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NOTES ON THE GEOLOGY OF MIDDLETON ISLAND, ALASKA

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Middleton island is situated opposite Prince William sound, in that part of the north Pacific which on some maps is named the gulf of Alaska. It is distant about sixty-four miles from the mouth of the Copper river, the nearest part of the mainland coast, and some fifty-five miles from the nearest points of any other land—these being parts of the shores of Kaye island, Alaganik island and Montague island. The three islands mentioned are all adjacent to the coast of the mainland and separated from it by comparatively narrow waters. They lie in northeast, north and northwest bearings respectively from Middleton island, which thus stands alone and not far from the edge of the hundred-fathom bank or margin of the continental plateau.

Mr J. M. Macoun was landed on this island on June 15, 1892, by H. M. S. *Nymphe*, and occupied the few hours at his disposal there in making a paced survey around the entire shore of the island, either on the beach or along the summit of the low bordering cliffs when walking on the shore itself proved to be impossible. He collected some specimens of the material of which the island is composed and made a few notes upon it, determining the heights of the cliffs, etc, by means of an aneroid barometer.

Mr Macoun does not profess to be a geologist, but on his return he submitted his specimens to me, and it was at once apparent that these represented a true till or boulder-clay. The position of this island—lying as it does so far to seaward—



rendered this fact interesting, and some examinations of this boulder-clay were made. It is proposed to give the results of these examinations.

Knowing that Dr W. H. Dall had visited the island some years ago, I wrote to him, after having examined the specimens, to ask whether any account of its geology had been previously published, and learned that a very brief note, based on Dr Dall's observations made in 1874, had lately been printed in Bulletin No. 84 of the U. S. Geological Survey, pages 259-260. Dr Dall further obligingly supplied me with an early copy of this publication, but the facts now ascertained appear to throw a wholly new light on the structure and geologic age of the island.

Mr Macoun has furnished me with a very clear general description of the island, based on his survey of it, which it is proposed to quote as introductory to the few remarks based on my study of the specimens. He writes:

"Middleton island is a little over five miles in length and a mile and a quarter in breadth at its southern and wider end. At its northern extremity it narrows to a low sandy point, from which a spit extends northward more than two miles. This spit is bare at low tide. For more than ten miles off the southern end breakers are to be seen at all stages of the tide, and at low tide several rocks or shoals show above water.

"About the center of the west side of the island there is good anchorage, and from there to the southern end there is no beach, the cliffs rising perpendicularly from the water to a height of about 100 feet. From 100 to 300 yards back from the edge of the cliff the ground is level and boggy, but it then rises abruptly between 25 and 40 feet. There is, in fact, here a distinct terrace cut back in the material of the island, at a height of 100 feet above sea-level. The surface of the island slopes gradually up from the eastern side to the high ground on the west, so that the greater part of the water that falls upon the island runs off on the eastern side. Not even the smallest stream is to be seen, but everywhere there is a constant trickling of water over the cliffs, and so soft is the material of which the island is composed, that on the eastern side it is being gradually worn away and forms a steep incline from the summit to the water.

"The cliffs on this side are from 30 to 50 feet in height, and from their summit it can be seen that the rock or general material of the island extends for some distance out from the shore, the slope being much less after the level of the sea is reached.

"For about two miles along the eastern shore of the island the beach is strewn with pebbles and small limestone boulders. At the northern end and for about two miles along the northwestern shore, the level rises but a few feet above the sea and the beach is composed of sand only. For nearly a mile beyond this, toward the south, there are a good many boulders along the shore, consisting of granites, as well as black argillite. Just opposite the anchorage a band of gravel not more than two feet in thickness was noticed running along the cliffs, and there may be more bands or beds of the same material elsewhere, as no special importance was attached to these at the time and they were in consequence not looked for or precisely noted, and none of the cliffs along the southern half of the island were seen from the water. In my notes, the material of which the island appears otherwise to be entirely composed was called a soft conglomerate, and the stones contained in it are often as large as the head or larger.

"These seen along the shore appear to be derived, at least for the most part, from the wearing away of the general material of the island, and vary in size from minute pebbles to large ones a foot or more in diameter. This action must be very rapid, for when there is no true pebbly or sandy beach, which is the case for about three miles of the shore line, the waves wash in against the actual base of the cliffs, which are in several places undercut. For about one and a half miles along the middle part of the island, on the east side, where the cliffs are from 10 to 25 feet high only, there is no beach, but the characteristic rock of the island extended here at half-tide from 10 to 20 yards out from the base of the cliff as a level floor. The sea was nearly calm at this time, but the water was discolored by earthy matter for some distance from the shore; and when wet, along the edge of the sea the material is not only very slippery, but so soft that it may be rubbed away by the hand. About two miles from the northern end of the island one of the officers of the *Nymphé*, who had been walking along the shore and had come to a point he could not pass, had climbed up the cliff by cutting places for his feet with his knife, and when I reached this place I ascended to the summit of the cliff in the same way."

