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YAZOO FORAMINIFERA

AND DEPOSITIONAL HISTORY, NORTHEASTERN GULF COAST

by

Bruce Gunnar Langhus

A thesis submitted to the

Faculty of Graduate Studies,

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In partial fulfillment of the requirements for

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The Upper Eocene Jackson Group displays striking vertical and horizontal facies changes throughout the orthern Gulf Coast. The Yazoo Formation of the Jackson Group and its eastern calcareous equivalent, the Crystal River Formation, clearly exhibit these changes in a series of ten outcrop sections 150 miles along strike between eastern Mississippi and central Alabama. Modal analyses of lithologic components from 309 samples and percentage values of microfossil components from 137 samples indicate horizontal and vertical changes in age, sediment regime and water depth.

Computerized factor analysis coupled with relative entropy mapping generates a facies breakdown of the Yazoo data into discrete variable groupings with interpretable, realistic two-dimensional distributions: Facies I is very similar to modern prodelta muds; Facies II resembles certain Pleistocene reefoid deposits which have been flooded by shelf waters; Facies III is analogous to muddy shoreline sands; and Facies IV strongly suggests modern continental slope muds.

Planktonic foraminifera and calcareous nannoplankton allow the outcrop sections to be correlated with published biochronologies and serve to divide the Yazoo into early, middle and late Late Eocene zones.

Age designations of the outcrops and facies analysis combine to provide a logical depositional history: During early Late Eocene time, several medium-sized deltas supplied sediment to the western and central parts of the area while the eastern part received a mixture of terrigenous and biogenetic detritals. Toward the end of this time, the shoreline retreated southward along part of its length. The subsequent marine transgression left muddy shoreline sands lying directly upon prodeltaic sediments.

Further transgression in the middle Late Eocene produced sediments of a thoroughly mixed nature. During the latter part of the middle Late Eocene, conditions stabilized and persisted into the Latest Eocene when deposition was characterized by deep-water muds in the west and indigenous carbonates in the east.

ACKNOWLEDGEMENTS

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Mr. G.E. Byers, Department of Agriculture, Province of Nova Scotia, who performed atomic absorption flame photometer determinations of $CaCO_3$ and $MgCO_3$.

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INDEX

INTRODUCTION AND SCOPE OF WORK

In the Northeastern Gulf Coastal Plain the upper part of the Eocene Jackson Group is splendidly represented by the Yazoo Formation and equivalent carbonates. Since the coming of Sir Charles Lyell, many paleontologists have visited the conspicuous outcroppings of the Yazoo to sample and study the prolific molluscs, ectoprocts, ostracodes, foraminifera, palynomorphs, and nannoplankton. The emphasis of all these studies and publications has been towards establishing biostratigraphic relationships, i.e. correlation between the various Yazoo outcrops, between the Yazoo members and other map units of the Gulf Coast, or between the Yazoo and distant standard Tertiary sections. A comprehensive reconstruction of the environment of deposition for the Yazoo has not been attempted. It is obvious that such a study would be useful in interpreting those Coastal Plain units which are similar to the Yazoo but only if it incorporated all the available information into a consistant story.

In any piece of research only a finite number of variables may be considered and of course only the most pertinent will be selected for study. In the present work, lithologic information will consist of those features that can be observed on a polished surface under a stereomicroscope. The fossil biota of the Yazoo changes in make-up from the clayey sections in the west to the carbonates in the east but the common and most ubiquitous component is the foraminifera. These will be classified and counted so as to be paired with the quantitative lithological data. Due to the extraordinary difficulties involved in obtaining adequate subsurface material, only outcrop sections will be sampled. The study area, shown in Figures 1 and 2, was selected because of the degree of outcrop exposure and the range of lithologies represented.

The body of sedimentological and micropaleontological data will then be processed and associated into paleoenvironmental facies each of which can be correlated with a depositional regime. The facies patterns within each section can then be fitted into the planktonic biostratigraphic framework and can be seen to not only change through time at any one locality but to change geographically along strike and dip within one isochronous unit. The changes between the several isochronous units will then illustrate the evolution of the Yazoo paleogeography.

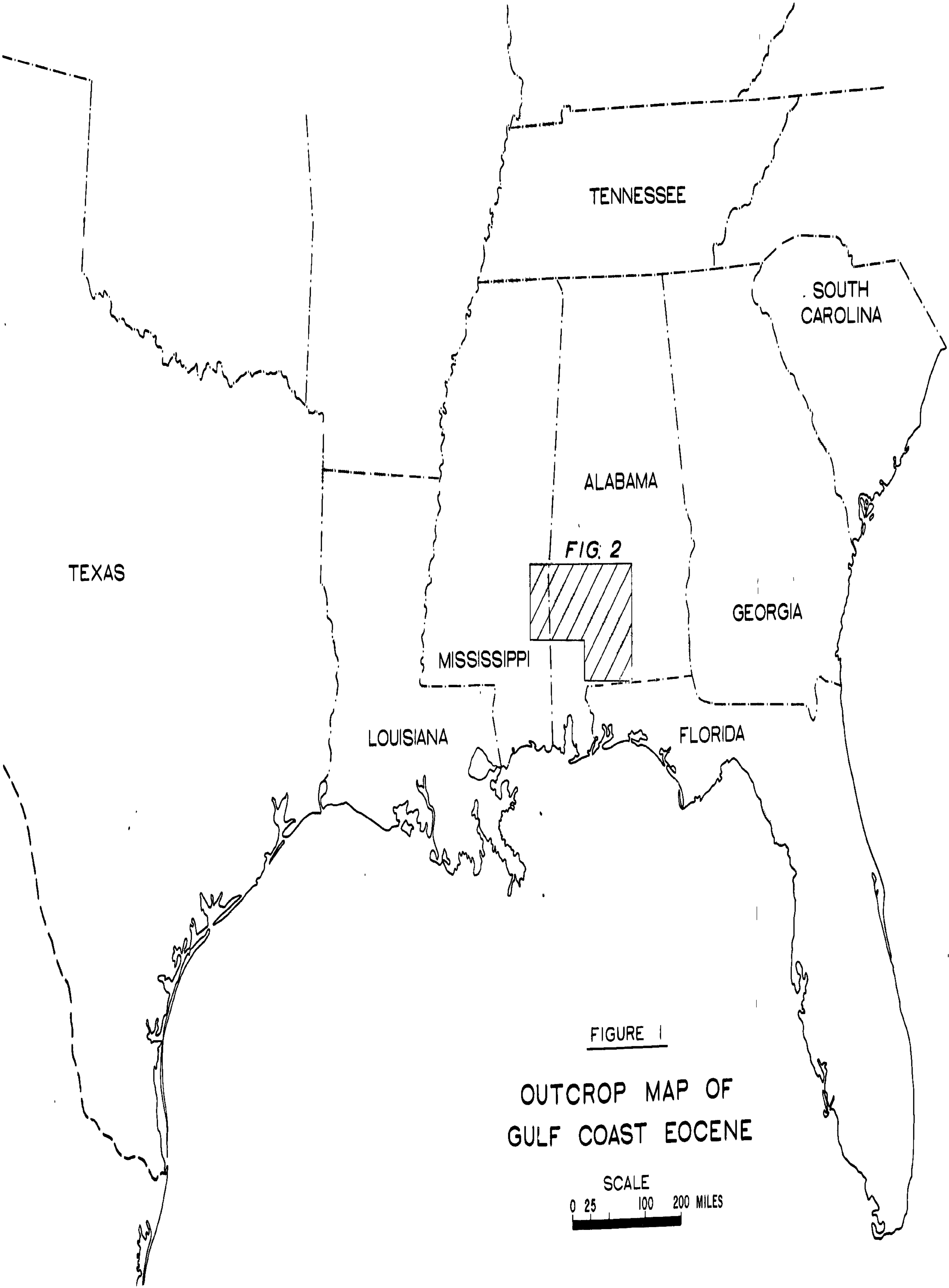


FIGURE 1

OUTCROP MAP OF GULF COAST EOCENE

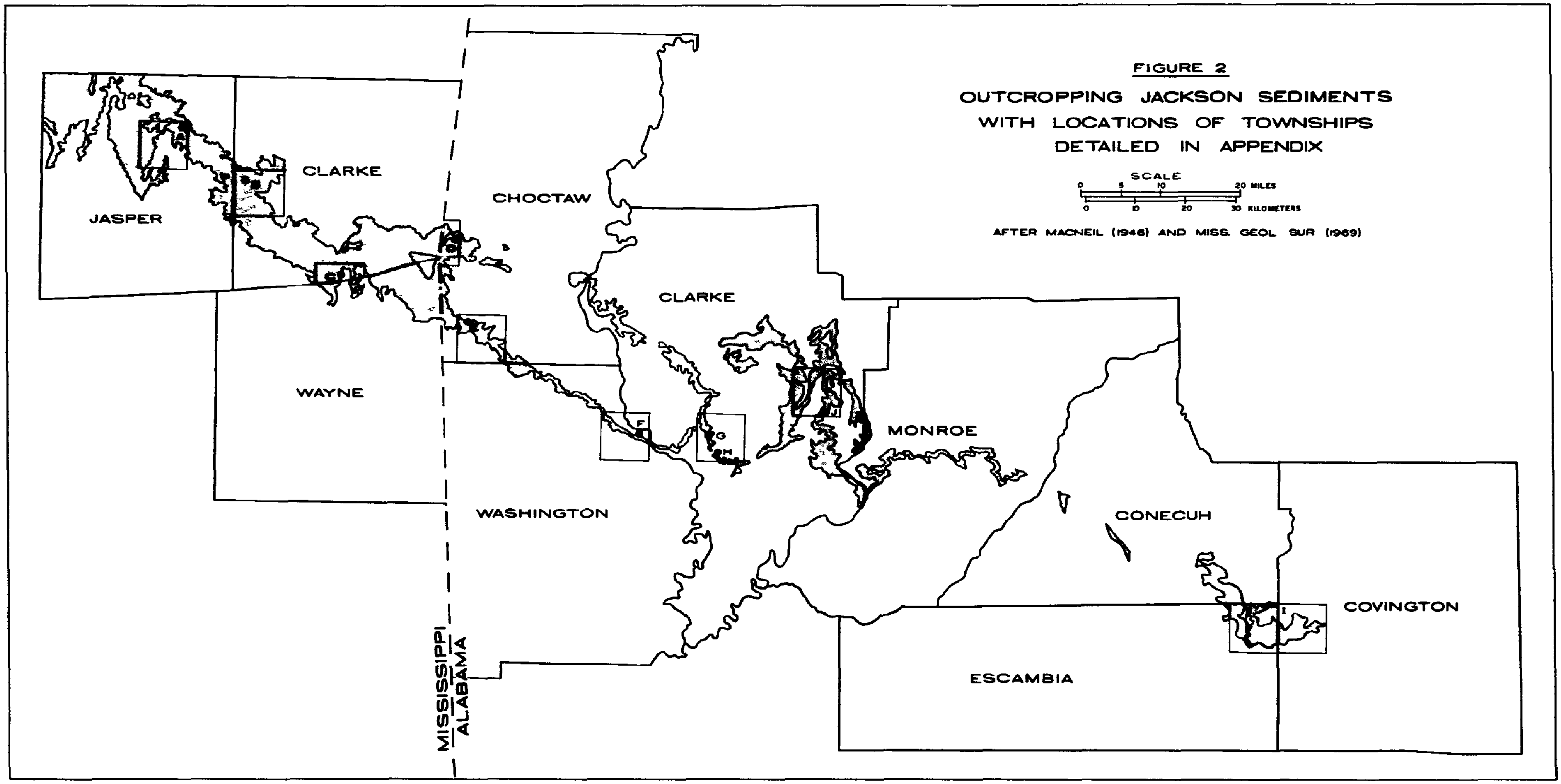


FIGURE 2
OUTCROPPING JACKSON SEDIMENTS
WITH LOCATIONS OF TOWNSHIPS
DETAILED IN APPENDIX
SCALE
0 5 10 20 MILES
0 10 20 30 KILOMETERS
AFTER MACNEIL (1946) AND MISS. GEOL. SUR. (1969)
JASPER
CLARKE
CHOCTAW
CLARKE
WAYNE
WASHINGTON
MONROE
CONECUH
COVINGTON
ESCAMBIA
MISSISSIPPI
ALABAMA

REGIONAL GEOLOGY

The Gulf of Mexico Basin contains several tens of thousands of meters of continental Triassic sediments and marine sediments of Jurassic through Recent age. The Basin is bounded on three sides by folded rocks - on the north by the Southern Appalachians and Ouachita Mountains; on the west and south by the Sierra Madre Oriental.

Rainwater (1964 and 1968) lucidly summarized the history of the Gulf Coast sedimentary basin. A shallow arm of the Atlantic Ocean filled the basin for the first time in the Late Jurassic. This nearly normal marine basin continued to collect clastics, limestones, and evaporites until the Laramide Orogeny in the Late Paleocene formed the Rocky Mountains. The Mississippi River, draining these new mountains, delivered huge quantities of coarse and fine clastics. The clastic sediments were deposited so quickly that basinal subsidence could not keep pace and for the first time since the Jurassic, nonmarine sediments were laid down. Many similar periods of rapid sedimentation were to follow, each separated from the others by periods during which the rate of basinal subsidence was greater than the rate of sedimentation and the shoreline transgressed onto the continent. Typically, the transgressions took place rapidly and were associated with slow rates of sedimentation while regressions were comparatively slow and accompanied by rapid sedimentation.

Throughout the Gulf Coast area, the Jackson Group is interpreted as an Upper Eocene transgressive sequence overlying the regressive Cockfield Formation of Middle Eocene age. Stuckey (1960) has surveyed the literature on the Jackson Group across the entire Coastal Plain; his conclusions are shown diagrammatically in Figure 3. Upper Jackson or Yazoo-age strata are present in a wide range of lithologies within the Gulf Coastal Plain. In southern Texas these strata are predominantly arenaceous. In Louisiana and western Mississippi, the Yazoo can be identified as a uniform, shaley unit. In eastern Mississippi and western Alabama the Yazoo Formation can be split into four mappable members - The North Twistwood Creek clay, the Cocoa sand, the Pachuta marl, and the Shubuta clay. In central Alabama, these members become progressively more calcareous and grade into the Crystal River Formation. In Florida, Yazoo equivalents are part of a wholly calcareous Tertiary section.

Yazoo-age strata are subject to influence by many structures of varying size. On a more local scale, the Yazoo outcrop belt in the study area is controlled by a southern primary dip and several rather small-scale structures as mapped in Figure 4.

Hatchetigbee Anticline - the most prominent structural feature is approximately 30 miles (50 kilometers) in length and extends from the Mississippi - Alabama border southeastward; it is thought to have a salt core (Copeland, 1968).

Pachuta Fault - located in the west central part of Clarke

			TEXAS			LOUISIANA			MISSISSIPPI			ALABAMA			FLORIDA		
ERA	SERIES	GROUP	FORM.	MEMBER	FORAMINIFERA	FORM.	MEMBER	FORAMINIFERA	FORM.	MEMBER	FORAMINIFERA	FORM.	MEMBER	FORAMINIFERA	FORM.	MEMBER	FORAMINIFERA
TERTIARY (PART)	UPPER EOCENE	VICKSBURG	WHITSETT	FASHING CLAY	DISCORBIS TEXANA				YAZOO	SHUBUTA CLAY	BULIMINA JACKSONENSIS	YAZOO	SHUBUTA CLAY	BULIMINA JACKSONENSIS	OCALA LIME-STONE	CRYSTAL RIVER	DISCOCYCLINA AMERICANA
				CALLIHAM SAND							MARGINULINA COCOAENSIS			MARGINULINA COCOAENSIS			
		JACKSON		DUBOSE SAND-SHALE	MASSILINA PRATTI	YAZOO	DANVILLE LANDING BEDS	MASSILINA PRATTI			GLOBOROTALIA COCOAENSIS			GLOBOROTALIA COCOAENSIS			
				STONES SWITCH SAND							HANTKENINA ALABAMENSIS			HANTKENINA ALABAMENSIS			
			McELROY	MANNING CLAY	TEXTULARIA HOCKLEYENSIS		VERDA	TEXTULARIA HOCKLEYENSIS		PACHUTA MARL	TEXTULARIA HOCKLEYENSIS		PACHUTA MARL	TEXTULARIA HOCKLEYENSIS			OPERCULINOIDES MARIANNENSIS
				WELLBORN SAND													
				WOOLEYS BLUFF CLAY			UNION CHURCH										
			CADDELL		TEXTULARIA DIBOLLENSIS		TULLOS	TEXTULARIA DIBOLLENSIS		COCOA SAND NORTH TWISTWOOD CREEK	TEXTULARIA DIBOLLENSIS		COCOA SAND NORTH TWISTWOOD CREEK	TEXTULARIA DIBOLLENSIS			
				(EAST TEXAS) MOODY'S BRANCH	CAMERINA MOODYBRANCHENSIS NONIONELLA COCKFIELDENSIS	MOODY'S BRANCH		CAMERINA MOODYBRANCHENSIS NONIONELLA COCKFIELDENSIS	MOODY'S BRANCH		CAMERINA JACKSONENSIS NONIONELLA COCKFIELDENSIS	MOODY'S BRANCH		CAMERINA JACKSONENSIS NONIONELLA COCKFIELDENSIS	MOODY'S BRANCH	WILLISTON-INGLIS	CAMERINA JACKSONENSIS

AFTER STUCKEY (1960)

FIGURE 3

CORRELATION CHART OF GULF COASTAL PLAIN JACKSON

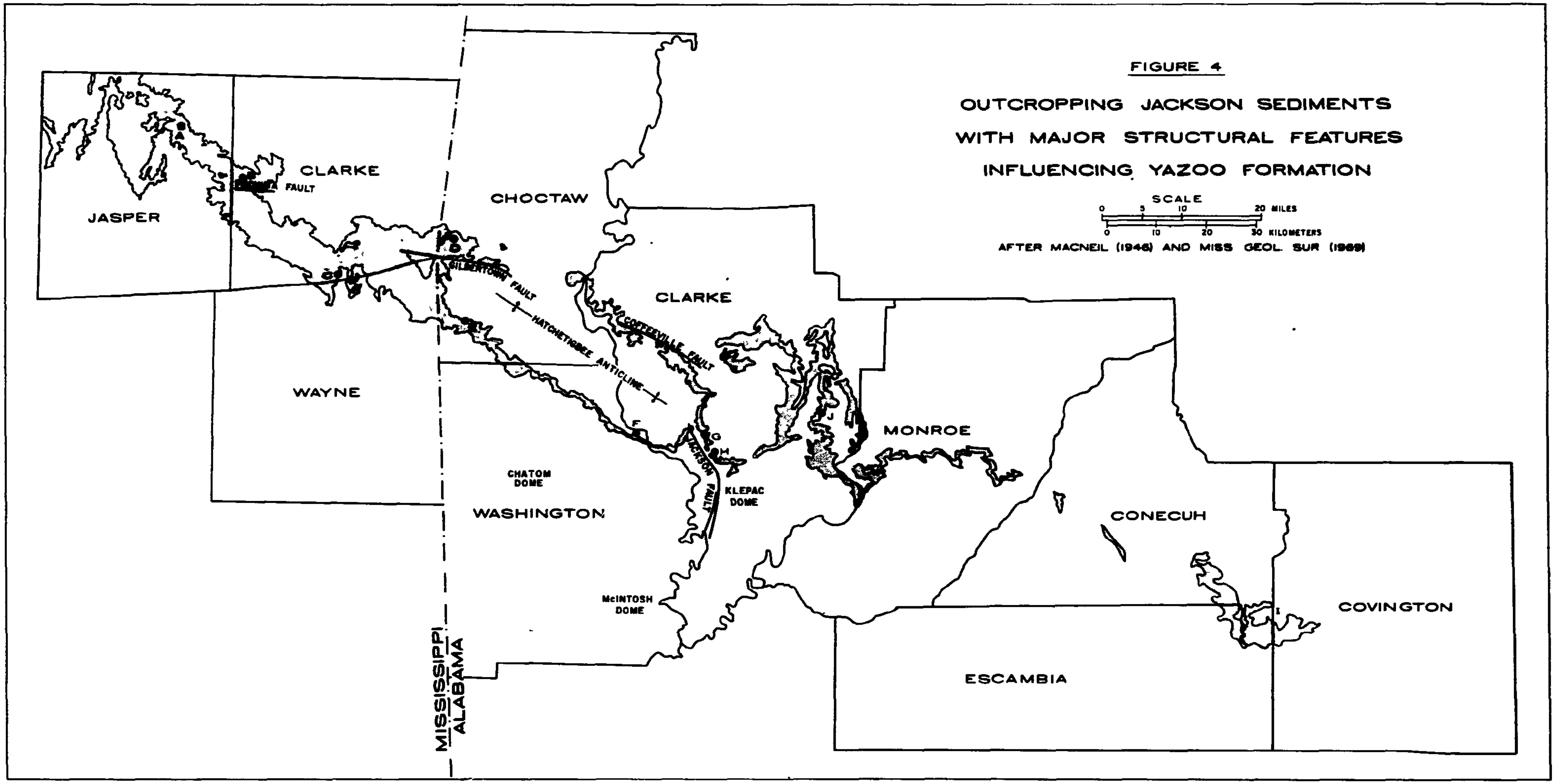


FIGURE 4

OUTCROPPING JACKSON SEDIMENTS WITH MAJOR STRUCTURAL FEATURES INFLUENCING YAZOO FORMATION

County, Mississippi, it is a small-displacement, east-west trending, normal fault displacing Yazoo strata (Tourtelot, 1944).

Gilbertown Fault - located in northeastern Wayne County, Mississippi and southwestern Choctaw County, Alabama; this feature is similar in strike and displacement to the Pachuta Fault (Huff, 1970).

Jackson Fault and Klepac Dome - in south central Clarke County, Alabama these two associated features influenced the thickness of the Tertiary section with thining noted over the dome (Copelan, 1968).

Chatom and McIntosh Domes - both are poorly understood salt domes to the south of the Yazoo outcrop belt (ibid.).

PREVIOUS WORK

The publications dealing with all aspects of the Yazoo Formation and correlative strata probably number in the hundreds; those papers which are pertinent to this study of paleoenvironments may be divided into the following categories: Stratigraphy and paleontology - biostratigraphy. In connection with the Yazoo, these categories both have had long, involved histories.

Stratigraphy

The body of literature connected with the stratigraphy of the Yazoo in the Northeastern Gulf Coast is not large. Field descriptions, although quite detailed, are sparse and scattered geographically, Stuckey (1960) exhaustively outlined the history of the various map unit names of the Jackson Group and the stratigraphic studies which cover them. Of notable importance are the studies by Lowe (1915) who subdivided the Jackson Group of Mississippi and Louisiana into the upper Yazoo and lower Moody's Branch Formations; and by Murray (1947) who was able to subdivide the Yazoo into the four members mapped in eastern Mississippi and western Alabama. Seven published reports of a more local scope provide valuable complimentary information - Mellen (1940), Bergquist (1942), Priddy (1960) and Moore (1965) reported the aspect of the Yazoo strata in western and central Mississippi; Toulmin et al (1951), De Vries (1963) and Huff (1970) detailed the geology of the counties of eastern Mississippi; Huddlestun (1965) covered the Yazoo-age sediments in part of central Alabama. Huff (1970), in his extensive report of Jacksonian strata and ostracodes of Mississippi, included some new information gathered by the Mississippi State Geological Survey in three shallow bore-holes drilled by the Survey as stratigraphic tests and cored to serve as alternate type sections to replace three badly weathered and overgrown outcrop sections.

Paleontology

There is a sizeable body of literature concerning the fossil biota of the Yazoo Formation with particular emphasis on micropaleontology as applied to biostratigraphy. The majority of published articles have dealt with either foraminifera or ostracodes. Huff (1970) included a listing of 39 papers dealing with ostracodes from rocks of the Jackson Group from the Northeastern Gulf Coast. Howe (1947) collated the literature of Jacksonian foraminifera and listed 47 articles. Cushman's report (1925) on Shubuta Foraminiferida was the first on Jacksonian material. Howe and Wallace (1932) published descriptions of a great many species from the Yazoo Formation of Louisiana. Cushman's summary (1935) listed and illustrated many forms found throughout the Gulf Coastal Plain, primarily from Yazoo equivalents. Monsour (1937) authored a basically micropaleontological subdivision of Jacksonian strata in eastern Mississippi. Bandy (1949) exhaustively researched the foraminifers recovered from the classic Tertiary section at Little Stave Creek, Clarke County, Alabama. Deboo (1965) reported on the benthonic and planktonic foraminifera from strata of the Jacksonian and overlying Vicksburgian stages in the present study area with the objective of fixing the biostratigraphic zone boundaries. Blow (1969), in his excellently illustrated compendium, included many Jackson - age planktonic foraminifera. Barker (<u>vide</u> Blow, 1969) defined international planktonic foraminiferal zones in the Jacksonian and Vicksburgian Stages through outcrops in eastern Mississippi and the Little Stave Creek section in Alabama.

Among the various remaining papers that could be grouped under the heading of micropaleontology, only a few stand out as relevant to the present research. Cheetham (1965) analyzed the ectoprocts in the Jacksonian and Vicksburgian strata of Alabama and Florida and was able to draw conclusions concerning biostratigraphy and paleogeography. Levin and Joerger (1967) examined the calcareous nannoplankton from the Yazoo strata of Alabama. Palynomorphs from the Yazoo section in Mississippi were the topic of the Ph. D. dissertation of Fredrickson (1970). Hazel (1970) clearly diagrammed Deboo's data and corroborated the latter's conclusions by means of a computer-generated cluster analysis.

A synopsis of the published literature shows a great deal of agreement on the stratigraphy of the Yazoo Formation. Nowhere, however, is there to be found a paleoenvironmental study as could be produced with the abundance of fossil indicators indigenous to the Yazoo and the wide range of lith- displayed along strike.

STRATIGRAPHY

Stratigraphic information concerning the Yazoo Formation and its calcareous equivalents to the east comes from two sources - published literature and work done in the field by the author in the course of this study. The author carried on field work in the area in the Fall of 1969 and the Spring of 1970. During these periods nine outcrop sections were measured, described, and sampled. One additional section had been measured and sampled by Dr. C. W. Copeland of the Geological Survey of Alabama, and splits of these samples were kindly supplied to the author.

The stratigraphy of the Yazoo can probably best be described by considering separately the outcrops within three geographic areas - western and central Mississippi, eastern Mississippi and western Alabama, and central Alabama. The first and westernmost region is made up of Madison, Hinds, and Scott Counties and contains the type section of the Yazoo. The second region, consisting of Jasper, Wayne, and Clarke Counties in Mississippi and Choctaw, Washington, and Clarke Counties in Alabama, contains the Yazoo Formation as four distinctive map units - the basal North Twistwood Creek Clay Member, the Cocoa Sand Member, the Pachuta Marl Member, and the uppermost Shubuta Clay Member. In the third and easternmost region Shubuta - age strata are represented by the calcareous Crystal River Formation.

Western and Central Mississippi

The type section of the Yazoo was originally described from Yazoo County, Mississippi. This section, from Lowe (1915) is now nearly lost as a result of severe weathering; as an alternative the Mississippi State Geological Survey drilled a test hole near the original outcropping in Yazoo City. The hole penetrated the full 180 feet (54.5 meters) of the Yazoo unit and the formation was extensively cored (Huff, 1970). Elsewhere in Yazoo County the formation reaches its maximum thickness of 500 feet (152 meters)(Mellen, 1940). Mellen was able to recognize two lithological subunits - the lower 350 feet (106 meters) was made up of "homogeneous, silty, calcareous, fossiliferous, gummy, plastic, montmorilonitic clay" and the upper Yazoo consisting of 150 feet (56 meters) of "massive, gummy, non-calcareous, montmorillonitic clays, beds of interlaminated silt and silty clay, a thin bed of bentonite, and lentils of limestone."

In Madison County the Yazoo is described as approximately 400 feet (121 meters) of homogeneous "blue-grey, slightly silty, fairly calcareous, massively bedded clay" (Priddy, 1960).

In Hinds County, Moore (1965) included about 450 feet (136 meters) of "fairly homogeneous . . . blue-green to blue grey, calcareous, fossiliferous clay with some pyrite."

In Scott County, Mississippi, Bergquist (1942) reported the Yazoo Formation to be about 300 feet (91 meters) in thickness and to be composed of clay which he described as "non-gypsiferous, calcareous, montmorillonitic, and uniformly greenish-grey, and in some places contain dark, finely comminuted marcasite streaks."

Eastern Mississippi and Western Alabama

North Twistwood Creek Clay Member

The type section of the North Twistwood Creek clay is located on the western edge of this region in Jasper County. This weathered section was measured and sampled by the author. The 22 feet (6.7 meters) of section measured are of light to dark olive-green clay becoming increasingly sandy toward the base of the section. The sandiness noted in the outcrop is very probably a weathering effect as the electric logs published by Huff (1970) from the Mississippi State Geological Survey stratigraphic test drilled on the same location indicates a total of 48 feet (14.5 meters) of uniformly clayey North Twistwood Creek clay. Elsewhere in Jasper County, this member has been reported to range from 19 feet (5.8 meters) to 43 feet (13 meters) in thickness (DeVries, 1963).

The North Twistwood Creek Clay Member is also present in Clarke and Wayne Counties, Mississippi, approximately 50 feet (15 meters) thick, and composed of grey to green, variably glauconitic, rather fossiliferous clay (Huff, 1970).

In western Choctaw County, Alabama, the North Twistwood Creek is approximately 40 feet (12 meters) to 60 feet (18 meters) thick and made up of greyish-green, silty, slightly fossiliferous, often sand-streaked clay (Toulmin et al., 1951).

No outcrop data have been published concerning this member in Washington County, Alabama but the author did measure and sample three surface sections in adjacent Clarke County. At the classic Little Stave Creek section in the western part of the county, this member consists of 20 feet (6.1 meters) of tan claystone overlain by 21 feet (6.4 meters) of greenish grey clay. Several samples from this unit were very sandy - over 50 percent of the rock volume by the author's findings. Some samples exhibited a high bioclastic content - several were over 15 percent bioclasts by volume. About two miles (3.2 kilometers) southeast of the Little Stave Creek section is located the North Jackson outcrop section at which the writer measured 42 feet (13 meters) of strata of the North Twistwood Creek Clay Member. This thickness consists of 28 feet (8.5 meters) of grey clay overlain by 14 feet (4.2 meters) of blue-grey marl. At an outcrop in the eastern portion of Clarke County the author measured about 55 feet (17 meters) of this member. At this location fully two-thirds of the member is covered but the bottom 13 feet (3.9 meters) are almost 70 percent carbonate and contain a considerable percentage of sand-sized bioclasts. In its upper six feet (1.8 meters) the member is streaked with sand.

<u>Cocoa Sand Member</u>

De Vries (1963) stated that the Cocoa could not be traced as far west as Jasper County, Mississippi. This is borne out by the test hole drilled by the Mississippi State Geological Survey nearby the the North Twistwood Creek type section in Jasper County. The bore-hole showed the Pachuta marl to be in contact with the North Twistwood Creek clay with no intervening Cocoa sand (Huff, 1970).

In Wayne County, Mississippi the Cocoa is present in several surface sections and consists of 13 feet (3.9 meters) to 15 feet (4.6 meters) of reddish to white sands (ibid.).

Across the border in western Choctaw County, Alabama the Cocoa Member ranges up to 60 feet (18 meters) in thickness (Toulmin et al., 1951). At the type locality of Cocoa Post Office, Alabama the writer sampled ten feet (3 meters) of friable, fossiliferous sand, generally low in carbonate except for two thin limestone ledges. At an outcrop near Isney, about 12 miles (19 kilometers) south and east of the type locality, the author measured 28 feet (8.5 meters) of the Cocoa sand. These sands are friable, fossiliferous, and contain limestone ledges similar to those of the type Cocoa.

No outcroppings of the Cocoa Sand Member have been reported from Washington County but the unit was measured and sampled by the author in Clarke County, Alabama. In both the Little Stave Creek and North Jackson sections the Cocoa is seen as being six feet (1.8 meters) in thickness and composed of fossiliferous, sandy clay. Farther east, in the writer's third Clarke County section, west of Claiborne, the Cocoa appears as five feet (1.5 meters) of glauconitic, sandy marl.

Pachuta Marl Member

The most westerly outcropping of the Pachuta Member has been reported from Jasper County, Mississippi where it consists of 15 feet (4.6 meters) to 22 feet (6.7 meters) of "tan to light greenish-grey, very fossiliferous, sandy, glauconitic, argillaceous marl" (De Vries, 1963).

The designated type section of the Pachuta, in western Clarke County, Mississippi, was measured by the author and found to be ten feet (3 meters) thick and made up of variably sandy clay containing only 6.3 percent of $CaCO_3$. This outcrop is weathered and extensively invaded by tree roots. This fact having been perceived by a number of workers, the Mississippi State Geological Survey put down a third bore-hole and cut core in the Pachuta Marl Member as an alternate type section. This stratigraphic test hole was drilled approximately eight miles (13 kilometers) southwest of the original type locality; the Pachuta was 12 feet (3.6 meters) in thickness (Huff, 1970). The Pachuta marl was also sampled and measured by the author in southern Clarke County at the type locality of the overlying Shubuta Clay Member. At this locality the Pachuta consists of at least seven feet (2.1 meters) of sandy, fossiliferous, glauconitic marl.

The Pachuta Member has been reported to be ten feet (3 meters) in thickness in outcrop near the northeastern corner of Wayne County, Mississippi where it is sandy, fossiliferous, glauconitic marl bounded at the top and bottom by thin limestone ledges (ibid.).

The Pachuta is only poorly exposed in Choctaw County, Alabama and thins from ten feet (3 meters) in the western part of the county to only five feet (1.5 meters) in the far southern part. It is characteristically "yellow, sandy, hard limestone with prints of fossils and light-grey, almost white, chalky marlstone irregularly indurated and containing white lime nodules" (Toulmin et al., 1951). At St. Stephen's quarry in Washington County, Alabama, the author measured the Pachuta as eight feet (2.4 meters) in thickness and found it to be very fossiliferous, highly calcareous, blue-gray marl. The lower contact of this member has not been observed in the quarry and its total thickness, therefore, cannot be fixed.

The three surface sections measured by the writer in Clarke County, Alabama show the Pachuta Marl Member to be six feet (1.8 meters) in thickness. At the Little Stave Creek section the Pachuta consists of glauconitic, fossiliferous marl. At the North Jackson locality, an incomplete section of this member consisted of two feet (0.6 meters) of sandy, fossiliferous claystone. In the section east of Claiborne, the member is made up of sandy, glauconitic, fossiliferous marl.

Shubuta Clay Member

Like all the Yazoo members, the Shubuta has been described no farther west than Jasper County, Mississippi. In that county the Shubuta reaches its greatest thickness, having been reported as ranging from 100 feet (30 meters) to 216 feet (65 meters) in thickness and consisting of "Light-green to greenish-gray, calcareous to non-calcareous, glauconitic, fossiliferous, silty clay" (DeVries, 1963).

The only documented, nearly complete section of the Shubuta in the eastern Mississippi counties of Clarke and

Wayne is the type section of this member south of the Shubuta townsite, Clarke County, Mississippi. The writer measured 59 feet (18 meters) of the Shubuta at this locality. Lithologically, the samples of this member are slightly to very fossiliferous, moderately calcareous clay or claystone.

In Choctaw County, Alabama, the Shubuta reportedly exists as greenish-grey to white, highly calcareous clay from 25 feet (7.6 meters) to 35 feet (10.6 meters) in thickness (Toulmin et al., 1951). In Washington County, the only reported outcropping of the Shubuta Member is at St. Stephen's quarry. At this locality, on the edge of the Hatchetigbee Anticline, the Shubuta is comparatively thin, the writer having measured only five feet (1.5 meters) of grey, very calcareous, fossiliferous, glauconitic, phosphatic marl.

Two of the author's sections in Clarke County, Alabama include strata of the Shubuta clay. The outcrop on the Little Stave Creek includes an entire Shubuta section of greenish-grey, fossiliferous, glauconitic marl, 20 feet (6.1 meters) thick. The section west of Claiborne contains nine feet (2.7 meters) of Shubuta Clay Member but the upper contact of the member is not exposed at this locality. The Shubuta consists of cream-colored, fossiliferous, very glauconitic marl.

Central Alabama

Field data on the character of the Yazoo in the central portion of the state, set down in this section, come from field studies done by Huddlestun (1965). The following sections are applicable to the present discussion: a composite from two outcroppings in west central Monroe County - at Claiborne Bluff and Perdue Hill; and a section along the Sepulga River which forms the borders of Conecuh, Escambia, and Covington Counties. The present author was not able to visit these sections but samples from the Sepulga River section were provided by Dr. C. W. Copeland of the Alabama Geological Survey and were utilized in the study.

North Twistwood Creek Clay Member

The basal portion of this member was measured at Claiborne Bluff, where it consisted of 11 feet (3.3 meters) of clay overlain by a four foot (1.2 meters) limestone ledge and 11 feet (3.3 meters) of clayey limestone. The upper portion of this member is present at Perdue Hill where Huddlestun found it to be 23 feet (7 meters) of clay. The total thickness of the North Twistwood Creek clay is 60 feet (18 meters) with a covered interval interpreted as 11 feet (3.3 meters).

On the Sepulga River, Huddlestun sampled 32 feet (9.7 meters) of this member, including 11 feet (3.3 meters) of sandy clay overlain by a two-foot (0.6 meters) thick limestone ledge and 19 feet (5.8 meters) of sandy clay.

Cocoa Sand Member

At Perdue Hill, the Cocoa exists as 13 feet (3.9 meters) of sandy, clayey limestone. On the Sepulga River, the Cocoa Member consists of ten feet (3 meters) of very sandy limestone.

Pachuta Marl Member

Six feet (1.8 meters) of sandy, glauconitic, fossiliferous limestone make up the Pachuta in the Perdue Hill section. Twelve feet (3.6 meters) of sandy, clayey, fossiliferous limestone form the Pachuta on the Sepulga River.

Crystal River Formation

The Shubuta Clay Member is not recognized in central Alabama. However, sediments of Late Yazoo age are present in the form of limestones similar to those of the same age present in Florida described by Puri (1956) as the Crystal River Formation of the Ocala Group.

The Perdue Hill section includes 18 feet (5.5 meters) of clayey, glauconitic carbonate which is not clearly referable to the Crystal River Formation or any other unit of the Ocala Group.

The surface section on the Sepulga River contained 67 feet (20 meters) of variable limestone which are comparable to the Crystal River.

Summary

Table I sets down in table form a synthesis of the information contained in the above section.

TABLE I SUMMARY OF YAZOO STRATIGRAPHY IN NORTHEASTERN GULF COASTAL PLAIN

North Twistwood Creek Clay	Cocoa Sand	Pachuta Marl	Shubuta Clay	
	undifferentiated Yazoo Fm. 180 to 500 feet thick; uniform, montmorillonitic, fossiliferous, usually calcareous, grey clay			Western and Central Miss.
60 to 19' thick; grey to green, sandy, fossiliferous clay	60 to 5' thick; friable, red, yellow, or white, fossiliferous sand or sandy clay	22 to 5' thick; grey, very fossiliferous, calcareous, sandy, glauconitic marl	216 to 5' thick; grey to green, variably fossiliferous clay or marl	Eastern Miss. and Central Alabama
60 to 32' thick; clay, limestone, and sandy clay	13 to 10' thick; sandy limestone	12 to 6' thick; sandy, fossiliferous limestone	Crystal River Fm. and similar limestones; 67 to 18' thick	Central Alabama

THE PRESENT STUDY

Raw material, in the form of outcrop samples, was collected in the field by the author during the fall of 1969 and spring of 1970. Dr. C. W. Copeland of the Alabama Geological Survey kindly supplied samples from outcroppings along the Sepulga and Conecuh Rivers that are no longer accessable. In each case, the outcrop to be sampled was first scraped clean of weathered material and approximately one-pound samples were then taken at one-foot intervals as measured by steel tape. Prior to disintegration, a 20 gram chip of each sample was labelled and set aside. After disintegration, the residues were split with a microsplitter until a fraction containing 200 to 500 foraminiferal tests was obtained.

Lithological data were collected by two alternate methods - modal analysis and seiving. Whenever possible, the chip sample was ground flat on one side, etched, stained and mounted on a glass slide. This slide was then examined with a binocular stereomicroscope equipped with a mechanical stage. Between 300 and 550 point counts per sample were recorded into one of a number of lithologic categories. Of the almost 30 preliminary categories, five proved to be dominant to the virtual exclusion of all the others - 1) clay plus silt, 2) quartz sand, 3) miscellaneous sand-sized bioclasts, 4) glauconite grains, and 5) foraminiferal tests.

Extremely friable samples could not be prepared in the above manner and so were analyzed by means of seiving and coarse-fraction examination. The chip was first oven-dried, weighed, disintegrated, wet-seived through a 230-mesh screen, dried, and weighed. After dry-screening, the residue was split and a portion counted into the four coarse-grain categories. Weight lost in seiving provided a clay plus silt measure and a basis for recalculating the other four values in terms of percent of original sample. These two methods, though very different, probably produce comparable results within the accuracies involved.

The chip samples also provided material for nannoplankton study and for geochemistry. The procedure for studying the nannofossils involved the inspection of mounted smear slides through a Zeiss Universal Photomicroscope equipped with a Nomarski interference contrast system. One sample - C-58, from near the top of the type Shubuta section - was viewed through one of several Phillips transmission electron microscopes freely supplied by Dr. M. Costerton, Department of Biology, University of Calgary. Geochemical analyses consisted of the determination of percent of $CaCO_3$ and percent $MgCO_3$ by atomic absorption.

In order to decrease the chances of a relatively biased selection, all the identifiable microfossils in a split were classified and counted. In several samples, the tests were very sparse and these required concentration by CCl_4 flotation. Not every sample was counted, but the author made a preliminary selection on the basis of the lithologic data plots to avoid counting adjacent, probably duplicate, suites.

The raw, basic data gathered in the above manner are displayed in graphic form for each of the outcrop sections in Appendix A and also in listed, numerical form as utilized in the following analysis in Appendix B.

This mass of information, consisting of five lithologic parameters for 309 samples and an additional 30 microfossil parameters for 137 of these samples, still required distilling or synthesizing in order to best reconstruct the Yazoo paleoenvironment. In the past history of stratigraphy, lithologic and microfossil data have been employed in the study of sedimentary strata, using schemes such as the following:

a) Plotting the distributions of only selected variables that are easily interpreted by the worker - sorting measures, abundances of sand, bioclasts, planktonic foraminifera, arenaceous foraminifera, etc.

b) Studying the distributions of all the available data in order to combine similar samples by purely subjective means.

c) Organizing the data into an array which can be assimilated by a multivariate computer program that groups the samples objectively.

Each of these techniques has built-in advantages and disadvantages.

Perhaps the most hackneyed of these schemes is the first mentioned, that of plotting those variables or parameters considered meaningful. This technique is comparatively clear-cut but the choice of variables is wide, the amount of data omitted from consideration is necessarily large, and any syntheses are subjective. The method, however, is well suited to the solution of strictly defined problems, the demonstration of preconceived hypotheses, or to the drawing of conclusions using data of a limited nature. A recently published study by Fisher, Proctor, Galloway, and Nagle (1970) of the Jackson Group of Texas is a good example of the utilization of only sedimentological data toward the end of paleoenvironment determination. Clarke and Bird (1966) employed the planktonic : benthonic foraminiferal ratio first utilized by Grimsdale and Van Morkhoven (1955) in a paleoenvironmental analysis of the Austin-Taylor boundary in north Texas. Exemplary recent publications which have made use of limited sedimentological and microfaunal measures are Schull, Fleix, McCaleb, and Shaw (1966); Tipsword, Setzer, and Smith (1966); and especially Gernant and Kesling (1966).

