XXV.—*Outline of the Geology of Prince Charles Foreland, Spitsbergen.* By R. M. Craig, M.A., B.Sc., F.G.S. (With Plates XXXVI and XXXVII).

(Read 17th February, 1915.)

I. Introduction—II. Topographic Features—III. Formations: (*a*) Hekla Hoek; (*b*) Conglomerate of North and South Sutors; (*c*) Tertiary; (*d*) Recent Formations:—(1) Raised Beaches, (2) Lagoons, (3) Glaciers, (4) Gravels, (5) Lakes, (6) Erratics, (7) Peat—IV. Acknowledgments.

I. Introduction.

The following outline of the geology of Prince Charles Foreland, Spitsbergen, is based upon—

(1) a number of traverses over the northernmost third of the island and along the west coast as far south as Mount Jessie made by the author during August 1914 as part of the work of the Scottish Spitsbergen Expedition of which he was a member. During the work over the northern part he was accompanied by Mr J. H. Koeppern; in the journey across the island from Richard Lagoon across the St Andrews Peaks to the west coast and along the west coast to Mount Jessie he was accompanied and assisted by Dr W. S. Bruce, leader of the Expedition.

(2) A series of rock specimens collected from various parts of the island by Dr Bruce in 1906, 1907, and 1909.

II. Topographic Features.

The history of exploration and the topographic features of Prince Charles Foreland have already been described by Dr Bruce,[1] who has also published a topographic map of the island on the scale of $\frac{1}{140,000}$. This is the map which the author used during his work on the island and the place names mentioned are those which occur upon it: a photographic reproduction of this map, on a slightly reduced scale, is given in Plate XXXVIII. It is only necessary here to describe briefly the main topographic features, as these are an expression of the geological structure.

Prince Charles Foreland, about fifty-five miles long and from six to eight broad, lies off the west coast of Spitsbergen, from which it is separated by the shallow strait known as Foul or Foreland Sound. The long axis of the island lies approximately north-north-west and south-south-east, that is parallel to the

[1] *Scottish Geographical Magazine*, March 1909, p. 141.

main fault lines[1] on the mainland, of which geologically it forms a part. The central axis of the island is made up of a chain of peaks, many of them over 3000 feet in height, but these mountains are not uniform either in height or in character throughout its whole length, and wide gaps occur. A striking group of peaks, collectively termed the Sidlaws, and including Vogel Hook, Mount Conway, and Mount Barents, marks the northern end. This is succeeded by a region about seven miles long, which includes Mount Balfour, Mount Taylor, and the St Andrews Peaks. By far the most prominent features of this region are two remarkable peaks known as the North and South Sutors which stand at the western end of Glen Mackenzie. This part of the island, with the exception of the Sutors, is marked by the fact that the mountains are relatively low, under 2000 feet; their outlines are smooth and rounded and the valleys between them are wide and well developed. The range of mountains from Mount Chisholm to Mount Jessie comprises at least eight peaks between three and four thousand feet in height, all remarkably alike in structure and appearance. They rise precipitously on the west from a low, flat and narrow plain, but on the east they slope more gently to Foreland Sound. The valleys in this region, especially on the west, are steep-sided, and the watersheds high.

Between Mount Jessie and Mount Methuen the hills are lower, less rugged and are cut through by one well-developed valley called Scotia Glen, which runs from Ferrier Haven on the east to Nathorst Bay on the west, and, unlike the other valleys, in a nearly north and south direction. The southern extremity of the island is marked by a group of low hills known as the Ross Heights, none of them being more than 1400 feet in height. From a distance they have the same general appearance as the mountains at Vogel Hook, but lower and less rugged. Between the Ross Heights and Mount Methuen lies the remarkable stretch of low ground aptly termed the Foreland Laichs, which is a nearly flat plain about 60 feet above sea-level.

Between the mountainous axis and the sea, and running almost completely round the island, is a low plain of variable width rising gently in a series of terraces from sea-level up to a height of about 200 feet. This plain is well developed at the north-east end of the island, where it is of such extent as to have been named by Dr Bruce the Aberdeen Machar.

