn	GPS	frg-ooid-skel(chae	tid)		20	5 25	5		2	10		?			2	3		1			5b(d)	11	1P
11530		tr f-m qtz tr dolomite xtl			+W ooid & pel-skel			45 1					5		1			1	5 1		3milio	lid?		5d		8P
11540		vf-C(vc) ooids & rd clast		GPS				55 1					2		2	1		1	3 1	1?	2	?		5d		8P
11550 11560			LMBn LMBn	GPS PS&	ooid WS ooid/frg & frg/pel			20 5	52 15	10rd		2 2? 2			?	1			1		1	12		5d (5d)	some loose ooids? more lithoclasts?less oolitic & muddier? Tr QTZ M	5P 8P
1		i -iii-o oolus, solile loose		I 1.54	colding a ligiper	I	I	2010	· 10	11014	' '	-	1 1	1 1	H	١.	l	1 1	I , I	1 1	1 1	11 ' '	I	(ou)	more manocasto: 1035 contito a madalor: 11 Q12 W	٠. ا

A 11570 LS 11580 LS	S	F.M i-i-							L			OIF		R S	5 T					AA AE	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				J Ar	`	AL	
11580 L		F-M ooids	LMBn	G(P)S	ooid			70		5	ird								2	3			1		50	d	uniform F-M ooid GSs rarer lithoclasts tr micropyrite	6P
	S	F-M-VC ooids	LMBn	G(P)S	ooid-rd lithoclast			70		8	rd				1		1	?	1	3		1	1		50	d	weird wt forms cri/anhyd??PX40 TR QTZ	7P
11590 LS	S	F-M-(C) ooids	LMBn	G(P)S	ooid	tr	cl ang calcXC	65	5		3		3		see P?	1				3		1	see	P? 1	50	d	check foosil in Ig chip P X40etc	6P
11600 LS	S	F-M ooids	LMBn		ooid-peloid	tr	vug cl calcXC	50	10	5			2	2						2		1			50	d	NOTE ooids often superficial=one coat but nucleiii V ^	5P
11610 LS	S	F-M ooids & rd lithoclas	LMBn	GPS	ooid-frg-peloid			40	15	10 5	ird		2	1											50	d	AAweird wt forms after ?anhyd?	6P
11620 LS	S	F-M(C) ooids & rd frg	LMBn	GPWS	ooid-frg- clast	tr	cl spar	30	10	15	5		1		1?	1			1?	4 1		1		2	? 5 d	i-	·	6P
11630 LS	S	f-M frg round-ooid black	LMBn	WP+MWs	rd frg-ooid-pel			20	10	20		1	1?							3 2					(50	d)	tr F qtx in lst, Sh cave	4P
11640 LS	S	F-C ooid/rd frg+clastXC	LMBn	GP+WS	rd frg-ooid-pel			25	15	15 1	10	1	1		?					4 1		1		2	(50	d)		6P
11650 LS	S	comp ooid?! BEST EG	LMBn	G(P)	ooid (F)MVC			70		3	3		1?	1	1?	1nu	cleus		1?	2 1		1		1	50	d	Loose complex ooid/rd miniclasts Skel&DK&rareQTZ nucleii	8P
11660 LS	S	vf-C ooids, pel vf-f	MLBn	GPWS	ooid-frg-peloid			40	8	15	2		1	2	1				1?	3 1		1	13	2	5 d	d	chaetetid or algae at 40X; many loose ooids	7P
11670 LS	S	vf-C ooids, pel vf-f	MLBn	GPS	ooid & peloid-clast	tr	cl calcspar V	45	20	10	0rd		1	1		1		1		3 2		1		1	50	d	many loose ooids	8P
11680 LS	S	vf-C ooids, pel vf-f	MdGyBn	GPS	ooid-rd frg/peloid			60			rd			1				1		2					50		mostly loose ooids darker ?Favereina fecal pellet	4P
11690 LS	S	vf-M(C) ooids, pel vf-f	MdGyBn	GPwS	ooid-rd frg/peloid			25	25	25rd	3		1							2 1		1			5d	i-	loose ooids, rounded particles F-VC	4P
11700 LS	S	POOR SAMPLE CAVE	MdBn		frg-peloid (ooid)			8	20	30			1?					2									VERY bad shale cave (tr wt weird ^?fabric)	2P
11710 LS	S	POOR SAMPLE CAVE	MdBn		peloid frag (ooid)			5dk	25	25		1	2	1				1		1		1		5			dk pyritic VC ooids; grumulous 'microb' thromb texture	4P
11720 LS	S	Sh Cave	MdBn	(P)WMS	frag-peloid			3		20			1	1	1?					3 2		1						3P
11730 Sh	n on log	still LS mostly	DK Gy+MDGyBn	SH+WMS					10	15		1	2		1?		1?			2 1	1onS	H 1					shelly SH chip 2P	5P
11740 SH	H-SS <mark>log</mark>	still LS mostly w Sh	? Dk Gy Sh	AA SS?	tr VF-F qtzSS calc															1 1							LIKELY NOT REPRESENTATIVE=CAVE?? stylolite	2P
		still LS mostly lessSh			tr VF-F qtzSS calc								1	1				1		1							LIKELY NOT REPRESENTATIVE=CAVE??	1P
		· /	wt & mdGy		fossil-calc			10				2	1		1?					2 1		1					tr qtz sandy ool. pyrite in SS and as 'pel'masses	3P
		calc VF-F-M(C) frg-skel	wt-LtBn & mdGy		fossil-calc WPS			3	3	10		1	2							2 1		1					skel-rich SS tr pyrite	4P
		· /	wt-LtBn & mdGy	SH-SS	fossil-calc WPS			7						1						1		1						3P
11790 S		` '	wt-LtBn & mdGy	SS-LS	fossil-calc WPS			10		5			1					1		1		2	1	1			F sdy SH	7P
11800 SI	HqtzSS	calc VF-F(M) -ool-frg	MdGyWtMdBn	SH-SS-LS	ooid-rd frg			20		5			1							1				1	(5c	,	qtz sdy LS ool w qtz nucleii	3P
		SdyLS ooid f-m(C)	MdBn LtGy	sdyGPS				40		15rd			2					1		2					50		qtz sdy LS ool w qtz nucleii	5P