Subjective classification of a large data set of many samples and many variables into biofacies, biotopes, or environmentally similar strata makes for no omissions of information but any results can be degraded by the researcher's own prejudices. Many classic studies of modern foraminifera involved such subjective grouping. The scheme produces quite useful generalizations of formidable data arrays, but is qualitative at best and not statistically verified. Phleger (1956), in an ambitious effort, tried to delineate foraminiferal occurrences in a modern shore-zone area. Phleger selected six biofacies - groups of taxa which are found living together - characteristic of various marine subenvironments or biotopes and finally defined each biofacies in terms of the constituent species. A rigorous statistical re-evaluation by Buzas (1967) demonstrated the validity of Phleger's subjective groupings. Results that must have taken a great deal of effort on the part of an eminent foraminiferologist were thus duplicated by Buzas solely by organizing the raw data for computer assimilation and performing a multivariate statistical analysis.

The proliferation of high-speed digital computers has provided the means by which multivariate statistical analysis routines can be useful tools. The classic multivariate analytic techniques, first published decades ago, are all used to simplify relationships inherent in large amounts of samples involving many variables. Kaesler (1969) described three routines that could be applied to the present problem - cluster analysis, canonical analysis, and factor analysis.

The basic process for interpreting and evaluating any paleoenvironmental study is the pragmatic study of plotted information. Because we have only this form of evaluation, the statistical routine must not only group the lithologic and microfossil data into groups presumably from one sedimentary regime but the routine must also generate groups as mappable facies. Cluster analysis emphasizes degrees of similarity between all samples or between all variables but in neither case produces mappable facies. Canonical analysis lists the statistical confidence one can place in an a priori group but also does not generate mappable facies. Factor analysis, on the other hand, groups the raw data matrix either according to samples or variables and produces mappable information that can be readily interpreted and evaluated. Factor analysis, like the other two techniques, can be used in two modes - Q-mode for sample to sample comparisons and R-mode for variable to variable comparisons - the former is used for biotope generation and the latter for biofacies generation.

Factor analysis was first applied to the solution of a geological problem by Imbrie and Purdy (1962) to classify modern carbonate depositional facies. Since that time it has been applied by a great many workers to many types of numerical and non-numerical geological data. Bearing on the problem of Yazoo paleoenvironments, Streeter (1963) was the first to apply Q-mode factor analysis to modern foraminiferal distribution data while Langhus (1968) first applied the method to define ancient microbiofacies.

Factor analysis routines have been discussed in publications of both an applied and pure statistical nature. As used above the term factor analysis implies two complimentary techniques - principal component analysis and factor analysis proper. These two techniques are discussed in detail by Seal (1962) from which the following discussion is taken.

The purpose of principle component analysis is to account for most of the information stored in a data matrix using a small number of synthetic, discrete factors instead of the large number of original variables. This is accomplished by means of extracting a best-fit factor, which accounts for the largest part of the data, from the original data set. The factor is listed with a measure of the amount of information it has accounted for and the remaining matrix is reprocessed in order to extract another factor. This technique usually is continued until ten factors have been extracted or until an arbitrary percent of the information has been accounted for, often this figure is 90 percent. When the factors have been generated, the samples are redifined in terms of these factors instead of the original variables.

The principle component matrix of samples and factors is next passed through factor analysis in order to clarify the factors and maximize the differences between them. The routine used in the present study is the most common form of factor analysis - the varimax method of factor "rotation" to alter the factors so that they represent theoretical end members that can easily be interpreted. After the new factors have been synthesized each is defined in terms of the original variables, the samples are redefined in terms of these new factors, and a measure of percent of information explained is calculated for each factor together with a cumulative value.

The computer program utilized in this study is a new one developed and kindly supplied by Dr. J. E. Klovan, Department of Geology, University of Calgary. The program is included in Appendix C.

When applied to the problem of Yazoo paleoenvironment, Q-mode factor analysis is meant to objectively group the data into a few mappable factors each defined in terms of the originally measured lithologic and microfossil constituents. Although an infinite number of possible interpretations exist, the most probable interpretation of these factors is that each represents ancient sediments having had the same environment of deposition. Thus, the paleoenvironmental facies are seen to have a characteristic lithology (as determined by the five lithological variables) and a characteristic microfauna (as determined by the 30 microfossil variables). Therefore the samples analyzed into computer facies are much easier to interpret than the bewildering array of samples and original variables.

The author has found that the primary drawback of factor analysis is the problem of fixing boundaries between concentrations of the computer-generated facies. Normally two areas featuring high concentrations of different facies are separated by a broad transitional zone. Miller and Kahn (1962) describe the relative entropy map as the solution to this problem. Relative entropy is defined as the ratio of the actual entropy or degree of mixing to the maximum possible entropy for the number of components involved. Areas or single samples with high relative entropy values can be termed mixtures of several facies and identified as transitional. In this manner boundaries can be mapped around areas of comparatively pure facics and zones of mixing.

LITHOSTRATIGRAPHY

Figure 5 is a plot of the lithologic data obtained by the author from 309 samples. Augmenting these modal analyses is information taken from published material discussed in the STRATIGRAPHY section. An examination of Figure 5 will show that none of the four Yazoo members is lithologically continuous along strike.

The North Twistwood Creek Clay Member is predominantly mud west of Little Stave Creek but becomes mixed to the east.

The Cocoa Sand Member is largely sand only at the western and eastern edges of the study area.

The Pachuta Marl Member exhibits a great deal of lateral variation from mud in the west, through a mixed zone, to predominantly bioclastic material in the central portion of the area, and finally to mixed lithologies at the eastern edge of the study area.

The Shubuta Clay Member shows a rather consistent mud to bioclastic limestone progression from west to east.

BIOSTRATIGRAPHY

A meaningful paleoenvironmental reconstruction of the Yazoo strata under study demands a valid biostratigraphy. The most obvious criterion on which to base such a biostratigraphy is the distribution of planktonic foraminifera and calcareous nannoplankton. After some study, the writer found that

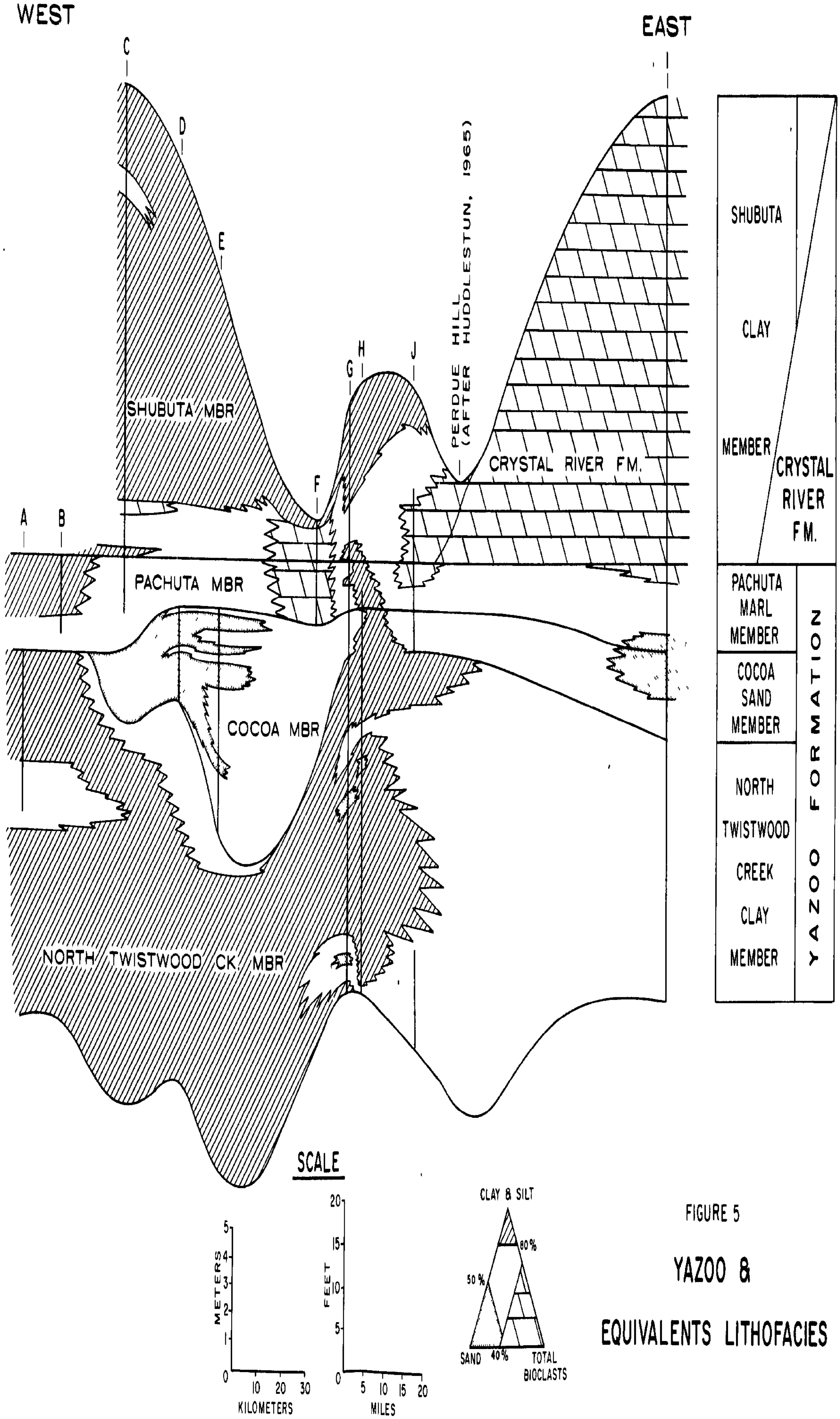


FIGURE 5

YAZOO &

EQUIVALENTS LITHOFACIES

based upon published studies of globigerinids, the strata could be placed into one of three biostratigraphic zones. Unfortunately, some species important to the zonation were exceedingly rare and indeed could not be expected to be found in samples of the more nearly barren sands and sandy claystones. Subsequently the author discovered that these same zones could also be defined in terms of the included nannoplankton.

Figure 6 shows the stratigraphic distribution of each of these zones while Table II shows in tabular form the vertical distributions of the pertinent species of each group of plankters. The distributions shown in Figure 6 are in close agreement with previous conclusions by Deboo (1965), Hazel (1970), Barker (*vide* Blow, 1969), and Huff (1970) and furthermore show that the map unit boundaries are synchronous except the upper contact of the Shubuta member which is a disconformity. Following are descriptions of the three biostratigraphic zones, the stratigraphic limits of each, and biochronologic designations for each zone.

Zone A

This zone encompasses all of the North Twistwood Creek and Cocoa members where the latter is present. The zone is an assemblage zone defined by the presence of *Chiloguembelina cubensis* (Palmer), *Hantkenina alabamensis* Cushman, and *Truncorotaloides danvillensis* (Howe and Wallace). The zone exists from the base of the Yazoo strata to the first occurrence of *Cribrohantkenina inflata* (Howe). Primarily on negative evidence

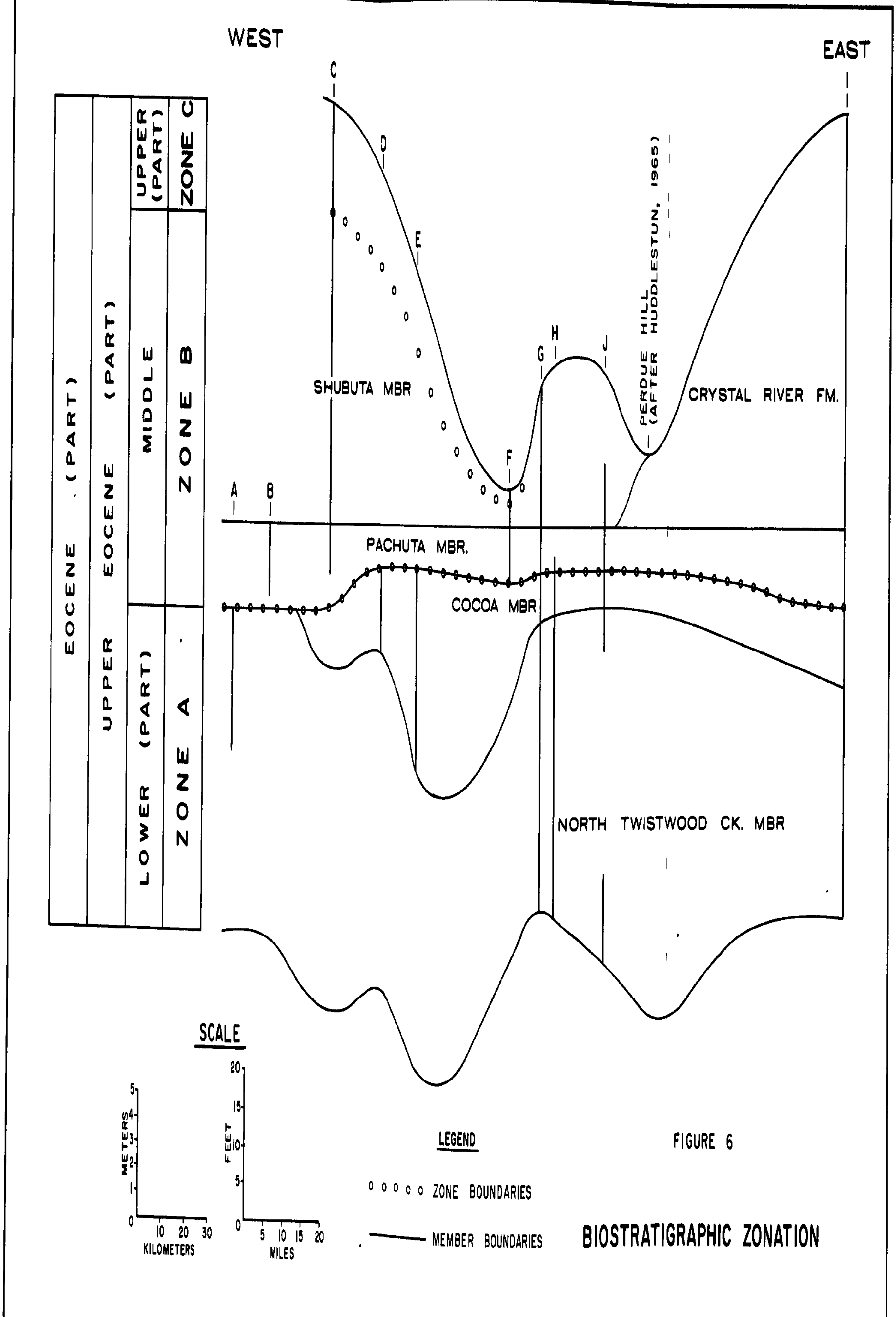


FIGURE 6

BIOSTRATIGRAPHIC ZONATION

TABLE II STRATIGRAPHIC DISTRIBUTION OF PLANKTON TAXA

ZONE C

Planktonic Foraminifera	Nannoplankton
Chiloguembelina cubensis	*Blackites amplus*
C. martini	*Cruciplacolithus tarquinius*
C. victoriana	*Discoaster tani nodifera*
Pseudohastigerina micra	*D. tani tani*
P. barbadoensis	*Isthmolithus recurvus*
Globigerina ampliapertura	

ZONE B

Planktonic Foraminifera	Nannoplankton
Chiloguembelina cubensis	
C. martini	
C. victorianna	*Discoaster barbadiensis*
Hantkenina alabamensis	*D. tani nodifera*
Cribrohantkenina inflata	*D. tani tani*
Pseudohastigerina micra	*Isthmolithus recurvus*
P. barbadoensis	
Truncorotaloides danvillensis	

ZONE A

Planktonic Foraminifera	Nannoplankton
Chiloguembelina cubensis	
C. martini	
Hantkenina alabamensis	*Discoaster barbadiensis*
Pseudohastigerina micra	
Truncorotaloides danvillensis	

and biostratigraphic position the author suggests that this zone is equivalent to part of the *Globigerapsis mexicana* zone of early Late Eocene age (Blow, 1969).

Zone B

This zone includes all of the Pachuta Marl Member and the Crystal River Formation and most of the Shubuta Clay Member within the study area. The author initially defined zone B as a total range zone of *Cribrohantkenina inflata* making it equivalent to the *C. inflata* zone of middle Late Eocene age (*ibid.*). The extraordinary scarcity of this foraminifer, however, forced the definition of this zone by calcareous nannoplankton.

Zone B, consequently, was redefined as an assemblage zone being present from the first appearance of *Isthmolithus recurvus* Deflandre to the first occurrence of *Blackites amplus* Roth and Hay or the disappearance of *Discoaster barbadiensis* Tan Sin Hok. This definition of zone B coincides with the latest Eocene *I. recurvus* zone of Hay, Molder, and Wade (1966). Hay et al. (1967), reviewing the research of Levin and Joerger (1967) into the nannoplankton in the Jacksonian and Vicksburgian strata in the Little Stave Creek section, placed the Cocoa, Pachuta, and Shubuta members into the *I. recurvus* zone. The present author would agree to the placement of the Pachuta and Shubuta at the Little Stave Creek locality into the *I. recurvus* zone, however, the writer could find no specimens of *I. recurvus* in the strata of the Cocoa sand in any of the study sections and must conclude that the Cocoa cannot be put into the above zone as defined by Hay, Molder, and Wade.

Zone C

Only the upper 12 feet (3.6 meters) of the Shubuta clay at its type locality in Clarke County, Mississippi and the upper two feet (0.6 meters) of the Shubuta at the St. Stephen's quarry section can be included in this zone. Zone C can be defined both in terms of globigerinids and calcareous nannoplankton.

The occurrence of *Globigerina ampliapertura* Bolli marks the presence of this zone and as such it is equivalent to part of Blow's *Globigerina gortanii gortanii* - *Globorotalia* (*Turborotalia*) *centralis* zone pf latest Eocene age (Blow, 1969).

The nannoplankton suite from samples of zone C contains elements from both the latest Eocene *Isthmolithus recurvus* zone and the Ologocene *Ellipsolithus subdistichus* zone as defined by Hay et al. (1967). *I. recurvus* appears to be restricted to the latest Eocene while *Blackites amplus* and *Cruciplacolithus tarquinius* Roth and Hay are restricted to the Oligocene. It seems likely that zone C of the present study is transitional between the two zones.

FACIES ANALYSIS

The body of laboratory data was prepared for factor analysis computer input by establishing five lithologic constituents, namely: 1) clay plus silt, 2) quartz sand, 3) miscellaneous bioclasts, 4) glauconite grains, and 5) foraminiferal tests; and 50 microfossil constituents - total planktonic foraminifera, total arenaceous foraminifera, total diatoms, and 47 benthonic foraminiferal taxa. These raw point-count data were first transformed into percentage values - the five lithologic constituents were recalculated to a total of 100 percent per sample and the 50 microfossil constituents were likewise recalculated to 100 percent per sample.

The first several computer trials indicated that 20 of the 47 hyaline benthonic taxa contributed only very minor amounts to the factor analysis picture and they were subsequently deleted from the study. Appendix B is the resultant data array of the 137 samples in which all the variables were measured. Lithologic data for the entire sample suite - the above 137 samples plus 172 samples for which only the lithologic variables were determined - is set in graphical form in Appendix A.

The final computer execution generated four rather equally-prevalent factors to be interpreted as facies, which left an uncorrelated residual of about seven percent of the total information in the data array. The varimax factor matrix consisting of measures for each of the computer facies in each of the samples is listed in Appendix D.

The four facies values of each sample as shown in the varimax matrix were then recalculated to total 100 percent per sample and used to compute a relative entropy value for each of the 137 samples. The literature of entropy mapping lists no criterion for defining samples with high degrees of mixing. To this end the 137 relative entropy values were plotted in a frequency histogram (Figure 7) which clearly shows a maximum in the 60 to 65 interval. Therefore, values of 60.0 or higher are considered as indicating zones of mixing.

The author has found that the computer-facies may be most easily defined by listing the basic statistics - mean and standard deviation - of the original variables in the unmixed samples (those that have relative entropy values of less than 60.0) of each facies. Table III lists the basic statistics for the original 35 variables in the 35 relatively pure samples of Facies One, the 11 samples of Facies Two, the 14 samples of Facies Three, the 16 samples of Facies Four, and the total sample suite. Figure 8 displays in histogram format the frequency distributions of four selected variables in the relatively pure samples mentioned above and in all 137 samples. Figure 8 dramatically illustrates the degree of diversity inherent between the facies which is unfortunately not statistically provable.

Figure 9 is a plot of the stratigraphic distribution of the four facies and zones of high mixing. Outlined below are the combinations of variables that characterize each facies that can be used to describe and interpret the facies-wise plot in Figure 9.

Facies One

Facies One is virtually restricted to strata of the North Twistwood Creek Member and the lower portion of the Cocoa Sand Member. Lithologically, Facies One is a lutite, the average sample containing only a negligible amount of

FIGURE 7

FREQUENCY DISTRIBUTION OF RELATIVE ENTROPY

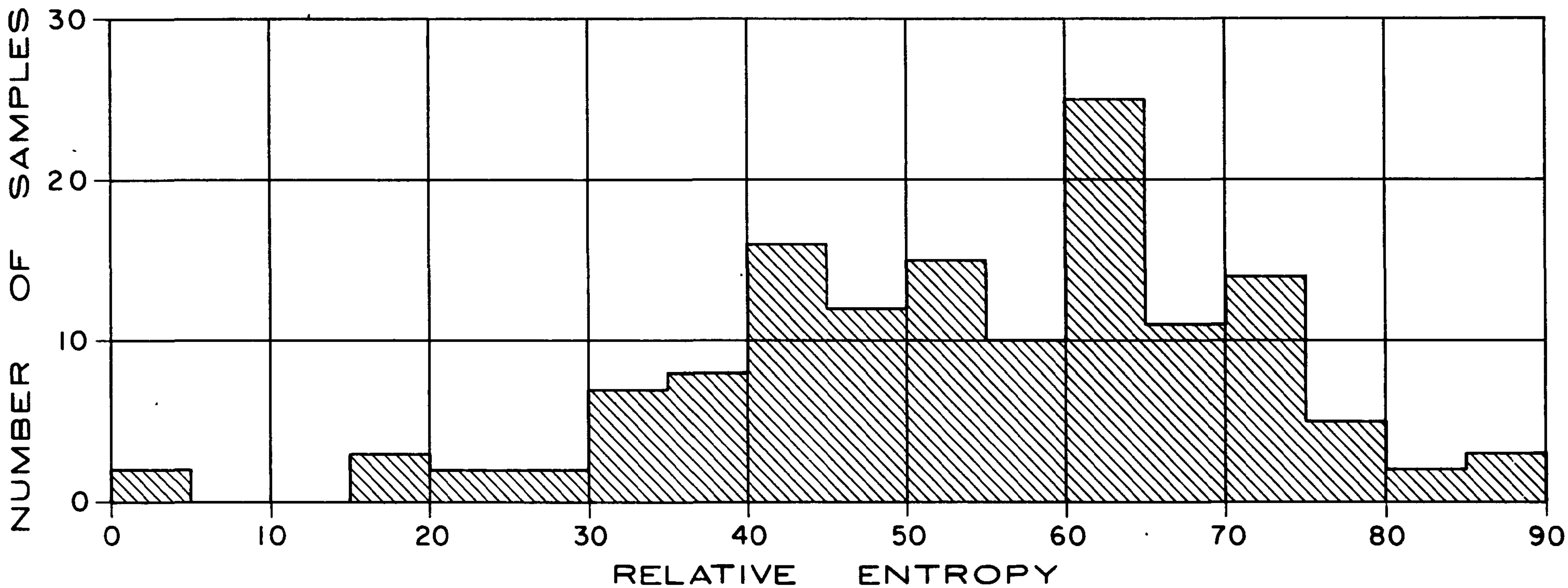


TABLE III

MEANS AND STANDARD DEVIATIONS OF THE 35 VARIABLES

VARIABLE	FACTOR ONE MEAN	FACTOR ONE ST. Dev.	FACTOR TWO MEAN	FACTOR TWO ST. Dev.	FACTOR THREE MEAN	FACTOR THREE ST. Dev.	FACTOR FOUR MEAN	FACTOR FOUR ST. Dev.	TOTAL MEAN	TOTAL ST. Dev.
CLAY PLUS SILT	93.0	6.8	24.7	10.7	28.4	10.6	76.6	24.4	67.1	25.9
QUARTZ SAND	3.7	5.2	2.0	3.5	63.4	12.0	2.2	5.8	13.2	20.4
MISC. BIOCLASTS	2.6	3.9	67.3	12.9	7.5	12.3	12.3	16.6	15.3	20.3
GLAUCONITE GRAINS	.3	.9	1.7	1.9	.2	.6	1.8	6.1	1.8	3.3
FORAMINIFERAL TESTS	.4	.6	4.2	2.9	.5	1.0	7.1	7.4	2.6	4.1
PLANKTONIC FORAMINIFERA	6.5	7.4	21.8	15.3	12.9	17.2	80.7	7.0	23.3	25.8
ARENACEOUS FORAMINIFERA	2.8	2.6	3.7	3.4	2.8	3.3	1.1	.8	2.8	2.7
DIATOMS	11.0	16.3	0.0	.1	2.1	4.1	0.0	0.0	3.1	9.0
GUTTULINA BYRAMENSIS	.6	[illegible]	.1	.2	.8	1.6	.2	.5	.9	4.3
BOLIVINA STRIATELLATA	2.8	[illegible].3	1.4	2.5	.5	1.6	.5	.7	1.6	4.8
BOLIVINA SP. A	9.0	8.9	7.0	6.5	5.5	5.8	.4	.8	5.6	7.5
BULIMINA JACKSONENSIS	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.4	.4	1.4
REUSSELLA SCULPTIS	.2	.5	5.0	4.6	1.1	3.4	0.0	.1	1.3	2.9
UVIGERINA COCOAENSIS	.1	.6	0.0	.1	0.0	.1	2.3	3.0	1.2	5.0
UVIGERINA DUMBLEI	.2	.6	.6	.7	.8	1.6	2.8	4.2	.8	1.8
UVIGERINA GLABRANS	.1	.4	.2	.4	.1	.5	.3	.7	.4	1.5
UVIGERINA JACKSONENSIS	.5	1.7	.2	.4	.1	.2	.6	.8	.6	1.3
TRIFARINA OCALANA	.5	1.4	1.2	.7	.2	.5	3.6	2.6	1.1	1.7
DISCORBIS GLOBULO-SPINOSUS	.4	.8	1.6	1.4	.2	.8	0.0	.1	.7	1.2
DISCORBIS HEMISPHAERICUS	2.2	3.0	.3	.6	1.6	1.6	0.0	0.0	1.0	2.1
VALVULINERIA JACKSONENSIS	4.2	5.8	.4	.5	3.9	7.1	.2	.9	2.1	4.8
VALVULINERIA OCTOCAMERATA	2.6	6.0	.3	.4	1.0	1.4	.8	1.3	1.2	3.2
SIPHONINA DANVILLENSIS	1.4	2.5	2.8	1.6	.5	.5	.8	.6	2.0	2.3
EPONIDES JACKSONENSIS	2.2	8.4	2.0	2.7	.4	1.1	0.0	.2	2.1	6.7
CIBICIDINA DANVILLENSIS	6.3	6.2	9.4	4.1	9.8	8.7	.2	.3	7.2	6.6
CIBICIDINA MISSISSIPPIENSIS	1.2	1.9	3.3	3.0	1.0	1.3	0.0	.1	2.0	2.8
CIBICIDES COCOAENSIS	3.0	7.0	10.3	8.2	.9	1.7	.6	1.3	4.8	7.2
C. FLORIDANUS DIMINUTIVUS	1.2	5.6	2.6	1.6	.3	.6	.3	.8	1.7	4.1
CIBICIDES TRUNCATUS	4.3	7.0	18.6	9.9	2.6	2.8	.4	.8	7.4	8.7
CASSIDULINA ARMOSA	.7	1.3	4.7	2.6	.4	.5	.1	.2	1.8	2.9
NONION ADVENA	23.3	19.1	.1	.4	37.7	21.3	.2	.6	11.5	16.7
NONION INEXCAVATUS	2.7	4.6	.1	.3	2.4	3.1	.2	.5	1.2	2.5
NONION PLANATUS	.3	.8	.3	.6	.9	1.2	0.0	0.0	.3	1.0
NONIONELLA SPISSA	5.9	6.0	.2	.2	8.5	6.1	.3	.6	3.1	4.8
ANOMALINA UMBONATA	3.6	4.8	1.7	1.9	1.4	2.2	1.3	1.7	2.2	3.2

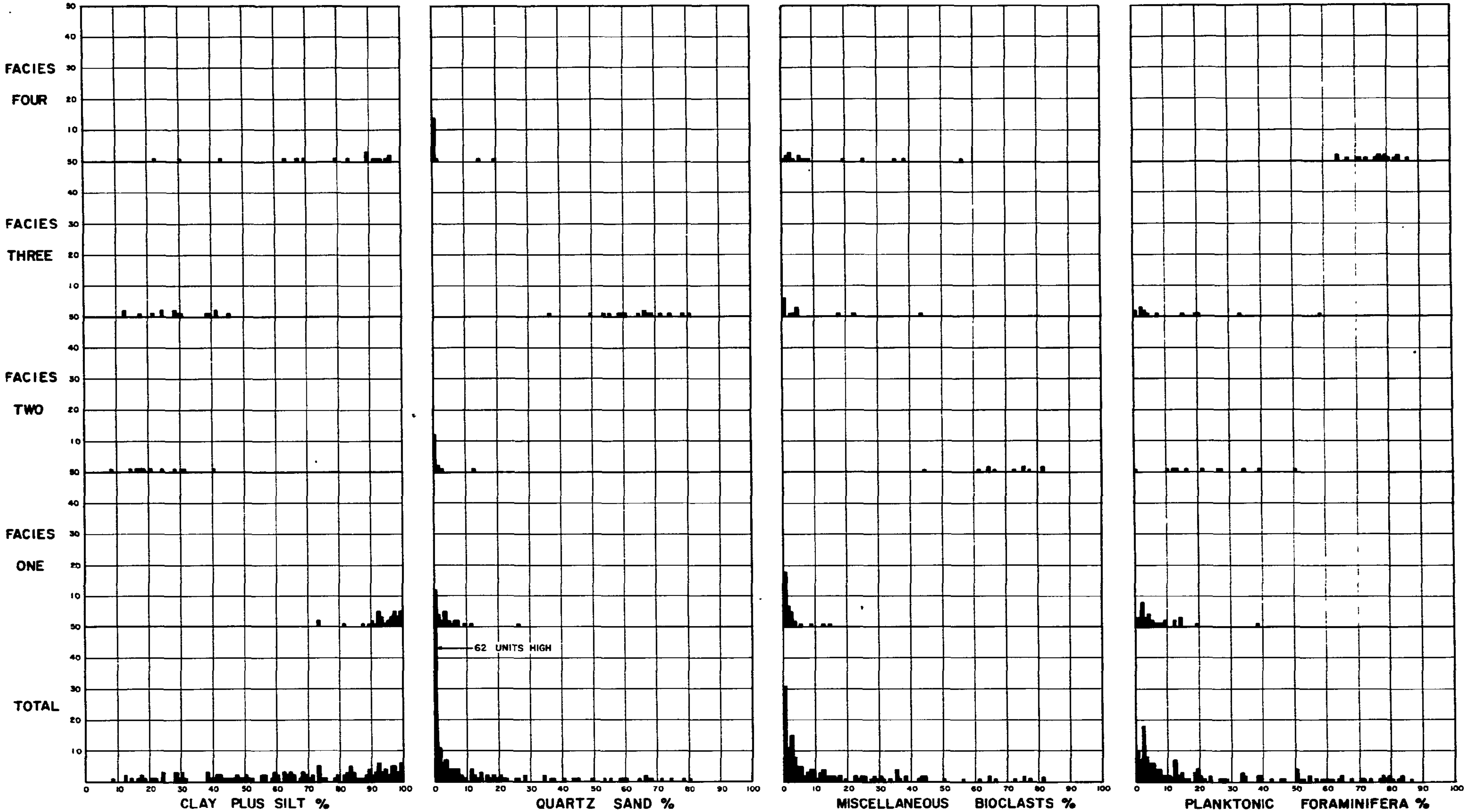


FIGURE 8

FREQUENCY DISTRIBUTIONS OF FOUR SELECTED COMPONENTS

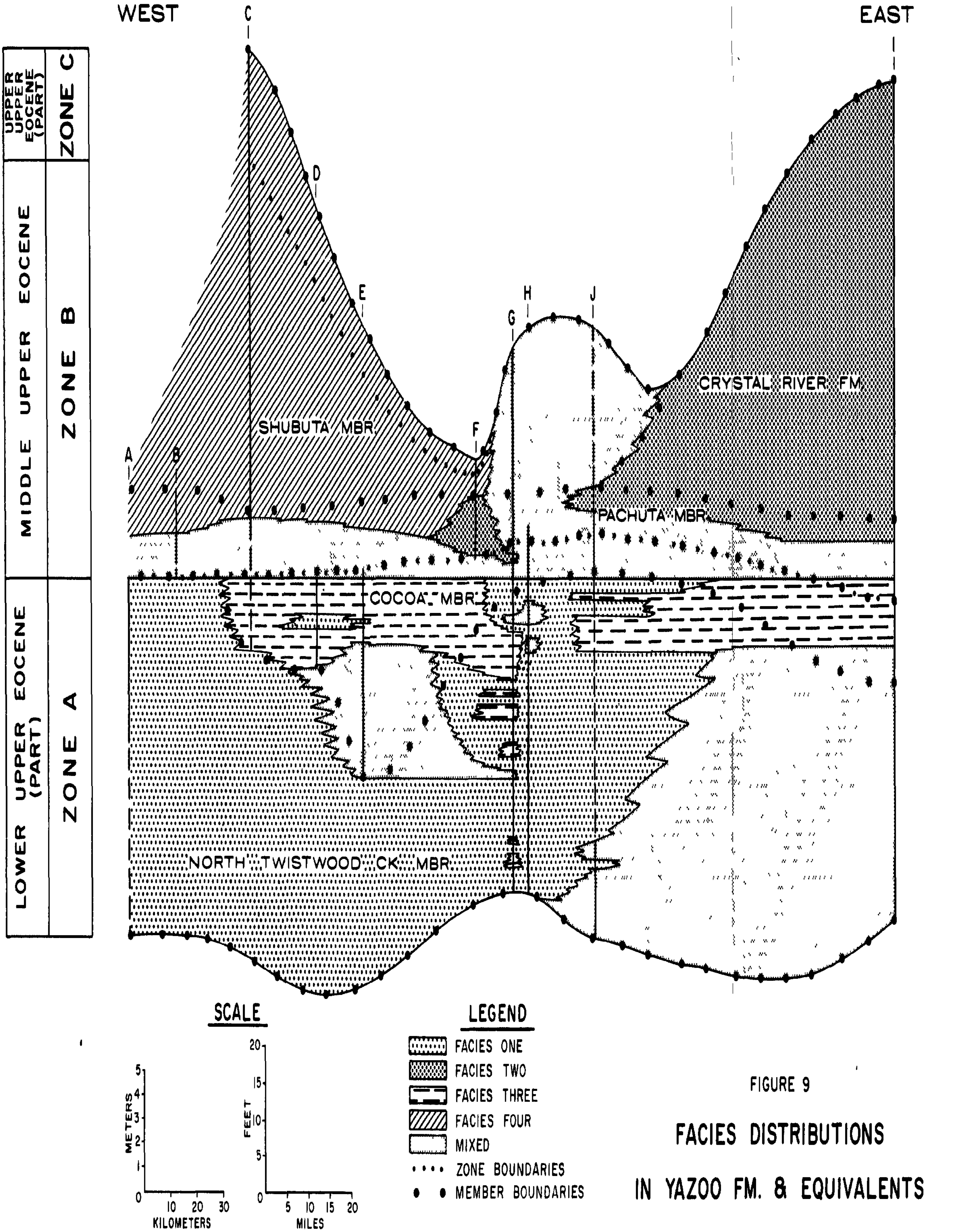


FIGURE 9

FACIES DISTRIBUTIONS

IN YAZOO FM. & EQUIVALENTS

sand-sized grains of all types. The microbiota of this facies is dominated by hyaline benthonic foraminifera and the common marine diatom Coscinodiscus, which is almost completely restricted to Facies One. The most common species of foraminifera are Nonion advenam and a nonspecifiable species of the genus Bolivina termed species A. by the writer. Several species reach their maximum concentrations in samples of Facies One - Bolivina striatella, Valvulineria jacksonensis, V. octocamerata, and Anomalina bilateralis.

Although slightly sandy muds are being deposited in many continental, brackish, and marine sites, the microfauna in the ancient muds of Facies One is rather distinct. This foraminiferal suite is quite similar to one described from the prodelta region of the Mississippi birdfoot delta by Lankford (1959): "The deltaic marine fauna occurs on the actively prograding delta where sedimentation rates are high and there is an essentially marine environment." Lankford found that the deltaic marine microfauna to be dominated by species of Bolivina, Buliminella, Epistomella, and Nonionella. The other taxa characteristic of Facies One - Valvulineria spp. and Anomalina bilateralis - have no common analogues in the modern Mississippi Delta region but both genera have been often reported from samples taken of the outer continental shelf of the Gulf of Mexico. Valvulineria was reported by Phleger (1960) and Anomalina by Bandy (1956). Specimens assigned to these genera (averaging 10.6 percent of each sample of Facies One) are perhaps present because of frequent, transient floodings by deeper, cooler waters.

Facies Two

Facies Two is restricted to two occurrences - the Pachuta Marl Member at the St. Stephen's quarry section and the Crystal River Formation together with the top three feet (0.9 meters) of the Pachuta where it underlies the Crystal River. The average sample of this facies can be lithologically classified as a packed biomicrite. The samples of Facies Two are the only ones that contain an appreciable macrofauna including ectoprocts, pelecypods, and large foraminifera. The microfauna emblematic of this facies is dominated by hyaline benthonic foraminifera but nonetheless has a considerable planktonic component. The most prominent taxa of Facies Two are the species of *Cibicides* and *Cibicidina*. Present in significantly large amounts are *Bolivina* sp. A., *Reussella sculptilis*, *Siphonina danvillensis*, and *Cassidulina armosa*.

Lithologically, samples of Facies Two closely resemble the relict carbonate deposits mapped by Ludwick and Walton (1957) as a small patch on the continental shelf edge off western Alabama. These carbonates were mapped again by Ludwick (1964) along broad areas of the outer shelf off Alabama and western Florida. These shelf-edge reefoid carbonates can be described as follows:

a) They contain varying but usually small amounts of quartz sand.

b) They are composed of at least 50 percent of sand-sized carbonate grains primarily of biogenetic origin.

c) They contain appreciable amounts of mud, largely lime mud.

d) They were formed under water depths much shallower than covers them at present (Ludwick and Walton, op. cit.)

Ludwick and Walton discovered the microfauna to be in two populations. One part of the fauna was made up of several species - Amphistegina lessoni, Archaias compressus, Peneroplis proteus, Asterigerina carinata, Reussella atlantica, Elphidium spp., Planulina exorna, etc. - specimens of which appeared brown and replaced, were never found as living specimens in these areas. They presumably date from the time of lowered sea level, i. e. Pleistocene. The second population of foraminifera included taxa - Cassidulina, Cibicides, Bolivina, Uvigerina, Trifarina, etc. - which were found living in the samples and were rather more typical of the present outer shelf environment.

Viewing Facies Two as the Jackson counterpart of the relict shelf-edge carbonates, the large foraminifera in the Pachuta and Crystal River samples are analogous to the typically large taxa (Amphistegina, Archaias, and Peneroplis) in the brown, replaced, shallow water component while the smaller Yazoo species (Cibicides, Cibicidina, Bulimina, Siphonina, Cassidulina, and Bolivina) are typical continental shelf taxa and quite possibly represent frequent, rapid floodings of the Jackson carbonates.

Facies Three

Facies Three transgresses several member boundaries, is almost always overlain by a zone of mixing (relative entropy values over 60.0), but often rests directly on Facies One strata in spite of the considerable lithological differences. These essentially muddy sands contain a small amount of bioclastic material in their make-up. Their microfossil component is dominated by hyaline benthonic foraminifers. By far the most common foraminiferal tests in samples of this facies are those of Nonion advenum. Also present in sizeable amounts is Nonionella spissa. The planktonic constituent is the least important in this facies out of the four, and is almost completely due to the presence of one species - Truncorotaloides danvillensis (Howe and Wallace). Of all the Yazoo samples, those from Facies Three had the least in terms of foraminiferal test material. Most samples required treatment in CCl_4 in order to float off and concentrate the test material.

Sands in a similar stratigraphic position to Facies Three strata have been reported by Fisk and McFarlan (1955), Shepard (1956), Curray (1964), and Ludwick (1964) from the modern Gulf of Mexico continental shelf. These sands have been interpreted by these workers as being the remnants of shoreline sands deposited during the Pleistocene transgression. These relict Pleistocene sands, unlike Facies Three samples, are composed of virtually pure quartz sand.

It is possible to reconcile the high mud content in the Facies Three strata (averaging 28 percent) with a transgressive shoreline origin by either of the two following hypotheses: a) the mud is present because the transgression during Facies Three time was substantially slower than the Pleistocene transgression. An oscillatory motion superimposed on the overall transgression would place clean shoreline sands in juxtaposition with muddy sands deposited off-shore. b) A more plausible explanation is that the Facies Three sands were deposited as two discrete units - an underlying clean shoreline sand and an overlying muddy off-shore sand. With time these two sands were thoroughly mixed by burrowing organisms, producing one homogeneously muddy sand.

The sparse microfauna of Facies Three is not mirrored by any modern foraminiferal distributions described in the literature. Species of Nonion have been reported from the modern Gulf of Mexico by Phleger (1954, 1960), Bandy (1956), and Lankford (1959). None of these authors has, however, placed any importance on the distribution of the genus and indeed it appears to be present in minor amounts all across the modern continental shelf.

It would seem likely, then, that the genus Nonion and to some extent also perhaps Nonionella have changed their ecology since the Late Eocene. A similar transformation has been deduced for the genus Cyclammina, a foraminifer that has altered its depth range during the Tertiary (Robinson, 1970). Perhaps during Jackson time, Nonion inhabited the environmental niche now occupied by Elphidium, a genus almost unknown from Jacksonian sediments of the Gulf Coast (Cushman, 1935). Elphidium spp. has been reported from the modern Gulf of Mexico in brackish interdistributary bays (Lowman, 1949 and Lankford, 1959), coastal lagoons (Phleger, 1954, 1960) and estuaries (Bandy, 1956).

Facies Four

Facies Four is stratigraphically limited to the upper part of the Pachuta marl and all of the Shubuta Member in the western portion of the study area. The slaystones designated as Facies Four contain an average of almost 20 percent bioclasts including a very sizeable amount of foraminiferal test material. The microfauna is quite distinctive, dominated by a varied planktonic component and containing taxa which are nearly absent from all the other samples - *Uvigerina cocoaensis*, *U. dumblei*, *Trifarina ocalana*, and *Bulimina jacksonensis*.

Samples of Facies Four can be interpreted as similar to prodelta and bottomset deltaic muds mapped by Shepard (1956). These muds are presently being deposited beyond the shelf break and up to 25 miles (40 kilometers) from the birdfoot delta (Ludwick, 1964). Curray (1964), however, states that except for the very large rivers such as the Mississippi, mud is only rarely carried more than 20 miles (32 kilometers) from the river mouth or deposited in water deeper than 90 feet (27 meters).

