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ACCOUNT OF AN EXPEDITION TO GREENLAND IN THE YEAR 1870.

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Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

Part I.

(PLATE VII.)

THE information gained by us during the first three Swedish expeditions to Spitzbergen having, either directly through our own experience, or indirectly through conversation with most of the intelligent and bold whalers and walrus-hunters of Northern Norway, fully confirmed the observations of Scoresby, Phipps, Tschitschagoff, Parry, Buchan, Franklin, Clavering and others, respecting the impossibility of penetrating by ship during the summer through the crowded ice-masses to the north of Spitzbergen, far beyond the 80th degree of latitude, an Arctic Expedition was sent out from Sweden in 1868, having for its object, among other things, to renew during the autumn months the attempt to sail towards the Pole from the northern coast of Spitzbergen. I have, in a report[1] of the expedition of 1868, given a brief account of the result of that undertaking, which showed that even at that period of the year, when the water is most free from drift-ice, the polar basin, at least to the north of Europe, and doubtless also to the north of America and Asia, is so full of drift-ice that all possibility of passing through it in a ship is out of the question.

This unsuccessful attempt did not, however, diminish the interest in Sweden for the polar question, but seemed, on the contrary, to excite to new exertions in the same direction. Almost immediately on the return of the expedition (1868), preparations were set on foot in Gothenburg to collect the necessary means for a new polar expedition, the object of which was to proceed during winter from the Seven Islands by sledge towards the Pole, and in less than a year the amount considered necessary for the purpose was collected.

It was our intention to use Greenland Esquimaux dogs for the proposed sledge-journeys. I determined, however, first personally to convince myself of the applicability of these animals as beasts of draught, and of the possibility of obtaining a sufficient number, and

[1] Proceedings of Royal Geogr. Soc., xiii., No. iii., p. 151 (1869).

this gave occasion to the expedition to Greenland, which forms the subject of the present description. But, before specially entering upon this subject, I take the opportunity to offer a few brief observations on the many suggestions that have been made and discussed by geographers concerning the most practicable way of approaching the Pole, and thus explain more in detail the reasons for the choice made by us of the proposed starting-point, plan, etc., of our expedition.

The real polar basin north of the 80th degree may be approached by the following ways:—

1st.—*Way to the east of Spitzbergen.*—Petermann has proposed that an attempt be made to pass, *by ship*, through the broad channel that separates Spitzbergen from Nova Zembla.

Respecting the condition of that sea ("Spitzbergen Sea," Petermann), as regards ice, we are in possession of numerous observations, made partly by older polar travellers, or rather searchers after a north-east passage; partly by the expeditions repeatedly sent to that part by the Russian Government; and lastly by sundry German, English, and especially Norwegian hunting and fishing expeditions of late years. These observations all agree that an unbroken ice-belt extends between these islands, at least as far as the 78th or 79th degree of latitude, leaving, in favourable years only, a broad channel running to 80°, partly along the east coast of Spitzbergen, and partly along the western coast of Nova Zembla.

How difficult it is, east of Spitzbergen, to reach as far as 80°, is evidenced by the circumstance that out of all the many attempts that have been made to sail round Nova Zembla, only one has succeeded, viz., Johannessen's remarkable voyage in the summer of 1870.[1] Norwegian fishermen from the south, though attracted by a rich booty, have never, on the eastern coast of Spitzbergen, reached 80°, and, although one might probably on the western coast reach the Seven Isles every year, the passage round the north-eastern extremity to the Thousand Isles has only once been successfully attempted, and even then with the hazard of being driven by the adjacent ice-fields upon the steep glaciers of the north-east land, and there crushed, as happened in 1864 to three fishing vessels. It is therefore utterly impossible to proceed by ship in this direction, nor does either Nova Zembla, or the eastern coast of Spitzbergen, or the as yet but little known Gillies Land, offer any easily accessible starting-point for sledge-journeys, situated sufficiently north. This course is then hardly to be thought of for a polar expedition with any prospect of success.

2nd.—*The way along the eastern coast of Greenland*, also ardently urged by Petermann. Numerous expeditions—of which only a few have been able to penetrate the ice so as to approach the coast, and only two, viz. Clavering and Sabine's in 1823, and the German polar expedition of 1869–70, reached 75°–76°—have made known that portion of the Arctic Ocean; and we know that the sea here, even at

[1] This was written in December, 1870. The expedition of the last summer seems to me wholly to confirm the result of the older expeditions, but by no means to prove the existence of an open polar sea extending to the Pole.

60° lat., is more impassable than at a corresponding latitude in any other part of the northern hemisphere. A broad, almost always densely-crowded, stream of ice is constantly carried down by the north polar stream, not only along the whole eastern coast of Greenland, but, during a great part of the year, past Cape Farewell a considerable distance into Davis Strait. Among the many empty reasons often adduced for the existence of an open polar basin, this stream is also appealed to, by which it is alleged that the ice in the polar basin must shortly be carried down into the Atlantic. A simple comparison of the extent and velocity of the ice-stream with the area of the polar basin is sufficient to show the futility of this argument. If we suppose the entire limit of the stream to lie in 5° west longitude from Greenwich, its breadth will be about 200 miles. With a velocity of four miles a day—(the German expedition, 1869-70, after the wreck of the "Hansa," drifted about 600 miles southward in 200 days)—by this process about 100,000 square miles would be removed from the polar basin during June, July, August, and September; that is to say, in the course of the months during which new ice is not forming in the polar basin, an area which does not constitute the tenth part of that basin north of 80°.

The following enumeration of the attempts which have been made to penetrate to the eastern coast of Greenland fully shows the difficulties met with in this part of the polar basin.

1579.[1] Jacob Allday was sent out by the Danish King, Frederick II., to rediscover Greenland, advanced so far as to see the east coast, but returned, as the ice nowhere permitted him to land (Rink).

1588 (1581 Rink, 1578 Graah). Mogens Heinesen was sent to rediscover Greenland for the benefit of Denmark, but returned without having been able to land.

1605. A new Danish expedition was sent out, under Godske Lindenow, and reached a harbour, probably on the south-western part of the coast (Rink).

1607. Carsten Richardsen was sent out to Greenland, but was everywhere prevented by ice from landing.

1607. H. Hudson reaches the eastern coast of Greenland, at 73½° latitude.

1652—54. Three expeditions, provided by H. Möller, and commanded by David Danel. These expeditions sailed along a considerable part of the west coast of Greenland, and had *nearly, but only nearly*, succeeded in landing on the east coast.

1670. A Danish expedition, sent out under Otto Axelsen. The expedition returned without accomplishing its object; hindered, in all probability by drift-ice from landing on the eastern coast.

[1] In this account, in which I have principally confined myself to the last generally known Danish expeditions, because their especial object was to reach East Greenland, I have followed partly W. A. Graah, *Undersögelses-Reise til Östkysten af Grönland. Kjöbenhafn*, 1832, and partly H. Rink, whose excellent work, richly stored with observations, "*Grönland, geographisk och statistisk beskrevet*," 3 Delar. *Kjöbenhafn*, 1852-1857, I have frequently made use of in this account.

1671. A new expedition, sent out under the same person. The expedition never returned, being most probably wrecked amidst the drifting ice.

1751—1753. Peder Olsen Vallöes' remarkable expedition in an "umiak" (Greenlandish boat rowed by women) from the west coast round Cape Farewell, in which he, in spite of a thousand difficulties amidst the crowded ice-masses, succeeded in reaching 60° 28′.

1786—1787. Expeditions under Lövenörn, Egede, and Rothe endeavoured to penetrate from Iceland to east coast of Greenland, but could only see its lofty hills at a distance. The land being rendered quite inaccessible by ice.

1819. Scoresby succeeded in reaching the east coast of Greenland, which during his many years of whaling-voyages he had always previously found completely blockaded by ice.

1823. Sabine and Clavering sail from Spitzbergen to the eastern coast of Greenland, which they reach in latitude 74°—75°.

1828—1831. Graah's journey round Cape Farewell, in a "koneboad." He succeeded with great difficulty in reaching 65° 15′ N.L. His account of his journey, which Dr. Petermann adduces as evidence that the east coast is free from ice, gives us clearly to understand, that it is only under very unusually favourable circumstances that a ship can make its way in these parts through the packed ice-masses.

1868. Dr. Petermann's expedition, under Capt. Koldewey, strenuously but vainly endeavoured to approach the eastern coast of Greenland.

1868. The Scottish whaler *David Gray* finds the east coast of Greenland free from ice at 74° N.L.

1868. The Swedish Polar expedition endeavours twice to approach the eastern coast of Greenland to the north of the 78th degree, but was, in the longitude of Greenwich, hindered by impenetrable masses of ice from proceeding farther towards the east.

1869. The second German Polar expedition under Koldewey and Hegemann. One ship lost in 70° 50′ N.L. among the ice-masses on the eastern coast, and the brave crew borne down among the densely packed ice-masses to the southern extremity of Greenland. The other ship reaches land at 75°—76°, but finds the ocean to the north completely blockaded by ice.

When we consider that all the Danish expeditions were undertaken with the expectation of recovering almost a northern Eldorado, which (as they imagined) had formerly been every year sailed over in frail Vikings' vessels,—and that these expeditions were conducted by efficient seamen well practised in their work by expeditions to Iceland and Finmark, at a time when not only Dutchmen and Englishmen, but also the Danes themselves, in other parts of the polar regions, had penetrated so far that even up to the present time in many places no farther advance has been made,—their repeated failures must surely prove, not only the impossibility of reaching the Pole by this course, but also the unfitness of East Greenland as

the starting-point for such expeditions, whether the object be to attain the Pole on board ship, or in a boat, or by dogs, or any other method of conveyance.

3rd. *The way through Behring's-strait,* proposed by Gustave Lambert. The waters north of Behring's-strait are one of the least known parts of the Arctic Ocean; it is, however, known that the sailor is there met by impassable ice-masses in a latitude where to the north of Europe scarcely any signs of ice are met with, even in the midst of winter, and that only a most unusual occurrence made it once possible for a whaler in these parts to reach 73° 30′ N.L. To choose this course for an expedition towards the Pole would therefore be contrary to all reason; and when the proposer of this plan, in a public lecture, stated that it might be confidently expected in France that the Tricolour would be waving at the North Pole of the Earth by the time the news of the expedition's arrival at the Sandwich Isles should reach Paris, it showed but a sorry acquaintance with the state of the Polar Seas—unless, indeed, we are to consider the words as a mere rhetorical phrase. Nevertheless, it may be adduced as one among various reasons that might be given for an Arctic (not Polar) expedition to these parts, that here, in the narrow strait between the old and new worlds, so many circumstances are as yet unexplored in natural history, geology, ethnography, and geography, that such an expedition, even if unable to proceed to the 80th degree, would probably furnish important scientific results, and greatly extend our knowledge of the wonderful kingdom of nature than a polar expedition following any other of the possible routes (over Spitzbergen or Smith's Sound), even if that expedition were crowned with perfect success. But if an expedition to Behring's Straits is to be of any value, it is an indispensable condition that it be manned, not with curious and adventurous tourists, but with men fully competent for scientific research.

4th. *The way over Spitzbergen,* and

5th, *that over Smith's Sound.*—These routes have been recommended by English, American, and Swedish polar voyagers, and as, in my opinion, it is only by choosing one or other of them as a starting-point that any prospect of attaining the proposed end can be entertained, and as moreover the advantages they each offer are in general of the same kind, I shall accompany this reference to them by a few short remarks on them in common.

The name "Polynia," imported from Siberia, has unfortunately produced a very considerable confusion of ideas in geographical science. In the first place, Polynia has been erroneously interpreted as a sea free from ice and accessible to ships, whereas, on the contrary, that word signifies sometimes a sea covered with broken ice (but not on that account navigable), sometimes a greater or smaller opening in an ice-field produced by accidental circumstances. Again, contrary to all real experience, the whole polar basin has been declared navigable simply because the famous Russian polar explorer, Wrangel, found a Polynia some miles north of the northern coast of Siberia, in about the latitude of North Cape, and Stewart,

in an American polar expedition, (as we now know through Petersen's more critical description,) gave a very exaggerated account of a larger opening in the ice in a part of the Polar Sea situated to the north of Smith's Sound, which nevertheless was not accessible even to a boat from the adjoining Rensselaer Harbour. In the observations of Wrangel, Kane, and Morton, I cannot discover any signs of a reason for assuming the existence of an open Polar Sea. It is, however, of importance in fitting out such expeditions as endeavour to approach the Pole on the ice by sledge, inasmuch as it shows that one cannot, even in the midst of winter, reckon on an unbroken field of ice. The travellers in these sledge-journeys will thus be obliged to take with them a boat of sufficient dimensions to contain the whole company, and so light as not too much to limit the number of days for which they can carry provisions. This circumstance renders it necessary to choose for starting-point an easily accessible spot situated as far north as possible; and a glance at the terrestrial globe shows us that only two points can be thought of for such a purpose, viz. the northern coast of Spitzbergen, and the most northerly part of the west coast of Greenland, or perhaps rather the corresponding part, Grinnel-land, situated on the other side of the narrow Smith's Sound. Each of these routes has its advantages. Spitzbergen lies near Europe, and is accessible all the year up to a latitude somewhat exceeding 80°, and one can almost every year sail over a sea free from ice even north of the Seven Islands.

An expedition, with the north coast of Spitzbergen for its base, might then choose as its starting-point a spot situated very considerably nearer the Pole, than if it set out from Smith's Sound, where it is hardly possibly to reckon on penetrating by ship much beyond 78°. This advantage on the side of Spitzbergen is however, in a great measure, if not wholly, counterbalanced by the circumstance, that in proceeding from Smith's Sound one advances for a considerable distance with land alongside, an immense advantage in the establishment of depots, etc., as also, though perhaps in a less degree, by the fact that the coasts at Smith's Sound are inhabited by an Esquimaux tribe, which, although now since its contact with Europeans thinned and dying out, can nevertheless, in spite of its helplessness, during the long and dangerous winter night, offer an assistance to an expedition that is to pass the winter there, which can hardly be compensated by any outfit from home, though designed with all the aids of civilization. For an expedition that can command unlimited pecuniary means, that is furnished with provisions for several years, and can afford to lose one or two of its ships in attempting to advance to winter quarters north of Rensselaer Harbour, I conceive, therefore, that this route may be preferable.[1] But with

[1] An expedition sent from America or England over Smith's Sound ought undoubtedly to have at its disposal several ships provided with steam, one large vessel, which should never proceed to parts from which it cannot with safety return, and several smaller (60 to 100 tons), which at different times and by different routes should endeavour separately to advance through the ice, secure, in case of wreck, of

the means at the disposal of the Swedish expedition, Spitzbergen ought to be chosen as the starting-point, more especially as we are thus enabled to lay the last stone upon a series of researches carried on during the course of several years concerning the physical condition and natural history of Spitzbergen.

These are the considerations to which most weight has been assigned in devising the plan of the Swedish expedition, which is to proceed to the north in 1872. It is intended that the expedition shall consist of three or four scientific men (among whom are to be a natural philosopher and a zoologist, the latter for the study of marine animal life during the winter), with the necessary crew, and that it shall pass the winter in a cot erected for the purpose, if possible, on the Seven Isles, with a magnetic observatory, storehouse, etc. From this point the expedition is to make during the latter part of the winter sledge-journeys northward, and, if the time admit of it, eastward toward Gillies Land. But it will be time to communicate further notices of this proposed polar colony, its composition, preparations, etc., when it is in possession of that of which it is as yet destitute—the interest of a *fait accompli*. I therefore proceed to a description of this summer's journey to Greenland, undertaken, as has been already mentioned, as preparatory to the polar expedition itself, occupying myself less with our own adventures, which for the public in general are but of little interest, than with giving an account of the scientific results obtained.

Greenland is not only the first land discovered in the new world, but it is the oldest European colony on the other side of the Atlantic, which, ever since its first planting, near a thousand years ago by Norse-Icelandic Vikings, has constantly, though for a time forgotten, belonged to the same mother-land; and it is honourable to that mother-land that the wild tribes, which for a while after the foundation of the colony came in contact with the colonists, have not been brought into that degraded condition indicative of speedily impending extinction which is the case with the original inhabitants of many other lands visited by European civilization. The Greenlanders, on the contrary, seem to be in a fair way of development to a small peculiar nationality, which is in a certain degree acquiring the culture of the Caucasian race. Already almost every West-Greenlander can read and write; a number of small works, not only on religion, but on history, geography, and natural history, are printed in Greenlandish; and a Greenlandish newspaper, which in respect of typography may vie with most of the European popular newspapers, is printed at Godthaab.

Greenland, as is known, belongs to Denmark, but is not governed by the ordinary state authorities, but by a Trading Directory (origin-

the possibility of returning to the depot-ship. Should any of these small vessels succeed in reaching an anchoring-place, e.g. in 81° lat., the success of the expedition would be much better secured than if the large vessel wintered in say 79° lat.; and if one of the small vessels should be lost, the loss is comparatively trifling. Such an event need not be accompanied by loss of life.

ally a private trading company), which has for its object to trade with the inhabitants for the benefit of the Danish state, that is to say, to buy up at certain, often merely nominal prices, train oil, skins, down, and other of Greenland's hunting and fishing productions, and to supply the Greenlanders with European wares instead, many of which, as for example firearms, ammunition, coffee, sugar, bread, have long been necessaries to the inhabitants. The chief management of the Greenland trade is confided partly to certain Directors residing at Copenhagen, partly to two resident Inspectors immediately appointed by the ministry. Under these are at present eleven Colonial Governors resident in Greenland (Julianshaab, Fredrikshaab, Godthaab, Sukkertoppen, Holsteinsborg, in the inspectorate of South Greenland; and Godhavn, Egedesminde, Jakobshavn, Ritenbenk, Omenak, Upernivik, in the inspectorate of North Greenland). To aid the Colonial Governors, they have "assistants" and "volunteers" (aspirants to the place of colonial governor), as also "emissaries" ("utliggare"). These last-mentioned offices are sometimes given to Greenlanders, the others exclusively to Danes. There are also in every colony some Danish artisans.

The shipping business in Greenland is carried on by the Greenland trade in the Company's own ships, which, as the cabins are fitted up to receive three or four passengers, offer a cheap though slow passage. The time of starting from Copenhagen is from the month of April to June, and all the vessels, unless hindered by ice, as sometimes happens in the harbours of South Greenland, return in the autumn, usually in the middle or at the latter end of September. A few of the ships, that have sailed earliest, return however in July, so as to make a second journey during the summer. The passage out usually occupies five to eight, the return voyage three to six weeks.

In the veteran ship of the company, the brig "Hvalfisken," commanded by Captain Sejstrup, the Swedish expedition departed from Copenhagen on the 15th of May, 1870. My original intention was only to make a short visit to Greenland, in order to take some steps preparatory to the contemplated polar expedition. I was however but little inclined to consecrate the whole summer to that purpose, and determined accordingly, with the permission of one of the most liberal patrons both of the preceding and the coming expeditions, Mr. Oscar Dickson, to expand the tour to Greenland into a little unpretending expedition, having for its object not only to make preparations for the future polar expedition, but also to carry on such researches in natural history, geology and geography as might be of importance in arranging the collections and observations made at Spitzbergen. For this reason the number of members of the new expedition was increased to four, including, besides myself, Dr. Sv. Berggren from Lund, also Dr. P. Öberg and Dr. Th. Nordström from Upsala.

Our plan was, on arriving in Greenland, to set in order and completely man, either with Danes or natives, two whale-boats. With one of these Dr. Nordström[1] and I were to penetrate into Auleitsi-

[1] During the voyage over Dr. Nordström caught a cold, which fortunately was not

vikfjord, never previously visited by European, and up to the present time not mapped; afterwards, for the purpose of geographical investigations, and especially for collecting fossil plants, we were to go round the shores of the Waigat, Disko Bay and Omenakfjord. Dr. Öberg and Dr. Berggren were, on the other hand, to travel in their boat round Disko Bay, and collect contributions to its flora and fauna. Öberg was for this purpose furnished with abundant zoological apparatus.

The undertaking excited, as usual, much interest at home. His Swedish Majesty's fleet, among other things, provided the expedition with the necessary apparatus for sounding, and the Royal Academy of Science in Stockholm lent chronometers, astronomical instruments, etc.

In the earlier times of communication with Greenland, the passage out was united with great difficulties, owing to the quantities of drifting ice met with in doubling Cape Farewell; experience however afterwards showed that this inconvenience might be almost entirely got rid of by entering Davis Strait between 57½° and 58½° N.L., that is, at least 1° or 2° south of that dangerous headland, which few of the Greenland travellers of our time have ever seen, and by this means one may in the spring sail up to North Greenland from Denmark, not indeed without now and then fetching a compass on account of the ice, but without being exposed to any very much greater risk than in other channels free from ice. On the present occasion also the "Hvalfisk" made that (by long experience) approved circuit, and, after four weeks' voyage, reached the longitude of Cape Farewell. Here we were exposed to a very violent storm, during which the ship was obliged to lie to nearly a fortnight, afterwards north of 60° lat. we were further obliged to make a number of delaying circuits, to avoid the ice driven by the storm to the mouth of the Strait. In consequence of this, our voyage out occupied about eight weeks. In fact, we landed on the 2nd of July at Godhavn, originally a Danish whalers' station, now, since the Danish whale-fisheries have been discontinued, one of the minor Danish colonies in that tract, but still, in consequence of its central position and of old custom, the seat of the principal magistracy in North Greenland, the *Inspectorate of* North Greenland.

Hudson, and other veteran mariners of the Arctic seas, mention the variety of colours that distinguish the water in certain parts of the polar sea, which are frequently so sharply distinguished that a ship may sail with the one side in blue and the other in greyish-green water. It was at first supposed that these colours were indications of different currents—the green of the Arctic, the blue of the Gulf-stream. Later, Scoresby affirmed that the phenomenon arose from the presence of innumerable organisms, which he seems to have considered as crustacea, in the water. This observation has since

of long duration, but hindered him from taking part, as had been intended, in the journey on the ice. His place was supplied by Berggren, who accordingly accompanied me to Auleitsivik.

been continued, partly by the former Swedish arctic expedition, and partly by Dr. Brown,[1] during the voyages made by him in the arctic seas as Surgeon in a whaler, and as a member of Whymper's expedition. We also endeavoured to divert the tedious monotony of the voyage by observations on this phenomenon.