The component material of Middleton island, as represented by the specimens brought back by Mr Macoun, is, as already stated, a good typical boulder-clay or

till, of rather dark, bluish-gray color, and somewhat unusually hard and compact. It shows no sign of oxidation by weathering, and in the actual specimens received is packed with small stones which vary in size from about an inch and a half in diameter downward. These lie in all positions, and there is no apparent stratification or lamination whatever, though here and there small parts of the whole appear to be more arenaceous than the rest. None of the stones are perceptibly faceted, nor on these seen can any distinct striation be observed. They are either subangular or fairly well-rounded in shape, and the surfaces of a few of them are so smooth as to be described as polished. It is apparent, in fact, that they represent water-rounded material.

The stones themselves consist almost exclusively of a hard, fine-grained, nearly black material, which has not been microscopically examined in thin sections, but appears to be undoubtedly a rather indurated argillite, resembling rocks seen by the writer on several parts of the Alaskan coast, and which, merely from their lithologic analogy with similar rocks on the better-known coast of British Columbia, may represent what has been named the Vancouver Group, of Triassic Age.

The material also contains rather numerous fragments of shells, but all so much broken in the specimens actually received as to be impossible of exact determination. One small piece of a ribbed shell appears, however, to represent a small specimen of *Cardium blandum*. Several fragments, when microscopically examined, were found to be slightly rounded on the broken edges, while others were quite angular. The whole mass of the clay is more or less calcareous, effervescing freely when an acid is applied. Though very hard when dry, fragments broken from the inner surfaces of the specimens of boulder-clay when placed in water partially break up, and with the aid of agitation and occasional slight pressure applied to the harder lumps the whole was easily and completely disintegrated.

After removing the larger stones from about an ounce of the material, the residue was subjected to a series of decantations at different intervals of time, by means of which its constituents were separated in accordance with their size and specific gravity, the *modus operandi* being the same as that employed in previous investigations of boulder-clays.\*

A microscopic examination of the various samples thus obtained, showed this boulder-clay to comprise a considerable proportion of very fine silty matter, of which the particles are nearly equal in size; also some formless argillaceous matter and a larger proportion of sand.

All grades of the sand proved to consist, to the amount of about one-third or one-half, of partially or well rounded grains of the dark argillaceous rock above referred to, while the remainder was chiefly composed of quartz, generally glassy and usually quite angular, though in part subangular or slightly rounded.

Two samples of this sand, of medium grade, were kindly examined in detail by Mr W. F. Ferrier, who states that, in addition to the argillite grains, the constituents of the coarser of these samples are as follows, in order of abundance:

Medium coarse.—Quartz, feldspar (no striated grains were observed), magnetite, a dark brown pyroxene (?), hornblende of various shades of green, brown mica, (biotite ?) and a very few grains of titanite.

Medium fine.—The same materials, but with mica and hornblende rather more abundant than in the last.

It may be added that the feldspar, pyroxene, hornblende, etc, are found in rather

\* Bull. Chicago Acad. Sci., vol. i, no. vi.



small quantity, the impression conveyed being that the sand cannot in any large part be considered as directly derived from crystalline rocks. In the coarsest specimens of sand resulting from the mechanical analysis of the boulder-clay the constituent grains were easily separable by the unaided eye, and among them were found small fragments of shells and a number of foraminifera. Of these a small collection was picked out and mounted, comprising about two dozen individuals, and representing perhaps half the number present in about an ounce of the material.

These have been examined by Mr J. F. Whiteaves, who reports all the specimens but three to be referable to *Polystomella striatopunctata*, Frichtel and Moll, while of the remaining specimens one is *Pulvinulina karsteni*, Reuss, another probably *Nodosaria (Glandulina) laevigata*, D'Orb., and the third not determinable, being encrusted and badly worn.

The *Polystomellæ* are rather small and depauperated in appearance, resembling in this respect those found in the upper part of the gulf of Saint Lawrence,\* where the water becomes distinctly less saline than normal, but the collection so far examined is quite too small to warrant any theorizing on this fact.

In examining the medium grades of sandy material under the microscope numerous fragments of sponge spicules were noticed. These were generally straight, simple and tubular, but, so far as observed, never perfect. No diatomacæ were seen, though more extended and minute search might probably lead to this discovery.