11820 LS		ooid-rd Frg F-M-C	MLBn		ooid-frg-peloid			20		25		1	2		1?			1		2 1			1 13	?	5d		stylolites	3P
11830 LS		rd frg F-C	MLBn		frg (ooid supeficial_	tr	VC calcspar	10		20 3	rd		4	2	2	1		1		2 2					5a	a		6P
11840 LS		frg skel peloid vf-F-C+	MdBn		frg-peloid-skel				15			1	7					1		3	1	1					tr XF pyrite	7'
11850 LS	_	ooid cave?	MLBn		frg-skel-stromatopoi	SPG		?	5	25	- :	2	8		??			1		2			1		5b		pyritic hexactinellid>:strom?encrusted X40	7P
11860 LS		frag vf-m	MLBn		frg (pel) framebldr			5		20		1	9	1	2	1		1		2 1	1	1			5b			7P
11870 LS		VF-Msftpel & GS frg	MLBN& LtGy		frg (pel)strom' throm	ıb?		2?		25			8	2 1		1			1	2 1	1	?		8? 1	5b	b	LGy M(G)S>peloid/grumulous=microb-thromboid??	11P
11880 LS			Lgy & MLBn		(pel) frg-skel			2?		15			3	1						1				3?			tr ooid (cave?) throm/microb=peloiid	6P
11890 LS		-	MLGyBn		frag skel			4?		25		2		4	1?			2		2 1				1?	5a		ooid GS cave?	4P
11900 LS			MdBn LtGy		strom-coral-frag			8	6	35		1 1	15	2	1? 5		:	2		2 1		1	1	4?	5b		ooid GS cave? tr micropyrite Thromb-microb cavity w Pe	8P
			MDgyBn&gy		strom-sponge-skel/f	rg		3	5	20	- 1	8	15	1	2		;	3		4		1	1	6?	5b		micropyrite in stromatoporid boring Microb-Thromb pel	8P
	_	drill mat?? Small ctgs	MDGyBn		frg skel(frmblr)				3	15			2	3	2	1	:	2		2				4?	5a		tr ?calcisphere in MS	5P
11930 LS	_	ooids F-M-C(VC)	LtGyBn		Ooid + pel-frg			65		8rd			1	1					2	3			1		50		some grey ooids Micropyritic	6P
11940 LS		cave? Eg=lg crinoid in s	LtMdGyBn		ooid & Mscave?			35?		15?	_		3	1	1?		1	?		2					5a		ooids & similar liths to above = cave?	5P
11950 LS			MdGyBn		ooid + strom'-skel			15		5			20		2			2		2 1		1			5b(1lg bryozona in sh= cave, stromatoporoiid FRS	8P
11960 LS	_		LtMdGyBn		ooid+skel-strom-frg			45		10			12	-	? 5			1		4 1	?			2?	5b		skeletal nucleii eg bryozoa crinoid	5P
11970 LS		F-C ooid/frag	LtMdGyBn		ooid-frag-skel			15		25rd			3	2	1	1		1	1	2 1		1			5a(often darker rd particles	5P
11980 LS	_		LtMdGyBn		frag-skel (pel.ooid)			10		20			4	1	2			1		3 2				2	(pyrite	3P
		some VF-f qtz sdy	LtMdGyBn		frg-skel-ooid-pel			12		30			8		2			1		4 2		1			5b(VF-M oooids/rd frag to VC	3P
12000 LS			LtMdGyBn		frg-skel-ooid-pel			7	5	25	1		5		2					2	_	1			5a		skeletal nucleii eg coral	6P
12010 LS		qtz M SS cave?	MGy & MLBn		frg-skel			2		45		7	2		?	1		1		1 1	?	1		?	5a	а	F-VC particles often rounded many dark	6P
12020 LS	_	sl sdy	LtMdGyBn		fragmental					40		,	1					1		1							Is a #0 VE E at a still a second	2P
		80%LS Sh 15-20%	MdDkGY +LMBnGy		fossiliferous-frag			45		?40		1	2					1	1	<u> </u>					/-	-J\	lag off? XF-F qtz sst increases dwnwd Main-GPSFrag	3P
		85%LS Sh 15-20%	MdDkGY +LMBnGy		frag-ooid-skel???			15		35			7					1		4					(50	u)	mostly grainy LS cave or lag off??	3P
			LtGy + DkGy		(20%sdyfrgLS					10								1									20%VFsdygrainyLS	3P
			LtBnGy + DkGy	SSSHLS	frag-skel			_		20			2		1			1		1								42
			MdGyBn		frag -ooid-skel			8		30			2		2	40		1		2	. م ا	2		20	ļ.,,	'L-\	more shale (20%)than above??!!	2P
12080 LS		20%SH cave?	MdGyBn		frag-skel			F ca	ve	30		4 6	3					1		4	1	1		2?	5a(l		most ctgs small (lg=Cave??)	3P
12090 LS			MdGyBn		frag-skel			2cave		25		1 2	2 4		1?	1		1		1		1			5a(l	n)	adv. I. C. v. ad V.C. al. ata- anaira	5P
	S arg?sdy		MdGyBn		frag-skel				3	25		1 1	2			1		1		1							sdy LS w rd VC cl qtz grain	4P
12110 LS			MDDkGyBn	WS marl						15 20		<u> </u>						1		1							minor M polito payo	2P
12120 LS			MDDkGyBn	WS marl F						20		1 1	1 1					1		1							minor M oolite cave	3P
12130 LS			MDDkGyBn	WS marl						20		<u> </u>	1					2		1							log off or cove more freely they should 20 Maind for AA	4P
12140 5	hSilt on log hsltycalc C	AVEIS	MDDkGyBn DkMdBnGv		frag MARL?							1 1	1 1					2		1							lag off or cave more frag's than above?? Weird fos AA	3P
12150 5	nsitycaic C	AVE LO	DkMdBnGy DkMdBnGy		fossiliferous-frag?? fossiliferous-frag??							1 2	2					1		1								2P 2P
12160 151		-	DIMINUDITOR	iviai i				1	1	1 I			1 1			11	1 1	· I	1 1	.	1 1	1 1	11	1 1	1			41