The sea-water in the neighbourhood of Spitzbergen is marked by two sharply distinguished colours—greyish-green and fine indigo blue. In the Greenland seas we also find water with a very decided shade of brown. These colours are seen most pure if one looks vertically down from the ship to the surface of the water through a somewhat long pipe. The green, or rather grey-green, water is generally met with in the neighbourhood of ice (whence it was supposed to arise from the arctic current); the blue where the water is free from ice; the brown, as far as I am aware, chiefly in that part of Davis Strait which is situated in front of "Fiskernaes." When specimens of the water are taken up in an uncoloured glass, it appears perfectly clear and colourless, nor can one with the naked eye discover any organisms to account for the colour. But if, when the velocity of the ship allows of it (i.e. when the ship makes from one to three knots an hour), a fine insect net be towed behind the ship, it will soon, in the green and brown water, be found covered with a film of in the former case green, in the latter case brown slime, of organic origin, and evidently the real cause of the abnormal colour of the sea-water. Just in these parts may be found swarms of small crustacea, which live upon this slime, and in their turn, directly or indirectly, become the food of larger marine animals. The blue water on the contrary, at least in these seas, deposits no slime upon the insect-net, and is far less frequented by Crustacea, Annelides, etc., than the green. Thus, as Brown, in the article above referred to, remarks, the presence of this slime, inconsiderable as it is, but spread over hundreds of thousands of square miles, is a condition necessary for the subsistence, not only of the swarms of birds that frequent the northern seas, but also of that giant of the animal creation, the whale, and all branches of industry dependent on whale-fisheries.

Of these remarkable organisms Dr. Öberg collected specimens when possible, during the voyage, which it is intended hereafter to submit to a careful scientific examination, in conjunction with similar specimens from preceding expeditions. Here we need only mention that the slime itself in each particular place is formed only of a few species of Diatomacea, often so large that after drying the mass, the siliceous frustules may be discerned with the naked eye; but on the other hand, different parts of the ocean exhibit entirely different forms, so that, for example, the green slime in one place has sometimes not a single species identical with that in another. A long continued collection will therefore be required to explain this scanty but, nevertheless, so remarkable and, we may safely say, important flora of the ocean's surface.

In Copenhagen our expedition was most kindly received by the

[1] A very interesting essay on this subject has been published by Dr. Brown: *The Farmer*, Jan. 1, 1868, p. 16.

Board of Directors of the Greenland trade, who not only granted us the same favourable terms for our voyage out in the "Trade's" ships which they grant to their own officers, but also gave us an unlimited letter of credit on their various stations, together with a letter patent of recommendation to their Governors, who also everywhere received us in the most hospitable manner, and assisted us in getting boats, provisions, and particularly crews. The obtaining of crews in Greenland is an especially difficult matter. A Greenlander's desire to earn is, in general, confined to the day's necessities; his unwillingness to undertake any service is particularly great; and lastly, he is so attached to his home, his wife and his children, and, if not provided with these, to his in general very ill-treated dogs, that already, after a fortnight's separation, he is quite homesick. This is equally true of the thoroughbred Greenlander and of the mixed races, which form a considerable portion of the population of the colony. The Danish artisans in Greenland, in fact, often marry natives. The children in these cases are said seldom to learn their father's language, but in general only Greenlandish, which language—difficult as it is to elder persons consciously or unconsciously accustomed to totally different linguistic rules,—perhaps on account of the abundance of expressions for the objects and actions amid which the children grow up—is caught by them with such ease and partiality that even pure European parents find it difficult to get their children to speak their real mother-tongue. Moreover, the necessity of earning their bread soon compels these children to have recourse to purely Greenlandish sources of gain, and to adopt Greenlandish customs. The child of a Danish father and a Greenlandish or mixed-race mother thus becomes, both in language and manners, a complete Greenlander; perhaps, however, a little less given to think *only* of the day actually passing, and therefore with a somewhat better prospect of maintaining himself than the more careless original natives.

Thus, while European customs of society and European language are almost powerless when in competition with those of Greenland, the European features and form of the body are preserved, almost without any alteration. The mixed-race, therefore, which meets us in almost every colony, is distinguished by a tall figure, often with light hair, and not unfrequently a very handsome person, if not too completely spoiled by Greenlandish dirt.

European features seem to have something more attractive to a Greenlander's sense of the beautiful than the flat form of countenance common among themselves, and thus many skin-clad canoe-men are descended, through several generations, from purely European fathers, married with women of mixed race; and there is, therefore, more Danish, Norwegian, Swedish, or English, than Greenlandish blood in their veins. Anything of that readiness to face danger and seek adventures, which, inherited from the wild piratic and chivalrous ages, forms a feature in our national character, will be looked for in vain in the descendants of Europeans in Greenland; and the European with Greenlandish blood in his veins is as timid and faint-

hearted as the Greenlander himself. Real service, in the European sense of the word, he will seldom bear long. He is unwilling, for any length of time, to leave his turf-house, his wife, children, and dogs. He avoids every danger to which his fishing does not drive him—nay, not only danger, but what he vainly imagines to be such; as, for example, a longer sail in a capacious and safe whale-fishing boat.

A Greenlander cannot now, at least in winter, dispense with several articles of food imported from Europe, e.g. bread and coffee, but he can never spare sufficient to purchase at once enough even for a week. He is accordingly obliged to reside so near a Danish trading-station (colony or depot) as to be able daily to barter the train and skin of the captured seal for bread, coffee, sugar, etc. The Greenlanders' winter dwellings are, therefore, seldom situated far from the trading-station, but in general crowded together in its immediate neighbourhood. But a Greenlander, who is active and able to hunt, is glad to leave his close hut in the summer, and betake himself, together with the women and children of his household, to a fishing or hunting district, at a distance of several dozen miles, where the family settles in a summer tent made of reindeer hides, to live for a time exclusively on the produce of the land.

On this account, there is in most of the colonies, during the summer, a dearth of men, and especially of such as are able and willing to undertake a longer journey in a whaling-boat. Immediately on our arrival at Godhavn we experienced this, finding it utterly impossible here to get together sufficient crews to man the two whaling-boats indispensably necessary for us. After more than a week's vain parleying, we were, therefore, glad to avail ourselves of the opportunity offered by one of the Trade's vessels of a passage for ourselves and our apparatus (the zoologists' chests, lines, dredges, etc., alone loaded a couple of boats) to Egedesminde, where we were assured we should meet with less difficulty.

We arrived at Egedesminde, a colony situated on the southern side of Disko Bay, after scarce half a day's voyage, and, thanks to the assistance given us by the hospitable governor of the place, Mr. Bollbroe, we found ourselves, within a few hours after our arrival, in a condition to begin our summer's work in earnest. One whaling-boat was purchased, and another was borrowed of Bollbroe, who also procured the crews necessary for manning the boats.

Dr. Öberg remained with one boat, in the neighbourhood of Egedesminde, for the purpose of dredging, and other zoological researches. Dr. Berggren, Dr. Nordström, and I proceeded with the other boat southward, past Manermiut and Kangaitsiak, to the most northerly of the long, narrow, almost river-like fjords, which penetrate far into the land between Egedesminde and Holsteinsborg. We left Egedesminde on the 12th of July, in the afternoon.

We took up our night-quarter, the 12th of July, at Manermiut, the 13th at Kangaitsiak, the 14th, 15th, and 16th on islands in Auleitsivik. On the 17th we at length arrived at the nearest object

of our voyage, the northern side of the glacier that shoots out from the inland ice, that occupies the bottom of the northern arm of Auleitsivikfjord, that is to say, the spot selected as the starting-point for our journey over the ice.

The tract through which we passed, like the whole west coast of Greenland south of the basalt region, bears a strong resemblance to the Scandinavian peninsula, and that resemblance is not the result of any accident, but of a similar geological formation, and a similar geological history. The surface of Greenland, like that of Scandinavia, is for the most part occupied by stratified crystalline rock (gneiss, hornblende-schist, hornblende-gneiss, mica-schist, etc.), crossed by dykes and veins of granite, which even bear the same peculiar minerals which distinguish the Scandinavian granite-veins; and, as in the case of our mountains, the mountains of these regions have once been covered with glaciers, which have left unmistakable marks of their presence in the boulders, which are met with scattered high up on the sides of the mountains, in the rounding off, in the polishing and grooving of the surface, and in the deep fjords, evidently scooped out by glaciers, which distinguish both Scandinavia's and Greenland's western coasts. There is, however, this difference, that whereas the glacial period of Scandinavia belongs to an age long past, that of Greenland, though it is receding,[1] still continues. While, in fact, numberless indications show that the inland-ice has in ancient times covered even the skerries round the coast, these are now so free from ice that a traveller in most places has to advance several miles into the country before reaching the border of the present inland-ice. It is at least certain that wherever any one hitherto has penetrated into the land, he has met with its border,[2] and in all instances has seen it from some neighbouring mountain-top, rising inwards with a gradual and regular ascent, till it levels undistinguishably hill and dale beneath its frozen covering, like the waves of a vast ocean.

Of this inland-ice the natives entertain a superstitious fear, an awe or prejudice, which has, in some degree, communicated itself to such Europeans as have long resided in Greenland. It is thus only that we can explain the circumstance, that in the whole thousand years during which Greenland has been known, so few efforts have been made to pass over the ice farther into the country. There are many reasons for believing that the inland-ice merely forms a continuous ice-frame, running parallel with the coast, and surrounding a land free from ice, perhaps even in its southern parts woody, which might perhaps be of no small economical importance to the rest of Greenland. The only serious attempt that has hitherto been made,

[1] Certainly receding, although the inland ice sometimes makes its way to the sea, and thus tracts that have been free from ice are again covered. We have an example of this in the ice-fjord of Jacobshavn, of which more hereafter.

[2] I have, however, met with persons in Greenland who do not consider it as fully proved, that the inland-ice really does form an inner border to the whole of the external coast. Many Danes have resided several years in Greenland without ever having seen the inland-ice.

in the parts of Greenland colonized by Danes,[1] to advance in that direction was made by—

A Danish expedition, fitted out for the purpose in 1728.—A Danish governor, Major Paars, with an armed company, artillery, etc., was that year sent from Denmark to Greenland, and took with him, among other things, also horses, with which it was intended to ride over the mountains, in order to rediscover, by an overland course, the lost (East) Greenland. The horses, however, died, either during the voyage out or shortly after their arrival in the country; and thus this expedition, really magnificent, but prepared in entire ignorance of the real nature of the country, was abandoned.

Dalager's attempt, 1751.—This year the Danish merchant Dalager made an attempt, in about 62° 31′ latitude, to advance in the beginning of September over the inland ice to the east coast. In the first volume of Kranz's "History of Greenland"[2] there is a short description of this journey, interesting, among other reasons, as recording an instance of a glacier, which since Greenland has been an inhabited land has forced its way forward and closed the entrance of a previously open fjord. We find further from that account, that Dalager, partly on foot and partly in a canoe, in company with five natives, reached the border of the inland ice near the bottom of a deep fjord situated north of Fredrikshaab. For two days they continued their journey over the ice, but succeeded during this time in advancing only eight English miles to some mountain summits rising above the ice-field, where a reindeer hunt was undertaken. Dalager would willingly have continued the journey a day or two longer, but was unable to do so, partly because the two pairs of boots taken with them for each person were so cut to pieces by the ice that they walked "as good as barefoot," partly because the cold at night was so severe that their limbs became stiff after a few hours of rest. On the other hand, the route chosen by Dalager seems not to have been interrupted by very many or deep chasms—in the beginning of the journey the surface of the ice was even "as smooth as a street in Copenhagen." Further on however it was extremely rough.

E. Whymper's expedition, 1867.—All that I know about this expedition is, that Mr. Whymper, in company with Dr. R. Brown, three Danes, and a Greenlander, endeavoured to make their way

[1] Dr. Hayes's remarkable journey, in October, 1860, over the fields of ice that cover the peninsula between Whale Sound and Kennedy Channel (78° N.L.), was performed, not upon the real inland-ice, but upon a smaller ice-field connected with the inland-ice, like the ice-fields at Noursoak peninsula. The character of the ice here seems to have differed considerably from that of the real inland-ice. Hayes ascended the glacier at Port Foulke, on the 23rd of October, and advanced on foot, the first day 5, the second 30, the third 25 miles, in all 60 English miles. He was here forced to return, in consequence of a storm. The height of the spot where he turned back over the level of the sea was 5000 feet (*The Open Polar Sea*, by Dr. J. J. Hayes, pp. 130–136).

[2] I have not had access to Dalager's original account. "Grönlandske Relationer, indehaaldende Grönländernes Liv og Levnet, deres Skicke og Vedtägter, samt Temperament og Superstitioner, tillige nogle korrte Reflexioner over Missionen, sammenskrevet ved Fredrickshaabs Colonia i Grönland, by Lars Dalager, Merchant."

upon the inland ice with dogs immediately to the north of the ice-fjord at Jacobshavn, but that they turned back again on the second day, after having proceeded only some few miles. The reason of this was probably the unfitness of dogs for such a purpose.

It was originally my intention to renew these attempts, but on conversing in Copenhagen with Messrs. Rink and Olrik, who had formerly been Inspectors in North Greenland, as also with several other persons who had visited Greenland, I found all so unanimous in considering further advance over the inland ice as impossible, that I determined not to risk the whole profit of the summer on an undertaking of the kind beforehand disapproved of by everybody. Nevertheless, I was unwilling entirely to abandon my plan, and determined therefore to make a little attempt at a journey on the inland ice only of a few days' extent.

If the inland ice were not in motion, it is clear that its surface would be as even and unbroken as that of a sand field. But this, as is known, is not the case. The inland ice is in constant motion, advancing slowly, but with different velocity in different places, towards the sea, into which it passes on the west coast of Greenland through eight or ten large and a great many small ice-streams. This movement of the ice gives rise in its turn to huge chasms and clefts, the almost bottomless depths of which close the traveller's way. It is natural that these clefts should occur chiefly where the movement of the ice is most rapid, that is to say, in the neighbourhood of the great ice-streams, but that on the other hand at a greater distance from these the ground will be found more free from cracks. On this account I determined to begin our wanderings on the ice at a point as far distant as possible from the real ice-fjords. I should have preferred one of the deep "Strömfjords" (stream-fjords) for this purpose, but as other business intended to be carried out during the short summer did not permit a journey per boat so far southward, I selected instead for my object the northern arm of the above-mentioned Auleitsivikfjord, which is situated 60 miles south of the ice-fjord at Jakobshavn, and 240 miles north of that of Godthaab. The inland ice, it is true, even in Auleitsivikfjord reaches to the bottom of the fjord, but it only forms there a perpendicular glacier, very similar to the glaciers at King's Bay in Spitzbergen, but not any real ice-stream. There was accordingly reason to expect that such fissures and chasms as might here occur would be on a smaller scale.

On the 17th July, in the afternoon, our tent was pitched on the shore north of the steep precipitous edge of the inland ice at Auleitsivikfjord. After having employed the 18th in preparations and a few slight reconnoitrings, we entered on our wandering inwards on the 19th. We set out early in the morning, and first rowed to a little bay situated in the neighbourhood of the spot occupied by our tent, into which several clayey rivers had their embouchures. Here the land assumed a character varied by hill and dale, and further inward was bounded by an ice wall sometimes perpendicular and sometimes rounded, covered with a thin layer of earth and stones,

near the edge, only a couple of hundred feet high, but then rising at first rapidly, afterwards more slowly, to a height of several hundred feet. In most places this wall could not possibly be scaled; we however soon succeeded in finding a place where it was cut through by a small cleft, sufficiently deep to afford a possibility of climbing up with the means at our disposal, a sledge, which at need might be used as a ladder, and a line originally 100 fathoms long, but which, proving too heavy a burden, had before our arrival at the first resting-place been reduced one-half. All of us, with the exception of our old and lame boatman, assisted in the by no means easy work of bringing over mountain, hill, and dale, the apparatus of the ice expedition to this spot, and after our dinner's rest, a little further up the ice-wall. Here our followers left us. Only Dr. Berggren, I, and two Greenlanders (Isak and Sisarniak) were to proceed farther. We immediately commenced our march, but did not get very far that day.

The inland ice differs from ordinary glaciers by, among other things, the almost total absence of moraine-formations. The collections of earth, gravel, and stone, with which the ice on the landward edge is covered, are in fact so inconsiderable in comparison with the moraines of even very small glaciers, that they scarcely deserve mention, and no larger, newly formed ridges of gravel running parallel with the edge of the glacier are to be met with, at least in the tract visited by us.

The landward border of the inward ice is however darkened, we can scarcely say covered with earth, and sprinkled with small sharp stones. Here the ice is tolerably smooth, though furrowed by deep clefts at right angles to the border—such as that made use of by us to climb up. But in order not immediately to terrify the Greenlanders by choosing the way over the frightful and dangerous clefts, we determined to abandon this comparatively smooth ground, and at first take a southerly direction parallel with the chasms and afterwards turn to the East. We gained our object by avoiding the chasm, but fell in instead with extremely rough ice. We now understood what the Greenlanders meant, when they endeavoured to dissuade us from the journey on the ice, by sometimes lifting their hands up over their heads, sometimes sinking them down to the ground, accompanied by to us an unintelligible talk. They meant by this to describe the collection of closely heaped pyramids and ridges of ice over which we had now to walk. The inequalities of the ice were, it is true, seldom more than 40 feet high, with an inclination of 25 to 30 degrees. But one does not get on very fast, when one has continually to drag a heavily-laden sledge up so irregular an acclivity, and immediately after to endeavour to get down uninjured, at the risk of getting one's legs broken, when occasionally losing one's footing on the here often very slippery ice in attempting to moderate the speed of the downward rushing sledge. Had we used an ordinary sledge, it would immediately have been broken to pieces, but as the component parts of our sledge were not nailed but tied together, it held together at least for some hours.

Already the next day we perceived the impossibility under such

circumstances of dragging with us the 30 days' provision with which we had furnished ourselves, especially as it was evident, that if we we wished to proceed further, we must transform ourselves from draught to pack horses. We therefore determined to leave the sledge and part of the provisions, take the rest on our shoulders and proceed on foot. We now got on quicker, though for a sufficiently long time over ground as bad as before. The ice became gradually smoother, and was broken by large bottomless chasms, which one must either jump over with a heavy load on one's back, in which case woe to him who made a false step, or else make a long circuit to avoid. After two hours' wandering, the region of clefts was passed. We, however, in the course of our journey, very frequently met with portions of similar ground, though none of any very great extent. We were now at a height of more than 800 feet above the level of the sea. Farther inward the surface of the ice, except at the occasionally-recurring regions of clefts, resembled that of a stormy sea suddenly bound in fetters by the cold. The rise inwards was still quite perceptible, though frequently interrupted by shallow valleys, the centres of which were occupied by several lakes or ponds with no apparent outlet, although they received water from innumerable rivers running along the sides of the excavation. These rivers presented in many places not so dangerous though quite as time-wasting a hindrance to our progress as the clefts—with this difference, however, that they did not so often occur, but the circuits to avoid them were so much the longer.

During the whole of our journey on the ice we constantly enjoyed fine weather, frequently there was not a single cloud visible in the whole sky. The warmth was to us, clad as we were, sensible; in the shade, near the ice of course, but little over zero; higher up, in the shade, as much as 7° or 8°; but in the sun 25° to 30° Centig. After sunset the water-pools froze, and the nights were very cold. We had no tent with us, and, although our party consisted of four men, only two ordinary sleeping sacks. These were open at both ends, so that two persons could, though with great difficulty, with their feet opposite to each other, squeeze themselves into one sack. With rough ice for a substratum, the bed was thus so uncomfortable that, after a few hours' sleep, one was awakened by cramp in one's closely contracted joints, and, as there was only a thin tarpaulin between the ice and the sleeping sack, the bed was extremely cold to the side resting on the ice, which the Greenlanders, who turned back before us, described to Dr. Nordström by shivering and shaking throughout their whole bodies. Our nights' rests were, therefore, seldom long; but our midday rests, during which we could bask in a glorious warm sun-bath, were taken on a proportionately more copious scale, whereby I was enabled to take observations both for altitude and longitude.

On the surface of the inland ice we do not meet with any stones at a distance of more than a cable's length from the border; but we find everywhere instead, vertical cylindrical holes, of a foot or two deep, and from a couple of lines to a couple of feet in section, so

close one to another that one might in vain seek between them room for one's foot, much less for a sleeping-sack. We had always a system of ice-pipes of this kind as substratum when we rested for the night, and it often happened, in the morning, that the warmth of our bodies had melted so much of the ice, that the sleeping sack touched the water, wherewith the holes were always nearly full. But, as a compensation, wherever we rested, we had only to stretch out our hands to obtain the very finest water to drink.

[*Extracted from the* Geological Magazine, Vol. IX., No. 8. August, 1872.]

PART II.

(PLATE VIII.)

THESE holes in the ice filled with water are in no way connected with each other, and at the bottom of them we found everywhere, not only near the border, but in the most distant parts of the inland ice visited by us, a layer, some few millimetres thick, of grey powder, often conglomerated into small round balls of loose consistency. Under the microscope, the principal substance of this remarkable powder appeared to consist of white angular transparent grains. We could also observe remains of vegetable fragments; yellow, imperfectly translucent particles, with, as it appeared, evident surfaces of cleavage (felspar?); green crystals (augite) and black opaque grains, which were attracted by the magnet. The quantity of these foreign components is, however, so inconsiderable, that the whole mass may be looked upon as one homogeneous substance. An analysis by Mr. G. Lindström of this fine glacial sand gave—

Silicic acid	62·25
Alumina	14·93
Sesquioxyd of Iron	0·74
Protoxyd of Iron	4·64
Protoxyd of Manganese	0·07
Lime	5·09

Magnesia	3·00
Potassa	2·02
Soda	4·01
Phosphoric acid	0·11
Chlorine	0·06
Water, organic substance (100° to red heat)	2·86
Hygroscopic water (15° to 100°)	0·34
	100·12

After long digestion with sulphuric acid only 7·73, and with muriatic acid 16·46, per cent. was dissolved. The remainder was entirely white, after heating to redness. The analysis gives the atomic relation—

$$2\,\dot{R} + \ddot{Al} + 7\,\ddot{Si} + \dot{H}$$

or the formula—

$$2\,\dot{R}\,\ddot{Si}^2 + \ddot{Al}\,\ddot{Si}^3 + \dot{H}$$

Specific gravity = 2·63 (21°). Hardness inconsiderable, crystallization probably monoclinic.

The substance is not a clay, but a sandy trachytic mineral, of a composition (especially as regards soda) which indicates that it does not originate in the granite-region of Greenland. Its origin appears therefore to me very enigmatical. Does it come from the basalt-region? or from the supposed volcanic tracts in the interior of Greenland? or is it of meteoric origin? The octahedrally crystallized magnetic particles do not contain any traces of nickel. As the principal ingredient corresponds to a determinate chemical formula, it would perhaps be desirable to enter it under a separate class in the register of science; and for that purpose I propose for this substance the name Kryokonite (from κρύος and κόνις).