The northern and southern parts of the island are free from glaciers, and in summer the lower slopes of the hills are free from

[1] De Geer, "Leading Lines of Dislocation in Spitzbergen," *Geol. Fören.*, Bd. 31, Haft 4, April 1909.

snow. Glaciers are confined to the mountainous central part and mainly to the east side. Here a number of valley glaciers coalesce on the low ground and push out to sea, forming in places an ice-cliff 80 feet high. The largest of the east coast glaciers covers practically all the low ground from Mount Chisholm to Mount Geddes and throughout the greater part of its breadth reaches the sea. The northern part is named the Monaco Glacier, the southern the Buchanan Glacier (Plate XXXVI), but these are parts of one continuous glacier. The heights around Mount Hannay form a gathering ground for the Geikie Glacier, which is smaller than the one last described and reaches the sea in Seahorse Bay.

The glaciers on the west side, unlike those on the east, are all small valley glaciers, none of which reaches further than the inner edge of the highest raised beach. The largest of these are the Miller Glacier and another one unnamed occupying the valley between Mount Mathieson and Mount Phipps.

III. Formations.

The following formations are present:—

(*d*) { Peat.
Glacial Deposits.
Raised Beaches, Lagoons.
(*c*) Tertiary.
(*b*) Conglomerate of North and South Sutors (Devonian?)
(*a*) Hekla Hoek (Silurian).

These will be described in order, taking the oldest first.

(*a*) *Hekla Hoek.*

The mountainous axis of the island from Vogel Hook to Mount Jessie, which the author had an opportunity of examining, is formed of the folded members of a great, mainly sedimentary series of rocks, which on the mainland of Spitsbergen has been called the Hekla Hoek series. From organic remains found in these rocks on Bear Island, by Professor Nathorst,[1] they are regarded as of Silurian age, and Professor Nathorst considers that they include representatives of both the lower and upper parts of that system. Rock specimens collected by Dr Bruce from the southern part of the island, which the writer did not visit, show that the remaining southern part of the central axis is, in the main, made up of rocks belonging to the same series.

[1] A. G. Nathorst, "Beiträge zur Geologie der Bären Insel, Spitsbergens, und des König-Karl Landes." *Bull. Geol. Instit. Upsala*, vol. x., 1910.

In the northern half of the island, and probably in the southern also, these rocks are steeply folded and often overfolded towards the north-east. Their general strike is, therefore, north-west and south-east, that is, their outcrops run obliquely across the island in that direction. On the west coast the more resistant beds run out to sea for several miles and the general line of strike determines the trend of the dangerous reefs represented by Fidra Rock, Inch Mickery, the Kittiewake Rocks, etc.

The rocks of the Vogel Hook region are mainly grits and quartzites, the latter white on a freshly broken surface but weathering to a bright reddish brown. The region characterised by rounded hills, *e.g.* Mount Balfour, Mount Taylor, Lord Stair's Heights, and the most northerly of the St Andrews Peaks, is made up of black shales, black and grey limestone along with subsidiary bands of grit and quartzite, the whole forming an assemblage not unlike the rocks which mark the southern margin of the Scottish Highlands. The grits and quartzites and some of the shales weather to a rusty brown colour, as also do some of the limestones, but certain of the black shales and limestones retain their black colour even when weathered, and their appearance has probably given rise to rumours of the existence of extensive coal seams. In the folding to which all the members of the Hekla Hoek have been subjected it is noticeable that the shales and limestones have fared worst. The black shales are crushed, sheared, and often graphitic; the limestones have been crushed, in part recrystallised, and contain numerous cavities filled with various carbonates along with traces of copper and iron sulphides. In the neighbourhood of Richard Lagoon there are numerous limestone bands from 2 to 4 feet thick, and at the east end of Glen Mackenzie, 300 yards east of a small loch, there is a black and grey limestone or marble at least 100 feet thick. This band dips steeply to the south-west and being associated with black shales forms a waterfall in the stream draining Glen Mackenzie. A similar limestone, accompanied by black shales, outcrops with a gentle dip to the south-west on the northern slopes of Mount Balfour and probably represents the northern limb of the asymmetrical fold into which these strata have been thrown. It is to the presence of these relatively soft beds of limestone and shale that the smooth outlines and low relief of this part of the island are due.

