IX.—*On the Geology of the Færöe Islands.* By James Geikie, LL.D., F.R.S. L. & E. (Plates XIII., XIV., XV., XVI.)

(Read March 15, 1880.)

CONTENTS.

I. Introduction.

In this paper I give an account of observations made during a visit in 1879 to the Færöe Islands in company with my friend Mr Amund Helland of Christiania. The principal object of our journey was to examine the glacial phenomena of the islands, but we studied so far as we could the various rock-masses of which the group is composed, and constructed a geological sketch-map to show the line of outcrop of coal, the disposition of the strata, the direction of dykes, and the trend of the glaciation. I have only to add, that all the observations recorded in the following pages were made in concert with my friend, and I am glad to say that we were quite at one in our general conclusions.*

The earliest references to the geology of the Færöe Islands are met with in a general description of the group by Lucas Jacobson Debes † (1673), but, as might have been expected, they are of no scientific value. He makes brief reference to the occurrence of coal in Suderöe, stating that it is found in only one place " to which one can with difficulty come ; " from which it is probable that he had in view some of the outcrops in the precipitous sea-cliffs.

In 1800 appeared a general account of the islands by Jorgen Landt, a resident Danish clergyman, in which the physical features of the islands are well described.‡ The author was no geologist, but he notes some of the more characteristic aspects of the rocks, and was clearly of opinion that some of these at least had been in a state of fusion. He also gives some account of the many large angular perched blocks which are so plentifully sprinkled over the islands. It was Landt's description of the igneous rocks which induced Sir George Mackenzie to visit the islands. Sir George was accompanied by Mr Thomas Allan, and each subsequently gave an account of his own observations; the papers appearing in an early volume of the Transactions of this Society.§

Sir George Mackenzie limits his remarks on the "trap" of the Færöes to such characters as seemed to him to demonstrate the igneous origin of that class of rocks. He distinguishes between the "tuff" or "tuffa" and the "trap ;" shows how they are interbedded; and gives the general inclination of

* Mr Helland's paper has been published since the present memoir was read. See "Om Færoernes Geologi," in the Danish Geografisk Tidskrift, 1881.

† Færoæ et Færoa Reserata, &c., Kiobenhafn, 1673.

‡ Forsog til en Beskrivelse over Færoerne, Kiobenhavn, 1800. An English translation of Landt's work appeared in 1810.

§ "An Account of some Geological Facts observed in the Faröe Islands" (Mackenzie), Trans. Roy. Soc. Edin., vol. vii. p. 213 ; and "An Account of the Mineralogy of the Faröe Islands" (Allan), *op. cit.* p. 229.

the strata as towards south-east at an angle of about 4° or 5°. He was of opinion that the bedded traps had been ejected from submarine volcanoes.

Mr ALLAN's paper is chiefly mineralogical, but he also gives some geological details. Both he and MACKENZIE noticed the dykes that here and there intersect the strata, but only Mr ALLAN describes the irregular masses of "greenstone" which are unconformable to the regular bedded trappean rocks among which they occur. He also insists upon the igneous formation of all the traps, but does not commit himself to MACKENZIE's submarine-volcano theory. The circumstances under which the traps were formed seem to him as inexplicable as ever, but he evidently leans to the view of their subaerial origin. He describes the smoothed appearance of the sides of the mountains, and particularly refers to a place at Eide in Österöe where "the rock is scooped and scratched in a very wonderful degree, not only on the horizontal surface, but also on a vertical one of 30 to 40 feet high, which had been opposed to the current, and presented the same scooped and polished appearance with the rest of the rock, both above and below." These phenomena he recognises to be the same as the smoothed and dressed rocks near Edinburgh.

MACKENZIE's and ALLAN's papers were supplemented by Mr W. C. TREVELYAN, who, in a letter to Dr BREWSTER,* gives descriptions of the geology of Myggenæs and Suderöe—two of the islands which MACKENZIE and ALLAN were unable to visit. His short description of the coal-beds of Suderöe is correct so far as it goes, but, curiously enough, he says the beds dip south-east, while the section given by him shows them dipping to the north. The letter is accompanied by some excellent sketch-sections, exhibiting the appearances presented by certain irregular masses of basalt.

A few years later Dr FORCHHAMMER, who does not appear to have known of MACKENZIE's and ALLAN's papers, visited the islands at the instance of the Danish Government, and afterwards published a very able description of their geognosy,† accompanied by an admirable geological map. His observations and views, however, I shall refer to more particularly in the sequel. He makes no reference to the phenomena of smoothed rocks which so impressed ALLAN.

The next geological notice of the Færöe Islands occurs in a series of articles by ROBERT CHAMBERS, entitled "Tracings in Iceland and the Færöe Islands."‡ He spent only some two or three days among the group, but recognised marks of glaciation at various places, as I shall afterwards point out.

Since the date of his visit, the islands have frequently been referred to in books of travel, but none of these has added anything to what was already

* "On the Mineralogy of the Faröe Islands" Trans. Roy. Soc. Edin., vol. ix. p. 461.

† "Om Færöernes geognostiske Beskaffenhed," Det kongl. danske Vidensk. Selsk. Skrifter, 1824. See also KARSTEN's Archiv. für Mineralogie; vol. ii. p. 197.

‡ Chambers's Edinburgh Journal, 1855.

known. In 1873, however, appeared an excellent paper by Professor JOHNSTRUP, in which he gives a detailed account of the coal-beds of Suderöe.* This, I believe, is the most recent addition to our knowledge of the geology of the Færöe Islands. It is referred to in my description of Suderöe.†

II. PHYSICAL FEATURES OF THE ISLANDS.

1. *Extent, Form, and Trend of the Islands and Fiords.*—The Færöe Islands‡ are upwards of twenty in number, and nearly all are inhabited. They extend over an area of about seventy miles in length from north to south, and nearly fifty miles in breadth from west to east. The two largest islands are Stromöe and Österöe, which closely adjoin and contain together upwards of 250 square miles, an area which is nearly equal to that of all the other members of the group. The extent of land in this little archipelago may therefore be roughly estimated at about 500 square miles. Nearly all the islands have an elongated form, and are drawn out in a N.N.W. and S.S.E. direction. This is the direction also of the more or less narrow sounds or open fiords that separate the islands in the northern part of the archipelago; and the wider belts of water in the south, such as Suderöe Fiord, Skuöe Fiord, and Skaapen Fiord, have the same general trend. A glance at the accompanying map (Plate XVI.) will show that many of the closed fiords which penetrate the islands extend in a similar direction throughout the whole or a large part of their course. There are no great depths in the immediate vicinity of the islands. None of the *closed* fiords is so deep as many of the Scottish and Norwegian sea-lochs, the deepest soundings indicated upon the charts never exceeding 65 fathoms. The soundings, however, are few in number, and we were told by the fishermen of considerably greater depths in some places than are shown on the chart. Thus we were assured that Skaalefiord is 40 or 50 fathoms deep. Immediately outside of the islands the sea-bottom appears to slope away somewhat gradually in all directions until a depth of upwards of 100 fathoms is reached at a distance of 15 or 20 miles, more or less, from the nearest coast-line.

* "Om Kullagene paa Færöerne samt Analyser af de i Danmark og de nordiske Bilande forekommende Kul," K. D. Vidsk. Selsk. Oversigt, 1873, p. 147.

† Since the above was written, I have met with another paper referring to Suderöe, by A. H. STOKES, H.M. Inspector of Mines, in "Trans. Chesterfield and Derbyshire Institute of Mining, Civil, and Mechanical Engineers," vol. ii. p. 320. The author seems to have examined only the mines and outcrops in the Trangjisvaag district, and he gives the average thickness of the coal seen by him, together with the heights above the sea-level of the various points at which the seam crops. He gives also analyses of the coal. He upholds the submarine origin of the volcanic rocks, and thinks the coal may be the remains of driftwood floated from America.

‡ For the spelling of place-names, I have followed the Danish Chart, although the orthography differs from that used in other Danish works. Some of the places I refer to are not given on the chart, and for the spelling of these I am indebted to my colleague Mr HELLAND. A number of the place-names in Suderöe, I have taken from the map accompanying Professor JOHNSTRUP's paper.

2. *Configuration and Height of the Land.*—The islands are for the most part high and steep, many of them being mere narrow mountain-ridges that sink abruptly on one or both sides into the sea. The larger ones, such as Stromöe, Österöe, and Suderöe, show more diversity of surface, but they possess very little level land. All the islands have a mountainous character—the hills, owing to the similarity of their geological structure, exhibiting little variety of feature. These high grounds form as a rule straggling, irregular, flat-topped masses, and sharper ridges which are notched or broken here and there into a series of more or less isolated peaks and truncated pyramids. Sometimes the mountains rise in gentle acclivities, but more generally they show steep and abrupt slopes, which in several instances are found to have inclinations of 25° to 27°, and even 30°. In many places they are still steeper, their upper portions especially becoming quite precipitous. They everywhere exhibit the well-known terraced character which is so common a feature of trappean masses. Precipices and long cliffs or walls of bare rock rise one above another, like the tiers of some cyclopean masonry, and are separated by usually short intervening slopes, which are sparsely clothed with grass and moss, and sprinkled with tumbled blocks and débris. The greatest elevations are reached in the two largest islands, Österöe and Stromöe, Slattaretind in the former attaining an elevation of 2852 feet, and Skiellinge Field in the latter of 2502 feet.* Many other hills in these two islands are over 2000 feet in height, and some approach within 200 or 300 feet of the dominating point. Indeed, the average elevation of Österöe and Stromöe can hardly be less, and is probably more than 1000 feet. The other islands are equally steep and mountainous, but in none do the hills seem to attain a greater elevation than 2000 feet. Thus Stoiatind in Waagöe is probably not over 2000 feet in height; Kalsöe in the north-east is 1817 English feet, Kunöe 2000 feet, and Naalsöe opposite Thorshavn 1276 feet. In Suderöe some of the hills are more than 1700 feet high—one of them, Kvanna-field, we found to be 539 mètres = 1786 feet. The mean elevation of all the islands (exclusive of Stromöe and Österöe) must exceed 800 feet, and is probably not less than 900 feet.

