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SOME FEATURES OF THE DRIFT ON STATEN ISLAND, N. Y.

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(Read October 17, 1898.)

[Plate I.]

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INTRODUCTION.

GENERAL GEOLOGICAL CONDITIONS.

IN order that the full significance of many of the features of the drift on Staten Island may be appreciated it is necessary to have at least a fair idea of the general geological conditions which prevail there. Topographically the island may be roughly divided into a hill region at the north and east and a plain region at the south and west. The hill region is limited on the east and south by a ridge of serpentine, which extends from the point nearest to New York City, at New Brighton, to

about the center of the island, at Richmond. The eastern and southern border of this ridge is abrupt, in places forming a steep escarpment and reaching a maximum elevation of 380 feet, at a point distant about a mile from the border. From the summit of the ridge to the north and west the surface is an irregular slope to tide water at the shores of the kills, which separate the island from the adjoining mainland. A low trap ridge is the only other well-defined rock exposure in this region. The plain region comprises the remainder of the island. It is an isolated portion of the Atlantic coastal plain, over the greater part of which is spread a series of morainal hills with a maximum elevation of 175 feet. The underlying strata are Cretaceous. Almost the entire area of the island is covered by boulders, till or modified drift.

TERMINAL MORAINE.

Earlier Descriptions.

Probably the earliest published account of the drift on Staten Island is in a communication from Mr. James Pierce, to the editor of the *American Journal of Science*, in 1818. In this he says: "Large beds of water-worn siliceous pebbles, in no way differing from those washed by the ocean, are seen on the height of the ridge, in which excavations have been made several feet, leaving the depth of the mass uncertain. * * * Adjacent to Fort Tompkins, detached pieces of copper ore have been found. I have observed petrifactions of marine shells in rocks excavated in that neighborhood, twenty feet from the surface and sixty above the ocean."

In 1838 Mr. W. W. Mather's preliminary report on the geology of New York was issued, in which he mentions the occurrence of fossiliferous boulders on Staten Island, as follows: "A boulder of limestone filled with fossil shells, and similar to that of Becroft's Mountain, near Hudson, was dug from a well at a considerable depth. A boulder of siliceous limestone, like one of the strata of the Helderberg, containing fossils, was dug from another well on Staten Island. * * * I found a small boulder

of decomposed rock, on the shore near the southwest lighthouse, filled with fossil remains similar to those of the middle limestone of Becroft's Mountain, Columbia county."

In his final report in 1843, he frequently refers to features of the drift on the island, noting among other facts that the soil is largely colored red by reason of the quantity of red sandstone contained in it.

In 1881 Dr. N. L. Britton read two papers on the geology of the island, before the Academy, in which the general features of the drift were discussed and the terminal moraine was described and mapped. (Annals, ii, 161–182; pls. xv, xvi. Transactions, i, 56, 57.)

During the same year the Natural Science Association of Staten Island was organized, thus providing a medium for the recording of local notes and the preservation of local specimens, and it is largely upon these notes, scattered through its Proceedings, and the specimens contained in its museum, that the present paper is based.

Location and Extent.

The terminal moraine extends through the island in an irregular line, from Fort Wadsworth, at the Narrows, to Tottenville, opposite Perth Amboy, N. J. It reaches tide-water at these localities and also near Great Kills, between which point and Prince's Bay it formerly extended beyond what is now the shore line. Only two limited areas are driftless. One of these, about 7½ square miles in area, is in the sinus where the moraine bends northward and rests upon the serpentine ridge, in the vicinity of New Dorp; the other is a similar, smaller area, in the vicinity of Tottenville.

Structure.

Where the moraine rests upon the serpentine ridge it presents but few features that are especially striking, consisting entirely of boulder till, gravel and occasional deposits of clay, varying in depth from a mere layer of scattered boulders to accumulations eighty feet in thickness.

Throughout the plain region, however, it is invariably found to consist of a core of contorted Cretaceous clays and Tertiary gravels, on top of which is the true morainal material. This structure is the same throughout Long Island, Block Island and Martha's Vineyard and is manifestly the result of ice action, first squeezing upward and pushing forward the incoherent strata of the coastal plain, afterwards melting and depositing the glacial débris on the ridge thus formed.

Character of the Material.