The microfauna from Facies Four is a common suite characteristic of outermost continental shelf or slope conditions. Lowman (1949) has described an assemblage composed of 60 percent planktonics and containing Cassidulina, Bulimina, Bolivina, and Uvigerina from Mississippi delta sediments at depths of approximately 2000 feet (600 meters). Bandy (1956) listed, in his fauna Five, 60 to 70 percent planktonics and the benthonic genera Bolivina, Planulina, Robulus, and Uvigerina characteristic of the upper continental slope of the Northeastern Gulf of Mexico. Phleger (1960) found foraminiferal suites consisting of 50 to 85 percent planktonic species and the benthonic genera Bolivina, Bulimina, Cassidulina, Pullenia, and Uvigerina common on the upper continental slopes of the Gulf of Mexico. Digesting a great many publications and studies, the S.E.P.M. Paleoecology Committee (SEPM, 1966) recognized eight foraminiferal ecologic zones. One of these - Upper Slope-Deep Marine - contained the following Late Eocene genera: Bulimina, Gyroidina, Bolivina, Pullenia, Siphogenerina, Cyclammina, Uvigerina, and Nonion. This ecologic zone was also characterized by a planktonic component of greater than 50 percent.

A synthesis of the microfaunal and lithological implications inherent in the data of Facies Four suggests that these samples were laid down as bottomset deltaic mauds several hundreds of feet below sea level.

DEPOSITIONAL HISTORY

The various environments of deposition shown so well by factor analysis can be put into chronological and geographic order to recreate the history of the Yazoo Formation. In the following section the author will attempt to tell a coherent story of the history of the Yazoo. He will be aided in this task by three artist's sketches of the study area as it perhaps appeared at three instants in time - early zone A (early Late Eocene), late zone A, and late zone B (middle Late Eocene). These sketches are based upon photographs taken by Apollo and Gemini astronauts of the modern Gulf of Mexico. The scale of the following sketches is the same as many of the satellite photographs and are intended to represent views from just such a vantage point orbiting the earth in the Tertiary.

The following history, due to the immensely increased efficiency of computerized factor analysis, encompasses all of the available data on the outcropping Yazoo Formation. Included in the interpretation are the structural make-up of the coastal plain and the sedimentary processes operating in the modern northeastern Gulf of Mexico.

The depositional history of the Yazoo and its equivalents in eastern Mississippi and Alabama is one of initial deltaic sedimentation, localized regression and exposure, and finally a rapid transgression across the continental shelf. During the Late Eocene this shelf received predominantly terrigenous clastics in the western part of the area and intermixed terrigenous and biogenetic clastics in the east.

The initial phase of sedimentation - shown in Figure 10 - was one of rather uniform deposition of terrigenous clastics over all but the eastern edge of the region. This terrigenous material was delivered to the continental shelf through several medium-sized rivers laying down an even thickness of typical prodelta muds except in central Alabama where bioclasts made up a significant percentage of the sediment volume. In western Clarke County, Alabama sedimentation was perhaps more rapid than the regional rate of subsidence, causing shallowing and the formation of thin lenses of Facies Three sands.

Towards the end of zone A time a portion of the Yazoo shelf was exposed by gentle, local crustal movements. The greatest amount of movement and, therefore, the most extensive regression took place in the vicinity of the Hatchetigbee Anticline, although less profound regression occurred east of this area as well. The supposition of movement in this structural feature is supported by the fact that repeated Tertiary movement has been documented for the nearby Klepac Dome which is also a fault-bounded, salt-cored structure (Copeland, 1968).

Closely following the regression, there took place a rapid transgression. As shown in Figure 11, a sandy beach was formed and swept northeastward over the emergent shelf, creating the thin, muddy sands of Facies Three which are observed to rest directly upon prodelta muds wherever appreciable regression had taken place. At the North Jackson locality regression apparently did not occur, perhaps because it and the river above it were located in a small graben and were not affected by even the sympathetic uplift that caused regressions in the eastern portion of the study area.

As the shoreline continued to advance northward in early zone B time, conditions were transitional. As water depth increased, sand was no longer being deposited in significant quantities at any of the outcrop locations. Instead, sediments of a thoroughly mixed character accumulated. In the west, prodelta muds were mixed with deep-water, outer shelf muds while in the central and eastern parts, prodelta muds were mixing with shallow-water bioclastic build-ups. This extensive mixing can have been due to rapidly vacillating water depths but more likely was due to arrested sedimentation which would have allowed burrowing organisms to thoroughly churn the muddy sediments.

Continued transgressions, in late zone B time, gave rise to deep-water conditions in the western part of the present study area and the establishment of frequently-flooded, shallow-water, reefoid carbonates in the eastern section. These conditions are shown in Figure 12. In eastern Mississippi, a considerable thickness of outer shelf muds accumulated, suggesting a major delta not too far distant that perhaps gave rise to the several hundreds of feet of Shubuta Clay Member present in central Mississippi. In the centre of the study area, conditions remained changeable and produced the mixed deltaic muds and reefoid carbonates found in the Little Stave Creek and North Jackson sections. These conditions were likely due either to changes in the rate of sedimentation or minor crustal movements. In central Alabama, the Crystal River Formation was deposited as bioclastic accumulations that were occassionally flooded by shelf waters characteristic of Facies Two.

SYSTEMATIC DESCRIPTIONS

The fossil biota dealt with in this thesis can be subdivided into three broad groups - calcareous nannoplankton, diatoms, and foraminifera. The taxonomy of these groups will be treated separately.

The body of taxonomic literature of calcareous nannoplankton is large but fraught with serious problems. Some genera (e. g. Coccolithus) are found in modern pelagic waters. Other genera (e. g. Blackites) are demonstrably related to living forms though they themselves are extinct. Still other genera (e. g. Discoaster) are neither found as living specimens nor can be shown to be related to a living form. Most studies include illustrations produced by either light microscopy or electron microscopy but not both. These problems have led to a great number of conflicting classifications as has been observed by Bramlette and Sullivan (1961), Hay and Towe (1962), and Barbieri and Medioli (1969). In the following descriptions, genera are listed alphabetically and no suprageneric classification is attempted.

The sole diatom genus described is one commonly found living in the modern Gulf of Mexico and is classified according to the taxonomy of Prescott (1968).

The foraminifera described in the following section are classified according to the taxonomy established by Loeblich and Tappan (1964).

Phylum Chrysophyta
Class Chrysomonadales
Family Coccolithophoridaceae

Genus Blackites Hay and Towe, 1962

Blackites amplus Roth and Hay

Plate 1 and Plate 2, figure 1

Blackites amplus ROTH AND HAY, 1967, p. 445, pl. 7, fig. 10.

Remarks - This distinctive coccolith, characterized by a ring of narrow struts and slits separating the inner and outer cycles of segments, is difficult to diagnose with the light microscope and perhaps for this reason has only appeared once in the literature.

Occurrence - Roth and Hay report this species to range from the Ellipsolithus subdistichus zone to the Reticulofenestra laevis zone, both labelled as Oligocene in age.

Distribution - B. amplus was not found in samples below zone C in the Yazoo material.

Genus Cruciplacolithus Hay and Mohler, 1967

Cruciplacolithus tarquinius Roth and Hay

Plate 2, figure 2

Cruciplacolithus tarquinius ROTH AND HAY, 1967, p. 446, pl. 6, fig. 8.

Remarks - This species was not found in samples analysed by the electron microscope. Forms resembling Roth and Hay's illustration were noted in samples studied through the light microscope.

Occurrence - This species has only been reported from the Oligocene Ellipsolithus subdistichus zone of the Blake Plateau.

Distribution - C. tarquinius was noted in small numbers only in samples from zone C.

Genus Discoaster Tan Sin Hok, 1927

Discoaster barbadiensis Tan Sin Hok

Plate 2, figure 3

Discoaster barbadiensis TAN SIN HOK, 1927, p. 119, (part); Hay et al., 1967, p. 439, pl. 2, figs. 6-9; Levin and Joerger, 1967, p. 172, pl. 3, figs. 17 a-b, (synonomy).

Occurrence - D. barbadiensis is confined to the Upper Eocene (Hay et al., 1967, p. 439).

Distribution - D. barbadiensis was found throughout material from zones A and B.

Discoaster tani nodifera Bramlette and Riedel, 1954

Plate 2, figure 4

Discoaster tani nodifera BRAMLETTE AND RIEDEL, 1954, p. 397, pl. 39, fig. 2; Hay et al., 1967, p. 438, 439; Levin and and Joerger, 1967, p. 172, pl. 4, figs. 4-6.

Occurrence - This species has previously been reported from the Upper Eocene and Oligocene of the Gulf Coast.

Distribution - D. tani nodifera was to be found in samples from zones B and C in the study material.

Discoaster tani tani Bramlette and Riedel, 1954

Plate 2, figure 5

Discoaster _tani_ BRAMLETTE AND RIEDEL, 1954, pl. 39, fig. 1; Levin, 1965, p. 271, pl. 43, fig. 6; Levin and Joerger, 1967, p. 172, pl. 4, figs. 3a,b.

Discoaster _tani_ _tani_ Bramlette and Riedel HAY ET AL., 1967, p.439, pl. 1, fig. 1.

Occurrence - Levin (1965) states that this subspecies has been reported from strata Middle Eocene to Oligocene in age.

Distribution - _D._ _tani_ _tani_ appeared in samples only from zones B and C.

Genus _Isthmolithus_ Deflandre, 1954

Isthmolithus _recurvus_ Deflandre

Plate 2, figure 6

Isthmolithus _recurvus_ DEFLANDRE, 1954, p. 169, pl. 12, figs. 9-13; Levin, 1965, p. 269, pl. 42, fig. 10 (synonomy); Hay et al., 1967, p. 439-440, pl. 1, fig. 12; Levin and Joerger, 1967, p. 173, pl. 4, fig. 11.

Occurrence - Hay et al. (1967) list _I._ _recurvus_ as being present in strata as young as Early Oligocene while Levin (1965) lists this species as having been found in rocks as old as Late Eocene.

Distribution - Contrary to Levin and Joerger (1967), this form was not found in zone A samples but did appear in zones B and C.

Class Bacillariophyceae
Order Centrales

Genus _Coscinodiscus_

Plate 3, figure 1

Remarks - The size of the Yazoo specimens varied considerably and the shape ranged from very flat, discoid to squat, columnar forms. All the specimens likely belong to this very common genus but probably represent several species.

Occurrence - Coscinodiscus has been widely reported from sediments ranging in age from Cretaceous (Hanna, 1927) to Modern (Phleger, 1960).

Distribution - Diatoms were almost totally restricted to samples of the prodelta Facies One.

Phylum Protista
Subphylum Sarcodina Schmarda, 1871
Class Rhizopodea von Siebold, 1845
Subclass Lobosia Carpenter, 1861
Order Foraminiferida Eichwald, 1830
Suborder Rotaliina Delage and Herouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family Polymorphinidae D'Orbigny, 1839
Subfamily Polymorphininae d'Orbigny, 1839

Genus Guttulina d'Orbigny in de la Sagra, 1839

Guttulina byramensis (Cushman)

Polymorphina byramensis CUSHMAN, 1922, p.94, pl. 17, fig. 2.

Guttulina byramensis (Cushman) CUSHMAN AND TODD, 1946, p. 86, pl. 15, fig. 3; Bandy, 1949, p. 68, pl. 9, figs. 14 a,b.

Test small, short, and broad, triangular, chambers variably inflated, sutures distinct and depressed, wall calcareous, smooth and shiny; aperture very finely radiate, slightly produced.

Remarks - This species is one of several of this genus found in the Yazoo Formation but is the dominanat species in the samples examined by the author.

Occurrence - This species, though rare throughout the area, is most often found in the sandy, shoreline Facies Three where it averages slightly less than 1 percent.

Superfamily Buliminacea Jones, 1875
Family Bolivinitidae Cushman, 1927

Genus Bolivina d'Orbigny, 1839

Bolivina striatellata Cushman and Applin

Bolivina jacksonensis striatellata CUSHMAN AND APPLIN, 1926, p. 167, pl. 7, figs. 5,6; Cushman, 1935, pl. 14, figs. 14-18; _________, 1937, p. 96, pl. 15, fig. 15.

Bolivina striatellata Cushman and Applin BANDY, 1949, p. 129, pl. 24, figs. 8a,b; Deboo, 1965, pl. 22, fig. 19.

Test moderately elongate, compressed, strongly diamond-shaped in cross-section, periphery with thickened keel, edge sharply rounded, apical end rounded and slightly bulbous; numerous chambers closely appressed with peripheral portions strongly oblique, median portions slightly curved back, sutures distinct, limbate becoming raised and fused to form a median ridge; wall finely perforate, bottom portion bearing fine longitudinal costae, aperture elongate, extending from the base of the last chamber part way up the septal face.

Occurrence - This species commonly makes up several percent of samples from Facies One and Two.

Bolivina sp. A

Test is small, slightly elongate, oval in outline, almost as thick as wide, edges are rounded, periphery is limbate and rather thickened; wall texture is glassy and often obliterated by drusy grains on the surface.

Remarks - The shape and chamber arrangement would suggest the assignment of this common form to the genus *Bolivina*. Its outline and size approach that of *B. ouachitaensis* Howe and Wallace.

Occurrence - This form is the most common of those assigned to this genus. It is present in amounts up to 10 percent in samples of Facies One and Two and lesser amounts in Facies Three.

Family Buliminidae Jones, 1875
Subfamily Bulimininae Jones, 1875

Genus *Bulimina* d'Orbigny, 1826

Bulimina jacksonensis Cushman

Bulimina jacksonensis CUSHMAN, 1925, p. 6, pl. 1, figs. 6,7; ________, 1946, p. 23, pl. 5, fig. 1; Cushman and Parker, 1947, p. 97, pl. 22, figs. 14-16; Bandy, 1949, p. 134, pl. 26, figs. 5a,b; Deboo, 1965, pl. 21, figs. 16,17.

Test moderate to large, elongate, tapering, distal end pointed, apertural end broadly rounded; chambers in seven or eight triserial whorls, in three regular columns, the later chambers slightly inflated; sutures flush in the early part and slightly depressed in the latter; surface smooth and glossy, ornamented by several prominent, sharp, serrate, longitudinal costae, much raised above the surface, continuous from distal to apical end; aperture virguline, nearly terminal in a slight depression with narrow lip.

Remarks - Specimens assigned to this species exhibited seven to 12 costae and apparently did not form two populations as described by Cushman (1925) - one having seven or eight costae (_B. jacksonensis_) and another having 10 to 12 costae (_B. jacksonensis cuneata_).

Occurrence - This species, except for a very few individuals, was restricted to the deep-water Facies Four where it averaged 2.7 percent of the samples.

Subfamily Pavonininae Eimer and Fickert, 1899

Genus _Reussella_ Galloway, 1933

Reussella sculptilis (Cushman)

Verneuilina sculptilis CUSHMAN, 1926, p. 34, fig. 3.

Reussella sculptilis (Cushman) CUSHMAN, 1935, p. 38, pl. 15, figs. 6,7.

Test slightly longer than broad, pyramidal, three-sided, triangular in transverse section, sides flattened to slightly convex, distal end tapering to point or spine, angles of test acute; central line of each side marked by a strongly raised costa; aperture on the inner border of the final chamber.

Occurrence - _R. sculptilis_ was most common in samples of Facies Two.

Family Uvigerinidae Haeckel, 1894

Genus _Uvigerina_ d'Orbigny, 1826

Uvigerina cocoaensis Cushman

Uvigerina cocoaensis CUSHMAN, 1925, p. 68, pl. 10, fig. 12; __________, 1935, p. 39, pl. 15; __________, 1946, p. 28, pl. 5, figs. 15-20; Bandy, 1949, p. 140, pl. 26, fig. 14; Deboo, 1965, pl. 21, figs. 7,12.

Test moderately large, elongate, conical, greatest width slightly above the middle; periphery rather lobulate; chambers few for the genus , evenly rounded; sutures slightly depressed, cyrved; wall ornamented with coarse, longitudinal costae, usually terminating at the suture lines, becoming lower and less conspicuous in later chambers, the last chamber often smooth; from 12 to 16 costae present in the widest region; wall finely perforate; aperture at the end of a neck with a phialine lip.

Occurrence - This species is almost entirely restricted to samples of the deep-water Facies Four. In these samples, it often makes up two to five percent of the total foraminifera.

Uvigerina dumblei Cushman and Applin

Uvigerina dumblei CUSHMAN AND APPLIN, 1926, v. 10, p. 177, pl. 8, fig. 19; Cushman, 1946, p. 28, pl. 5, fig. 21; Bandy, 1949, p. 141, pl. 27, fig. 6; Deboo, 1965, pl. 21, fig. 20.

Test medium-sized, subfusiform, about twice as long as broad; periphery lobulate; chambers inflated, three per whorl; sutures depressed; wall ornamented with numerous fine longitudinal costae, often 10 to 12 per chamber, partly continuous across sutures; aperture round, terminal, on short neck, usually lacking a lip.

Occurrence - This species is the most common of the genus. It is most abundant in samples of deep-water Facies Four, but is present in amounts up to one percent in the other three facies.

Uvigerina glabrans Cushman

Uvigerina glabrans CUSHMAN, 1933, p. 13, pl. 1, fig. 28;

__________, 1946, p. 28, pl. 5, figs. 23-26; Bandy, 1949, p. 142, pl. 27, fig. 3; Deboo, 1965, pl. 21, fig. 11.

Test moderately large, short fusiform, greatest width near the middle; periphery slightly lobulate; chambers in three or four whorls, somewhat inflated, evenly rounded; sutures depressed; surface smooth, vaguely costate near distal end; wall finely perforate; apertural end truncate, with a short, thick, cylindrical neck and phialine lip.

Occurrence - This species is rather evenly distributed throughout the samples, being present as sparsely scattered individuals.

Uvigerina jacksonensis Cushman

Uvigerina jacksonensis CUSHMAN, 1925, p. 67, pl. 10, fig. 13; Howe and Wallace, 1932, p/ 65, pl. 12, figs. 7,8; Cushman, 1935, p. 40, pl. 16, figs. 1-3; Deboo, 1965, pl. 21, fig. 10.

Test moderately large, broadly fusiform, periphery slightly lobulate; chambers relatively few in number, inflated; sutures somewhat depressed, basal part of chamber not conspicuously overhanging, evenly curved; wall ornamented with coarse, longitudinal costae, in the early portion usually limited to the individual chamber, in the later portion, usually extending across sutures; about 18 to 22 costae in the complete circumference in the widest portion; wall rather coarsely punctate, the last-formed chamber tending to lose costae, with a cylindrical neck and phialine lip.

Occurrence - This uncommon species is present in samples from all facies, being slightly more abundant in the samples of deep-water Facies Four.

Genus Trifarina Cushman, 1923

Trifarina ocalana (Cushman)

Angulogerina ocalana CUSHMAN, 1933, p. 14, pl. 1, fig. 30; __________, 1935, p. 41, pl. 16, figs. 7,8; __________, 1945, p. 8, pl. 2, fig. 9; Cushman and Todd, 1945, p. 99, pl. 15, fig. 23; Cushman, 1946, p. 29, pl. 6, fig. 6.

Test small for the genus, elongate, fusiform, periphery very slightly lobulate, somewhat triangular in section, the angles rounded, especially in the early pertion; wall ornamented with numerous very fine, slightly raised costae, the outer edge broken into a finely serrate line; apertural end with the chambers somewhat loosely arranged, the costae less prominent or nearly absent, the chambers more definitely triangular, angles sharper; apertural end extended into a short neck with a slight lip.

Remarks - Hofker (1956) and Loeblich and Tappan (1964) consider Angulogerina to be a junior synonym of Trifarina.

Occurrence - This species, the most common of the genus in the sample suites, is sparingly present in all facies but is most abundant in the deep-water Facies Four.

Superfamily Discorbacea Ehrenberg, 1838
Family Discorbidae Ehrenberg, 1838
Subfamily Discorbinae Ehrenberg, 1838

Genus Discorbis Lamarck, 1804

Discorbis globulo-spinosus Cushman

Discorbis globulo-spinosa CUSHMAN, 1933, p. 14, pl. 2, figs. 1a-c; __________, 1935, p. 43, pl. 16, figs. 14a-c.

Test rather small, ventral side flat, dorsal side strongly convex, composed of several whorls, last-formed one with five chambers, ventral peripheral angle sharp and somewhat keeled; early chambers somewhat indistinct, later ones more so, narrow and high, and inner portion on the dorsal side produced into a distinct, raised ridge, which often becomes spinose in the central portion; sutures only slightly depressed and very oblique on the dorsal side, on the ventral side nearly radial; wall coarsely perforate both on the dordal and ventral sides, ventral side smooth; aperture a curved, arched opening on the ventral side of the test, extending toward the umbilicus.

Occurrence - D. globulo-spinosus is present in very small quantities in the suite. It is most common - up to several percent - in carbonate Facies Two.

Discorbis hemisphaericus Cushman

Discorbis hemispherica CUSHMAN,1931, p. 59, pl. 7. fig. 14; Ellisor, 1933, pl. 3, figs. 17,18; Howe, 1939, p. 73, pl. 10, figs. 16-19; Cushman and Todd, 1945, p. 100, pl. 15, figs. 30,31; Bandy, 1949, p. 96, pl. 16, figs. 2a-c.

Test small, hemispherical, dorsal side strongly convex, ventral side slightly convex due to the presence of three or four large, inflated, supplimentary chambers near the umbilical area; edge rounded and with slight carina which is somewhat jagged in some specimens; periphery slightly lobulate; four chambers in the last whorl; sutures distinct, oblique and slightly depressed dorsally; ventral sutures nearly radial, slightly depressed; wall coarsely and conspicuously perforate on both sides; aperture a large, high opening on the ventral side of the test extending from near the periphery to the umbilicus, with a prominent lip.

Occurrence - This species is also rather rare in the Yazoo samples. It makes up a few percent of both Facies One and Three.

Subfamily Bagginінae Cushman, 1927

Genus Valvulineria Cushman, 1926

Valvulineria jacksonensis Cushman

Valvulineria jacksonensis CUSHMAN, 1933, p. 18, pl. 2, figs. 9a-c; ________, 1935, p. 44, pl. 18, figs. 2a-c; ________, 1946, p. 34, pl. 6, fig. 14.

Test biconvex, compressed, dorsal side with a very low spire, ventrally convex toward the periphery, but depressed at the umbilicus, which is somewhat finely papillate, periphery rounded; chambers distinct, about eight in the adult whorl, of uniform shape, gradually increasing in size as added, not inflated; sutures distinct, on the dorsal side gently curved, limbate, not depressed, ventrally almost straight, oblique, slightly depressed; wall smooth; aperture ventral beneath the umbilicate lobe of the last chamber.

Occurrence - V. jacksonensis and V. octocamerata are present in all facies but most prevalent in Facies One. These species commonly total 5 percent or more of samples from Facies One.

Valvulineria octocamerata (Cushman and Hanna)

Gyroidina soldani octocamerata CUSHMAN AND HANNA, 1927, p. 223, pl. 14, figs. 16-18; Cushman, 1935, p. 45, pl. 18, fig. 18; Howe, 1939, p. 75, pl. 9, figs. 34-36; Cushman, 1946, p. 31, pl. 6, fig. 15.

Valvulineria octocamerata (Cushman and Hanna) BANDY, 1949, p. 84, pl. 13, figs. 1a-c.

Test small, dorsal side flattened, ventral side very convex, composed of about three coils, the last one consisting of about eight chambers; edge broadly rounded with a slight dorsal shoulder; periphery smooth, becoming somewhat lobulate in the later portion; ventral side strongly umbilicate; chambers distinct, increasing gradually in size as added; sutures distinct, slightly depressed, ventrally nearly radial and slightly curved, dorsally somewhat oblique; wall finely perforate, smooth; aperture elongate, a very low arch extending from near the periphery along the base of the last septal face into the umbilicus under a thin, valvular flap.

Family Siphoninidae Cushman, 1927

Genus Siphonina Reuss, 1850

Siphonona danvillensis Howe and Wallace

Siphonina danvillensis HOWE AND WALLACE, 1932, p. 70, pl. 13, fig. 1; Bergquist, 1942, p. 89, pl. 9, figs. 3a-c; Cushman, 1946, p. 35, pl. 7, figs. 3,4; Bandy, 1949, p. 115, pl. 21, figs. 8a-c.

Test biconvex, trocoid, the last whorl containing about five chambers; periphery with broad, thin, denticulate keel; edge sharp; chambers distinct on the ventral side, indistinct on dorsal; sutures on ventral side nearly radial, slightly curved and somewhat depressed; dorsally sutures oblique to periphery, somewhat curved, and indistinct, especially in the spire; aperture elongate, elliptical, located slightly to the ventral side of the plane of coiling, distinct short neck, thin, flaring lip.

Remarks - S. danvillensis was the most common species of the genus but other species - S. advena, S. clabornensis - appear sparingly.

Occurrence - Siphonina danvillensis was uncommon in the sample suite but reached its maximum abundance of 2-4 percent in samples of Facies Two.

Superfamily Orbitoidacea Schwager, 1876
Family Eponididae Hofker, 1951

Genus Eponides de Montfort, 1808

Eponides jacksonensis (Cushman and Applin)

Pulvinulina jacksonensis CUSHMAN AND APPLIN, 1926, p. 181, pl. 9, figs. 24,25.

Eponides jacksonensis (Cushman and Applin) CUSHMAN, 1935, p. 46, pl. 19, figs. 4-8; __________, 1946, p. 34, pl. 7, figs. 1,2; Bandy, 1949, p. 87, pl. 14, figs. 1a-c.

Test large, trochoid, spire high, obscured by thickening, much more convex than the ventral side; edge slightly rounded; periphery smooth, very slightly lobulate; chambers six to eight in last whorl; dorsal sutures straight and completely tangential to the earlier whorl, ventral sutures radial, slightly curved and somewhat depressed; wall smooth, conspicuously but finely perforate; aperture forming a distinct angle in the border of the test and extending to near the umbilicus with a ventral lip.

Occurrence - Though not common, this species was present in amounts up to several percent in Facies One and Two.

Family Cibicididae Cushman, 1927
Subfamily Planulininae Bermudez, 1952

Genus Cibicidina Bandy, 1949

Cibicidina danvillensis (Howe and Wallace)

Cibicides danvillensis HOWE AND WALLACE, 1932, p. 77, pl. 14, fig. 5, Cushman and Herrick, 1945, p. 72, pl. 11, fig. 14; Cushman, 1946, p. 39, pl. 8, figs. 7,8.

Cibicidina danvillensis (Howe and Wallace) BANDY, 1949, p. 92, pl. 14, figs. 7a-c.

Test rather small, planoconvex, trochoid, subcircular in outline, ventral side convex with a central clear boss of calcareous material, dorsal side flat to slightly concave, edge acute or subacute; periphery smooth, not lobulate; chambers seven to eight in the last whorl with extensions of the inner ends nearly to the center in young specimens, only becoming slightly evolute in adult and gerontic specimens; sutures limbate, nearly flush, curved on both dorsal and ventral sides; wall smooth, finely perforate; aperture a low arch at the base of the last septal face extending across the periphery and continuing along the base of the last chamber dorsally for a distance of several chambers.

Remarks - This species was placed in a new genus by Bandy on the strength that "adult and gerontic" individuals displayed evolute coiling on the umbilical side. These larger, evolute forms were also noted in this study but were found only in the Shubuta and mostly east of Shubuta, Mississippi.

Occurrence - The form is quite common in all but the deep-water sediments, making up nearly 10 percent of the samples from Facies Two and Three.

Cibicidina mississippiensis (Cushman)

Anomalina mississippiensis CUSHMAN, 1922, p. 98, pl. 21, figs. 6-8; Cole and Ponton, 1930, p. 46, pl. 9, figs. 2,3.

Cibicides mississippiensis (Cushman) ELLISOR, 1933, pl. 5, fig. 6 (not Fig. 7); Cushman, 1935, p. 54, pl. 22, fig. 3; ________, 1946, p. 39, pl. 8, figs. 5,6.

Cibicidina mississippiensis (Cushman) BANDY, 1949, p. 94, pl. 16, figs. 5a-c.

Test planoconvex, dorsal side flattened to slightly concave, involute to proloculus, ventral side very convex, involute to umbilicus with large umbilical depression; periphery smooth, very slightly lobulate; edge broadly rounded with sharply rounded shoulder; chambers six to eight in the last whorl, much inflated in the later part, increasing rapidly in size, especially the last few; sutures curved on the dorsal side, broad, limbate and flush with the surface, on the ventral side much narrower, slightly limbate in the early portion of the last whorl, depressed in the remainder; wall thin and translucent, with medium-sezed, conspicuous perforations, fewer on the dorsal side; aperture a narrow slit extending dorsally from the periphery along the base of the last chamber to the base of the last septal face.

Occurrence - C. mississippiensis occurs in small percentages in the three shelf facies and is most commonly found in Facies Two.

Subfamily Cibicidinae Cushman, 1927

Genus Cibicides de Montfort, 1808

Cibicides cocoaensis (Cushman)

Eponides cocoaensis CUSHMAN, 1928, p. 13, pl. 10, fig. 2; ________, 1935, p. 47, pl. 19, figs. 1,2; ________, 1946, p. 34, pl. 6, fig. 16.

Cibicides cocoaensis (Cushman) BANDY, 1949, p/ 103, pl. 18, figs. 4a-c.

Test rather small for genus, conical, ventral side only slightly convex, with central, low small umbo, dorsal side more strongly so with broadly rounded spire, circular in side view; periphery smooth, with very narrow keel; edge acute; chambers numerous, not inflated, about 12 in the last whorl, all but the last few indistinct from the dorsal side; sutures on ventral side nearly radial, gently curved; dorsal side with the spiral suture distinct and somewhat limbate, sutures between chambers oblique, limbate; wall coarsely perforate, smooth except for the ventral boss; aperture a very small, low slit at the base of the last septal face next to the periphery and extending very slightly over the periphery to the dorsal side, more so in some individuals than in others.

Occurrence - C. cocoaensis is most common in Facies Two, often making up more than 10 percent of the fauna.

Cibicides floridanus diminutivus Bandy

Cibicides floridanus diminutivus BANDY, 1949, p.104, pl.

17, figs. 4a-c.

Test small for the genus, subcircular, biconvex, ventral side with prominent central boss; periphery smooth, with a thin border of clear shell material; edge acute to subacute; chambers 11 to 13 in the last whorl. increasing gradually in size; ventral sutures gently curved, limbate, raised and coalescing with the umbo; dorsal sutures little curved, limbate, raised; spiral sutures limbate, raised, the earlier chambers reduced at the surface as a spire of round depressions; wall coarsely perforate; aperture a slit at the base of the apertural face extending from the edge onto the dorsal side, continuing between the last two chambers and the previous whorl.

Occurrence - This species is sparsely present in all facies but most common in Facies Two where it makes up two to three percent of each sample.

Cibicides truncatus Bandy

Cibicides truncatus BANDY, 1949, p. 111, pl. 19, figs. 2a-c.

Test small, subcircular, dorsal side flattened or slightly concave, ventral side a truncated cone, with small, shallow umbilicus; edge acute; periphery keeled, moderately lobate; chambers about seven in the final whorl, increasing very gradually in size as added; sutures strongly curved and limbate on the dorsal side, curved, narrowly limbate and raised on the ventral side; wall coarsely perforate, more so on the dorsal side; aperture at the periphery, with a distinct upper lip, extending over onto the dorsal side and continuing along the spiral suture for a distance of two or three chambers.

Occurrence - This species is most often found in Facies Two where it is the dominant species, averaging almost 20 percent of each sample.

Superfamily Cassidulinacea d'Orbigny, 1839
Family Cassidulinidae d'Orbigny, 1839

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina armosa Bandy

Cassidulina armosa BANDY, 1949, p. 139, pl. 26, figs. 12a,b.

Test small, biconvex, biumbonate, subcircular in side view; periphery slightly lobulate; edge rather sharply rounded or angled; chambers short and wide with nearly parallel edges in the last few chambers, about five pairs in the last whorl; sutures slightly curved, limbate, slightly depressed particularly near the periphery; wall smooth, finely perforate; aperture an elongate slit at the base of the last septal face with a projecting flap concealing most of it.

Remarks - Material examined for this paper contained several forms of *Cassidulina*, the most common contained about five pairs of chambers in the last whorl but exhibiting an edge which varied from quite sharp to very broadly rounded. The few type specimens of *C. armosa* examined all displayed a sharply rounded edge.

Occurrence - *C. armosa* is almost nonexistent except in samples from Facies Two where it makes up several percent of the total fauna.

Family Nonionidae Schultze, 1854
Subfamily Nonioninae Schultze, 1854

Genus Nonion de Montfort, 1808

Nonion advena (Cushman)

Nonionina advena CUSHMAN, 1922, p. 139, pl. 32, fig. 8; Cushman and Applin, 1926, p. 181, pl. 10, figs. 16,17.

Nonion advena (Cushman) HOWE, 1928, p. 175 (list).

Nonion advenum (Cushman) CUSHMAN AND HERRICK, 1945, p. 61, pl. 10, fig. 9.

Nonion advena (Cushman) BANDY, 1949, p. 71, pl. 10, figs. 8a,b.

Nonion advenum (Cushman) PURI, 1957, p. 132, pl. 9, figs. 4a-c.

Test rather small, subcircular in side view, biconvex; edge rounded, periphery smooth; nine to eleven chambers in the last whorl; umbilical region on both sides occupied by a boss of clear shell material; surface smooth; sutures curved, slightly sigmoied, the inner portions excavated and broadened; aperture a series of about 10 small pores at the base of the septal face.

Occurrence - The very common form is virtually restricted to samples of Facies One and Two where it is the dominant species in each facies.

Nonion inexcavatus (Cushman and Applin)

Nonionina advena inexcavata CUSHMAN AND APPLIN, 1926, p. 182, pl. 10, figs. 18,19.

Nonion inexcavatum (Cushman and Applin) ELLISOR, 1933, pl. 2, fig. 7; Cushman, 1935, p. 30, pl. 11, figs. 5-8; __________, 1945, p. 5, pl. 1, fig. 16.

Nonion inexcavatus (Cushman and Applin) BANDY, 1949, p. 72, pl.10, figs. 9a,b.

Test medium sized, circular in outline, biconvex; periphery faintly to moderately lobulate; edge sharply rounded; shambers 12 to 15 in the last whorl, distinct, slightly inflated, sutures slightly curved, slightly to moderately depressed; umbilical areas with small knob of clear calcite shell material and additional pustulose ornamentation, especially toward the aperture; surface smooth; aperture a series of small pores at the base of the septal face, and a few pores on the septal face.

Occurrence - This species is not common in any samples but is most prevailent in samples of Facies One and Two where it is present in amounts of a few percent.

Nonion planatus Cushman and Thomas

Nonion planatum CUSHMAN AND THOMAS, 1930, p. 37, pl. 3, figs. 5a,b; Cushman and Dusenbury, 1934, p. 60, pl. 8, figs. 6a,b; Cushman and Applin, 1943, p. 37, pl. 7, fig. 24.

Nonion planatus Cushman and Thomas BANDY, 1949, pl.11, figs. 1a,b.

Test small, planispiral, biumbilicate; edge rounded; periphery smooth, very slightly lobulate in the later portion; chambers nine to ten in the last-formed whorl, mostly distinct, increasing gradually in size; sutures flush, slightly depressed in the later portion, ending in thickened ring with slight inward projections about both umbilici; surface smooth; wall finely but conspicuously perforate; aperture a low arch at the base of the septal face.

Occurrence - *N. planatus*, though not found in Facies Four, is evenly scattered throughout samples of the other three facies.

Genus *Nonionella* Cushman, 1926

Nonionella spissa Cushman

Nonionella hantkeni spissa CUSHMAN, 1931, p. 58, pl. 7, fig. 13; ________, 1939, p. 30, pl. 8, fig. 5; Cushman and Herrick, 1945, p. 63, pl. 10, fig. 12.

Nonionella spissa Cushman BANDY, 1949, p. 78, pl. 11, figs. 4a-c (not 2a-c).

Test rather large, thick, somewhat longer than wide; periphery nearly smooth; edge rounded; slightly evolute on one side; sutures distinct, very slightly depressed except in the later portion of the test, slightly curved; surface very smooth; wall finely perforate with variably papillate umbilicus on the involute side; aperture a very low arch at the base of the septal face, extending slightly farther toward the involute side.

Remarks - Cushman and colleagues illustrate forms which exhibit uniformly undepressed sutures and a smooth periphery. In his illustrations Bandy shows two forms with smooth and slightly lobulate periphery; the latter form was not seen in the study material.

Occurrence - *N. spissa* is by far most abundant in Facies One and Three where it often constitutes ten percent of the total microfauna.

Family Anomalinidae Cushman, 1927
Subfamily Anomalininae Cushman, 1927

Genus Anomalina d'Orbigny, 1826

Anomalina umbonata Cushman

Anomalina umbonata CUSHMAN, 1925, p. 300, pl. 7, figs. 5,6; _________, 1927, p. 170, pl. 27, figs. 10,11; Howe, 1939, p. 86, pl. 13, figs. 6-8; Bandy, 1949, p. 102, pl. 18, figs. 3a-c.

Test planoconvex, dorsal side nearly flat or slightly concave with a central spiral umbonate mass, ventral side moderately convex with a rather large raised umbo of clear shell material; periphery smooth becoming slightly lobulate in the later portion of the final whorl; edge rounded; chambers ten to 12 in the final coil, closely appressed; sutures distinct, those of the ventral side flush or very slightly depressed and gently curved, those of the dorsal side raised and limbate in the early portion of the test becoming flush between the last few chambers, the inner ends of the dorsal sutures becoming fused in the early portion giving rise to the spiral umbonate mass in the umbilical region; wall medium to coarsely perforate; aperture a narrow arch at the base of the last chamber on the periphery and extending about one chamber back between the whorls dorsally.

Occurrence - A. umbonata is present in samples of all four facies but is most common in those of Facies One where it comprises several percent of the total fauna.

Superfamily Globigerinacea Carpenter, Parker and Jones, 1862
Family Heterohelicidae Cushman, 1927
Subfamily Heterohelicidae Cushman, 1927

Genus Chiloguembelina Loeblich and Tappan, 1956

Chiloguembelina cubensis (Palmer)

Plate 3, figure 2

Guembelina cubensis PALMER, 1934, p. 74, text-figs. 1-6.

Chiloguembelina cubensis (Palmer) BECKMAN, 1957, p. 89, pl. 21, fig. 21, text-figs. 14 (5-8) (synonomy).

Occurrence - C. cubensis is an ubiquitous form reported from the Eocene and Lower Oligocene of the Gulf Coastal Plain, the Caribbean, and South America.

Distribution - C. cubensis occurrs throughout the Yazoo samples.

Chiloguembelina martini (Pijpers)

Plate 3, figure 3

Textularia martini PIJPERS, 1933, p. 57, figs. 6-10.

Guembelina martini (Pijpers) DROOGER, 1953, p. 100, pl. 1, fig. 2; text-fig. 4.

Chiloguembelina martini (Pijpers) BECKMAN, 1957, p. 89, pl. 21, fig. 14, text-figs. 14 (9-11, 14-18, 20-23) (synonomy).

Occurrence - C. martini has been previously reported from the Upper Eocene of the Gulf Coast and the Caribbean.

Distribution - C. martini occurs throughout the sample suite in sparse amounts.

Chiloguembelina victoriana Beckman

Plate 3, figure 4

Chiloguembelina victoriana BECKMAN, 1957, p. 91, pl. 21, fig. 7, text-fig. 15 (43-45).

Remarks - This species differs from C. cubensis in that the chambers are less inflated and broader and increase in size less rapidly. The aperture of C. victoriana is also higher and narrower than C. cubensis. Beckman states that C.

victoriana possesses a wall smoother than *C. cubensis*, but this did not appear to be true in the Yazoo material.

Occurrence - According to Beckman this species is confined, in Trinidad, to the Upper Eocene *Globorotalia cocoaensis* zone and the Lower Oligocene *Globigerina ampliapertura* zone.

Distribution - *C. victoriana* occurs only in samples of zones B and C in very spare amounts.

Family Hantkeninidae Cushman, 1927
Subfamily Hantkenininae Cushman, 1927

Genus *Hantkenina* Cushman, 1924

Hantkenina alabamensis Cushman

Plate 3, figure 5

Hantkenina alabamensis CUSHMAN, 1924, p. 3, pl. 1, figs. 1-6, pl. 2, fig. 5; __________, 1925, p. 7, pl. 1, fig. 11; Cushman and Applin, 1926, p. 177, pl. 10, fig. 3; Cushman, 1927, p. 160, pl. 25, fig. 17; Howe, 1928, p. 14, text-fig. 1; Howe and Wallace, 1932, p. 54, pl. 10, fig. 3; Ellisor, 1933, pl. 6, fig. 5; Howe and Wallace, 1934, p. 35, pl. 5, fig. 13; Hadely, 1934, p. 15, pl. 2, fig. 4; Cushman, 1935, p. 49, pl. 13, figs. 1-5; Coryell and Embick, 1937, p. 299, pl. 43, fig. 10; Bermudez, 1938, p. 13; Cushman, 1939, p. 74, pl. 12, fig. 18; Bergquist, 1942, p. 96, pl. 10, figs. 2,4; Bandy, 1949, p. 76, pl. 11, figs. 9a,b; Puri, 1957, p. 127, pl. 12, figs. 7a-c; Deboo, 1965, pl. 15, figs. 5,7,8; Blow, 1969, p. 377.

Occurrence - This species has been widely reported from Yazoo age strata. Blow lists the range as Middle to Late Eocene.

Distribution - This form is confined, in the Yazoo material, to zones A and B. Within these zones it is quite common.

Genus *Cribrohantkenina* Thalman, 1942

Cribrohantkenina inflata (Howe)

Plate 4, figures 1 and 2

Hantkenina inflata HOWE, 1938, p. 13, 14, fig. 2.

Hantkenina (Cribrohantkenina) bermudezi THALMAN, 1942, p. 812, 815, 819, pl. 1, figs. 5,6.

Cribrohantkenina inflata (Howe) SPRAUL, 1962, p. 343-347, pl. 1, figs. 1a-4b (synonomy); Deboo, 1965, p. 31, pl. 15, figs. 4,6; Blow, 1969, p. 377, pl. 52, figs. 1-3.

Occurrence - Also widely reported in the literature, Blow cites its distribution as limited to Zone P. 16 of Late Eocene age.

Distribution - *C. inflata* is present only in samples zone B in the Yazoo material.

Genus *Pseudohastigerina* Banner and Blow, 1959

Pseudohastigerina micra (Cole)

Plate 4, figure 3

Nonion micrus COLE, 1927, p. 22, pl. 5, fig. 12.

Hastigerina micra (Cole) BOLLI, 1957, p. 161, pl. 35, figs. 1a-2b.

Pseudohastigerina micra (Cole) BLOW AND BANNER, 1962, p. 129, pl. 16, figs. E-F.

Globanomalina micra (Cole) LOEBLICH AND TAPPAN, 1964, p. 665, fig. 531 (6-8).

Pseudohastigerina micra (Cole) Berggren, Olsson and Reyment, 1967, p. 265; Blow, 1969, p. 377, pl. 53, figs. 1,4,5,6; Cordey, Berggren and Olsson, 1970, p. 236, text-figs. 1-5.

Remarks - The taxonomic history of this rather small form has been most complex. Berggren, Olsson and Reyment have published a most exhaustive analysis of the genus to defend their classification.

Occurrence - Blow states that P. micra has been found in sediments of Middle Eocene to Middle Oligocene age.

Distribution - In the study material, P. micra is quite common in the planktonic fraction of the entire sample suite.