The coasts are usually precipitous, many of the islands having only a very few places where a landing can be effected. Store Dimon, for example, possesses but one landing-place, and even that is accessible only in calm weather. The west coasts that face the open sea are as a rule the most precipitous—the

* The height of Slattaretind is given in some Danish geographies which I consulted in the islands, as 2710 feet (Danish) = 2789 feet English; FORCHHAMMER makes it 2816 French feet; and another authority gives it at 882 metres = 2894 English feet. The height adopted in the text is that obtained by MACKENZIE and ALLAN. There is a similar uncertainty as to the exact height of Skiellinge Field; some Danish geographies and gazetteers giving it as 2350 feet = 2418 English feet. The height mentioned above is taken from the Danish Chart, which in Danish feet is 2431 feet or 2502 English feet. This corresponds with the height of 763 mètres given by some writers.

finest mural cliffs occurring in Stromöe, between Westmannshavn Fiord and Stakken. These cliffs range in height between 900 and 2000 feet, and at Mÿling the nearly vertical walls of rock are even 2277 feet high. Österöe and the north-east islands show sea-cliffs which exceed 1000 feet in height, and similar lofty cliffs occur in Waagöe, Sandöe, Suderöe, and all the other islets.

3. *Character of Valleys.*—The best defined valleys are often comparatively broad in proportion to their length. Followed upwards from the head of a fiord, they rise sometimes with a gentle slope until in the distance of two or three miles they suddenly terminate in a broad amphitheatre-like cirque. In many cases, however, they ascend to the water-parting in successive broad steps or terraces (Plate XIII. figs. 2 and 3),—each terrace being cirque-shaped, and framed in by a wall of rock, the upper surface of which stretches back to form the next cirque-like terrace, and so on in succession until the series abruptly terminates at the base, it may be, of some precipitous mountain. Occasionally the *col* between two valleys is so low and level that it is with some difficulty that the actual water-parting can be fixed. Such is the case with Kolfaredal between Höi and Leinum-mjavatn in Stromöe, where a well-defined hollow passes right through the hills, leading from the head of Kollefiord to the sea at Leinum. The height of the flattened *col* in this hollow is only 259 feet, yet it is overlooked by hills that exceed 2000 feet in elevation. A similar long hollow crosses the same island between Saxen and Qvalvig. In Österöe, likewise, a long low-level pass serves to connect the head of Fundingsfiord with that of Skaalefiord. In Sandöe and Suderöe, similar appearances may be noted. Besides these more or less well-defined valleys, the mountains frequently show isolated amphitheatric cirques. Sometimes these cirques open directly upon the sea, and may possibly represent the upper terminations of valleys, the lower portions of which have been removed by marine erosion. As examples, I may refer to the wide cirque (half mile in breadth and same in length) in Österöe, which is cut across by the sea-cliffs between Andafiord and Fuglefiord, and to the narrower but equally well-marked cirque-valley (one mile long by about $\frac{1}{5}$th mile broad) which is abruptly truncated by the steep cliffs of Tiödnenaes in Suderöe. Other isolated cirques, much smaller than these, but yet sometimes of considerable size, may often be noted on the mountain-slopes at heights of several hundred feet or even yards above the bottoms of the valleys into which they discharge their drainage. Good examples occur amongst the high grounds above Saxen, where the small upper cirques must be 1200 or 1400 feet above the broad valley into which their waters tumble down a series of cliffs and precipices.

4. *Lakes and Streams.*—There are numerous lakes in the islands, but they are mostly of small size. The two largest occur in Waagöe—one of them being

about 4 miles long, by half a mile in breadth. These, however, we did not visit. None of those we saw exceeded half a square mile in extent, and most were much smaller. At Sand in Sandöe, there is a narrow lake-like expanse of water about 1½ mile in length, which appears to be almost on the level of the sea, from which it is separated by low flats and sand dunes. But nearly all the lakes occupy rock-basins.

Streams are very abundant, but none is of much importance. Owing to the excessive rainfall,* however, they must occasionally discharge very considerable bodies of water, and as we shall see in the sequel they are potent agents of geological change.

III. Geological Structure of the Islands.

1. *General Dip of the Strata.*—The geological structure of the islands is very simple. The principal rocks are bedded basalts, with intercalated partings and layers of tuff, and in Myggenæs and Suderöe of clay, shale, and coal. The prevalent dip of the strata in the northern islands is south-easterly, at a low angle, as was first pointed out by Mackenzie. In the north part of Österöe, however, the dip is towards north-east, according to Forchhammer, whose observations we were able to confirm, and the same geologist states that the dip in Myggenæs is easterly. In Suderöe, again, the strata incline uniformly to N.N.E. Nowhere is there any trace of a westerly inclination, and the steepest dips are found in Myggenæs, Waagöe, and Suderöe. In the former, Trevelyan says it is near 45°, while Forchhammer, who is probably nearest the truth, gives it as 10°. Judging from the view we had of the cliffs of Waagöe, the dip appeared to be 10° or 12° in the west of that island, but it decreased towards the east. In Suderöe the dip varies from 2° or 3° to 15° or thereabout. The south-easterly dip of the strata in the northern islands is certainly less than Mackenzie makes it, and cannot be greater than 2° or 3° on the average. Forchhammer is unquestionably correct in his view, that the rocks of Suderöe and Myggenæs are the oldest of the series, and it will be most convenient therefore to treat of these rocks first.

2. *Contemporaneous or Bedded Basalt-rocks of Suderöe.*—The basalt-rocks of Suderöe do not show much variety. The most common rock is a dark blue, almost black, and sometimes brown, fine-grained crypto-crystalline anamesite, which is usually scoriaceous and slaggy above and below, and not infrequently

* On an average of several years, there are only forty days in the year on which it does not rain. The annual fall is 78 inches. It is a common belief out of Færöe that the islands are shrouded in fogs during the greater part of the year. This, it seems, is a mistake. We were told by Danes who had resided for some years in the islands, that they had not experienced more mist and fog than in Denmark; and the meteorological records which are kept show that fogs occur on only thirty-nine days in the year. They are worst in the beginning of summer. The best time to visit the islands is from about the end of July to the end of August or middle of September.

contains irregular layers of amygdaloidal cavities, ranged along the central or middle zone of the bed. It is composed of plagioclase, augite, magnetite, and olivine, the last being often more or less altered into serpentine. Such is the average character of the rocks which immediately overlie the coal-bearing strata, and anamesites of similar appearance predominate in the island. They generally decompose with a rusty brown crust, and are frequently much broken up, weathering into irregular spheroids. On slightly weathered faces, the rock has often a dull greenish colour and somewhat earthy appearance. The most distinctly amygdaloidal portions of a rock, are usually of a paler shade, and more close-grained texture than the darker less porous areas by which they are surrounded, and, viewed from a little distance, the various parts of one and the same flow resemble a series of separate beds. This peculiarity, which is sufficiently striking, was noted by FORCHHAMMER, who remarks that "the amygdaloidal rock alternates with the basalt, but these alternations shade into each other, and are not at all well-defined, but are very distinctly seen when the rock is looked at from a distance of some hundred feet. Then the different layers are seen with their different colours, and one finds that the junction line is parallel to the plane which the principal mass of the dolerite forms with the claystone (*i.e.*, tuff), and therefore parallel to the stratification."

The dark anamesite frequently becomes more coarsely crystalline, so as to assume the character of a typical dolerite, which is often rendered more or less porphyritic with plagioclase. This porphyritic character, however, is certainly much less common and less distinctly marked in the basalt-rocks of Suderöe than in those of the northern islands. FORCHHAMMER, indeed, maintains that the traps above the coals are markedly porphyritic with "glassy felspar," while those underlying the coals are not porphyritic. Accordingly, he has in his map coloured all the northern islands and certain parts of Suderöe and Myggenæs as "dolerite-porphyry"—the remaining portions of Myggenæs and the southern island, which are below the horizon of the coal, being distinguished as "dolerite without glassy felspar." We could not, however, trace any difference in Suderöe between the basalt-rocks below and those immediately above the coals. At the same time, well-marked porphyritic and coarsely crystalline dolerites do occur in Suderöe at some distance above the coal. In the mountain called Nakin, for example, there is a highly crystalline and porphyritic dolerite quite like many which occur in Stromöe and Osteröe. No hard and fast line, however, like that suggested by FORCHHAMMER, can be drawn between the beds above and those below the coal. The most that can be said is simply this, that while highly porphyritic dolerites prevail above the horizon of the coal, and therefore throughout the northern and smaller part of Suderöe, and over all the northern islands, dark non-porphyritic and fine-grained rocks are the most common varieties met with below that horizon, so that anamesites predominate in Suderöe, and dolerites in the northern islands.

The anamesites of Suderöe are, upon the whole, less strikingly amygdaloidal than the basalt-rocks of the northern islands, and the cavities seldom or never attain the large size that is frequently to be seen in the rocks of Stromöe and Österöe. They are generally, but by no means always, drawn out in the plane of the bedding, and have thus often a flattened appearance; frequently, however, they are almost circular, but more commonly still, perhaps, their shape is ragged and irregular. I have mentioned the fact that amygdaloidal areas often traverse the face of the rock in the plane of bedding, so as to form more or less well-defined lines. They also occasionally show a kind of curled, coiled, or involved arrangement, as if the rock had been rolled over upon itself while in a plastic or viscous state. Some of the largest amygdaloidal cavities we saw were in the rocks of Nakin and on the sea-coast at Waag, where they contain very beautiful zeolites. I noticed here stilbite, chabasite, quartz, and calcedony. Heulandite is said also to occur in amygdaloidal cavities in Suderöe, and chlorophæite is found at Qvalböe. Probably other minerals are to be met with, for I made no special search. According to Trevelyan, native copper is very frequent, though not abundant. Near Famarasund he found it in thin plates in a bed of "claystone;" some of it, he says, contains gold, which is "also, but rarely, found separate." The place referred to by him is near the base of a sea-cliff which the boatmen pointed out to us as we sailed past, but we could not stop to visit it.