PEX-Shell Penobscot L-30 Annotated Litholog (A.Essery)

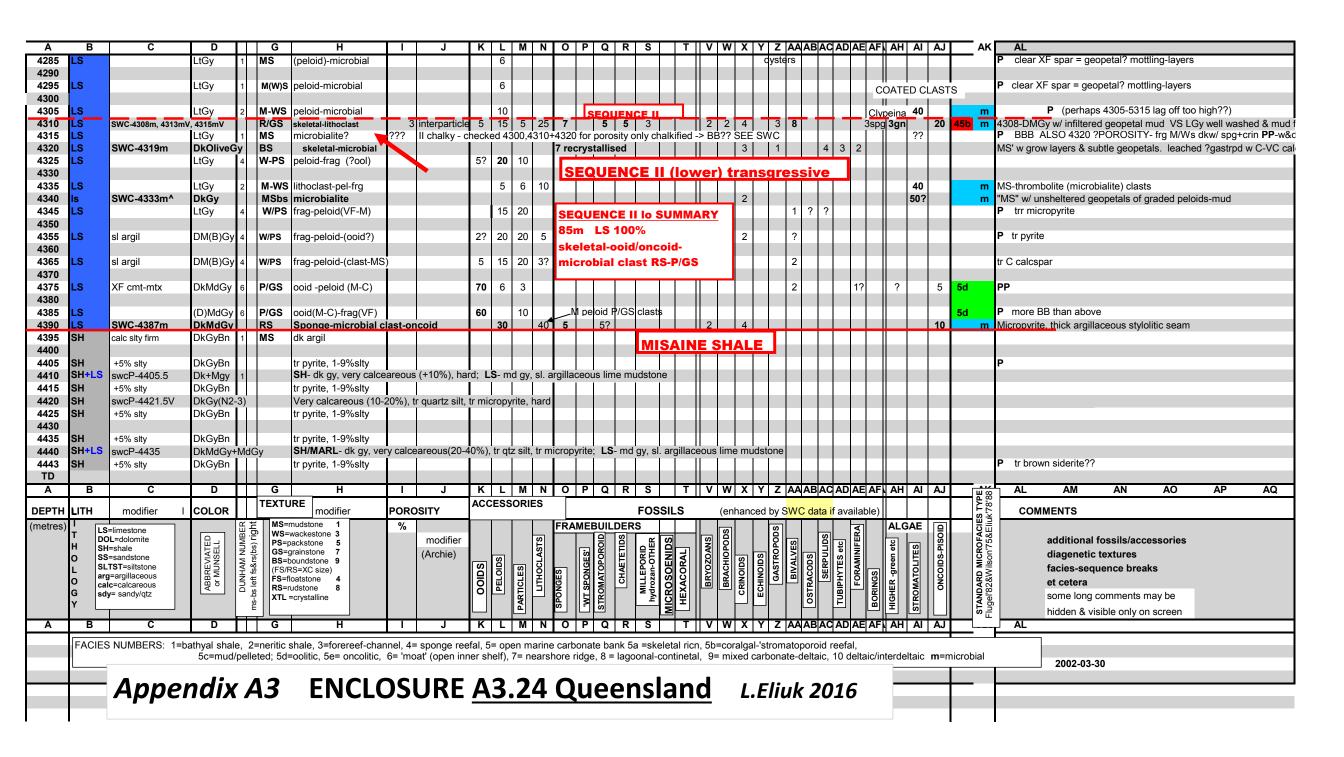
Lower section (12900'-TD) by L.Eliuk 2002- 04 LEGEND T = foram tubules, Tubiphytes, etc. P = photographs of cuttings MICROBIAL-PELOIDAL MUDSTONE (BOUNDSTONE) F = foram (miliolid) S = sponge CH = chaetetid (rare, coralline sponge) C = coral (rare, microsolenid) M = mollusc (bivalve or/+ gastropod) O = ostracod CHECKED CUTTINGS 12600 to TD B = bryozoan PHOTOS - 12620, 12680, 12740, 12800, 12860 MINOR LIMESTONE CAVE TO 10% IN SHALES ooids & gtz SST S C?microsolenid 4Pp pyrite in SS M bivalve CAVE ooid GS pyritic stylolitic siderite? SEE CORE 2 since all M? rextl gastropod LIMESTONES like It = PELOIDAL-: See Pp MICROBIAL BOUNDSTONE (BS) with CALCSPAR in MUDSTONE T10%F=miliolid (hence Essery's calcspar symbol in lime MUDSTONE (MS) texture) F=miliolid M? rextl gastropod and common presence of tubules but few/no macrofossils nor P framebuilders P T P siderite/sphalerite P TRIP (6 sity in tubule P prin calcspar -tr porosity in tubule " 2 P CORE 2 thrombolitic BS see photos & Jansa, Pratt+Dromart 1988 13285microbial LS, sub'emts & hard grounds sharp contact with slightly burrowed dark shale (#15 macrofossils) = dysaerobic? 13315 pyritic = hdgd? CAVE ooid GS F?=miliolid 1125 6' 2P+ brn calcspar T 5 138057 T5% B chaetetid T amber brn calcspar T2-3% 詽 3P CAVE ooid GS pyriitic sponge spicules Sponge wt granule of quartz XM Bryozoan wt P P . P CAVE limestone pyriitc chips as above 20-40% pyriitc chips Sponge wt **CAVE** limestone P as above 10-20% to TD P

P all shales Crinkly today P TSprep P **ENCLOSURE A3.23b Penobscot L-30 lower (slope-foresets)**

Encl	osure	A3.24 Pan	Canadian-Mu	rphy QUEENSLAND M-88 GeoTours Consulting Inc L.Eliuk P.Geol.	. ∀PE	PAGE
_		7 (0.12.1	TEXTU	IRE ACCESSORIES		
DEPTH	LITH	modifier I	COLOR DUNHA	M modifier POROSITY FOSSILS (enhanced by SWC data if available)	CIES	COMMENTS
(metres)	T DO H SH O SS L arg Cal	=limestone DL=dolomite l=shale =sandstone TST=siltstone =argillaceous lc=calcareous y= sandy/qtz	ABBREVIATED or MUNSELL DUNHAM NUMBE s left is&rs(bs) righ s 2	midistone 1 warestone 2 stranger 4 modifier BRYOZOANS BRACHIOPOBS BESTC size) loatstone 4 moditier GRINGIDS BRYOZOANS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOPOBS BRACHIOP	STANDARD MICROFACE Flugel'82&Wilson'75&E	additional fossils/accessories diagenetic textures facies-sequence breaks et cetera some long comments may be hidden & visible only on screen
Α	В	С	D G	H I J K L M N O P Q R S T V W X Y Z AAABACADAE AF AH AI AJ	AK	AL
3550						SAMPLES BADLY BIT BRUISED
3555	SH	sl silty, noncalc	DkGyBn	soft, tr muscovite, tr micropyrite, ?coaly flecks? SEQUENCE VII? Top 35m SS/SItS at 3420m		P = photo (BBB) - LIGHTER COLOR AND
3560 3565	SH	sl silty, noncalc	DkGyBn	soft, (tr SS qtz F-M = cave?)		CHALKIER THAN ACTUAL =BBB
3570	311	Si Siity, Horicaic	DKGybii	SWC - SideWall Cores		
3675	SH	sl silty, noncalc	DkGyBn	soft SWC - Sidewall Cores SWC= rotary drilled (SS & LS)		trip or increased siltst + F SS MdGy
3580	011	04	DO: D: DII:	swcP = percussion shots (SH)		P 50/50 soft, noncalc VS hard black (?noncalc)
3585 3590	SH	2types=AA+black	DGyB+BIK	noncalc, soft + hard (black) placed in interval if in 'even' depth or above (V = indicator down)		P 50/50 sort, noncaic VS hard black (?honcaic)
3595	SH	tr slt, sl calc	DMGyBn	or below (^ = indicator up)		P some striated = slicken-sided or bit bruised/crushed
3600		,				
3605	SH	8/2 as 2585m	DGyB+Blk	soft + hard AA		20% black to VDkGy AA
3610	еп	5/5 AA	DGyB+Blk	soft + hard AA, occasional pyrite		50/50 soft, noncalc VS hard black (?noncalc)
3615 3620	SH SSqtzF-M	SWC-3524mV	LBnGy(5YR6-7/1)	Qtz(sublith), sl calc-sil, pvritic SR-SA, F-Gsort, burrows w/shale fill, NVP		50/50 SOIL, HORCAIC VS HAID BLACK (PHONCAIC)
3625		F-VC qtz, 20%SLTS		. A-SR. P-Msort tr lintergranular		P 20% shaly siltst pyritic
3630		SWC-3527.8m		blith) to XC, sil cmt. 3-5 intergranular tr pyritic caly clasts, SA, F-Psort, burrows w/shale fill, NVP SEQUENCE VI?		
3635 3640	LS sdy SSVF-XC	20% sandy SWC-3529.5m^^	MdBnGy 5 GS/PS LBnGy(5YR6/1)	sponge-ooid-quartz 20 10 20 6	2 5d?	PPP Probably insitu sponges & allochthon's ooid-sandy lime PS/GS
3645		(SS cave?)	DkGyBn	soft.		P disintegrates when wet - swelling??
3650		SWC-3534m^^^	L(B)Gy(N6-7) (VF-V	C), sil cmt, (tr clayey) 2-4 intergranular SA-SR, F-Wsort (some clayey and microqtz matrix)		, ,
3655	SH		DkGyBn	soft,		disintegrates when wet - swelling??
3660	CLI		DI(C) Dr	SEQUENCE VI? - SUMMARY 165m		disintegrates when wat awalling 22
3665 3670	SH		DkGyBn	soft, SHALE 88%		disintegrates when wet - swelling??
3675	SH	2% silt	DkGyBn	soft, SANDSTONE 9% (near seq' top)		disintegrates when wet - swelling??
3680				LIMESTONE 3% (seq' top)		
3685	SH		DkGyBn	soft, LS = sandy-ooid-sponge G?PS		P disintegrates when wet - swelling??
3690						F. 1
3695	SH	2600	DkGyBn (EVD2/1)	soft,		disintegrates when wet - swelling??
3700 3705	SH SH	swcP-3696 tr SS XF-VF	DkGyBn (5YR3/1) DkGyBn	v.sl calc, miicromicaceous, soft (disintegrates when wet) soft,		
		swcP-3710		v.sl calc, 5% qtz silt, micromicaceous(biotite), soft (disintegrates when wet); few soft off-white silty patches = burrows?		
	SH	0.701	DkGyBn DkGyBn	soft,		
		swcP-3717.5+22	DkGyBn (5YR3/1to N2-3)	non-calc, tr qtzsilt, micromicaceous(biotite), soft (disintegrates when wet)		
3725	SH		DkGyBn	soft,		
		swcP-3730	DkGyBn (5YR3/1)	non-calc, tr qtz silt, micromicaceous(biotite), soft (disintegrates when wet)		la anno alla meta 00 ta 1/0 (0 anno 0)
		20%SS VF-Cqtz	, ,	soft, tr glauconite in SS		Increasing qtz SS to VC (?cave?)
3740 3745		SWC-3742.3mV watery', tr SS AA	DM(B)Gy(N4-5)	very soft = mud		Mush - very soft shale when wet
			DkGyBn + MdGy	laminated to v.thin bedded w/ silt-filled 2.5mm burrows; SH-non-calc, tr qtz silt, micromicaceous(biotite); SILTST quartz, sl. calc		