The rocks of the St Andrews Peaks, so far as these were examined, were found to consist of thin bedded grits and quartzites with subsidiary beds of crushed and cleaved shale.

The lofty mountains from Mount Chisholm to Mount Jessie, collectively termed the Northern Grampians, are made up of

beds similar to those of the St Andrews Peaks, along with a great thickness of quartzites of Vogel Hook type, thick bands of grey chert and several thick bands of a brecciated calc-chlorite schist. One of these latter forms a well marked feature on the steep western side of Mount Monaco, where it is seen to thicken gradually to the south from 15 to 20 feet. This rock has a very uniform system of jointing, and at the foot of the precipitous side of Mount Monaco great rectangular blocks as much as $20 \times 12 \times 12$ feet, which have fallen from the cliffs above, form a prominent feature. These bands of chloritic schist may possibly represent basic intrusions among the sediments of the Hekla Hoek. If so, they are probably older than the folding to which these beds have been subjected. The height and uniform character of the peaks of the Northern Grampians appear to be due to the presence of these hard quartzites and cherts and to their uniform folding.

The author did not have an opportunity of examining the ground south of Mount Jessie, but rock specimens previously collected by Dr Bruce show that the southern part of the island, including the Foreland Laichs and the Ross Heights, include representatives of the rocks found farther north. Specimens from the Foreland Laichs include black shales and limestones similar to those which occur near the Richard Lagoon, while the Ross Heights possibly include beds like those at Vogel Hook.

The author searched long and carefully in these Hekla Hoek rocks, more especially in the neighbourhood of Richard Lagoon, on both sides of Glen Mackenzie and on the north side of the Gill, but failed to find any determinable fossils. The rocks most likely to contain fossils, however, namely the shales and limestones, have been so crushed that the failure to find any organic remains may be due to the fact that they have been destroyed rather than that they never existed.[1]

The rock specimens collected by Dr Bruce in 1906 and 1907 from the Foreland Laichs and from the neighbourhood of Scotia Glen include, besides examples of Hekla Hoek rocks, a number of specimens of hard black crystalline limestone with abundant carbonaceous matter, also whitish-grey siliceous and highly fossiliferous limestone weathering with a yellow surface. These have been examined by Dr Lee.[2] He finds that the

[1] Dr W. S. Bruce informs me that in 1907 he collected what he considered to be specimens of graptolites from black shales in the Hekla Hoek beds from the shore in the vicinity of Mount Allan and again north of Cape Cold. Unfortunately these specimens were lost. Dr Adolf Hoel of Christiania informs me that he failed to find fossils in the Hekla Hoek rocks during his visit to the Foreland in 1909.

[2] *Proceedings of the Royal Society of Edinburgh*, vol. xvii., no. 4, p. 149.

black carbonaceous limestone contains—*Stenopora Brucei*, a number of brachiopods, *e.g.* *Marginifera*, Rhynchonellids and Athyrids, as well as other forms. The grey limestone contains *Spirorbis*, *Stenopora*, *Fenestella*, *Productus horridus*, *Productus leplayi*, and others. Commenting on the palæontological evidence Dr Lee indicates that "the presence of the genus *Marginifera* points to the Upper Carboniferous age of the black limestone. *Productus horridus* proves the presence of Permian strata on the island, and it is also interesting to note the occurrence of Bryozoa reefs similar to those which are met with in the Zechstein of Germany and the corresponding strata of Yorkshire."[1]

The exposure from which Dr Bruce collected these specimens in 1906 was again examined in 1907 by him along with Dr Rudmose Brown, Mr Hannay, and the late Mr A. M. Peach, when they came to the conclusion that the rocks were not *in situ*.[2] It is possible, however, that Permian and Carboniferous rocks do occur to the south of the summit of Mount Jessie, for certain strata different in appearance from the Hekla Hoek beds and, unlike them, lying almost horizontally, were seen by the author, though time did not admit of their examination. This point can only be settled by further study of the ground.