When I persuaded our Botanist, Mr. Berggren, to accompany me in the journey over the ice, we joked with him on the singularity of a botanist making an excursion into a tract, perhaps the only one in the world that was a perfect desert as regards botany. This expectation was, however, not confirmed. Dr. Berggren's quick eye soon discovered, partly on the surface of the ice, partly in the above-mentioned powder, a brown polycellular alga, which, little as it is, together with the powder and certain other microscopic organisms by which it is accompanied, is the most dangerous enemy to the mass of ice, so many thousand feet in height and hundred miles in extent. The dark mass absorbs a far greater amount of the sun's rays of heat than the white ice, and thus produces over its whole surface deep holes which greatly promote the process of melting. The same plant has no doubt played the same part in our country, and we have to thank it, perhaps, that the deserts of ice which formerly covered the whole of northern Europe and America have now given place to shady woods and undulating corn-fields. Of course, a great deal of the grey powder is carried down in the rivers, and the blue ice at the bottom of them is not unfrequently concealed by a dark dust. How rich this mass is in organic matter is proved by the circumstance, amongst others, that the quantity of organic matter in it was sufficient to bring a large collection of the grey powder,

which had been carried away to a distant part of the ice by sundry now dried up glacier-streams, into so strong a process of fermentation or putrefaction, that the mass, even at a great distance, emitted a most disagreeable smell, like that of butyric acid.

Dr. Berggren has communicated the following notice[1] of the microscopic organisms met with on the inland ice.

"One of the species of algæ met with on the inland ice occurred in such vast quantities, that the surface of the ice throughout larger or smaller tracts was tinted with a peculiar colour. Two others seemed exclusively to belong to the fine sand, which is found either in the form of a thin covering on the surface of the ice, or as a more or less thick layer at the bottom of the pipe-like holes that appear in the surface. The first-mentioned species, occurring copiously, does not require any such substratum, but is found principally on the sides of ice-hills, where the water from the melting ice filtered itself out between the little inequalities of the surface.

"The most copiously represented species has the form of a short thread, not spreading out in branches, but consisting of a single row of cells; the number of cells in each thread is 2, 4, 8, or at most 16. Threads of 4 and 8 cells are most common. The species very frequently appears only as a single cell. The threads are usually a little bent, sometimes, when the number of cells is 16, forming a complete semicircle. The number two or its multiples taken as the standard for the number of cells in the separate threads is accounted for by the regular continuous bisection of the cells, whereby their propagation proceeds. The connexion between the cells is the looser the older the partitions become, as the older membranes assume a looser consistence. In a thread of 16 cells, the connexion between the eighth and ninth cells is soon broken, and in the two threads thus resulting the connexion between the fourth and fifth cells is weaker than that between the second and third or the sixth and seventh. The threads therefore often lie bent at an angle. The diameter of the cells is 0·008 — 0·012 mm., and their length 0·016 — 0·040 mm. Individual cells may sometimes attain a length 0·065 mm. and a breadth of 0·015 mm., whereas a great number of other single cells are met with of very small dimensions, from spherical forms of only 0·006 mm. diameter to those of ordinary form and size. As the ends of the cells, where they are joined together, are rounded, there is, of course, a contraction between them, which becomes more and more conspicuous as the connexion between them is loosened by time. The membrane is thin and hyaline, and its outermost layer (the remnants of the membranes of the mother-cells altered after division) is of an almost slimy consistence, whereby the cells are for some time kept together. The contents of the cells are in part concealed by a dark purple-brown colouring-matter, which in dried cells is immediately drawn out on wetting them. The centre of the cells is occupied by an oblong or cylindrical mass of chlorophyll, of somewhat irregular

[1] A more detailed account, accompanied by drawings, of these remarkable Algæ will hereafter be published in the "K. Vet. Akademiens Öfversigt."

contour, in the extremity of which two kernel-formed rounded bodies are imbedded, which in general cannot be perceived by the eye till the colouring-matter has been removed by means of reagents. We sometimes meet with four such bodies in one cell, sometimes but a single one: the former a result of accidentally checked division of the cells; the latter of such division having lately taken place. In the liquid of the cells a number of small grains are found, which are for the most part collected round the periphery of the cell or at its ends.

"Judging from the construction of the cells, and the manner of their multiplication, the alga before us would appear to belong to the *Conjugatæ;* but as I have not succeeded in discovering fructification in it, it would be rash to decide to which genus it is to be referred. The thread-like rows of connected cells agree with the *Zygnemaceæ;* whereas, on the other hand, an unmistakable similitude to the *Desmidiaceæ*, especially *Cylindrocystis*, and the nearly related genera, is indicated by the strongly-marked divisions into multiples of two, and by the tendency of the rows of cells to fall asunder, as far as the destructibility of the uniting cell-membranes permits, into parts consisting of cells united in pairs, which however is seldom possible, in consequence of the greater energy possessed by the power of multiplying the cells. As the above-mentioned small single cells, which occur in great numbers, are much less in diameter than those cells which arise from the bisection of the threads, they have perhaps a different origin from these latter, although the researches which I have hitherto been enabled to devote to this subject have not furnished any illustration of it. Were these daughter-cells arising from the division of the sporæ, if the above-mentioned supposition with respect to the systematic place of the species be correct, the stadium of copulation or sporæ, in some period of its development, ought to be found. Two rare forms of peculiarly constructed cells perhaps ought not to be passed over in silence. I have sometimes found the extreme cell in a thread considerably more swelled than the others, more elliptic in form, also provided with a thicker membrane, and with the contents of the cell more coarse-grained. I once found one of the middle cells in a thread thus transformed, and on two occasions I have met with single cells of the same kind. I also once met with a cell of very peculiar construction. It had the usual form, but was unusually large, with a long mass of chlorophyll, as usual, in the midst, and the granular matter grouped rather towards the ends of the cell. In it were found about twenty larger or smaller spherical bodies. Four of these lay arranged at each end of the cell, and were almost entirely opaque, of a dark brown colour, and in appearance much resembled the smaller cells of *Protococcus nivalis*. The others were translucent, with sharply defined contours. As our knowledge of the nature of these bodies is confined to what is here stated, the fuller explanation of their significance must be reserved for a future investigation.

"In places similar to those in which this species occurs, and often

in company with it, *Protococcus nivalis* was met with. Amidst the fine gravel upon the ice, but to a trifling amount, small green cells are found, sometimes united in little groups, sometimes isolated, which appeared to belong to *Protococcus vulgaris*. *Scytomena gracile*, on the other hand, is everywhere met with in great profusion, wherever the gravel either lies in thinly scattered grains on the surface of the ice or forms more or less thick layers. The threads lie either alone, or united in small bunches, as they join together at the lower part, and bend backwards higher up. They are pretty stiff, S-shaped, or forming a curve of several undulations, and yellowish-brown in colour. Their length is very various, their breadth generally about 0·009 mm."

At our midday rest on the 21st we had reached latitude 68° 21′ and 36′ longitude east of the place where our tent was pitched; and a height of 1400 feet above the level of the sea.

Later in the day, at our afternoon rest, the Greenlanders began to take off their shoes and examine their little thin feet—a serious indication, as we soon perceived. Isak presently informed us, in broken Danish, that he and his companion now considered it time to return. All attempts to persuade them to accompany us a little further failed; and we had therefore no other alternative than to let them return, and continue our excursion without them.

We took up our night-quarters here. The provisions were divided. The Greenlanders, considering they might perhaps not be able to find our first depôt, were allowed to take as much as was necessary to enable them to reach the tent. We took out cold provisions for five days. The remainder, together with the excellent photogen portable kitchen, which we had hitherto carried with us, were laid up in a depôt in the neighbourhood, on which a piece of tarpaulin was stretched upon sticks, that we might be able to find the place on our return; which however we did not succeed in doing, though we must have passed in its immediate vicinity.

After these preparations for a parting, Dr. Berggren and I proceeded alone further inward. The Greenlanders turned back.

At first we passed one of the before-mentioned extensive bowl-formed excavations in the ice-plain, which is here furrowed by innumerable rivers, which often obliged us to make long circuits; and when to avoid this, we endeavoured to make our way along the margin of the valleys, we came, instead, upon a tract where the ice-plain was cloven by long, deep, parallel clefts running true N.N.E.—S.S.W., quite as difficult to get over as the rivers, but far more dangerous. Our progress was accordingly but slow. At twelve o'clock on the 22nd we halted, in glorious, warm, sunny weather, to make a geographical determination. We were now at a height of 2000 feet, in latitude 68° 22′, and in a longitude of 56′ *of arc* east of the position of our tent at the fjord.

During the whole of our excursion on the ice we had seen no other animals than a couple of ravens, which on the morning of the 22nd, at the moment of our separation, flew over our heads. At first, however, there appeared in many places on the ice remnants of

ptarmigans, which seemed to indicate that these fowls visit these desert tracts in by no means inconsiderable flocks. Everything else around us was lifeless. Nevertheless silence by no means reigned here. On bending down the ear to the ice, one could hear on every side a peculiar subterranean hum, proceeding from rivers flowing within the ice; and occasionally a loud single report like that of a cannon gave notice of the formation of a new glacier cleft.

After taking the observations, we proceeded over comparatively better ground. Later in the afternoon we saw, at some distance from us, a well-defined pillar of mist, which, when we approached it, appeared to rise from a bottomless abyss, into which a mighty glacier-river fell. The vast roaring water-mass had bored for itself a vertical hole, probably all the way down to the rock, situated certainly more than two thousand feet beneath, on which the glacier rested.

The following day (the 23rd) we rested in latitude 68° 22′ and 76′ of arc longitude east from the position of our starting-point at Auleitsivik.

The provisions we had taken with us were, however, now so far exhausted, that we were obliged to think of returning. We determined nevertheless first to endeavour to reach an ice-hill visible on the plain to the east, from which we hoped to obtain an extensive view; and, in order to arrive there as quickly as possible, we left the scanty remains of our provisions and our sleeping sack at the spot where we had passed the night, taking careful notice of the ice-rocks around, and thus proceeded by forced march, without encumbrances.

The ice-hill was considerably further off than we had supposed. The walk to it was richly rewarded by an uncommonly extensive view, which showed us that the inland ice continued constantly to rise towards the interior, so that the horizon towards the east, north, and south was terminated by an ice-border almost as smooth as that of the ocean. A journey further (even if one were in a condition to employ weeks for the purpose—which want of time and provisions rendered impossible to us) could therefore evidently furnish no other information concerning the nature of the ice than that which we had already obtained; and even if want of provisions had not obliged us to return, we should hardly have considered it worth while to add a few days' marches to our journey. Our turning-point was situated at a height of 2200 feet above the level of the sea, and about 83′ of longitude, or 30 miles west of the extremity of the northern arm of Auleitsivikfjord.

On departing from the spot where we had left our provisions and sleeping sack, we had, as we supposed, taken careful notice of its situation; nevertheless we were nearly obliged to abandon our search as vain—an example which shows how extremely difficult it is, without lofty signals, to find objects again on a slightly undulating surface everywhere similar, like that formed by the inland ice.

When, after anxiously searching in every direction, we at length found our resting-place, we ate our dinner with an excellent appetite, made some further reductions in our load, and then set off with all

haste back to the boat, which we reached late in the evening of the 25th.

At a short distance from our turning-point, we came to a copious, deep, and broad river, flowing rapidly between its blue banks of ice, which were here not discoloured by any gravel, and which could not be crossed without a bridge. As it cut off our return, we were at first somewhat disconcerted; but we soon concluded that—as in our journey out we had not passed any stream of such large dimensions—it must at no great distance disappear under the ice. We therefore proceeded along its bank in the direction of the current, and before long a distant roar indicated that our conjecture was right. The whole immense mass of water here rushed down a perpendicular cleft into the depths below. We observed another smaller but nevertheless very remarkable waterfall the next day, while examining, after our midday rest, the neighbourhood around us with the telescope. We saw in fact a pillar of steam rising from the ice at some distance from our resting-place, and, as the spot was not far out of our way, we steered our course by it, in the hope of meeting—judging from the height of the misty pillar—a waterfall still greater than that just described. We were mistaken: only a smaller, though nevertheless tolerably copious, river rushed down from the azure-blue cliffs to a depth from which no splashes rebounded to the mouth of the fall; but there arose instead, from another smaller hole in the ice, in the immediate vicinity, an intermittent jet of water, mixed with air, which, carried hither and thither by the wind, wetted the surrounding cliffs with its spray. We had then here, in the midst of the desert of inland ice, a fountain, as far as we could judge from the descriptions, very like the geysers which in Iceland are produced by volcanic heat.

In order, if possible, to avoid the district of ice-rocks, which on our journey out had required so much patience and exertion, we had in returning chosen a more northerly route, intending to endeavour to descend from the ice-ridge higher up on the slip of ice-free land, which lies between the inland ice and Disko Bay. The ice was here, with the exception of a few ice-hillocks of a few feet high, in most places as even as a floor, but often crossed by very large and dangerous clefts, and we were so fortunate as immediately to hit upon a place where the inclination towards the land was so inconsiderable that one might have driven up it four-in-hand.

The remainder of the way along the land was harder, partly on account of the very uneven nature of the ground, and partly on account of the numerous glacier streams which we had to wade through, with the water far above our boots. At last, at a little distance from the tent, we came to a glacier stream, full of muddy water, so large that, after several failures, we were obliged to abandon the hope of finding a fordable place. We were therefore obliged to climb high up again upon the shining ice, so as to be able to find our way down again further on, after passing the river; but the descent on this occasion was far more difficult than before.

Laborious as this journey along the land was, it was nevertheless

extremely interesting to me in a geological point of view. We passed in fact over ground that had but lately been abandoned by the inland ice, and the whole bore so confusing a resemblance to the woodless gneiss-districts in Sweden and Finland, that even the most sceptical persons would be obliged to admit that the same formative power had impressed its stamp on both localities. Everywhere rounded, but seldom scratched, hills of gneiss,[1] with erratic blocks in the most unstable positions of equilibrium, occur, separated by valleys with small mountain lakes and scratched rock-surfaces. On the other hand, no real moraines were discoverable. These, indeed, seem to be in general absent in Scandinavia, and are generally speaking more characteristic of small glaciers than of real inland ice.

Fig. 1, Fig. 2, and Fig. 3. Inland Ice abutting on Land.
A. Inland Ice; B. Solid Rock; C. Small Collection of Earth at the foot of the Glacier; D. Lake; E. Separate Block of Ice.

Fig. 1.

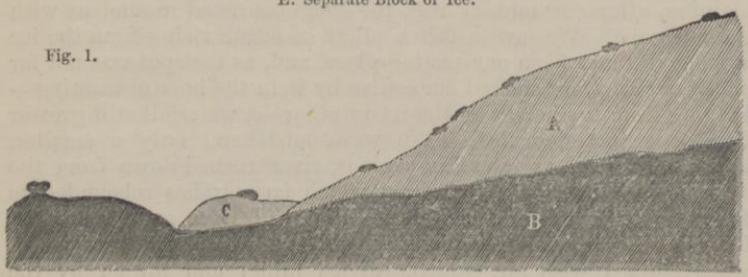


Fig. 2.

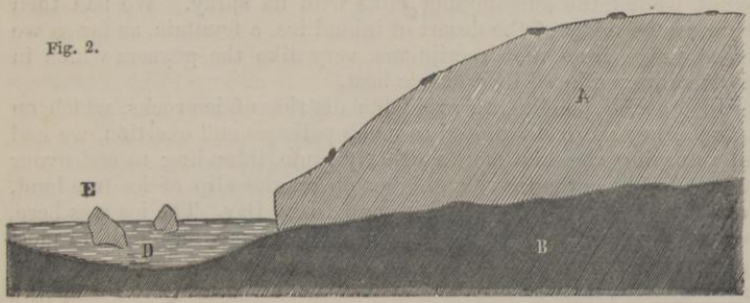
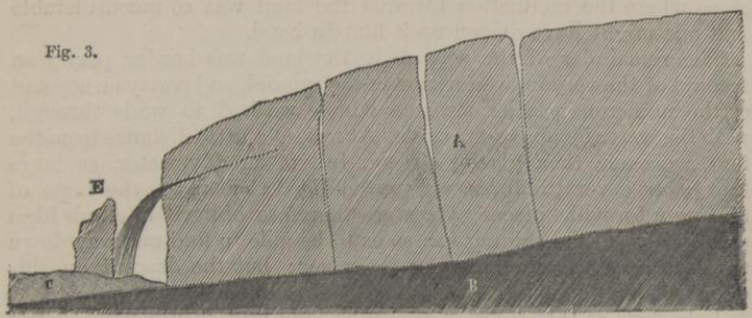


Fig. 3.



[1] For the preservation of a scratched stone surface it is necessary that it should be

The border of the ice is, as indicated in the woodcuts, everywhere sprinkled with smaller boulders, partly rounded, partly angular; but the number of these is so inconsiderable, that, when the ice retires, they only give rise to a slope covered with boulders, not to a moraine, similar, for example, to that which the little Assakak glacier in Omenakfjord drives before it. The little earth-bank, which at most places collects at the foot of the glacier, is frequently washed away again by the glacier streams and rain. We often find at the foot of the glacier, as indicated in Fig. 2, ponds or lakes in which a fresh-water glacial clay, containing angular stone blocks, scattered around by small icebergs, is deposited.

It is a common error among geologists to consider the Swiss glaciers as representing on a small scale the inland ice of Greenland, or the inland ice which once covered Scandinavia.[1] The real glacier bears the same relation to inland ice which a rapid river or brook does to an extensive and calm lake. While the glacier is in perpetual motion, the frozen water of the inland ice, like the water of a lake, is comparatively at rest, excepting in those places where it streams out into the sea by vast but short glaciers. If one of these glaciers, through which the ice-lake falls out into the sea, pass over smooth ground where the ocean's bottom gradually changes into land without any steep breaks, steep precipitous glaciers are produced, from which

Fig. 4.

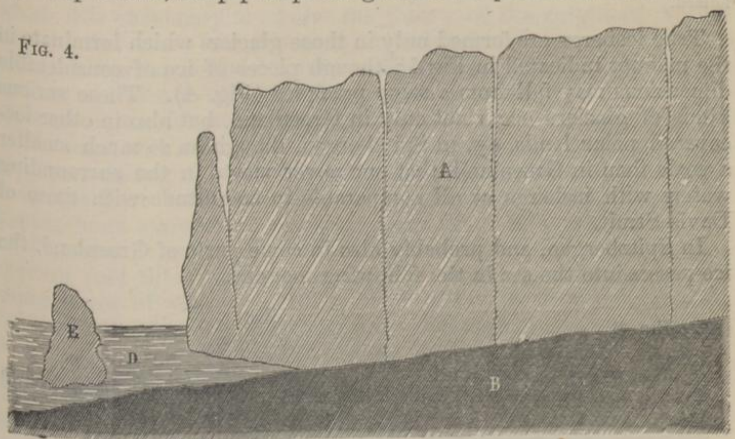


Fig. 4. Inland ice extending into the sea and terminating in a steep edge, 100 to 200 feet high.

indeed large ice-masses fall down, but do not give rise to any real iceberg. But if the mouth be narrow, the depth of the outlying sea great, and the inclination of the shore considerable, the result will

protected by a layer of water, clay, or sand, from the destructive effects of frost, and more especially from those of lichens. The finest scratches disappear in a few years from a mountain slab, the position of which is favourable to lichen vegetation, but are on the contrary preserved where lichen vegetation cannot develope itself—as for example, when the rock is for a time in the spring covered with water.

[1] Switzerland was probably never quite covered with real inland ice, its glaciers have only been considerably more extensive than they now are.

be one of those magnificent ice-fjords which Rink so admirably describes, and which we, later in the course of our journey, had an opportunity of visiting. The following diagram will illustrate this more clearly.

Fig. 5.

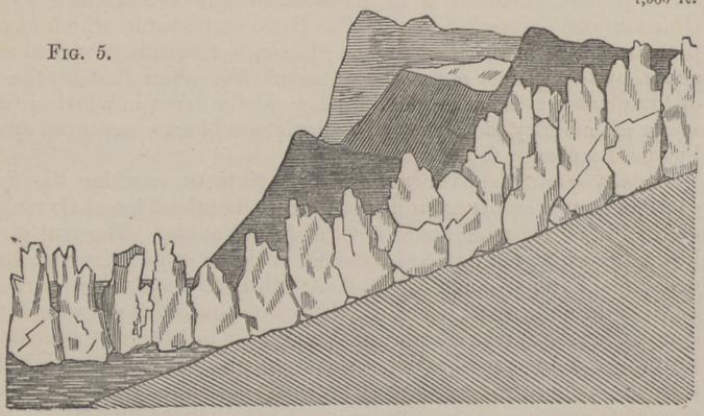


Fig. 5. Inland ice abutting on the bottom of an ice-fjord, *i.e.* a fjord in which real icebergs are formed.

True icebergs are formed only in those glaciers which terminate in the manner indicated in Fig 5; though pieces of ice of considerable dimensions may fall from a steep precipice (Fig. 4). These various kinds of glaciers occur not only in Greenland, but also in other ice-covered polar lands, *e.g.* in Spitzbergen, though on so much smaller a scale than in Greenland, that one never meets in the surrounding waters with icebergs at all comparable in magnitude with those of Davis Strait.

In Spitzbergen, and probably also in some parts of Greenland, the ice passes into the sea in the following manner.

Fig. 6.

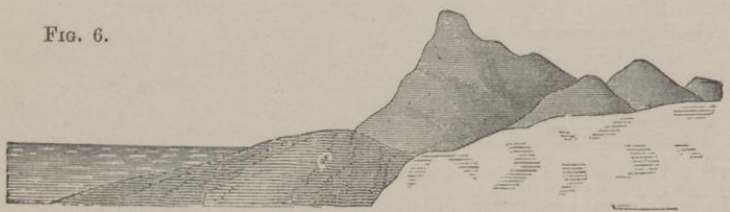


Fig. 6. Inland ice abutting on a mud-bank.

As I have already remarked in the account of the geological relations of Spitzbergen, this last-mentioned kind of termination of inland ice towards the sea is met with only either in those places where the limits of the inland ice rapidly recede, or where the ice breaks for itself a new channel or way to the sea. This is, for example, the case with Axels glacier in Bell Sound, which, when I first visited the spot in 1858, had an edge like that indicated in

Fig. 6, but which a couple of years later filled the whole of the harbour lying before it, and is now terminated in the manner shown in Fig. 5.

The great denuding effect of the glaciers has been, as is known, proved by numerous and accurate investigations. Greenland also offers examples of this in the long and deep fjords that indent its coasts, and which, if they run parallel to ante-glacial depressions of the earth's crust, yet, as the smoothed, scratched and grooved rocks and the erratic blocks strewn high up upon the slopes show, have been widened, formed, and cleansed from earth, gravel-beds, and looser sedimentary mountain detritus by the operation of the glaciers. The mere effect of the immovable inland ice cannot be any thing like so great. Nevertheless, here also the earth and the layers of gravel are completely washed away by the rapid glacier streams running under the ice. The subjacent original rock is thus exposed, and perhaps to some extent worn away, especially in places where the ice passes over layers of limestone, sandstone, or slate. Its original depressions, filled during the older geological periods, therefore re-appear, and often form—when the ice covering has again retired—the basins of those beautiful lakes which characterize all glacial lands. To assume that the whole lake-basin has been scooped out during the glacial period is, however, evidently a mistake; and equally erroneous is the form in which it is customary to clothe the theory of the origin of Alpine lakes. But when we take into consideration how rapidly (even within historical periods) a lake is filled and converted—first into a morass, and then to a level and dry plain—we easily see the reasonableness of the following proposition:

We meet with lakes only in those places where, from some cause or other, during the latest geological periods, depressions or excavations have taken place in the crust of the earth; and since, among more generally operating causes than this, we know only of the volcanic and glacial powers, it is natural to conclude that modern (not filled up) lake-basins only occur where the strata, in consequence of volcanic activity, have fallen in, or where the ice has ground to powder, and the glacier-streams have swept away, the looser earth and rocks situated nearest to the surface of the earth.