The morainal constituents comprise practically all rocks which outcrop between Staten Island and the Adirondacks. The boulders most abundantly represented are of diabase, evidently derived from the Newark system of New Jersey, while the bulk of the finer material which enters into the composition of the till is Triassic shale or sandstone, giving to it a prevailing red color. A large number of other boulders have been more or less definitely identified from their lithological characters, but by far the most satisfactory determinations have been made from those in which fossils were found.

Lists of Fossils.

Two lists of these fossils have been prepared. The first contains 112 Palæozoic species, the second 42 Mesozoic species.

I. Palæozoic Fossils found in the Drift on Staten Island.

	NAME.	GEOLOGICAL HORIZON.	LOCALITY.
1.	Ambonychia radiata Hall.	Hudson (Lorraine)	Kreischerville.
2.	Anoplia nucleata (Hall).	Oriskany.	Clifton.
3.	Anoplotheca concava (Hall).	Lower Helderberg.	Clifton.
4.	" flabellites (Hall).	Oriskany.	Clifton. Tottenville.
5.	Aspidocrinus scutelliformis Hall.	Lower Helderberg.	Prince's Bay.
6.	Atrypa reticularis Linn.	Schoharie. Lower Helderberg.	Prince's Bay. New Brighton.
7.	" " impressa Hall,	Schoharie.	New Brighton.
8.	Atrypina imbricata Hall.	Lower Helderberg.	Clifton.
9.	Aviculopecten recticostus Hall.	Oriskany.	Clifton.
10.	" umbonatus Hall.	Lower Helderberg.	Prince's Bay.

I. Palæozoic Fossils found in the Drift on Staten Island.

(Continued.)

	NAME.	GEOLOGICAL HORIZON.	LOCALITY.
11.	Chonophyllum conatum Hall.	Schoharie.	New Brighton.
12.	Chonostrophia complanata Hall.	Oriskany.	Clifton.
13.	Conocardium attenuatum Conr.	Schoharie.	New Brighton.
14.	Cryptopora mirabilis Nicholson.	Schoharie.	New Brighton.
15.	Cyathophyllum rugosum Ed. & H.	Schoharie.	New Brighton.
16.	Cyrtina rostrata Hall.	Oriskany.	Prince's Bay.
17.	Cyrtolites (?) curvilineatus Conr.	Schoharie.	New Brighton.
18.	Cyrtoceras eugenium Hall.	Schoharie.	New Brighton.
19.	Cystiphyllum sp.?	Schoharie.	Prince's Bay.
20.	Dalmanella sub-carinata Hall.	Lower Helderberg.	Clifton.
21.	" concinna Hall.	Lower Helderberg	Clifton.
22.	" testudinaria (Dalm.).	Hudson (Lorraine)	Tottenville. Richmond Valley. Prince's Bay. Rossville. New Brighton.
23.	Dalmanites anchiops Green.	Schoharie.	New Brighton.
24.	Dalmanites micrurus Green.	Lower Helderberg.	Clifton.
25.	" nasutus Conr.	Lower Helderberg.	New Brighton.
26.	" pleuroptyx Green.	Lower Helderberg.	Clifton.
27.	Dictyonema fenestratum Hall.	Upper Helderberg.	Clifton.
28.	Eatonia medialis Vanux.	Lower Helderberg.	Clifton.
29.	" peculiaris Conr.	Oriskany.	Clifton. Prince's Bay.
30.	Favosites emmonsii Rom.	Schoharie.	New Brighton.
31.	Fenestella æsyle Hall. (?)	Lower Helderberg.	Prince's Bay.
32.	" biserialis Hall.	Lower Helderberg.	Clifton.
33.	" nervia Hall.	Lower Helderberg.	Clifton. New Brighton.
34.	" obliqua Hall.	Lower Helderberg.	Clifton.
35.	" parallela Hall.	Schoharie.	Prince's Bay.
36.	" precursor Hall.	Lower Helderberg.	New Brighton.
37.	Fistulipora sp.?	Lower Helderberg.	Tottenville.
38.	Gosseletia mytilimera Conr.	Lower Helderberg.	Clifton.
39.	Heliophyllum exiguum Billings.	Schoharie.	New Brighton.
40.	Hipparionyx proximus Vanux.	Oriskany.	Clifton.
41.	Leptæna rhomboidalis Wahl.	Schoharie. Lower Helderberg.	Prince's Bay. New Brighton. Clifton.
42.	Leptænisca concava Hall.	Lower Helderberg.	Prince's Bay.
43.	Lichas bigsbyi Hall (?)	Lower Helderberg.	Prince's Bay.
44.	" pustulosus Hall.	Lower Helderberg.	Prince's Bay.
45.	Lichenalia concentrica Hall.	Schoharie.	New Brighton.
46.	" sp.?	Lower Helderberg.	Prince's Bay.
47.	Lingula rectilatera Hall.	Lower Helderberg.	Huguenot.
48.	Megambonia sp.?	Oriskany.	Tottenville.
49.	Meristella arcuata Hall.	Lower Helderberg.	Clifton. New Brighton.
50.	" bella Hall.	Lower Helderberg.	Prince's Bay.