(*b*) *Conglomerate of North and South Sutors.*

The western end of Glen Mackenzie presents within a small compass one of the finest bits of scenery in the whole island, for here on either side of the mouth of the glen rise two steep and craggy peaks which form prominent landmarks at sea. Both these peaks attain a height of about 1100 feet and have been named by Dr Bruce the North and South Sutors. Rising steeply, especially on the seaward side, they are in great part inaccessible and form in summer a favourite breeding place for numerous sea-birds (Plate XXXVII, Fig. 2). They are both formed of a very coarse conglomerate like some of the conglomerates of the Lower Old Red Sandstone of Scotland, and represent an isolated relic of what was once a much more extensive deposit, for the conglomerate does not extend more than half a mile north of the North Sutor and does not appear at all south of the South Sutor, the whole visible exposure being confined to a strip about a mile long and from a quarter to half a mile broad. Opposite the North Sutor, where it forms a low cliff, this con-

[1] *Ibid.*, p. 165.

[2] Dr Hoel informs me that he examined the same ground in 1909 but failed to find any Carboniferous or Permian beds *in situ*.

glomerate has been cut back by the sea along lines of joint into a series of picturesque chasms. In front of the South Sutor on the beach occurs a small exposure of much crushed and jointed greyish green and brown slate, but the relation of this latter to the conglomerate is not seen. The beach in front of both North and South Sutors is cumbered by enormous blocks of conglomerate which have fallen from the cliffs above.

The conglomerate is composed of boulders, including examples of the shales, limestones, and grits belonging to the Hekla Hoek rocks in the immediate neighbourhood, and numerous specimens of the quartzites and grits of the same series such as occur at Vogel Hook, as well as others of which the origin was not recognised. The matrix in which these boulders lie is sandy, greenish in colour, and much decomposed.

The relation of this conglomerate to the Hekla Hoek rocks of Glen Mackenzie could not be closely examined owing to the inaccessible nature of much of the high ground and to the great development of scree which masks the junction, especially at the foot of the slope. But, whether the plane of contact between the two at this particular part is a fault or an unconformability, it is steep (70° in the case of the South Sutor, somewhat less at the North Sutor), and it dips to the west; and there is certainly a marked discordance between the two. The conglomerate here possibly occupies an indentation in the old coast line along which the waste of the Hekla Hoek beds was deposited.

The absence of fossils, and indeed the unlikelihood of finding fossils in such a deposit, render it impossible to fix the age of this conglomerate more definitely than to say that it is younger than the Hekla Hoek series from the waste of which it has in great part been derived. It is most probably of Old Red Sandstone age and marks the very base of the system. Similar beds have been described from Red Bay in the north-west of Spitsbergen by Hoel and Holtedahl.[1]

(*c*) *Tertiary.*

The presence of rocks of Tertiary age in Prince Charles Foreland was first made known by Dr Bruce, who in 1906 collected plant remains from shales exposed in a stream near Point Carmichael. These plants were examined by Professor Nathorst, who stated "that they must have been collected from the lower plant-bearing horizon at the base of the Tertiary series."[2]

[1] O. Holtedahl, "The Old Red Sandstone Series of North-west Spitzbergen." *Congrès Géologique International*, Canada, 1913.

[2] Quoted from Dr Lee's Paper already cited.

The rocks in which these fossils were found belong to a series which underlies the broad stretch of low ground called the Aberdeen Machar. They are well exposed along the coast from Point Carmichael to Heemskerke Ness (Plate XXXVII, Fig. 1), between which points they are seen to consist of a rapid alternation of coarse and fine conglomerates, yellowish-grey sandstones, and black shales. The dip of these beds is to south-east and varies in amount, being from 30° to 40° at Point Carmichael and decreasing gradually to Heemskerke Ness, where it is not more than 20°. The rapid alternation of different kinds of sediment is well marked, none of the beds at this part being more than a few feet in thickness. The conglomerates contain well rounded pebbles of vein quartz, quartzite, hard black shales and cherts, along with specimens of a green schist. Coarse and fine pebbles occur together in the same band; and the matrix in which these pebbles are embedded is, in the examples observed by the author, a black shale or a black indurated mud.