On observing Tessiursarsoak from the heights nearest to the spot where we had first descended from the glacier, we had perceived that its appearance had changed in a remarkable manner; its surface was bright as a looking-glass, and so thickly covered with ice that our first impression was that we had an arm of the inland ice before us. On arriving at the tent we discovered the cause of this. During our absence the inland ice had launched or deposited ice in such quantities that the whole bay was almost choked with it, and the Greenlanders were very uneasy, for fear partly of our being inclosed, and partly of the violent waves caused by the deposition. They were therefore very glad when, immediately on our arrival at the boat, we declared our readiness to start on the following day.

In order to be in time to meet the Inspector—who just at this time was expected to visit the colonies around Disko Bay in a commodious

yacht, whence he was to sail through the Waigat up to Upernivik, and who had offered us a place on board as far as our routes were the same—we had agreed with several Kayak men from Ikamiut and the surrounding districts, that they on an appointed day were to meet at the place of our tent at Tessiursarsoak. Our intention was to have the whale-boat dragged over the low neck of land which at Sarpiursak separates the innermost part of the north arm of Auleitsiviksfjord from Disko Bay, and thus entirely to avoid the long circuit round Kangaitsiak. At the appointed time we saw a whole flotilla of these small, elegant, and light vessels approaching our tent. We immediately started, and, as soon as the necessary dram of welcome had been distributed to the canoe-men, rowed over to the other side, where Dr. Öberg, with the crew of the zoological boat and a number of other men, awaited us. We were now a numerous body of men, but Greenlanders are neither strong men nor inclined to unusual exertions. We were accordingly obliged to let our people row the whale-boat all the way round, while we ourselves, with our effects, passed directly over to Sarpiursak, where two other whale-boats lay at our disposal.

According to Dr. Rink, the interior of the fjord we had just left had never before been visited by Europeans, and even natives only visit it in summer to hunt and fish, usually in an "umiak," which is carried over the neck of land. It is seldom that they row from the mouth to the end of the fjord. They are afraid of the violent currents which the tide water produces in the long narrow estuary, and which, as the Greenlanders several times, with horror painted on their countenances, informed us, when we wished to take advantage of the favourable but violent current to get on faster, had once swallowed up two "umiaks," with all the men, women, and children on board. There must now, however, be but very little to be got by hunting there; at least, during the whole of our journey we saw no reindeer. But there are persons still living who remember the time when thousands of reindeer were killed in these parts for the sake of the skins only. This abundance of game enticed a few families to settle there also during winter, and one meets in several places traces of old houses. The shores of the fjord are occupied by gneiss hills separated from each other by valleys, in which grass and lichen grow plentifully, thus affording copious pasture for such reindeer as may occasionally stray thither. This is an event which has now become rare, but many maintain that the good times may return, for that, according to their account, the reindeer make periodical migrations, sometimes appearing at a particular place in vast numbers, and then suddenly disappearing, and there are many persons who connect this account with that of an inland tract free from ice, or even with the story of wild inhabitants with European features in the interior of the country. To us the visit to this fjord was interesting, partly because we hoped thus to become acquainted with the true, unmixed Greenlander scarcely in contact with civilization, and partly for botanical reasons. We hoped in fact here, far from the moist fogs of the ocean, to find a

far richer vegetation than on the outer coast. A very small tree was said to have been thence transplanted to the clergyman's garden at Egedesminde. This anticipation of the botanist was however not confirmed, at least not to the amount expected. The flora was indeed richer and the willow-bush larger than at Egedesminde, but not so rich nor so large as in the more northerly situated but fertile basalt-region of Disko, which is travelled by subterranean streams of warm water. The insect Fauna, on the other hand, appears to be somewhat richer here than on the coast; at least we collected the best harvest of insects that we had during the whole summer on the 17th of July, on a little island in Tessiursarsoak, and the time we spent at the foot of the inland ice was, although in other respects extremely pleasant, embittered to a degree—of which those who have not experienced it cannot form an idea—by countless swarms of gnats. The Greenland gnat is like ours, but its bite is far more venomous, though at first not particularly painful. One is therefore usually too incautious at first, and exposes oneself to twenty or thirty gnat-bites in the face at once. A few hours later one's face becomes unrecognizable with the boils and swellings caused by the bites, and this is followed by pain and fever, especially at night, which hinders sleep, and is almost enough to drive one mad.

The inland ice, in former times, evidently covered the whole of Auleitsiviksfjord, together with the surrounding valleys, mountains, and hills. The ice has accordingly, during the last thousand or hundred thousand years, considerably retired. Now, on the contrary, its limit in these parts is advancing, and that by no means slowly. Of late years the rowing of an "umiak" in Tessiursarsoak has been rendered difficult by ice-blocks fallen from the glaciers, which is said not to have been the case formerly; and one of our rowers, Henry Sissarniak, even affirms that he, seven years ago, without obstruction rowed round an island, which now forms a peninsula jutting out from the margin of the inland ice. Many similar examples in North Greenland are adduced: thus, for example, the glacier that issues into Bläsedal, near Godhavn, has, since the time when Dr. Rink mapped that place, according to the statement of Inspector Smith, advanced much farther into the valley,—in the fjords around Omenak the ice has advanced considerably within the memory of man,—a path formerly often frequented between Sarfarfik and Sakkak is now closed by inland ice, etc., etc. I shall have occasion hereafter to mention a similar case in the ice-fjord at Jakobshavn. In a word, there can be no doubt that in many parts of North Greenland the inland ice is certainly gaining ground; but I nevertheless think that the conclusion drawn by many persons, that the whole coast of North Greenland will, at no very distant period, be again covered with ice, is somewhat too hastily made. These persons, in observing the phenomena relative to this subject, not only seem to have forgotten to register the examples occasionally adduced by the Greenlanders of a retiring of the ice—a less striking and therefore less observed phenomenon,—but they have also attributed far too great weight to an experience extending only over a

few years, which may perhaps have been peculiarly unfavourable. On the contrary, the extensive, rounded, polished, and grooved border of land, which almost everywhere separates the inland ice from the extreme coast, shows plainly that the inland ice has in many places during the last geological period retired several miles. That this border-land has been uncovered later even than that at Spitzbergen is evidenced, by this fact, among others, viz. that not one of the numberless small sea-basins in North Greenland, in spite of the suitableness of the locality for moss-vegetation, has yet become filled with turf, even to the depth of a few feet, which indicates that the slip of ice-free land is but a child of yesterday. It is true that "turf" is the Greenlander's principal winter fuel, but what he means by that name is, in almost all instances, merely an earth consisting of rotten moss, grass-roots, and guano and refuse, which to the depth of a few inches is soon formed on the skerries and islands in the sea, and serves the sea-fowls as places of incubation. The greatest part of the Greenlander's turf-beds are situated on gulls' hillocks ("maagetuer"), and have, therefore, geologically speaking, nothing in common with what we mean by turf layers. It was accordingly impossible for me to collect, as I had desired, by an examination of the older turf-beds, materials for determining the latest Post-tertiary changes of climate that have taken place in Greenland. But instead, we, find here many other deposits, which serve at least to give an indication of the changes that the animal world has undergone during the Glacial period.

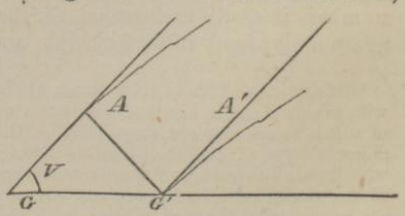
[*Extracted from the* Geological Magazine, Vol. IX., No. 9. September, 1872.]

PART III.

BEFORE proceeding to give an account of these changes in the fauna of Greenland, I wish to draw attention to the possibility which exists in these parts of obtaining a comparison between the units of geological and historical chronology, that is—if by collecting observations and reports from many different localities, it be possible to determine certain limits for the velocity with which the border of the inland ice moves. One may arrive at the lower limit from the following considerations. The breadth of the slip of border-land at Auleitsiviksfjord is about 60 miles, or 350,000 ft. The annual retreat can, of course, never exceed the thickness[1] of the covering that yearly melts, divided by the sine of the inclination of the icy surface, which in the places passed by us was nowhere less than 30°. It is hardly probable that during a summer in Greenland an ice-layer of more than 10 ft. can melt away, so that a yearly retreat exceeding $\frac{10}{\sin 30^\circ} = 20$ ft., is not to be thought of. This would give for the time that has been required for the uncovering of the outer strip of land at Auleitsviksfjord a period of at least 17,000 to 18,000 years. But this number is evidently too low, for neither the yearly falls of snow nor the advance of the ice-mass has been taken into account, as they of course ought to be; and yet we have here to do with a geological period, which undoubtedly forms but a small fraction of the interval that has elapsed since the first appearance of man.

The point at Sarpiursak forms a very level and extensive plain, elevated about 60 to 150 feet above the sea, covered with a vegetation of "lyng," moss and sedge, too scanty to conceal the clay which forms the bottom of the plain. Similar formations in many other places along the shores of Disko Bay and Auleitsiviksfjord have given rise to vast clay-beds, which attracted attention long ago in these parts so ill supplied with clay. Our Greenlanders even mentioned that they contained petrified shells and "Angmaksäter" (a species of fish). These fossils are also mentioned by Dr. Rink in his work on North Greenland; and he adds, that a collection which he had sent home had been examined by Dr. O. A. L. Mörch, who found the shells partly to belong to species still existing on the coasts of N. Greenland,

[1] Estimated at right angles to the surface of the ice. The annexed cut shows this more clearly. If G is the surface of the ice in *e.g.* 1870, G′ and the same surface in 1871, then AG′ is the thickness of the layer that has melted; and the distance the ice has receded is = AG′ : Sin V. The angle V is, of course, determined by the relation between the velocity of melting and the velocity with which the ice flows out of the higher parts of the glacier.



partly to more southern forms. As the collection of materials for forming a judgment relative to the changes in the climate of the polar regions was one of the principal objects of the purely scientific part of our expedition, it was natural that we should pay especial attention to these circumstances.

Older glacial[1] fossils occur in N. Greenland in two different formations, namely, either imbedded in clay (the layers south of Waigat), or else at Pattorfik in a somewhat hardened basalt sand in course of transformation to basalt tufa. The material of the clay-beds has evidently been deposited by the glacier rivers whose muddy water everywhere bursts out from under the inland ice, but in general the deposits are sea-formations, *i.e.* they have been deposited under the level of the sea, which proves that these regions, in the course of the present glacial period, have been elevated at least 100 feet. The Danes, on the other hand, who have long resided in Greenland, declare most decidedly that a depression is now taking place in most parts of the country. Herr Einar Hansen, who has for 19 years lived in the colony of Omenak, says that even in that short period he has clearly seen this; and it is still more evident when we compare the present sea-level with the statements left by Herr Hansen's predecessor relative to its height 60 years ago. The situation of the blubber house at Fredrickshaab, as well as many other observations in South Greenland, shows the same. At Godhavn, in Disko, on the contrary, a rise is said to be taking place. It would be an important service if these circumstances, to which attention has been called by Pingel, Brown, and others, were fully investigated by an accurate and critical collection of all data relating to the subject; as also by fixing proper bench-marks in appropriate spots among the skerries along the coast of Greenland.

Just as the glacial clay at the present time, covered with muddy water, is poorly supplied with animal life, so also do these clay layers deposited in ancient times present but a scanty variety of fossils. In the clay-beds at Auleitsiviksfjord, for example, we could only find a few shells of *Saxicava arctica*, and in the deep clay-beds of Sarpiursak we at first sought in vain for any remains of animal life. These were, on the contrary, very numerous on the sea-shore itself, partly shells of bivalves still united, inclosing and often inclosed in a hardened mixture of sand and clay, accordingly genuine fossils, partly flat, often ringshaped claystones, containing remains of Fish, Ophiuræ, Crustaceæ, etc. That fossils should be found there in great numbers is easily understood, for the sea is constantly washing away again a clay bank of 60 feet high, and in this process of course larger

[1] Of course one finds in many places, at about the level of the sea, modern deposits, with sub-fossil shells, identical with forms now living. From these formations those of which we are now speaking differ, by the great age of these latter, and a very different type of the shell-remains found therein. This is especially the case with the shell-deposits at Pattorfik, which appear to me to belong to the earliest part of the glacial period of Greenland. A very considerable but lately formed bank of shell-earth, with bones of Whales and Walruses alternating with beds of sea-weed, occurs at Saitok, at the mouth of Disko-fjord. Unfortunately we had only time to investigate it cursorily.

objects (fossils and claystones) are left on the shore. But even here the fossils met with in the clay itself are but few. The claystones on the contrary form a separate layer, in which they are heaped close together. Similar fossils, together with a few Gasteropods, were collected by Dr. Öberg at the foot of a clay-bank, South Leerbugt, near Claushavn.

The fossils at Pattorfik were large and with thicker shells. They are found at a height of from 10 to 100 feet above the sea-level, imbedded in greyish green basalt sand, in part hardened into basalt tufa. This is especially the case in the neighbourhood of shells, and accordingly they were most easily discovered by breaking up the hard round nodules that are imbedded in the rest of the mass. These nodules are, however, often so hard and tough, that they cannot be broken up with an ordinary hand hammer. Besides these the basalt tufa contains large rolled blocks of stone, indicating that at the time of the formation of these layers, a glacial period had already prevailed in these regions.

The fossils[1] brought home by us from these parts have been examined by Professor S. Lovén, who gives the following list of them.

Subfossil Species of Animals collected in Greenland during the Expedition of 1870.

	Pattorfik	Sarpiursak	Leerbugt	Tessiursarsoak.
Mya truncata, L.	x	x	x	
Mya arenaria, L.	x	x	x	
**Cyrtodaria siliqua*, Spgl.	x		x	
Saxicava arctica, L.	x		x	x
**S. Norvegica Spol.*	x			
Lyonsia arenosa, Möll.		x		
Tellina sabulosa, Spgl.	x	x	x	
T. tenua, Leach	x	x		
Astarte corrugata, Br.	x	x		
A. elliptica, Br.	x		x	
A. striata, Leach		x		
Cardium Islandicum, Chem. ...	x	x	x	
C. Grœnlandicum, Chem.	x	x	x	
Leda pernula, M.	x	x		
Yoldia truncata, Br.		x	x	
Y. hyperborea, Lovén.		x	x	
Mytilus edulis, L.	x			
Pecten Islandicus, L.	x			
Tritonium undulatum, Möll. ...			x	
T. Grönlandicum, Chem.			x	
T. hydrophanum, Hancock ...	x	x		
Natica clausa, Sow.		x		
Idothea Sabinei, Kröyer		x		

All species still living in the Arctic Seas. Those marked with * are called "fossil" by Dr. Rink—perhaps not found living in the Greenland waters.

After passing some time at Sarpiursak in collecting fossils, we removed to Christianshaab, and thence onward to Leerbugten,

[1] Krantz in his work speaks of fossil shells at Godthaab, *which are nowhere else found in these parts.*

south of Claushavn. By means of certain arrangements made by the Inspector, we were enabled to make a particularly interesting tour inland, to the extremity of one of the largest ice-fjords in Greenland—the ice-fjord of Jakobshavn.

This fjord is found inserted on very early maps of Greenland, though generally as a sound uniting the North Atlantic with Baffins Bay. It is now known that the supposed sound is only a deep fjord, filled throughout its whole length with huge icebergs, which completely close the fjord, not only to ships, but also to whale-boats and umiaks, nay, even to kajaks (canoes). The shores of the fjord are therefore uninhabited, and seldom visited. A tradition exists among the Greenlanders, that the fjord was in former times less obstructed by ice, and was consequently a good hunting and fishing place; and this is confirmed by the older maps of the fjord, but especially by the numerous remains of old dwellings, which are still met with along the shores, not only of the principal fjord, but of its southern arm, Tessiursak, now completely barricaded by icebergs and inaccessible from the sea (not to be confounded with the fjord Tessiursarsoak which we had just left). Tessiursak itself is still tolerably free from ice, and is easily reached by dragging an umiak over the point which separates the western shore of Tessiursak from the ocean. For such a purpose, however, a traveller must take his umiak with him, partly because he cannot obtain any boat at the now deserted Tessiursak, partly because about half-way over the point he meets with a lake, to go round which would be a considerable circuit.

On our arrival at Leerbugten, we found, in consequence of the Inspector's excellent arrangements, a Greenland family there to meet us, and the woman's boat, or "umiak," lay drawn up upon the shore. The journey over the point was immediately commenced. Six men took the roomy umiak upon their shoulders, others took our instruments, provisions for us and our people for two days. The way was taken first over a highland ridge, which separates the sea from the lake, on the shore of which the Greenlanders had pitched their summer tent. Here we rested awhile, and tried the temperature of the water (12° Centigr.), by a bathe in the lake, to the great astonishment of the Greenlanders. We then rowed over the lake in the umiak, took it up and carried it on our shoulders over another point, steeper but shorter than the former, and clothed just at this time in all the colours that the Flora of the extreme north can offer. On the other side of this point was water again, not however fresh, but salt—it was the above-mentioned southern arm of Jakobshavn ice-fjord. The umiak was again launched, and, after a row of a few hours, interrupted by hunting after young seagulls, we reached the spot where Tessiursak falls into the main ice-fjord very near its inner extremity. Here the water that was free, or nearly free from ice, terminated, and we had to make our way along the southern shore of the ice-fjord for a distance, not indeed long, but dangerous, on account of the masses of ice driven hither and thither by the violent currents near the shore.

Further out the fjord was completely covered with lofty sharp-

pointed icebergs, some of which stood so firmly on the ground that the stream could only move them at flood-tide. Others, which did not draw so much water, were carried hither and thither by the currents, and it is difficult to describe in words the deep booming and scraping which took place when these were driven against each other or on the still mightier masses aground. A loud report sometimes gave notice of the splitting of an iceberg, which was usually followed by a violent undulation reaching to the shore. It is not surprising that the Greenlanders do not like to make long voyages in such waters. Neither did we long continue our row. Just on the other side of a headland formed by a high steep gull-hill, bordering the mouth of Tessiursak, were the remains of an old house, which formed the terminus of our journey. Here we rested for the night, and returned next day by the same route by which we had come. We employed our time partly in an examination from the tops of the neighbouring hills of the vast iceberg-factory that lay at our feet, and partly in a careful investigation of the remains of the dwellings left desolate for a century, perhaps many centuries, where we now rested.

I have already given a profile of the contour of this glacier, from which it may be seen that it is impossible to draw any definite line of boundary between the inland ice and the sea. The glacier is in fact, as its profile indicates, to a considerable distance up, probably several miles from its border, broken up into icebergs, the original situation of which has, by the continual advance of the ice, been entirely disturbed, so that they are thrown in confusion one over the other. Even at the mouth of the fjord these icebergs are as closely packed as when they formed a part of the glacier, and most of them perhaps always aground. It is not till a considerable distance further on that they are separated from each other, so far at least as to allow the surface of the water to be seen between them.

Even if there had been time to take topographical measurements, it would not have been possible for me to state how many hundred yards the situation of the house we now visited lies from the spot where the fjord and inland ice meet. What is certain is, that at present the distance is not very great, and the appearance of the environs must have been very different when Kaja—such is said in former times to have been the name of the locality—was an inhabited place. That it was so for a long period is shown by the magnitude of the kitchenmiddens, and by the number of remains of houses and of graves. Also either the level of the water in the fjord has risen or the land sunk considerably since that time. It is not in fact probable that the situation of a house would be chosen so close to the shore that not even a canoe could find room in front of the dwelling.

As a Greenlander now seldom resides at any distance from the Danish-trading stations, one finds in numberless places along the coast old deserted dwelling-places. They are recognizable at a distance by the lively verdure, arising from the rich vegetation, which the remnants of fishing and hunting prey scattered round the

cottages or tents has produced. On taking a few spadefuls of earth, or on examining the walls of the new houses,—generally built with turf taken from these spots,—one everywhere finds the earth and grass-roots mixed with the bones of the animals which the Greenlanders hunt. The animals killed by the men are in fact cleansed by the women beside or in the cottage itself, and the refuse after the cleansing or the meal is thrown away—seldom far from the cottage-door. Even now, in the course of years, a heap is frequently collected as truly circular as if it had been drawn with a pair of compasses round the door as a centre. On examining its contents, it is found to consist of a black, fat earth, formed of decayed refuse—frequently bits of bone gnawed asunder and broken, shells, especially those of *Mytilus*, lost or broken household goods, etc. This bone-mixed earth most likely contains, like guano, not only considerable quantities of phosphoric acid, but also ammoniac salts, and it may happen that the trade of Greenland may find in this a valuable article of export.

As the kitchenmidden dates from the Stone-age in Greenland,—which undoubtedly extended beyond the epoch at which the whalers first began to visit these coasts,—we find in it points of arrows, skin-scrapers, and other instruments of various kinds in stone, and especially a mass of stone-flakes knocked off in forming the instruments, easily recognizable, not only by their form, but by their being of a species of stone—chalcedony, agate, and especially green jasper (called by the Greenlanders "angmak"), not met with in the gneiss formation, but only at certain spots in the basalt region of Disko or the peninsula of Noursoak. One sometimes finds smaller instruments of clear quartz, as also half-wrought crystals of the same mineral. Everything shows that the material was carefully chosen among such minerals as united the necessary hardness *with absence of cleavage, and a flat conchoidal fracture.* Among minerals in general, the different varieties of quartz (rock crystal, agate, chalcedony, flint, and jasper) are the only ones which fully satisfy these conditions; and it is therefore almost exclusively these minerals that the various races of men have chosen for making their *chipped* (not ground) stone instruments.

The two largest of the old house sites, among which we were now resting, lay so near the sea that their bases were washed by the water. A small stream had found its way through one of them, and had thus not only exposed a profile of the kitchenmidden, but also subjected a part of it to a washing process, in consequence of which bits of bone and other heavier objects lay clean washed at the bottom of the kennel and in the hollows of the gneiss slabs of the shore. These were carefully examined, and a number of stone instruments and stone chips were collected. There were no traces of iron, but a small piece of copper—an oval perforated piece—which had evidently once served as an ornament. At the largest site a tolerably thick round stone wall, 8 or 10 feet high, and 26 in section, was still distinguishable, divided into two unequal portions by a party-wall. The entrance seems to have led into the larger of these areas, judging from the extensive kitchenmidden situate just outside it.