The upper and under surfaces of the anamesites form an interesting study. Sometimes the upper portion for several feet in thickness appears to be composed of a jumbled mass of irregular-shaped fragments of scoriaceous rock, which gradually shades, as it were, into the denser, non-porous crystalline mass of which it forms the crust. In other cases, however, the slaggy part appeared somewhat distinctly marked off from the denser rock on which it seemed to rest. Here and there the beds show a wrinkled and crumpled surface like that assumed by viscous bodies in motion. Some anamesites, again, appeared to have little or no scoriform crust, but were only somewhat amygdaloidal and vesicular atop,—the rock then having a tendency to weather into spheroidal masses. This latter character, however, was more frequently characteristic of the lower or under surfaces of the beds. These basal portions, so far as I had opportunity in Suderöe of observing them, appeared to be less scoriaceous than the upper surfaces, and they were often much less amygdaloidal and vesicular than the central part of the same flow. Sometimes one might detect bits of red tuff and shale caught up in the under surface of an anamesite, and very often the beds showed strong red discolorations below, when they came into contact with a pavement of tuff. Now and again, too, the under part of a basalt-rock would present a highly broken and jumbled appearance—crystalline, compact, and non-amygdaloidal rock being commingled with highly vesicular and honeycombed fragments, but all welded together so as to form one solid mass.

Many of the anamesites are more or less distinctly columnar. Good examples of such are seen in the Trangjisvaag district, in the valley above Howe and along the sea-coasts. In Kvannafield these columnar rocks break up into fantastic walls and isolated peaks and tors not unlike ruined masonry. Even when true prismatic and columnar structure is wanting, the rocks are yet traversed by well-marked vertical joints, which, as will be pointed out more fully afterwards, greatly assist the denuding agents in their work of destruction.

The beds appear to vary much individually in thickness, but I think 40 to 70 feet would be a good average. Some, however, were certainly not over 30 feet thick, while others may have reached and even exceeded 100 feet. We did not trace out any one particular bed to see how far it would extend, but could quite well follow the lines of bedding along the slopes of the hills, and could thus carry the outcrop of a particular anamesite for a distance of several miles. The rocks, however, have so much in common that I doubt whether in most cases one could surely identify the same bed in different valleys, unless the outcrop itself were actually followed. The anamesite overlying the coal-beds appeared to be one and the same flow, for wherever we examined it the rock showed a very similar character—the only differences being merely such as frequently can be traced in closely adjoining portions of one and the same rock-mass. And this is equally true of the anamesite upon which the coal-bearing strata repose. The separate flows, however, thicken and thin out, and although I nowhere in Suderöe chanced to come across the terminal portion of a sheet, yet I have no doubt that those beds which did not measure more than 12 or 15 feet in thickness were merely the attenuated terminal portions of much thicker flows.

3. *Bedded Tuffs.*—The anamesites are usually separated from each other by tuff which varies in thickness from mere thin layers of a few inches up to beds 30 or 50 feet in thickness; in some places the tuffs are even thicker. These tuffs are generally fine-grained, like indurated mud, but occasionally they pass into a kind of tufaceous grit. They are generally of a bright brick-red colour, but sometimes they are grey, blue, green, and yellow. In some good sections they are seen to consist of alternate ribbons and bands of fine-grained tuff, with shattery, crumbling, fissile, shaly clays. Often, however, a bed of tuff will show no lines of bedding, and looks like an amorphous structureless mudstone. Even in such beds, however, it will often be found that the tuff splits most readily along the plane of bedding, and a close inspec-

tion will sometimes reveal several lines of coarser granules alternating with the finer-grained sediment. Under the microscope, the red tuffs are seen to be made up essentially of so-called "palagonite."

In the numerous exposures we visited I never was able to find any true lapilli. In a coarse-grained tuff that crops out on the eastern slope of Kvannafield a few small stones were detected, but none of these exceeded half-an-inch in diameter. Only in one place did we come upon what seemed to be a true agglomerate. On the shore at Qvalböe, the low cliffs, 10 to 12 feet high, are formed of an agglomeratic tuff resting upon anamesite. The matrix of comminuted gritty débris is crammed with angular and subangular stones and lapilli of all shapes and sizes, from mere grit up to blocks more than one foot in diameter. The included fragments were all of basalt-rock, and the mass showed no trace of bedding. It is just possible, therefore, that it may be only the scoriform brecciated upper surface of an anamesite.

4. *Coal and Coal-bearing Beds.*—The strata immediately associated with the coals of Suderöe may be described as dark carbonaceous shales and clays, which frequently have a tufaceous aspect. But their general appearance will be gathered from the sections given in Plates XIII. and XIV. figs. 5–9, and described in the Explanation. The coal occurs as more or less lenticular layers in beds of dark indurated clay and shale. The seams, therefore, are very inconstant, and thicken and thin out in the most irregular manner. They appear mainly along one horizon, occupying a position about midway between the top and bottom of the trappean rocks of Suderöe. This is the only horizon along which they have been worked to advantage, and it is doubtful whether they occur anywhere else in a workable condition. About 1100 feet lower down, however, another outcrop of coal occurs, but it appears to be very local. The section seen is shown in the illustration (Plate XIII. fig. 7). The whole thickness of the coal-bearing beds at this place was 10 to 15 feet. They consisted of fine-grained greenish mudstone and tufaceous shales, with some nodules of coarse ironstone. FORCHHAMMER says that a layer of glance coal, 3 inches thick, was got here, but we saw only fragments of it lying about. This appears to be the lowest horizon at which coal has been met with.

It is in the central and northern part of the island where coal has been principally worked, and there can be no doubt that all the workings are upon one and the same horizon (see Plate XIII. figs. 1 and 4). TREVELYAN knew this, and the section which accompanies his paper gives a correct generalised view of the geological structure of Suderöe.

The coal is of two kinds: one a bright lustrous coal, which does not soil the fingers, having a glassy fracture, and closely resembling in general appearance some of the glossy parrot coals of the Scottish coal-fields—the other, a dull lustreless coal, which soils the fingers, and in which one may readily detect a vegetable structure. These two kinds of coal alternate in one and the same seam (Plate XIII. figs. 5 and 6)—sometimes a bed of glance coal being streaked with laminæ of dull slaty coal, at other times a seam of slaty coal showing many thin lines of glance coal. This last, indeed, appears to be most usually the case, as the slaty coal is the commoner variety of the two. JOHNSTRUP states that every lenticular mass of glance coal represents the flattened trunk of a tree, in which can be seen the annual rings of growth. This, I do not doubt, may be true of the thicker layers, but it does not seem to be the case with the finer streaks and threads; at all events I could see no trace in these of flattened stems. But our examination was necessarily imperfect and incomplete. It seemed to me, however, that the alternating layers of bright and dull coal spoke to the gradual accumulation in water of different kinds of vegetable matter or of different parts of the same plants, and that the coal was analogous to what is sometimes seen in our Scottish coal-fields, where thin layers of gas-coal, black-band ironstone, and common coal alternate and interosculate in one and the same seam.

The comparative composition of the two kinds of coal is shown in the following analyses, which are taken from JOHNSTRUP'S paper :—

GLANCE COAL.

	I.	II.
Organic,	85·3	83·1
Inorganic (Ash),	2·5	2·5
Hygroscopic Water,	12·2	14·4

COMMON OR SLATE COAL.

	Good Coal.		Bad Coal.	
	I.	II.	I.	II.
Organic,	78·0	73·4	65·0	60·6
Inorganic (Ash),	10·7	9·2	16·2	29·3
Hygroscopic Water,	11·3	17·4	18·8	10·1

JOHNSTRUP tells us that some of the coals are extremely ashy, containing as much as 51 and even 74 per cent. of inorganic material. This latter, however, is rather a carbonaceous clay than a coal. In open-air sections it is not difficult to trace the passage from coal into shale—an appearance which, taken in connection with the general aspect of the beds, is strongly suggestive of the aqueous formation of the coal-seams. I saw no trace of a true underclay, and nothing resembling rootlets. Indeed I was rather surprised at the apparent scarcity of plant-remains in the shales. Dark vegetable impressions were observed, but there was nothing among these which could have been specifically determined. The shales and clays associated with the coals generally contain thin lines and layers of glance coal and dull common coal, and now and then small nodules of coarse grey clay-ironstone make their appearance. The mode of occurrence of these thin lines and streaks of coal in the shale seems clearly to indicate deposition in water of vegetable débris and muddy sediment. The shales and clays are generally dark dull grey, but sometimes they are rusty brown; in close contact with the thicker coals they are usually very dark or black. In some places, as at Syd i Hauge (see Plate XIII. fig. 8), they have quite a tufaceous aspect, are dull green in colour, and do not differ from the green tufaceous shales which are sometimes met with between separate beds of anamesite.

The outcrop of the coal-beds is shown upon the accompanying map, and does not differ much from that given by FORCHHAMMER. JOHNSTRUP's map only indicates the areas over which, according to his opinion, the coals extend. He has also left uncoloured those parts of the coal-beds that are at a lower level than the sea, and consequently considerable tracts in the north and north-east of Suderöe are ignored as coal-bearing. In the mountainous tracts of Borgaknappen and Kvannafield the coal-bearing strata seemed to us likewise to have a wider extension than JOHNSTRUP's map allows. The line of bedding could be quite well followed from Kvannafield round to Borgaknappen, and the same beds occupy a considerable area in Tuanahelgafield. Of course, I do not maintain that workable coal will be found everywhere along the outcrop given upon the map. The seams, as I have said, thicken and thin out irregularly, and in no part of the coal-field probably will they be found to preserve for any distance an equable thickness or even to be continuously present. The line of outcrop simply indicates the geological horizon of the coal—the outcrop of the shales and clays in which the coals are found.