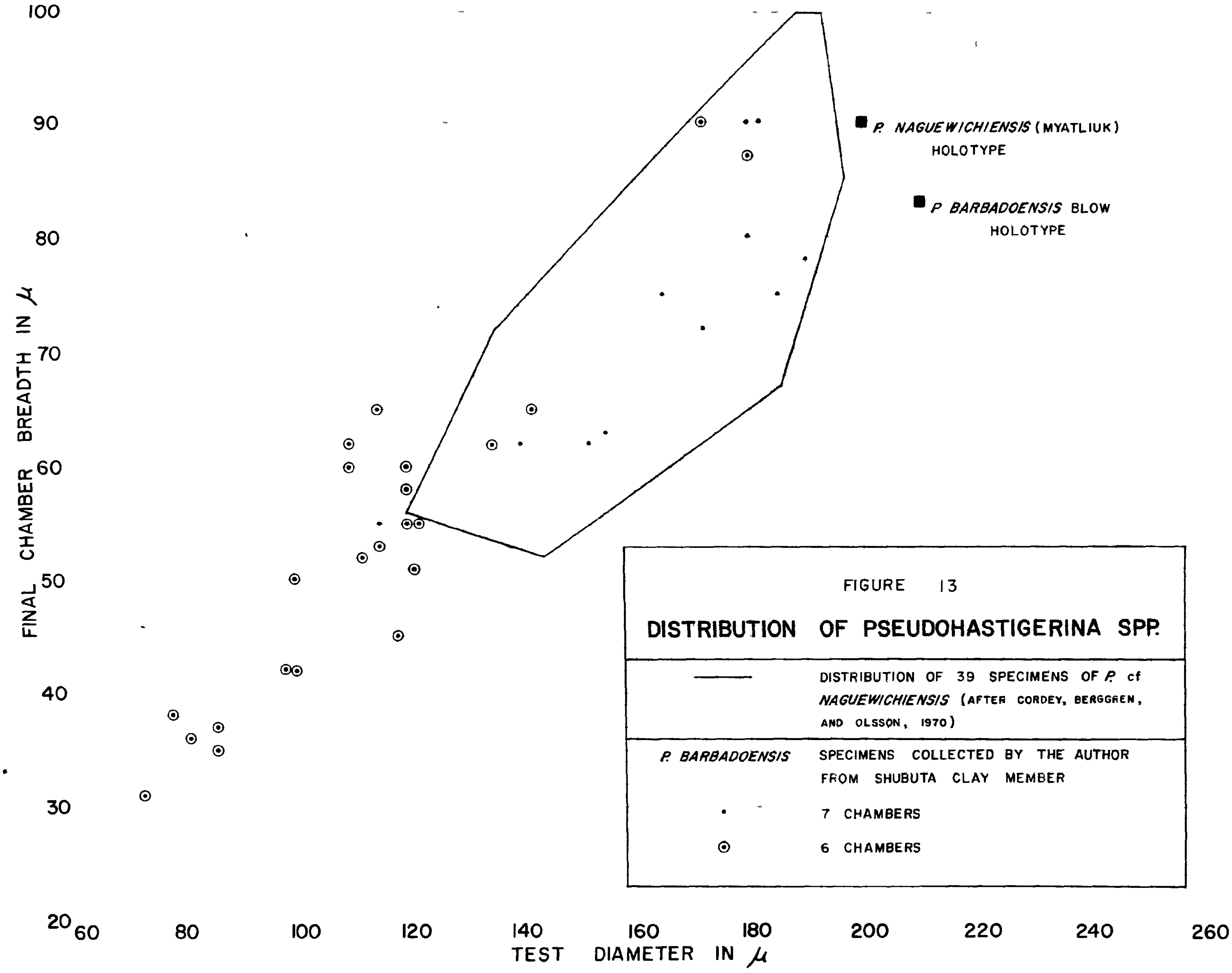
Pseudohastigerina barbadoensis Blow

Plate 4, figure 4

Pseudohastigerina barbadoensis BLOW, 1969, p. 409, pl. 53, figs. 7-9, pl. 54, figs. 1-3; Cordey, Berggren and Olsson, 1970, p. 238, text-fig. 1.

"The small test is composed of about 17 chambers coiled in an evolute planispire with 7½ chambers visible in the final whorl. The test is moderately laterally compressed but the periphery is gently rounded. The chambers of the last whorl are slightly inflated and the intercameral sutures only shallowly depressed; the intercameral sutures between the last few chambers of the final whorl show a banded appearance due to a greater degree of smoothness of the wall and to a reduction in the density of the pores. In some parts of the intercameral sutures, pores seem to be virtually absent or very fine. In optical appearance the tests seem to be finely perforate but Stereoscan electronmicroscopy shows comparatively large pores moderately densely scattered over the test surface. The pores seem to open to the exterior without any distinct pore-pits. The evolute test possesses a wide umbilicus and the relict apertures of the last two chambers can be seen. The apertural porticus is well developed and the junction of the porticus and the test wall in the apertura region forms a virtual right angle. The aperture is a moderately low arch and is completely bordered by the porticus which seems to be imperforate. The wall is calcareous, radial hyaline and slightly pustulose but the surface is without pore-pits. Maximum diameter of the holotype is 0.20 mm." (Blow, 1969, p. 409.)

Remarks - The genus first appears in rocks of Early Eocene age as P. wilcoxensis, in the late Middle Eocene a compressional trend gives rise to P. micra, and in the Late Eocene a trend in size reduction gives rise to forms labled P. cf. naguewichiensis (Cordey, Berggren and Olsson, 1970). These authors based their classification upon the test geometry of the various species. Figure 13 includes a part of this pub-



P. NAGUEWICHIENSIS (MYATLIUK) HOLOTYPE
P BARBADOENSIS BLOW HOLOTYPE
FINAL CHAMBER BREADTH IN μ
TEST DIAMETER IN μ
20
30
40
50
60
70
80
90
100
60
80
100
120
140
160
180
200
220
240
260
FIGURE 13
DISTRIBUTION OF PSEUDOHASTIGERINA SPP.
DISTRIBUTION OF 39 SPECIMENS OF P. cf NAGUEWICHIENSIS (AFTER CORDEY, BERGGREN, AND OLSSON, 1970)
P. BARBADOENSIS SPECIMENS COLLECTED BY THE AUTHOR FROM SHUBUTA CLAY MEMBER
7 CHAMBERS
6 CHAMBERS

lished data in conjunction with plots of specimens taken from the study material. The two populations - those plotted by Cordey, Berggren and Olsson and those plotted by the present author - have very similar distributions.

Cordey et al. were reluctant to split P. barbadoensis and P. naguewichiensis for on the basis of test geometry, they appear quite similar. As noted by Blow, however, the former species possesses less inflated and less hispid chambers. This distinction becomes quite clear in SEM photomicrographs supplied by Blow. The lack of a hispid surface and the only moderately inflated chambers in the Yazoo specimens support the assignment of this form to P. barbadoensis Blow.

Occurrence - Blow states that this species first appears in the P. 16 zone (Late Eocene) and continues into the Oligocene.

Distribution - This species is not a common planktonic form. The author did not observe it in zone A but did recover it in zones B and C.

Family Globorotaliidae Cushman, 1927
Subfamily Truncorotaloidinae Loeblich and Tappan, 1961

Genus Truncorotaloides Bronnimann and Bermudez, 1953

Truncorotaloides danvillensis (Howe and Wallace)

Plate 5, figures 1,2,3 and 4

Globigerina danvillensis HOWE AND WALLACE, 1932, p. 74, pl. 10, fig. 9; Bergquist, 1942, p. 95, pl. 9, figs. 24,25; Stainforth, 1948, p. 117, pl. 25, figs. 24,25.

Pseudohastigerina micra (Cole) DEBOO, 1965, p. 32, pl. 15, figs. 1-3.

Test is small, low-spired trochoid, dorsal side only slightly convex, ventral side dominated by large umbilicus; chambers are inflated and subspherical, about six chambers in the final whorl; wall is calcareous and finely porous; surface of test rough with short, narrow to pyramidal spines, these are densest on the dorsal side and in the earlier chambers; primary aperture is interio-marginal, secondary, sutural apertures on the dorsal side. The majority of the Yazoo specimens possess a greatest diameter ranging between 0.29 mm and 0.16 mm.

Remarks - This small form has not appeared extensively in the literature. Previously *T. danvillensis* has been illustrated and described as not possessing dorsal secondary apertures. These can be seen in SEM photomicrographs or best while the specimens are immersed in water or oil. Secondary apertures could not be found in every individual, perhaps a function of preservation.

The specimens from the Yazoo Formation show a close relationship to *Truncorotaloides collactea* (Finlay) reported from sediments ranging in age from Middle to Late Eocene Berggren, 1969). *T. collactea*, however, has a much rougher surface, is uniformly hispid, and has less incised sutures.

Occurrence - *T. danvillensis* has been described from the Upper Eocene of Alabama, Mississippi, Louisiana, Peru, Columbia, Mexico, and Ecuador.

Distribution - This species was found by the author in zones A and B but not C. The species was extremely prolific in samples of sandy Facies Three where it existed to the virtual exclusion of any other planktonic form.

Family Globigerinidae Carpenter, Parker and Jones, 1862
Subfamily Globigerininae Carpenter, Parker and Jones, 1862

Genus *Globigerina* d'Orbigny, 1826

Globigerina ampliapertura Bolli

Plate 5, figure 5

Globigerina ampliapertura BOLLI, 1957, p. 108, pl. 22, figs. 5-7; Blow and Banner, 1962, p. 83, pl. 11a-d, 17c, fig. 12b; Srinivasan, 1968, p. 147, pl. 16, figs. 5,6; Beckman et al., 1969, p. 99; Berggren, 1969, p. 125-129, 141, Table 3, pl. 2, figs. 19-21, pl. 4, figs. 4-6; Blow, 1969, p. 315, 349, pl. 12, figs. 6,9,10.

Remarks - This robust form has figured in the majority of the published planktonic foraminiferal biostratigraphic zonations. The best illustrations of this species appear in Blow; SEM photomicrographs show clearly the typical contiguous pore-pits and lipless aperture.

Occurrence - *G. ampliapertura* is characteristic of Blow's zone P. 17 of latest Eocene age. Berggren lists this species as occurring in highest Eocene and Oligocene strata of the North Sea Basin. Beckman et al. state that *G. ampliapertura* is associated with foraminifera of the *Globigerina sellii* zone of Late Eocene age in Egypt. Srinivasan cites this species as occurring in rocks of Late Eocene and Oligocene age in New Zealand.

Distribution - *G. ampliapertura* occurrs only in samples of zone C in the study material.

CONCLUSIONS

A few concluding statements should be made concerning the uses and utility of fossil, benthonic foraminifera, the science of paleoecology, and the deposition of the Yazoo Formation.

1) Yazooian strata in the study area can be divided into two series - the lower consisting of the North Twistwood Creek and Cocoa Members and the upper series made up of the Pachuta Member, Shubuta Mmeber, and the Crystal River Formation - separated by a thin zone of mixing.

2) The lithofacies displayed by the Yazoo in eastern Mississippi and western and central Alabama are due primarily to regressions and transgressions across the Eocene continental shelf.

3) Differences in shoreline migration along strik sug-gest that transgressions and regressions were not wholly due to basin-wide eustatic changes in sea-level but were largely due to small-scale, localized flexing of the crust.

4) Lithological and foraminiferal data can be combined to produce a vivid paleoecological interpretation most effeciently by computerized statistical analysis.

5) Although most of the fossil genera found in the Yazoo material occupy similar modern ecological niches, some - Nonion and perhaps Nonionella - play different roles in the foraminiferal ecology of the modern Gulf of Mexico.

REFERENCES

Bandy, O. L., 1949, Eocene and Oligocene foraminifera from Little Stave Creek, Clarke County, Alabama: Am. Paleo. Bull., v. 32, no. 131, p. 1-210.

__________, 1956, Ecology of foraminifera in northeastern Gulf of Mexico: U. S. Geol. Sur. Prof. Paper 274-G, p. 179-204.

Barbieri, F. and F. Medioli, 1969, Calcareous nannoplankton from the Upper Cretaceous of southern Saskatchewan (Canada): Riv. Ital. Paleo., v. 75, no. 4, p. 725-758.

Beckman, J. P., 1957, Chiloguembelina Loeblich and Tappan and related foraminifera from the Lower Tertiary of Trinidad, B. W. I.: U. S. Nat. Mus. Bull. 215, p. 83-95.

Beckman, J. P., I. El-Heiny, M. T. Kerdany, R. Said, and C. Viotti, 1969, Standard planktonic zones in Egypt: in Proceedings of the First International Conference on Planktonic Microfossils, ed. Bronnimann and Renz, Brill, Leiden; v. 1, p. 92-103.

Berggren, W. A., R. K. Olsson and R. A. Reyment, 1967, Origin and development of the foraminiferal genus Pseudohastigerina Banner and Blow, 1959: Micropal., v. 13, no. 3, p. 265-288.

Berggren, W. A., 1969, Paleogene biostratigraphy and planktonic foraminifera of northern Europe: in Proceedings of the First International Conference on Planktonic Microfossils, ed. Bronnimann and Renz, Brill, Leiden; v. 1, p. 120-160.

Bermudez, P. J., 1938, Foraminiferos pequenos de las margas eocenicas de Guanajay, Provincia Pinar del Rio, Cuba: Mem. Soc. Cubana Hist. Nat., v. 12, p. 1-26.

Bergquist, H. R., 1942, Scott County fossils, Jackson foraminifera and Ostracoda: Miss. Geol. Sur. Bull., no. 49, p. 1-146.

Blow, W. H., 1969, Late Middle Eocene to Recent planktonic biostratigraphy: in Proceedings of the First International Conference on Planktonic Microfossils, ed. Bronnimann and Renz, Brill, Leiedn; v. 1, p. 199-422.

Blow, W. H. and F. T. Banner, 1962, The Midtertiary (Upper Eocene to Aquitanian) Glogigerinaceae, in Fundamentals of Midtertiary Stratigraphical Correlation, Eames et al., Cambridge Univ. Press, New York; p. 61-147.

Bolli, H. M., 1957, Planktonic foraminifera from the Eocene Navet and San Fernando Formations of Trinidad, B. W. I.: U. S. Nat. Mus. Bull. 215, p. 155-172.

Bramelette, M. N. and W. R. Reidel, 1954, Stratigraphic value of discoasters and some other microfossils related to Recent Coccolithophores: Jour. Paleo., v. 28, no. 4, p. 385-403.

Bramelette, M. N. and F. R. Sullivan, 1961, Coccolithophorids and related nannoplankton of the Early Tertiary in California: Micropal., v. 7, no. 2, p. 129-188.

Buzas, M. A., 1967, An application of canonical analysis as a method for comparing faunal areas: Jour. Animal Ecol., v. 36, p. 563-577.

Cheetham, A. H., 1957, Eocene-Oligocene boundary, eastern Gulf Coast region: Gulf Coast Assoc. Geol. Soc. Trans., v. 7, p. 89-97.

__________, 1963, Late Eocene zoogeography of the eastern Gulf Coast region: Geol. Soc. Am. Mem. 91, p. 1-113.

Clark, D. L. and K. J. Bird, 1966, Foraminifera and paleoecology of the upper Austin and lower Taylor (Cretaceous) strata in north Texas: Jour. Paleo., v. 40, no. 2, p. 315-327.

Cole, W. S., 1927, A foraminiferal fauna from the Guayabal Formation in Mexico: Am. Paleo. Bull., v. 14, no. 51, p. 1-46.

Cole W. S. and G. M. Ponton, 1930, The foraminifera of the Mariana Limestone of Florida: Fla. Geol. Sur. Bull. 5, p. 19-69.

Copeland, C. W., 1968, Geology of the Alabama Coastal Plain, a Guidebook: Geol. Sur. Ala. Circ. 47, p. 1-97.

Cordey, W. G., W. A. Berggren and R. K. Olsson, 1970, Phylogenetic trends in the planktonic genus Pseudohastigerina Banner and Blow, 1959: Micropal., v. 16, no. 2, p. 235-242.

Coryell, H. N. and J. R. Embich, 1937, The Tranquilla Shale (Upper Eocene) of Panama and its foraminiferal fauna: Jour. Paleo., v. 11, p. 289-305.

Curray, J. R., 1964, Transgressions and Regressions: in Papers in Marine Geology, ed. R. L. Miller, Macmillan Co., New York, p. 175-203.

Cushman, J. A., 1922, The foraminifera of the Mint Springs calcareous marl member of the Marianna Limestone: U. S. Geol. Sur. Prof. Paper 129, p. 128-152.

__________, 1924, A new genus of Eocene foraminifera: U. S. Nat. Mus. Proc., v. 66, art. 30, p. 1-4.

__________, 1925, Eocene foraminifera from the Cocoa sand of Alabama: Cush. Lab. Foram. Res. Contr., v. 1, p. 65-69.

__________, 1926, Some new foraminifera from the Upper Eocene of the southeastern coastal plain of the United States: Cush. Lab. Foram. Res. Contr., v. 2, p. 29-36.

__________, 1928, Additional foraminifera from the Upper Eocene of Alabama: Cush. Lab. Foram. Res. Contr., v. 4, no. 64, p. 73-79.

__________, 1931, The foraminifera of the Saratoga Chalk: Jour. Paleo., v. 5, no. 4, p. 297-315.

__________, 1933, New foraminifera from the Upper Jackson Eocene of the southeastern coastal plain region of the United States: Cush. Lab. Foram. Res. Contr., v. 9, pt. 1, p. 1-21.

__________, 1935, Upper Eocene foraminifera of the southeastern United States: U. S. Geol. Sur. Prof. Paper 181, p. 1-88.

__________, 1937, A monograph of the foraminiferal family Valvulinidae: Cush. Lab. Foram. Res. Spec. Pub. 8, p. 1-210.

__________, 1939, A monograph of the foraminiferal family Nonionidae: U. S. Geol. Sur. Prof. Paper 191, p. 1-100.

__________, 1946, A rich foraminiferal fauna from the Cocoa sand of Alabama: Cush. Lab. Foram. Res. Spec. Pub. 16, p. 1-40.

Cushman, J. A. and E. R. Applin, 1926, Texas Jackson Foraminifera: A. A. P. G. Bull., v. 10, no. 2, p. 154-189.

__________, 1943, The foraminifera of the type locality of the Yegua Formation of Texas: Cush. Lab. Foram. Res. Contr., v. 19, pt. 2, p. 18-46.

Cushman, J. A. and A. N. Dusenbury, 1934, Eocene Foraminifera of the Poway conglomerate of California: Cush. Lab. Foram. Res. Contr., v. 10, pt. 3, p. 51-65.

Cushman, J. A. and M. A. Hanna, 1927, Foraminifera from the Eocene near Coalinga, California: Calif. Acad. Sci., Proc., ser. 4, v. 16, no. 8, p. 205-228.

Cushman, J. A. and S. M. Herrick, 1945, The foraminifera of the type locality of the McBean Formation: Cush. Lab. Foram. Res. Contr., v. 21, pt. 3, p. 55-73.

Cushman, J. A. and F. L. Parker, 1947, Bulimina and related foraminiferal genera: U. S. Geol. Sur. Prof. Paper 210-D, p. 55-176.

Cushman, J. A. and N. L. Thomas, 1930, Common foraminifera of the east Texas greensands: Jour. Paleo., v. 4. p. 33-41.

Cushman, J. A. and R. Todd, 1945, Foraminifera of the type locality of the Moodys Marl Member of the Jackson Formation of Mississippi: Cush. Lab. Foram. Res. Contr., v. 21, pt. 4, p. 79-105.

__________, 1946, A foraminiferal fauna from the Byram marl at its type locality: Cush. Lab. Foram. Res. Contr., v. 22, pt. 3, p. 76-102.

Deboo, P. B., 1965, Biostratigraphic correlation of the type Shubuta member of the Yazoo clay and Red Bluff clay with their equivalents in southeastern Alabama: Ala. Geol. Sur. Bull. 80, p. 1-84.

Deflandre, G., 1954, in Deflandre and Fert, Observations sur les Coccolithoporides actuels et fossiles en microscopie ordinaire et electronique: Ann. Paleont., v. 40, p. 115-176.

De Vries, D. A., 1963, Jasper County mineral resources: Miss. Geol. Econ. and Topog. Sur. Bull. no. 95, p. 11-52.

Drooger, C. W., 1953, Late Eocene smaller foraminifera from Curacao and Bonaire (B. W. I.): Proc. Nederl. Akad. Wetenschappen, ser. B, v. 56, no. 1, p. 93-103.

Ellisor, A. C., 1933, Jackson Group of formations in Texas with notes on Frio and Vicksburg: A. A. P. G. Bull., v. 17, no. 11, p. 1293-1350.

Fisher, W. L., C. V. Proctor, Jr., W. E. Galloway and J. S. Nagle, 1970, Depositional systems in the Jackson Group of Texas: Gulf Coast Assoc. Geol. Soc. Trans., v. 20, p. 234-261.

Fisk, H. N. and E. McFarlan, Jr., 1955, Late Quaternary deltaic deposits of the Mississippi River - local sedimentation and basin tectonics: in Crust of the Earth - a symposium: Geol. Soc. Am. Spec. Paper 62, p. 279-302.

Fredrickson, N. O., 1970, Stratigraphy and palynology of the Jackson Stage and adjacent strata of Mississippi and western Alabama: unpublished Ph. D. thesis, Univ. of Wisconsin, p. 1-356.

Gernant, R. E. and R. V. Kesling, 1966, Foraminiferal paleoecology and paleoenvironmental reconstruction of the Oligocene middle Frio in Chambers County, Texas: Gulf Coast Assoc. Geol. Soc. Trans., v. 16, p. 131-158.

Grimsdale, T. F. and R. P. C. M. van Morkhoven, 1955, The ratio between pelagic and benthonic foraminifera as a means of estimating depth of deposition of sedimentary rocks: World Petroleum Cong., 4th, Rome, Proc., ser. 1, p. 473-491.

Hadley, W. H., Jr., 1934, Some Tertiary foraminifera from the north coast of Cuba: Bull. Am. Paleo., v. 20, no. 70A, p. 1-40.

Hanna, G. D., 1927, Cretaceous diatoms from California: Occasional Papers of the Calif. Acad. Sci., no. 13, p. 1-48.

Hay, W. W., H. P. Mohler, P. H. Roth, R. R. Schmidt and J. E. Boudreaux, 1967, Calcareous nannoplankton zonation of theCenozoic of the Gulf Coast and Caribbean - Antillean Area and transoceanic correlation: Gulf Coast Assoc. Geol. Soc. Trans., v. 17, p. 428-480.

Hay, W. W., H. P. Mohler and M. E. Wade, 1966, Calcareous nannofossils from Nal'chik (northwest Caucasus): Eclogae Geol. Helv., v. 59, no. 1, p. 379-400.

Hay, W. W. and K. M. Towe, 1962, Electron microscopic examination of some coccoliths from Donzacq (France): Eclogae Geol. Helv., v. 55, no. 2, p. 497-517.

Hazel, J. E., 1970, Binary coefficients and clustering in biostratigraphy: Geol. Soc. Am. Bull., v. 81, no. 11, p. 3237-3252.

Hofker, J., 1956, Tertiary foraminifera of coastal Ecuador, Part II Additional notes on the Eocene species: Jour. Paleo., v. 30, p. 891-958.

Howe, H. V., 1928, Additions to the list of species occurring in the type Red Bluff clay, Hiwannee, Mississippi: Jour. Paleo., v. 2, no. 3, p. 173-176.

__________, 1939, Louisiana Cook Mountain Eocene foraminifera: Louisiana Geol. Sur. Geol. Bull. 14, p. 1-122.

__________, 1947, Status of micropaleontology in eastern Gulf region: A. A. P. G. Bull., v. 31, no. 4, p. 713-730.

Howe, H. V. and W. E. Wallace, 1932, Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana: Louisiana Geol. Sur. Geol. Bull., no. 2, p. 1-118.

__________, 1934, Apertural characteristics of the genus

Hantkenina, with description of a new species: Jour. Paleo., v. 8, no. 1, p. 35-37.

Huddlestun, P. F., 1965, Correlation of Upper Eocene and Lower Oligocene strata between the Sepulga, Conecuh, and Choctawhatchee Rivers of southern Alabama: unpublished M. Sc. thesis, Florida State Univ., p. 1-101.

Huff, W. J., 1970, The Jackson Eocene Ostracoda of Mississippi: Miss. Geol. Econ. and Topog. Sur. Bull. 114, p. 1-289.

Imbrie, J. and E. G. Purdy, 1962, Classification of Modern Bahamian carbonate rocks: A. A. P. G. Mem. 1, p. 253-272.

Kaesler, R. L., 1969, Aspects of quantitative distributional paleoecology: in Computer Applications in the Earth Sciences, ed. D. E. Merriam, Plenum Press, New York, p. 99-120.

Langhus, B. G., 1968, Paleoecological and biostratigraphic zonation of Upper Cretaceous foraminifera, Vancouver Island, British Columbia: unpublished M. Sc. thesis, Univ. of Calgary, p. 1-79.

Lankford, R. R., 1959, Distribution and ecology of Foraminifera from east Mississippi Delta region: A. A. P. G. Bull., v. 43, no. 9, p. 2068-2099.

Levin, H. L., 1965, Coccolithophoridae and related microfossils from the Yazoo Formation (Eocene) of Mississippi: Jour. Paleo., v. 39, no. 2, p. 265-272.

Levin, H. L. and A. P. Joerger, 1967, Calcareous nannoplankton from the Tertiary of Alabama: Micropal., v. 13, no. 2, p. 163-182.

Loeblich, A. R. and H. Tappan, 1964, Treatise on Invertebrate Paleontology, Part C, Protista 2, Sarcodina, Chiefly Thecamoebians and Foraminiferida: Geol. Soc. Am. and Univ. Kansas Press, 2 volumes.

Lowe, E. N., 1915, Mississippi, its geology, geography, soils, and mineral resources: Miss. Geol. Sur. Bull. 12, p. 1-335.

Lowman, S. W., 1949, Sedimentary facies in Gulf Coast: A. A. P. G.Bull., v. 33, no. 12, p. 1939-1997.

Ludwick, J. C., 1964, Sediments in northeastern Gulf of Mexico: in Papers in Marine Geology, Macmillan Co., New York, p. 204-238.

Ludwick, J. C. and W. R. Walton, 1957, Shelf-edge, calcareous, prominences in northeastern Gulf of Mexico: A. A. P. G.

Bull., v. 41, no. 9, p. 2054-2101.

MacNeil, F. S., 1946, Geologic map of the Tertiary formations of Alabama: U. S. Geol. Sur. Oil and Gas Inv. Prelim. Map 45.

Mellen, F. F., 1940, Geology 1, of Yazoo County mineral resources: Miss. Geol. Sur. Bull. 39, p. 9-72.

Miller, R. L. and J. S. Kahn, 1962, Statistical Analysis in the Geological Sciences, John Wiley and Sons, New York, p. 1-483.

Mississippi Geological Survey, 1969, Geological Map of Mississippi: Mercury Maps, Jackson, Miss.

Monsour, E., 1937, Micropaleontological analysis of Jackson Eocene of eastern Mississippi: A. A. P. G. Bull., v. 21, no. 1, p. 80-96.

Moore, W. H., 1965, Hinds County geology and mineral resources: Miss. Geol. Econ. Topog. Sur. Bull. 105, p. 21-145.

Murray, G. E., Jr., 1947, Cenozoic deposits of central Gulf Coastal Plain: A. A. P. G. Bull., v. 31, no. 10, p. 1825-1850.

Palmer, D. K., 1934, The foraminiferal genus Gumbelina in the Tertiary of Cuba: Mem. Soc. Cubana Hist. Nat., v. 8, p. 73-76.

Phleger, F. B., 1956, Significance of living foraminiferal populations along the central Texas coast: Cush. Found. Foram. Res., v. 7, p. 106-151.

__________, 1960, Sedimentary patterns of microfaunas in northern Gulf of Mexico: in Recent Sediments, Northwest Gulf of Mexico, A. A. P. G., Tulsa, p. 267-301.

Pijpers, P. J., 1933, Geology and paleontology of Bonaire (D. W. I.): Univ. Utrecht Geogr. Geol. Med., Phys.-Geol. Reeks, no. 8, p. 1-103.

Prescott, G. W., 1968, The Algae: A Review; Houghton Mifflin Co. Boston.

Priddy, R. R., 1960, Madison County geology: Miss. Geol. Sur. Bull. 88, p. 1-123.

Puri, H. S., 1957, Stratigraphy and zonation of the Ocala Group: Fla. Geol. Sur. Bull. 38, p. 1-248.

Rainwater, E. H., 1964, Transgressions and regressions in the Gulf Coast Tertiary: Gulf Coast Assoc. Geol. Soc.

Trans., v. 14, p. 217-230.

________, 1968, Geological history and oil and gas potential of the central Gulf Coast: Gulf Coast Assoc. Geol. Soc. Trans., v. 18, p. 124-165.

Robinson, G. S., 1970, Change of the bathymetric distribution of the genus Cyclammina: Gulf Coast Assoc. Geol. Soc. Trans., v. 20, p. 201-209.

Schull, B. J., C. J. Fleix, S. B. McCaleb and W. G. Shaw, 1966, The inter-discipline approach to paleoenvironmental interpretations: Gulf Coast Assoc. Geol. Soc. Trans., v. 16, p. 81-130.

Seal, H., 1964, Multivariate Statistical Analysis for Biologists, John Wiley and Sons, New York, p. 1-207.

Shepard, F. P., 1956, Marginal sediments of Mississippi Delta: A. A. P. G. Bull., v. 40, no. 11, p. 2437-2623.

S. E. P. M., Paleoecological Committee, 1966, Foraminiferal ecological zones of the Gulf Coast: Gulf Coast Assoc. Geol. Soc. Trans., v. 16, p. 345-348.

Spraul, G. L., 1962, Current status of the Upper Eocene foraminiferal guide fossil, Cribrohantkenina: Gulf Coast Assoc. Geol. Soc. Trans., v. 12, p. 343-347.

Srinivasan, M. S., 1968, Late Eocene and Early Oligocene Planktonic foraminifera from Port Elizabeth and Cape Foulwind, New Zealand: Cush. Found. Foram. Res. Contr., v. 19, pt. 4, p. 142-159.

Stainforth, R. M., 1948, Applied micropaleontology in coastal Ecuador: Jour. Paleo., v. 22, no. 2, p. 113-151.

Streeter, S. S., 1963, Foraminifera in the sediments of the northwestern Great Bahama Bank: unpublished Ph. D. thesis, Columbia Univ.

Stuckey, C. W., Jr., 1960, A correlation of the Gulf Coast Jackson: Gulf Coast Assoc. Geol. Soc. Trans., v. 10, p. 285-298.

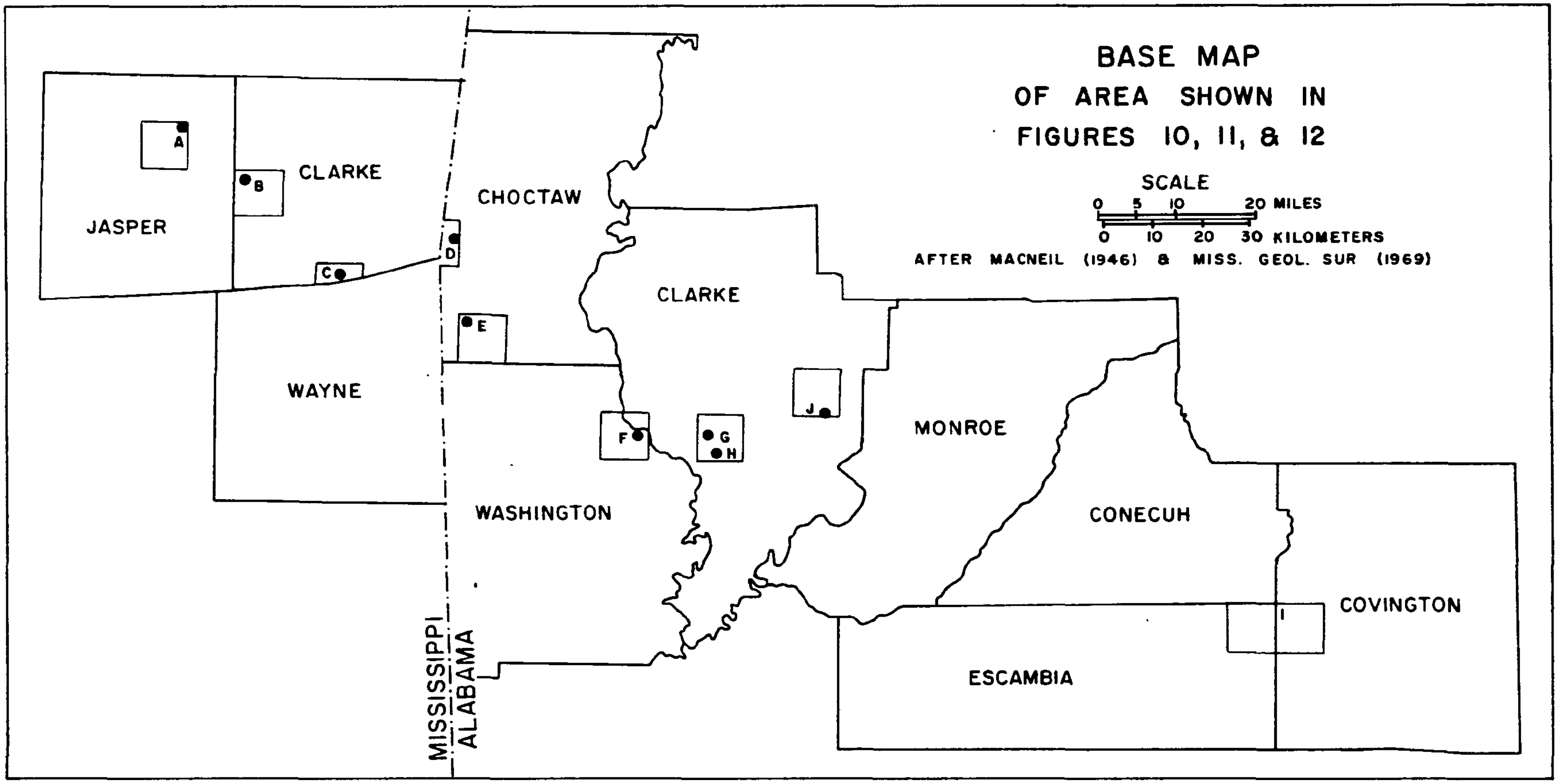
Tan Sin Hok, 1927, Discoasteridae incertae sedis: Sect. Sci. K. Akad. Wet. Amsterdam, Proc., v. 30, p. 411-419.

Thalman, H. E., 1942, Foraminiferal genus Hantkenina and its subgenera: Am. Jour. Sci., v. 240, no. 11, p. 809-820.

Tipsword, H. L., F. M. Setzer and F. L. Smith, 1966, Interpretation of depositional environment in Gulf Coast petroleum exploration from paleoecology and related stratigraphy: Gulf Coast Assoc. Geol. Soc. Trans., v. 16, p. 119-130.

Toulmin, L. D., Jr., P. E. LaMoreaux and C. R. Lanphere, 1951, Geology and groundwater resources of Choctaw County, Alabama: Ala. Geol. Sur. Spec. Rept. 21, and County Rept. no. 2, p. 1-196.

Tourtelot, H. A. and J. H. Morris, 1944, Reconnaissance geologic map of the Quitman fault zone, Clarke and Wayne Counties, Mississippi, and Choctaw County, Alabama: U. S. Geol. Sur. Oil and Gas Inv. Prelim. Map no. 6.


BASE MAP
OF AREA SHOWN IN
FIGURES 10, 11, & 12
SCALE
0 5 10 20 MILES
0 10 20 30 KILOMETERS
AFTER MACNEIL (1946) & MISS. GEOL. SUR (1969)
JASPER
CLARKE
CHOCTAW
CLARKE
WAYNE
WASHINGTON
MONROE
CONECUH
COVINGTON
ESCAMBIA
MISSISSIPPI
ALABAMA
A
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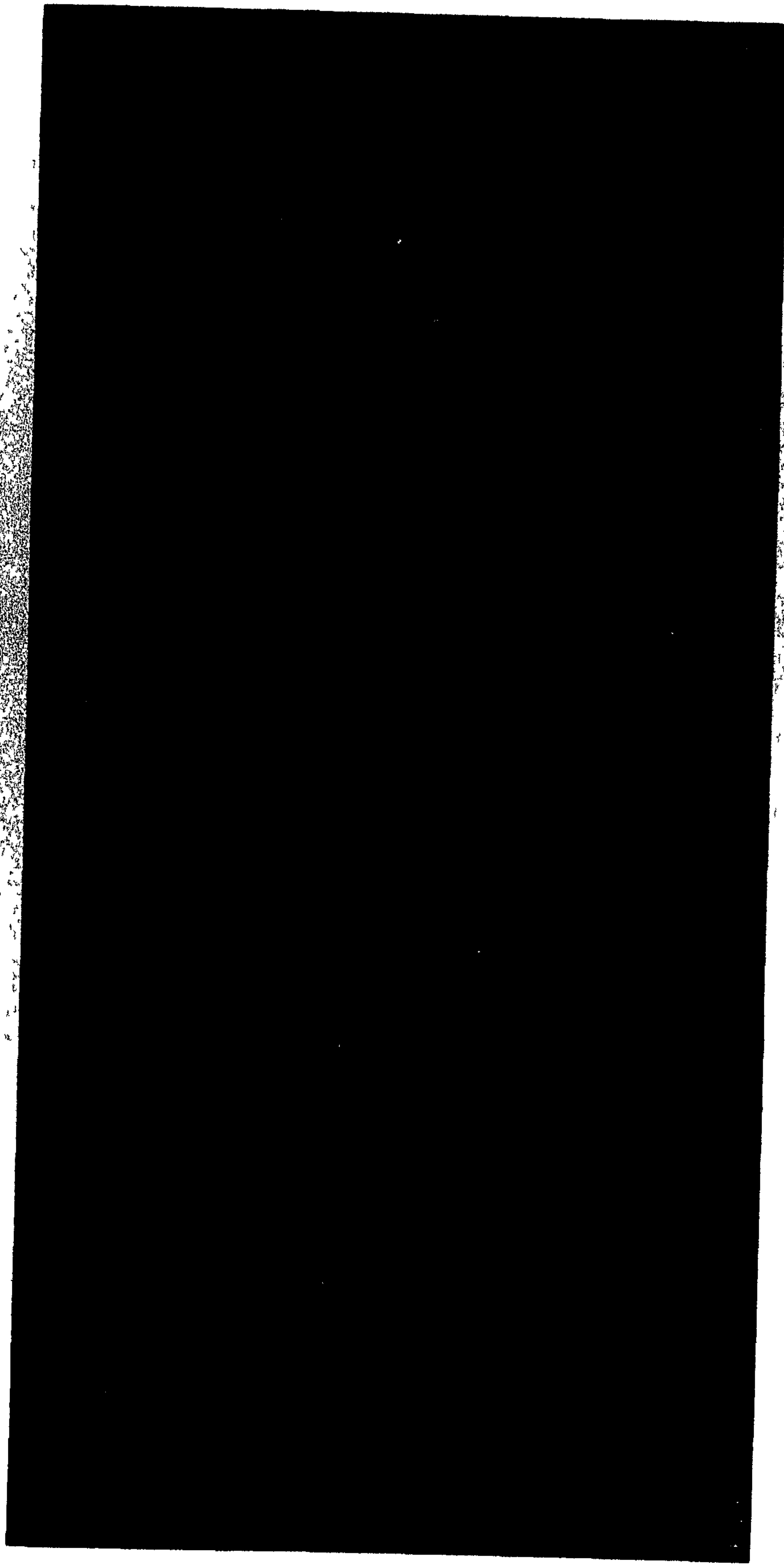
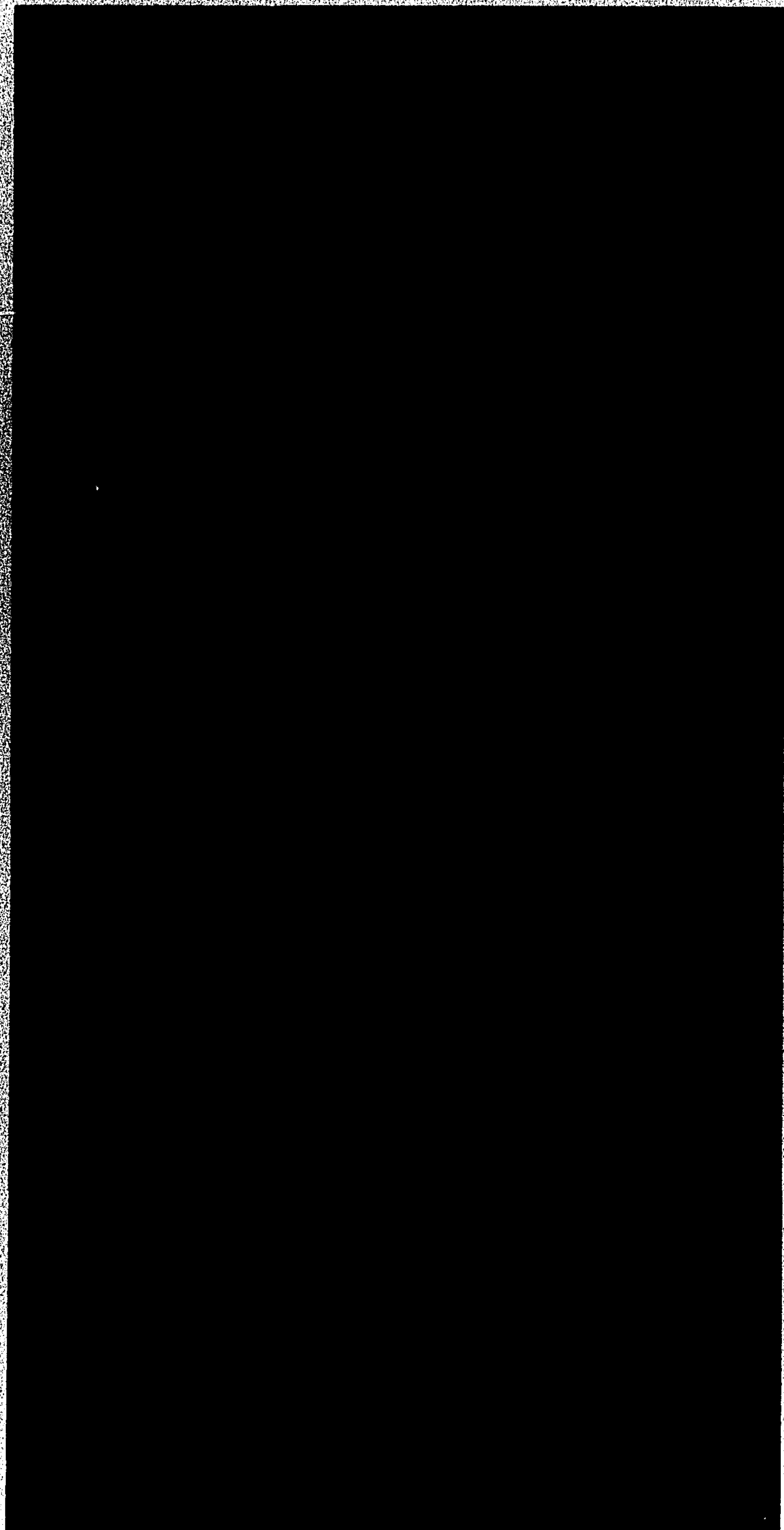
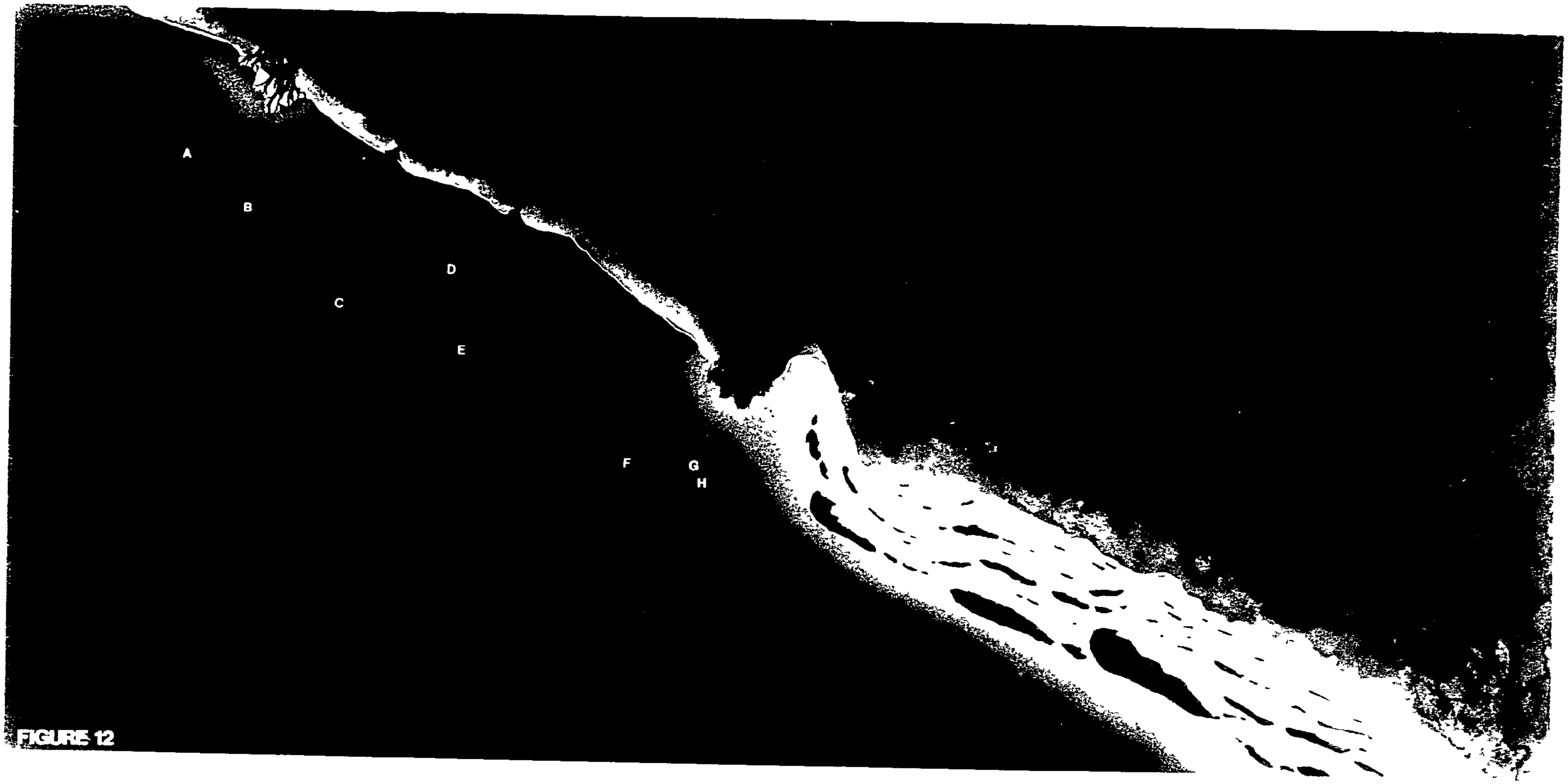



C
D
E
F




A
B
C
D
E
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G
H
FIGURE 12

EXPLANATION OF PLATE 1

Blackites amplus Roth and Hay. Sample C-58. Transmission electron micrograph, 37,000 X.