In one of the other heaps of bones a flat stone was found, so large as to require the united efforts of several Greenlanders to turn it They declared that the workshop for the fabrication of stone instruments must have been situated on that spot, and expected accordingly to find a great quantity of chips in its vicinity, which—however, the result of their searches did not confirm.

The kitchenmiddens outside the large cot rested on a low slab of gneiss, separated from it by a thin layer of turf, in which were no traces of any pieces of bone, and which had therefore been formed before the place was inhabited. In other respects this turf, of which specimens were taken away, was perfectly like the earth, which was mixed with bones and stone-chips. Here, there were no *Mytilus* shells, though these are everywhere else found around Greenland dwellings — an indication that the inhabitants were not formerly obliged to have recourse to the species of famine-food, whereof these bear witness.

To discover the various animal forms that had here been the prey of the hunter, Dr. Öberg collected a quantity of bones, in which work the Greenlanders took a lively interest, usually determining with great certainty the species to which the pieces of bone had belonged.

The following species could be ascertained:

Cervus tarandus.
Ursus maritimus.
Trichechus rosmarus.
Cystophora cristata.
Phoca barbata
Phoca Grœnlandica.
„ *hispida.*
„ *vitulina.*
Delphinapterus leucas.

Even if we suppose that this spot was first inhabited shortly after the Esquimaux entered Greenland over Smith's Sound, its age will still be scarcely more than five hundred years, a period generally too short to show marks of the slow but continuous changes to which the organic world is subjected. Neither do the kitchenmiddens of Kaja contain any other forms of animals than those still living on the coast of Greenland. Nevertheless we obtain here an interesting confirmation of the changes that the ice-fjord has undergone. The Walrus, *Phoca barbata*, *Cystophora cristata*, no longer ventures into this long ice-blockaded fjord; and even the bear has now become so scarce, in the colonies of North Greenland south of the Waigat that most of the Danes resident in those parts have never seen it. The remnants of bones in the kitchenmiddens on the other hand prove that these animals were abundant there formerly, and are consequently an evidence that the fjord at Jakobshafn was less filled

[1] The views we got of the land inwards from a high mountain near Kaja showed, however, clearly, that the often repeated story of a strait passing completely across Greenland has arisen from a misunderstanding of the Greenlanders' accounts of the long narrow fjord. We received from the Greenlanders at Auleitsiviksfjord a similar account of the southern arm of that fjord; but on questioning them more closely, it appeared that they only meant that the distance to the extremity of the fjord was, according to their notions, immensely great. Krantz (in the middle of the last century) speaks of the fjord as quite full of ice. It was then so long before Giesecke's time, when, according to Brown, "this inlet was quite open for boats" (Quart. Journ. Geol. Soc., xxvii. p. 684.)

with ice than now. The uniform agreement of the older maps in placing here a strait, extending completely across Greenland, indicates that it is only within the last few centuries that this fjord has been converted into an ice-fjord, and that accordingly the same phenomenon, though on a larger scale, has taken place here as in the northern harbour of Belsound, Spitzbergen. Krantz mentions a similar case with reference to the ice-fjord north of Fredrickshaab, in South Greenland.

At all the old house-sites in Greenland one meets with graves, and such is the case here. The grave usually consists of a cairn, built of moderately sized stones, in the middle of which an oblong excavation, about the length of a man, and covered with a large flat stone, forms the chamber. In these we usually find the skeletons of several persons, so that the grave has been a sort of family tomb. Peculiar small chambers close beside the real grave-chamber form store-rooms for the deceased's outfit for the next world. We find here arrow-heads, scraps of leather, bone, stone or iron knives, water-ladles, bits of stone pans, lamps, pieces of flint, bows, models of canoes, oblong smoked pieces of pebble-stones, small wooden staves, according to the statement of the Greenlanders, dipped in oil, and to be used as torches, etc., etc. In a similar grave-chamber at Fortune Bay I found a number of glass beads, evidently of European origin, beads of bone, flint-points, and some rusty nails (these last probably the most costly among the valuables, which the male or female potentate resting in the grave was to take with him or her to the other world). A Greenlander gave to Dr. Öberg a pair of blinkers, or, more intelligibly speaking, snow-spectacles, made of wood, found in a grave. The proprietor would seem to have suffered from weak eyes, and to have been afraid of the reflexion of the light from the snow-fields in the abode of the blessed.

It seems to be usually assumed, that whatever iron is met with among the Greenlanders is either of meteoric origin, or else has come from the original Northmen colonists, or from the Greenland merchants and whalers of modern times. This assumption appears to me erroneous. First, as regards meteoric iron, it is certainly met with in Greenland, as in all other lands that have been but a short time inhabited by man; in other countries it has been used up during the period when iron was more valuable than gold. The meteoric iron that has hitherto been found in Greenland is, however, generally too hot-short, cold-short, and brittle, to be otherwise than exceptionally used; and even if a piece of better quality should be met with, I cannot see how the Greenlanders, with the tools they at present possess, could possibly forge an arrow-point out of a piece of iron weighing a couple of pounds. But, on the other hand, since the time when ships first began to cross the Atlantic, a wreck may now and then have been carried by the current on to the coast of Greenland, sometimes far up Baffin's Bay. We were able to verify an example of this. In fact, during our stay in North Greenland, a fragment of a small schooner or brig drove on shore at Disko, between Diskofjord and Mellanfjord. As soon as notice of the

matter was given, the Greenlanders in the neighbourhood made an accurate inventory of everything on board that could be turned to any useful purpose. They found bread and sundry other provisions, also potatoes, but no paper or any indication of the name the ship had once borne, or the nation to which it had belonged, further than that the brass bolts by which the timbers were fastened together bore the stamp "Skultuna;" they were therefore from the Swedish brass-foundry of that name, and it is perhaps probable that the vessel itself was either Swedish or Norwegian. It was a two-masted vessel of 100–150 tons burden, according to the estimate of the Danes, and, according to the Greenlanders, could take a cargo equal to about half that of a three-master. The timbers were of oak, the outer covering of pine, the sides were not strengthened to resist ice, the stern was round "as a Dutchman's." The Greenlanders asserted that undoubtedly the ship was neither a whaler nor intended to sail amongst ice—and there is not the slightest reason to doubt the accuracy of their judgment, which is most sagacious in such matters. We have then here an example of a wreck drifting hither from the southern seas. Similar events must of course have often happened before, and what an abundance of iron the wreck of a ship supplies to a Greenland colony with its limited wants, is evident from the quantity of iron lying, at our visit, scattered around the houses in Godhavn, and obtained from whalers that had been stranded there in the preceding year. Here again was evidence of the Greenlander's improvident character. It never entered the mind of any one of them, out of all that quantity of iron—sufficient perhaps to supply the wants of the Greenlanders for a century—to preserve more than what he for the moment required; and if the regular exportations from Europe were to cease, the colony would again in a few years have to go back to the bone-knife, the bow and the flint implements.

For bone-knives, such as are sometimes found in old graves, the edge of which is formed by an iron plate let into a groove in the bone, a piece of an iron hoop of a barrel, that may have washed ashore, may easily enough have been used; an old worn-out iron knife would have been less fit for the purpose. These iron-shod bone-knives are therefore by no means always remnants from the time when the iron brought into the country by the Northmen in the beginning of the present millennium had begun to be scarce, but merely examples of the Greenlanders' way of turning to use for their simple wants, in the most appropriate manner, any objects that may come in their way.

At Kaja persons have been buried, not only in ordinary graves, but in low caves formed at the foot of neighbouring steep cliffs of gneiss by huge blocks of rock fallen from the mountain one over another. Most graves in the vicinity of the colonies have been long ago plundered by searchers after antiquities. This was not the case in this distant locality; nevertheless, all that we found in the graves was a pair of water-ladles and arrow-heads. On the other hand, as has been already said, a rich harvest was gathered at the sites of the

old houses.[1] Some skulls were also taken, the Greenlanders not appearing to object to this; and as it is a matter of the greatest scientific interest to obtain perfectly authentic skulls of the original inhabitants of Greenland before any mixture of race had taken place.

On the 31st of July we returned to Leerbugten, where we were obliged to divide our little expedition into two parties. It was of interest to the geologists to visit as many places along the coast as possible, even if it were only for a few hours, whereas the botanist and the zoologist for their researches, and especially for the preservation of their collections, were obliged to remain at least some days at each place. Dr. Berggren and Dr. Öberg therefore now went together, to collect from the bottom and from the mountainous shores of Disko Bay materials for the fauna and flora of the place. Dr. Nordström and I, on the other hand, hastened to the Basalt region, to seek for new sources of the climatological history of the extreme north in the coal, sand, and clay-beds to be met with there. The harvest we gathered was rich beyond our expectations.

In the first volume of his work on Greenland, Krantz has introduced some notices of the mineralogy of the country, whence we find that the coal-beds of Disko were then (1765) already known. A statement of the Greenlanders is moreover adduced, that in certain distant parts all sorts of fishes were to be found turned into stone. Some years later the surgeon Brasen, who in 1767 made a voyage to these parts for his health, collected a quantity of minerals, of which a catalogue is given in the third volume of Krantz's work. This catalogue contains twenty-five items, including different varieties of quartz, granite, graphite, pot-stone (steatite), pumice-stone (of which it is justly remarked, that it has been brought hither by the currents from Iceland), and so forth. In the beginning of the next century (1806-1813) C. Giesecke—who was first an actor, afterwards a mineralogist with the title of "bergsraad," and lastly professor in Dublin—and Knight made extensive mineralogical excursions on the coasts of Greenland. Giesecke himself has published but little of his observations,[2] though carefully kept journals of his travels are preserved in manuscript at Copenhagen. Numerous and important new discoveries prove that his researches were carried out in a true scientific spirit, and with a completeness and accuracy the like of which but few of the old civilized lands of Europe could at that time produce. Even North Greenland was visited by Giesecke. Here he discovered, among other things, plant-fossils at Kome[3] and at the east coast of Disko,[4] and furnished several instructive sections.

[1] Stone implements of various kinds were collected and purchased by us at several other places, so that the collection we brought home consisted of above 1000 specimens. Dr. Öberg made the richest harvest at Kikertak.

[2] In Brewster's Edinburgh Encyclopædia, vol. x., pp. 481–502, under the word "Greenland," is an article written by Giesecke, containing, among other things, some short notices of the mineralogy of that country. There is also a work by him on Cryolite in Edinburgh Philo. Journal, vi., 1822.

[3] Giesecke's Journal. Heer's Flora Fossilis Arctica, p. 7.

[4] The above-mentioned article in Brewster's Edinburgh Encyclopædia, p. 493.

Subsequently (1838) the coal-beds of North Greenland were, by order of the Danish Government, examined by J. C. Schythe, though, as it appears, chiefly for technical purposes. A more important event for geological science was Dr. Rink's four years' residence (1848–1851) in North Greenland, during which time he visited many parts of the Basalt region, whence rich collections were taken home, among which may be mentioned fossil trunks of trees from several places, as also the fossils from Kome described in Heer's Flora Fossilis Arctica. Some years later a Dane, Jens Nielsen, residing at Atanekerdluk, discovered magnificent Miocene fossils there, a large number of which were collected, when Captain Inglefield, in company with Captain Colomb, and Obrik, the Inspector of North Greenland, visited the place in July, 1854.

These strong proofs of a climate formerly warm, up in the neighbourhood of the Pole, aroused wonder and astonishment in all who saw them. More collections were made, partly by Inspector Obrik,[1] partly by other officials of the Danish Trade. Also Prof. Torell, Dr. Walker, Dr. Lyall, and others brought home not inconsiderable collections from their travels in Greenland.

The importance of this discovery to the history of our globe was, however, first taught by means of Heer's Flora Fossilis Arctica, in which these fossils are described, together with similar fossils collected during the English Franklin Expeditions from the most northerly archipelago of America, by Prof. Steenstrup from Iceland, and by the Swedish Polar Expeditions from Spitzbergen. The British Association had already (1867), at the instance of Mr. Robert H. Scott, F.R.S., sent out an expedition to make new researches in this geologically interesting quarter. These were entrusted to Messrs. Whymper and Brown;[2] but in consequence of a combination of unfavourable circumstances, the new researches were confined to the already well-examined locality of Atanekerdluk and the opposite shore of the Waigat. The new collections thus indeed completed the knowledge we already possessed of the Flora of the Miocene Period in the extreme north, but they opened no new views of the periods which immediately preceded and followed it.

As in 1858, and especially in the Spitzbergen expedition of 1868, I had had the opportunity of contributing in some measure to the climatic history of the extreme north, this question interested me in

[1] Mr. Obrik's collections were given partly to the University Museum at Copenhagen, partly to Capt. M'Clintock, who, on his return in 1859, passed Disko, and, on returning home, presented them to the Royal Society in Dublin, the same institution to which Capt. Colomb had presented his collections. Capt. Inglefield's collections were given partly to the Geological Survey in London; Dr. Walker's and Dr. Lyall's (from the eastern side of Disko, near the surface of the sea) to the Botanical Museum at Kew; Prof. Torell's to the National Museum at Stockholm; Mr. Whymper's and Mr. Brown's to the British Museum. The collections from Spitzbergen and of the expedition of 1870 will be divided between the Museums of Stockholm and Gottenburg.

[2] On this journey, see Osw. Heer, "Contributions to the Fossil Flora of North Greenland, being a Description of the Plants Collected by Mr. Edward Whymper during the Summer of 1867."—Phil. Transactions of Roy. Soc., vol. 159, part ii., p. 445. 1870.

the highest degree. It was especially desirable to collect materials from the Cretaceous beds at Kome, and to obtain, if possible, plant-fossils from the long periods intervening between the fern-forests of the Cretaceous and the beech and plane woods of the Miocene Epoch; as well from the ages intervening between the last-mentioned era and the present time. This was the object of Dr. Nordström's and my tours during the remainder of the summer.

Aug. 1. We departed in the Inspector's yacht, with our own whale-boat in tow, from Sandbugten to Flakkerhook, where the Inspector took leave of us, promising to meet us again at Atanekerdluk. We rowed, touching at a number of intermediate places to collect plant-fossils, past Mudderbugten, round Isungoak, to Ujarasusuk, whence I passed, in a boat obtained from the Danish officer, to Ritenbenk coal-mine, north of Kudliset, and then crossed the Waigat to Atanekerdluk. Dr. Nordström stopped a little longer to collect more fossils at Ujarasusuk, and thence sailed in somewhat rough weather direct to our appointed place of meeting. On this now uninhabited spot we all met on the 5th of August. On the 9th we rowed farther, to Mannik, Atane, Noursak, and Noursoak, where we remained a couple of days (August 12 and 13).

The time was employed partly by a visit to the coal-beds of Netluarsak, situated high up in the basalt beds between the two last-mentioned places. From Noursoak the Inspector continued his journey to Upernivik, while we rowed along the shore of Omenak-fjord, touching at Niakornet, Ekkorfat, Karsok and other places, to Pattorfik. From Niakornet and Karsok two trips were made into the interior, to coal-beds at Ifsorisok and to the famous graphite-bed at Karsok. From Pattorfik we rowed over the fjord, though densely packed with icebergs, to Omenak, where we arrived on the 20th of August. Here we were detained by the ice a couple of days, during which we were lodged in the most hospitable manner by the local Colonial Governor, Mr. Boye.

On the 22nd, in the afternoon, we rowed over to Assakak glacier, and the following day onward to Kome, whence we went on board a ship lying there belonging to the Greenland Trade, in which, in the evening of the 24th, we set sail for Godhavn, where we arrived on the 30th, and whence some excursions were made to the spot where the meteoric iron was discovered at Ovifak; to Saitok, at the mouth of the Disko fjord; to Puilasok, and Sinnifik. Shortly after our arrival at the last-mentioned place (Sept. 3), we received a Kayak express from Godhavn with the news that war had broken out, which induced us to hasten back to the colony in order to avail ourselves of the first opportunity to return to Europe. As no vessel was just then lying there, nor was any expected to arrive at Godhavn for the next few days, I immediately passed over to Egedesminde. Dr. Nordström remained at Godhavn, awaiting Drs. Öberg and Berggren, to return home with them. At Egedesminde I went on board the brig Thialfe, commanded by Captain Brockdorff. Contrary winds prevented our departure till the 23rd of September, and the passage was slow in consequence of storm and unfavourable

winds, so that it was not till the 2nd of November that I could land at Elsinore.

During the whole period of our boat excursions in Greenland we had, with the exception of one rainy night, a constantly clear sky and a favourable sailing breeze: circumstances which greatly facilitated our movements, and rendered it possible in so short a time to investigate at least the principal geological features of that remarkable tract, and to collect extensive series of plant-fossils from above twenty separate localities and belonging to five widely-separated geological horizons.

Like previous similar collections from the Arctic regions, these have been transmitted for examination to Prof. Osw. Heer, of Zurich, and I venture to hope that, when duly interpreted, they will give us an idea of the changes of climate these regions have undergone since the epoch when serious variations of climate first took place upon the globe. I will only offer a few short remarks on the geognosy of these interesting beds.

Greenland basalt or, as it is also called, trap-formation, probably extends completely across the country north of the 69th degree of latitude; at least Scoresby found, in his remarkable visit to the eastern coast of Greenland, trap with the impression of plants[1] at many places along the extent of coast visited by him. It is possible that the same formation may continue under the sea to Iceland, and thence, partly in a more northerly direction over Jan Mayen to Spitzbergen, partly in a southern direction from Jan Mayen, over the Faroe Islands, to the Hebrides and Ireland.[2] The same eruptive formation extends also westward over a vast part of Franklin's Archipelago, perhaps even to the volcanic tracts at Behrings Sound. These basalt beds probably all arise from a volcanic chain, active during the Tertiary Period, which perhaps indicates the limits of the ancient polar continent, in the same manner as is now the case with the eastern coast of Asia and the western of America, thus confirming the division of land and water in the Tertiary Period, which upon totally different grounds has been supposed to have existed.

This formation appears most developed in North Greenland on the large Island of Disko, as also on the peninsulas of Noursoak and Sortenhook, where it occupies an area of above 7000 square miles with a vertical section of 3000 to 6000 feet.

Even here these eruptive rocks are divided into beds which, between Godhavn and Fortune Bay, rest immediately upon the gneiss formation; on the strand of Omenakfjord, between Ekkorfat and Kome, upon sand and clay beds belonging to the Cretaceous age. To the east of Godhavn, again, at Puilasok and Sinnifik, we meet with sand and clay beds lying between, not under, the basalt

[1] Scoresby's collections from these parts seem to have been lost. On the other hand the last German expedition to East Greenland brought back collections of plant impressions which have also been placed for investigation in the hands of Prof. Osw. Heer.

[2] The agreement between the basalt formations of Greenland and the British Islands, both as regards the character of the rocks and the age of the beds, seems to be perfect.

rocks, and accordingly newer than these latter. Also the fossils in these beds belong to the Tertiary Period. It follows then, *that the eruptions, which have given rise to these vast beds of basalt, have taken place subsequently to the commencement of the Cretaceous, and have ceased before the termination of the Tertiary Period.*

In the preceding pages I have intentionally spoken of basalt strata and schists. In almost every place where I have had the opportunity of examining it, the Greenland basalt is so stratified that one is forced to admit, that it is only exceptionally that we have to do with consolidated masses of lava, but for the most part with eruptive sedimentary beds of volcanic ashes and volcanic sand, which in the course of thousands of years have become hard again and assumed a crystalline structure.

Any clearly decided lava-streams I have scarce had occasion to observe, even larger or smaller dykes are not so common as one might expect, and where they are found the mass of lava ejected has scarcely produced any effect upon the loose beds of sand, clay, or basalt that it has pierced.

No volcanoes, either extinct or active, are met with in these parts, although circular depressions in the basalt plateau, caused by glaciers or brooks, may, when carelessly observed, easily be mistaken for true craters. It is, of course, quite natural that great cavities in the interior of the earth must arise in the places whence the great eruptions have issued, which have produced the basalt region of Greenland, and that these in their turn must, within a short period, be followed by the destruction of the superjacent volcanic cone. The place or places where these old volcanoes once rose high over the surrounding plains will therefore now most probably correspond to the greatest depths in the neighbouring sea.

At Godhavn the lowest strata resting immediately upon the gneiss formation (*e.g.* outside Bläsedalen) consist of a basalt tuff or breccia containing various species of zeolites (according to Giesecke, only apophyllite), next comes columnar basalt, free from zeolites, then again basalt tuff with zeolites, alternating with true basalt. A coarse crystalline dolerite, very similar to the Spitzbergen hyperite, forms at Atanekerdluk, near the shore, a hill several thousand feet high.

The basalt beds are 50 to 100 feet thick, and may be traced for miles along the shores, often separated from each other by thin layers of red basaltic clay. Sometimes the layers are crossed by dykes of a hard, fine-grained basalt.

Not only dykes, but also basalt beds have, on the cooling of the melted mass, or during the drying and crystallizing process which the volcanic ashes have undergone in their transformation to basalt, been broken into regular columns, mostly hexagonal. Brännvinshamn, Skarffjäll, Kudliset, and other places on Disko and the peninsula of Noursoak, afford examples of this kind of basaltic structure, comparable in magnificence with Staffa and other geologically famous European localities.

Volcanic eruptions, as has been above remarked, no longer occur in this region. Yet, in consequence of the rapidity with which

basalt is destroyed, layers of basalt sand constantly collect on the shores—beds which, in the course of thousands of years, may, under favourable circumstances, harden to a rock not distinguishable from real basalt, unless perhaps it be by the circumstance, that as these beds are deposited in the sea, they may possibly contain marine fossils, which the tuffs of pure basalt formations do not. Such a hardened fossiliferous basalt sand occurs at Pattorfik, in Omenakfjord and between that place and Sarfarfik. This stratum, which has already been described, is, however, evidently far more recent than the newest beds of the real basalt.

Young as the colonies in these parts as yet are, tradition can nevertheless adduce sundry examples of the rapidity with which basalt rocks are destroyed. It is difficult to induce a Greenlander to penetrate by boat into the inner parts of the three fjords which cut into the west coast of Disko Island. The reason of this is said to be, that on one occasion a whole house with all its inhabitants was crushed by a sudden fall of a basalt rock. At Godhavn, on the brow of the basalt mountain, there were formerly twelve huge projecting elevations, called the twelve apostles. Of these there is now but one remaining.

