

VII.—ACCOUNT OF AN EXPEDITION TO GREENLAND IN THE YEAR 1870.

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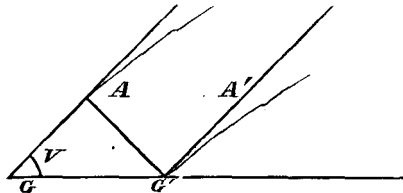
Part III.

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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 Auleitsviksfjord is about 60 miles, or 350,000 ft. The annual retreat can, of course, never exceed the thickness¹ 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 Sarpisursak 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 Auleitsviksfjord 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 glacial¹ 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 ring-shaped claystones, containing remains of Fish, Ophiuræ, Crustacæ, 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 Walruscs 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 fossils¹ 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	Tessiur-sarsoak.
<i>Mya truncata</i> , L.	X	X	X	
<i>Mya arenaria</i> , L.	X	X	X	
* <i>Cyrtodaria siliqua</i> , Spgl.	X		X	
<i>Saxicava arctica</i> , L.	X		X	X
* <i>S. Norvegica</i> Spol.	X			
<i>Lyonsia arenosa</i> , Möll.		X		
<i>Tellina sabulosa</i> , Spgl.	X	X	X	
<i>T. tenua</i> , Leach	X	X		
<i>Astarte corrugata</i> , Br.	X	X		
<i>A. elliptica</i> , Br.	X		X	
<i>A. striata</i> , Leach		X		
<i>Cardium Islandicum</i> , Chem.	X	X	X	
<i>C. Grænlandicum</i> , Chem.	X	X	X	
<i>Leda pernula</i> , M.	X	X		
<i>Yoldia truncata</i> , Br.		X	X	
<i>Y. hyperborea</i> , Lovén.		X	X	
<i>Mytilus edulis</i> , L.	X			
<i>Pecten Islandicus</i> , L.	X			
<i>Tritonium undulatum</i> , Möll.			X	
<i>T. Grönlandicum</i> , Chem.			X	
<i>T. hydrophanum</i> , Hancock	X	X		
<i>Natica clausa</i> , Sow.		X		
<i>Idothea Sabinei</i> , 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 sea-gulls, 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 :

<i>Cervus tarandus.</i>		<i>Phoca Greenlandica.</i>
<i>Ursus maritimus.</i>		„ <i>hispida.</i>
<i>Trichechus rosmarus.</i>		„ <i>vitulina.</i>
<i>Cystophora cristata.</i>		<i>Delphinapterus leucas.</i>
<i>Phoca barbata</i>		

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 Jakobshavn 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 Auleitsviksfjord 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 Kome³ 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. Whympcr 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. Whympcr'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 Whympcr 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 Ovfak; 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 Berggrøn, 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 plants¹ 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 Patorfik, 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-formation¹ 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

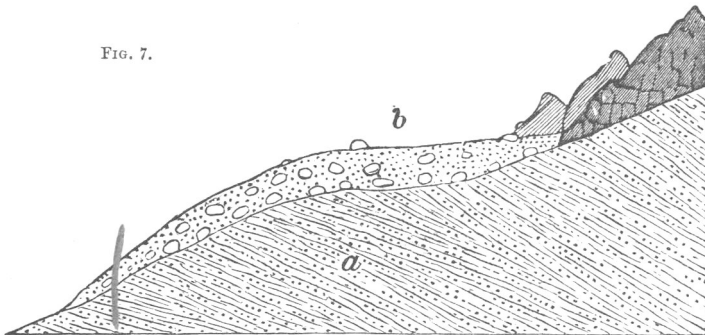


FIG. 7.—Section before any modern denudation had taken place.
(a) Tertiary strata without erratic blocks. (b) Glacial strata with erratic blocks.

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 Puillasok, 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:—

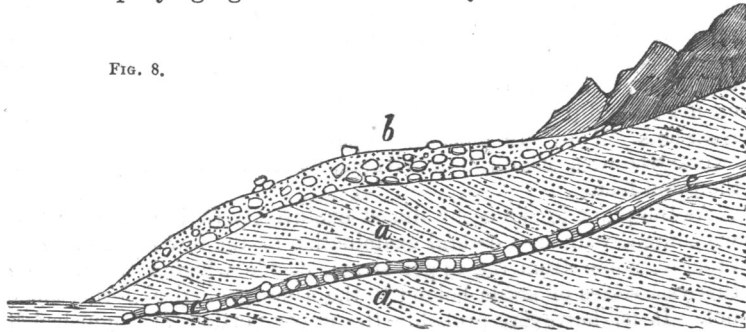


FIG. 8.—Section along a modern mountain-stream (*c-c'*).

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-beds¹ 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.*

(To be continued in our next.)

NOTICES OF MEMOIRS.

I.—ON THE OCCURRENCE OF THE "CHALK ROCK" NEAR SALISBURY. By WILLIAM WHITAKER, B.A. (Lond.), F.G.S., of the Geological Survey of England.

[From the Magazine of the Wiltshire Archæological and Natural History Society, vol. xiii., 1871, p. 92.]

IN 1861 a bed was described, under the name "Chalk-rock," which, in the counties of Wilts, Berks, Bucks, Oxon, and Herts, seemed to form the top of the Lower Chalk.¹ Its occurrence in the Isle of Wight, though in a less marked form, has since been noticed;² some new sections in North Wilts have been described in the Wiltshire Society's Magazine by my friend Mr. T. Codrington,³ and I have also seen it in Bedfordshire⁴ and Dorsetshire. As it is open to view near the town (Wilton) where the Society is to hold its meeting this year (1870), a description of two sections in that neighbourhood may perhaps be acceptable.

The Chalk-rock, where best developed (from near Marlborough to near Henley-on-Thames), is a hard somewhat crystalline cream-

¹ Quart. Journ. Geol. Soc., vol. xvii., p. 166. See also Geological Survey Memoirs on Sheet 13, p. 19 (1861), and on Sheet 7, p. 5 (1864).

² Quart. Journ. Geol. Soc., vol. xxi., p. 400.

³ Vol. ix., p. 167.

⁴ Mr. J. Saunders, whose notice I called to this bed, has described a section near Luton, GEOL. MAG., Vol. IV., p. 154.