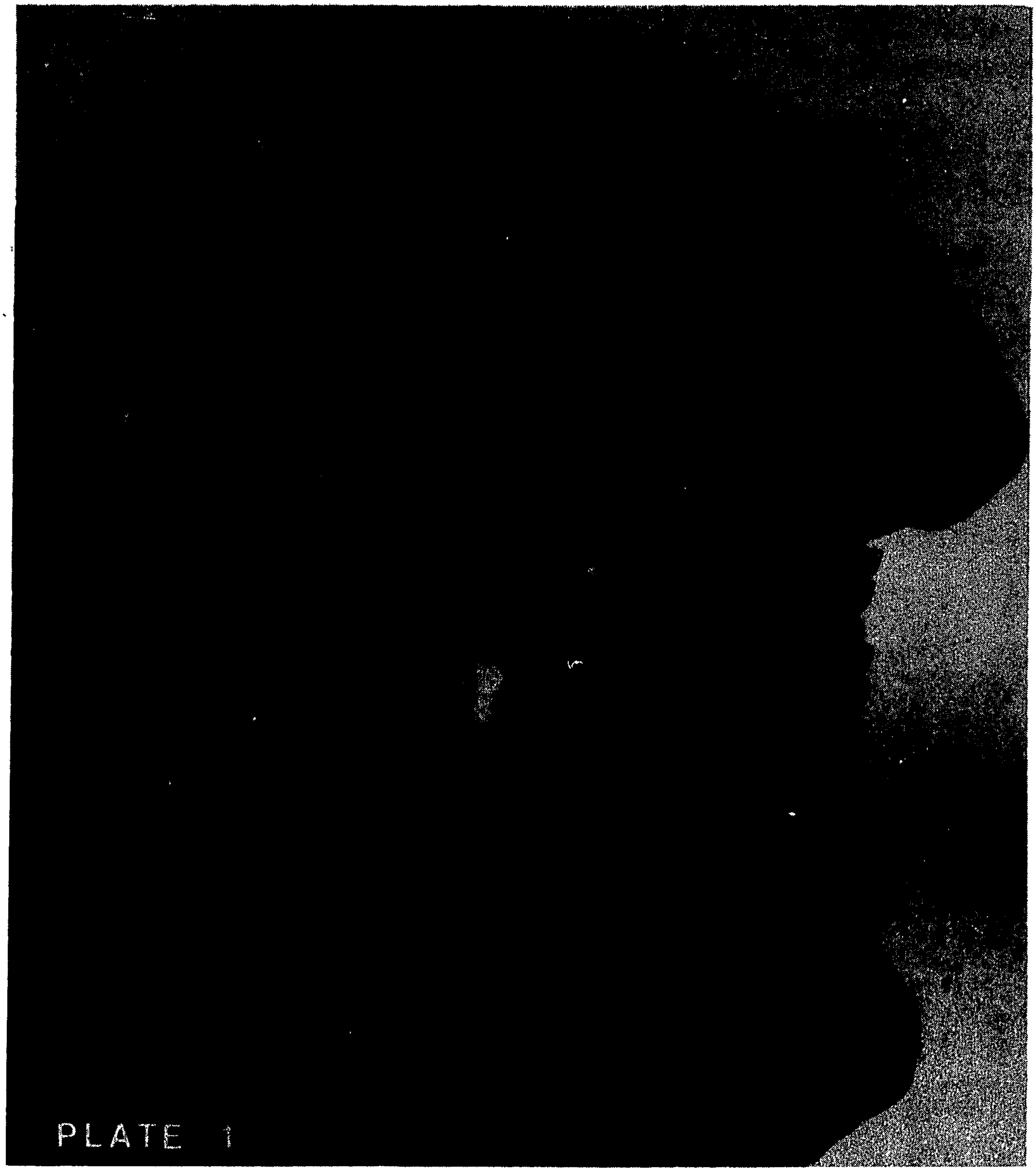


PLATE 1

EXPLANATION OF PLATE 2

Fig. 1 - *Blackites amplus* Roth and Hay. Sample C-66. Int. contr., 7600X.

2 - *Cruciplacolithus tarquinius* Roth and Hay. Sample C-66. Int. contr., 6700 X.

3 - *Discoaster barbadiensis* Tan Sin Hok. Sample C-42. Int. contr., 5900 X.

4 - *Discoaster tani nodifera* Bramlette and Riedel. Sample C-66. Int. contr., 5900 X.

5 - *Discoaster tani tani* Bramlette and Reidel. Sample C-66. Int. contr. 6500X.

6 - *Isthmolithus recurvus* Deflandre. Sample C-66. Int. contr., 5400 X.

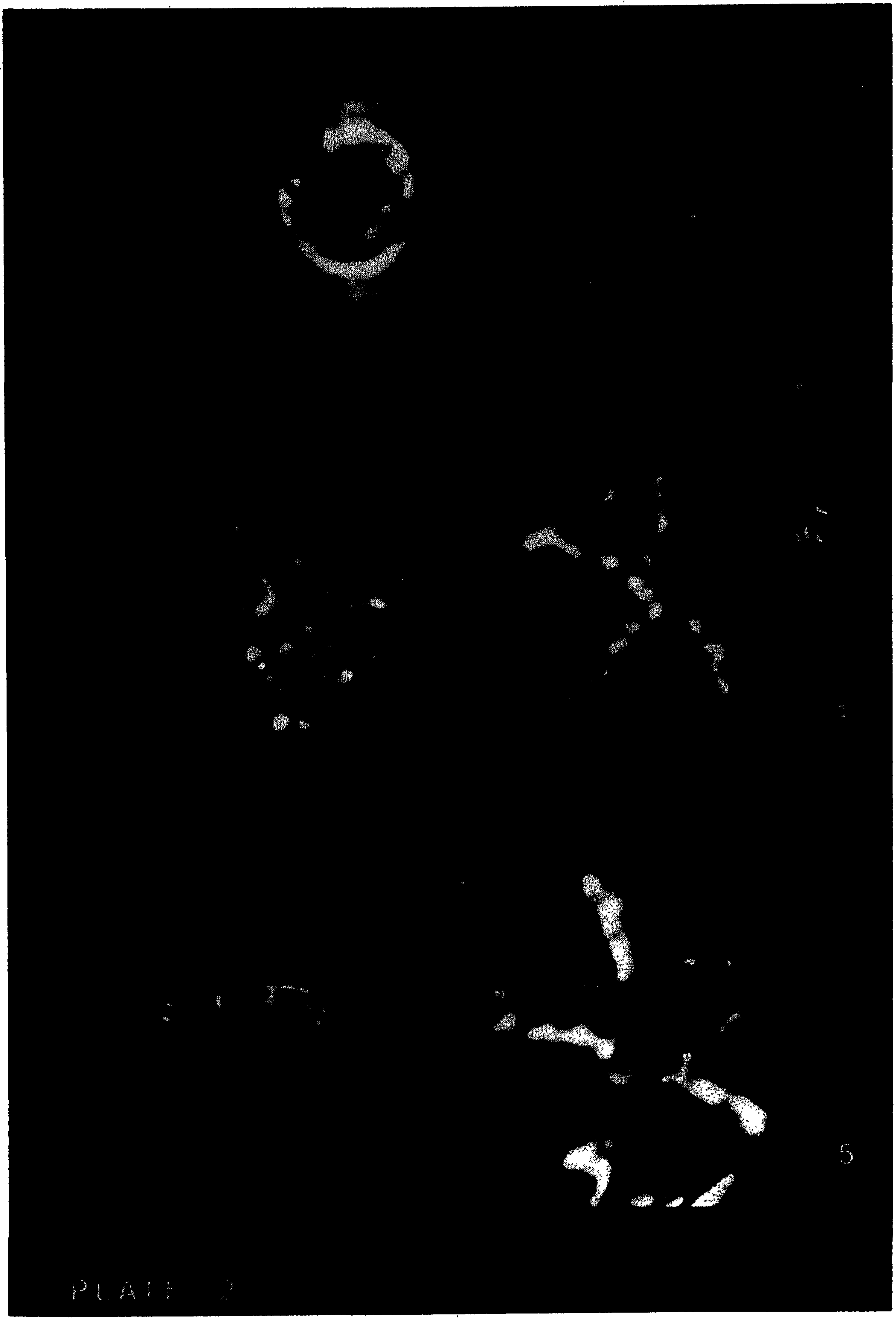


PLATE 2

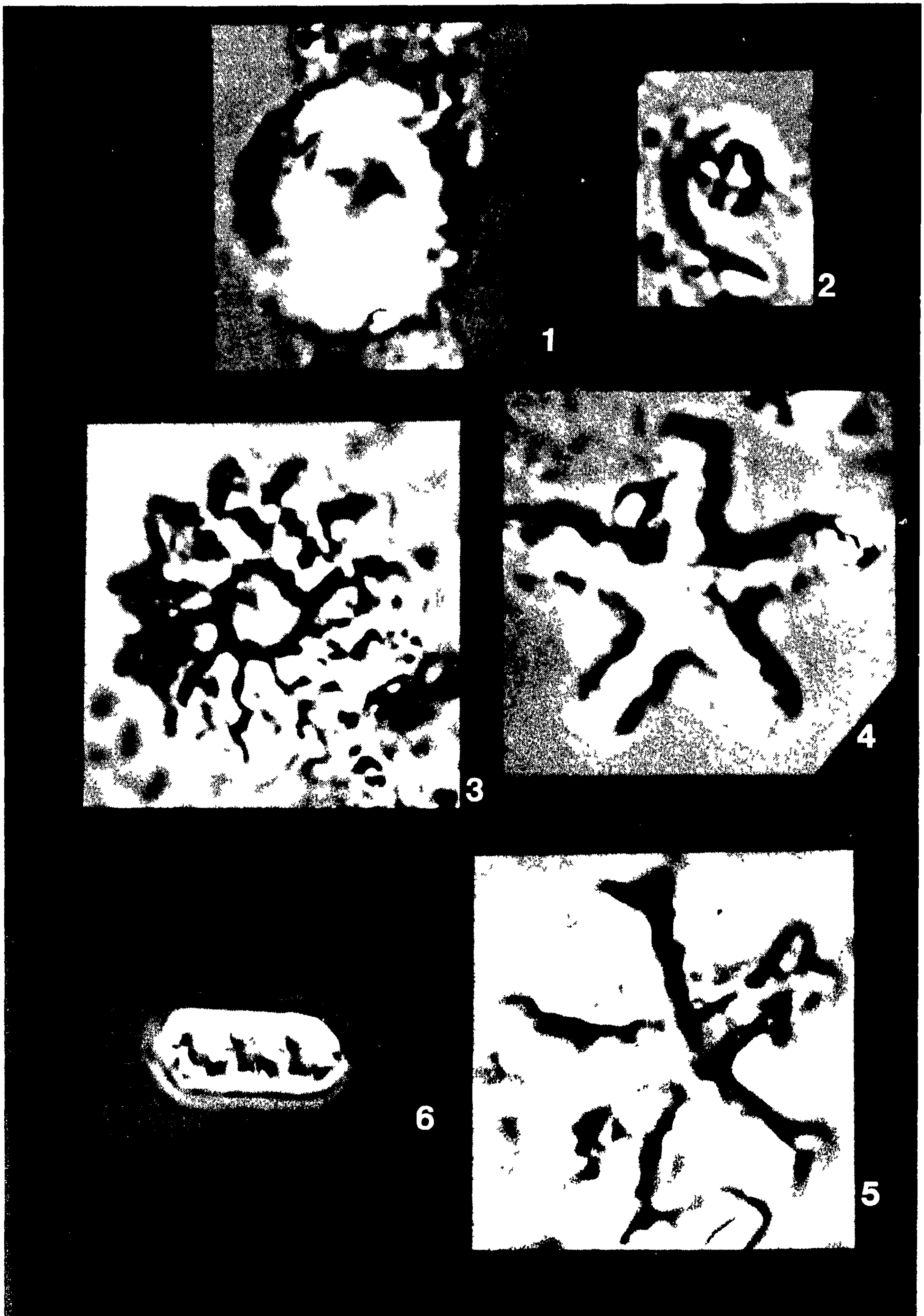


PLATE 2

EXPLANATION OF PLATE 3

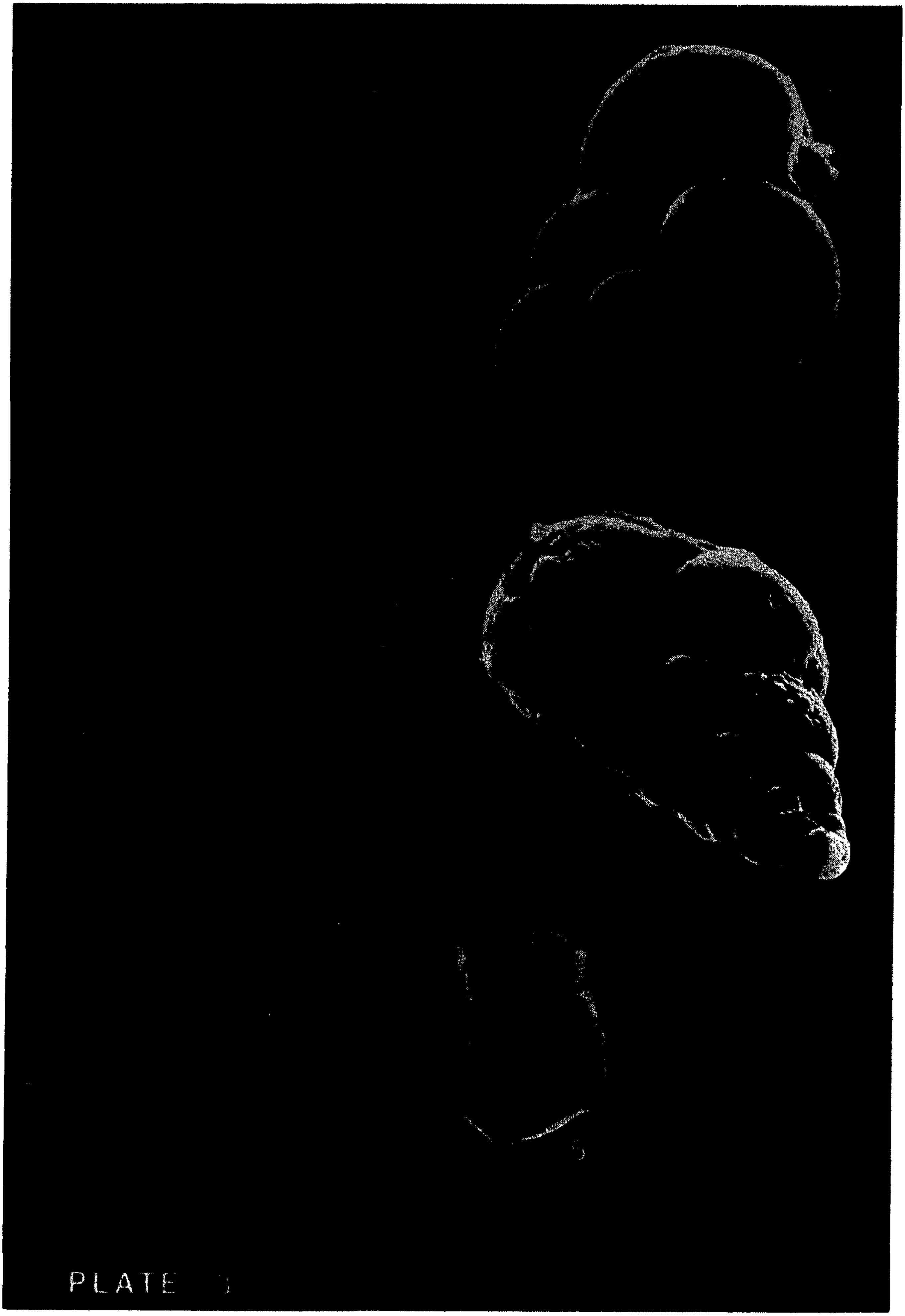
Fig. 1 - Diatom referrable to the genus *Coscinodiscus*. Sample H-20. SEM, 275 X.

2 - *Chiloguembelina cubensis* (Palmer). Sample C-23. SEM, 420 X.

3 - *C. martini* (Pijpers). Sample C-23. SEM, 500 X.

4 - *C. victoriana* Beckman. Sample C-23. SEM, 465 X.

5 - *Hantkenina alabamensis* Cushman. Sample C-12. SEM, 90 X.



PLATE

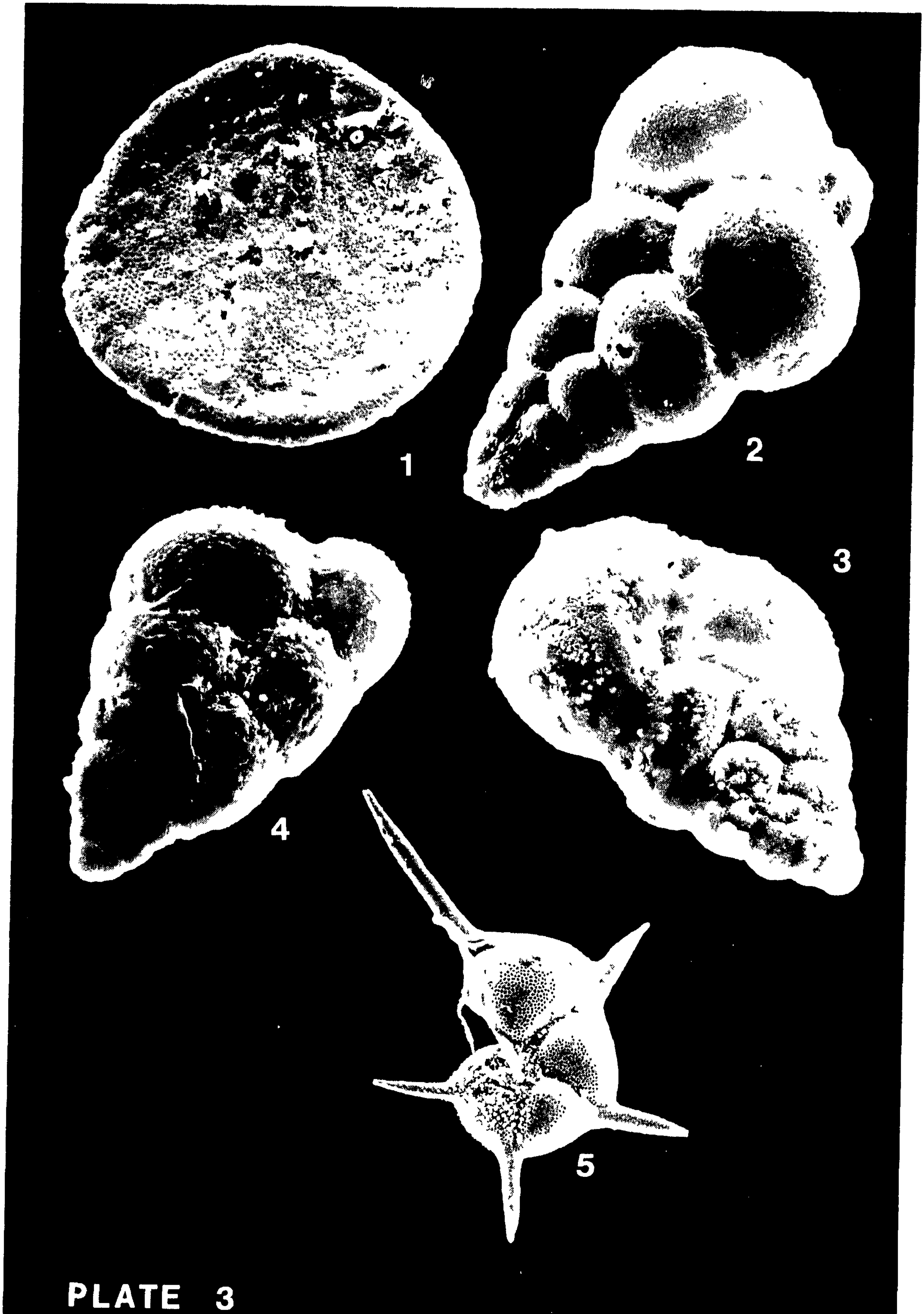


PLATE 3

EXPLANATION OF PLATE 4

Figs. 1,2 - Cribrohantkenina inflata (Howe). Sample C-23.

Fig. 1, overall view, SEM, approximately 70 X.

Fig. 2, detail of apertural area, SEM, approximately 230 X.

3 - Pseudohastigerina barbadoensis Blow. Sample C-21. SEM, 460 X.

4 - P. micra (Cole). Sample C-21. SEM, 310 X.

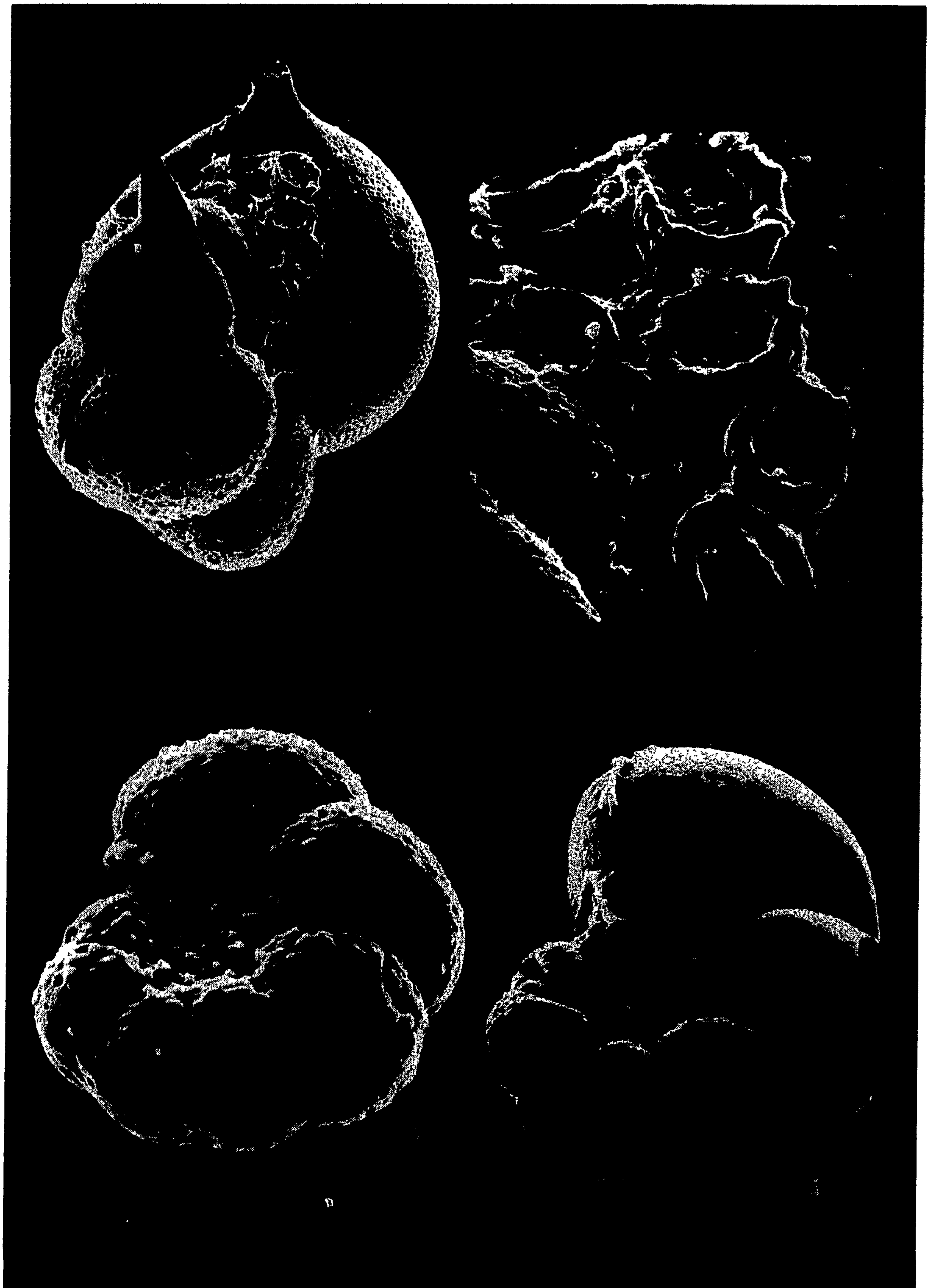


PLATE 4

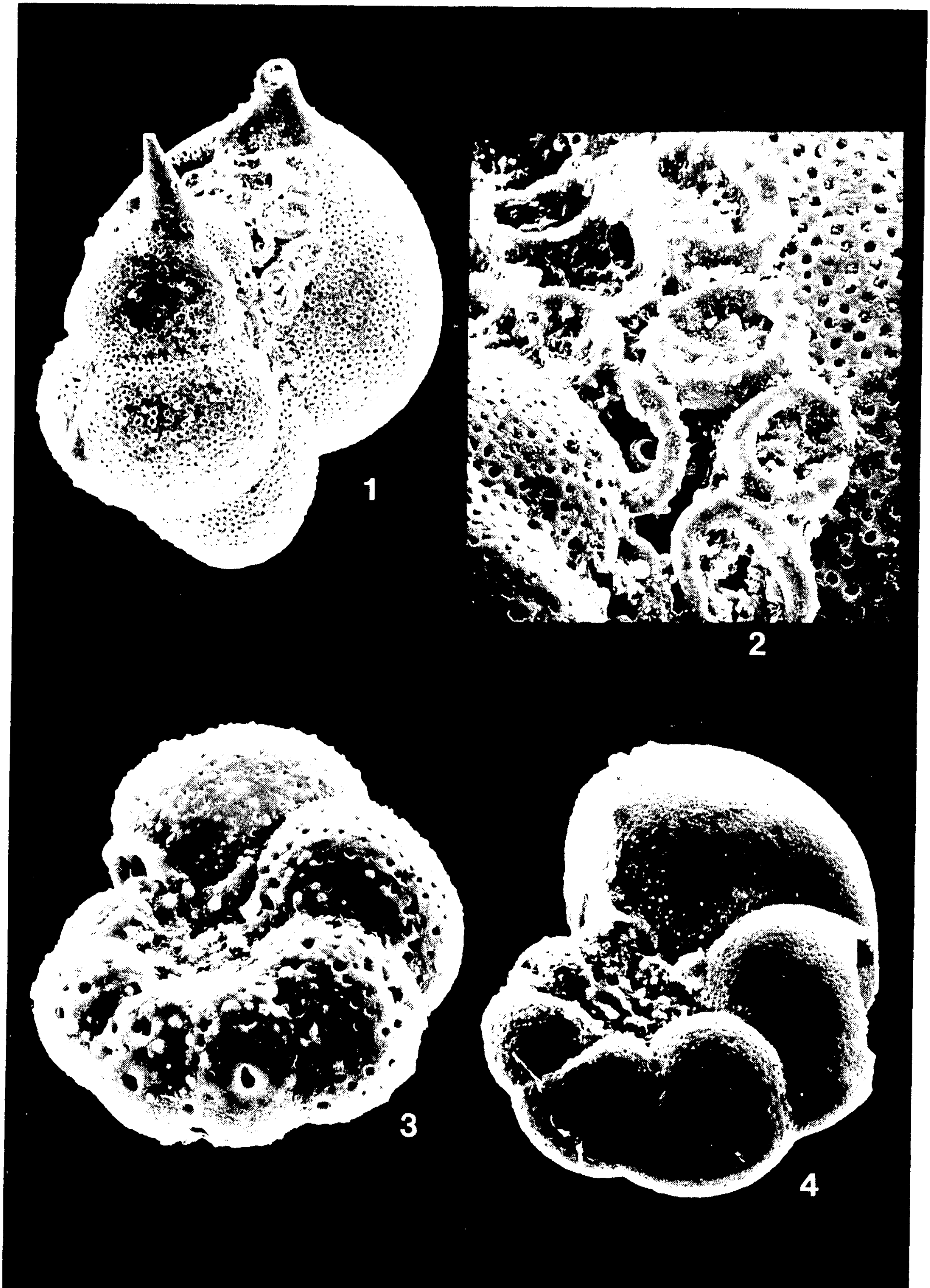
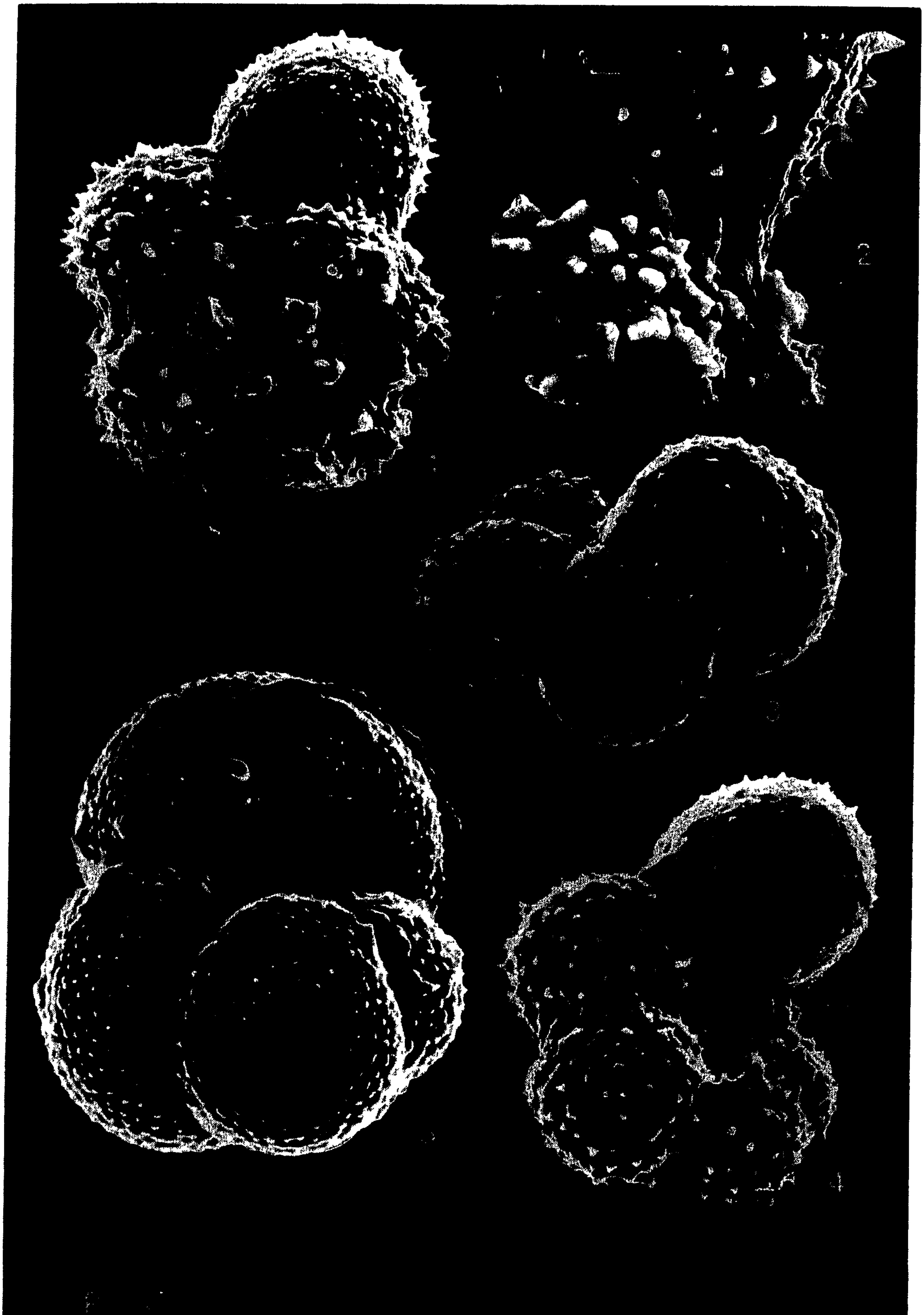


PLATE 4

EXPLANATION OF PLATE 5

Figs. 1-4 - Truncorotaloides danvillensis (Howe and Wallace). Sample A-6. Fig. 1, dorsal view, SEM, 420 X. Fig. 2, detail of secondary aperture on dorsal side, SEM, 1130 X. Fig. 3, oblique view of ventral side of a second specimen, SEM, approximately 450 X. Fig. 4, ventral view of a third specimen, SEM, 400 X.

5 - Globigerina ampliapertura Bolli. Sample C-58. SEM, 210 X.


2

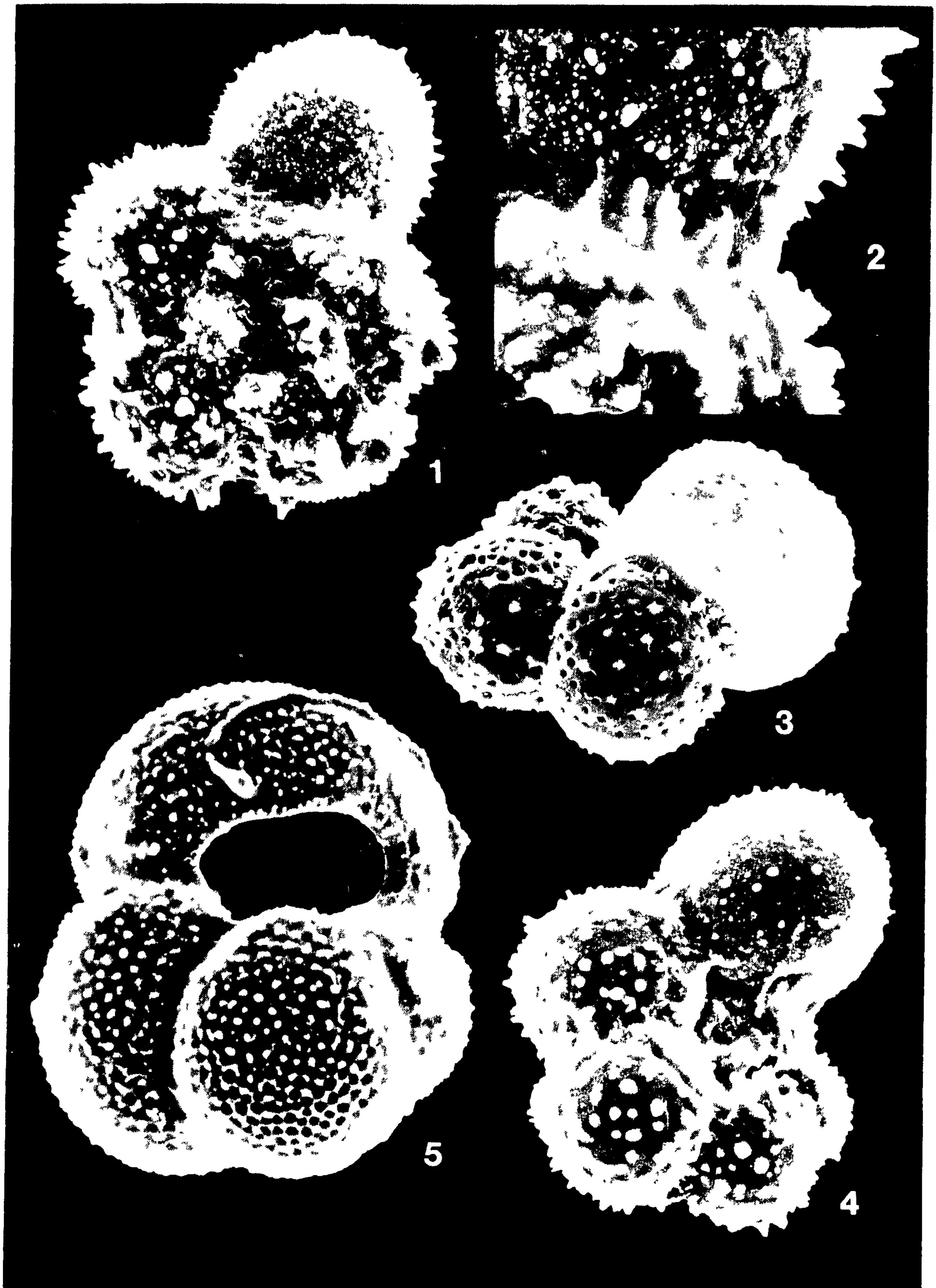
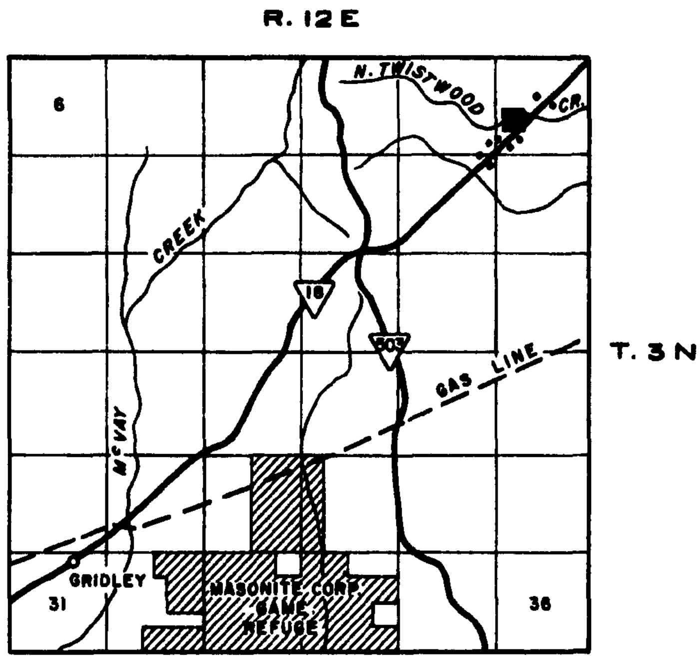


PLATE 5

APPENDIX A

Locations of Surface Sections and Outcrop Data

In Figures 14 A, 15 A, 16 A, etc., the ten outcrop sections are located in the townships shown in Figure 2. Lithologic data are presented graphically in Figures 14 B, 15 B, 16 B, etc. with horizontal ruling representing clay plus silt, diagonal ruling representing total bioclasts, stipling representing quartz sand, and solid inking representing glauconite grains.



