TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1904-1905.

Pre-Cambrian Volcanic Bombs from near Lake Ainslie, Inverness Co., N. S.

—By Henry S. Poole, D. Sc., Assoc. R. S. M., F. G. S., F. R. S. C.

(*Read 17th October, 1904.*)

Among the rocks of Cape Breton, N. S., classed in the Report of the Geological Survey of Canada of 1882-4 as pre-Cambrian, in a deposit on the east side of Lake Ainslie, are some globular balls associated with modified forms presenting marked features. They differ in so many respects from concretions ordinarily seen taking spherical shape in sandstones, plaster and shales, that these balls could not be grouped with them and thus dismissed. It may first be noted they are found with pyroclastic rocks, and next that such concretionary structure as they do present is in most cases merely superficial; they are associated in a bed which has cavities coated with matter that has flowed while in the condition of thick mud or paste and retained the forms then taken as ridges and layers of varied consistency. The balls have an indurated appearance with a smooth surface, and vary in size from that of a pin's head to a cricket ball. Rarely over three inches in diameter, the largest seen was a flattened oval of 7 in. by 5 in. by 3 in. that apparently had lost, through impact or pressure on contact with

others, an original shape more nearly spherical. The crushing it was subjected to, would appear to have taken place when the interior was still in a semi-plastic state and the crust alone was broken into irregularly shaped plates, the edges of which were more or less displaced. The distortion of form which the balls suffered on impact varied in degree with their size and plasticity. Some retained their form unaltered when they dropped to earth, others appear to have had an exterior sufficiently viscid at the moment of contact to coalesce, while yet others suffered deformation without cohesion, or had their crust fractured, while the displaced pieces were held together by the pasty condition of the interior. While I have said the external surface of the balls is smooth, this statement requires qualification, as parts have a rough or broken appearance where they have been in contact with others. A few show where a spherulitic structure with fibrous radiations has been developed, a form recognized as incipient of crystallization in igneous rocks of the more acid constituents. There was also to be seen on one or two specimens a faint trace of venation somewhat similar in character, and this feature has also been detected on the ridges of flow structure with the associated ash bed. Contact probably gave to the surface of the softer balls a cup-shaped depression, or flattened or simply depressed it, the ultimate form retained by the balls doubtless being determined by the relative hardness of the impinging bodies. Some of the forms found were oblong with rounded ends and somewhat constricted in the middle; they had a dumbell-like appearance fitting into the inequalities of one another with, in many cases, such slight adhesion that at a light tap of the hammer a group of them would fall apart.

Of the largest a fragment has been put in the Provincial Museum It presents a curiously pitted appearance all over its surface, giving to the plates, into which the crust is cracked, a likeness to the scutes of ganoid fishes; and taken alone it might be supposed to be part of a fossil.

The pitting is fairly uniform and about of the size and depth given to the depressions on the top of ladies' sewing thimbles. An appearance somewhat similar may be produced by stirring on a glass plate or other non-absorbent surface a thick mud of proper consistency, and allowing it to dry. When mud is rightly prepared and globules of air are incorporated in the mass, there is left on evaporation a coating having a pitted surface like that on this stone. To account then for this pitting phenomenon we may assume that the final concentric coating possessed such a consistency and the usual cementing qualities. I may add that Mr. M. V. Grandin, of Cheticamp, informs me he has seen the same external structure on fragments of lava on the slopes of Vesuvius.

On fracture these balls show an interior of irregular composition sometimes with cavities, parts being granular and easily pulverized and parts being like that of the outside coating, of a fine homogeneous material. The cavities were not found to contain crystals, but one was lightly bridged over by a crust not a 32nd of an inch thick. The concretionary exterior may be somewhat shelly, and shows that it has gathered additions splashed on in drops or patches. These are easily distinguishable by the slight irregularity of form thereby produced, which is often enhanced by a variation in col ring. That the accretions have been of varied degree of fluidity, is made evident by the extent to which they have spread out over the spherical surface, and their appearance would remind one who has visited a pottery establishment, of the action of 'slip' on the clay forms in the hands of the potter.