Between Point Carmichael and Heemskerke Ness these rocks strike out to sea in a north-east direction and the harder beds, usually the sandstones, can be detected at least half a mile from the shore beneath the clear and shallow water of Foreland Sound, because they form a firm point of attachment for *Fucus*, *Laminaria*, and other marine algæ which live here below the limit of the scour of drifting pack ice.

The extension of the Tertiary beds south of Heemskerke Ness cannot be clearly traced, but on several islands in the Richard Lagoon, and at several points on its western shore, a series of sandstones and fine conglomerates, containing abundant but fragmentary plant remains, were observed having a gentle dip to south-east. Similar beds also occur at Point Rottenburg. To the south of this Dr Bruce found them at Point Sword in 1907, and the late Mr A. M. Peach observed rocks at Point Napier in 1909, which he considered to be of Tertiary age.[1]

It seems likely, therefore, that lower Tertiary rocks occupy a narrow but continuous strip of the low ground on the east coast of Prince Charles Foreland from near Vogel Hook on the north to at least as far south as Point Napier.

(*d*) *Recent Formations.*

(1) *Raised Beaches.*—Raised beaches are well developed in Prince Charles Foreland as elsewhere in Spitsbergen. They

[1] Dr Hoel informs me that he definitely proved the presence of Tertiary beds at Point Napier in 1909.

have been carefully studied by the late Mr A. M. Peach,[1] so that no further reference will be made to them here.

(2) *Lagoons.*—One of the most striking features of the coast of Prince Charles Foreland is the presence of a number of shallow lagoons, generally with a narrow entrance through which they partially fill and empty with the tides. Numerous examples occur, especially on the west coast, *e.g.* Dyer Lagoon, Kerr Lagoon, and the Wilson Lagoon. By far the largest and most striking is the Richard Lagoon which occurs on the east coast between Heemskerke Ness and Point Rottenburg. It is about 5 miles long and from ½ to 1 mile broad. Its seaward boundary consists of two banks nearly equal in length, about 10 feet high and from 30 to 50 yards broad, made up of well-rounded and water-worn coarse shingle and small boulders. The northern bank runs south-south-west from Heemskerke Ness, the southern north-north-west from Point Rottenburg. The entrance between the ends of the banks is about 50 yards wide. Just within the entrance is a fan-shaped bank partially uncovered at low water, on either side of which is a narrow channel from ½ to 1 fathom deep at low tide, and this seems to be the average depth within the lagoon though the southern half is probably somewhat shallower than the northern. From the southern of the outer banks a number of tapering ridges of sand and fine gravel run inwards at right angles to the land. The bottom over the greater part of the northern half was observed to consist of a fine grey mud with occasional stones, and showed numerous worm casts and a sparse crop of various marine algæ. In a fine silt at the northern end and just above high-water mark a number of empty valves of *Mya truncata* and *Saxicava arctica* were found, and that the sheltered waters support abundant marine life is shown by the number of sea-fowl to be seen fishing there. Dotted over its surface are several islets of two kinds. Some are merely shifting banks of sand and gravel; others are formed of rock and are composed of the yellow sandstones and fine conglomerates which have already been noticed as possibly a southerly extension of the Tertiary beds of Heemskerke Ness. These rocky islets rise 2 or 3 feet above high-water mark, and in virtue of their greater stability carry a sparse peaty soil and are used as nesting places by sea-birds.

At half tide the current at the entrance must run at a rate of at least six or seven miles an hour, and the outflow caused by the ebb tide forms a "roost" or tidal race in Foreland Sound, at least a mile from the shore. A number of fair-sized streams

[1] A. M. Peach, "The Preglacial Platform and Raised Beaches of Prince Charles Foreland," *Trans. Edin. Geol. Soc.*, vol. x., p. 289, 1916.

flow into the lagoon from the neighbouring land, and the amount of fresh water gained in this way, especially in early summer, during a single tide must be considerable.

The two long narrow banks which limit the lagoon on its seaward side are so regular in character as to appear artificial rather than natural. They are made up, as already stated, of rounded, water-worn coarse shingle and stones up to a foot or more in diameter. Most of this material has been derived from the Hekla Hoek series and from the Tertiary beds in the vicinity; the shallower parts of Foreland Sound are covered with similar material.