The dip of the strata in Suderöe is uniformly N.N.E. Between Waag and Kvannafield the inclination probably does not average over 2° or 3°. It increases slightly north, and at Frodböenÿpen (see Plate XIV. fig. 9), it is as much as 11°; at Kvanhauge the rocks dip at 10° to 14°. Owing to the lowness of the dip, it will be seen that the coal-strata occur as isolated cappings on the crests of the high grounds in the middle of the island (see Plate XIII. figs. 1 and 4).

5. *Coal, &c. of Myggenæs and Tindholm.*—The only other islands in which coal occurs are Myggenæs and Tindholm,* in Sörwaagsfiord. We did not visit these, but I may mention what FORCHHAMMER says about them. The coal of Myggenæs, according to this authority, occurs as a thin layer, from ¼ of an inch to 5 inches thick, embedded in a brownish clay or clunch. Associated with this clunch is a black schistose clay which now and then contains reed-like impressions, like those which occur in the black shales or schistose clays of Suderöe. The whole thickness of the coal-bearing beds is from 3 to 6 feet. They occur at an elevation of 1000 feet.

* According to an old writer (HENSCHEL), whose MSS. are in the Royal Danish Archives, coal is said to occur in Gaasholm and in Waagöe. But it seems this is doubtful (JOHNSTRUP).

In Tindholm coal and clay are found irregularly associated with basalt. FORCHHAMMER's description, which is not very clear, would lead one to suppose that the beds are much disturbed, interrupted, caught up, and enclosed in the basalt. He gives a section in which basalt is seen terminating abruptly against clay, and in the latter he says there are sporadic lumps of basalt. Perhaps these "lumps" may be only veins seen in cross-section.* Many of the basalt-dykes which intersect the sea-cliffs of the northern islands are accompanied by what seem to be irregular lumps of black basalt completely isolated and embedded in the surrounding dolerite and tuff—but these are clearly only the sectional faces of smaller veins proceeding from the main dyke (see Plates XIV. and XV. figs. 14 and 15).

According to FORCHHAMMER, the coal-beds of Tindholm are perhaps on a different horizon from those of Myggenæs.

6. *Subsequent or Intrusive Basalts of Suderöe.*—Basalt occurs intrusively in Suderöe both in the form of sheets and veins or dykes. Very fine exposures of a sheet of prismatic basalt 30 to 50 feet thick are seen on the shore at Frodböe, where the rock is fine-grained and of a dark blue colour. It shows a few small round vesicles, which are usually filled with calcspar. The columns of this basalt vary in diameter from a few inches up to 1 foot 6 inches and 2 feet. They are often extremely regular, and sometimes show beautiful radiating forms. Similar prismatic basalt occurs at Kvannabotnir. There and at Kvanhauge irregular dykes, veins, and sheets are intruded among the anamesites, tuffs, and shales. All these dykes and sheets are evidently part and parcel of one and the same irruptive sheet, which may be traced in the cliffs round into Qvalböefiord as far as Tiödnenæs, and a similar irregular mass occurs on relatively the same horizon on the opposite side of the fiord at Qvalböe, from which place it continues along the coast for some distance down the fiord. At one place to the north-east of Qvalböe the veins and dykes proceeding from this mass are beautifully displayed in the cliffs as they traverse a bright red rock, which is probably tuff (Plate XIV. fig. 10). Close to Qvalböe the basalt is quite prismatic. It is most probable that all these intrusive basalts belong to one and the same intrusive sheet. At Frodböe the rock occurs a little below the horizon of the coal-beds (see Plate XIII. fig. 1), while at Kvanhauge the latter are highly confused and disturbed by it; and it continues at the same level all round the coast to Tiödnenæs. On the opposite shore of the fiord it reappears at Qvalböe, where it seems to occupy the position of the coal—the coal never having been observed at this place. These phenomena are quite in keeping with what we know of the intrusive basalt-rocks of the Scottish coal-fields, which are peculiarly prone to occupy the position of coal-seams. Not unusually our miners find some particular coal destroyed over a wide district by

* TREVELYAN says that the coal and clay of Tindholm are "apparently enclosed in the trap."

the intrusion of a sheet of dolerite. Occasionally such a sheet will leave its usual horizon, and, after rising through a considerable thickness of sandstone and shale, will push itself laterally into an upper seam, and continue along that line for some distance until it may ascend to a yet higher coal which it will "burn" in the same manner as the others. The coal-beds in the Carboniferous series of Scotland would thus appear to have been "lines of weakness." In like manner, the coal-bearing beds of Suderöe would seem to have yielded more readily to the assaults of the intrusive basalt than the harder and less easily divided anamesites with which they are associated. It is remarkable, at all events, that nowhere else in the island do such intrusive sheets occur. We could hardly have missed seeing them had they been present, for each cliff and mountain-slope is a magnificent geological diagram, in which every detail of structure is graphically exhibited.

Dykes and veins of basalt, however, were noted in the cliffs between Famarasund and Famöyë. These seemed to trend N.W. by N., nearly in the same direction as the coast. They sent out numerous small veins and threads in all directions, and appeared to be of the same character as the similar dykes which we observed in great abundance throughout the northern islands.

7. *Contemporaneous or Bedded Dolerites of the Northern Islands.*—As I have already indicated, the basalt-rocks of the northern islands (Stromöe, Österöe, Sandöe, &c.) are upon the whole more coarsely crystalline than those of Suderöe, and rather dolerites than anamesites. But, just as in Suderöe we occasionally come upon sheets of coarse dolerite interstratified with anamesites, so in the northern islands anamesites are now and again encountered among dolerites. The prevailing colour of the dolerites of the northern islands is some shade of blue, but there are many black, grey, red, and purple varieties. All are composed essentially of augite, plagioclase, and magnetite, and most contain olivine, which is often abundant. Some of them are extremely coarse in texture—the crystals of plagioclase with which the rocks are invariably porphyritic, sometimes reaching half an inch or more in length,* and being often developed in great abundance, so much so indeed as occasionally almost to obscure the matrix in which they are embedded. It is this markedly porphyritic character which serves to distinguish the basalt-rock of the northern islands from those which in Suderöe underlie and immediately overlie the coals. Among the most beautiful porphyritic dolerites which we saw were those of Skaapen in Sandöe, of Höÿviig near Thorshavn, and of the hills at Storevatn near Leinum. The weathering of the augite, when the crystals are distinguishable, often imparts a reddish-brown tint to the rock on slightly weathered

* Forchhammer says they sometimes reach an inch in length. This able geologist's geognostic descriptions are in general singularly lucid, and he has given in small compass what seemed to us a perfectly accurate account, so far as it goes, of the principal features presented by the dolerites of these islands.

faces. The olivine occurs either as dark or pale green rounded and amorphous granules or imperfect crystals, but very frequently it is more or less altered into serpentine. So abundant is the magnetite that it often strongly affected the compass, and one had to be on one's guard while taking the direction of dips and glacial striæ. Some of the rocks at Eide in Österöe were particularly magnetic. The fracture of the dolerite varies of course according to the character of the rock; sometimes it is smoothly conchoidal, but more generally it is somewhat irregular, more particularly in the case of the highly crystalline and more coarsely porphyritic varieties, some of which have quite a hackly fracture.

I selected for microscopic examination a number of specimens which might be taken as fairly representative of the rocks of Suderöe and of the northern islands. Like the anamesites, the dolerites of the northern islands differ chiefly in texture and the varying proportion of their component minerals. In some cases, as at Skaapen, the base of the rock is quite compact like that of a basalt; in many others it is crypto-crystalline, like that of the anamesites of Suderöe; while in yet others the texture is coarse and granular, and between these varieties there is every gradation. Again, some of the dolerites are much more abundantly and coarsely porphyritic than others. Occasionally the disseminated crystals of plagioclase are small and few in number, while in some rocks, as already mentioned, they are large and thickly interlaced. The crystals of olivine also occasionally attain a large size. Owing partly to these differences and partly to structural peculiarities, the dolerites are variously acted upon by the weather, as will be afterwards pointed out more particularly. I found that as a rule the more highly amygdaloidal portions of a rock succumbed most readily to the denuding forces—the denser or less amygdaloidal areas often projecting beyond these latter for several feet.

Amygdaloidal and non-amygdaloidal areas frequently alternate in more or less regular bands which are parallel to the plane of bedding, and several of these alternations might be observed in one and the same bed, the line of separation between the bands appearing at the distance of a few yards to be often well-defined (see Plate XIV. fig. 11). The matrix of the amygdaloidal areas was frequently finer grained than the other parts of the rock; it varied also in colour, and was often dull and earthy, becoming soft, wacké-like, and crumbling. The non-amygdaloidal bands, on the other hand, were generally coarser grained, crystalline, and hard. The more crystalline parts of a dolerite might thus be black or blue, while the amygdaloidal portions were pale red or brown, grey, yellow, or dirty green. Small amygdaloidal cavities often occurred more or less numerously in the harder crystalline bands, along the line of junction with the wacké-like areas; but, so far as my observations went, they quickly disappeared at the distance of a few feet from the junction-line, although a few might now and again be detected through the body of the rock; and even occasionally a sporadic area, more or less vesicular and honeycombed, might be seen completely enclosed in crystalline non-amygdaloidal rock. Such alternating and variously coloured layers, although the individual zones are frequently of very irregular thickness, have yet all the appearance of true bedding when viewed from a little distance.