Besides the deformation due to impact or pressure, it will be seen they have suffered fracture under two distinct conditions, one in common with rocks in general from shrinkage in some ordinary form, and the other exceptional and attributable to sudden violence while in a non-homogeneous state such as is possessed by many articles of domestic confectionary like

chocolate drops and meringues. Pieces of the fractured crust of some of the smaller balls appear to have fallen out and been lost at the time.

I have yet to speak of another feature, and that not of any lesser interest than the foregoing. Parallel to the major diameter of several of the balls, there is a more or less complete striation or grooving around the circumference. The grooves may be single or double, and have a width of as much as an eighth of an inch, while the striæ are more numerous and in a belt of fourteen or more on a scale of even less than thirty to the inch. In the specimen on the table this equatorial linear engraving can best be seen when light is made to fall parallel to the axis of rotation. It is further to be seen passing under the remains of an adhesion giving priority to its formation; but how this engraving was produced, or how the tool which made the lines was held, I am at a loss to suggest.

We may now consider how came these balls of matter, doubtless volcanic ashes, to acquire their present form, and under what conditions would it seem most probable they were produced? Whatever may be the ultimate concensus of opinion, it seems to me their formation can best be conceived by comparison with that of a modern volcanic bomb, and is due to swirling gases of an explosion giving a gyratory motion to the ejected particles of attrition and their aggregations.

Messrs. Chamberlain and Salisbury, in their recent work on geology,* write :—"The larger masses of lava ejected into the air are often caused to rotate by the unequal force of the projection, or by the unequal friction of the air, and to assume spheroidal forms. . . . These rounded projectiles are known as volcanic bombs." Of the ejected dust from Vesuvius they further say—"A finer variety [than lapilli] of the nature of sand, much used in making Portland cement, is locally known as puzzolana." This latter quotation is made as bearing on the rapid cementa-

*T. C. Chamberlain and R. D. Salisbury, *Geology*, 1904, vol. 1, p. 386.

tion which apparently took place in the crust of our Ainslie bombs under consideration. Another extract from the writings of an authority on volcanic rocks I make as apposite to the question at issue. Professor I. C. Russell, writing on the eruptions on Martinique in 1902, says—"In addition to the angular fragments of fresh lava, minor quantities of more or less spherical masses of similar material, which were projected into the air while yet moderately plastic, have also been observed. While the term volcanic bomb has been applied to much of the ejected material, it is evident that only the somewhat spherical masses referred to deserve to be so called, and even in such instances there is doubt as to the propriety of using the term. Typical volcanic bombs have a round or oval form with extended and spirally twisted projections at the ends of the longer axis, the spherical or more commonly oval form and the spirally twisted extremities being due to the rotation of the mass during its serial flight and while yet plastic. . . The nearest approach to a characteristic bomb are certain rudely spherical masses of lava with cracked surfaces and without protections to which have been given the name of Breadcrust volcanic bombs. Evidently these poorly shaped bombs are composed of fresh lava which was sufficiently hot to make it somewhat plastic at the time it was blown into the air, but was too rigid to acquire the typical shape frequently to be seen about certain basaltic craters. The absence of characteristic bombs on Martinique and St. Vincent is in keeping with the composition of the lava thrown out. The fresh lava is an andesite having in a general way the composition of refractory brick, and unless very highly heated would not be plastic. . . Not only are true volcanic bombs absent, but dots and splashes of plastic or fluid rocks such as are common about many volcanoes that have erupted easily fusible material are also lacking."