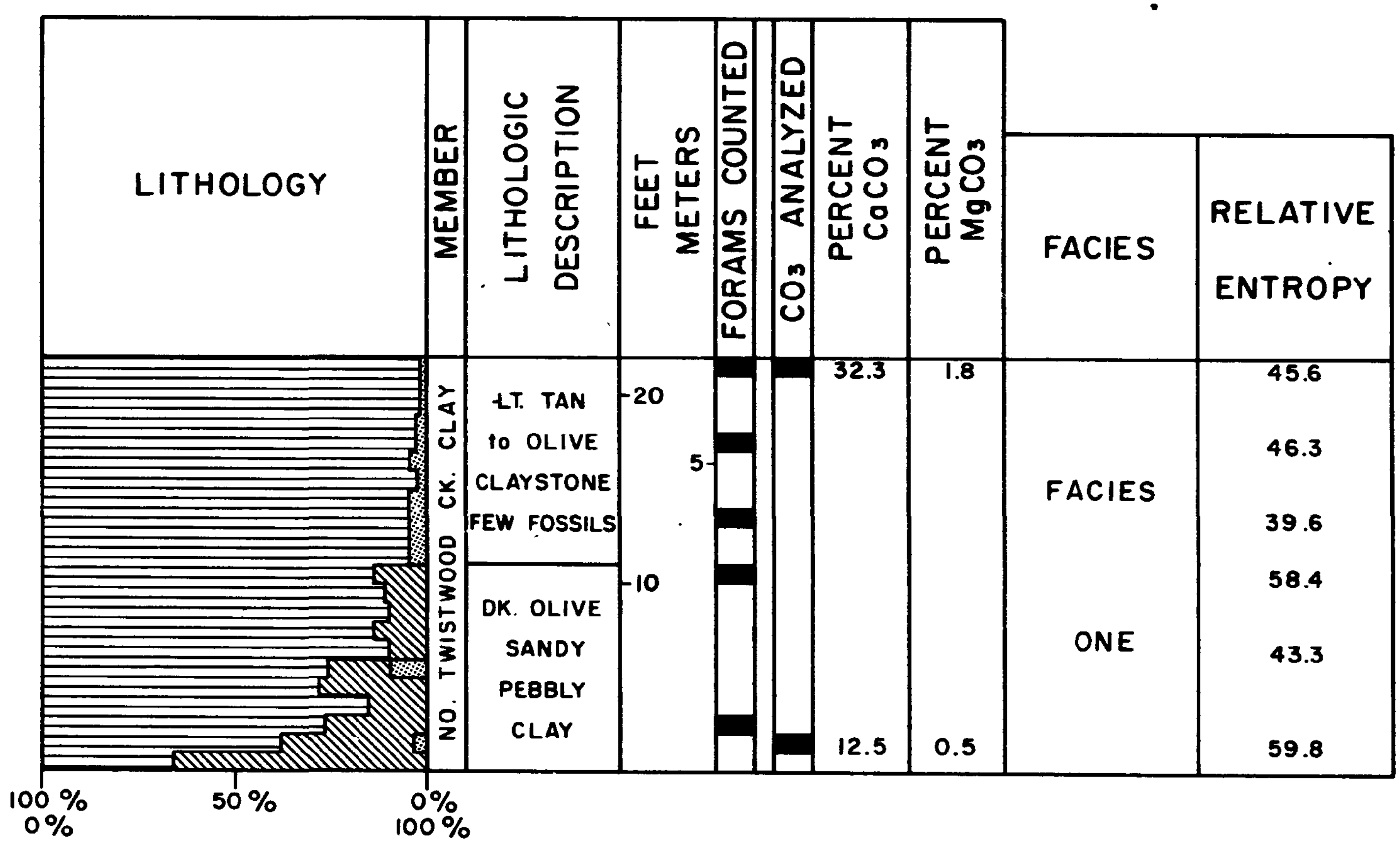
OUTCROP A FIGURE 14 A

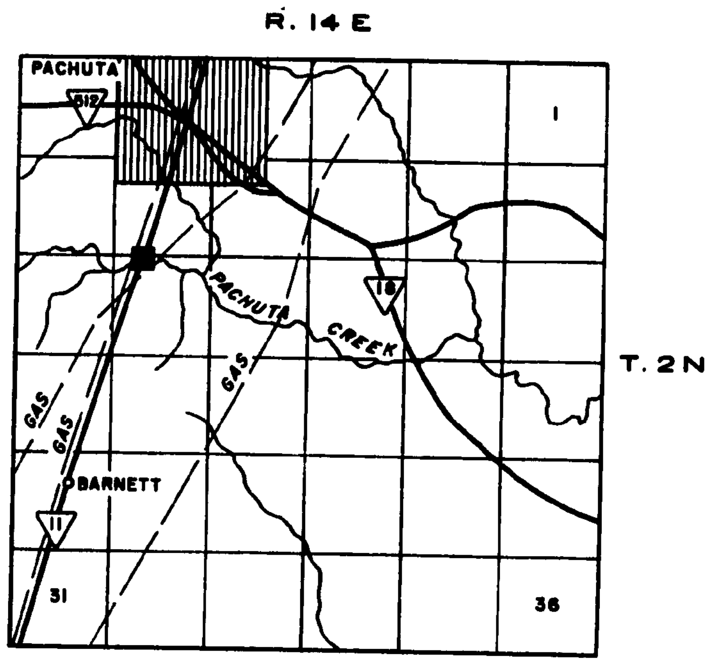
FIGURE 14B

SECTION A

TYPE NORTH TWISTWOOD CREEK MEMBER

SW 1/4, SEC. 1, T3N, R12E





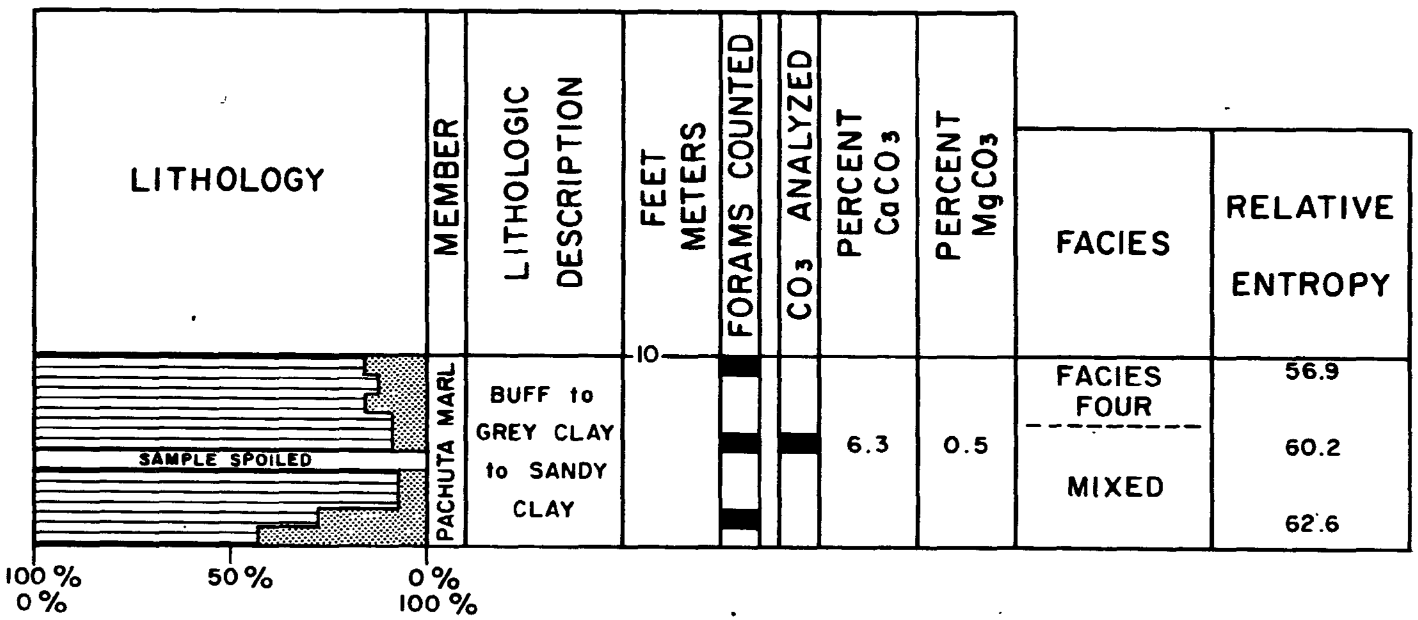
OUTCROP B FIGURE 15 A

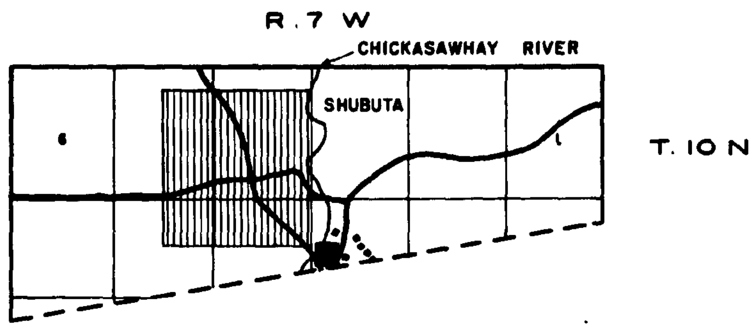
FIGURE 15 B

SECTION B

TYPE PACHUTA MARL MEMBER

SW 1/4, SEC. 8, T 2 N, R 14 E





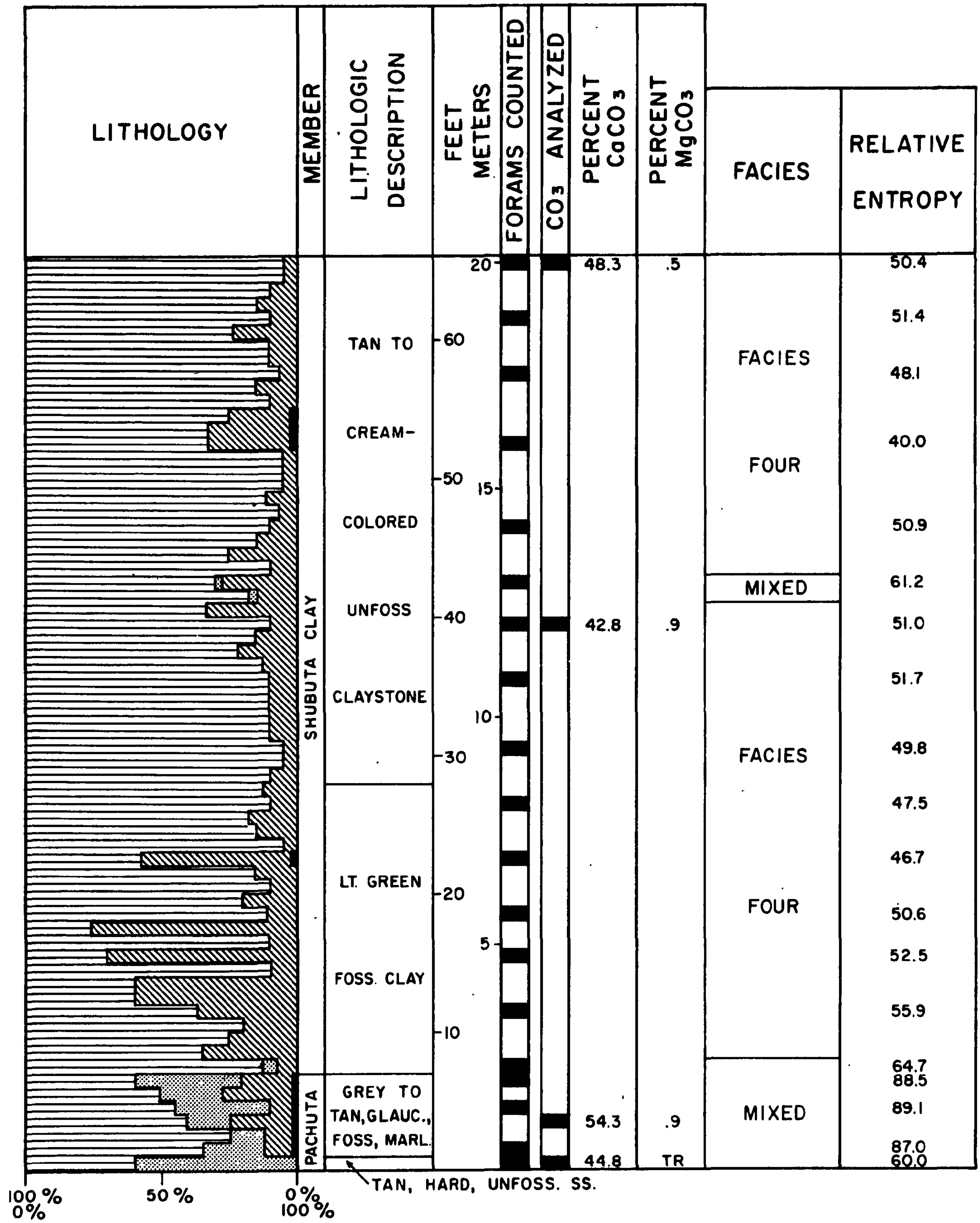
OUTCROP C FIGURE 16A

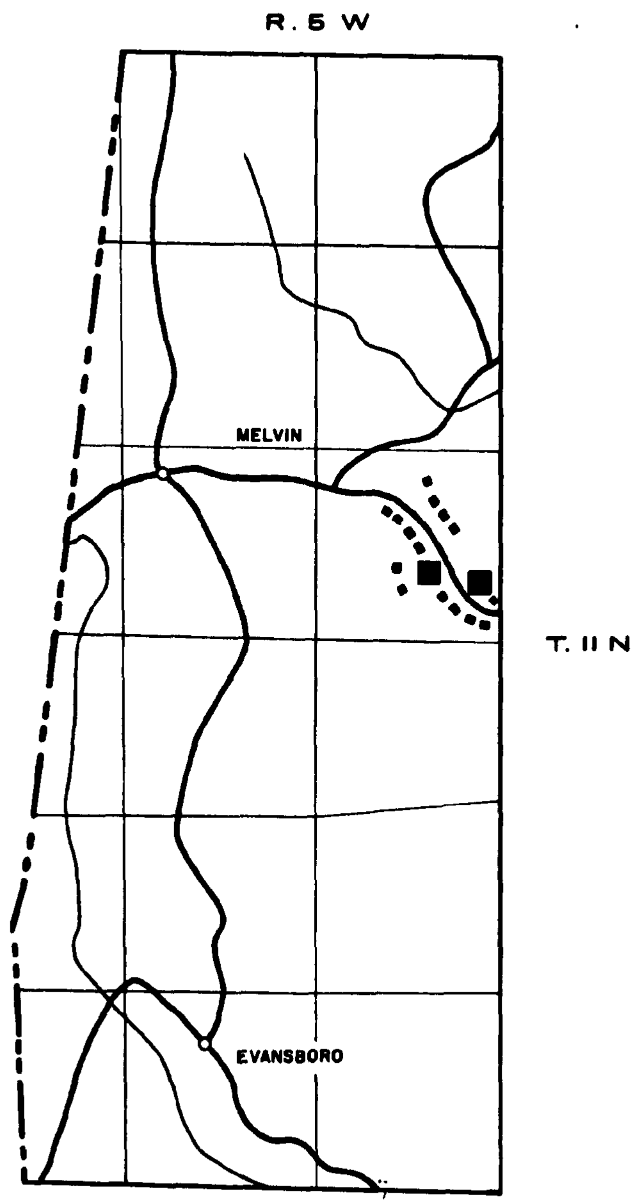
FIGURE 16B

SECTION C

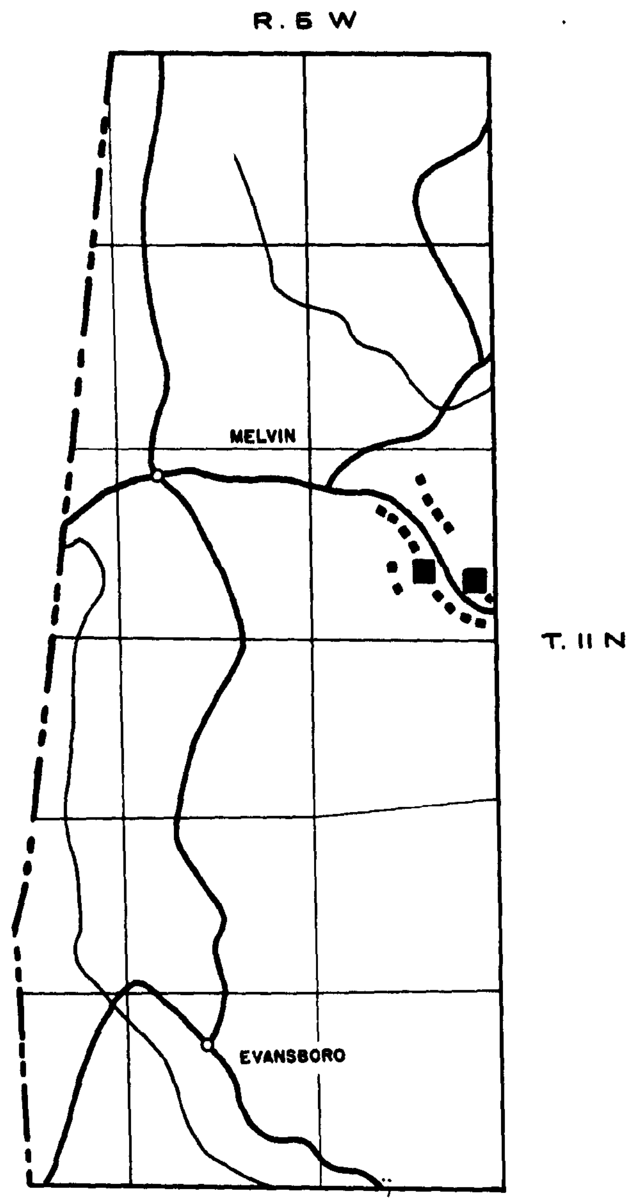
TYPE SHUBUTA CLAY MEMBER

NW1/4, SEC. 10, T10N, R 7 W





OUTCROP D FIGURE 17 A



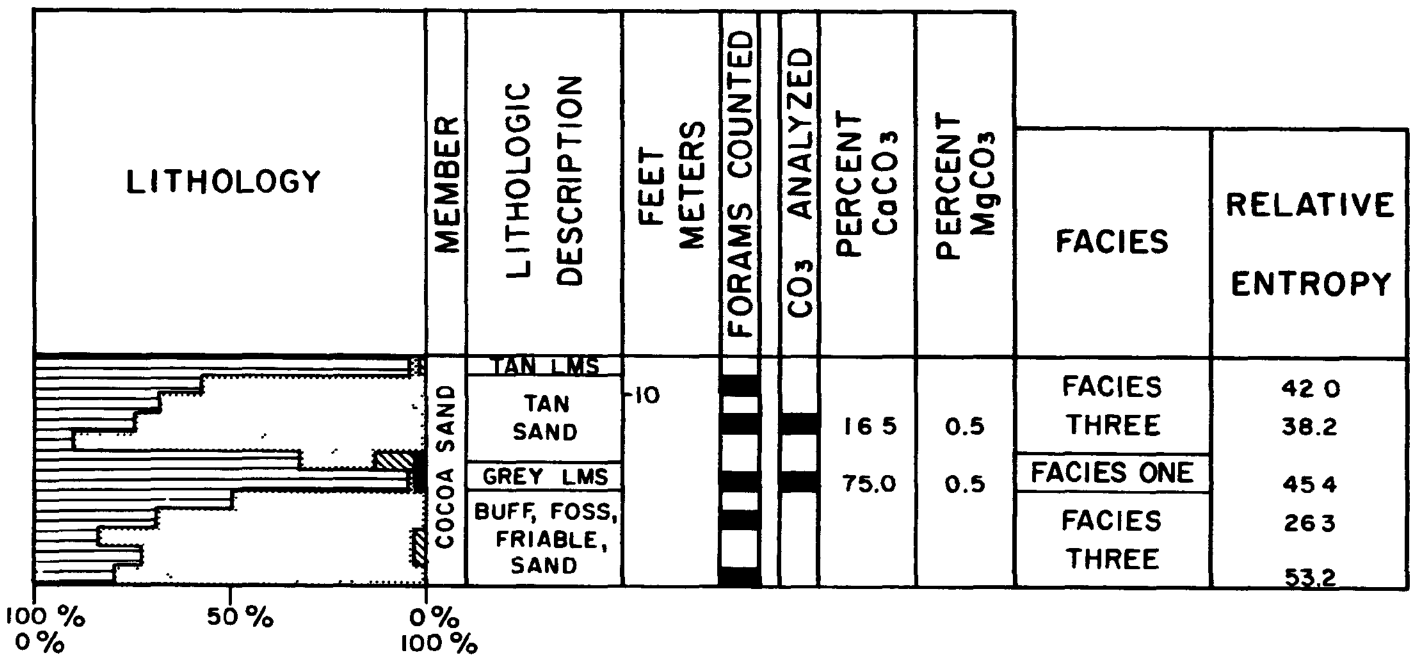
OUTCROP D FIGURE 17 A

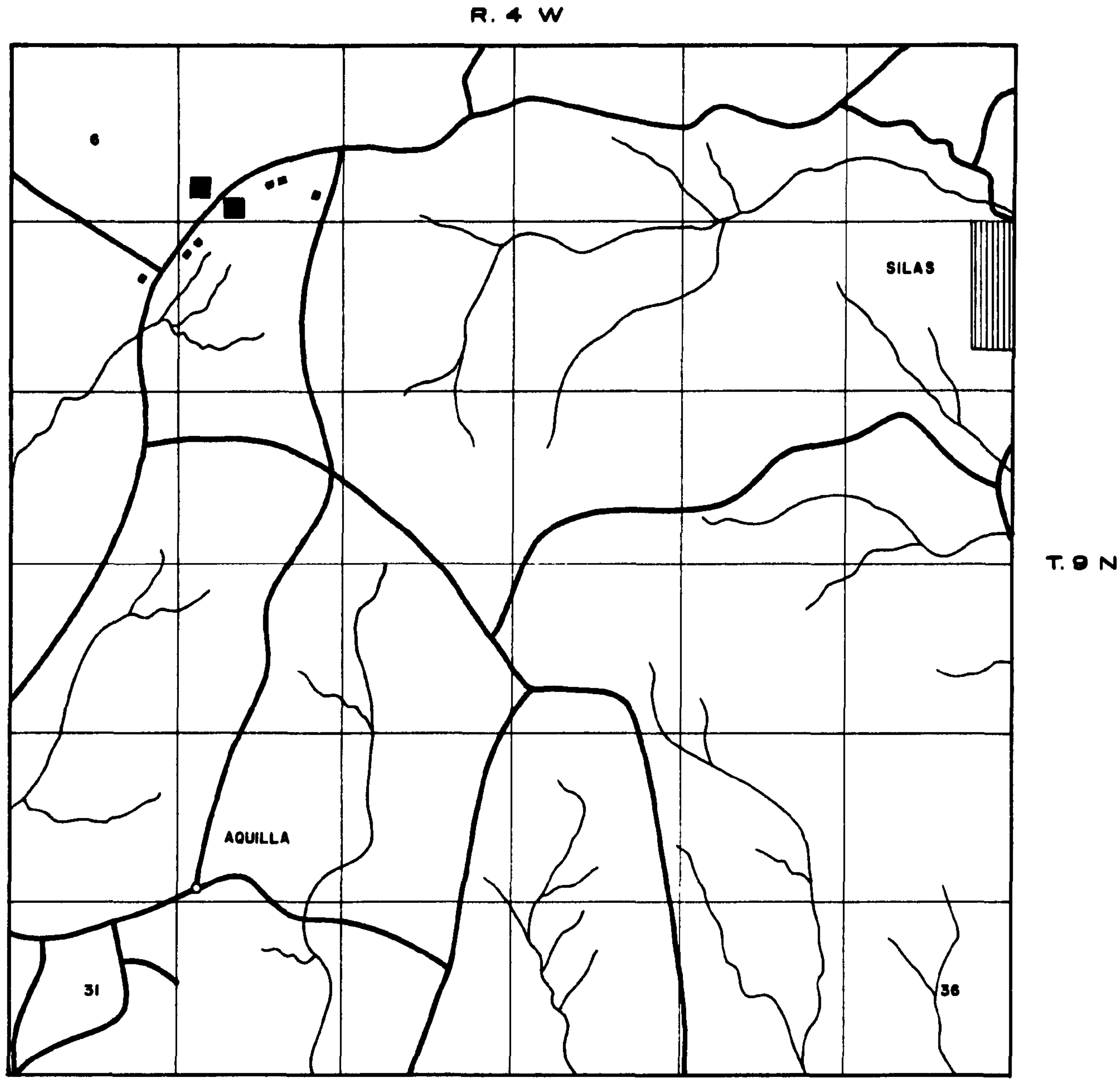
FIGURE 17B

SECTION D

TYPE COCOA SAND MEMBER

SW 1/4, SEC. 13, T11N, R5W





OUTCROP E

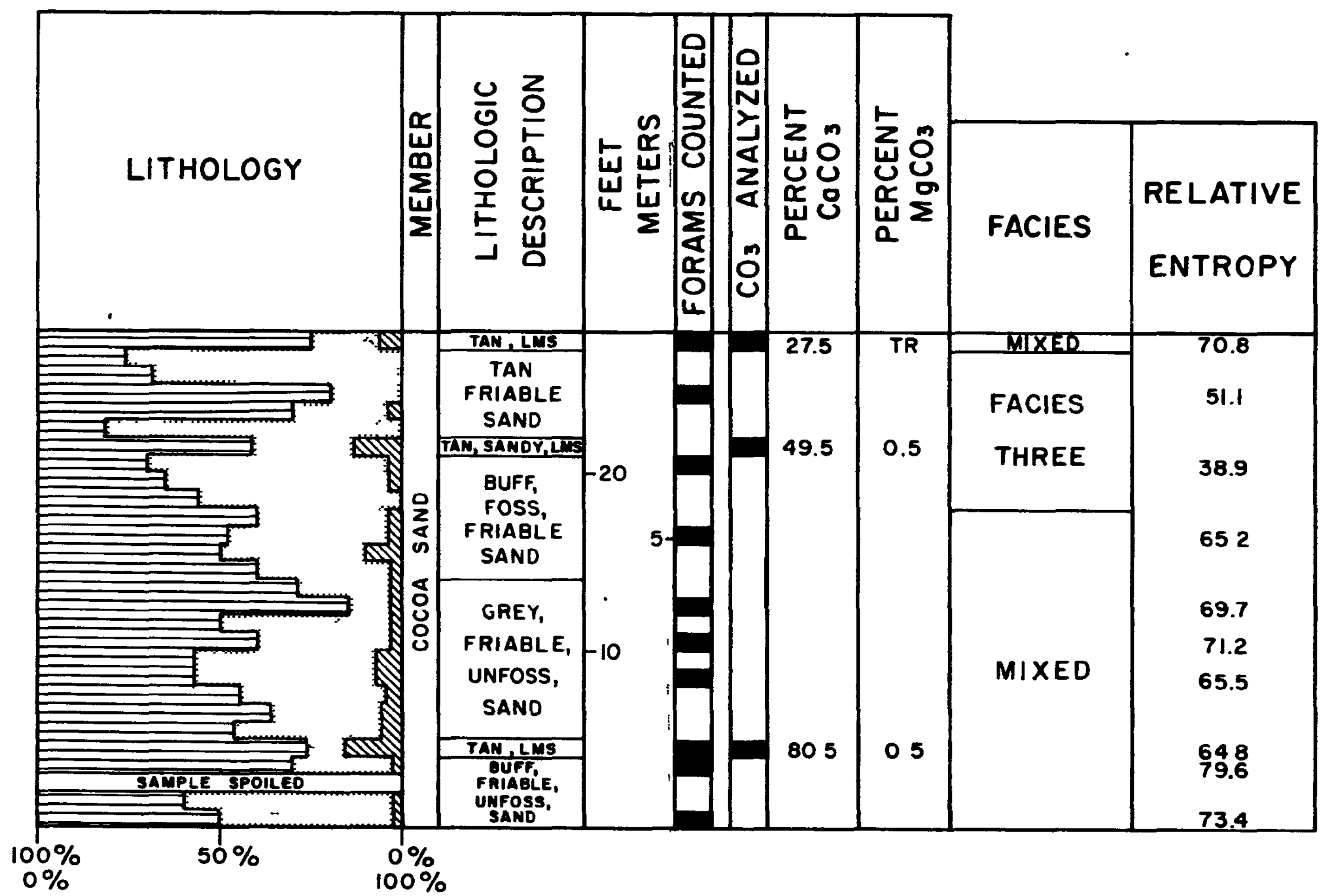
FIGURE 18 A

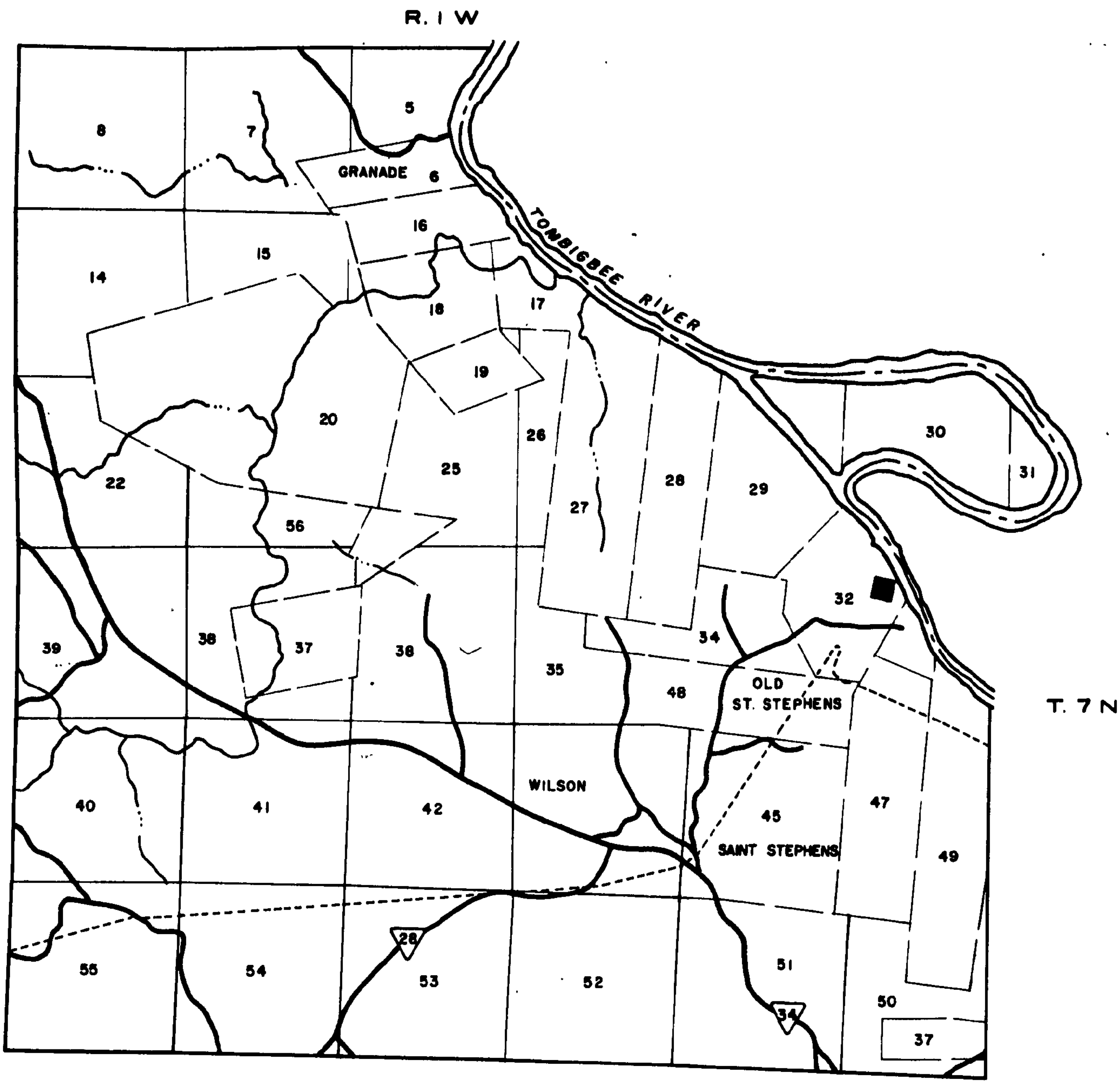
FIGURE 18B

SECTION E

3 MILES EAST OF ISNEY

SW 1/4, SEC 5, T9N, R4W





OUTCROP F

FIGURE 19 A

FIGURE 19 B

SECTION F

ST. STEPHEN'S QUARRY

SEC. 14, T 7 N, R1W

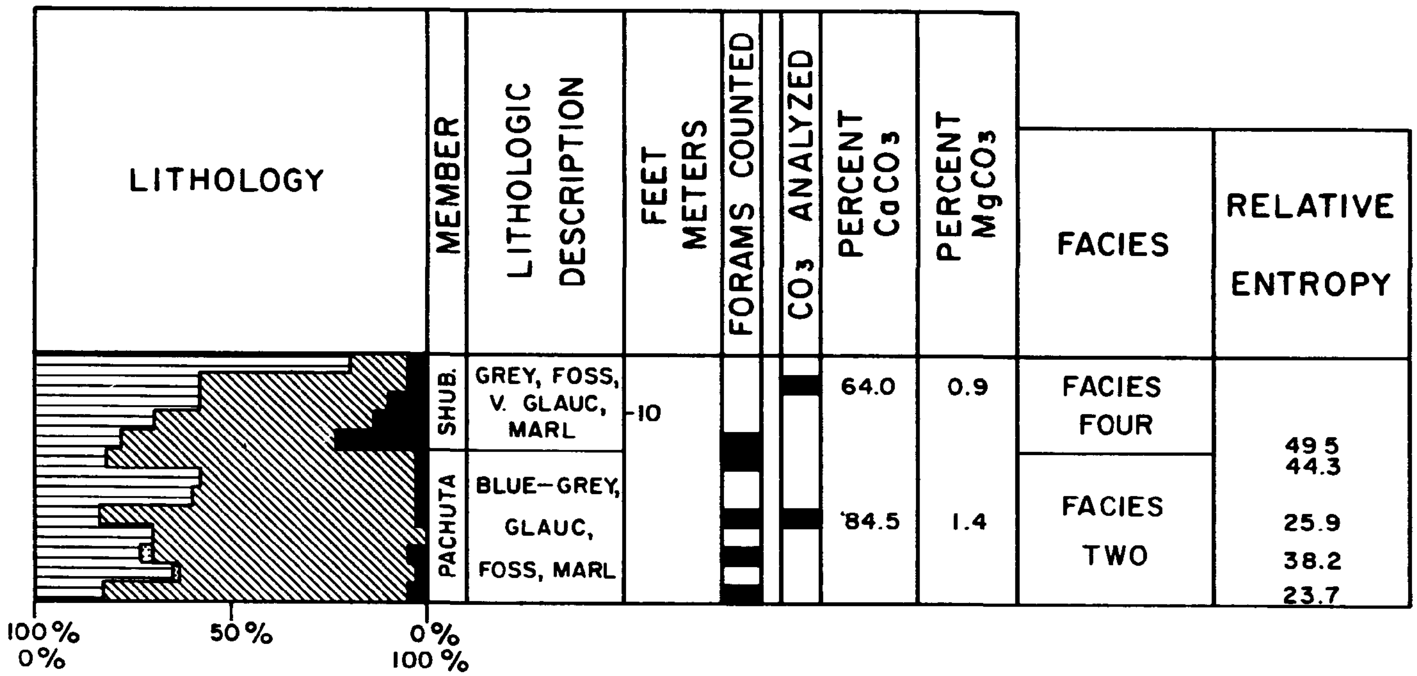
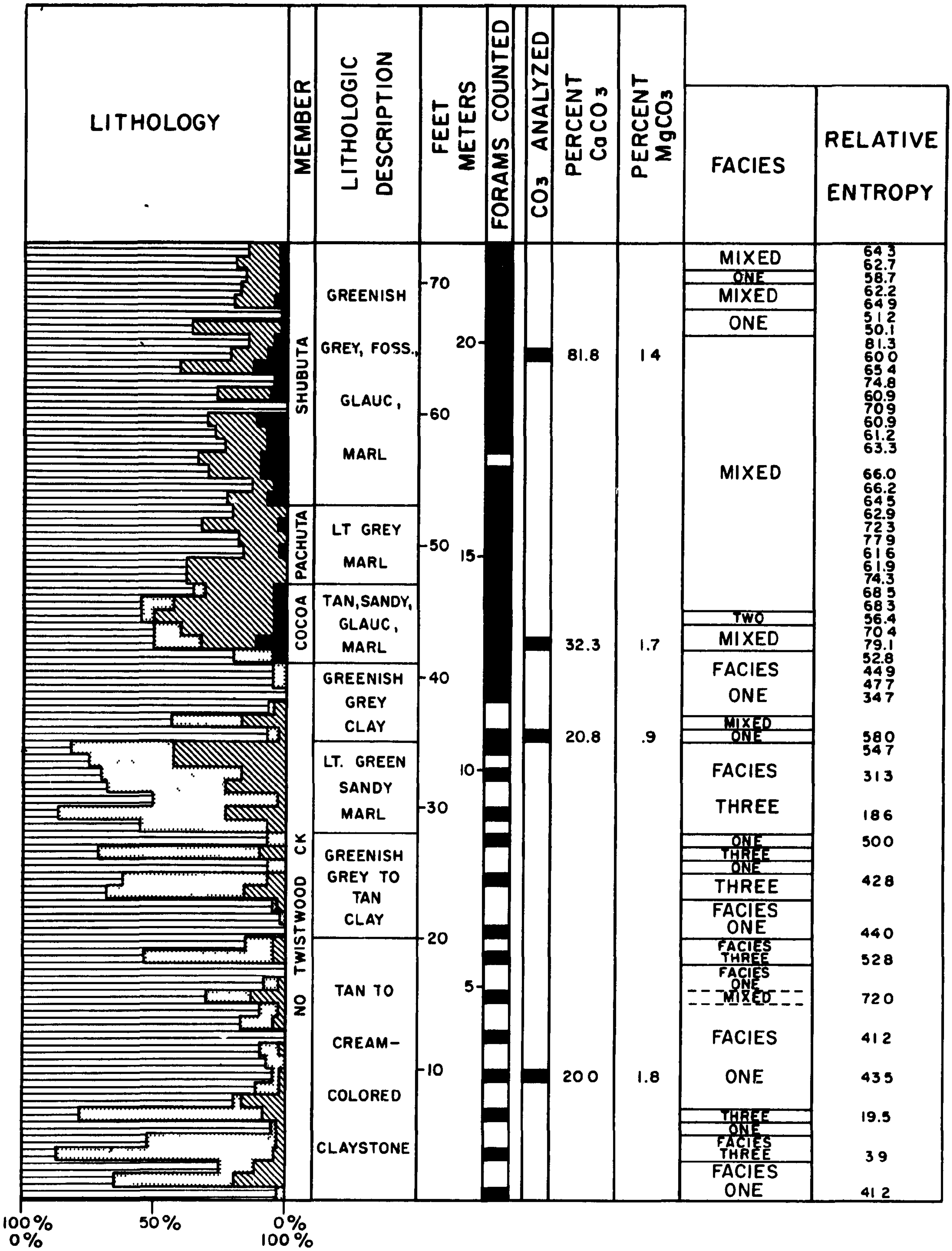