I. Palæozoic Fossils found in the Drift on Staten Island.

(*Continued.*)

	NAME.	GEOLOGICAL HORIZON.	LOCALITY.
51.	Meristella lata Hall.	Oriskany.	Prince's Bay.
52.	" nasuta Conr.	Schoharie.	Prince's Bay.
53.	Metaplasia pyxidata Hall.	Oriskany.	Clifton.
54.	Nucleospira concinna Hall.	Schoharie.	Prince's Bay.
55.	Orthoceras pelops Hall.	Schoharie.	New Brighton.
56.	Orthodesma parallelum Hall.	Hudson (Lorraine).	Kreischerville.
57.	Orthothetes woolworthanus Hall.	Lower Helderberg.	Clifton.
58.	Pentamerella arata Conr.	Schoharie.	New Brighton.
59.	Phacops cristatus Hall.	Schoharie.	Prince's Bay.
60.	" logani Hall.	Lower Helderberg.	Clifton.
61.	Phillipsastrea verneuilii Ed. & H.	Schoharie.	New Brighton.
62.	Pholidops arenaria Hall.	Oriskany.	Clifton. Tottenville.
63.	Platyceras nodosum Conr.	Oriskany.	Clifton. Prince's Bay.
64.	Platyostoma ventricosum Hall.	Oriskany.	Clifton.
65.	Plectambonites sericeus (Sow.).	Hudson (Lorraine).	Clifton. Rossville.
66.	Proëtus crassimarginatus Hall.	Schoharie.	New Brighton.
67.	Pterinea communis Hall.	Lower Helderberg.	Prince's Bay.
68.	" gebhardi Hall.	Oriskany.	Prince's Bay. Clifton.
69.	" textilis Hall.	Oriskany.	Clifton. Tottenville.
70.	Pterinopecten bellulus Hall.	Lower Helderberg.	Prince's Bay.
71.	Ptilodyctia tenuis Hall.	Lower Helderberg.	Clifton.
72.	Rafinesquina alternata Emmons.	Hudson (Lorraine).	Prince's Bay.
73.	Rensselæria mutabilis Hall.	Lower Helderberg.	Prince's Bay.
74.	" ovoides Eaton.	Oriskany.	Prince's Bay. Clifton.
75.	Rhipidomella alsa Hall.	Schoharie.	Prince's Bay. New Brighton.
76.	" eminens Hall.	Lower Helderberg.	Prince's Bay.
77.	" oblata Hall.	Lower Helderberg.	Prince's Bay New Brighton.
78.	" peloris Hall.	Schoharie.	New Brighton.
79.	Rhychonella multistriata Hall.	Oriskany.	New Brighton.
80.	" sp.?	Schoharie.	New Brighton.
81.	" sp.?	Lower Helderberg.	New Brighton.
82.	Schizophoria multistriata Vanux.	Lower Helderberg.	Clifton.
83.	Scolithus linearis Hall.	Potsdam.	Tottenville. Prince's Bay. Clifton.
84.	Spirifer arenosus Conr.	Oriskany.	Tottenville. New Dorp.
85.	" arrectus Hall.	Oriskany.	Tottenville. Prince's Bay. New Dorp. Clifton. Old Place.