The amygdaloidal cavities vary in size from mere points up to hollows more than 2 feet in diameter. Many of them are round, others are more or less flattened and drawn out in the plane of bedding, while yet others are quite irregular, and seem to have been formed by the confluence of several vesicles. In some places the cavities are very abundant—the rocks being literally honeycombed with them. When such is the case they are generally small—the larger cavities being perhaps most common when the rock is least porous. Some of the largest we saw were on the east coast of Skaalefiord. Very frequently the cavities occur in more or less continuous lines or layers, parallel to the plane of bedding (see Plate XIV. fig. 12), a feature which may be noted again and again in the sea-coast sections, particularly along the north-west shores of Stromöe. Now and again also may be observed that involved appearance of the cavities which has already been described as occasionally visible in the anamesites of Suderöe. The prevailing amygdaloidal minerals are chabasite, stilbite, mesotype, apophyllite, analcime, quartz, chalcedony, calcspar, and green earth. It is not uncommon to find two, three, or even four different zeolites in one and the same drusy cavity.

I have said that more highly amygdaloidal parts often alternate with harder non-amygdaloidal zones in one and the same bed. This, however, is far from being always the case. Sometimes the vesicular areas appear to be as durable as the other portions of a rock, and do not differ from these either in colour or texture. Frequently the dolerites seem to be tolerably homogeneous throughout—there being no trace of that alternation of zones just referred to. The under and upper surfaces, however, wherever they came under my observation, were always more or less vesicular, and often highly slaggy and scoriaceous. These scoriaceous portions are very striking in appearance. They appear to be made up of jumbled and broken fragments of highly vesicular dolerite—varying in diameter from a few inches up to several feet, enclosed in a less vesicular matrix of the same material. At other times the matrix appears to be amorphous, earthy-like, and highly discoloured, generally becoming bright red, and showing occasional yellow and parti-coloured areas. These red discoloured areas so closely resemble the tuffs upon which the dolerites repose that it is sometimes hard to say where dolerite ends and true tuff begins. When the rock is highly porphyritic, however, the presence of the large crystals of plagioclase in the reddened portions usually enables one to detect the line of junction between the two rocks, which is frequently very irregular. This discoloration is probably due to the decomposition of the augite and olivine, and the production of sesquioxide of iron, and the resultant rock thus resembles the "palagonite" of petrologists. It seemed to me, however, that in some cases the tuff over which the old lava flowed had been caught up and commingled with the latter, as I have frequently observed to be the case with the porphyrites of Carboniferous and Old Red Sandstone tracts in Scotland, as in the Cheviots, the trappean hills of Ayrshire, the Ochils, the Sidlaws, and other Lowland ranges. In these Scottish areas the under portions of the porphyrites often contain quantities of baked sandstone and mudstone, which have evidently been caught up while in the condition of soft sand and mud, and become inter-coiled and involved with the once molten rock. Some of the dolerites of the islands now under review appeared to be much more scoriaceous above and below than others. Occasionally the slaggy under surface did not measure more than a foot or two, while in other cases it would reach as many yards. The upper surfaces were likewise often scoriaceous, but, owing perhaps to the comparative absence of red palagonitic matter, they were as a rule less conspicuous than the under surfaces. Some superficial crusts which I saw might readily have been mistaken for volcanic agglomerate. On the shore at Klaksvig, for example, a fine reddish brown vesicular dolerite is seen with a highly scoriaceous upper surface. This crust is made up of fragments chiefly vesicular, of all shapes and sizes, from mere grit up to pieces 6 inches and 1 foot in diameter. Some of the fragments were not unlike bombs, and had only the crust itself been visible it would have been difficult to distinguish the rock from a true volcanic breccia or agglomerate. Another appearance presented by the upper surface of some of the dolerites has been described by Sir G. MACKENZIE as "not unlike coils of rope or crumpled cloth, an appearance which we should expect to be assumed by any viscid matter in motion."

The beds of dolerite vary much in thickness, and it is not easy to give any average. Some were less than 20 feet thick, while others exceeded 100 feet. But as they do not preserve the same thickness throughout, it would only be possible to give a reliable average after a large number of individual beds had been followed along their entire extent, which has not yet been done. It may be that the thinner beds seen in a section attain a greater thickness in some other part of their course, and that no single bed has a maximum thickness so inconsiderable as 20 feet. It is remarkable, however, for what a distance a bed will retain an uniform thickness. One could follow some well-marked sheets often along the whole course of a fiord, throughout which they seemed to retain very much the same thickness. As giving some notion of the number of beds, I may mention that in the hill-slopes and cliffs between Kollefiord and Kalbaksfiord we counted some twenty sheets of dolerite, separated by lines and layers of tuff—the highest bed visible being perhaps some 1500 feet or so above the sea-level. Again, in the fine mural cliffs and bare rugged slopes of Skiellinge Field, as viewed from Höi at the head of Kollefiord, some thirty beds of basalt-rock and tuff-partings were visible, which would give an average of about 80 feet for each bed. Some of the beds, however, were considerably under that thickness, while others could hardly have been less than 120 feet or even more.

None of the bedded dolerites that we saw was so markedly columnar as the more typical of the anamesites of Suderöe. Now and again, however, we observed a rude approximation to columnar structure, and the rocks were very generally traversed by strong master-joints at right angles to the plane of bedding.

8. *Bedded Tuffs of the Northern Islands.*—The tuffs of the northern islands are precisely similar to those of Suderöe, and they need not therefore be specially described. I may merely state that we never chanced to come across any clunch or clay similar to that with which the coals of Suderöe are interbedded, and no trace of coal has ever been met with in the islands at present under review. The thickness of the tuff beds is very variable ; sometimes they consist of mere lines, while in other cases I saw in the cliffs beds which may have exceeded 100 feet in thickness. It is just possible, however, that these tuff-like beds, which were merely observed as we boated past, may have been earthy decomposing dolerites. Now and again I saw a tuff thin out as in the sea-cliffs near Gritenaes in Stromöe (see Plate XIV. fig. 13). But upon the whole the tuffs are less conspicuous than the dolerites, for while the latter form cliffs and steep faces, the latter usually give rise to slopes and ledges which are covered over with débris and vegetation. Some of these slopes indicated a thickness of 200 or even 300 feet of soft rock underneath, but whether this thickness was all tuff or partly tuff and rotten dolerite, I cannot say. In other places again, particularly in the sea-cliffs in the north-west of Stromöe, the tuff seems to occur as mere thin lines and partings. Some very instructive sections showing the rapid alternation of tuff and basalt-rock are seen along the southern shores of Fundingsfiord. Here beds of red tuff, varying from a foot or less up to several yards, are interbedded with irregularly weathering dolerite, and show well the undulating surface over which the old lavas occasionally flowed (Plate XIV. fig. 12).

9. *Subsequent or Intrusive Basalts of the Northern Islands.*—Two sheets of intrusive basalt have been described as occurring—the one in Stromöe and the other in Österöe ; but neither of these was visited by us. They are mentioned by every writer who has treated of the geognosy of the northern islands. The more striking of the two masses is that which is seen exposed along the western face of Skiellinge Field. It is a columnar basalt of an average thickness of 100 feet, which traverses the beds obliquely, and is represented by

TREVELYAN in a section as extending from Norderdahl to Leinum. Its general features are well described by ALLAN. Another and thicker basaltic mass is figured by TREVELYAN as occurring near Zellatrae (Selletrod) in Österöe. These, so far as I know, are the only intrusive sheets which have been observed in the northern islands. Vertical or approximately vertical dykes and veins, however, are exceedingly numerous. We saw many in the cliffs, and these are indicated upon the map, and there are probably many more in those regions which we did not visit. We also came upon fragments of close-grained blue basalt in many places upon the hill slopes, which had doubtless been derived from dykes and veins exposed to denudation on the steep precipices above us. All the dykes seem to consist of the same kind of rock—a hard, fine-grained compact blue basalt (of the same composition as the bedded basalts), abundantly jointed at right angles to its direction, with several more or less continuous joints running parallel to its trend. The cross-joints give the rock quite a prismatic structure, the prisms being confined between the parallel joints, or between these and the walls of the dyke. Thus in one and the same dyke there may be several series of prisms ; but as both the dykes themselves and their parallel jointing are very irregular, the prisms are irregular also. Each dyke sends out numerous small veins which ramify in all directions, and are invariably minutely jointed across. The connection between these veins and the main dyke is often clearly exposed; but very frequently this is not the case, and the small threads and veins then appear quite isolated, the connection with the dyke having either been removed by denudation, or being still concealed behind the visible surface of dolerite through which the veins are squirted. Owing to their highly jointed character, these dykes fall rapidly before the action of the weather and the denuding agents. Thus in the sea-cliffs they almost invariably give origin to caves. Nothing can well be more striking than the appearance presented by many of these curious dykes. In the sea-cliffs they generally appear superficially black or dark green, and contrast very strongly with the ruddy coloured dolerites and tuff across which they break. I give sketches of a few of the more remarkable ones I saw (Plates XIV. and XV. figs. 14–17). Fig. 14 represents a set of dykes which are probably part and parcel of one and the same intrusive mass. All the appearances connected with this and other similar dykes gave one the impression that the basalt at the moment of intrusion must have been in a condition of extreme fluidity. Nowhere that we saw did the dykes disturb the bedding—they seemed to have cut the dolerites very much as a knife cuts cheese. Another very remarkable dyke is shown in fig. 16 *a*, *b*, Plate XV. The decomposition and erosion of this dyke have given rise to a curious cave which forms a kind of natural arcade with a double entrance, as shown upon the plan (fig. 16 *a*). The dyke is in the form of a cross, and the two limbs meet in the roof of the arcade where the beknotted mass projects downwards, reminding one of the groined ceiling of some Gothic structure. But the eccentricities of these dykes are endless, and no two are ever alike. They strongly reminded me of the irregular basalt-dykes and veins which occur so numerously in the Outer Hebrides.*

There appear to be two systems of dykes, but they probably belong to the same age. One series trends from a little east of north to west of south, and the other from north of west to south of east; but the precise direction of some of those which we saw is not quite certain. When a dyke is only seen in one vertical sea-cliff section, and has not been traced inland, its true direction may easily be mistaken, and such may quite well be the case with some which are indicated upon the map. Many of them, however, were so placed as to show their trend conspicuously enough, and these certainly gave evidence of a double series, one set running at approximately right angles to the other. But until the dykes in all the islands have been carefully mapped out this point will not be definitely settled. I may remark in passing, that they are never so regular as the Miocene dykes in Scotland; these latter, as is well known, traverse the country in great wall-like sheets, from which often few or no subsidiary veins proceed; but the dykes of the Færöes divide and subdivide again and again, and send out veins and threads innumerable.