Α	В	С	D	l G	н П	J K L	MN	O P	QRS	TIVI	V X Y Z	AAABAC	ADIAEI AF I	AH A	AI AJ	AK	AL
3755		5% SS XF F aa	DkGyBn	++	soft,		 			+ + + + + + + + + + + + + + + + + + + +	++++						AA or aa = "As Above"
3760	SH =		DkGyBn (5	YR3/1)	v.sl calc, ~3% qtz sand XF-M	ounded dessimina	ed, micace	eous(VF-M	// biotite) soft (c	ı II I lisintegrates w	hen wet).						
3765			DkGyBn		soft,												TROMATOLITES =
3770		swcP-3762^+ 68			calcareous, (no silt?), tr micro	nicaceous(hiotite)	soft (disint	earates wi	hen wet so calc	content not ce	menting) la	minatd					obialites as shown by
3775		2% SS XF F aa	DkGyBn (c		soft.	incaccous(biotite),		l I	I I I					geo	petais,	borings,	etc.
3780	011	270 00 XI _I da	DROYDII		SOIT,										,		
3785	SH	calc, 4%slty	Dk(B)Gy		blocky, hard, micropyritic										7		P Lag in cuttings may be off by 5-10m high
3790	011	caic, 4703ity	DK(D)Cy		blocky, flard, filleropyflad												Lag in callings may be on by 8 Tom might
3795	SH/LS	6/4 SH AA	Dk(B)Gy	W/DC	frag-peloid	?10 20	25		SEQUEN	ICE V?							P LS - chalkified a+ bruised BB
3800		SWC-3802mV	DMBnGy		microbial-sponge NVP	10 20	33	20 - 2 to	/pes - eg Shuqraiop			2 5	2 5	2	20	4 m	Borings by bivalves (Gastrochaenolites) and ?worms (Trypanites?)
	-		DMGyBn				20	30 - 2 ty	rpes - eg Shuqralor	1515 !			3 3		27		P Microfragmental argillaceous LS (?microbial?)
3805	LS SH colo	argillaceous		WS	Frag(VF-M)	 5								,	· f	m?	P Microffagillerital argillaceous L3 (!fflicrobial!)
3810		swcP-3815-V	DkGyBn (5		calcareous, micromicaceous(b	iotite), tr XF-F qua	tz angular	grains									
3815		sl calc, <5%slty	DkBnGy							_ _	\perp						quartz silty
3820		swcP-3820	DkGyBn (5	YR3/1)	calcareous, (no silt?), micromi	caceous(biotite + n	iuscovite),	soft (disin	itegrates when v	wet so calc cor	ntent not cen	nenting))					
3825	SH	sl calc, sl slty AA	DkBnGy														quartz silty
3830						V? SUMMARY											
3835	SH	sl calc, 5% slty AA	DkBnGy		SHALE 71	% SA	NDSTO	NE 7% k	pasal beds								quartz silty
3840					LIMESTO	NE 21% top -	sponae-	microbi	al BS and	basal be	ds - ooid (G-PS					
3845		sl calc, 10%slty A	DkBnGy														quartz silty, sl lignitic flecks
3850	SH calc	swcP-3845	DkGyBn (5	YR3/1)	calcareous, (no silt?), tr micro	nicaceous(biotite),	with broke	n white ch	alky shell (?biva	alve), minor we	ell-cemented	quartz grains	s or vein, mir	nor pyr	ite patc	h	
3855	SH	calc, tr qtz slt	Dk(B)Gy		micromicaceous + tr pyritic												
3860	SH	swcP-3855	DkGyBn (5	YR3/1)	sl. calcareous, (no silt?), mino	micromicaceous(l	oiotite), mir	nor micorp	yrite, (disintegr	ates when wet)						
3865	SHslty	calc, 10%XF-VFq	DkGyBn		common VF pyrite												
3870					SEC	HENCE IV. CH	MMADV	455	CHALE 440/	(love 2/5)	CANDET	NIE 40/ ba	and bade				
3875	SH	10%slty LS	DkGyBn			UENCE IV SU				•							P TINY CUTTINGS
3880					L	MESTONE 55	% micro	obial MS	S-'BS' with	cap beds	= corallin	e sponge	BS				
3885	LS sdv	+10% XF-Fatz	DMGyBn	6 G/PS	Ooid(F-M)-sandy	40	10					<u> </u>					P TINY CUTTINGS!
3890	SS shly	SWC-3887.5m	Md(L)Gy(I		VF-F qtz w/ SH parting (thin la			A. Wsort.	SH - micropytii	ic. NVP	3?						
3895	,	~10% qtz sandy			sdy ooid + mud frag	10	20	2		1 1				?	2		P
3900	SH	swcP-3894.5^	V.DkGyBn		slnoncalcareous, (no silt?), n				rates when wet								
3905	LS	000 1.0	LM(B)Gv	·		BB chalky ??		7	l l					2	?		P (in 3910 SWC-UV-faint fluorescence in chaetetid borings) BE
3910		SWC-3910m	Md(B)Gy		coralline sponges NVP	BB chancy	10	5	20 30 3?			Ento	bia 10			5b-4	coralline sponges = stromatoporoids+chaetetids+milleporids
3915	LS	0110 0010111	LMBnGy			BB chalky			20 00 0.				10	?	2	-	P BBB
3920			LIVIDITO	. (**)		BB charky			SEQUEN	CE IV							
3925	10		LMBnGv	1 M/M/S	?microbial	BB chalky			SEGUEN	CL IV				50	0?	m2	P BBB
	LO	CMC 2022mV				,		4E 4				E E	15 5 2				
3930	LS LS	SWC-3932mV	Md(B)Gy		Tubiphytes-lithoclast (micro	BB chalky		15 4				5 5	15 5 ?		90	4 M	stylolitic, NVP, P large chalky cuttings BBB
3935		CMC 2020	LMBnGy	1 M(W)S				\Box									, , , , , , , , , , , , , , , , , , ,
3940		SWC-3939m	DkBnGy		microbialite? (peloid MS-PS				s w/ large cavit	es with unshe	tered geope	tals			50		NVP to trace in remnant unsheltered voids = stromatactis-like. Stylo
3945	LS	014/0 0054 5 14	LMBnGy		sponge (peloid)	/	6	15			- - -				?	4	P few chipe identified but 1/3 to 1/2 sponge BBB
3950		SWC-3954.5mV	DkBnGy	6 8 R/FS	skeletal-microbial -P/GS mt			9	8		5 5 ?	3 1	4 2 5spg		30	45b m	hollow spines. Tr XF dolomite rhombs. Edge of microbialite BS or I
3955	LS		L(M)Bgy	2 W/MS	(?microbial)	5	10?	4				1	1?	?	77		P ^^BS or lg microbialite clast -sponge bored
3960																	
3965	LS		L(M)Bgy	1 MS	microbialite?			?				1	?		0?		PP
3970		SWC-3967m	DkBnGy	1 9 BSms	, ,					;	3 ?	4	15 5		10		micropeloidal (WS-PS/GS) infested by tubules w/ algal/microbial coa
3975	LS		L(M)Bgy	1 MS	microbialite	4		2				1?	1?	5	50	m	P BBB All poor samples but some look microbial
3980																	
3985	LS		L(M)Bgy	1 MS		ıg calcsp 2		1?						5	50	m	P BBB
3990	SH	swcP-3995.5	V.DkGyBn (5YR2/1-N2)	noncalcareous, (no silt?), mind	r micromicaceous	biotite),										
3995	LS/SH	5/5 5%slty LSaa	D(M)BGy		microbialite(skel-pel)	5		1?		1whit	е			2	25	m	P interbedded SH & LS and both micropyritic
4000			• ` ´ ´		i i i												
	SH	noncalc, calc sity	D(M)BGy														
				5YR2/1-N2)	noncalcareous, (no silt?), mind	r micromicaceous	muscovite), thin tiny	spines or mine	la rods (spond	e spicules?	See photos)					
		noncalc, calc sity	D(M)BGy					,,y									P
7010	3.1	nonouio, caic sity	J(W) JOOY	1.1	1 1	I I	1 1 1	1		1 11 1	1 1 1	1 1 1 1					ľ'