In the immediate neighbourhood of Godhavn the basalt either extends completely down to the sea or lies immediately upon the gneiss formation, which there occupies the strand-cliffs. On rowing from this point further to the east, as soon as one is past Skarffjället,[1] sand or sandstone beds are found nearest the shore, increasing in thickness as one approaches the Waigat, so that at Flakkerhook and Isungoak they form mountains of 1500 to 2000 feet high, frequently crowned with a perpendicular basalt diadem. The same formation is met with on the other side of the Waigat at Atanekerdluk. Further north-west in the strait, however, the conformably stratified sand and basalt beds sink again, so that before one arrives at Noursak the basalt reaches the sea-level. Beyond that point the peninsula is entirely occupied by basalt-beds, terminating in terraces, between which no sand-layers can be discovered from the shore. But at a height of from 1000 to 2000 feet above the sea we find here, also, purely sedimentary formations of sand, clay, coal, etc., but very thin, and therefore, for the most part, concealed by basalt detritus.

Further inward, the shore of Omenakfjord is occupied exclusively by basalt, extending beyond Niakornet; but afterwards we again meet with a formation similar to that of Atanekerdluk, though of a widely different age, and resting, not upon basalt, but upon gneiss. These layers belong to the lower Cretaceous. Here the basalt strata no longer extend down to the water, and the shore pebbles farther inward are again of gneiss. But the glaciers that extend downwards from the interior continually carry with them basalt blocks and basalt columns, indicating that the lofty inland mountains are still

[1] Some of these beds (at Puilasok and Sinnifik) nearest Godhavn are however more recent than the basalt formation, i.e. stratified *between*, not *under*, the rock of the basalt formation.

composed of that rock; and that there also it is interstratified with Tertiary schists is evidenced by the plant-remains that, on the Assakak glacier, lie mixed with pieces of basalt on the surface of the ice.

Here also was found a piece of basalt with wood immediately inclosed in the basalt; but, with this one exception, all the fossils have been found in the Coal-bearing sand and clay beds which accompany the basalt, and in Greenland are met with only in the basalt regions. I have, however, no doubt that organic remains will be found in the red basalt clay that lies between the real basalt beds, though we had not time to look for them.

The fossils in the sedimentary strata of the trap-formation[1] in Greenland consist exclusively of plant-remains, and fragments of one or two insects and fresh-water mollusca; there are no traces of marine mollusca nor vertebrate animals. An extensive continent, then, occupied this portion of the globe at the time when these strata were deposited; and the abundance of the sand strata, furthermore, seems to indicate that, during the Cretaceous and Tertiary Periods, this was a vast sandy desert, varied only by oases of inconsiderable extent. *At that time there were no glaciers in these parts.* For the sand strata contain no traces of any such erratic blocks or large boulders as always accompany and characterize the Glacial formations, and which are met with even in loose clay-beds of Glacial origin, which, where a subsequent denudation has taken place, cover the beds of basalt and Tertiary sand. I ought however to mention that in places where both the modern Glacial formation and a part of the subjacent Tertiary sand have been washed away, sections often occur, which, on a cursory examination, seem to indicate that the Tertiary sand contains a vast quantity of erratic granite and gneiss blocks. But wherever time permitted us to make a careful investigation, or where, as is the case in most of the places

Fig. 7.

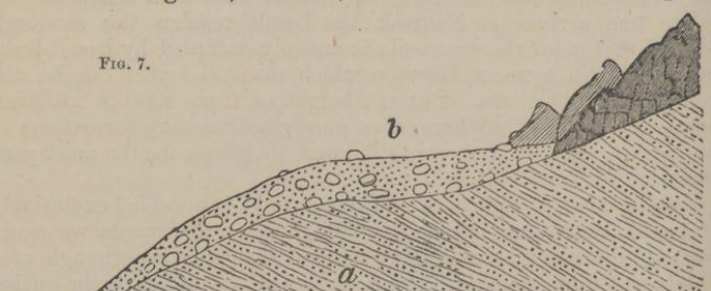


Fig. 7.—*Section before any modern denudation had taken place.*
(*a*) Tertiary strata without erratic blocks. (*b*) Glacial strata with erratic blocks.

[1] I have preserved this name as used in Greenland as a common denomination for the Cretaceous formation, dolerite, diabase, basalt, the Tertiary strata included in basalt, as also the strata at Sinnifik and Puilasok, probably deposited shortly after the cessation of the eruption of the basalt.

where plant-remains are found, fresh perpendicular sections are exposed, it has become evident that these blocks have been washed down from superjacent more recent Glacial strata (*b*), and in no wise belonged originally to the Tertiary strata (*a*), in which they now lie. The accompanying figures show this clearly :—

Fig. 8.

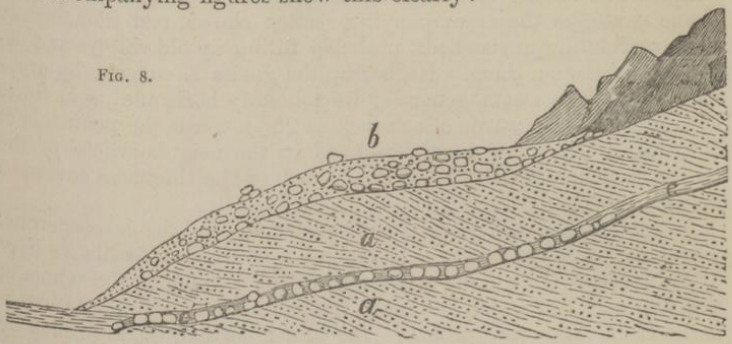


Fig. 8.—Section along a modern mountain-stream (*c*—*c'*).

These Tertiary beds therefore do not afford any evidence that the favourable climatic circumstances of the Tertiary era have been interrupted by a separate Glacial period, which has subsequently disappeared. The Cretaceous, Miocene, and recent sand-beds are in outward appearance perfectly alike, and if a new elevation should expose the sand-beds now in process of formation in many places at the bottom of the Waigat, these, wherever they were destitute of organic remains, would be very difficult to distinguish from the Cretaceous sandbeds at Kome, or the Miocene beds at Atanekerdluk, Isungoak, etc.

It was formerly supposed that the whole Coal-formation of Greenland belongs to the same geological period. Heer's important discovery, that the beds at Kome and Atanekerdluk belong to two widely different periods, showed that this is not the case. Subsequently a stone was found in Disko containing an impression of a real *Sigillaria*. This stone, however, appears either to have been brought hither as ballast or by ice. At least, we could not anywhere in these parts discover beds belonging to the old Carboniferous Period.[1] The discovery of Heer was not only confirmed by our researches last summer, but we also discovered plant-remains from one or two geological horizons quite new for N.W. Greenland.

In the description of these I follow the chronological order, beginning with the oldest.

I.—*The Kome strata* (older division of the Cretaceous formation, according to Heer).

By this name I designate a sedimentary, coal-bearing formation, occurring here and there between Kome and Ekkorfat, on the line of the coast of Noursoak peninsula, situated S.W. of Omenak. The

[1] Fossils really belonging to the Coal period have since (Expedition of 1871) been found by Dr. Nauckhoff, at Kudliset.

name is taken from the place where the chief coal-bed is found, and from which, in all probability, the plant impressions came, which were brought thence by Giesecke and Rink. These strata, however, occur not only at Kome, but all along the above-mentioned coast, with the exception of a few interruptions by gneiss hills. The Kome strata, as the accompanying section shows, rest immediately upon undulating gneiss-beds, probably filling up old valleys and depressions between them. Higher up the gneiss is covered by eruptive rock. The strata generally lie tolerably horizontal, sometimes even with a dip inwards of as much as 20° towards the peninsula of Noursoak. They are most developed in the neighbourhood of the two extremities, Ekkorfat and Kome, where the thickness exceeds a thousand feet.

As the plant fossils occur almost exclusively in the lowest strata, we cannot, without a careful examination of the few fossils we have brought home from the upper strata, decide whether the whole of this vast series of strata belong to the same geological formation or not. It is, however, probable the upper portion, distinguished by its thick coal-bed, belongs to the next division.

Most part of the Kome strata consists of sand or a loose sandstone, often, however, interstratified with beds of slate and bands of coal. The slate is generally mixed with sand, and, as it were, thoroughly corroded by acids, and in these cases so loose that the plant fossils it may perhaps contain can scarcely be preserved. Fortunately there is also found, especially in the neighbourhood of the lowest coal-beds, a harder, sometimes argillaceous, sometimes talcose, slate with numerous impressions, chiefly of ferns and Coniferæ (not only twigs, but cones, seeds, and leaves). The leaves especially occur in abundance, generally transformed into a dark brown, semitransparent, parchment-like mass, resembling the vegetable parchment which is produced by the action of sulphuric acid on lignite. Some beds occur in which these leaves are so numerous that the beds form a felt, which is flexible, and can almost be ravelled, woven of leaves and other similarly transformed remnants of plants. It is possible that this fossilization depends upon the action of the acid gases which have come forth during the volcanic eruptions and condensed themselves in the waters of the locality, and thus that the condition of the fossil leaves is connected with the extremely corroded appearance of the slate and sandstone.

The most important of the coal-beds[1] occur in the upper part of the strata at Kome, but bands of coal are interstratified with the slate in many other places, but they are not very extensive, though sufficient to provide a few Greenland households with the few tons of coal they want in the year. At present, according to the statement of the Governor of the colony, coal is thus collected, not only at Kome, but also at Sarfarfik, Pattorfik, Avkrusak, and, though less frequently, at Ekkorfat.

To this, or rather to a still more recent formation, belongs also

[1] As stated above, the coal-beds probably do not belong to the *under*, but to the *upper* Cretaceous (the Atane beds).

the remarkable layer of graphite at Karsok, and probably also the layer of graphite at Niakornet. One has to pass over a tolerably extensive subjacent band of gneiss before arriving at the sedimentary strata, which appear, with a steep inclination, on the bank of the Karsok river at a height of 840 feet. Afterwards, slopes of basalt, boulders, gravel washed down from the mountains, etc., continue, till, at a height of 1150 feet, one arrives at a terrace covered with gravel, in which a few angular fragments of graphite may be discovered, as also angular fragments of a hard sandstone impregnated with coal. In consequence of the unfitness of our Greenland assistants for real labour, our attempts to dig through the strata of gravel, and reach the graphite bed, were unsuccessful; but we were informed by Capt. G. N. Brockdorff—master of the ship which, in 1850, was to have taken out a cargo of graphite to Europe, and which actually carried over about five tons of that mineral—that the graphite here forms a horizontal bed eight to ten inches thick, covered with clay, sand, and angular fragments of sandstone. This interesting graphite bed does not contain any organic remains; but as both the underlying Cretaceous strata and those of graphite lie horizontally and in the neighbourhood of each other, and the latter is situated about 300 feet higher up, it is evident that *the graphite at Karsok belongs either to the Cretaceous or to a still later period.*

[*Extracted from the* GEOLOGICAL MAGAZINE, Vol. IX., No. 10. October, 1872.]

PART IV.

SOMEWHAT further to the west of Karsok, and about 50 feet higher up, occurs another similar stratum, containing a mass of graphite, so soft that it may be cut with a knife. This spot was not, however, accurately examined. A similar stratum of graphite imbedded in sand and clay occurs also at a very great height above the sea at Niakornet, but time did not admit of our visiting that spot.

The graphite from Karsok is perfectly compact, without any signs of cleavage. On being heated, some pieces decrepitate violently and yield water. An analysis by Dr. Nordström gave:

	I.	II.	III.
Carbon	93·70	95·68	95·42
Hydrogen ...	0·69	0·22	0·27
Ash	4·92	3·60	3·60
	99·31	99·50	99·29

Part of the loss was probably oxygen. The ash contained per-oxide of iron, alumina, and 50 per cent. of silica; so that even these analyses indicate that this mineral is much nearer pure graphite, with which it fully agrees in appearance, than the coal that is usually found in these formations.

In the strata belonging to this division we found plant-remains at the following places:—

1. *Ekkorfat.*—The strata here rest

Fig. 9. Succession of strata at Ekkorfat.

upon a red gneiss, with a tendency to break off in scaly flakes, thus forming rounded hills on the shore. Nearest to the gneiss, at an inconsiderable distance from the strand, a little above the level of the water:

(1) (Lowest) Hard sandstone, unfossiliferous (60 feet).
(2) Carbonaceous slate, with sandstone and coal-bands, interstratified with thin layers of leaves of Coniferæ (30 feet).
(3) Hard red and white sandstone (300 feet).
(4) Red sandstone, with bands of slate and evident ripple marks (30 feet).
(5) Hard grey sandstone, almost like porphyry, inclosing round nodules of small stones and fragments of coal (100 feet).
(6) Alternating layers of sandstone and carbonaceous slate, with seams of coal, layers of harder slate, impressions of leaves, etc. (100 feet).
(7) Black slate and grey sandy slate with sandstone veins, no fossils (300 feet).
(8) Sandstone of uniform yellow colour, the upper part, for a depth of 200 feet, interstratified with grey slate, sandstone, and coal seams (300 feet).
(9) Basalt.

2. *Angiarsuit.*—Yellow sandstone, interstratified with grey slate, with seams of coal and impressions of plants; the same stratum as No. 8 (Fig. 9) at Ekkorfat. At Ekkorfat the strata, with the exception of occasional irregularities, dip towards S.W., so that nearer Karsok the yellow sandstone (8) reaches to the level of the sea. We thus had an opportunity of collecting fossils from this stratum, at a place called by the natives Angiarsuit, which, however, decidedly belong to the same formation as the fossils from the lower strata at Ekkorfat.

3. *Avkrusak.*—Fine impressions of plants are found here, near the shore, immediately under the sandstone, in horizontally-stratified slate.

4. *Karsok.*—The coast-land here, as has been mentioned above, is occupied by gneiss rocks, which, at a height of eight or nine hundred feet, are covered by a layer of slate containing fine impressions of ferns. The slate is, however, soon covered by gravel, so that the formation here is exposed only for a very limited distance close to the Karsok river.

5. *Pattorfik.*—For a distance of six English miles from Karsok the coast-land towards the fjord is occupied by gneiss; but on the other side of the river, at Pattorfik, first slate strata and then sandstone reappear close to the shore,—the first with particularly beautiful fossils, found principally in the beds nearest the gneiss. No extensive sections are however to be met with here, for the perpendicular exposed cliff, some yards above the surface of the sea, is covered with detritus of basalt, often hardened to a tuff-like mass, and inclosing the large subfossil shells mentioned above.

6. *Kome* or more properly Kook.—The former name, though grammatically wrong, ought however to be retained, as having been already introduced into science. The lowest portion of these strata forms on the shore an abruptly-terminated terrace of 80 to 150 feet high. Higher up the strata terminate in a gravel-covered slope,

scored by a number of deep ravines, which offer very clear sections of the various strata of the formation, for the most part nearly horizontal, or slightly dipping inwards towards Noursoak peninsula. The series is as follows (beginning at the top) :—

On the brow of the hill.....	*Basalt.*
About 1500 to 1200 feet above the level of the sea	*Thick banks of gravel*, concealing the strata below.
1200 to 1000 feet above sea-level	*Slate.* *Sandstone.*
1000 to 750 feet above sea-level	*Slate.* *Sandstone.* *Slate, with seams of coal* and a few plant-impressions. *Sandstone.*
750 feet above sea-level	*A thick stratum of coal.* *Slate, with layers of sand.* *Sand.* *Slate.* *Sand.* *Sandstone*, very loose.
150 feet above sea-level	*Carbonaceous slate, with bands of sand and coal.* *A coal seam.* *Slate, with abundance of impressions of plants.* *Strata not exposed.* *Gneiss.*

This section was taken in a ravine opening into the centre of Kome bay. The finest impressions of plants, however, occur in the neighbourhood of the house-sites, not far from the limit of the gneiss, which here forms a high mountain, immediately east of the river (Kook), which on that side seems to form the limit to the Lower Cretaceous beds of Greenland.

Thick as the Lower Cretaceous strata are, they are now visible only over a small area, as they only fill up the valleys between the gneiss hills by the coast. The strata at Kome are separated by gneiss hills from the strata at Pattorvik, and these again in the same manner from those of Karsok, Angiarsuit, Avkrusak, and Ekkorfat. The main mass of the formation, which evidently once extended over Omenak Fjord, is now washed away. Whether it extended inward into Noursoak peninsula under the basalt or not, it is impossible with certainty to say, as several of the deeper valleys are filled with ice. I however think this extremely probable, although the real Kome strata seem to be wanting at Atanekerdluk. They may possibly reappear between the last-mentioned place and the gneiss formation at Takkak. Calcareous strata are entirely absent in the Greenland Cretaceous, and it is useless to look for marine fossils there—everything shows that what we here have before us is a fresh-water deposit.

The fossils are most numerous and best preserved in the lowest strata, and consist principally of ferns and Coniferæ. Leaves of Coniferæ and other plant-remains are also met with, although rarely in the upper strata; but those found there, in consequence of their friability, can hardly be preserved. As regards these fossils, Prof. Oswald Heer has made the following communication :—

"All the places where these remains have been discovered (Kome, Avkrusak, Angiarsuit, Karsok, Ekkorfat, Pattorfik) have the same Flora, the character of which is marked by numerous ferns, among which the Gleicheniæ (*Gleichenia Rinkiana, Zippei, Gieseckiana*) play the chief part; by a remarkable Cycad (*Zamites arctica*), magnificent leaves of which are found, and by a large number of Conifers (*Pinus Crameri, Sequoia Reichenbachii, Widdringtonia gracilis*, etc.), and, in addition to this, by the almost total absence of Dicotyledons. The fine new discoveries tend to confirm the opinion I (Heer) have already expressed,[1] that this Flora belongs to the Lower Cretaceous, in all probability to the Urgonian strata. This is particularly shown by the beautiful Cycad, *Glossozamites Heheneggeri*, discovered at Kome. The Greenland collections contain many specimens, which resemble the plants from Wernsdorff, which belong to the Urgonian, and have exactly the same character as those from Kome. Among the most remarkable new species from the Greenland Lower Cretaceous, a fine *Tæniopteris*, n. sp., an *Adiantum* (both from Avkrusak), and an elegant new *Sequoia* from Pattorfik, deserve special mention."

Fig. 10.

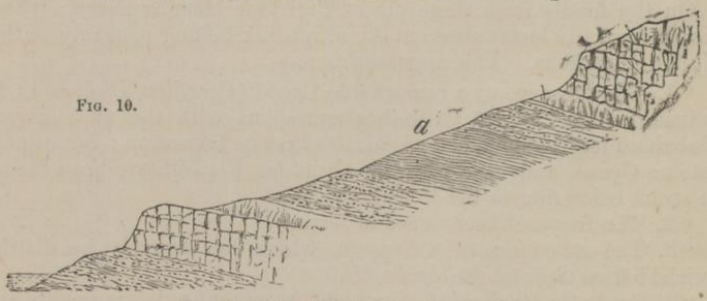


Fig. 10.—Series of strata below Atanekerdluk.

II.—*The Atane strata* (Upper Cretaceous, according to Heer).

These strata occur on the southern side of Noursoak peninsula, between Atanekerdluk and Atane, and probably also further on to the north on the eastern side of the Waigat. Some few, and not very clearly determinable, vegetable remains from Kome (750–1100 feet above the sea), and from the strata situated nearest the surface at Kudliset[2] (Ritenbenk coal-mine), probably belong to this formation, which contains more slate than either the subjacent Cretaceous strata or the superimposed Miocene beds, besides sand and loose sandstone, but no traces of limestone. The thickest Coal strata in Greenland—as well those at Atane (the richest I have seen in Greenland) as those near the surface of the water at Ipiit, and probably also those situated 750 feet above the sea at Kome—belong to this period. The same is probably the case with the strata inclosing retinite (not *amber*) at Hare Island. Small nodules of resin, however, occur in the Greenland Miocene.

[1] Heer's Flora Fossilis Arctica.

[2] The upper strata in the neighbourhood of Kudliset are Miocene.

The above profile shows the stratification at (Lower) Atanekerdluk. The mass of the formation consists of very fine black argillaceous slate (*a*), resembling the slate from Cape Starastschin, in Spitzbergen, containing a quantity of plant-remains, which, however, it is very difficult to preserve, in consequence of the brittleness of the slate. There are no marine fossils whatever here, so that it is evidently a fresh-water formation.

At Atane the adjoining cliffs nearest to the water's edge are concealed by stone and gravel, consisting partly of sandstone and partly of basalt and basalt breccia containing zeolite. Over these we have:

At 450 feet, horizontal strata of hard sandstone.
At 600 feet, argillaceous slate which soon alternates with sandstone.
At 650 feet, a thick coal-bed resting upon fine slate, with impressions of plants (Upper Cretaceous) and particles of resin. Then again slate, often interstratified with coal-beds of considerable thickness.
At 900 feet, a coal-bed two feet thick, from which on the side left bare by the ravine a white salt has fretted out (sulphate of alumina). On this is a stratum of sandstone 50 feet thick, then argillaceous slate, and over that sandstone again, and lastly basalt.

On the fossils from these places Professor Heer remarks: "The fossils from the lower strata at Atanekerdluk belong probably to the Upper Cretaceous. This appears from:—

"1. The presence of a remarkable Cycad (*Cycadites Dicksoni*). It is true that this is not altogether consistent with the supposition, that these impressions belong to the Eocene formation; but at any rate no Cycad, and especially no *Cycadites*, has hitherto been found in strata belonging to the Eocene epoch.

"2. The frequent occurrence of ferns.

"3. The occurrence of a *Sequoia*, which can scarcely be distinguished from *Sequoia Reichenbachii*.

"4. And of a *Credneria*, of which, however, only fragments are before us.

"On the other hand, this Flora differs entirely from that at Kome, especially by the presence of pretty numerous dicotyledonous leaves, which are, moreover, quite unlike the Greenland Miocene plants. The investigation of these fossils presents serious difficulties, as the greater part of them are those of full-bordered leaves with a complicated nervation offering but few fixed points of discrimination. One leaf seems to agree with *Magnolia alternans*, Heer, from the Upper Cretaceous of Nebraska.

"These dicotyledonous leaves indicate the Upper Cretaceous formation, but to which of its subdivisions the lower strata at Atanekerdluk are to be assigned can only be determined by a closer investigation. This new flora is, at any rate, one of the greatest discoveries of the Expedition of 1870, opening, as it does, for North Greenland an entirely new geological horizon, which shows that in the Arctic regions, as in Europe, *Dicotyledonous plants* do not occur in the Cretaceous beneath the Gault, whereas immediately above it they appear in a great variety of forms. In North Greenland then, as well as in Europe and America, the vegetable world has undergone great changes during the course of the Cretaceous age."

III.—*The Miocene formation.*

During the Miocene period masses of basalt, sand, and clay, to a depth of many thousand feet, have been piled together in the district of Greenland we are now considering, and by far the greater part of the rocks on Disko Island and Noursoak peninsula belong therefore to that epoch. The Greenland Miocene strata (of sedimentary and eruptive origin) may be arranged under three divisions, namely :

(*a*) *Lowest.* Sand or loose sandstone, with slate, coal-bands of slight thickness, and ferruginous clay-beds, very rich in impressions of plants.