There is no evidence to show whether or not there is any connection between the dykes and the larger intrusive masses of prismatic basalt. It is quite possible, however, and even probable, that both belong to the same period of volcanic activity, and that they may have been injected from below at a time when sheets of basalt still continued to be poured out at the surface.

IV. Thickness of the Strata: Conditions under which they were amassed.

1. *Thickness of the Strata.*—The dip of the basalt-rocks and tuffs in the northern islands, exclusive of Myggenæs, is somewhat persistently towards south-east, at an angle which hardly ever reaches 5°, and is usually much less. Sometimes, indeed, the dip is barely appreciable, and the beds appear to be quite horizontal. The average inclination certainly does not exceed 3°, but is probably greater than 2°. We have thus a thickness of 9000 or 10,000 feet for the rocks in the northern islands. To this must be added the thickness of the lower series (the beds under the coal) as developed in Myggenæs, Suderöe, and Munken, which cannot be less than 4000 feet.

2. *Igneous Rocks of Subaerial Origin.*—Sir George Mackenzie was of opinion that the "traps" of the Færöe Islands were the products of submarine volcanic

* Quart. Journ. Geol. Soc., vol. xxxiv. p. 854.

action, and this view has been generally accepted by geologists. Indeed, the Færöe Islands are sometimes referred to as "a typical example of an upheaved submarine volcano." The greater lateral extension of the basalt-beds as compared to their thickness is supposed to indicate a flow under heavier pressure than that of the atmosphere alone. The phenomena presented by the old basaltic plateaux of Færöe, Iceland, and other countries, are contrasted with the appearances which are known to characterise the eruptive products of Hecla, Etna, Vesuvius, and other modern subaerial volcanic cones, and since these latter rarely or never form such vast successions of parallel and widely extended sheets of lava, the older basalts I refer to are believed to have been spread out upon the bed of the sea. But if we put aside the fact of their greater horizontal dimensions, we find that the basalt-rocks of the Færöe Islands present most of the features which are commonly supposed to be characteristic of subaerial lava-flows. They are generally vesicular, and often scoriform above and below; they exhibit layers and lines of pores and larger cavities, often flattened out in the plane of bedding; now and again their upper surfaces have that slaggy, wrinkled, and crumpled appearance which is so typical of certain modern lavas; while their middle parts are not more vesicular than are the central portions of undoubtedly subaerial flows. The absence of fragmental accumulations, such as volcanic breccias and agglomerates, is really no proof of the submarine origin of the basalt-rocks of Færöe and other similar trappean plateaux. Such coarse accumulations are generally distributed round the immediate neighbourhood of the orifice from which they are ejected. The basalt beds of the Færöes may quite well have been ejected from one or more central orifices, in which case the absence of fragmental materials would only serve to indicate that the focus or foci of eruption must have been at a considerable distance from the present islands. Or it may be that the whole series of basalt-rocks are the products of vast fissure-eruptions. But if this be their origin I certainly met with no direct evidence in its favour. None of the numerous dykes which we saw could possibly be the feeders that supplied the bedded basalts. Most of the dykes died out upwards—often wedging out in the middle of a basalt-bed or tuff—and the rock of the dyke could always be clearly distinguished from that in which it terminated. The dykes, in short, are only thin, irregular veins that ramify and split up into mere threads, and have no resemblance to those great wall-like basalt-dykes of supposed Miocene age, which are so common in Scotland. Veins exactly similar to those of the Færöes, however, are very common in the Outer Hebrides.

But whatever the particular origin of the bedded basalts of the Færöe Islands may have been—whether they flowed from one or more foci like the lavas of modern volcanoes, or welled up from below along the lines of great fissures—all the evidence is against the view that they were erupted upon the bed of the sea. If this had been their origin, we should be at a loss to account for the total absence of marine organic remains in the interstratified tuffs. Nothing at all resembling the fossiliferous tuffs of the Campagna di Roma and the Terra di Lavoro is to be found. Instead of these we have the coal-beds of Suderöe; and hitherto the only fossils which the Miocene volcanic rocks of northern regions have yielded are land-plants, which would be inexplicable enough if these igneous masses had invariably been the products of submarine volcanoes.* The equable thickness and wide extension of the bedded basalts, which have been thought by some to indicate that the old lavas have been spread out under the weight of a superincumbent ocean, are equalled and even surpassed by the great lava-flow from Skaptur Jokul in 1783, which covers an area as extensive as that of all the Færöes, and which in the open country does not average more than 100 feet in thickness. It may be admitted that the lavas of some modern volcanoes have "a more rugged and porous aspect" than many of the basalt-sheets of the Færöes—amongst which we look in vain for those great "clinker-fields" and cinder-like masses which are often met with in the products of recent eruptions. But all modern lavas are not equally scoriaceous, and many have no thicker cinder-like crust than the old basalts of the region under review.

While not disputing that the Færöe basalt-beds may have been poured out from fissures, it seems to me that the phenomena are not inexplicable on the view that they have proceeded from one or more foci in the manner of modern lavas. But if this has been the case, then it is obvious that the centre or centres of eruption must have been far removed from the site of the present islands. This, as I have already remarked, would explain the absence of breccias and agglomerates, of lapilli and bombs. It would also account for the uniform character of the ancient lavas. It is well known that in modern volcanoes lavas and tuffs of very different character issue at different times from one and the same orifice, or from craters which are contiguous. Thus a volcanic mountain may be built up of a great succession of basalt-rocks, trachytes, trachy-dolerites, obsidian, agglomerate, fine tuff, &c. And the basalts of modern formation do not differ essentially from those of older tertiary, secondary or primary age—such differences as do occur being sufficiently accounted for by long-continued chemical action. It is likewise true that trachytic rocks are not confined to modern volcanoes, but occur also interstratified with tertiary and secondary strata. We may reasonably infer, then, that if the Færöe basalts came from volcanic foci, and consolidated in proximity to these, they ought to have been associated not only with coarse agglo-

* Marine fossils are said to occur in the *Surtarbrandr* or lignite-beds of the sea-coast, near Húsavík in Iceland; but this appears to be exceptional—the palagonite-tuffs of that island being otherwise as destitute of any trace of marine life as those of the Færöes.

merates but with other varieties of lava. But as this is not the case, it may be supposed that the whole vast series of basalt-beds and tuffs (13,000 feet or 14,000 feet in thickness) accumulated upon the outskirts of an old volcanic area. They would, in this view, represent the heavier and more fluid lavas, derived from foci which may also have ejected agglomerates and many lavas of lighter specific gravity—these last having been unable to reach the great distances attained by the basalts. This would only be upon a larger scale than what we know has taken place in regions like Auvergne, where, as "in the Mont Dore, the trachytic currents," according to SCROPE, "have in no instance flowed more than from 4 or 5 miles from the central heights of the volcanoes; the basaltic currents, on the contrary, have reached a distance of 15 miles or more."

3. *Miocene Age of the Strata: Physical Conditions under which they were amassed.*—Although, as I have said, the plant-remains of Suderöe have not been specifically determined, there is no reason to doubt that geologists are right in referring the igneous rocks of the Færöe Islands to the Miocene period. They almost certainly belong to the same great series of which the basalt-plateaux of Iceland, Greenland, Spitzbergen, and our own islands form separate portions. Such being the case, it may be allowable to offer a few remarks on the physical conditions under which the rocks of the Færöe Islands would seem to have been accumulated.

We know that during the Miocene period there existed a very wide extent of land in northern regions. It is even highly probable that America and Europe were at that time connected, so that plants could migrate freely across broad areas which now lie drowned beneath the waters of the Arctic Ocean. It is not unlikely that during Miocene times land may have stretched continuously westward from what are now the Færöe Islands to Iceland and Greenland. This belt of land must have been the scene of great volcanic activity, and we may conceive how after many successive sheets of lava had been poured out from one or more vents, or from long fissures, all the hollows of the old land-surface would be filled up for as great a distance as the molten rock flowed. If the lavas flowed from orifices like those of ordinary volcanoes, there may have been one or more central cones, rising probably to a considerable elevation, and surrounded by vast plains that sloped outwards with a diminishing inclination in all directions. The cones themselves would be built up of irregular masses of different kinds of lava and heaps of more or less loose scoriæ, lapilli, bombs, and tuff. The same materials would also enter largely into the composition of the immediately adjacent low grounds. But the further one travelled from the centre of dispersion, the less abundant would lapilli and other loose ejecta become. Highly porous and scoriaceous lavas and clinkers would in like manner abound in the vicinity of the volcanic centre, but they would become less conspicuous as the outskirts of the igneous area were approached. The lavas would still continue to show scoriform crusts, but many of them would begin to exhibit a somewhat smoother or less rugged surface, showing, in place of great fields of cinder heaps, a wrinkled and crumpled appearance, such as is assumed by any viscid substance in motion. In short, the outlying parts of the igneous region would be invaded only by the more fluid and specifically heavier lavas, the lighter and more porous lavas and agglomerates would in great measure be restricted to the cone or cones and their vicinity. Tufaceous deposits, however, would not be wanting in any part of the land to which the lavas might flow, and they might well extend even much further. The tuffs of the outlying regions, however, would generally be fine-grained, consisting of the volcanic dust which the winds had power to carry to considerable distances; of volcanic mud or tuff; and of the materials derived from the subaerial disintegration of the exposed lavas. Such fine-grained detritus, whether washed down the gentler slopes by rain or swept forward as mud, would tend to accumulate in the hollows of the ground. Moreover, since the inclination of the surface in the outer zone of the volcanic area must have been as a rule very gentle, there would be no rapid flow of water, and therefore comparatively little aqueous erosion; and thus coarse gravel and shingle would be generally absent. But, just because the slope of the land was gentle and tolerably equable, fine tufaceous alluvia would tend to be widely distributed—gathering thickly in the hollows, and thinning off where the ground rose in swells and undulations. In short, they would form rather sporadic patches and layers of variable depth, than widespread continuous sheets of equable thickness. These assumptions, as we have seen, are confirmed by direct observation; the tuffs are much less continuous and of less uniform thickness than the basalt-rocks with which they are interstratified.