Concerning the mode of formation of this lagoon little can be said, observations upon it extending over so short a period, but it may be stated that the material composing the outer banks has most probably reached its present position from the outside, for the boulders and shingle composing them resemble the banks which can be seen in the shallower parts of Foreland Sound, and material of that size is not at present being moved by water operating inside the lagoon, for the mouths of the streams which flow into it are marked by sand and fine angular gravel. Again, the bottom of the northern half is composed of mud, that of the southern mainly of sand and fine gravel. It is suggested, therefore, that the rapid erosion of the coast which is taking place in the immediate neighbourhood has supplied the material which by wave action has been driven across what was a shallow bay between Heemskerke Ness and Point Rottenburg. These banks once formed have been pushed landward by stranded pack-ice, their irregular hummocky surface, and the lack of arrangement among the material composing them, being probably due to this cause. The entrance is no doubt kept open because, owing to the great supply of fresh water from the land, in summer at least, the scour of the ebb tide is greater than that of the flood tide.

The other lagoons in the island, some of which have been already mentioned, have the same general characters as the one just described, but they are smaller and less symmetrical. It is interesting, however, to note that several examples occur high and dry on the raised beaches. Some of these are on the Aberdeen Machar, but the best one which the writer had an opportunity of examining, lies on the second highest terrace on the west side of the island opposite Mount Mathieson. It is a small lagoon 300 yards long and half as much in breadth; the shingle banks on the seaward side with the opening which formerly communicated with the sea, remain as fresh and well marked as when first formed. Another example of the same

kind was observed by Dr Bruce about 60 feet above sea-level to the north of Mount Allan.

(3) *Glaciers.*—The nature and distribution of the chief glaciers has been already noticed, but as time did not admit of their detailed study a few points only are here set down.

The Monaco glacier at its northern end does not now reach the sea probably owing to the diminished snow fields of the lower hills immediately behind it. The terminal moraine at this part sweeps in a gentle curve from Murray Ness first to the north then to north-west and at its northern end nearly west. The narrow strip of ground next the sea, about 500 yards broad, is covered by a mixture of rounded and sub-angular stones, apparently a mixture of the material of the youngest raised beach and fluvioglacial gravel. Between this strip of ground and the present terminal moraine the ground is occupied by a grey-blue plastic clay with sub-angular stones —an unconsolidated boulder clay which renders this part almost impassable. Numerous small and shallow lochs occur occupying hollows in the gravel and in the clay, and numerous streams trickling through the terminal moraine make their way along gravelly and stony channels to the Richard Lagoon. These streams were noticed to have their flow markedly affected, increased or diminished, even during twenty-four hours, according as the temperature rose or fell even a few degrees above or below freezing point. At its northern end the Monaco glacier seems to have retreated at least 600 yards since the period of the youngest raised beach. The boulder clay at this point does not seem to be more than a few feet thick, and further south Dr Bruce informs me it is even thinner.

The glaciers on the west side of the island are small compared with those on the east, because the watershed is nearer the west side; the valleys in which most of them occur are short and steep. None of the west coast glaciers now reach the sea, nor in fact further than the inner margin of the highest raised beach; but that some of them extended much further at a comparatively recent date is shown by the occurrence of several patches of ice half way between the ends of several of the glaciers and the sea. One of these, which will serve as an example, lies about half a mile in front of the glacier (unnamed) which occupies the valley between Mount Mathieson and Mount Parnassus. It consists of a lenticle of ice from 3 to 4 acres in extent, flat-topped and saucer shaped on its under surface and from 5 to 8 feet thick in its thickest part. It appears to occupy a hollow, and at the time the writer visited it a small stream from the glacier had cut a channel completely through it and was washing out all the

finer material underneath, leaving only gravel. The ice was pure and contained no englacial material.

Numerous examples of small hanging glaciers also occur, especially on the steep western face of Mount Monaco and Mount Jessie.

(4) *Gravels.*—The streams issuing from the ends of the smaller glaciers have re-sorted the moraine material, washing out and carrying away the finer material and pushing forward the gravel in cones, covering and partially obliterating the highest raised beach.