																											E	
Α	В	C	D		G	Н ,			K L				Q		S									АН	AI A	<u> </u>	ΔK	AL
4020	SH	swcP-4018	V.DkGyBn (5YR2	/1)	noncalcareous, (no si	ılt?),sl. mıc	cromicaceo	ous(mus	COVIT	e), (art	etact-b	lack o-r	ing o	r soft p	lastic	trag c	t SWC	mech	anısm	i? See	photo	o)					
4025 4030	SH	noncalc, calcslty	D(M)BGy																									
4035	SH	hard pyritic	Blk-DGyB																									Basal shale - hard black pyritic
4040	SH	swcP-4039	Black			calcareous, pyritic(~5	-10%! XF-	-VF crvstal:	s). in co	ncen	trated	partche	es. hard	with	minor (l calca	reous	F-M atz	z SST	interb	ed							Basar share Thara black pyritio
4045	SHslty		Blk-DGyB			black SH->pyritic		I		1			1 1				Ш			1 1								PP 30% interbeds qtz SLTST-F SS (MdGy)
4050																												
4055	SS/LS	6/4 VF-Fqtz	MdGy(B)	4	M/PS	sdy pel-frag-microbial	i		15	10		1?						2	1			?	?		??			PP pyrite cmts SS, tr green = glauconite?
4060	LS slty	SWC-4063mV	DkBnGy	1 9 E	B/RS	microbialite-sponge	(micropel	loid'MS')	30			25					ÌТ	2		3		5			30 5	4		Stylolitic, Fracture? Tr XF-VF qtz in spg clasts
4065	LS	tr micropyrite	ML(B)Gy	1 I	M(W)S	peloid (microbial)			9			?	1					/			1				??			P bit bleached but not too chalky nor tiny BB
4070														2	<u>EQU</u>	EN	CE	<u> </u>	<u> J&L</u>)								
4075	LS	tr XF calcsp	LtGy-N6	1 N	MS	(peloid-microbial)			5				?									?	1		??		n?	ВВ
4080									_															1				
4085	LS		LtGy-N6	1	MS	(peloid-microbial)			/	<u> S</u>	EQU	ENCE	III S	<u>UMN</u>	<u>//ARY</u>	13	5m L	.IMES	STON	IE 10	0%				??			BB
4090 4095	LS	\/F agleon	LtGy-N6		MANANC	(peloid-microbial)			8	ш	mic	robial	MS-	BS'	with	cap	bed	s = s	pong	e-mi	crob	ial B	S		??		~2	P BB
4100	LS	VF calcsp	LIGY-IND	111	IAI(AA)2	(pelolu-microbial)			٥	-							П							4	: 1	-	111	
4105	LS	tr XF-VF calcsp	LtGy-N6	1 1	M(W)S	peloid (microbial)			5			?		do	licate l	hrano	hing					1	,		??		1	
4110	LS	SWC-4112mV	DkBnGy		B/FS	microbialite-coral	tr NV	/P	10			8		T			71111 <u>9</u> 3	7			4	2	1		50	5b	m	microbial-coral-foram-serpulid consortia
4115	LS	2% XF calcsp	LtGy-N6			peloid-microbial			8			2									1				50		m	
4120																												
4125	LS		LtGy-N6	1 N	MS				4																50		m	P
4130																												
4135	LS		LtGy-N6		M(W)S				9														?					
4140	LS	SWC-4142mV	DkGy			Microbialite (microp	eloid M-P	PS)	30								2	5				4	2		50			Geopetals in stylotlic clotted peloid fabric, tr pyrite
4145	LS		LtGy-N6	3 V	ws	peloid			20										3			?					n?	PP minor VF pyrite patches
4150 4155			L+Cv NG		W MC	peloid ?microbial			45	 (F-VF															50?		~2	ir miaranyrita. DD
4160	LS		LtGy-N6	2 1	VV-IVI S	pelolu illiciobiai			157	\r-vr														,	30 f			tr micropyrite BB
4165	LS		L(MB)Gy	1 1	MS	(peloid)			4																			BB
4170			L(IVID)Oy			(polola)																						
4175	LS		LtGy	1 N	MS		Tr? ?vu	ug-calcsp	3													nub	eculine	llid for	ams			P BB
4180	LS	SWC-4180m	MdGy	E	BS	Microbialite (microp												6			5	4			50		m	Varied geopetals in 'mud' VF pel'fabric w/ tubular area & burrows/bor
4185	LS		LtGy	1 N	MS				3							L				/								BB
4190				Щ												L	<u>seq</u>	<u>UEN</u>	CE	<u>II (t</u>	<u>ippe</u>	<u>er)</u>					Ц	
4195	LS		LtGy		MS				1																			BB
4200	LS LS	SWC-4199m	DkMdGy		B/R-FS	sponge	NVP		10			45 5			?			5								4		stylolitic. Sponges?=check if microsloenid corals???
4205	LS		LtGy	1 1	MS				5								Ш					Щ					ı	stylolitic BB
4210 4215	LS		LtGy	1	MS				1	SEC	QUEN	ICE II	up S	UMI	//ARY	<u>.</u> 11	5m	LIME	STOP	NE 10	00%							
4215			LiOy	11						mic	crobi	al MS	-'BS'	wit	h ca	p be	eds =	spon	ige B	B/RS								
4225	LS		LtGy	1 N	MS				1										<u> </u>									stylolitic, tr pyrite
4230			,																									
4235	LS	3% C-VC calcspa	LtGy	1 N	MS		tr? ?vu	ug?																				P tr C-VC calcspar = vug lining
4240	LS	SWC-4236.5m	DkMdGy	E	BSms	microbialite	NVP														1	1			??	1	n?	growth' lines in MS and mega-birdseyes, tr pyrite
4245	LS		LtGy	1 I	M(W)S	peloid			6																??		n?	
4250																												
	LS		LtGy	1 N	MS																				?			BBB bleached
4260									ľ																			D 20/ VE VE selector
4265	LS		LtGy	2	M-WS	peloid			8																40		m	P 2% XF-VF calcspar
4270 4275	LS	cmts??	LtGy	, ,	MS	(peloid)-microbial			3													pub	eculine	llid fo	rame			P tr pyrite, 2-4% XF-F calcspar
		SWC-4276m	LtMdGy			microbialite (peloid-	 -skeletal 'N	MS'-WS)	15			9						5			3	2	2		45		m	u pyrite, 2-4/0 Ai -i Calcapai
7200		5715 TE7011	aoy			si obiante (perola-	Cheretai I		13												1	-	-					