Now let us suppose that, after many sheets of lava had been poured out and spread above the site of the future Suderöe, a pause in the volcanic activity ensued, and the region referred to ceased for a time to be overflowed. We can readily believe that, under the climatic conditions prevailing in Miocene times, vegetation would sooner or later creep over the surface of the cooled basalts. Rain-water would gather in the depressions of the ground, and so give rise to swamps and pools and shallow straggling lakes, in which mineral and vegetable matter would gradually accumulate. It is not improbable that the basalt-plateaux might even be densely wooded. Such conditions might obtain for a prolonged period, so as to allow of the accumulation in swamps, bogs, and lakes of very considerable depths of vegetable matter, mixed with mud and clay and fine sand, and now and again with small stones or pebbly grit. At other times the suspension of volcanic activity might not be so prolonged, and a renewed incursion of lava might take place before the last current had sufficiently cooled to permit of vegetation spreading over its surface, or indeed before the plants themselves had time to occupy the ground. Again, it might occasionally happen that, owing to the nature of the volcanic surface, there could be little or no accumulation of vegetable matter in swamps and pools, and the mere "carpet of greenery" which may have covered the ground in whole or in part, might well be destroyed upon the advance of another lava-flow.

The appearances which have just been described as the most likely to occur under the circumstances I have supposed, are precisely those which are found associated with the coal-beds of Suderöe. The character of the clays and tufaceous shales with which these coals are interbedded, and the manner in which mineral and vegetable layers interosculate, all point to quiet deposition in shallow lakes, and the slow accumulation of plant-remains in swamps, marshes, and bogs. The thin layer of coal at Dalbofos may indicate a comparatively short period of rest, while the thicker coals at the higher level seem to bespeak a pause of much longer duration. In like manner, many of the tufaceous shales which appear to be unfossiliferous, may yet have been accumulated in precisely the same manner as the shales which accompany the coal layers, and which in some places they closely resemble. The mere absence from these shales of coal or plant-remains does not necessarily prove that no vegetation covered the plateaux at the time the shales in question were accumulated. The presence of the little patch of coal at Dalbofos, which is quite local—none ever having been seen elsewhere on the same horizon—shows us how easily all trace of a vegetable layer might be obliterated. But while it may be true that some of the darker tufaceous shales may thus be of the nature of "surface-wash," and owe their origin directly to the action of the weather, there can be little doubt that by much the greater proportion of the red and particoloured tuffs are due more or less directly to igneous action. They consist of the finer dust and grit blown out during eruptions, and spread by the winds over vast areas, and partly no doubt of the same material carried down by rain and swept from higher to lower levels by running water—sometimes, perhaps, the tuffs may represent former currents and streams of volcanic mud.

4. *Position of old Volcanic Centre of Eruption.*—It would be interesting to ascertain the locality of the volcanic centre from which the old lavas of the Færöe Islands were ejected. I am inclined to think that it lay somewhere to the westward, partly for the reason that the rocks have an average easterly dip, and partly because the sea between the Færöe Islands and Iceland is not so deep as it is in the direction of Scotland. The dip, although it may have experienced subsequent modification, may yet indicate the original inclination of the ground, while the lesser depth of the sea to the west does not imply such extreme depression and denudation as must have taken place if the site of the ancient volcano lay far to the east of the present islands. At the same

time, there is something to be said for the view that the old volcanic centre may after all have occurred in that direction, and that owing to the sinking down of the central region, the dip of the great basalt plateaux has been reversed. Such enormous denudation and so many great movements of the earth's crust have taken place since Miocene times, that too much stress may easily be laid upon the configuration of the sea-bottom, and the present dip of the strata. In whatever direction the centre of eruption lay the fact remains, that in the basalt-masses of Færöe we see only a few shreds of what must at one time have been a continuous plateau, occupying a much wider superficial area. The lofty cone or cones, if from such rather than fissures the basalts were erupted, have entirely disappeared—perhaps the looser and less consolidated materials of which they would probably be composed, having, we may suppose, contributed to their overthrow. This, I may remark, is the fate which has overtaken all the great volcanic centres of our own islands. Thus the volcanic products of the Old Red Sandstone, Carboniferous, and Permian formations are now represented chiefly by sheets of igneous rock, many of which have consolidated at a greater or less distance from the points of eruption. Such cones of scoriæ and lava as may formerly have existed have been entirely demolished—their sites being now indicated by the hard plugs of rock that occupy the pipes or necks through which ashes and molten rock found a passage to the surface.

V. Glacial Phenomena of the Islands.

1. *Early Notices of Glacial Phenomena.*—The earliest notice of the abraded and striated rocks of the Færöe Islands occurs as already mentioned in Mr Allan's paper. His description does not tell us in what direction the abrading agency moved ; but Robert Chambers, who visited the islands forty-three years afterwards, and saw the *roches moutonnées* and striæ described by Allan, was clearly of opinion that the ice had come from the north. He says, "They (the striæ) presented themselves in abundance in several places, most strikingly of all within sea-mark on the shore of the quiet bay, being all directed from the north," &c. Again he describes similar striæ observed by him in Iceland, which had the same trend with those at Eide, and concludes that these facts, taken in connection with observations of a like kind in the north of Europe and America, indicate "that there has been one universal sweeping of the surface by ice, down to some point in latitude which remains to be determined. The parallel channels between the Færöe Islands, all lying between north-west and south-east, I regard as excavations made by this wide-spreading arctic ice-sheet." Mr Chambers likewise noticed the glaciated rocks at Thorshavn, but failed to see the striæ which many of them present. Again,

he chronicles the occurrence of striæ at Westmannshavn, "directed from N. 80° E. (when 30° were allowed for variation)." Since CHAMBERS' visit no geologist, so far as I know, has published any account of the glaciation of the islands. Professor JOHNSTRUP'S interesting paper makes no reference to the "superficial geology" of Suderöe, and this paper, as I have said, is the latest contribution to our knowledge of the geology of the Færöe Islands.

I shall describe the glacial phenomena under the following heads:—*Glaciation; Till or Boulder Clay; Erratics and Morainic Débris;* and *Lake-Basins.* Some further remarks on the subject will also be given when I come to discuss the origin of the valleys and fiords.

2. *Glaciation of the Islands.*—Every island visited by us showed conspicuous marks of glacial abrasion. Sometimes the striæ were finely preserved, at other times they were faint, and only the deeper ruts were conspicuous upon the smoothed faces, while in very many cases all the more delicate ice-markings had disappeared, and only the characteristic rounded and dome-shaped outlines remained. Frequently, too, the *roches moutonnées* have been broken and shattered by the action of frost to such an extent that the glacial form is best seen from a little distance. Some of the most perfect examples of striated rock-surfaces occur in Stromöe. Thus at Thorshavn we detected a number of well-smoothed faces, the direction of the striæ varying from E. 40° S. to E. 45° S., the abrading agent having clearly come from north-west. Some of these striated faces occur in the little town itself; as, for example, upon rounded rocks on the side of a street or road not far from the church. They are visible also upon *roches moutonnées* at various places along the shores of the little promontory, upon which a considerable part of the town is built. But perhaps the best example is seen upon the side of the path that leads to the fort. Here, at the distance of 90 or 100 yards from the latter, there is a wide surface of basalt planed down to a level and traversed by long parallel striæ and ruts which trend E. 35°–45° S. In the immediate outskirts of Thorshavn several other striated faces were observed showing a similar direction; but on one face the direction was more easterly—E. 10° S. Some good examples were also noted in the neighbourhood of Höÿviig, a mile or two to the north of Thorshavn. At this place fine *roches moutonnées* may be seen, and well-marked striæ pointing E. 40° S., which occur both on horizontal, sloping, and vertical surfaces. The hills immediately to the west of the town show marks of glacial abrasion up to and over their summits (1048 feet), and the high ground between Arge and Kirkeböe appear in like manner to have been smothered in ice, the basalt-cliffs and terraces have been bevelled and rounded off, and the hill-slopes generally show a well-marked glaciated contour or outline.

All the steep seaward slopes between Thorshavn and Kalbaksfiord are highly glaciated, fine *roches moutonnées* being seen on the shore at Qvitenæs, where the tops of the columns of basalt are finely smoothed off. Although we only saw these rocks from the boat as we passed along the shore, we were yet near enough to distinguish the coarser striæ, which appeared to have the same direction as those at Höÿviig and Thorshavn. The appearance of the glaciation on the hill-slopes in Kalbaksfiord is very impressive. Here one can see at a glance in which direction the ice has flowed; it has clearly crossed the lower reaches of the fiord from north-west to south-east, a direction which corresponds with the trend of the upper part of the fiord. On the south side (the *Stoss-seite*) the hill-face exhibits the strongest marks of glaciation, while on the north side (the *Lee-seite*) the dolerites are rough and rugged, and show little or no trace of abrasion. The seaward slopes between Kalbaksfiord and Kollefiord also exhibit marks of glacial abrasion.