(*b*) Basalt, Tuff, and Lava beds of several thousand feet in thickness, usually as regularly stratified as sand-beds, often alternating with basalt beds. In about the middle of this basalt formation layers of fossiliferous clay, sand, and ferruginous clay, of limited thickness, are met with.

(*c*) Loose layers of sand, and one or two bands of clay, deposited on the southern strand of the Isle of Disko, *between* the basalt rocks, and therefore more recent than them.

From all these localities, separated from each other by basalt strata of 2000 feet thick, numerous fossils have been collected, indicating according to Heer the Miocene period. As the strata are nevertheless in geological respects widely different from each other, I give an account of each separately.

III. *a.—Upper Atanekerdluk strata.*—At Atanekerdluk we meet with fossils from two different periods, namely : (1) 300—400 feet above the sea slate-beds with thin sand-layers and coal-seams (*e*),[1] containing fossils imbedded in black slate and belonging to the Upper Cretaceous (the Atane strata described in II.) ; and (2) thick sand-beds, with occasional bands of slate (*c*, *d*), containing but few fossils. At a height of 1000—1200 feet above the sea these layers of sand begin to be interstratified with a ferruginous clay, which, as well as the sandstone that occurs in its immediate vicinity, is remarkably rich in impressions of plants. The greatest part of the fossils that have been brought home from Greenland belong to this locality, of the discovery and scientific examination of which I have already given a succinct account. Here I will only add a few words on the hitherto imperfectly, and in part, inaccurately, described geognostic relations of the place.

By the name "Atanekerdluk," the Greenlanders properly designate a little peninsula, four hundred feet high, and connected with the main land only by a small isthmus, which in the southern part of the Waigat forms a projection from the cliffs of the land of Noursoak, which are bold everywhere else, and whose brow is elevated even close to the coast 3000 feet. The place was formerly the seat of a Greenland colony assembled round a Danish "outpost" (Utliggare), but is now deserted and uninhabited. Deserted house-sites and paths, which in Greenland remain unobliterated for a great length of

[1] See further on, Figs. 12 and 13.

time,[1] and a number of graves, still serve to remind us of the now dead or scattered little colony. The peninsula itself is formed of a rusty brown, rather coarse-grained dolerite, composed of two species of felspar (labradorite and sanidin?), titanic iron, crystallized in thin hexagonal laminæ and augite. In this it differs from the genuine Greenland basalt and basalt-tuff, although it evidently only forms the oldest link of the vast volcanic and plutonic chain of rocks of North-west Greenland. At the steep cliffs on the western side of the peninsula one can see even that dolerite is lying on sandstone of the same loose character as the superjacent sand and sandstone beds.

Immediately on the other side of the low isthmus, that rises only a few feet above the water, and unites this peninsula with the main land, we first meet with the above-described Atane strata (*e*), then follows sand, after which a basalt bed again, covered by layers of sand alternating with slate, and crossed by vast plutonic veins (*a*, *a'*, *a''*, *a'''*), which seem not to have had the smallest influence on the sand through which they have broken. Only here and there a grain of sand is found melted or rather rusted into the surface of the dyke, the upper part of which now generally forms a ridge[2] standing up from the surrounding loose layers of earth. Between the layers of slate we find one or two small seams of coal, and in the sand here and there a carbonized stem of a tree, but no real impressions of leaves, till we come to a height of 1200 feet above the sea.[3] Here commences sand or sandstone mixed with clay, covered by a tolerably firm slate, and interstratified with thin beds of ferruginous claystone (*b*), often broken up into larger or smaller lenticular masses, and extremely rich in Miocene fossils. These occur not only in the ferruginous clay, but also in the surrounding somewhat hardened sandstone, and may perhaps be obtained from this sandstone in greater perfection than from extremely hard and unmanageable ferruginous clay. We often find in sandstone nodules and flat ellipsoids of ferruginous clay so full of remains of plants, especially on the surface, that it looks as if these nodules, before they had hardened and been imbedded in the sand, had been rolled in a heap of leaves. The ferruginous clay has, when newly broken, a dark grey fracture, which, by exposure to the air and the polishing effect of the sand, acquires as it were a polish and a brick-brown colour. Pieces of it are plentifully scattered about in the confined locality where these vegetable-remains occur. In the same sandstone, a little south of the spot where the impressions of leaves are met with, may be found at the edge of the glen, very deep at this spot, trunks of trees, the tops of which rise above the sand, or form black spots in the white sand. An excavation was made in our presence, and we

[1] Rink mentions paths still remaining in districts uninhabited since the time of the old Northmen colonists, and we ourselves could clearly distinguish at Kaja the paths round the long deserted house-sites there.

[2] The remarkably slight effect which the eruptive rock has produced on the surrounding layers of sand astonished Mr. Brown.

[3] 1084 Inglefield; 1175 mean of six measurements with the aneroid by Whymper; 1203 by the aneroid used by the Expedition of 1870.

saw, as the annexed woodcut indicates, the roots branch out in an underlying clay-bed. There can, therefore, be no doubt that these trunks once grew in the place where they are now found. Above these strata is sand, then a thick stratum of basalt, over which sand again, and lastly a basalt bed of perhaps 2000 feet thick, and, as far as one can judge from a distance, not interstratified with layers of sand or slate.

Fig. 11.

Fig. 11.—Bituminized tree stem from Atanekerdluk.

At Atanekerdluk itself the strata follow the direction of the strait (or, more correctly speaking, run true NNW. SSE.[1]), and the slope, as indicated in the following sections, taken from a ravine the direction of which was at right angles to the shore, is 8°–32° ENE. Further up in the strait the strata gradually sink, so that the capping of basalt, a little north of Atane, reaches down to the surface of the sea. The perturbations at Atanekerdluk, therefore, seem to have been only local, and on the whole the strata would seem to lie pretty nearly horizontal, with a slight dip to NW.

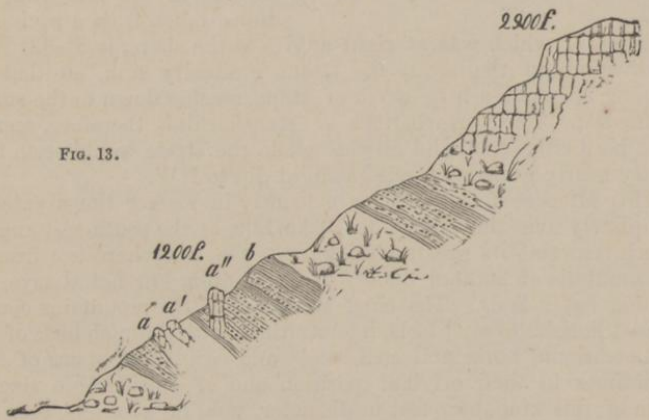
This Miocene formation has evidently in former times extended completely over the Waigat to Disko Isle, at the south-east angle of which it attains its greatest thickness. One may here see from the sea sandhills of 2000 or 3000 feet high, often, but not always, containing basalt-beds. The chief substance of the mountains consists of vast horizontal sand-beds, interstratified with thinnish beds of clay, and occasional horizontal coal-bands, and carbonized stems of trees, sometimes in their original position and of considerable size. A stem of this kind, two feet in diameter, was, for example, seen in a rock in the district about Mudderbugten. The quantity of carbonized stems of trees is often so great that it is worth the while of the Greenlanders to collect and use them as fuel. Silicified stems of trees are also met with, though more rarely. The greatest number of impressions of leaves occur on the western shore of the Waigat, as also at Atanekerdluk, almost invariably imbedded in hard, grey ferruginous claystone, that turns red by exposure to the corroding effect of the atmosphere ("Atanekerdlukstone"), which forms either peculiar beds of one or two inches thick and a few fathoms in extent, or lenticular masses imbedded in sand or clay, or small balls inserted in huge, almost spherical sandstone nodules, detached from the sand by the infiltration of some conglomerating medium, often of remark-

[1] Mean of several observations made in the ravine along the side of which I ascended this slope. Brown gives E. and W. as the direction. The difference probably arises from the circumstance that the magnetic perturbations at Atanekerdluk are of a local nature, and thus different in different ravines.

ably regular form and some yards in section. Atanekerdlukstone, like the nearest neighbouring sand and clay beds, always contains remains of leaves, which may then either form small separate layers

Fig. 12.

Fig. 13.



Figs. 12 and 13.—Series of Strata at Atanekerdluk: the scale of the second section being about half that of the first.

or an isolated nodule in the sand of some few inches diameter; whereas it would be vain to look for impressions of leaves in the more distant sand-beds. Coal strata worth working probably do not occur in this horizon of the Miocene; at least the layers at Atane, the largest coal-beds at Kome, and at Ipiit near Kudliset, seem to *belong to the Upper Cretaceous*, while the strata at Netluarsak, Isorisok, the coal in the high fells at Skandsen and Assakak, belong *to the middle, not the lower horizon, of the Miocene of Greenland.* Probably also the coal-beds at Hare Island do not belong to this formation, as I have already observed.[1]

From the Lower Miocene strata at Disko Isle we collected fossils

[1] Dr. Nauckhoff's and Dr. Pfaff's discovery of Sigillaria makes it possible that the Coal strata of the Coal formation occur at Ujarasusuk.

at Flakkerkuk, the rocks adjoining Mudderbugten, Isungoak, Ujarasusuk, Iglosungoak. None of these localities is in richness to be compared with Atanekerdluk.

III. *b.—Ipsorisok strata.*—By this name I designate the thinnish layers containing fossils that occur imbedded in the basalt of the high hills. Such strata have been met with at—

Netluarsuk, between Noursoak and Noursak. A little north of Atane the basalt strata sinks down to the surface of the sea, and from a distance it is impossible to discover in the very regularly stratified basalt-beds, ending at the shore with a vertical section of several thousand feet, any sand or argillaceous slate-beds. Neither do the Greenlanders know of any other coal-beds in that neighbourhood than one which is met with at Netluarsuk, at an elevation of about 1000 feet. The strata are here for a distance of a few dozen feet exposed at a steep gorge between the basalt hills. They seem to be of trifling thickness, and consist of alternating beds of from 0·2 to 2 inches thick of sand, coal, slate, and a ferruginous clay, different in appearance from the ferruginous clay at Atanekerdluk, though, like it, full of fossils, chiefly of fir leaves and twigs, mixed with clay or coal. Among these fossils occur not only leaves and cones, but also seeds. The coal consists almost exclusively of flattened and carbonized stems.

Ifsorisok, a place situated about 12 miles from the coast, and 2250 feet above the sea. We visited the spot from Holländarbugten or Itiblit, situated a little to the north of Niakornet. Some distance from the coast we first find thick layers of a rock, which appears to be a much changed siliceous slate. Afterwards the path proceeds up steep slopes of basalt detritus and basalt rocks, or (at 2300 feet) extensive plains, covered with the same material, and, at the period of our visit, free from snow, though hardly clothed with any vegetation. Here one has to pass long distances over weathered and crumbling slabs of basalt, which show that the underlying rocks are everywhere composed of eruptive masses. From these plains considerable basalt hills rise further inward, among which Kinnitok—a lofty mountain ridge between Niakornet and Ekkorfat—is the largest. This mountain is probably 5000 or 6000 feet high, and, seen from a distance, appears also to be composed entirely of the eruptive rock common in these parts.

Somewhat beyond the spot where one passes the highest point of the plains are some shallow valleys. In the slope of one of them is the spot which formed the object of our visit. The place betrays itself by larger or smaller pieces of coal lying mixed with the basalt detritus, and, on digging here, sedimentary strata, consisting of caol-seams some inches thick, sandy clay, and fine, grey, hardened clay are discovered. The clay contains impressions of plants, and among the coal flattened and imperfectly carbonized tree-stems are met with. Silicified wood is also found in the gravel. The schists are evidently of no great thickness, but regularly stratified with a dip of about 10° towards the north.

Assakak.—Immediately south of Kome river, Noursoakland, nearest

the shore is occupied by lofty gneiss rocks, between which a number of glaciers project. One of these, Assakak glacier, has long been celebrated for the charred tree-stems lying scattered on the surface of the ice. The glacier itself does not reach down to the sea, but is separated from the strand by a low foreland, covered with boulders of gneiss, and passing without any discoverable line of demarcation into the glacier, which is there also itself covered with gravel. The gravel, however, here principally consists of angular fragments of basalt, among which pieces of charred wood may be here and there remarked. Higher up the mass of charred or silicified wood increased considerably, and was often piled together as if by human hand. It was, however, easy to satisfy oneself that this was not the case, but that the coal came from some stratum in the neighbourhood of the glacier, on the surface of which it now lay scattered, chiefly at a height *estimated* by me at about 300 feet. The nearest high mountains surrounding the glacier seemed to consist of gneiss, hornblende slate, etc. A thick fog prevented us from seeing far inward, and induced us to defer an excursion we had intended in that direction, which probably, as far as the object of finding the stratum from which the pieces of wood had come is concerned, would not have been crowned with success. In fact, it is probable that the fragments of wood belong to a Tertiary stratum *beneath* the glacier. After a careful search, pieces of clay and sandstone were found, containing remnants of plants exactly similar to the fossils at Ifsorisok, whence I draw the conclusion, that the strata, where the coal has originated, were about contemporaneous with those of Ifsorisok and Netluarsuk.

The strata of this horizon are separated from the Lower Miocene strata at Atanekerdluk by basalt-beds several thousand feet thick, for the stratification of which an immense space of time must have been required, and one would accordingly expect to find here remains of a vegetation very different from the Miocene vegetation of Atanekerdluk. But this is not the case. According to Professor Heer, the fossils in both these places have a purely Miocene stamp. As evidence of this Professor Heer adduces the presence of *Sequoia Langsdorfii*, at Ifsorisok, and that of *Taxodium distichum*, *Glyptostrobus Europæus* and *Chamæcyparis massiliensis*, at Netluarsak.

IV.—*The Sinnifik strata.*

At Godhavn the basalt rests immediately upon gneiss, but only a little way to the east the eruptive rock reaches the sea-level, and in rowing here along the southern shore of Disko, one passes by cliffs of basalt-tuff and basalt, often (as, for example, at the Brännvinshamnen) broken up in the most splendid manner into hexagonal basalt columns, basalt grottoes, and basalt arches. On the other side of Brededalen the basalt first begins to be interstratified with sand and slate beds, which probably are the beginnings of those vast sand strata that meet us on both sides of the entrance to the Waigat.

Further on, at Puilasok and Sinnifik, the shore itself consists of sand strata, with very thin slate seams, here and there interrupted

by basaltic cliffs, with a worn and smooth surface. The sand strata around the cliffs were not in appearance distinguishable from the sand still heaped by the action of wind and wave around the basalt rocks on the shore. Everything seems to show, that in many places hereabouts,[1] we have before us sand strata deposited between basalt rocks. In this case these layers are more recent than the whole basalt formation, and the fossils they contain, imbedded partly in an extremely brittle argillaceous slate, partly (at Sinnifik) in hard marl nodules resembling those at Atanekerdluk, but not containing very much iron, are of interest as indicating the limit of the period, during which this tract was the scene of the vast volcanic eruptions, which have given rise to the basalt masses of North-west Greenland. These fossils consist, at Puilasok, only of fragments of leaves of trees (*Salix, Myrica, Platanus aceroides, Cratægus antiqua*, etc.); at Sinnifik, both leaves of trees and Coniferæ (*Sequoia Langsdorfii, Taxites Olrikii, Populus arctica*), and, according to Heer, bear constant witness to a Miocene, perhaps an Upper Miocene epoch. If this be so, the volcanic agency in these parts commenced during the Cretaceous and terminated previously to the close of the Miocene period. The basalt-beds in the Cretaceous and Lower (Greenland) Miocene are, however, quite trifling in comparison with those which cover the Miocene deposits at Atanekerdluk, Ujarasusuk, Isungoak, etc. Accordingly in these (Greenland) districts the volcanic action has attained its greatest intensity in the Middle Miocene.

During our involuntary stay at Godhavn, I made an excursion, in company with some comrades, in a boat manned by Greenlanders, to the spot whence the Rudolph meteoric iron was supposed to have been taken, namely, the old whaling-station of Fortune Bay, situated in the neighbourhood of Godhavn. On arriving there, I ordered the Greenlanders to look after *heavy, round, rusty-brown stones, which I knew would certainly be found somewhere thereabout.* It was in vain. No meteoric stones, or rather pieces of meteoric iron, were on this occasion to be found; but before leaving the spot I again repeated to the Greenlanders, that pieces of iron of the nature described *were most unquestionably to be met with somewhere in that neighbourhood,* and I promised them a reward, if they could, against my return in the autumn, discover them.

When, at the end of August, we returned from Omenak to Godhavn, one of the Greenlanders communicated to me, with many lively gestures to express their size, shape, etc., that they had decidedly hit upon the stones I had described. A small specimen was shown, which really confirmed the statement.

The place where the iron masses were found was not, however, at Fortune Bay, but one of the shores most difficult of access in the whole coast of Danish Greenland, namely Ovifak, or the Blue Hill, which lies quite open to the south wind, and is inaccessible, even in a very moderate sea, between Laxe-bugt and Disko-fjord. I

[1] In this neighbourhood we even meet with sand layers lying beneath the basalt.

scarcely need mention that this discovery completely altered the plan for our further excursions. Our intention had been to employ the rest of our sojourn in Greenland in an examination of the basalt formations between Skandsen and Godhavn, and we had therefore, immediately on our arrival at Godhavn, hired two whale-boats manned with Greenlanders, with a view to rowing in short day-journeys with them along the coast of Disko to the eastward of Godhaven. These boats, on the morning when the discovery of the meteorites was made, lay ready and provisioned on the strand. We immediately set sail, and sailed favoured by a tolerably good wind, not eastward, but westward to Ovifak, where we arrived the same evening before sunset. The sea was calm, so that it was possible to land, and the very stone at which we lay to was itself a piece of meteoric iron, probably the largest piece as yet known. On searching more carefully we further discovered two large and a great number of smaller pieces of meteoric iron scattered over an area of a few square fathoms in the vicinity of the large stone.

The meteorites lay as on the accompanying map (Pl. VIII., Figs. 1 and 2)[1] and ideal section, between high and low water, among rounded gneiss and granite blocks, at the foot of a vast basalt slip, from which, higher up the perpendicular, horizontally stratified basalt-beds of Mount Ovifak projected. Sixteen metres from the largest iron block a basalt ridge of a foot high rose from the detritus on the strand, and could be followed for a distance of four metres, and was probably part of the rock. Parallel with this and nearer to the strand ran another similar ridge, also about four metres long. *The former contained lenticular and disk-shaped blocks* of nickel iron, in external appearance, chemical nature, and relation to the atmosphere (weathering), like meteoric iron. On being polished and etched this iron exhibited fine Widmanstädt's figures. The native iron lay imbedded immediately in the basalt, separated from it at the most by a thin coating of rust. Moreover, in that basalt, in the neighbourhood of the blocks of native iron, nodules were found of Hisingerite, evidently formed by the oxidation of the iron, as also small imbedded particles of nickel iron.

The meteorites themselves were of various colours, from that of tombac to rusty brown, and at least in some places had a metallic lustre on the surface. Here and there one could discover upon their surface and in the iron nearest the surface pieces of basalt or fragments of a crust of basalt perfectly similar to the basalt in the above-described ridge. The inner part of the iron mass contained no basalt, and as far as analysis has yet been able to discover, scarcely any traces of silica. In the neighbourhood of the smaller stones the sand and gravel were rusty with the effects of the weathering of the meteorites, yet their upper surface was usually pretty pure, but the under surface generally rusty. The larger stones were strongly polar-magnetic, so that the upper part of the stones attracted the north, the lower part the south pole of the magnetic needle.

[1] This Plate was inserted at p. 355, Geol. Mag. for August last, with Part II. of Prof. Nordenskiöld's paper.—Edit. Geol. Mag.

Within the area represented on the rough chart, not exceeding 50 square metres, the following blocks of meteoric iron were found by the Expedition of 1870:

Fig. 14.—The three largest Meteoric Stones.[1] From a sketch made on the spot by Dr. Th. Nordstrom, A.D. 1870.

1.	A stone, ovally rounded. Greatest diam.[2] 2 met. smallest 1·7 m. Probable weight[1]	21,000	Kilogr.
2.	A nearly spherical stone. Greatest and least diam. 1·3 and 1·27 met. Probable weight[1]	8,000	„
3.	A somewhat conical stone. Greatest and least diam.[2] 1·15 and 0·85 met. Probable weight[1]	7,000	„
4.	An oval stone (Plate XIX.–XX., Fig. 1) weighing	142	„
5.	A drop-shaped stone (Fig. 2) weighing	96	„
6.	A ditto ditto, now belonging to the British Museum about	87	„
7.	A stone (Fig. 3) weighing ... ... „	54	„
8.	A stone (Fig. 4) weighing	81	„
9.	A stone (Fig. 5) weighing ... ... about	42	„
10.	A stone (Fig. 6)	18	„
11.	A stone (Fig. 7)	24	„
12.	A stone which immediately after our arrival home fell to dust, originally weighing... ... ... about	54	„
13.	A smaller stone weighing	6·4	„
14.	A ditto ditto	3·4	„
15.	A ditto ditto	2·5	„
	Several lenticular pieces of iron from the basalt vein, of 3–4 inches thick, weighing altogether ... ... about	100	„

The Ovifak iron is extremely crystalline and brittle, so that smaller pieces may be broken with a hammer, and, with the exception of the little bits of basalt on or near the surface, is not mixed with any silicates visible to the naked eye. The iron from the basalt ridge differs from the other by a rougher fracture and greater toughness. With the naked eye one can seldom discover any nodules of troilite or iron-sulphide. In the weathered detritus, on the other hand, a few black magnetic grains were found, with strongly reflecting facettes and octahedral surfaces, which on examination we found to be magnetite. When cut and polished, the different

[1] Brought to Europe by the Swedish Greenland Expedition of 1872, under command of Capt. Baron von Ober.

[2] Of the parts of the stones that lay above ground.

specimens varied very greatly; on some of them parts yellow as brass, of troilite were discernible, and the polished surface of the metal itself appeared, when the light fell on it in a certain direction, divided into rounded parts of different brilliancy and shades of colour. Other pieces seemed to form a perfectly homogeneous aggregate of crystal needles of carburetted nickel iron. The Widmanstädt's figures were visible after etching on some, but not all, of the specimens. *These were particularly distinct on the iron from the above-mentioned basalt ridge.* In general the iron was so hard that they would not undertake at the ironworks to saw through any of the larger balls, in consequence of which I know no more of the internal character of the meteoric iron than what I could ascertain from the specimens which fell to pieces.

[*Extracted from the* Geological Magazine, Vol. IX., No. 11. November, 1872.]

PART V.

NOTWITHSTANDING the very inconsiderable amount of sulphur it contains, this Greenland iron has a remarkable tendency to fall to pieces by the action of the air. The weathering depends on an oxidation, probably produced by a quantity of chlorine contained in the iron, and its great porosity; nevertheless, some of the phenomena connected with the weathering still appear to me inexplicable. I shall therefore somewhat more fully detail the observations and experiments made towards explaining this very disagreeable circumstance.