(5) *Lakes.*—The whole of the low ground is dotted with numerous lakes, mostly small and, so far as observation went, shallow. Most of these occupy depressions in the gravel of the raised beaches and form favourite breeding places for numerous sea-birds.

Inland, however, on higher ground, lakes of glacial origin were observed. In Glen Mackenzie there are two small lochs, one on each side of the watershed. The one which drains to the east is a rock basin, the other which drains to the west is held up by a moraine. Two beautiful examples of rock basins, unmarked on the map, were discovered during a traverse of the island from the west coast through the Gill to Richard Lagoon. Both occur about 1100 feet above sea-level at the foot of a short steep slope between the peaks marked 418 and 446. They are elliptical or nearly circular in outline, about 100 yards in greatest breadth, and when visited were found to have about one-third occupied by the snout of a small glacier.

(6) *Erratics.*—Numerous erratics were found scattered over the island at various levels. Most of these were observed to be blocks of the Hekla Hoek rocks, such as occur in the immediate neighbourhood, and may not have come from any great distance. A few, however, apparently confined to the low ground, must have come from a distance. Two of these occur on the beach near Point Carmichael. Both are masses weighing 3 or 4 tons of a grey biotite granite, and that they once formed part of a plutonic mass which invaded an area of metamorphic rocks is shown by the fact that they contain numerous included fragments, from an inch to six inches or more in length, of a finely laminated mica schist. Mr J. Mathieson informs me that similar boulders, and also examples of what he describes as red granite, occur on the Foreland Laichs. Rocks of this kind have not hitherto been found in situ in Prince Charles Foreland, but an area from which they may possibly have been derived is known to exist in the north-west corner of the mainland of Spitsbergen in the neighbourhood of Red Bay.

(7) *Peat.*—The vegetation of Prince Charles Foreland,[1] which is sparse and of the usual Arctic type, is confined mainly to the low ground, to the neighbourhood of bird-rookeries, and to the flat tops of talus slopes. The vegetation on the west side is much more luxuriant than on the east. Formation of peat is therefore rare, but, on the driest portions of the Foreland Laichs, the Aberdeen Machar, and around the Richard Lagoon a thin film of peat a few inches thick has been formed. On the west side of Vogel Hook, and resting on the highest of the Horne Beaches, a deposit of peat about 2 feet thick occurs. At the west end of Glen Mackenzie near the South Sutor a deposit of the same material in places as much as 3 feet thick has been formed.

IV. Acknowledgments.

In conclusion, I wish to express my hearty thanks to Dr W. S. Bruce, leader of the expedition, who placed his wide knowledge of Prince Charles Foreland and other parts of Spitsbergen entirely at my disposal. He personally accompanied me along the west coast, and without his help and his knowledge of travelling in that difficult region it would have been impossible for me to see so much of the island.

It gives me pleasure also to acknowledge my indebtedness to Dr Hoel of the University of Christiania, who very kindly furnished me with information about parts of the island which, from lack of time, I was unable to visit.

I have also to express my thanks to the Carnegie Trust for the Universities of Scotland for a grant to defray the cost of the illustrations which accompany this paper.

Explanation of Plates.

Plate XXXVI.

Prince Charles Foreland, east side. The Northern Grampians, steeply folded Hekla Hoek Beds. Part of Buchanan Glacier in the foreground.
W. S. Bruce, *photo.*

Plate XXXVII.

Fig. 1.—Prince Charles Foreland, east side. View looking north from Heemskerke Ness. In the foreground raised beeches resting on Tertiary rocks. In the background the Hekla Hoek beds of Vogel Hook.
J. H. Koeppern, *photo.*

Fig. 2.—Prince Charles Foreland, west side. View looking north from Cape Sitoe. Sutor Conglomerate in foreground, raised beaches in middle distance, Vogel Hook in distance. J. H. Koeppern, *photo.*