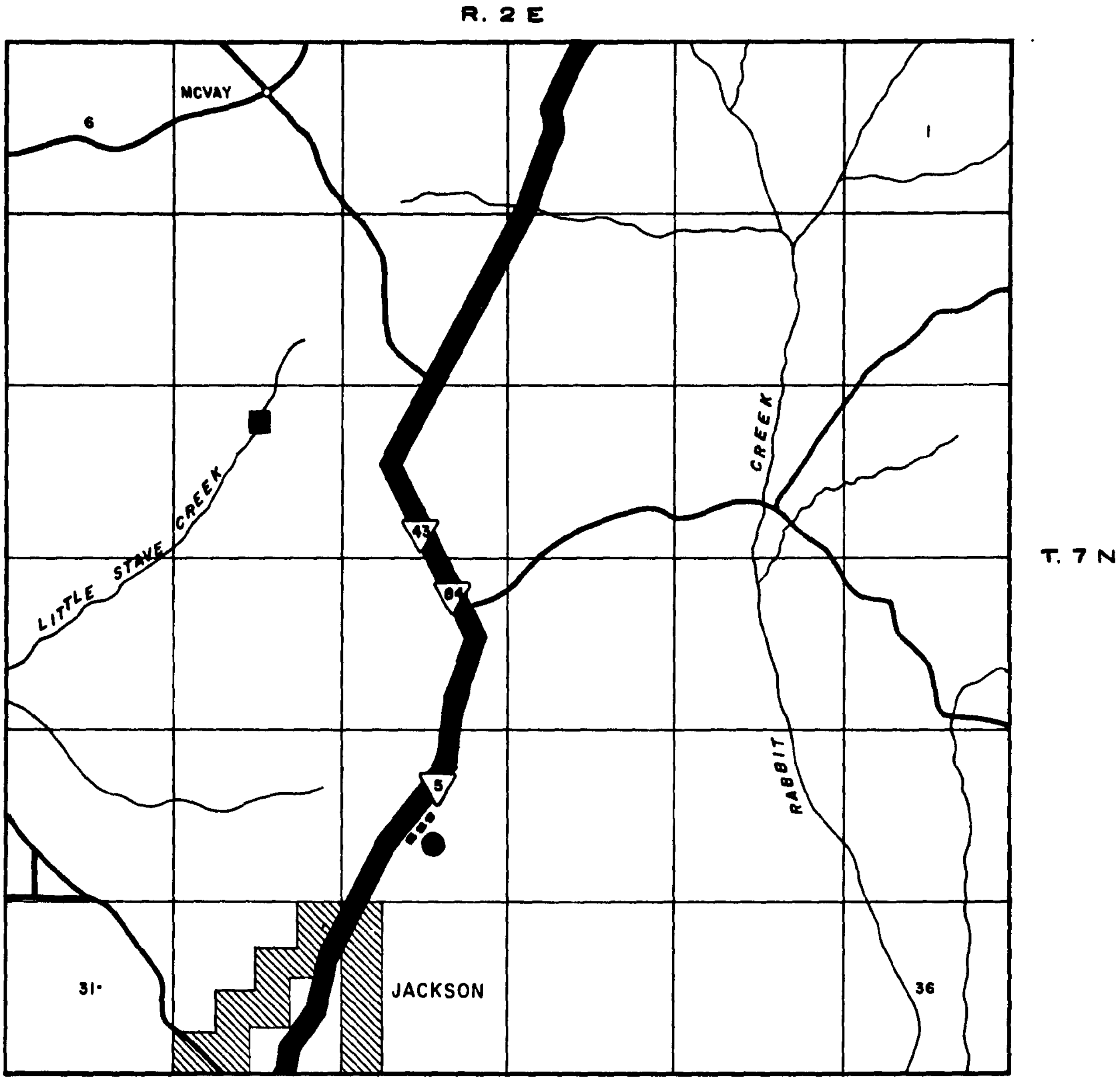
FIGURE 20B

SECTION G

LITTLE STAVE CREEK

SEC. 17, T7N, R 2 E





OUTCROP G - ■

OUTCROP H - ●

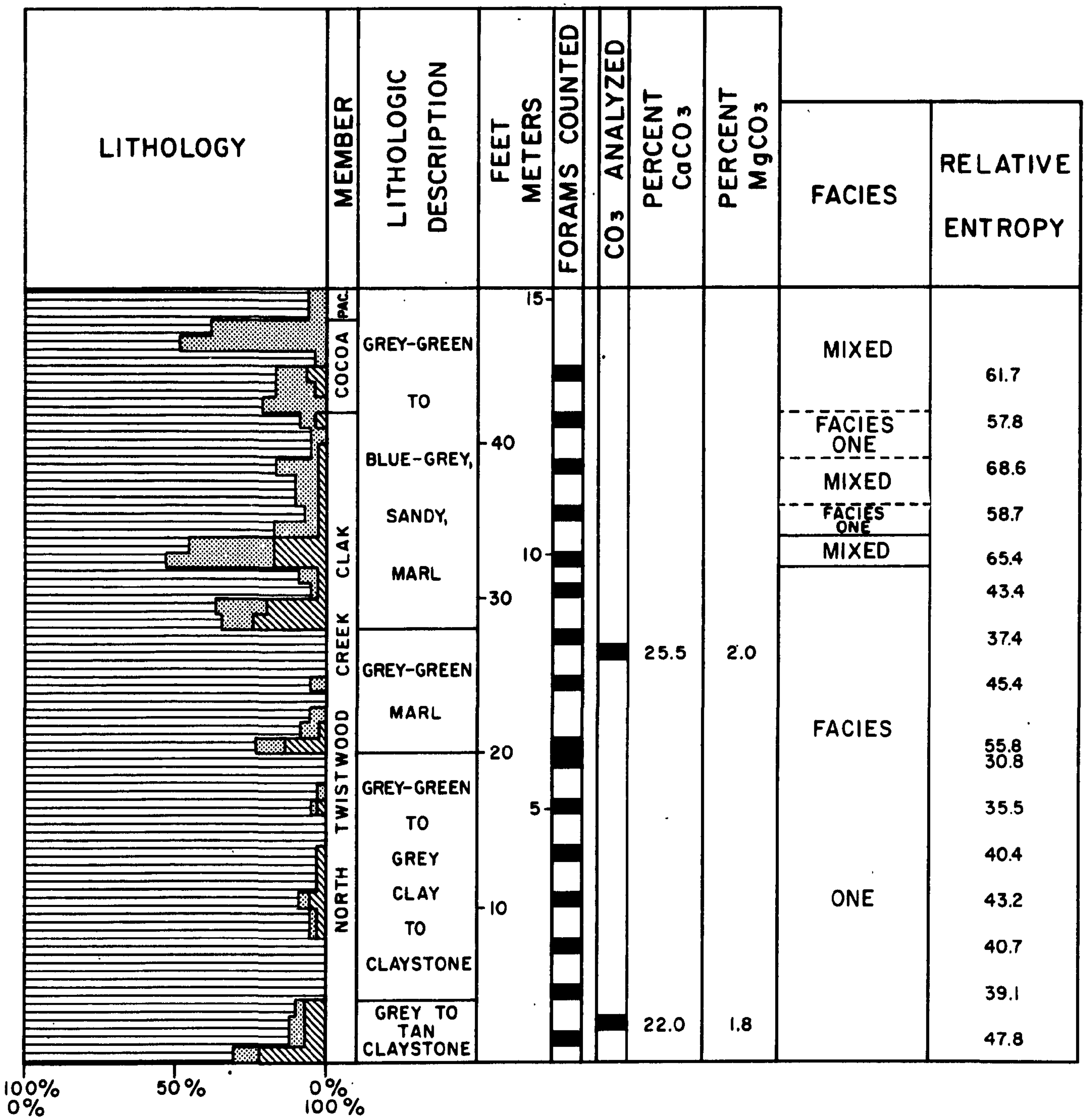
FIGURE 20 A

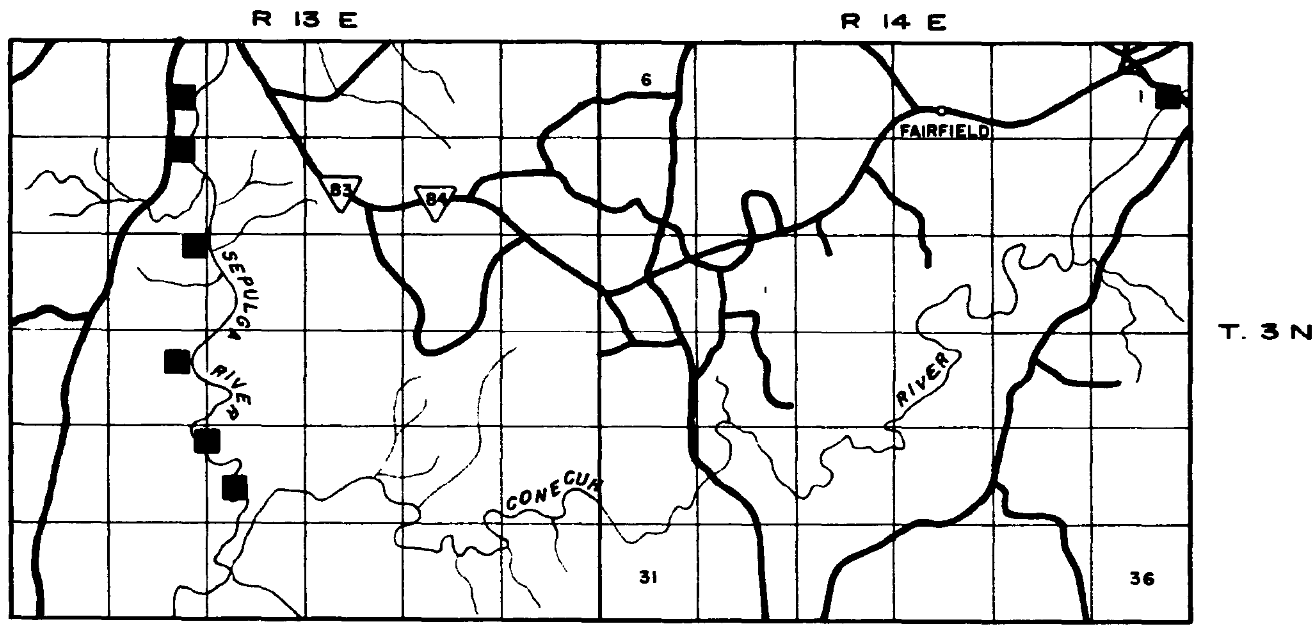
FIGURE 20 C

SECTION H

NORTH JACKSON

SE 1/4, SEC. 28, T 7 N, R 2 E

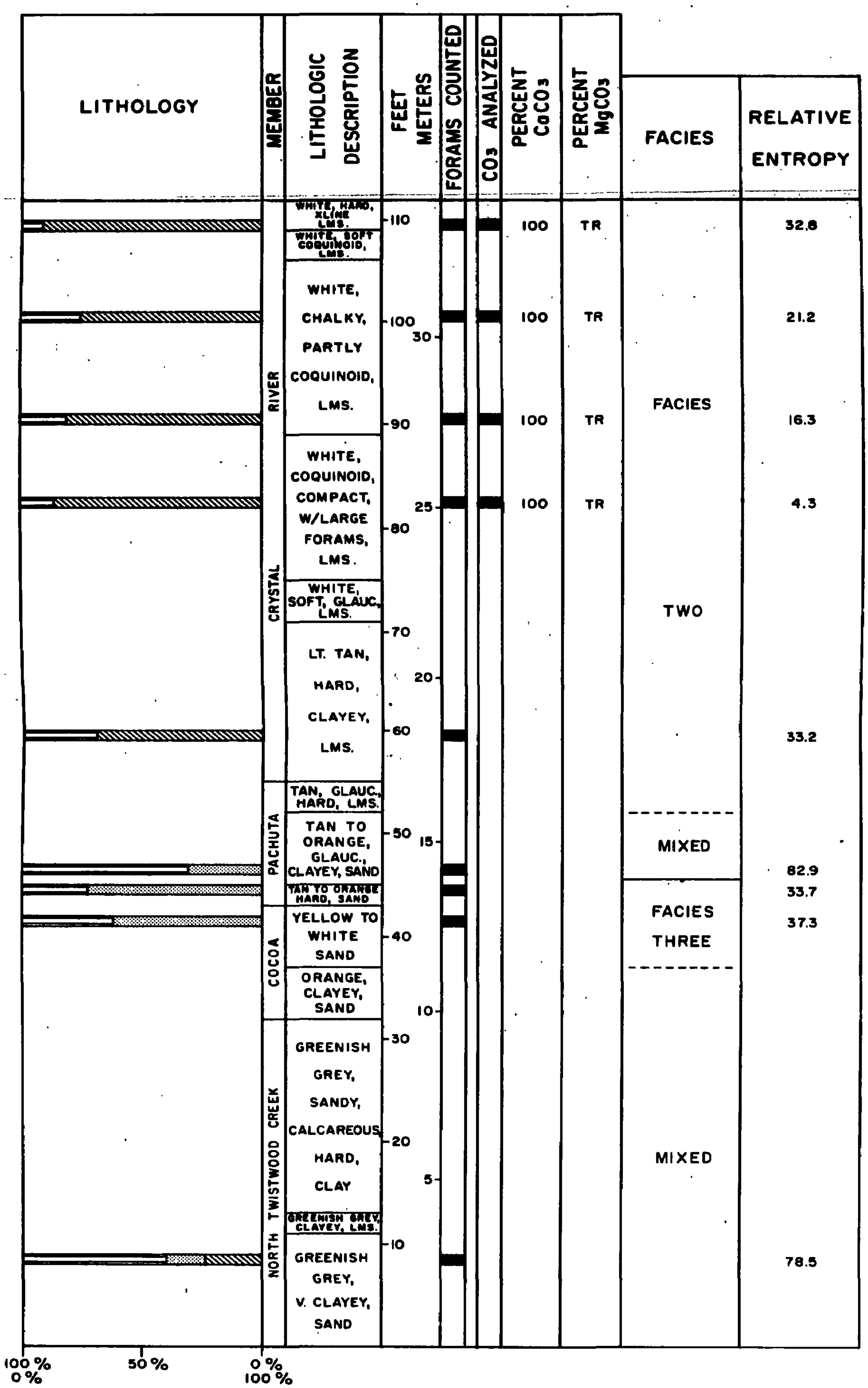


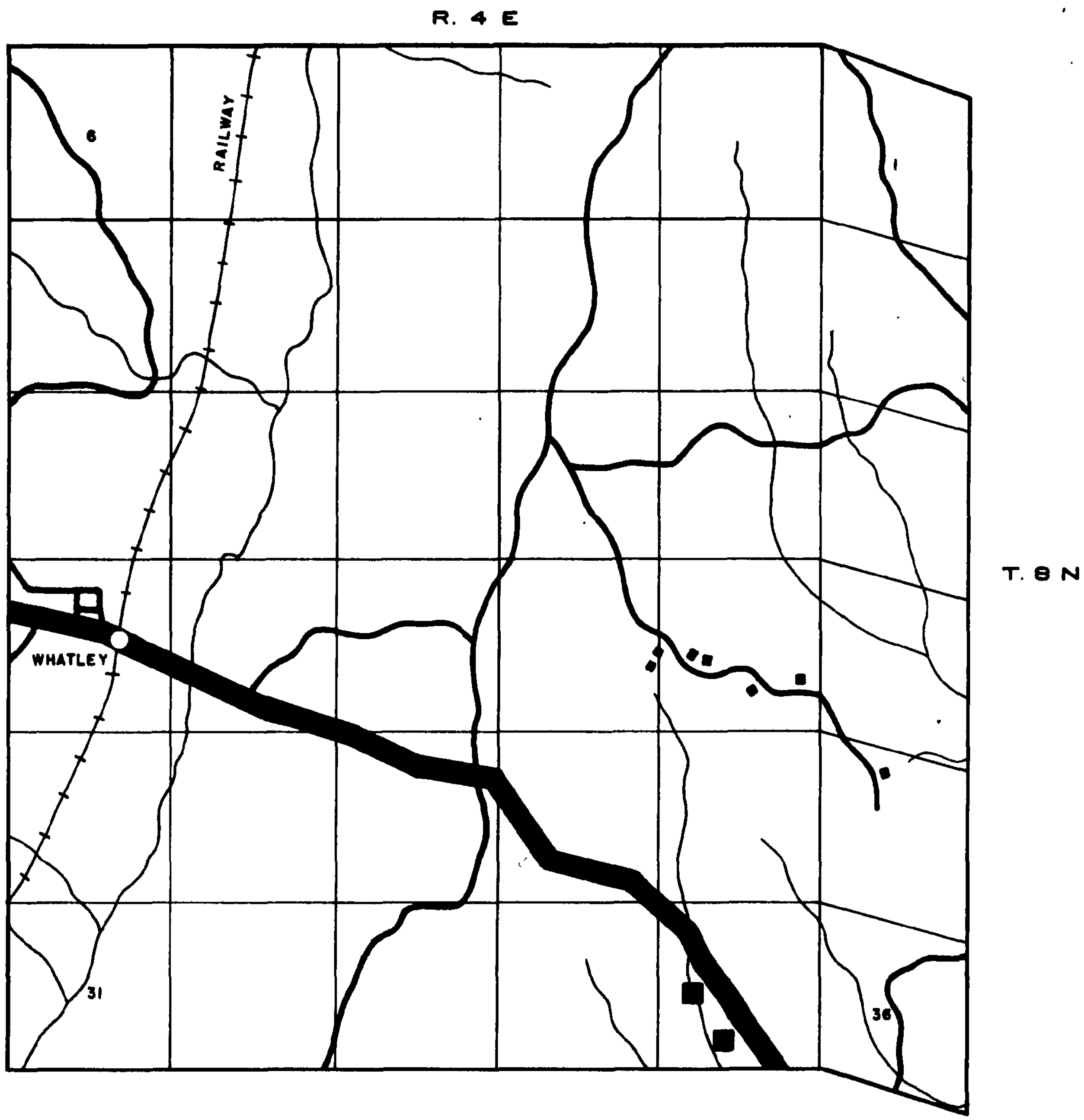


SAMPLE OUTCROPS ON SEPULGA AND CONECUH RIVERS

FIGURE 21 A

FIGURE 21 B
SECTION I
SEPULGA-CONECUH RIVERS





OUTCROP J

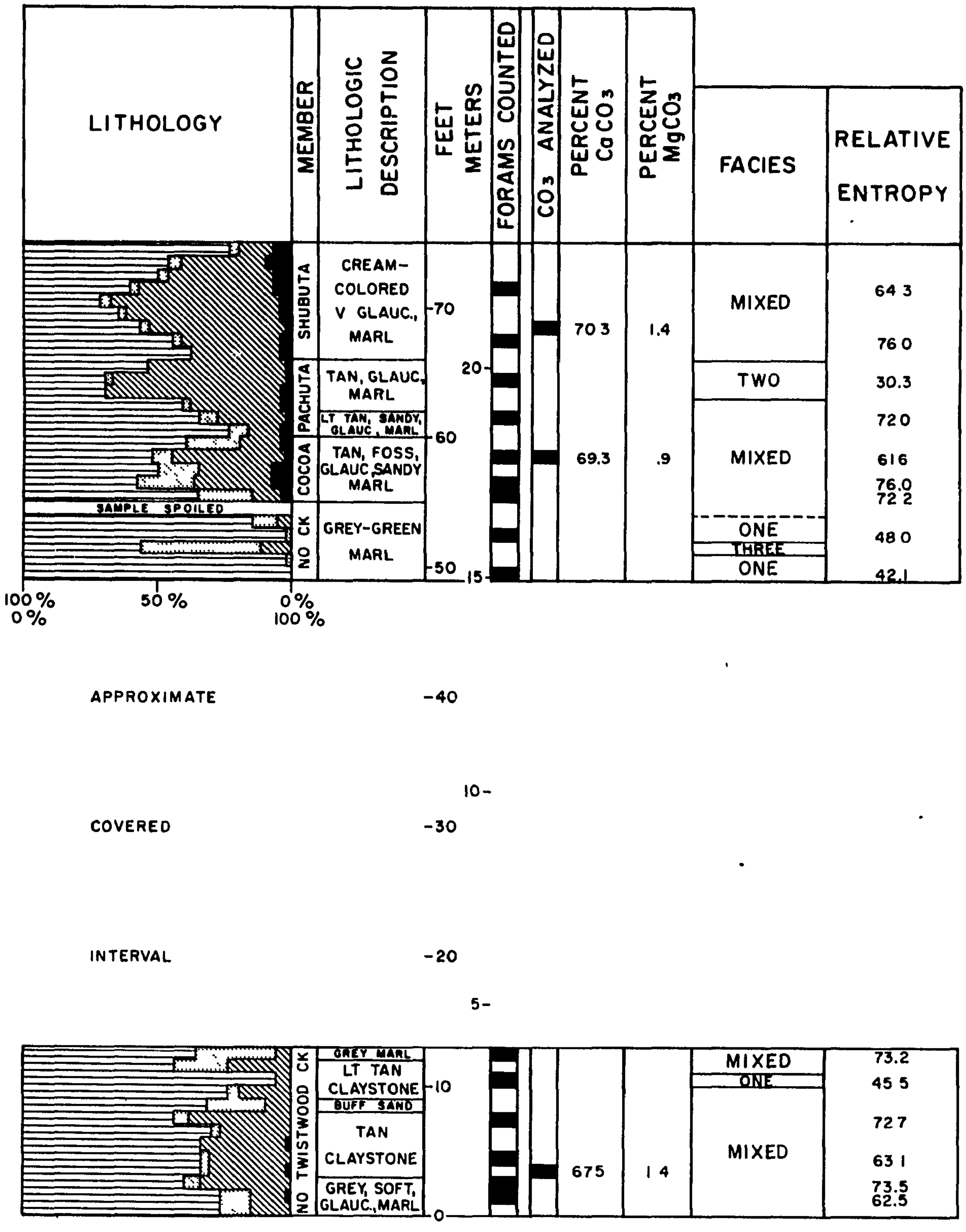
FIGURE 22 A

FIGURE 22 B

SECTION J

WEST OF CLAIBORNE

SW 1/4, SEC. 35, T 8 N, R 4 E



APPENDIX B

Percentage Data Matrix

Explanation:

1 - Clay plus silt
2 - Quartz sand
3 - Miscellaneous bioclasts
4 - Glauconite grains
5 - Foraminiferal tests

6 - Total planktonic foraminifera
7 - Total arenaceous foraminifera
35 - Total diatoms

8 - Guttulina byramensis
9 - Bolivina striatellata
10 - Bolivina sp. A
11 - Bulimina jacksonensis
12 - Reussella sculptilis
13 - Uvigerina cocoaensis
14 - Uvigerina dumblei
15 - Uvigerina glabrans
16 - Uvigerina jacksonensis
17 - Trifarina ocalana
18 - Discorbis globulo-spinosus
19 - Discorbis hemisphaericus
20 - Valvulineria jacksonensis
21 - Valvulineria octocamerata
22 - Siphonina danvillensis
23 - Eponides jacksonensis
24 - Cibicidina danvillensis
25 - Cibicidina mississippiensis
26 - Cibicides cocoaensis
27 - Cibicides floridanus diminutivus
28 - Cibicides truncatus
29 - Cassidulina armosa
30 - Nonion advena
31 - Nonion inexcavatus
32 - Nonion planatus
33 - Nonionella spissa
34 - Anomalina umbonata

	A- 3	A- 7	A-11	A-14	A-18	A-22	B- 1	B- 2	B- 6
1	73.77	92.06	90.13	97.86	97.79	98.22	56.40	71.52	91.03
2	26.23	7.94	9.87	0.00	0.32	0.00	43.60	28.48	8.97
3	0.00	0.00	0.00	2.14	1.89	1.18	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00
6	39.23	0.00	16.67	2.60	10.12	9.88	0.00	0.00	67.04
7	3.08	0.00	0.00	2.60	3.50	0.00	0.00	0.00	1.12
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1.54	0.00	8.33	0.65	0.39	0.00	0.00	50.00	0.00
9	3.08	0.00	0.00	30.84	21.79	36.36	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.77	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00
15	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	5.38	0.00	8.33	2.92	0.39	0.40	0.00	0.00	0.56
17	1.54	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.56
18	0.00	0.00	0.00	0.97	1.95	0.40	0.00	0.00	0.00
19	0.00	0.00	0.00	1.95	12.06	3.95	0.00	0.00	0.00
20	0.77	33.33	0.00	2.92	7.39	6.72	0.00	0.00	0.56
21	5.38	33.33	16.67	1.62	6.61	3.56	0.00	0.00	0.00
22	2.31	0.00	0.00	10.71	8.17	3.16	0.00	0.00	1.12
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	2.31	0.00	16.67	3.90	5.84	4.35	0.00	0.00	0.00
24	0.77	0.00	0.00	2.60	0.00	0.00	0.00	0.00	1.12
26	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.56
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	2.37	25.00	0.00	4.47
29	0.00	0.00	0.00	0.32	0.00	0.40	0.00	0.00	6.15
30	0.77	33.33	0.00	0.00	0.00	2.37	25.00	0.00	0.00
31	3.08	0.00	25.00	0.00	0.00	0.79	0.00	0.00	3.91
32	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	24.62	0.00	0.00	13.64	8.17	11.86	25.00	0.00	3.91
34	2.31	0.00	8.33	20.78	13.62	13.44	25.00	0.00	5.59

	B-10	C- 1	C- 2	C- 5	C- 7	C- 8	C-12	C-16	C-19
1	83.17	39.60	64.78	55.87	42.01	88.14	63.80	30.09	89.68
2	14.85	59.54	22.85	34.92	40.13	4.81	0.00	0.00	0.00
3	0.99	0.87	8.06	4.76	12.54	5.45	19.02	56.53	5.16
4	0.99	0.00	3.23	1.90	3.45	1.28	0.31	0.30	0.00
5	0.00	0.00	1.08	2.54	1.88	0.32	16.87	13.07	5.16
6	75.75	57.63	36.53	35.52	35.11	62.14	66.00	71.48	81.46
7-	0.66	3.39	5.90	4.25	3.31	1.46	2.00	1.01	0.66
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1.33	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
9	0.00	3.39	5.54	3.86	2.04	2.43	0.00	1.68	0.00
10	2.99	0.00	10.33	13.13	6.11	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	12.33	6.71	2.98
12	0.00	3.39	1.11	0.39	1.53	0.00	0.00	0.00	0.33
13	0.00	0.00	0.00	0.00	0.00	0.00	4.33	1.34	4.64
15	1.33	0.00	0.00	2.70	3.31	0.97	12.00	14.09	2.32
16	0.00	1.69	0.00	0.00	0.00	0.00	0.33	0.34	0.99
14	1.00	3.39	4.43	1.16	1.02	0.00	0.33	0.67	0.00
17	2.33	1.69	0.00	3.09	3.05	0.00	0.67	0.00	4.30
18	0.00	3.39	0.37	1.16	0.51	0.49	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	3.32	0.00	0.74	0.39	3.05	0.49	0.00	0.00	0.00
22	0.66	1.69	3.69	4.25	6.11	1.94	1.00	1.01	0.33
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.33	1.69	8.49	8.88	8.40	7.77	0.00	0.00	0.00
24	0.00	0.00	1.11	1.93	1.53	1.46	0.00	0.00	0.00
25	3.99	0.00	5.17	11.20	9.16	10.68	0.67	0.67	0.00
27	0.00	0.00	1.11	2.70	2.80	0.97	0.33	0.00	0.33
28	2.66	5.08	2.21	1.93	2.54	3.88	0.00	0.67	0.33
29	0.00	0.00	9.23	1.54	8.40	2.91	0.00	0.00	0.99
30	0.00	3.39	2.95	0.00	0.00	0.00	0.00	0.00	0.00
31	1.33	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	1.00	1.69	0.74	0.77	0.76	0.49	0.00	0.34	0.00
34	1.33	6.78	0.37	0.77	1.27	1.94	0.00	0.00	0.33

	C-23	C-27	C-31	C-36	C-40	C-43	C-47	C-53	C-58
1	43.31	92.31	96.28	95.28	89.70	69.63	89.97	67.95	94.18
2	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00
3	38.54	3.53	2.17	2.36	6.98	25.46	5.31	7.37	2.49
4	1.59	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00
5	16.56	4.17	1.55	2.36	3.32	4.29	4.72	23.08	3.32
6	81.10	89.35	85.71	80.19	83.12	68.75	80.37	84.59	88.37
7	1.37	0.65	0.34	0.63	3.13	2.21	1.84	0.60	0.39
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.82	0.97	0.34	0.00	0.00	0.00	0.00	2.42	0.78
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.39
11	4.66	0.32	1.02	3.77	1.56	4.78	2.15	0.30	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	2.47	0.97	0.00	1.26	0.94	8.82	12.58	1.21	2.33
15	1.64	0.32	2.04	3.14	4.37	2.21	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	1.10	0.31	0.30	0.39
14	1.37	0.00	1.36	2.83	0.94	2.94	0.00	0.00	0.39
17	3.56	3.87	3.40	1.89	4.06	4.78	2.76	7.55	5.43
18	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.32	0.68	0.31	0.00	0.37	0.00	0.91	0.00
22	0.55	0.32	1.02	1.57	0.94	2.21	0.00	1.21	0.78
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.31	1.10	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.27	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00
28	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.34	1.26	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00
34	1.92	2.90	3.40	2.52	0.62	0.74	0.00	0.00	0.78

	C-62	C-66	D- 1	D- 4	D- 6	D- 9	D-11	E- 1	E- 4
1	91.30	96.24	21.70	30.69	92.41	24.55	41.70	51.40	71.40
2	0.00	0.00	78.30	68.62	3.63	74.65	58.30	45.50	25.40
3	8.03	1.57	0.00	0.70	2.31	0.79	0.00	2.50	2.20
4	0.00	0.00	0.00	0.00	1.65	0.00	0.00	0.00	0.50
5	0.67	2.19	0.00	0.00	0.00	0.00	0.00	0.60	0.50
6	84.45	83.15	60.34	15.84	2.08	35.71	7.30	12.74	40.88
7	2.10	1.12	0.00	0.00	2.08	0.00	0.00	0.32	2.52
35	0.00	0.00	3.45	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	4.95	0.00	0.00	1.89	3.18	3.77
9	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.32	0.00
10	0.00	0.00	1.72	0.99	11.46	2.38	1.08	0.32	1.89
11	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	1.26	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.37	3.45	0.00	0.00	4.76	2.16	0.32	0.00
16	0.00	0.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.32	0.00
17	7.14	8.61	1.72	0.00	0.00	0.00	0.00	0.32	1.26
18	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.64	3.14
19	0.00	0.00	0.00	0.99	0.00	2.38	0.00	0.00	0.63
20	0.00	0.00	0.00	1.98	3.13	0.00	18.65	35.35	3.77
21	4.20	1.87	5.17	1.98	4.17	0.00	1.35	2.23	1.26
22	0.00	0.75	0.00	0.00	1.04	0.00	0.81	3.18	6.29
23	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00
25	0.00	0.00	1.72	1.98	22.92	16.67	2.43	1.91	3.77
24	0.00	0.00	3.45	0.99	4.17	2.38	0.54	1.91	3.14
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63
27	0.00	0.00	0.00	0.00	5.21	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	14.58	7.14	0.27	0.00	0.63
29	0.00	0.00	1.72	0.00	6.25	0.00	0.00	0.32	0.00
30	0.00	0.00	6.90	45.54	13.54	19.05	37.03	9.87	6.92
31	0.00	0.00	3.45	10.89	2.08	2.38	4.32	3.82	5.03
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.24	3.77
33	0.00	1.50	5.17	11.88	4.17	7.14	21.89	11.78	10.69
34	0.42	0.00	0.00	1.98	0.00	0.00	0.00	1.91	0.00

	E- 5	E- 9	E-11	E-13	E-17	E-21	E-25	E-28	F- 1
1	75.64	42.44	59.96	84.32	52.05	28.60	79.60	73.58	18.12
2	13.46	51.85	37.04	11.99	44.06	66.40	19.00	20.74	2.19
3	9.94	4.50	2.20	2.10	2.30	4.20	1.40	5.69	72.81
4	0.96	0.60	0.40	0.00	0.80	0.00	0.00	0.00	4.69
5	0.00	0.60	0.40	1.60	0.80	0.80	0.00	0.00	2.19
6	4.17	6.79	58.36	47.58	64.22	22.16	87.46	60.18	29.01
7	4.17	2.71	2.21	12.73	2.88	1.35	0.00	1.18	0.76
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1.39	0.90	4.42	5.76	2.88	3.78	1.46	4.72	0.00
9	6.94	9.05	0.00	0.30	0.00	0.27	0.29	0.00	0.00
10	0.00	0.45	0.00	0.00	0.00	0.81	0.00	0.00	14.12
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.45	0.00	1.52	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	1.39	0.00	0.00	0.00	0.00	0.81	0.00	0.29	0.00
17	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.76
18	0.00	0.90	0.32	0.00	0.32	0.27	0.29	0.00	0.38
19	5.56	15.38	0.63	0.30	0.00	1.08	0.00	0.00	0.00
20	5.56	7.24	0.63	12.42	2.56	21.35	3.50	11.21	0.00
21	0.00	0.45	1.26	0.61	0.96	2.43	0.00	0.00	0.76
22	1.39	2.26	0.63	0.91	0.96	1.35	0.00	0.29	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
25	11.11	13.57	5.36	0.61	0.32	6.22	1.17	0.59	14.50
24	1.39	0.00	1.89	0.91	1.28	3.51	0.00	0.88	3.05
26	25.00	9.05	0.00	0.00	0.00	0.00	0.00	0.00	17.94
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.58
28	16.67	2.71	0.00	0.00	0.96	1.62	0.29	0.29	9.92
29	4.17	7.69	0.32	0.30	0.00	0.81	0.00	0.00	1.53
30	4.17	9.05	7.26	7.27	13.42	15.68	2.62	9.73	0.00
31	4.17	1.36	2.21	2.73	3.83	5.95	0.87	5.01	0.00
32	0.00	0.00	0.63	0.61	0.00	2.16	0.00	0.29	0.00
33	0.00	2.71	13.88	3.94	4.47	7.57	2.04	5.31	0.76
34	2.78	7.24	0.00	1.52	0.96	0.00	0.00	0.00	0.00

	F- 3	F- 5	F- 8	F- 9	G- 1	G- 4	G- 7	G-10	G-13
1	28.48	16.62	17.65	22.36	95.70	12.26	24.00	95.03	99.51
2	1.99	0.30	0.00	1.21	2.32	80.97	67.60	2.98	0.49
3	64.57	77.34	75.54	35.65	1.99	4.52	4.60	1.99	0.00
4	4.64	3.02	1.86	24.47	0.00	1.94	0.00	0.00	0.00
5	0.33	2.72	4.95	16.31	0.00	0.32	3.80	0.00	0.00
6	27.24	34.87	51.29	67.96	2.12	3.94	5.10	2.75	4.53
7	0.00	4.61	4.84	1.06	3.17	3.94	9.41	4.71	3.14
35	0.00	0.00	0.00	0.00	16.40	11.82	10.98	8.24	6.62
8	0.34	0.00	0.32	0.00	0.00	0.30	0.39	0.78	0.00
9	0.34	0.00	1.29	1.06	0.00	0.00	5.88	0.00	0.35
10	15.86	10.20	3.23	1.76	10.05	7.58	10.98	13.33	19.16
11	0.00	0.33	0.00	0.35	0.00	0.00	0.00	0.00	0.00
12	1.38	0.66	1.61	0.00	0.00	0.61	0.00	0.00	0.35
13	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00
15	0.34	0.33	0.32	2.82	0.00	0.00	0.00	0.00	0.00
16	0.00	0.33	1.29	2.82	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
17	0.69	1.64	2.26	1.76	0.00	0.00	0.00	0.00	0.00
18	0.69	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.35
19	0.00	0.00	0.00	0.00	2.12	4.85	1.96	4.31	6.27
20	0.00	0.00	0.00	0.00	4.23	0.00	5.49	1.57	1.39
21	0.00	0.66	0.32	0.35	0.00	0.91	0.39	0.39	0.00
22	1.72	2.96	3.55	2.11	0.00	0.00	0.78	0.39	0.70
23	0.00	0.00	0.32	0.70	0.00	0.00	0.00	0.00	0.00
25	10.69	10.86	8.71	0.70	7.41	6.97	7.06	10.98	6.27
24	1.72	1.32	1.94	0.35	0.00	0.00	0.00	0.00	0.00
26	25.17	12.83	6.13	3.52	1.06	0.61	0.00	1.96	2.09
27	1.72	3.62	3.55	3.17	0.00	0.00	0.00	0.00	0.00
28	7.24	10.20	3.87	2.11	5.29	7.88	0.39	9.80	7.32
29	2.76	1.97	0.97	0.00	0.00	0.61	0.00	0.00	0.35
30	0.00	0.00	0.00	0.00	30.16	36.06	24.31	29.80	27.18
31	0.00	0.99	0.00	0.00	0.00	0.00	0.78	0.39	0.00
32	0.00	0.00	0.00	0.00	0.53	2.12	0.39	0.39	1.74
33	0.34	0.00	0.00	0.00	15.34	10.61	15.29	8.63	9.41
34	1.72	1.64	2.90	5.99	2.12	1.21	0.39	1.57	2.79

	G-16	G-19	G-21	G-25	G-28	G-30	G-33	G-35	G-36
1	68.81	45.81	99.41	41.30	92.33	12.58	29.39	17.78	93.14
2	17.04	49.34	0.00	55.47	7.33	64.57	53.35	36.83	6.54
3	13.83	3.96	0.59	2.83	0.33	22.85	17.25	43.17	0.33
4	0.32	0.00	0.00	0.40	0.00	0.00	0.00	1.27	0.00
5	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.95	0.00
6	6.73	2.33	6.25	2.37	7.61	2.57	0.00	0.00	15.03
7	5.13	3.99	5.86	3.56	3.81	8.09	0.89	1.00	0.52
35	4.49	0.00	3.52	1.58	11.76	1.47	0.00	0.00	1.55
8	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	1.04
9	0.96	0.00	0.00	0.40	0.35	0.37	0.00	0.00	0.00
10	12.18	21.26	9.38	8.30	11.42	4.41	1.34	0.00	7.25
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.32	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00
18	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	2.24	3.32	4.69	2.37	3.81	4.04	0.45	0.00	1.55
20	3.53	1.99	1.17	0.79	5.54	4.41	0.00	0.00	0.00
21	0.00	0.00	0.39	0.40	0.00	0.74	0.00	0.00	0.00
22	1.28	0.00	0.39	0.00	0.69	0.74	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	9.29	6.31	8.20	15.42	6.23	4.04	2.23	15.00	10.88
24	0.00	0.66	0.78	0.40	1.04	1.47	0.00	0.00	0.00
26	5.13	1.99	4.30	5.93	2.42	1.84	0.00	0.00	1.04
27	0.00	0.00	0.78	0.40	0.35	0.74	0.00	0.00	0.00
28	4.17	3.65	3.91	4.74	1.73	1.47	3.13	0.00	0.00
29	0.96	0.66	0.39	0.40	0.69	0.37	0.00	0.00	0.00
30	29.49	34.22	34.77	43.87	32.87	52.94	85.71	67.00	54.92
31	0.96	1.00	0.39	0.40	0.35	0.74	0.00	3.00	2.07
32	1.28	0.33	3.13	0.79	1.73	0.74	0.00	0.00	0.00
33	11.22	10.63	8.59	5.53	6.92	6.62	2.23	14.00	2.07
34	0.32	7.64	1.56	1.98	0.69	1.84	4.02	0.00	2.07

	G-39	G-40	G-41	G-42	G-43	G-44	G-45	G-46	G-47
1	99.58	92.59	96.32	82.20	50.58	49.00	44.49	46.20	68.88
2	0.00	5.26	3.09	14.66	18.27	8.46	5.22	11.89	4.11
3	0.42	1.36	0.19	2.27	8.08	28.11	42.75	36.45	22.70
4	0.00	0.39	0.39	0.70	11.73	3.98	4.06	2.53	3.72
5	0.00	0.39	0.00	0.17	11.35	10.45	3.48	2.92	0.59
6	0.00	3.21	3.77	0.51	2.79	0.00	2.58	2.85	5.72
7	0.00	0.64	0.00	0.00	0.00	2.89	9.79	12.60	11.11
35	35.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1.11	1.92	0.00	1.54	1.29	1.16	0.00	2.03	0.34
9	1.11	0.00	0.00	0.00	9.01	12.72	5.67	0.81	0.00
10	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.64	1.89	0.00	0.00	4.62	5.67	6.50	3.37
13	0.00	0.00	0.00	0.00	1.29	0.00	0.00	0.00	0.34
15	0.00	0.00	1.89	0.00	1.50	1.73	1.55	2.85	2.36
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00
17	0.00	0.00	3.77	0.00	1.72	1.16	0.52	1.22	2.69
18	0.00	0.00	1.89	0.00	1.72	1.16	1.55	0.00	1.01
19	0.00	1.92	0.00	2.56	0.00	0.00	0.00	0.00	0.00
20	3.33	4.49	1.89	2.56	1.29	0.58	1.55	0.41	0.00
21	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.81	0.00
22	1.11	0.64	1.89	0.00	5.58	6.94	6.19	3.66	3.03
23	0.00	0.00	0.00	0.00	0.00	0.58	0.52	0.00	0.00
25	0.00	8.97	9.43	10.26	11.80	6.94	10.31	8.54	11.78
24	0.00	3.21	3.77	2.05	12.88	10.40	10.31	4.88	7.74
26	3.33	0.00	0.00	0.00	0.00	0.00	0.00	14.63	11.78
27	0.00	0.64	1.89	0.00	6.44	17.34	0.52	8.54	20.54
28	1.11	1.92	5.66	0.51	15.02	19.65	36.08	18.70	13.13
29	0.00	3.85	1.89	0.00	15.02	7.51	4.12	2.85	2.36
30	38.89	51.92	39.62	57.44	6.22	2.31	0.00	0.41	0.00
31	1.11	8.97	7.55	11.79	2.15	0.58	0.00	0.00	0.00
32	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	3.33	7.05	13.21	10.77	3.86	1.73	3.09	7.32	2.69

	G-48	G-49	G-50	G-51	G-52	G-53	G-54	G-55	G-56
1	60.53	62.58	83.12	83.12	62.73	78.09	78.47	85.68	73.75
2	0.00	1.75	0.21	0.00	0.00	0.00	0.98	1.24	1.16
3	35.17	25.82	11.67	16.88	30.00	17.85	3.91	4.98	11.20
4	1.64	2.41	2.29	0.00	3.86	1.62	8.41	6.22	10.23
5	2.66	7.44	2.71	0.00	3.41	2.43	8.22	1.87	3.67
6	6.69	10.67	12.28	8.70	18.64	19.35	53.60	53.09	52.94
7	3.34	5.79	1.75	0.87	1.69	1.08	4.80	3.70	1.31
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1.00	0.30	0.00	0.87	0.00	0.00	0.40	0.00	0.65
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
12	2.01	2.13	0.88	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	2.44	0.00	0.00	0.00	4.30	3.20	6.17	3.92
15	3.34	2.13	1.75	1.74	0.85	1.08	1.60	2.47	1.31
16	0.00	0.00	0.00	0.00	0.00	0.00	2.80	4.12	9.15
14	0.00	0.00	0.00	0.00	0.85	0.00	2.80	0.00	1.96
17	1.00	2.13	0.88	0.00	0.00	0.00	0.00	0.00	0.65
18	0.33	0.30	0.00	1.74	2.54	0.00	0.00	0.00	0.00
19	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.61	0.00	0.00	0.85	0.00	0.00	0.00	0.00
21	0.33	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3.34	5.79	1.75	0.00	0.00	2.15	3.20	4.53	3.27
23	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.41	0.00
25	17.39	13.11	21.05	20.00	11.86	19.35	14.40	11.93	9.15
24	7.36	8.84	2.63	5.22	7.63	4.30	4.00	4.94	2.61
26	20.40	13.72	31.58	29.57	15.25	13.98	2.80	4.53	5.23
27	5.35	4.27	10.53	12.17	7.63	6.45	2.80	2.06	7.19
28	12.04	11.89	7.02	8.70	18.64	16.13	0.00	2.06	0.00
29	12.37	9.76	1.75	7.83	10.17	6.45	2.80	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	3.68	5.49	6.14	2.61	1.69	5.38	0.80	0.00	0.00

	G-57	G-59	G-60	G-61	G-62	G-63	G-64	G-65	G-66
1	63.04	70.88	68.66	99.03	74.16	94.78	58.95	79.45	84.82
2	1.98	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.19
3	12.45	7.66	3.30	0.00	7.36	0.00	24.32	10.36	9.30
4	11.86	8.24	12.16	0.97	5.57	1.49	12.84	6.55	2.85
5	10.67	13.22	15.67	0.00	12.92	3.73	3.89	3.64	2.85
6	48.98	44.64	40.48	57.01	37.83	32.14	13.23	20.48	14.56
7	1.36	1.38	0.35	3.17	2.17	4.76	7.00	6.02	2.91
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.68	0.00	0.00	0.45	0.00	1.19	0.78	0.40	0.97
9	2.04	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1.02	6.57	4.84	0.00	0.00	0.00	0.39	0.00	0.00
12	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	5.78	13.84	29.41	0.45	0.43	0.00	0.00	0.00	0.00
15	0.34	1.73	2.77	0.00	0.00	0.00	1.17	0.00	0.00
16	8.50	7.96	10.38	2.26	1.30	0.00	2.33	0.40	0.00
14	4.42	7.61	3.11	0.00	0.00	3.57	2.33	4.42	1.94
17	0.34	0.00	0.00	6.33	6.52	9.52	1.56	0.00	1.94
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.00
21	0.00	0.35	0.00	3.62	9.57	5.95	2.33	2.01	5.83
22	7.14	4.84	0.00	0.45	7.39	5.95	7.39	4.02	14.56
23	3.40	2.08	0.00	0.45	3.04	4.76	29.18	28.11	16.50
25	4.08	2.42	5.88	7.69	5.22	4.76	3.89	4.02	5.83
24	2.38	2.77	1.73	6.79	5.22	8.33	7.78	9.64	12.62
26	2.04	1.38	0.35	2.71	2.61	3.57	6.61	4.82	4.85
27	4.08	2.08	0.00	0.45	0.00	0.00	0.00	0.00	0.00
28	1.02	0.00	0.00	6.33	18.26	15.48	12.84	12.45	16.50
29	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.97
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.40	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	1.02	0.00	0.35	1.81	0.00	0.00	0.00	1.61	0.00

	G-67	G-68	G-69	G-70	G-71	G-72	G-73	H-2	H-5
1	60.18	97.72	81.38	83.05	82.90	81.66	84.41	89.05	98.82
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.48	0.30
3	35.23	0.76	12.28	13.56	12.13	15.44	9.16	5.47	0.89
4	2.63	1.14	4.80	1.69	2.98	2.90	2.53	0.00	0.00
5	1.97	0.38	1.54	1.69	1.99	0.00	3.90	1.00	0.00
6	35.94	12.90	2.91	20.22	13.35	7.23	18.73	5.05	4.56
7	3.69	3.23	1.16	3.93	5.90	8.43	3.19	7.34	4.18
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.59	17.49
8	0.00	0.65	0.00	0.56	0.62	0.00	0.00	0.46	0.38
9	0.00	0.00	0.00	0.56	0.31	2.41	1.59	0.92	1.52
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.90	13.31
11	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00
13	2.30	0.65	3.49	0.00	0.00	0.00	0.00	0.00	0.00
15	2.30	1.94	1.16	1.69	0.00	0.00	0.00	0.00	0.00
16	0.00	2.58	0.58	0.00	0.31	0.00	0.00	0.00	0.00
14	0.00	0.00	1.74	1.69	0.00	0.00	0.00	0.00	0.00
17	2.30	5.81	0.58	2.81	2.48	4.82	2.39	0.46	0.38
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	1.14
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.63	10.27
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.21	9.13
21	4.15	3.23	1.74	0.00	1.55	0.00	1.20	3.21	1.52
22	6.45	0.00	6.98	2.81	5.59	4.82	7.57	0.46	1.14
23	9.22	25.16	44.77	44.38	19.88	8.43	27.49	0.46	0.00
25	0.92	3.87	0.00	2.25	3.42	8.43	1.59	4.59	4.56
24	2.76	7.74	6.40	6.74	5.28	3.61	3.19	0.46	0.00
26	7.83	3.87	5.81	3.93	12.42	0.00	1.59	7.34	9.13
27	0.00	0.65	0.00	0.00	0.93	33.73	8.76	0.46	0.00
28	20.74	25.16	22.09	7.87	27.64	18.07	21.91	0.00	1.90
29	0.00	1.94	0.58	0.00	0.00	0.00	0.00	1.38	1.52
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.80	2.28
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	0.38
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.46	0.00	0.00	0.56	0.00	0.00	0.40	6.88	12.55
34	0.92	0.00	0.00	0.00	0.31	0.00	0.00	1.83	2.66

	H-8	H-11	H-14	H-17	H-20	H-21	H-25	H-28	H-31
1	97.26	92.01	96.44	96.02	99.67	73.97	94.81	98.48	93.18
2	0.61	3.58	1.37	1.83	0.00	11.19	4.90	0.30	3.76
3	1.82	3.31	1.37	0.61	0.33	14.36	0.00	0.00	2.12
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.30	1.10	0.82	1.53	0.00	0.49	0.29	1.22	0.94
6	3.98	1.92	3.51	2.35	1.52	2.75	8.56	3.83	4.80
7	5.58	6.54	5.96	3.76	3.41	7.84	7.03	0.38	2.95
35	12.35	5.38	12.98	44.13	64.39	44.71	25.69	36.02	27.68
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
9	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.38	0.00
10	14.74	23.08	29.47	16.43	10.23	10.98	16.21	12.26	7.75
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.77	0.35	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00
18	0.80	0.00	0.35	0.47	0.00	0.00	0.00	0.00	0.00
19	3.19	2.69	3.16	0.47	0.38	0.39	0.92	0.77	1.48
20	10.76	8.85	0.00	2.82	3.41	5.10	4.59	2.30	5.90
21	1.20	2.69	1.40	2.35	0.38	0.00	1.83	0.38	0.37
22	2.79	0.38	1.40	0.47	0.76	0.39	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	2.39	2.31	0.70	0.94	0.38	2.75	3.36	2.68	7.01
24	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	1.48
26	2.79	1.92	3.16	0.00	0.76	1.57	1.53	0.38	0.74
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.80	0.38	1.40	0.00	0.00	0.00	0.31	0.38	1.48
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
30	23.90	26.15	28.42	15.96	10.23	13.73	15.90	27.59	28.04
31	4.38	3.46	2.61	1.41	1.89	1.18	3.36	1.53	5.17
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	5.18	11.92	3.86	7.98	1.52	8.63	7.65	9.20	1.11
34	5.18	1.54	1.05	0.47	0.76	0.00	1.53	1.92	2.95