Appendix A3 ENCLOSURE A3.24 Indicator fossil occurrences L.Eliuk 2016

Survey of microsolenid corals and Tubiphytes et al. and Bryoderm/mol (5-10%) in Cuttings (core)

T+Tubiphytes or similar tubular forams etc.

see reference below on new name possibly for Tubiphytes

West Venture C-62 CORE ONLY

T thru out thrombolitic areas & upper spg beds (lots seprulids too)

DEBRITE bed - T w.spg, bryo, broken shell

South Desbarres O-76 CORE ONLY

no T noted BUT many reddened areas both massive and amongst fossils = sideritic-limonitic???

corals, bryozoa, large bivalves, lithistid sponges

Penobscot L-30 cuttings and core

Foreset=slope beds cuttings: microbialite/thrombolite thru out with T (ubiquitous 80-90% occurrence)

600'-700'- thick Annotated Essery log

minor bivalves - gastropods 3 or so, forams miliolid-like (usually shallow???)

Microsolenid corals possibility noted at top of foreset limestone-shale 12950"

?coral-spg top lst

1 chaetetid, 1 wt spg (& 1 in SH below), pyritic spg spicules, 1 wt bryozoan in basal 200' of LST

Core #2 - T common, serpulids submarine cmts w/ thrombolite/microbialite - part of Jansa et al. 1988 Tubiphytes nubecullenid forams, details on thrombolites

TOPSET oolitic beds --- no T noted chaetetids common framebuilder but dispersed Graded oolite as bar.

Core logged, upper cuttings review 2011

Marquis L-35 cuttings

(often not PDC bit? So much better cuttings than other 2000's wells of EnCana)

Microsolenid corals 5 - 3520 arg Is by reefal most others in strmtpd reefal @ 3555, 3760, 3790, at 4350 4% in between strmpd-chaetetid reefal Bryozoa mostly scattered low % but common 37 w/ 11 all in lowest reefal section, 4500 to 4% in spg-strmtpd = 10% @4520, 5% base AB3 transgr Tubiphytes et al. check 4505 photos thick Ts; not in oolite

60ish Ts in strmtpd & microb/peloid beds esp in lo 1/2 below 4150 ie. 20 1-3% in reefal beds of AB2 4410/4435-4452TD

Marquis L-35A cuttings (not PDC bit? Deviated basinward = more slope beds but much reefal too)

Microsolenid corals 2 only 3500m in skel-frg lst in SST w/ T's too, 3555m @% in strm-skel-ooid FS also T's

Bryozoa no higher 1-3% in strmtpk-spg reefal & microb beds but 1 in oolite **tubiphytes et al.**

some in/near SST-oolite (see above) eg. 3420,3545-2575, 8- 3610-3655 ooid&reefal 5 at top carb in ool & pellet just below last SST 24 in bottom 200m or so in microb/peloid & reefal a-3% 3920-4105TD

Cohasset L-97 cuttings and core

Microsolenid corals present in cuttings & core (to 10% base core w/ microbialite & corals)

3210-1? In lo fossil-rich, 3250 1T-mixfrmbldr 10%, & bryozoa, 3865 core 1-10% in coral microb BS-FS, 3865 -? In microb, 4095 1% peloid ws w microb 5%, 4605 1T in oolite w/ microb 15%

Bryodem/mol interval 3275+3280 start 3260 w/ micob 5%, crinoid 2-5/6% bivalve 2-5% 1%T's

to 3% in core 1 lower middle

Tubiphytes & tubular forams etc.