In containing broken shells and other forms of marine life, the boulder-clay here described resembles that of some parts of the Queen Charlotte islands already described by the writer.† The available evidence is, however, insufficient to enable us to refer the deposit of boulder-clay of which Middleton island is composed to its proper place in the sequence of events of the glacial period, for elsewhere on the coast, and probably generally, there are two distinct boulder-clays, which can only be separated with certainty when both are seen. This boulder-clay may have been formed as a marine bank in proximity to the fronts of great glaciers debouching along the coast of the mainland to the northward, upon which detached icebergs grounded from time to time.

The interstratified layer or layers of pebbly material observed by Mr Macoun might thus be explained, and it appears further to be borne out by the description by Mr Dall, whose attention seems to have been more particularly directed to evidences of bedding, and who writes:

"The island is composed of nearly horizontal layers of soft clayey rock, containing many pebbles and even boulders of syenite and quartzite, some rounded and others of angular shape. Above the claystone is a layer of gray sand covered with several feet of mould and turf."‡

It is perhaps, however, on the whole more probable that this projecting mass of boulder-clay forming Middleton island represents a portion of a morainic accumulation formed at or near the seaward edge of an ice-field derived from the adjacent mainland, and which pushed southward or in a direction at right angles to that of the average trend of the nearest continental coast.

The broken character of the shells seems to favor the belief that the material was ploughed up from the sea bottom and greatly disturbed, rather than to show that it represents merely a bank upon which glacial débris was occasionally discharged. Such a bank might probably be from time to time poached up by

\* See Canadian Naturalist, 1870. p. 172.

† Quart. Jour. Geol. Soc., May, 1831. Report of Progress, Geol. Surv. of Canada, 1878-'79, p. 91 B.

‡ Op. supra cit., p. 260.

grounding ice, but this alone would appear to be scarcely sufficient to explain the always broken appearance of the mollusks in the specimens actually to hand.

The distance from the border of the mainland (about 55 miles) would seem to indicate that it represents a portion of the morainic deposits formed at the outer edge or along the retreating front of that part of the continuation of the Cordilleran glacier which is believed to have occupied the highlands of the corresponding part of the Alaskan coast during the first and most important period of glaciation.\*

It will be noted that the island lies opposite an extensive indentation in the general coast line, marked by Prince William sound and also by the Copper River valley, and it is therefore possible that the corresponding portion of the great glacier here stretched farther seaward than elsewhere. The water between the mainland coast and Middleton island is not very deep, varying, according to the few soundings shown on the chart, from 30 to 50 fathoms. It is therefore quite probable that a glacier-sheet moving outward from the land may still have borne upon the sea-bed with sufficient weight to produce the effects above alluded to, even were the relative elevations of sea and land the same as those of to-day. There is, however, so much reason to believe that very extensive changes in levels have occurred in the region during and subsequent to the glacial period, that it is not safe to assume that the relative levels were identical with those now existing. It is reasonably certain that the island, composed of such relatively soft material, and exposed as it is with few protecting beaches to the full force of denudation exerted by a stormy ocean, has not for any very protracted period, from a geologic point of view, stood at its present level. Mr Macoun's description of the western side of the island in fact distinctly indicates the existence there of a well-marked terrace, cut back at a height of about 100 feet above the present sea-level. Whether this actually represents, in a modified form, that pause in elevation which the coast further south seems to have experienced during the closing events of the glacial period (there at an elevation of about 200 feet) † it is difficult to say; but it indicates, with scarcely any doubt, one stage in that general and last process of elevation. The unoxidized character of the boulder-clay itself seems to show that it can never for a very prolonged period have been subjected to subaerial agencies.

In Dr Dall's observations on Middleton island, already quoted, the following statements are in conclusion made:

"Below the sea-level some of the rock appeared to be quartzite in place and very hard. Whatever its nature, it extends in reefs and shoals to a distance of several miles from the island in different directions. No fossils were found in the claystone, but from its character it was suspected to be post-Miocene and possibly Pliocene" ‡

Respecting the existence of a quartzite basis of the island, Dr Dall writes doubtfully as above, while Mr Macoun did not note any such underlying rock in following the shores. It would appear to be very probable that the surrounding reefs or shoals are merely the higher parts of a plane of marine denudation or banks thrown up upon such a plane, which now surrounds this rapidly diminishing island and corresponds with its original size under the existing relative levels of sea and land in the region. As to the age of the material composing the island itself there seems to be no room for doubt that this is Pleistocene and referable to the Glacial Period.

\* Later Physiographical Geology of the Rocky Mountain Region, etc.: Trans. Royal Soc. Canada vol. viii, sec. iv, map 4.

† Ibid, p. 54.

‡ Op. supra cit., p. 200.