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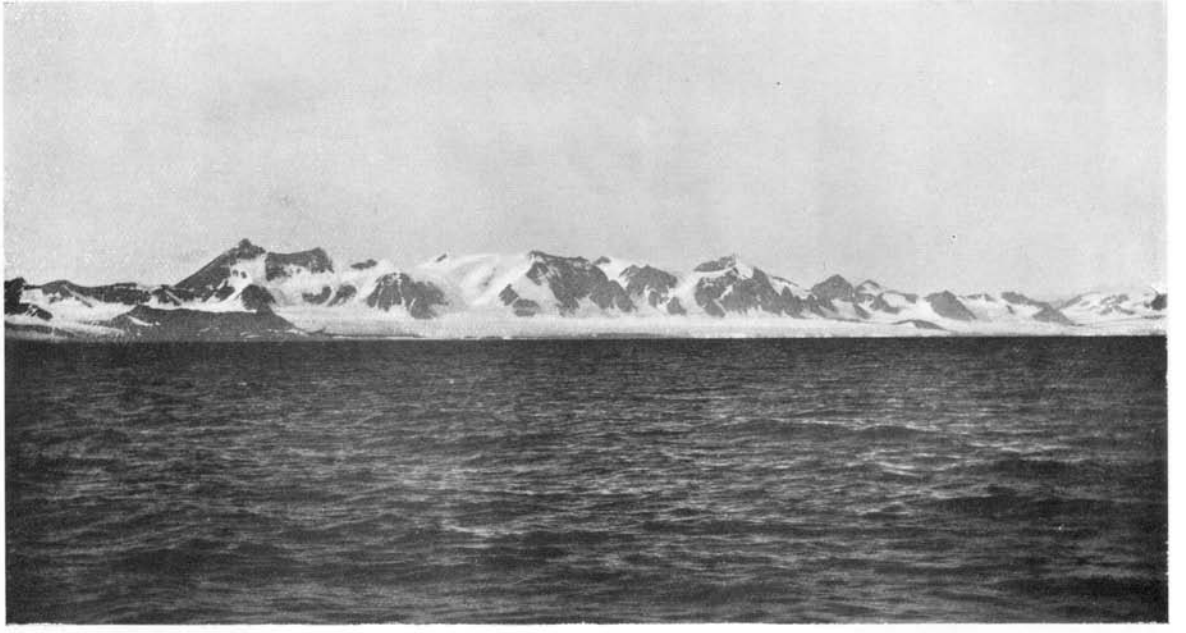
[1] Dr R. Brown, *Trans. Bot. Soc. Edin.*, vol. xxiii., 1908, p. 313.



Prince Charles Foreland, Spitsbergen, east side.

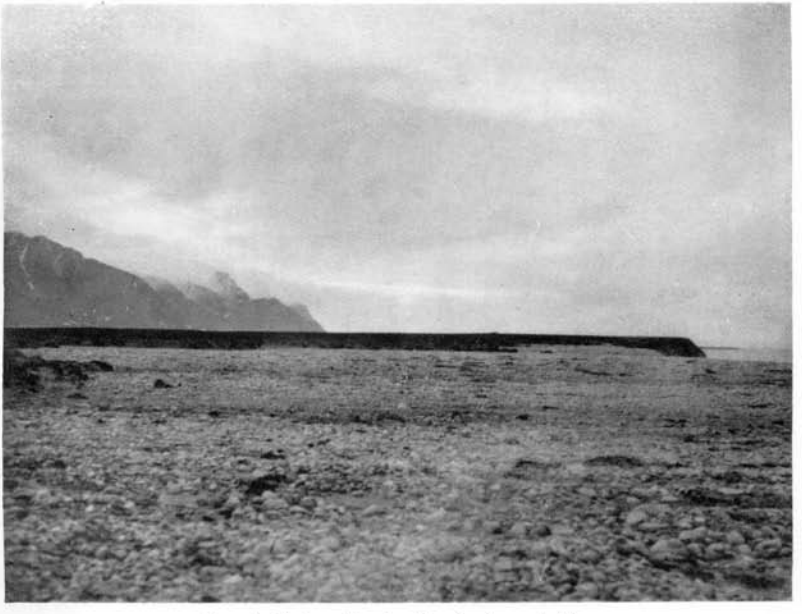


FIG. 1. Prince Charles Foreland, east side.

FIG. 2. Prince Charles Foreland, west side.