I. Palæozoic Fossils found in the Drift on Staten Island. (*Continued*).

	NAME.	GEOLOGICAL HORIZON.	LOCALITY.
86.	Spirifer concinnus Hall.	Lower Helderberg.	Prince's Bay.
87.	" cyclopterus Hall.	Lower Helderberg.	Prince's Bay. New Brighton.
88.	" macropleurus Conr.	Lower Helderberg.	New Brighton. Clifton.
89.	" mucronatus Conr.	Hamilton.	New Brighton. Richmond.
90.	" perlamellosus Hall.	Lower Helderberg.	New Brighton Clifton.
91.	Streptelasma strictum Hall.	Lower Helderberg.	New Brighton.
92.	Stropheodonta beckii Hall.	Lower Helderberg.	Prince's Bay. Huguenot. Clifton.
93.	" demissa Conr.	Schoharie.	New Brighton.
94.	" inæquiradiata Hall.	Schoharie.	Prince's Bay. New Brighton.
95.	" magnifica Hall.	Oriskany.	Tottenville. Clifton.
96.	" parva Hall.	Schoharie.	New Brighton.
97.	" perplana Conr.	Schoharie.	New Brighton.
98.	" varistriata Conr. (?)	Lower Helderberg.	Prince's Bay.
99.	" " arata Hall.	Lower Helderberg.	Prince's Bay.
100.	Strophonella ampla Hall.	Schoharie.	New Brighton.
101.	" headleyana Conr.	Lower Helderberg.	Huguenot.
102.	" punctulifera (Conr.)	Lower Helderberg	Tottenville.
103.	" radiata (Vanux.)	Lower Helderberg.	Clifton.
104.	" sp.?	Lower Helderberg.	New Brighton.
105.	Syringopora hisingeri Billings.	Schoharie.	New Brighton.
106.	Taonurus cauda galli (Vanux.)	Schoharie.	Tottenville. Clifton.
107.	Tentaculites gyracanthus (Eaton.)	Lower Helderberg.	Tottenville.
108.	Trematopora corticosa Hall.	Lower Helderberg.	New Brighton.
109.	" regularis Hall.	Lower Helderberg.	New Brighton.
110.	" rhombifera Hall.	Lower Helderberg.	Clifton.
111.	Trematospira concava Hall.	Lower Helderberg.	New Brighton.
112.	Uncinulus nobilis Hall.	Lower Helderberg.	Clifton.

Note.—The identifications in this list were all either made or verified by Professor R. P. Whitfield and Mr. L. P. Gratacap, of the American Museum of Natural History. For the final revision I am indebted to Mr. Gilbert van Ingen of Columbia University.

II. Mesozoic Fossils found in the Drift on Staten Island.

	NAME.	GEOLOGICAL HORIZON.	LOCALITY.
1.	Equisetum rogersi Schimp (?)	Triassic.	Clifton.
2.	Andromeda parlatorii Heer.	Cretaceous (Clay Series.)	Tottenville.
3.	Aralia rotundiloba Newb. (?)	" " "	"
4.	Dalbergia hyperborea Heer.	" " "	"
5.	Dammara borealis Heer. (?)	" " "	"
6.	Dewalquea grœnlandica Heer.	" " "	"
7.	Diospyros primæva Heer.	" " "	"
8.	Eucalyptus geinitzi Heer.	" " "	"
9.	Ficus atavina Heer. (?)	" " "	"
10.	" proteoides Knowlton.	" " "	"
11.	" woolsoni Newb. (?)	" " "	"
12.	Hedera sp. ?	" " "	"
13.	Laurus plutonia Heer.	" " "	"
14.	Liriodendron primævum Newb.	" " "	"
15.	Liriodendropsis simplex Newb.	" " "	Tottenville. Prince's Bay.
16.	Magnolia glaucoides Newb.	" " "	Tottenville.
17.	" longifolia Newb. (?)	" " "	"
18.	Moriconia cyclotoxon Deb. and Ett.	" " "	Prince's Bay. Clifton.
19.	Myrica longa Heer.	" " "	Clifton.
20.	Myrsine elongata Newb.	" " "	"
21.	Paliurus sp. ?	" " "	Tottenville.
22.	Pinus sp. ? (cone and cone scales).	" " "	Tottenville. Clifton
23.	Platanus newberryana Heer (?)	" " "	Prince's Bay.
24.	Populus apiculata Newb. (?)	" " "	Clifton.
25.	" harkeriana Lesq.	" " "	Tottenville.
26.	Proteoides daphnogenoides Heer.	" " "	"
27.	Pterospermites modestus Lesq.	" " "	Tottenville.
28.	Rhamnus pfaffiana Heer.	" " "	Tottenville. Prince's Bay.
29.	Salix inæqualis Newb.	" " "	Clifton.
30.	Sapindus morrisoni Lesq.	" " "	Tottenville. Prince's Bay.
31.	Sequoia reichenbachi Gein.	" " "	Tottenville.
32.	Sterculia snowii Lesq. (?)	" " "	"
33.	" sp. ?	" " "	"
34.	Thinnfeldia lesquereuxiana Heer.	" " "	Tottenville. Prince's Bay.
35.	Tricalycites papyraceus Newb.	" " "	Tottenville.
		" (Marl Series).	
36.	Aphrodina tippana Conr. (?)	" " "	Clifton.
37.	Cardium dumosum Conr.	" " "	"
38.	Gryphæa sp. ?	" " "	"
39.	Ostrea plumosa Morton (?)	" " "	"
40.	Pachycardium burlingtonense Whitf.	" " "	Tottenville.
41.	Terebratella vanuxemi Lyell & Forbes.	" " "	"
42.	Terebratulina atlantica Morton (?)	" " "	"