	H-33	H-36	H-39	H-42	H-45	I-9	I-42	I-45	I-47
1	47.49	90.19	83.56	91.73	82.34	59.64	38.70	28.20	69.87
2	34.56	6.96	14.64	3.89	12.17	16.57	60.70	71.80	28.53
3	14.78	2.22	1.80	3.65	1.19	15.46	0.60	0.00	0.80
4	1.32	0.00	0.00	0.00	0.24	1.31	0.00	0.00	0.00
5	1.85	0.63	0.00	0.73	4.06	7.03	0.00	0.00	0.80
6	2.34	14.81	21.20	19.52	13.36	5.84	3.27	19.15	24.50
7	3.13	3.03	2.12	0.40	2.30	8.25	7.01	0.00	0.40
35	0.78	1.01	15.19	26.29	9.22	0.00	0.00	0.00	0.00
8	0.78	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61
10	9.77	26.26	10.60	9.96	14.29	22.34	7.48	8.51	4.42
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.34	0.35	0.00	0.00	18.56	1.87	12.77	0.40
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	1.03	0.47	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
18	0.39	0.00	0.00	0.00	0.92	2.06	2.80	0.00	1.20
19	1.95	2.02	1.41	0.40	1.84	3.44	0.93	0.00	0.00
20	5.47	1.68	2.47	1.20	4.15	0.00	0.00	0.00	0.40
21	0.00	0.67	0.00	0.80	2.30	0.00	0.00	0.00	0.40
22	0.39	0.00	0.35	0.00	0.46	0.34	0.93	2.13	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.47	4.26	8.03
25	11.72	12.79	7.77	3.98	5.53	1.37	18.69	31.91	20.48
24	0.39	2.02	0.00	0.40	0.46	1.72	0.00	0.00	0.80
26	3.13	3.37	1.41	0.00	0.00	3.78	1.87	0.00	3.61
27	0.00	0.00	0.00	0.00	0.00	0.69	0.93	2.13	0.40
28	3.91	0.00	0.35	0.00	1.38	10.65	5.61	0.00	6.43
29	0.00	0.00	1.06	0.40	0.00	1.03	0.47	0.00	0.00
30	43.36	28.62	31.80	33.86	36.87	16.15	42.52	17.02	24.10
31	1.56	0.67	2.47	1.59	1.38	0.34	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	3.74	2.13	0.00
33	7.42	2.02	1.06	1.20	5.07	2.41	0.47	0.00	0.80
34	3.52	0.67	0.35	0.00	0.00	0.00	0.47	0.00	1.61

	I-60	I-83	I-91	I-101	I-110	J-2	J-3	J-5	J-8
1	31.83	14.50	20.70	24.30	8.90	73.67	59.50	65.71	56.19
2	0.00	0.00	0.00	0.00	0.90	12.01	6.50	2.54	5.44
3	61.36	81.20	75.30	66.60	81.10	11.51	31.00	28.89	36.86
4	0.00	0.00	0.00	0.00	0.00	1.90	0.50	1.27	0.91
5	6.81	4.30	4.00	9.10	9.10	0.90	2.50	1.59	0.60
6	13.80	12.50	21.74	17.83	40.07	2.83	3.38	1.13	5.10
7	0.67	0.99	4.04	1.75	9.56	2.12	5.80	2.63	0.00
35	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.35	0.00	0.35	0.48	0.00	0.00
9	0.00	0.66	1.24	0.00	0.37	2.83	3.86	1.13	0.00
10	1.01	2.96	3.73	0.70	1.84	35.34	17.87	21.43	19.61
11	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00
12	16.16	10.20	6.83	4.90	3.31	2.83	6.76	3.38	3.14
13	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
15	0.00	0.33	0.00	0.00	0.74	0.00	0.48	0.00	0.00
16	0.00	0.00	0.31	0.00	0.00	0.71	0.00	0.00	0.00
14	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00
17	0.67	1.97	1.24	1.40	1.10	1.06	0.48	0.00	0.00
18	4.04	2.96	1.86	3.15	0.37	0.35	1.93	3.76	0.00
19	1.68	0.66	0.31	1.05	0.00	0.00	1.93	0.00	1.18
20	0.67	0.99	0.31	0.00	0.74	0.00	0.00	1.13	0.00
21	0.34	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00
22	3.37	3.29	3.42	2.45	4.04	2.83	2.42	1.50	1.18
23	0.00	7.24	6.21	3.85	4.78	0.00	0.00	0.38	0.00
25	12.12	9.87	5.59	4.90	2.94	15.55	19.81	8.65	21.96
24	1.68	3.62	2.17	6.29	6.99	1.77	0.00	0.75	0.00
26	7.41	8.55	5.28	6.64	4.41	6.36	7.25	13.91	10.20
27	3.03	4.61	2.17	1.40	1.84	2.12	0.00	0.75	0.78
28	21.89	22.70	26.40	30.42	12.87	13.43	9.18	22.93	17.25
29	7.74	5.92	6.52	9.09	2.94	3.18	1.93	7.89	2.75
30	0.00	0.00	0.00	0.00	0.00	0.71	10.14	3.01	14.12
31	0.34	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.39
32	2.02	0.00	0.00	0.70	0.37	0.00	1.45	0.00	0.00
33	0.00	0.00	0.31	0.00	0.00	1.77	3.86	0.75	0.00
34	1.35	0.00	0.00	1.40	0.37	3.18	0.00	4.89	2.35

	J-11	J-13	J-50	J-53	J-56	J-57	J-59	J-62	J-65
1	93.23	65.53	99.99	97.33	64.86	42.68	48.04	64.69	30.69
2	0.97	5.49	0.00	1.59	20.61	21.18	7.25	7.19	1.98
3	5.81	23.08	0.00	0.53	9.80	27.41	43.20	24.06	64.69
4	0.00	0.00	0.00	0.00	4.39	8.10	1.51	3.44	1.98
5	0.00	5.89	0.00	0.00	0.34	0.62	0.00	0.62	0.66
6	0.32	7.89	2.12	6.04	1.39	0.00	2.04	6.41	10.06
7	0.63	0.00	0.00	0.00	8.68	5.36	7.48	3.85	5.66
35	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	2.54	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	1.27	2.20	0.00	0.00	0.00	1.28	0.00
10	18.61	15.79	0.00	0.00	3.82	7.14	15.99	21.15	15.09
11	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
12	1.26	1.32	0.00	0.00	4.86	3.57	3.74	2.24	3.46
13	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20
18	1.58	2.63	0.00	0.00	7.64	3.57	5.10	1.28	3.14
19	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.00	0.00
20	0.63	2.63	9.32	5.49	0.69	0.00	0.00	0.00	0.00
21	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.64	1.26
22	0.32	0.00	0.00	0.00	5.56	0.00	4.08	2.24	2.20
23	0.00	0.00	0.00	0.00	0.35	0.00	1.70	1.92	0.63
25	28.39	11.84	0.42	5.49	18.75	8.93	18.71	25.00	16.67
24	0.00	0.00	0.00	0.00	5.21	14.29	2.04	2.56	0.94
26	8.83	6.58	0.42	0.00	5.90	5.36	2.72	6.73	4.40
27	1.89	0.00	0.00	0.00	6.94	0.00	7.14	3.85	4.72
28	13.88	25.00	0.42	0.00	13.89	37.50	24.83	17.95	20.44
29	1.26	5.26	0.00	0.00	6.25	7.14	2.72	0.96	5.66
30	18.61	15.79	52.54	73.63	7.64	5.36	0.34	0.00	0.00
31	0.00	0.00	4.24	1.65	0.00	0.00	0.34	0.00	0.00
32	0.00	0.00	2.54	0.55	0.35	0.00	0.68	0.00	0.00
33	1.58	1.32	18.64	2.75	1.74	0.00	0.34	0.00	0.00
34	1.89	2.63	4.24	2.20	0.35	0.00	0.00	1.92	1.26

	J-68	J-72
1	55.45	38.79
2	2.80	2.87
3	33.96	50.86
4	4.98	6.90
5	2.80	0.57
6	12.94	50.52
7	3.15	0.00
35	0.00	0.00
8	0.00	0.35
9	0.00	0.35
10	13.99	5.19
11	0.00	0.00
12	2.80	2.08
13	0.00	0.00
15	0.70	0.00
16	0.00	0.35
14	0.00	1.04
17	0.00	4.15
18	2.10	0.35
19	0.35	0.00
20	0.00	0.00
21	1.05	0.35
22	3.15	1.73
23	3.50	2.08
25	20.98	8.65
24	2.45	1.38
26	4.90	1.38
27	5.94	1.38
28	15.03	15.57
29	5.94	2.77
30	0.70	0.00
31	0.00	0.00
32	0.00	0.00
33	0.00	0.00
34	0.35	0.35

APPENDIX C

Factor Analysis Routine

This program is written in Fortran IV, compiled for use in the IBM System 360-65.

```
                C     Q-MODE FACTOR ANALYSIS USING DUALITY CONCEPT (AFTER J.E. KLOVAN)
                C
                C     GULF CANADA CALGARY
                C
                C     A.GRAVES      NOV. 1970
                C
                C       DOCUMENTATION REFERENCE   PEDRAD MANUAL, SECTION F585
                C
                C-----------------------------------------------------------------------
0001                  DIMENSION F(750,10),NAME(2),COM(750)
0002                  DIMENSION X(50),R(50,50),A(50,50),FS(50,10)
0003                  DIMENSION       VAR(10),XX(10),T(10,10)
0004                  DIMENSION TITLE(20),FMT(20)
0005                  EQUIVALENCE (R(1,1),F(1,1)),(A(1,1),F(1,6))
0006                   COMMON KT1,KT2,KT3,KT4,KT5,IT1,IT2,IT3,IT5
                C     ---------------------------------------------------------------------
                C
                C     KT1 = CARD READER
                C     KT2 = CARD PUNCH
                C      KT3= PRINTER
                C      KT4 & KT5 = SCRATCH TAPES
                C
                C     A(1,.) = VARIABLE MEANS
                C     A(2,.) = VARIABLE STD. DVNS.
                C     A(3,.) = VARIABLE MINIMUMS
                C     A(4,.) = VARIABLE MAXIMUMS
                C
                C     IF IT1 NOT = 0 CONVERT RAW DATA TO PERCENTS (OF SAMPLE)
                C     .
                C     IF IT2 NOT = 0 PRINT PRINCIPAL AND VARIMAX FACTOR LOADINGS
                C
                C     IF IT3 NOT = 0 GIVE NORMALIZED LOADINGS FOR 3 AND 2 FACTORS
                C
                C     IF IT4 NOT = 0  IT4 = DEVICE NO. FOR INPUT (DEFAULT = 5)
                C
                C     IF IT5 NOT = 0  IT5 = NO. OF FACTORS FOR WHICH LOADINGS ARE
                C       TO BE PUNCHED (IT2 NOT = 0 IF IT5 NOT = 0)
                C
                C     IF IT6 NOT = 0  IT6 = NO. OF FACTORS TO BE ROTATED (VARIMAX
                C       CALLED ONCE ONLY)
                C
                C
                C
                C-----------------------------------------------------------------------
                C
0007                  KT1 = 5
0008                  KT2 = 7
0009                  KT3 = 6
0010                  KT4 = 4
0011                  KT5 = 8
0012                  REWIND KT4
0013                  REWIND KT5
0014                   READ(KT1,1020) TITLE
0015            1020  FORMAT(20A4)
0016            1007  FORMAT(1H1,20A4,///)
0017                  WRITE(KT3,1007) TITLE
0018                  READ(KT1,1000) NV,QUIT,IT1,IT2,IT3,IT4,IT5,IT6
0019            1000  FORMAT(I2,1X,F5.2,5(1X,I1),I2)
```

```
          IF(IT4.EQ.0) IT4 = KT1
          IF(NV-50) 408,408,410
      410 WRITE(6,411)
      411 FORMAT(34H TOO MANY VARIABLES.  RUN STOPPED.)
          GO TO 35
      408 READ(KT1,1020) FMT
          DO 1 I=1,NV
          A(1,I) = 0.
          A(2,I) = 0.
          A(3,I) = 1.0E30
          A(4,I) = -1.0E30
          A(5,I) = 1.0E30
          A(6,I) =-1.0E30
          DO 1 J=1,NV
        1 R(I,J) = 0.
          NS = 1
    C
    C     BEGIN READ IN LOOP AND COMPUTATION OF BASIC STATS.
    C
        3 READ(IT4,FMT,END=99) NAME,(X(I),I=1,NV)
          SAMSSQ=0.0
    C
    C     TRANSFORM RAW DATA TO PERCENTS (OF SAMPLE) IF IT1 NOT = 0
    C
          GO TO (90,776,785,800),IT1
          GO TO 93
       90 SUM = 0.
          DO 774 I = 1,NV
      774 SUM = SUM + X(I)
          DO 775 I = 1,NV
      775 X(I) = X(I)/SUM
          GO TO 93
      776 DO 778 I=1,NV
      778 X(I) = ALOG(X(I)+1)
          GO TO 93
      800 DO 806 I = 1,NV
          IF(X(I)-A(5,I)) 803,804,804
      803 A(5,I) = X(I)
      804 IF(X(I)-A(6,I)) 806,806,805
      805 A(6,I) = X(I)
      806 CONTINUE
          WRITE(KT5) NAME,(X(I),I=1,NV)
          NS = NS+1
          GO TO 3
      810 DO 850 K=1,NS
          READ(KT5) NAME,(X(I),I=1,NV)
          SAMSSQ=0.0
          DO 812 I=1,NV
          IF(A(6,I).EQ.A(5,I)) GO TO 812
          X(I) = (X(I) - A(5,I))/(A(6,I)-A(5,I))
      812 CONTINUE
          GO TO 6
      850 CONTINUE
          IT1 = 5
          NS = NS+1
          GO TO 99
      785 SUM = 0.
          DO 786 I = 1,5
```

```
0072     786 SUM = SUM + X(I)
0073         DO 787 I = 1,5
0074     787 X(I) = X(I)/SUM
0075         SUM = 0.
0076         DO 788 I=6,NV
0077     788 SUM = SUM + X(I)
0078         DO 789 I = 6,NV
0079     789 X(I) = X(I)/SUM
0080     93  CONTINUE
0081     6   DO 5 J = 1,NV
0082         A(1,J) = A(1,J) + X(J)
0083         A(2,J) = A(2,J) + X(J)*X(J)
0084         IF(X(J)-A(3,J)) 42,43,43
0085     42  A(3,J) = X(J)
0086      43 IF(X(J)-A(4,J)) 5,5,44
0087     44  A(4,J) = X(J)
        C
        C    COMPUTING VECTOR LENGTHS
        C
0088       5 SAMSSQ= SAMSSQ +X(J)* X(J)
0089         COM(NS) = SQRT(SAMSSQ)
0090         SAMSSQ = COM(NS)
0091         IF(SAMSSQ)4,8,4
0092       8 WRITE(KT3,1001)NAME
0093    1001 FORMAT(1H0,'NO VARIABLES FOR SAMPLE ',2A4,'.')
0094         IF(IT1.EQ.4) GO TO 850
0095         GO TO 3
0096       4 CONTINUE
        C
        C    NORMALIZE THE DATA AND PUT IT ON KT4
        C
0097         DO 7 J=1,NV
0098       7 X(J) = X(J)/SAMSSQ
0099         WRITE(KT4)NAME,(X(J),J=1,NV)
        C    ------------------------------------------------------------------------
        C
        C    COMPUTE PSEUDO COS THETA MATRIX
        C
        C    ------------------------------------------------------------------------
        C
0100         DO 9 I=1,NV
0101         DO 9 J=1,NV
0102       9 R(I,J)= R(I,J)+ X(I)*X(J)
0103         IF(IT1.EQ.4) GO TO 850
0104         NS = NS + 1
0105     2   GO TO 3
        C      DATA HAS BEEN READ IN
0106      99 REWIND KT4
0107         REWIND KT5
0108         NS = NS - 1
0109         IF(IT1.EQ.4) GO TO 810
0110         WRITE(KT3,1008) NV,NS
0111    1008 FORMAT(1H0,'NUMBER OF VARIABLES = ',I3,4X,' NUMBER OF SAMPLES = ',
           1 I4)
0112         IF(NS-750) 403,403,401
0113     401 WRITE(6,402)
0114     402 FORMAT(32H TOO MANY SAMPLES.  RUN STOPPED.)
0115         GO TO 35
```

```
      403 CONTINUE
          SN=NS
          VN=NV
          SSN = SQRT(SN)
          SVN = SQRT(VN)
          GO TO (81,860,81,870,870),IT1
       80 WRITE(KT3,1010)
     1010 FORMAT(///' GENERAL STATISTICS FOR RAW DATA',//)
          GO TO 82
      860 WRITE(KT3,1013)
     1013 FORMAT(///' GENERAL STATISTICS FOR LN(X+1) DATA',//)
          GO TO 82
      870 WRITE(KT3,1014)
     1014 FORMAT(///' GENERAL STATISTICS FOR PERCENT-RANGED DATA',//)
          GO TO 82
       81 WRITE(KT3,1011)
     1011 FORMAT(///' GENERAL STATISTICS FOR PERCENTAGED DATA',//)
       82 WRITE(KT3,1012)
     1012 FORMAT(10H  VARIABLE 19X 8HSTANDARD 7X 7HMINIMUM 8X 7HMAXIMUM/9H
         1 NUMBER 6X 7HAVERAGE 7X 9HDEVIATION 7X 5HVALUE 10X 5HVALUE //)
          KILL = 0
          DO 10 I=1,NV
          DO 16 J = I,NV
          R(I,J) = R(I,J)/SN
       16 R(J,I) = R(I,J)
          IF(A(2,I)) 404,404,406
      404 WRITE(6,405) I
      405 FORMAT(22H NO DATA FOR VARIABLE ,I2, 16H.   RUN STOPPED.)
          KILL = 1
      406 CONTINUE
          A(1,I) = A(1,I)/SN
          A(2,I) = SQRT(A(2,I)/SN - A(1,I)*A(1,I))
       10 WRITE(KT3,1005) I,A(1,I),A(2,I),A(3,I),A(4,I)
     1005 FORMAT(I7,4F15.4)
          IF (KILL) 407,407,35
C         ------------------------------------------------------------------------
C
C         CALL THE EIGENVALUE ROUTINE
C
C         ------------------------------------------------------------------------
C
      407 CALL EBERVC(NV,R,A)
C
C
C         R(I,I) CONTAINS THE EIGENVALUES
C         A  CONTAINS THE EIGENVECTORS
C
C-----------------------------------------------------------------------
C
C         NOW DETERMINE THE RIGHT NUMBER OF EIGENVALUES
C
          WRITE(KT3,15)
       15 FORMAT(1H0, 'NO.   EIGENVALUE   CUM. VAR.',//)
          EVSUM = 0.
          DO 11 I = 1,NV
          NF = 1
          EVSUM = EVSUM +(R(I,I)*100.)
          WRITE(KT3,14) I,R(I,I),EVSUM
```

```
   14 FORMAT(1H ,I2,2X,F10.6,3X,F7.2)
      IF(NF-10) 18,13,13
   18 IF(R(I,I)-0.0001) 13,12,12
   12 IF(EVSUM - QUIT) 11,13,13
   11 CONTINUE
C     ------------------------------------------------------------------
C
C     TRANSFER EIGENVECTORS TO FS
C
   13 DO 50 J = 1,NF
      DO 50 I = 1,NV
   50 FS(I,J) = A(I,J)
      WRITE(KT3,1007) TITLE
C     ------------------------------------------------------------------
C
C     BEGIN MAJOR LOOP COMPUTING THE PRINCIPAL FACTOR MATRIX
C
C     ------------------------------------------------------------------
      DO 19 I = 1,NF
   19 VAR(I) = 0.
C
C    PRINT PRINCIPAL FACTOR MATRIX IF IT2 NOT = 0
C
      IF(IT2) 17,17,29
   29 WRITE(KT3,1210) (J,J=1,NF)
 1210 FORMAT(1H0, '                         PRINCIPAL FACTOR LOADINGS ',//12X,
     1 '   COMM.',I6,10I8,/)
   17 DO 20 K=1,NS
      READ(KT4) NAME,(X(I),I=1,NV)
      DO 24 J=1,NF
      F(K,J) = 0.
      DO 24 I=1,NV
   24 F(K,J) = X(I)*FS(I,J)+F(K,J)
      COMAL = 0.
       DO 25 J = 1,NF
      COMAL = COMAL + F(K,J)*F(K,J)
   25 VAR(J) = VAR(J)+F(K,J)*F(K,J)
C
C     STORE PRINCIPAL FACTOR MATRIX ON KT5
C
      WRITE(KT5) (F(K,I) , I = 1,NF)
      IF(IT2) 20,20,21
   21 WRITE(KT3,1003) NAME,  COMAL,(F(K,I),I =1,NF)
 1003 FORMAT(5H     ,2A4,11F8.4)
   20 CONTINUE
C
C     EXPRESS COL SUM OF SQUARES AS A PERCENT OF TOTAL VARIANCE
C
       DO 26 I = 1,NF
   26 VAR(I) = VAR(I)/SN*100.
      X(1) = VAR(1)
      DO 27 J = 2,NF
      K = J -1
   27 X(J) = X(K) + VAR(J)
        WRITE(KT3,1015) (VAR(I), I = 1,NF)
 1015 FORMAT(1H0,'VARIANCE     ',8X,10F8.2)
      WRITE(KT3,1016) (X(I), I = 1,NF)
 1016 FORMAT(1H ,'CUM. VARIANCE        ',10F8.2)
```

```
      C-----------------------------------------------------------------
      C
      C     COMPUTE PRINCIPAL FACTOR SCORES
      C
      C-----------------------------------------------------------------
            WRITE(KT3,1007) TITLE
            WRITE(KT3,1030) (J,J=1,NF)
       1030 FORMAT(1H0,' PRINCIPAL FACTOR SCORE MATRIX'//11X,'VAR.',5X,10I8//)
       1031 FORMAT(1H ,12X,I2,6X,10F8.3)
            DO 55 I = 1,NV
            DO 56 J = 1,NF
         56 XX(J) = FS(I,J) * SVN
         55 WRITE(KT3,1031) I,(XX(J),J=1,NF)
      C
      C
            NFF = NF
            IF(IT6.GE.1) NF = IT6
      C-----------------------------------------------------------------
      C
      C     CALL VARIMAX ROTATION PROCEDURE
      C
      C-----------------------------------------------------------------
         38  CONTINUE
            CALL VARMAX(NF,NS,NV,TITLE,F,T,COM,NAME)
      C
      C     COMPUTE VARIMAX FACTOR SCORE MATRIX
      C
         62 WRITE(KT3,1007) TITLE
            WRITE(KT3,1041) (J,J=1,NF)
       1041 FORMAT(1H0,' VARIMAX FACTOR SCORE MATRIX'//11X,'VAR.',5X,10I8//)
            DO 69 K=1,NV
            DO 68 I=1,NF
            XX(I) = 0.
            DO 68 J=1,NF
         68 XX(I) = FS(K,J) * T(J,I) + XX(I)
            DO 67 J = 1,NF
         67 A(K,J) = XX(J) * SVN
         69 WRITE(KT3,1031) K,(A(K,J),J=1,NF)
      C
      C     CHECK TO SEE IF ADDITIONAL ROTATIONS ARE REQUIRED
      C
            IF(IT5.GE.1) GO TO 35
             NF = NF - 1
             IF(NF -2) 35,30,30
         30 IF(X(NF) - 70.)  35,31,31
         31 REWIND KT5
            DO 37 K=1,NS
         37 READ(KT5) (F(K,I),I=1,NFF)
            GO TO 38
         35 CALL EXIT
            END
```

```
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    *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
    *OPTIONS IN EFFECT*  NAME = MAIN     , LINECNT =        60
    *STATISTICS*    SOURCE STATEMENTS =       229,PROGRAM SIZE =     43522
    *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
      SUBROUTINE EBERVC(N,A,AV)
      DIMENSION A(50,50),AV(50,50)
      DO 5 I=1,N
      DO 5 J=1,N
      AV(I,J) = 0.0
      AV(J,I) = 0.0
    5 IF(I.EQ.J) AV(I,J) = 1.0
      NBMAX = 200
      EPS = 0.01
      EPS1 = 0.001
      EF = 1000
      EPS=EPS/EF
      EPS1=EPS1/EF
      NB=0
   18 DR=0.0
      DI=0.0
      DO 17 I=2,N
      IJ=I-1
      DO 17 J=1,IJ
      C=A(I,J)+A(J,I)
      D=A(I,I)-A(J,J)
      IF(EPS.LE.ABS(C)) GOTO 23
   21 CC=1.0
      SS=0.0
      GOTO 22
   23 CC=D/C
      SIG=SIGN(1.0,CC)
      COT=CC+SIG*SQRT(1.0+CC*CC)
      SS=SIG/SQRT(1.0+COT*COT)
      CC=SS*COT
      DR=DR+1.0
   22 E=A(I,J)-A(J,I)
      IF(EPS.GT.ABS(E)) GOTO 31
      CO=CC*CC-SS*SS
      SI=2.0*SS*CC
      H=0.0
      G=0.0
      HJ=0.0
      DO 40 K=1,N
      IF(K.EQ.I) GOTO 40
      IF(K.EQ.J) GOTO 40
      H=H+A(I,K)*A(J,K)-A(K,I)*A(K,J)
      S1=A(I,K)*A(I,K)+A(K,J)*A(K,J)
      S2=A(J,K)*A(J,K)+A(K,I)*A(K,I)
      G=G+S1+S2
      HJ=HJ+S1-S2
   40 CONTINUE
      D=D*CO+C*SI
      H=2.0*H*CO-HJ*SI
      F=(2.0*F*D-H)/(4.0*(E*E+D*D)+2.0*G)
      IF(EPS1.GT.ABS(F)) GOTO 31
      CH=1.0/SQRT(1.0-F*F)
      SH=F*CH
      DI=DI+1.0
      GOTO 36
   31 CH=1.0
      SH=0.0
   36 C1=CH*CC-SH*SS
```

```
      C2=CH*CC+SH*SS
      S1=CH*SS+SH*CC
      S2=SH*CC-CH*SS
      IF((ABS(S1)+ABS(S2)).EQ.0.0) GOTO 17
      DO 52 L=1,N
      A1=A(L,I)
      A2=A(L,J)
      A(L,I)=C2*A1-S2*A2
      A(L,J)=C1*A2-S1*A1
      A1=AV(L,I)
      A2=AV(L,J)
      AV(L,I)=C2*A1-S2*A2
      AV(L,J)=C1*A2-S1*A1
   52 CONTINUE
      DO 53 L=1,N
      A1=A(I,L)
      A2=A(J,L)
      A(I,L)=C1*A1+S1*A2
      A(J,L)=C2*A2+S2*A1
   53 CONTINUE
   17 CONTINUE
      IF((DR+DI).LT.0.5) GOTO 16
      NB=NB+1
      IF(NB.NE.NBMAX) GOTO 18
   16 CONTINUE
      DO 80 I=1,N
      SUM=0.0
      DO 81 J=1,N
   81 SUM = SUM + AV(J,I)*AV(J,I)
      SUM=SQRT(SUM)
      DO 82 J=1,N
   82 AV(J,I)=AV(J,I)/SUM
   80 CONTINUE
  100 M3 = N-1
      DO 110 I=1,M3
      IJ=I+1
      DO 110 J=IJ,N
      IF(A(I,I).GE.A(J,J)) GO TO 110
      TEMP = A(I,I)
      A(I,I) = A(J,J)
      A(J,J) = TEMP
      DO 105 K=1,N
      TEMP = AV(K,I)
      AV(K,I) = AV(K,J)
  105 AV(K,J) = TEMP
  110 CONTINUE
      RETURN
      END
```

```
*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
*OPTIONS IN EFFECT*  NAME = EBERVC  , LINECNT =       60
*STATISTICS*    SOURCE STATEMENTS =      106,PROGRAM SIZE =      2988
*STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
      SUBROUTINE VARMAX(MAXF,MAXT,NV,TITLE,F,T,COM,NAME)
C     VARIMAX MATRIX ROTATION
C     MAXT = NO. OF SAMPLES, NS = NO. OF VARIABLES,MAXF = NO.OF FACTORS
      DIMENSION F(750,10),COM(750),VAR(10),CUM(10),TITLE(20),
     1 NAME(2)
      DIMENSION  T(10,10)
       COMMON KT1,KT2,KT3,KT4,KT5,IT1,IT2,IT3,IT5
      DO 801 I=1,MAXF
      DO 801 J=1,MAXF
      IF(I-J) 803,802,803
  802 T(I,J)= 1.0
      GO  TO 801
  803 T(I,J) = 0.0
  801 CONTINUE
      REWIND KT4
      EPS = 0.06993
  150 DO 103 N = 1, MAXT
      COM(N) = 0.0
      DO 102 M = 1, MAXF
  102 COM(N) = COM(N) + F(N,M) * F(N,M)
      COM(N) = SQRT (COM(N)   )
      DO 103 M = 1, MAXF
  103 F(N,M) = F(N,M)/COM(N)
      L = MAXF - 1
  104 NOROT = 0
      DO 123 M = 1, L
      K = M + 1
      DO 123 MONE = K, MAXF
      A = 0.0
      B = 0.0
      C = 0.0
      D = 0.0
      DO 105 N = 1, MAXT
      U=F(N,M)*F(N,M) - F(N,MONE)*F(N,MONE)
      V = F(N,M) * F(N,MONE)* 2.
      A = A + U
      B = B + V
      C=C+U*U - V*V
  105 D = D + U * V * 2.0
      R = MAXT
      QNUM = D - 2.0 * A * B / R
      QDEN = C - (A *A   - B *B  ) / R
      IF(ABS(QNUM) + ABS(QDEN)) 120,120,106
  106 IF(ABS(QNUM) - ABS(QDEN)) 107,114,111
  107 R = ABS(QNUM/QDEN)
      IF(R - EPS) 109,108,108
  108 CS4TH = COS(ATAN(R))
      SN4TH = SIN(ATAN(R))
      GO TO 115
  109 IF(QDEN) 110,120,120
  110 SNPHI = .70710678
      CSPHI = SNPHI
      GO TO 121
  111 R = ABS(QDEN/QNUM)
      IF(R - EPS) 113,112,112
  112 SN4TH = 1.0/ SQRT(1.0 + R *R)
      CS4TH = SN4TH * R
      GO TO 115
```

```
      113  CS4TH = 0.0
           SN4TH = 1.0
           GO TO 115
      114  CS4TH = .70710678
           SN4TH = CS4TH
      115  R = SQRT((1.0 + CS4TH) * 0.5)
           CSTH = SQRT((1.0 + R) * 0.5)
           SNTH = SN4TH/(4.0 * CSTH * R)
           IF(QDEN) 116,117,117
      116  CSPHI =.70710678*(CSTH+SNTH)
           SNPHI =.70710678*(CSTH-SNTH)
           GO TO 118
      117  CSPHI = CSTH
           SNPHI = SNTH
      118  IF(QNUM) 119,121,121
      119  SNPHI = - SNPHI
           GO TO 121
      120  NOROT = NOROT + 1
           GO TO 123
      121  DO 123 N = 1, MAXT
           R = F(N,M) * CSPHI + F(N,MONE) * SNPHI
           F(N,MONE) = F(N,MONE) * CSPHI - F(N,M) * SNPHI
            F(N,M)= R
           IF(N-MAXF) 804,804,123
       804 TP = T(N,M)
           T(N,M)= TP * CSPHI + T(N,MONE) * SNPHI
           T(N,MONE) = -TP * SNPHI + T(N,MONE) * CSPHI
      123  CONTINUE
           IF(NOROT -(MAXF * L)/2) 104,124,104
      124  DO 125 N = 1, MAXT
           DO 127 M = 1, MAXF
       127 F(N,M) = F(N,M) * COM(N)
       125 COM(N) = COM(N) * COM(N)
C     PRINT VARIMAX FACTOR MATRIX IF IT2 NOT = 0
           IF(IT2) 132,130,132
       132 WRITE(KT3,60) TITLE
        60 FORMAT(1H1, 20A4,///)
            WRITE(KT3,30)
        30 FORMAT(22HOVARIMAX FACTOR MATRIX  //)
           WRITE(KT3,40) (J,J = 1,MAXF)
        40 FORMAT(1HO,19X,'COMM.',1X,10(I5,4X),/ )
           DO 126 N = 1, MAXT
           READ(KT4) NAME
           IF(IT5-MAXF)126,700,126
      700  WRITE(KT2,710)NAME,(F(N,M),M=1,MAXF)
      710  FORMAT(2A4,9F8.4)
       126 WRITE(KT3,20) N,NAME,  COM(N),(F(N,M),M=1,MAXF)
        20 FORMAT(1H ,I5,2X,2A4,11F9.4)
       130 DO 200 I = 1,MAXF
           VAR(I) =0.
       200 CUM(I) = 0.
            FN = MAXT
           DO 201 I = 1,MAXF
           DO 201 J = 1,MAXT
       201 VAR(I) = VAR(I) + F(J,I) * F(J,I)
            DO 500 I = 1,MAXF
       500 VAR(I) = (VAR(I)/ FN) * 100.
            CUM(1) = VAR(1)
```

```
          DO 202 I = 2, MAXF
      202 CUM(I) = CUM(I-1) + VAR(I)
          WRITE(KT3,502) (VAR(I), I = 1,MAXF)
      502 FORMAT(1H0,16X,8HVARIANCE,2X,10(F7.3,2X))
          WRITE(KT3,503)(CUM(I), I = 1,MAXF)
      503 FORMAT(1H0,16X,8HCUM. VAR,2X,10(F7.3,2X))
          IF(MAXF - 3) 600,600,601
C
C    PRINT NORMALIZED VARIMAX MATRIX IF IT3 NOT = 0
C
      600 IF(IT3) 601,601,607
     607  WRITE(KT3,60) TITLE
            WRITE(KT3,602)
      602 FORMAT(1H0,'  NORMALIIZED VARIMAX FACTOR COMPONENTS    ' )
           WRITE(KT3,40)(J,J = 1,MAXF)
           DO 603 N = 1, MAXT
           DO 603 M = 1,MAXF
          S = F(N,M)
           F(N,M) = (F(N,M) * F(N,M))/COM(N)
          IF(S) 605,603,603
      605 F(N,M) = -F(N,M)
      603 CONTINUE
           DO 604 N = 1,MAXT
      604 WRITE(KT3,20) N, NAME,COM(N),(F(N,M),M=1,MAXF)
      601 CONTINUE
      100 RETURN
          END
```

APPENDIX D

VARIMAX FACTOR MATRIX

Sample	Facies 1	Facies 2	Facies 3	Facies 4
A- 3	0.7917	0.0868	0.3558	0.3422
A- 7	0.8460	0.0551	0.2616	0.2843
A-11	0.7706	0.1249	0.1898	0.4659
A-14	0.8391	0.1292	0.0960	0.3381
A-18	0.8361	0.1337	0.1055	0.4122
A-22	0.8191	0.1265	0.1105	0.3915
B- 1	0.5920	0.1176	0.6467	0.1459
B- 2	0.5745	0.0553	0.2872	0.2700
B- 6	0.5360	0.1547	0.1737	0.8032
B-10	0.4419	0.1613	0.2146	0.8503
C- 1	0.1124	0.1322	0.6503	0.6971
C- 2	0.5659	0.2734	0.3722	0.6510
C- 5	0.4678	0.2465	0.4901	0.6303
C- 7	0.3049	0.3405	0.5782	0.6115
C- 8	0.5567	0.2247	0.1434	0.7779
C-12	0.3591	0.3202	0.0980	0.8427
C-16	-0.0110	0.6261	0.0883	0.7200
C-19	0.4540	0.1810	0.1001	0.8630
C-23	0.0980	0.4712	0.0956	0.8455
C-27	0.4312	0.1663	0.1010	0.8761
C-31	0.4676	0.1557	0.1010	0.8596
C-36	0.4894	0.1578	0.1009	0.8479
C-40	0.4449	0.1932	0.1018	0.8640
C-43	0.3810	0.3603	0.1082	0.8326
C-47	0.4591	0.1787	0.0994	0.8577
C-53	0.3082	0.2092	0.0962	0.9029
C-58	0.4449	0.1587	0.1003	0.8711
C-62	0.4451	0.1965	0.1016	0.8613
C-66	0.4790	0.1509	0.1008	0.8540
D- 1	-0.0864	0.0729	0.7571	0.5969
D- 4	0.2233	0.0046	0.9404	0.1937
D- 6	0.8933	0.2022	0.2009	0.2834
D- 9	0.0546	0.1039	0.8801	0.3951
D-11	0.3903	0.0051	0.8688	0.1753
E- 1	0.4731	0.0815	0.6511	0.3462
E- 4	0.5677	0.1520	0.4013	0.6853
E- 5	0.8046	0.3289	0.2458	0.2935
E- 9	0.4332	0.1780	0.7491	0.2370
E-11	0.3471	0.1432	0.4931	0.7711
E-13	0.6144	0.1455	0.2503	0.7126
E-17	0.2412	0.1308	0.5609	0.7757
E-21	0.1527	0.0972	0.8758	0.3300
E-25	0.3554	0.1457	0.2506	0.8834
E-28	0.4669	0.1706	0.3398	0.7868

APPENDIX D continued

Sample	Facies 1	Facies 2	Facies 3	Facies 4
F- 1	0.0416	0.9269	0.1070	0.2539
F- 3	0.1747	0.8841	0.1104	0.2967
F- 5	0.0062	0.9203	0.0845	0.2998
F- 8	0.0641	0.8363	0.0845	0.4664
F- 9	-0.0457	0.5210	0.0953	0.7755
H- 2	0.8657	0.1848	0.1888	0.3227
H- 5	0.8921	0.1300	0.1211	0.3447
H- 8	0.9052	0.1053	0.2122	0.3084
H-11	0.8905	0.1184	0.2602	0.2720
H-14	0.8918	0.1079	0.2298	0.2762
H-17	0.8659	0.0715	0.1739	0.2827
H-20	0.8202	0.0574	0.1162	0.2682
H-21	0.7765	0.1985	0.2727	0.2474
H-25	0.8753	0.0925	0.2165	0.3540
H-28	0.8839	0.0628	0.2104	0.2860
H-31	0.8833	0.0951	0.2500	0.2969
H-33	0.5822	0.2346	0.7385	0.1091
H-36	0.8327	0.1436	0.3003	0.3691
H-39	0.7826	0.1106	0.3867	0.4328
H-42	0.8162	0.1060	0.2758	0.4066
H-45	0.8167	0.0959	0.3919	0.3528
J- 2	0.7938	0.3379	0.2360	0.2516
J- 3	0.7231	0.5647	0.2577	0.2045
J- 5	0.7589	0.5657	0.1412	0.1895
J- 8	0.6662	0.6420	0.2553	0.1696
J-11	0.8918	0.2404	0.1983	0.2364
J-13	0.7642	0.4890	0.2545	0.2574
J-50	0.8568	0.0390	0.3014	0.2459
J-53	0.7992	0.0360	0.3595	0.2230
J-56	0.7773	0.3349	0.3774	0.2459
J-57	0.5414	0.6302	0.3625	0.0859
J-59	0.5642	0.7603	0.1859	0.1230
J-62	0.7332	0.5234	0.1946	0.2605
J-65	0.2784	0.9280	0.1128	0.1146
J-68	0.6325	0.6573	0.1516	0.3209
J-72	0.1924	0.7320	0.1320	0.6150
I- 9	0.7269	0.3632	0.3914	0.2555
I-42	0.3925	0.0762	0.8924	0.0840
I-45	0.1631	0.1086	0.8616	0.2453
I-47	0.6693	0.1649	0.5147	0.4667
I-60	0.2716	0.9159	0.0800	0.1814
I-83	0.0482	0.9779	0.0547	0.0558
I-91	0.0873	0.9566	0.0643	0.1840
I-101	0.1586	0.9437	0.0611	0.1794
I-110	0.1158	0.8992	0.0719	0.3203

APPENDIX D continued

Sample	Facies 1	Facies 2	Facies 3	Facies 4
G- 1	0.9025	0.1058	0.2569	0.2687
G- 4	0.0675	0.0595	0.9778	-0.0056
G- 7	0.2060	0.0758	0.9373	0.0895
G-10	0.9056	0.1381	0.2603	0.2691
G-13	0.9070	0.1165	0.2236	0.2959
G-16	0.7858	0.2602	0.4609	0.2669
G-19	0.5180	0.1126	0.8156	0.1211
G-21	0.8946	0.1080	0.2465	0.3058
G-25	0.4461	0.0946	0.8751	0.0817
G-28	0.8757	0.0910	0.3125	0.3170
G-30	0.0942	0.2069	0.9448	-0.0542
G-33	0.2885	0.1060	0.8312	-0.0538
G-35	0.1932	0.3859	0.7420	-0.1044
G-36	0.8046	0.0731	0.3693	0.3259
G-39	0.8862	0.0518	0.2349	0.2382
G-40	0.8450	0.0752	0.3451	0.2428
G-41	0.8757	0.0962	0.2794	0.2800
G-42	0.7916	0.0621	0.4554	0.1862
G-43	0.6904	0.3395	0.3645	0.2612
G-44	0.6405	0.6017	0.1938	0.1787
G-45	0.5107	0.7697	0.1360	0.1261
G-46	0.5679	0.7200	0.2318	0.1781
G-47	0.7554	0.4763	0.1291	0.3064
G-48	0.6706	0.6394	0.0917	0.2645
G-49	0.7128	0.5463	0.1146	0.3602
G-50	0.7849	0.3404	0.0931	0.3790
G-51	0.7907	0.3875	0.0889	0.3362
G-52	0.6518	0.5967	0.0941	0.4142
G-53	0.7508	0.4215	0.1017	0.4504
G-54	0.5646	0.2153	0.1185	0.7721
G-55	0.6008	0.2187	0.1169	0.7496
G-56	0.5323	0.2785	0.1152	0.7746
G-57	0.4874	0.3036	0.1176	0.7874
G-59	0.5631	0.2320	0.0919	0.7537
G-60	0.5557	0.1807	0.0903	0.7102
G-61	0.6350	0.1699	0.1020	0.7385
G-62	0.6424	0.2970	0.0923	0.6603
G-63	0.7552	0.1937	0.0882	0.5918
G-64	0.6572	0.4917	0.0635	0.3907
G-65	0.7484	0.2976	0.0724	0.4934
G-66	0.8011	0.2927	0.0766	0.4375
G-67	0.5100	0.5998	0.0883	0.5806
G-68	0.8298	0.2098	0.0663	0.4111
G-69	0.7722	0.3020	0.0424	0.2920
G-70	0.7132	0.2837	0.0618	0.4657
G-71	0.7905	0.3561	0.0682	0.3945
G-72	0.7816	0.3471	0.0725	0.3365
G-73	0.7667	0.2944	0.0667	0.4610