In the case of the Ainslie bombs, the composition is more acidic than andesite, and there is an entire absence of fusion in the mass, without any trace being observed of the spiral pro-

jections belonging to characteristic bombs. We have therefore to assume some marked change in the conditions to meet their peculiarities, for the special interest which these balls of undoubtedly igneous origin possess, lies not merely in their being volcanic bombs of very ancient geological horizon but in the presumption that they indicate phenomena of unusual type and a rapid cementation of volcanic ashes of a composition differing from those of ordinary modern volcanoes which, generally highly basic, make a mud which of itself does not possess the property of speedily setting as a cement.

The value of intimate grinding to an extreme fineness is well known in the manufacture of commerical cement, but conditions could not be reproduced which are effected during a volcanic explosion when the separation of impalpable dust is under the influence of the chemical agency of superheated steam and other gases, and which for the moment, it is here assumed, existed when these bombs were taking their natal flight. The late exhibition of vulcanism at Martinique and St. Vincent makes the contemplation of a rapid setting cem nt within reason, but requires that the composition of the powder be otherwise than that met with in the ejecta of the Lesser Antilles.

A complete comparison is not at present possible, as no ultimate analysis of the Lake Ainslie ash-bed has been made. That it materially differs from that of the dust from the Windward Islands is evident. Analysis showed the latter to be very basic, with an average of 55% of silica at St. Vincent, and 62% of silica at Martinique; while from the accompanying letter from Dr. Hoffmann of the Geological Survey it is clear the silica contents of the Lake Ainslie rock is very much higher.

OTTAWA, AUGUST 8TH, 1904.

My dear Mr. Poole.

I duly received your letter of the 30th ult., as likewise the specimens therein referred to. With regard to the "concretions of felsite." In so far as composition is concerned, they co. sist essentially of silica, with a little alumina, etc., etc. The amount of alumina, in the specimen examined, was comparatively small

and would represent but a small proportion of felspar. Thin splinters of the material are with great difficulty fusible before the blowpipe, becoming in fact only just, and no more, rounded on the thinnest edges. This also would tend to show that the amount of felspar present is but small. There is not, so far as I am aware, any fixed ratio between the quartz and felspar in what are commonly designated felsites. Hence the material in question might by many, if not most, be referred to as felsite —and possibly permissively so. They exhibit an unmistakable concentric structure. I am disposed to refer to them as "slightly felspathic quartzose concretions." When next writing would you kindly mention locality of occurrence, and I will then place the same in our museum collection—duly crediting you with the presentation.

I remain,
Yours faithfully,
G. CHAS. HOFFMANN.

The locality where these bombs were found is on the Gairlock mountain road, half a mile from the east shore of Lake Ainslie, on the slope of the hillside within the loop which the road makes opposite the entrance to the ravine and within a stone's throw of the barite mine on the lands of Johnstone. The barite veins occur in a reddish volcanic ash or quartz-felsite and the bed of bombs appears to be at or about the contact of the ash bed with a band of basic volcanic rocks. The limits of the trap rocks are easily distinguished, as its beds are all dark in color while that of the quartz-felsite varies through light shades of yellow and pink to those of a reddish cast, weathering even to whiteness with minute crystals of sanidine (?) sparkling on the faces of fracture.

The deposit was very superficially exposed and where it had been long subject to surface influences. It seemingly was on edge, and apparently considerable excavation would be required to lay bare the bed where it had not been disturbed in order to establish the relation of the basic lava flows to the highly silicious tuff to which evidently belongs the special portion of the deposit containing the bombs, and a further

investigation of the relation of these very distinctive varieties of igneous rocks would be desirable.

The views respecting the formation of these bombs which I would offer for consideration are these, that during the propulsion upwards of the erupted dust and steam, there was a rapid growth of these spherical forms, augmented during flight, after partial cooling had taken place, by additions received from instrusions of fresher and hotter blasts meeting the descending bombs; that the agglomerates resulted from the clash of matter still in the formative stage and the process of cementation was very rapid and took place during the time of flight, the drying of the crust being completed in many cases even before the bombs fell back to earth.