Note.—In the preparation of this list I am indebted to Dr. Lester F. Ward of the United States Geological Survey, for verifications of doubtful species of plants and to Professor Whitfield for identification of the molluscs. All the species enumerated in the two lists, together with many others not yet identified, are in the museum of the Natural Science Association of Staten Island.

A number of species first described from Staten Island specimens are not included, for the reason that the geological age of such species might be questioned.

SUMMARY AND CONCLUSIONS.

There are but few rock outcrops on the island sufficiently hard to preserve the glacial striæ, but from the few that are available the direction has been ascertained to be between north 13 degrees west and north 20 degrees west, which, if extended northward, may be seen to cross the known outcrops of the rocks represented in the list.

Satisfactory lithological identifications have also been made of labradorite and other crystalline boulders, which would extend the geographic and geologic range of the morainal material at one extremity into the Archæan of the Adirondack region and of sandstone, conglomerate and gravel which would extend it at the other extremity into the Tertiary of the coastal plain. If the lists alone are examined, however, it may be seen that in the Palæozoic the range of the fossils is from the Potsdam to the Hamilton while in the Mesozoic there is represented the Trias and the middle and upper Cretaceous.

There are, therefore, two breaks—the first between the Hamilton and the Trias, the second between the Trias and the middle Cretaceous. Indications of either Carboniferous or Jurassic rocks are entirely lacking, which is in accordance with our knowledge in regard to the absence of any rocks of these periods along the line of glacial movement towards Staten Island.

Probably one of the most interesting facts which may be noted, from an examination of the list of localities, is that the Cretaceous fossils are confined to those parts of the moraine which lie south of the serpentine ridge. Tottenville and Prince's Bay are the two localities at one extremity of the island where they occur, while Clifton is the one locality at the other. Between these two extremities they are absent, and the natural conclusion to be drawn from this fact is that there was never any Cretaceous extending around to the north of the serpentine ridge, otherwise some evidence or at least indications of it ought to occur in that portion of the moraine which rests upon the ridge, but thus far not a fragment of a fossil or piece

of rock, which could be even provisionally identified as Cretaceous in age, has been found there.

The character of this Cretaceous material is identical with that which is found in connection with the moraine throughout Long Island and the islands to the eastward, consisting of ferruginous shaly fragments, or concretionary nodules of hardened clay or marl, due to oxidation of the included iron salts or to the formation of limonite layers over the exterior. The lithologic character of this material, even in the absence of any palæontologic evidence, is so peculiar that once recognized it can not be mistaken for anything else. It evidently represents fragments of clay or marl which have been torn up and included in the moraine, after which it became oxidized and hardened into the condition in which we now find it.

Attention should also be called to the significance of the occurrence of marl fossils at Clifton, indicating beyond doubt that the marl belt, which now has its farthest eastward exposure in New Jersey, at the Atlantic Highlands, must originally have extended across the Lower Bay to Staten Island and occupied part of what is now New York Harbor. This fact gives us the connecting link between what we know of the outcrop of New Jersey and what we infer in regard to its eastern extension, from the occurrence of similar fossils in the moraine of Brooklyn, Montauk Point, Block Island and Martha's Vineyard. Thus far, however, no exposure of marl strata has been found on Staten Island.