NOTE calcispheres scattered thru out ~25 occurrences ?-1% in microb MWS

3?s in top spg-str reefal, almost continuous 1-2% in microb-rich (5-20% from 3360-4420 Jmis) and also in reefal (3405-60 core too; 3610-3640; 3690-3700 etc.)

10% T at 3450m in 20% microb plus coral-3%, stromatoporoids-3%

possible cave -- in Misaine shale & absent main ool but lower Scatarie oolite and non-ool below but !% T's

Dominion J-14 cuttings (PDC bits) shale plug

best examples of bryoderm beds amongst spg-strmtpd reefal beds

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals present in cuttings 3 to 1-3% @ 3220-3245 in spg reefal, @ 3340 to 5?% in skel-strmtp

Bryoderm beds -3% thru out but rich beds (4-15% bry, 5-15% crin <3% ech) @ 3205&3215 in arg calc SST, 3280-3295=20m spg frg lst, 3370-3380 4/5-5/4; trangressive bed just above SH ?> 3435m 15-8 T-cri

Tubiphytes et al

7 @1-5% reef top spg & sst-afg 3200-3230, 4 scattered below (Not in Sh) 4 more belw sh in slope beds

Dominion J-14A cuttings (PDC bits) 1km near horiz sidetrack south into carbonate bank

Microsolenid corals present in cuttings 10 to 1-3/7% @ 3290 arg lst, in Strmtpd reefal BS to 10%@ 3320, 3710,3750,3760 (7%), 3800, 3850, 4140, 4240, 4305 (7%), 4350, 4360 (8%),

Bryoderm beds -1-2% thru out upper beds (3240-4200), 3270=15-25%, 3280=9-12%, 3360=10-10% lower amts- 3440=3-5%, 3480=3*7%. 3350=5-5%, 3670=4-4%, 3970=5-3%

Tubiphytes et al

only 7 (3 at bottom ?-1%) nearly absent = why = shallow reef???

Kegeshook G-67 far shelf interior 10-12km back marquis highly oolitic-occ pelletal (based on rechecked Shell Bogoslowski log)

NO microsolenid corals nor Tubiphytes

Bryozoans no bryoderm/mol beds but 5 occur scatter ?-1% even in oolite

Como P-21 far shelf interior 9km back panuke highly oolitic-occ pelletal

Microsolenid coral 1 @ 3040 within 10m top Jabk in oolite

Bryozoa not bryoderm beds but 15 1-2% scttered thru out and 5%@3185 & 4%@3295mid seq wrt sst alone vs 3%&3% @ 3098&3105 amongst 1-2% cor Corals 29 scattered low 1-2% thruout CF J-56??)

Tubiphytes

8 - ?-1/2% scattered thru out 3210-3360 (surprising since oolite)

Bottom highly oolitic +50m have none including the above nor corals

MarCoh D-41 ctgs & SWCs

next to no ooids (tr=5?%, 2%)

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals only 1 present in SWC 2% = 3510 w/ spg strmtp brysozoa to 9%

Bryozoa = not crinoid rich; 6605=10% but cri only 2%, 3320=16% but cri 1% w/ spg beds above; 1% in spg reefal

Tubiphytes et al

complexes in SWCs so check TS etc; in strmtp and esp spg rich upper beds; 3268 SWC SPG, 3280 SPG, 3295 SWC SPG, 3385 SPG STRMTP CHAET, 3315 SPG STRMTP, 3560 SWC STRMTP, 3605 COEAL STRMTP 5%

Cohasset D-42 near shelf edge to proximal interior ~1km (Eliuk 1978) somewhat argillaceous esp top

Microsolenid corals not looked for in 1978	10400-11150	11150-12300	12300-13400	13400-13820/80 Misa	oolite GS below 13370
Bryozoa = not crinoid rich; ubiquitous only 1-2% except 3% at top	13	28	48	26	corals less but also common but 1-2% w/ strmtp
Tubiphytes et al minor ubiquitous in frag-skel WS's (occ ool)	4 (1w/ coral)	2	22 & 6 <deeper?< td=""><td>8</td><td></td></deeper?<>	8	

Margaree F-70 ctgs/swc's & whole core (only example of microsolenid coral thin biostromes/reeflets w/ microb-spg at top core & above large coral RS at base core Dolomite obscures)

No ooids

Microsolenid corals 6 mainly in core or near in SWC of 2-3%/5m

in core microsolenids seem to replace stromatoporoids-corals upward then more lithistid sponges too

CORE eg. in reeflets in core eg. 10-40% with sponge-microb top 2.7m above crinoid GS beds then below dolm in 3.3m (3449-52.3) Ist of spg -strmtpd-coral- microsolenid

Then at a base core large coral debris overlain by micosolenid reeflet (no spg?)

PDC bits = chalky poor samples = under representation need SWCs

Bryozoa 4- 1% above core crinoid bed "4%" of 5m few to none below

CORE eg. In crinoid bed couple 8-10% intervals =?bryoderm %like but not in situ in mid lst (3449-52)get 7-10% at top & base and at base 10% crinoid w/ 10% strom's (CHECK MAYBE EG??)

Tubiphyes et al 10 @ ?-1-2% in ctgs/swc only above core/ABV CORE In core 1-10% only above and at top of crinoid beds in spg-microsolenid beds esp where corals less

Panuke B-90 back bank margin ~3km after arg strmtpd top highly oolitic shallow penetration possibly to to no artimon spg's but argil with stromatoporoids beds

Microsolenid corals 2 in frg-skel WS 3325m in ool GS 3400

Bryozoa 16 usually 1-2% scattered not in oolite but near base seq w/sst at 3260-70 = 6-5, 3-8, 10-3+6=ech for bryo-crin so byrodem transgressive

Tubiphytes none

Panuke F-09 back bank margin ~3km after arg spg-rich top highly oolitic ctgs & swcs' did check DP reservoir levels no dolm/no porosity

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 3 + ? In SWC in arg or sdy 'reefa' lst even in oolite

Bryozoa 13 usually 1-2% scattered sometimes in oolite too (but 12 in SWC only 2 w/ool)

Tubiphytes 7 & 3? (w/ 3 in SWC id in spg bed or in ool bed) 5 in ool????)

Panuke M-79 only deep well to Scatarie in DP ctgs & SWCs

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 2 or 3 in swc basal AB6lo=2 in spg-strmtpd reefal beds and 50m above misaine 1 in oolite interval

Bryozoa 25 intervals mainly in SWCs scattered thru out (7 in Scatarie SWC w/ ooids??)