The Ovifak meteoric iron does not fall to pieces at the place where it was found, though sometimes washed by the sea, sometimes left bare; but on the shore it was preserved at the temperature of the sea, which varies but little during the whole year.

Even during the passage, when the masses lay packed in wooden chests in the hold, and were exposed to a very moist atmosphere and at a temperature but little above freezing-point, the unbroken stones did not suffer perceptibly; whereas almost all the fragments packed in the same manner split into pieces, more particularly those which I had preserved in the heated cabin.

From some of the pieces of iron sea-green drops oozed out, which afterwards became reddish brown by the action of the atmosphere. They contained protochloride of iron with traces of sulphate.

One of the larger pieces, which, after our return home, was placed in a room of ordinary temperature, soon began to crack on its surface, and ultimately, when unpacked two months later in Stockholm, crumbled to a reddish brown powder, consisting partly of a fine rust powder, partly of angular bits of iron, rusty on the surface, and varying in magnitude from the size of a pea to that of a hemp-seed. An entirely unchanged, and therefore, on a fresh surface of fracture still metallic, portion of Stone 4, began at one corner to rust, swell and crumble, while the remainder of the iron remained unaltered. The rust spread itself like a fungous growth over the rest of the piece, and extended itself to the interior, which thereupon swelled and crumbled like an efflorescent salt. During this time the weight of the piece of iron increased.

Weight of a fragment of iron when packed	29·935 gr.
,, after 129 days	30·143 gr.
Weight of the unchanged iron	24·529 gr.

so that 5·406 gr. had weathered away to a rusty-brown powder and during this time had increased in weight 0·208 gr. or 3·8 per cent.

In a hermetically sealed glass tube the iron was completely unchanged.

In a glass tube, that had been hermetically sealed, but in which a fine crack had taken place in cooling, the iron continues to crumble.

In a eudio neter over mercury, the iron in a few days absorbed a

considerable amount of oxygen, in consequence of which the mercury rises in the tube.

In alcohol, the iron does not crumble. In water, it rusts, but does not appear to fall to pieces.

In air dried by sulphuric acid the crumbling process takes place slowly.

Varnishing does not fully protect these pieces of iron from weathering, not even if immersed in warm copal-varnish. I thought at first that the cracking was the result of the contracting and shrinking of the mass, but this is not the case. On the contrary, the cracking is caused by dilatation. With what force this operates may be judged from the fact, that a piece of iron, on which chisel and saw are without effect, is broken or bent by the decomposition of the mass. In general, cracks first appear at right angles to the surface of the stone; these diverge as from a centre, and at a depth of a few lines below the surface of the stone meet a crack that runs parallel with the surface, which, by the swelling of the overlying crust, is soon formed into a little dome, sometimes an inch in height. In the mean time the overlying crust is raised, doubled up and broken in a manner which bears a striking likeness to the doubling of the stratified rocks by the so-called eruptive forces,—that is, if one supposes that the cracks, instead of being empty, are filled with detritus, which gradually hardens to an "eruptive" rock.

When fragments of the largest stone weighing 134 gr. were heated to redness, they parted with nearly two litres of gas, or about 100 times the volume of the iron, as also a considerable amount of water, which, like the gas, had a bituminous smell. The gas was clearly no primary constituent, but formed partly by the decomposition of organic matter in the meteorite, partly by the reducing operation of compounds containing carbon on the oxide of iron in the meteorite, which was found to be completely reduced at the termination of the experiment. On the iron being dissolved in chloride of mercury, only a trifling quantity of gas was emitted, probably coming from the pores in the iron. In hydrochloric and nitric acid the meteoric iron is dissolved, leaving in some cases a residue containing much carbon, in others very little residue at all. The gas that escapes during solution in hydrochloric acid has a most penetrating smell, probably due to some hydrocarbon. On dissolving Ovifak iron, which has been heated to redness, in air or oxygen, in acid, there often remains a flocky, voluminous, brown material soluble in warm, but hardly so in cold water, which in ammonia is very easily dissolved, forming a dark brown, almost opaque fluid. The same material is obtained from the carbon that remains after the solution of the iron in acids. It can again be precipitated by means of acids from the ammoniacal solution, though not quite completely, so that the acid solution is also brown, but of a very light tint. This material is a humus-like compound, which probably did not originally exist in the meteorite, but arises from the solution of the carboniferous iron in acids.[1] This humus-like body can be broken

[1] A similar substance, obtained by dissolving iron containing carbon, has been

up only with difficulty by long boiling in strong nitric acid or chlorate of potash and hydrochloric acid.

The following analyses have been made of this iron from Ovifak:—

I. Analysis of a fragment from one of the large stones, by A. E. Nordenskiöld.
II. Analysis of a specimen of more compact iron, by Th. Nordström.
III. Analysis of iron with conspicuous Widmanstättian figures from the basalt ridge by G. Lindström.

	I.	II.	III.
Iron	84·49	86·34	93·24
Nickel	2·48	1·64	1·24
Cobalt	0·07	0·35	0·56
Copper	0·27	0·19	0·19
Alumina	hardly perceptible	0·24	——
Lime		0·48	——
Magnesia	0·04	0·29	some traces.
Potash	scarcely enough to weigh.	0·07	0·08
Soda		0·14	0·12
Phosphorus	0·20	0·07	0·03
Sulphur	1·52	0·22	1·21
Chlorine	0·72	1·16	0·16
Silicic acid	scarcely perceptible	0·66	0·59
Insoluble portion	0·05	4·37	
Carbon, Organic matter, Oxygen, and Water (loss)	10·16	3·71	C. 2·30 H. 0·07
	100·00	100·00	99·79

I. Contained scarcely any traces of silicic acid, alumina or lime. The iron was therefore entirely free from silicates, although large lumps of basalt were firmly rusted on to the surface of the meteorite, and one or two fragments of basalt surrounded with iron could be observed within the iron near the surface. Even before heating to redness, I. emitted a good deal of water and gas, as much apparently as amounted to about 100 times the volume of the iron,—that is to say, considerably more than the iron examined in Analyses I. and II. This explains the large loss in I. The specific gravity of I. was ascertained, from two (porous) fragments of some grammes weight, to be 6·36 and 5·86. The smaller specific gravity here arises evidently from the large quantity of carbonaceous matter that is contained in this iron. Nordström obtained the specific weight of II. from two experiments on small pieces = 7·05 and 7·06. Lindström found the specific gravity of III. at 17° C. to be equal to 6·24. The iron employed in Analysis II. was less crystalline and more compact than that used in Analysis I. It was hard to break, and small grains could be hammered flat without disintegration. In Analyses II. and III. the materials examined were in external appearance precisely alike, and I

mentioned by Berzelius, in *Afhandl. i Fysik, Kemi och Mineralogi*. When iron containing carbon is dissolved in hydrochloric acid of proper strength and temperature, not only is this humus-like matter generated, but hydro-carbons also, and (according to a statement made to me by Prof. Eggertz) even fluid hydro-carbons, the atomic composition of which is very complicated. We have here, then, a method for attempting the synthesis of organic substances from their inorganic components unemployed hitherto, as far as I am aware, in synthetic organic chemistry. *Iron containing carbon was pointed out by Berzelius in* 1818 (Aph. i. Fysik, Kemi, etc., vol. v. p. 534) *as an inorganic material which might serve as a means for the synthetical formation of organic compounds.*

therefore consider it as probable that the material of II. also was from the basalt ridge, although it had afterwards crumbled apart.

IV. Analysis of the silicate that remained undissolved in Analysis II. by Dr. Th. Nordström. V. Analysis of a piece of basalt firmly rusted on to the surface of the largest meteorite, by Dr. Th. Nordström.

	IV.		V.
Silicic Acid	61·79	...	44·01
Alumina	23 31	...	14·27
Sesquioxide of Iron	1·45	...	3·89
Protoxide of Iron	—	...	14·75
Magnesia	2·83	...	8·11
Lime	8·33	...	10·91
Potash, Soda (loss included)	2·29	...	0·97, 2·61
	100·00	...	99·52

VI. and VII. Analyses of the carbonaceous matter in the iron of II. by Nordström, 33·0479 gr., gave after first treating with chloride of copper, and afterwards with chloride of iron, 4·79 per cent. of a carbonaceous matter, containing 42·58 per cent. ash. An elementary analysis of this carbonaceous matter, deducting the ash, gave—

	VI.		VII.
Carbon	63·59	...	63·64
Hydrogen	3·26	...	3·55
Oxygen (loss included)	33·15	...	32·81
	100·00	...	100·00

The substance is not soluble in either alcohol, ammonia, or potash, and evidently consists of a mixture of organic matter, water and carbon.

The discovery at Ovifak is remarkable, not only as the largest discovery of meteoric iron hitherto known to have been made, but also as that which is richest in carbon, excepting the carbon powder that fell at Hessle. Add to this, the remarkable circumstance, partly that lenticular and discoidal pieces of native iron occur *at the same place* in the underlying basalt, partly that basalt pieces of considerable size, in numerous spots, form a crust on the larger meteorites, and are even sometimes met with driven through the surface into the iron. Nevertheless, in spite of this, it appears to me that there cannot be a doubt of the really meteoric origin of the large masses. Their form, their composition, their appearance, sufficiently indicate this. To explain the occurrence of meteoric iron together with basalt we must then assume:

(1) Either that the ridges FG and GH (see map[1]) are only apparently in solid connexion with the rock, but are really only fragments of one large meteorite of 20 to 40 feet in diameter, formed principally of a mass of basalt-like matter, with balls of iron disseminated through it, that has fallen at this spot. This assumption would, however, be too hazardous, and is rendered improbable by the circumstance that the basalt that surrounds the meteoric iron is perfectly similar to the exact variety of the Greenland basalt, which forms the rocks of the

[1] Published with Part II. in the August number, p. 355.

locality.[1] The greatest part of the stone mass into which the iron particles are scattered is, however, very unlike genuine basalt, and in external appearance rather resembles the meteoric stone from Tanacera Pass, in Chili. Time has not yet permitted a more accurate investigation.

Or, (2) that the whole fall of meteoric iron took place during the period when the piling up of these Greenland basalt rocks was in progress, *i.e.* during the latter portion of the Cretaceous and the beginning of the Tertiary periods. Some of the pieces of meteoric iron have fallen to iron-dust, and filled cracks in the basalt, where they have again hardened into the iron above described as found in the ridge FG. Of similar origin are also the particles of native iron in the basalt lying nearest the iron, which occasionally has a conglomerate-like structure.

As considerable masses of iron, of a composition probably very similar to that of meteoric iron, without a doubt occur in the interior of the earth, it may be suggested that the Ovifak iron may be of telluric origin, and that it has been, together with the plutonic rocks, thrown up during the eruptions that have given rise to the vast strata of basalt in this neighbourhood. But not only does the fully marked meteoritic form of the many iron pieces militate against this supposition, but also the circumstance that the iron in question—as the facts of its containing organic matter, its porosity etc., show—*has evidently never been heated even to a temperature of a few hundred degrees.*

Neither is it possible that these masses of iron can have arisen from the reduction by gases developed in connexion with basalt eruptions of a ferruginous mineral. Iron pyrites cannot be reduced by these means, while no oxide-of-iron-mineral containing nickel, and at the same time almost free from lime and silica, is known. The formation of the iron from chloride of iron, which had been erupted from the interior of the earth and since been reduced, can hardly be supposed. The explanation I have given above, that the iron is the result of an unusually rich Miocene fall of meteoric iron, seems, therefore, to me most plausible.

Öberg also was fortunate enough to meet with a piece of meteoric iron from the neighbourhood of Jakobshavn. He received the piece, which weighed 7½ Skålpund (7lb Avoird.), from Dr. Pfaff, of Jakobshavn. This piece, which is now preserved in the Riks Museum at Stockholm, is an oval lump, with a somewhat rough surface, consisting principally of very hard, tough, not crumbling iron. On being sawn through, it presented the appearance of a mass of iron grains welded together, here and there impregnated with a basalt-like black silicate. On etching, fine Widmanstättian figures are obtained. We have not had time to analyse it, and I need not therefore dwell longer on the description of it, especially if, as is greatly to be wished,[2] the three larger iron blocks left at Ovifak

[1] Only the basalt in some parts of the ridge FG and GH, but not the basalt from other districts of Disko and Noursoak, does contain native iron.

[2] As I have above mentioned, the Swedish Government sent for this purpose

should be brought home, in which case I shall be enabled to give a complete account of all the Greenland discoveries of iron, together with more analyses. I will here simply enumerate the discoveries of iron hitherto made on the western coast of Greenland.

(1). *Ross and Kane's discovery of iron in Davis Strait.*—According to these famous polar navigators, the Esquimaux in North Greenland make knives and instruments of iron from some large blocks situated probably somewhere to the north of Upernivik.

(2). *Rink's discovery of iron at Niakornak, Jakobshavn District.*—In 1847 Rink found in the possession of some Greenlanders an iron ball, which they said they had found in a plain covered with boulders near the mouth of the Anorritok River. It weighed 21lb, with a specific gravity of 7·02. Analysed by Forchammer. Crumbling scarcely perceptible.

(3). *Rudolph's discovery of iron at Fortune Bay.*—A piece of iron weighing 11,844 gr. was found by Colonial Governor Rudolph among ballast that had been taken in at Fortune Bay. The iron crumbles much, and belongs probably to the same fall as the iron found at Ovifak.

(4). *Fiskernäss.*—A small piece of metallic iron was found by Rink at Fiskernäss in South Greenland. The iron was declared by Forchammer to be of meteoric origin.

And lastly:—

(5). *The Pfaff-Öberg iron from Jakobshavn.*

(6). *The iron discovered at Ovifak.*

Lastly it should be mentioned, that the old northern chronicles state, that during the time the old colonies existed in Greenland, so violent a shower of stones once happened that several churches and other buildings were destroyed.

It is remarkable that Giesecke, in his many years of travel in Greenland, should not have met with any meteoric iron, whereas he mentions that huge balls of iron pyrites were found in the sand-beds of the basalt formation. We also met with some such balls at an elevation of a couple of hundred feet above the sea, between Ujarasusuk and Kudliset. They were as much as from 3 to 4 feet in diameter, spherical, and lay loose in the sand close to a basalt dyke. Nevertheless, they did not contain pyrites, but a mineral (not yet analysed) like magnetic pyrites of a very unusual appearance.

In our excursions round Disko Bay and the Waigat, I availed myself of such opportunities as offered themselves for astronomical determinations of localities. These have since been calculated by Mr. Edward Jäderin, and a detailed account of them will hereafter be published. Here I shall only append a table of the results of the calculations, together with a copy of a part of Rink's map of North Greenland, corrected according to these geographical determinations,

an expedition to Greenland, 1872, which succeeded in bringing home not only the three meteorites of 21, 8, and 4 tons, but also several smaller ones of from 4 to 200 kilogr.

and a small number of angular measures. The places whose positions were astronomically determined by us are on the map marked with a cross. Spots where fossil plants were discovered are distinguished by a different mark.

Geographical Determinations made in the Expedition of 1870, calculated by E. Jäderin.

	N. Lat. ° ′ ″	Long. from Godhavn. ° ′ ″	Long. from Greenwich. ° ′ ″
Godhavn, our place of residence	69 13 57	———	53 24 0 W.[1]
Egedesminde, Colonial Gov. house ...	68 42 9	0 37 36 E.	52 46 24 „
Kangaitsiak, Emissary's (Utliggares) Residence	68 18 19	0 3 57 „	53 20 3 „
Narrow place on the Northern strand of Auleitsivik	68 10 43	1 9 51 „	52 14 9 „
Site of old house on the northern strand of Auleitsivik	68 16 23	1 55 42 „	51 28 18 „
Island in Tessiursarsoak	68 16 58	2 13 48 „	51 10 12 „
Place of our tent beside Tessiursarsoak	68 20 50	2 17 43 „	51 6 17 „
Landing place, south side of isthmus at Sarpiursak	68 25 36	1 51 29 „	51 32 31 „
Ditto north side ditto	68 29 49	1 48 10 „	51 35 50 „
Christianshaab. Colonial Gov. house...	68 48 34	2 15 46 „	51 8 14 „
Kaja, inner extremity of Jakobshavn ice-fjord	69 7 26	2 43 0 „	50 41 0 „
Mudderbugt, deserted house	69 38 7	1 32 12 „	51 51 48 „
Ujarasusuk, Emissary's (Utliggares) Residence	69 51 2	1 4 54 „	52 19 6 „
Atanekerdluk, south of the low isthmus	70 2 30	1 8 57 „	52 15 3 „
Waigat, eastern shore near Mannik ...	70 10 1	0 55 14 „	52 28 46 „
Ditto south of Atane River ...	70 15 20	0 37 51 „	52 46 9 „
Noursoak, Emissary's Residence	70 40 4	1 4 25 W.	54 28 25 „
Niakornet, Emissary's Residence	70 46 46	0 5 52 „	53 29 52 „
Karsok, Emissary's Residence	70 43 28	0 53 36 E.	52 30 24 „
Pattorfik. Sea-shore 400 feet south-east of mouth of river	70 42 6	1 2 51 „	51 21 9 „
Omenak, New Col. Government house	70 39 53	1 25 11 „	51 58 49 „
Kome, deserted house	70 37 18	1 15 16 „	52 8 44 „

It was hardly compatible with Dr. Berggren's and Öberg's botanical and zoological interests to participate in the long, tedious, boat excursions Dr. Nordström and I intended to make round the shores of Disko Island and Noursoak peninsula, and accordingly, as above stated, after the excursion to Kaja, our little expedition divided itself into two parties on the 31st of July. The proceedings of the one party I have already related: concerning those of the other, Dr. Berggren has made the following communication :—

"It was Aug. 1, at 5 A.M., that we took leave of each other, Prof. Nordenskiöld and Dr. Nordström to proceed to the peninsula of Noursoak, Dr. Öberg and I to continue our zoological and botanical researches up to the mouth of the Waigat. Claushavn, which formed our principal station from the 1st to the 13th of August, offered—on account of the roominess of the Colonial Governor's house, which was placed at our disposal—a convenient place for arranging and preserving the collections made in the previous boat excursions, but which it had previously been impossible to treat with sufficient care.

[1] According to Graah's determination.

For the purpose of dredging, for which two crews were sometimes employed, new men were obtained from Claushavn, and those we had hitherto employed were dismissed home. The country round about the colony is a plain rich in flowers, surrounded by hills of only a few hundred feet high, with a fenny moor-land soil, and a small lake in the middle. This, like other lakes in the neighbourhood, was interesting both in zoological and in botanical respects, on account of three phanerogamous plants, not previously met with in Greenland, being there found. As the stay of nearly two weeks which we made here happened just when the phanerogamic flora—which, in consequence of the varied nature of the ground, is here very richly represented—is in its fullest flower, and as moreover the moss-flora, for the same reasons, is one of the richest in the gneiss-regions, and the dredgings brought in a number of marine algæ, the botanical collection made at Claushavn forms a considerable part of the whole.

"We left Claushavn in the afternoon of the 13th of August, and after three or four hours rowing, passed the ice-stream, just at that moment giving off its ice into the sea, to Jakobshavn. In consequence of the vicinity of that colony to the ice-stream, the dredging here produced an interesting collection of marine animals, as well as of algæ, among which was the *Laminaria solidungula*, previously only known as belonging to Spitzbergen. The ruins and dirt-beds at the old deserted site of Sermermiut were examined, and both from thence and other places a number of flint tools were collected. The country immediately around the colony consists of low rounded hills, but further inland lies a tolerably extensive plain, with marshy soil and some lakes, which is again inclosed by higher mountain ridges. This likeness to the environs of Claushavn causes the vegetation at the two places to be generally of a similar nature.

"Aug. 19. At 11 A.M. we left Jakobshavn, and steering our course northward, arrived in the evening at the mouth of Illartlek. After passing through the narrow entrance to that fjord, inclosed on either side by lofty cliffs, where there is a very strong current, we encamped at 11 P.M. beside a little calm harbour in the peninsula, which separates the two arms of the gulf.

On the 20th and 21st dredgings and botanical excursions were made into the inner part of the gulf, extending nearly up to the inland ice. It was from this point that Whymper and Brown ascended the inland ice in 1867. I occupied myself principally with examining the vegetation of the mountain tops, which do not here usually exceed 1000 feet in height. Instead of the fine weather which had hitherto favoured us, on the 21st of August it began to rain, which hindered our work, and the rain flowed down in such quantities from the mountain slopes over the spot where our tent stood, that we were obliged to leave. To get under cover we first rowed to the Greenlanders' houses at Pakitsok. Rain and contrary winds detained us in these cottages (uninhabited during the summer) till the afternoon of the 23rd of August, when we departed for Ritenbenk, where we arrived in the night between the 23rd and 24th of August.

"In contrast to the southern side of Disko Bay, the mountains on

the northern side, about Illartlek and Arveprindsens Eiland, sometimes attain a height of 2000 feet, and frequently terminate towards the sea in perpendicular walls. In consequence of this greater height, the snow lies there longer in the summer, which gives rise to a constant moisture on the hill-slopes; and these two circumstances produce a landscape and a vegetation of a character different from those of the more southern regions. Several of the valleys on Arveprindsens Island, as well as their fresh-water lakes and surrounding mountain heights, were visited by us. From Ritenbenk we undertook (Aug. 29th, Sept. 1st) a boat excursion to Kikertak Island, in the interior of a fjord on the southern part of Noursoak peninsula. Dredgings were made in the water, here chilled by the ice-stream of Tossukatek, and excursions were undertaken along the hill-slopes of Noursoak peninsula to Majorsoeitsiak, with the view of studying the vegetation of that desolate locality, where belts of inland ice extend in the form of glaciers into the valleys, which in many parts are almost bare, covered with stone boulders, and with little lakes at the bottom.

The vessel "Rjukan," hired by the Danish Trade, had, on the 28th of August, arrived at Ritenbeuk, and, as the time for our return home was fast approaching, we sailed on the 7th of September by that vessel to Godhavn, where Nordström had already arrived. The botanical and zoological excursions, which on our former visit to this place in July had been interrupted by the preparations for boat journeys, were now resumed, while the vessel lay at Godhavn to unload and reload.

"Frequent falls of snow announced the approach of winter. On the 18th September the "Rjukan" weighed anchor for Sukkertoppen (the Sugar-loaf), in South Greenland. When, on the 22nd of September, we reached that colony, the winter had already commenced, and snow a foot deep covered the ground. Though the vessel cleared by the 4th of October, we were detained, by contrary winds and the consequent failure of our repeated attempts to get out of the harbour, till the 21st of October. Favoured during the rest of the voyage by a fair wind, which for some days on the Atlantic rose to a storm, we arrived at Kleven, in Norway, on the 11th of November, whence we started by steamboat, and arrived at Gothenburg on the 17th of November."

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