Finally, it is of interest to note the relation which the moraine bears to the underlying or pre-glacial topography. Apparently the serpentine ridge served as a more or less effective barrier to the advance of the ice, as indicated by the morainal sinus immediately south of the highest point of the ridge, from whence the ice was deflected eastward towards Fort Wadsworth and southward toward Prince's Bay, forming the lobes in the moraine at those localities and protecting the plain region between by checking the further advance of the ice in that direction.

COLUMBIA UNIVERSITY,
October, 1898.

PLATE I.

PLATE I.

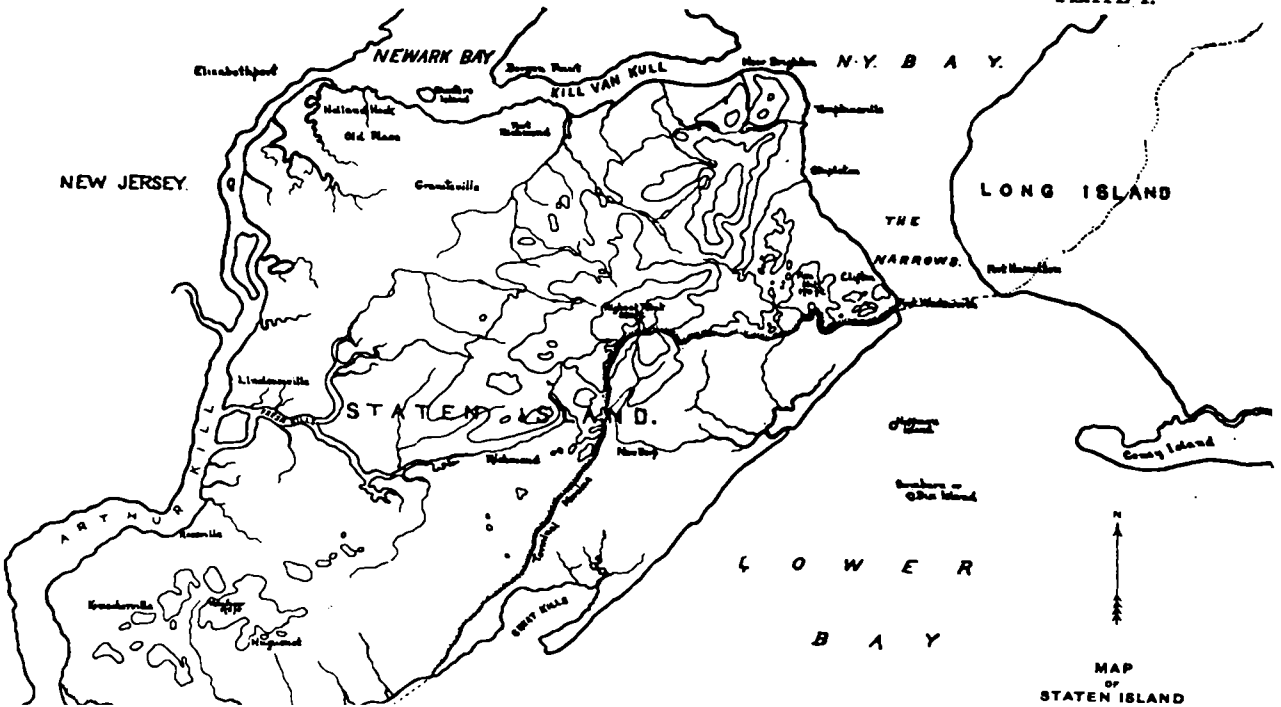
NEWARK BAY
KILL VAN KULL
N.Y. B A Y.
NEW JERSEY
LONG ISLAND
THE NARROWS.
STATEN ISLAND.
KILL VAN KULL
ARTHUR
L O W E R
B A Y
N
MAP OF STATEN ISLAND

PLATE I.

TERMINAL MORAINE ON STATEN ISLAND.

The terminal moraine is indicated by hachure when known, by dotted lines where inferred.