Tubiphytes et al

43 scattered mainly reefal intervals from SWCs ?-1% (to 5% in swc)

Panuke M-79A sidetrack basinward near horizontal in final dolm's ctgs no SWCs

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 9 all but 1 in Ab7&6 in spg-strmtpd beds

Bryozoa 36 scattered thru out 1-10% Some mixed liths (AB6U 3305/15) of 10 & +5+% bryozoa and ooids??? But only high crinoids 3420 10-5% bry-cri

Tubiphytes et al

15 mainly in strmtpd-spg reefal beds

Panuke PI-1A (J-99) deviated E from prod-injector well

ctgs & swc's

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 15 mainly in AB5Lo and 5 (latter 6 in swc) in spg-strmtod-coral reefal beds

Bryozoa 20 - 1-2% scattered but at top AB5 (3860&70) 8+ & 10% w/ cri to 5% bryoderm beds below the transgressive break or break picked high

Tubiphytes et al

6-8 in reefal beds 1=@%

Panuke PI-1B (J-99) deviated E&S from prod-injector well

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 9 @ 1-5% spread thru out in strmtpd reefal beds

Bryozoa 23 @ 1-3% scattered thru out mainly in strmtpd reefal bed but 10% in topmost AB5 but crinoids low

Tubiphytes et al 5-8 1-?% widely spread in strmtpd beds

Panuke PP-3C (J-99) deviated SW from prod-producer slot mostly lost circulation drilled blind below AB6

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals only 2 possibly seen (older log) @ 3790 & 3850 in spg-strmtpd reefal beds

Bryozoa 10+ @ 1-2% scattered in reefal beds of AB6

Tubiphytes et al 2-4 of 1&?% in reefal beds

Panuke H-08 short setion since lost circulation below topmost AB5 below core

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals none (older logging) but few hexacorals (10-20%) except just before lost circulation in core with high stromatop' chaetetids (20 & 10%) & 10% crinoids (refractory to dissolution perhaps)

Bryozoa 4+ @ 1-2% but in 3m core locally to 10% avg 2-4%

Tubiphytes et al only seen in core mainly at top (1-3%) and base (1%)

Queensland M-88 drilled on slope as seen seismically in foresets and in cutting-SWCs facies

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals only 1 seen in swc 4110 with other hexacorals 50 m below top AB3? Lst beneath second shale

Bryozoa just 4 only in swc widespread 2%

Tubiphytes et al 11 @ 2-15% only in SWCs and 3? In ctgs widespread in limestone

FOLLOW UP SWCs AND TSs FOR MICROBIAL/THROMBOLITIC SLOPE FACIES

Musquodoboit E-23

PDC bits = chalky poor samples = under representation need SWCs

Microsolenid corals 8 @ tr-5 (1 SWC 3369 near top all bored MS) in upper 'muddy' E-23 spg-strm reefal; 2 @ 1-5 in lower 'grainy' E-23 ool & strmtpd reefal

Bryozoa 6 @ 1-5 upper M' e-23l; 14 @ 1-3 lower G' E-23 minl in strmtpd reefal

Tubiphytes et al

14 (8-6?) @ 1-3+ in upper M' all in spg-strmtpd reefal beds; 9 (6-3?) @1-2 in lower G' mostly in strmtpd reefal & none in oolite

Demascota G-32 GSC ctgs thin sections and Eliuk 1978 log

Microsolenid corals not looked for in 1978; in core =1-2% in Core#1 11230', not in #2&3&4 in #5 14400', in TS=11770, 12380, 12480+

Bryozoa 1978 ubiquitous in low % to below core2 1280 esp w. spg or strmtpd reef in microb slope present irregularly thru out not in basal oolite **TS**=11770. 11830 strm/coral, 11880+ strm/cor, 12030l, 12430, 14630; **Tubiphytes et al 1978 all core but #4** dolm; **most spls** in spg reefal down to core #2 at 11880 gap to 12100 & core#3 and in dolm 12900-13400, again from 12120-13000 incl core 3;

in all microb slope intervals 13900=14300 except in basal oolite

TS = @1-4+% 11110, 11120spg, 11130, 1110+, 11210, 11230, 11270, 11310s, 11340, 11370+spicules. 11410spicules, 11430, 11460 <<all preceding spg reefal, 11489, 11540, 11560+ <<all shally lst, 11570, 11640, 11670+, 11770strm, 12030strm, 12160 strm microb, 12280+microb, 12430 strm/micb SLOPE/MICROB from 13460/13760 to 15160 with tubiphytes & microb/thrombolite in 51 TS then some oolite/microb at 15160 w/ no T's in oolites (but 15160both, 15180, 15230 no ool but T) (from TS = oolite seems to occur in more of section??)

Acadia K-62 wellsite & TS GSC

no microsolenids?? few bryozoa (at 3718m to 5% but not crinoids nor bivalves)

Tubiphytes et al

only 4Ts in upper oolite over 300-400m oncolite facies over 180m had only 4Ts then basal reefal-oncoid beds 50m w/ 3 (lower core 4 had few Ts) below 3655-4150m (500m= 100-150 3-5m samples) mainly peloid and nearly continuous T's (72 or so but only 1-2%) likely oolite or oncoid slope debris or cave??

Albatross B-13 cuttings (oolite core N/A)

no microsolenids?? no bryozoa over 2% and not common

Tubiphytes et al.

none (1?) in oolite, 5 in reefal beds ~230m mainly near base, scattered 19 of 1-2% 9? In microb-peloid beds over 900m

Also 1% thru out top in 'Artimon'

NOTE ???? is there a fundamental difference in being in Panuke trend vs western shelf for T occurrences????

OR white on white hard to see??

Bonnet P-23 cuttings

no microsolenids

Bryozoa only minor scattered bryozoan until uppermost Abenaki = 'Artimon' where common and 8% at base/1865m w/ 10% bivalves & cri/ech 6% = bryomol transgressive bed

Tubiphytes et al

none in most of Baccaro except in lower argil lst 3245-3430m amongst Misaine (new & former) arg lst & shales

Appears to be a really good indicator of slope and near margin reefal and argil open marine settings Really helps decide if peloids are slope or lagoon

Crescentiella, a new name for "Tubiphytes" morronensis CRESCENTI, 1969: an enigmatic Jurassic – Cretaceous microfossil

Baba Senowbari-Daryan1 Ioan I. Bucur, Felix Schlagintweit, Emanoil Săsăra and Jacek Matyszkiewicz Geologia Croatica 61/2–3 185–214 8 Figs. 8 Pls. Zagreb 2008 AB STRA CT

Several organisms or interaction of organisms have been described over a long time interval from the Late Palaeozoic to Cretaceous as Tubiphytes, with the type species being T. obscurus MASLOV, 1956.

Palaeozoic Tubiphytes were revised by SENOWBARI-DARYAN & FLÜGEL (1993). Triassic representatives still need to be revised. For Jurassic (extremely abundant in upper Jurassic) and

Cretaceous organisms, known as "Tubiphytes" morronensis CRESCENTI, 1969, we propose here the genus name Crescentiella. Differences between Crescentiella nov. gen. and Tubiphytes MASLOV are discussed.

The systematic position of Crescentiella as a foraminifera, interaction of foraminifera and cyanophyceans or as a special kind of oncolite is discussed. It is interpreted as symbiosis or encrustation between cyanobacteria and a nubecularid foraminifera, uncertain tube or rarely, other biogenic components. Comments on similar associations, e.g. the genus Labes ELIASOVA, are provided.

Keywords: Crescentiella, Tubiphytes, Labes, Cyanobacteria, Foraminifera, systematics, Jurassic, Cretaceous.