We crossed Stromöe from Öreringe to Westmannshavn. The lower parts of the mountains that overlook Kolfaredal are smoothed and abraded in a south-east direction, and we estimated the height reached by the glaciated outline to be some 1500 or 1600 feet. Above that level all is rough and rugged, and destitute of the slightest trace of glacial abrasion. At the Storevatn of Leinum we found the *roches moutonnées* at the exit of the lake gave evidence of an ice-flow towards the south-west into Westmannshavnfiord. The pass across the dividing ridge between Kolfaredal and the valley that leads down to Westmannshavn we found to be 1243 feet (379 mètres). At this level are *roches moutonnées,* but we saw no striæ. The glaciated outline was continued up the mountain-slopes above us for not less than 400 feet.

At Westmannshavn many well glaciated surfaces occur, but the striæ have in most cases disappeared. In one or two places, however, upon the steep hill-slopes to the west of the large waterfall, faint striæ and ruts were observed with a trend of W. 30° S., while close to the waterfall itself we got them pointing S. 5° W. Again, upon a point that juts into the sea E.S.E. from the church, ruts and striæ, directed to S. 40° W. and S.W., occur upon the surface of *roches moutonnées.* All the hill-slopes surrounding the bay are highly abraded, the basalt-cliffs and terraces being rounded and smoothed off in a striking manner (Plate XV. fig. 18).

The valley that opens upon Saxenfiord is likewise well glaciated, and exhibits smoothed and striated rocks in several places. On the plateau near the church many smoothed surfaces appear, but the striæ have in most cases vanished. We got several good examples, however, all of which pointed in the same direction, namely, W. 25° N. or down the valley. Between the church and the lake we met with other instances, but the *roches moutonnées* were, as a rule, much broken up, and to a large extent masked by their own ruins. We traced the glacial outline in the district between Saxen and

Tiörnevig up to within 100 feet or so of the *col* or water-parting, immediately above which the rocks give no evidence of having been subjected to glacial abrasion. The *col* we found to be 1693 feet (516 mètres) above the sea, and the glaciation came close up to this level; the rocks upon the *col*, however, were much broken up by frost, but abraded rocks with the characteristic glaciated contour certainly reached 1600 feet. We saw no striæ at Tiörnevig, but the sea-ward slopes of Stromöe opposite Österöe show well-marked *roches moutonnées* between Tiörnevig and Haldervig, and much further south, as we could see very plainly from the high grounds of Österöe.

Perhaps the best preserved *roches moutonnées* we anywhere observed were in Österöe and Sandöe. It was with considerable interest that we visited the northern portion of the former island, for we felt that the evidence to be gathered there would go a long way to settle the question which we had come to solve. No difficulty was experienced in finding the locality described so long ago by ALLAN, and subsequently visited by CHAMBERS, but the striæ, instead of being "directed from the north," had clearly been graved by ice coming from quite the opposite point of the compass. The Kodlen peninsula we found glaciated all over, the *roches moutonnées* on both sides of the isthmus being beautifully perfect, and showing *Stoss-* and *Lee-seiten* in the most admirable manner. In many places the striæ are well seen, and long ruts and channelings or grooves and trenches, well smoothed and ice-worn, traverse the rock-surface. The direction of the striæ, ruts, and grooves varied a little from N. 10° W. to N. 10° E.—the variation being evidently due to the form of the ground.

We traced the glaciated contour up to a height of 1302 feet (397 mètres), which was the summit level of the pass leading from Eide to Funding, but the slopes facing the sound between Österöe and Stromöe seemed to be glaciated to a somewhat greater height. The direction of glaciation upon those slopes, so far as we could observe them, seemed to be in a direction corresponding with the trend of the sound, namely from S.S.E. to N.N.W. Crossing the ridge to Funding, we found that the glaciation pointed east into Fundingsfiord, and that ice had evidently gone down the valley. The rugged mountains overlooking the upper reaches of Fundingsfiord from the east appeared conspicuously glaciated in the direction of the fiord, but the upper parts of the rough hills between that and Andafiord were above the limits of glaciation. At Andafiord we got striæ upon a surface of basalt under boulder-clay. The striæ pointed down the fiord or E. 40° N.

The rugged promontory between Leervigsfiord and Giötheviig shows strong marks of glacial abrasion in the direction of those fiords, but the higher parts of the ridge project above the glaciated area. The southern shores of Giötheviig are well rubbed in the same direction. Between Giöthe and Skaalefiord the *roches moutonnées* are well defined, and show striæ, ruts, and grooves, which point E. 35°–40° N., evidently the work of ice which overflowed from Skaalefiord. The dividing-ridge between Skaalefiord and Giötheviig, at the place we crossed, was 410 feet high, but the glaciation swept up to within a short distance of the hill-tops. Skaalefiord itself has brimmed with glacier-ice, the great body of which flowed down the fiord, as the highly abraded seaward slopes on both sides clearly attest. The glaciation is particularly well seen at Tofte Naes—the whole of that peninsula exhibiting every evidence of severe glaciation. The direction of ice-flow, as shown by the *roches moutonnées*, was towards S.S.E. The west coast of Österöe, opposite Kollefiord, also gives evidence of having been abraded in a south-east direction.

I have no doubt that glacial striæ might be found in other parts of Stromöe and Österöe which we did not visit. In the neighbourhood of Qvalvig, for example, glacial phenomena are probably well developed. But the localities we examined sufficed for our purpose, and supplied abundant evidence to show that these islands had been glaciated by a local ice-sheet. We found not the slightest indication that they had ever been impinged upon by ice flowing from the north.

The evidence obtained in the smaller islands served further to establish this conclusion. We visited Boröe and found that Boröevigfiord was abraded in a S.S.E. direction—in other words, the ice had flowed down the fiord. We boated along a portion of the coast-line of Kalsöe and Kunöe, but the other islands, Wideröe, Svinöe, and Fuglöe, we did not approach. We could see, however, that the higher parts were extremely rugged and quite destitute of any appearance of glaciation; and from the analogy supplied by Boröe, I have no doubt that their lower portions will give evidence of a local ice-flow.

Naalsöe, opposite Thorshavn, appears smoothed off to its summit; and the seaward slopes of Waagöe opposite Westmannshavn are glaciated in the direction of Westmannshavnfiord. But I could not be sure whether the ice in this fiord had moved to north-west or south-east. It is most probable, however, that the ice-flow was in both directions—in the northern reach going towards north-west, and in the southern section to east and south-east. The rugged mountain of Stoiatind in Waagöe soars above the limit of glaciation.

The direction of glaciation in Hestöe we did not determine, but it will doubtless be found to agree with that of the hill-slopes on the Stromöe side of Hestöefiord, which, so far as I could make out, was towards S.S.E. Unfortunately, thick fog prevailed when we traversed the district between Thorshavn and Kirkeboe, and we were not fortunate enough to find any striæ at the latter place.

At Skaapen, in the north of Sandöe, the ground is highly glaciated, but owing to the absence of any well-defined *Lee-seite,* and the disappearance of the striæ, we could not be certain as to the direction followed by the ice. On the opposite side of the island, however, we found strongly marked *roches moutonnées,* and very fine examples of striation. As these are perhaps the best preserved specimens to be found in the Færöe Islands, it may be well to indicate the precise locality. We met with them at the point which forms the south-west limits of Sandsbugt. Close to this point there is a deep ragged cleft in the rocks into which the sea has access by a subterranean passage. The dolerite at this place shows fine striæ pointing to S. 40° W., but the best example occurs on the headland at the point itself. Here the *roches moutonnées* indicate very clearly the direction of the ice-flow, and the striæ (S. 40° W.) are particularly sharp and fresh. Nearer the village of Sand, we found striæ with a more southerly trend—S. 15° W. Of the interior part of Sandöe I can say very little —for we traversed it in a dense drizzling fog. We could only see that *roches moutonnées* and ice-worn rocks accompanied us across the hills.

The higher parts of Skuöe, as seen from our boat, appeared to be smoothed off from the north or north-east; but Store Dimon and Lille Dimon, when we passed them the first time, were shrouded in mist, and on our return from Suderöe rough weather prevented us approaching them.

Suderöe has supported a considerable mass of ice, for we traced the glaciated outline up to a height of 1400 feet. Above that level all is rough, angular, and serrated. The low ground that extends from the head of Qvalböe-fiord to the west coast is highly moutonnée, the position of the *Stoss-* and *Lee-seiten* indicating an ice-flow from east to west. Here also the striæ point E. and W. In Trangjisvaag valley, the direction of glaciation is towards south-east, as shown both by *roches moutonnées* and striæ. Both sides of the fiord into which this valley opens are highly glaciated in the same direction. At Ördevig, the striæ point E. 30° N., and correspond in direction with the trend of the valley in which they occur. The fine cirque-like valley of Howe affords admirable examples of glaciation. The whole broad amphitheatric space has been filled with ice, like a great reservoir; the flat bottom being thickly set with *roches moutonnées,* and the smoothed and rounded glacial contour rising on the hill-slopes to a height of 1400 feet. The upper part of the valley is sprinkled with many lakelets, which rest in true rock-basins. Striæ are not abundant, but we noticed them in several places, and they all pointed to the east, or down the valley. Another finely glaciated cirque valley descends from Kvannafield and Borgaknappen to the cliffs on the west coast, north of Fama-rasund. The ice that filled Howe valley must have brimmed over and become confluent, not only with the Trangjisvaag ice, but also with the glacier masses that descended the Dalbofos valley and Waagsfiord, for the hills above Porkerji and Naes are strongly glaciated all over. The trend of the abraded rocks on both sides of Waagsfiord is towards the south-east, but at Waag there is a hollow which runs from the head of the fiord south-west to the open sea coast, along which a stream of ice has flowed, as is shown by *roches moutonnées* and striæ pointing S.W. At Famöÿe, likewise, we got evidence of an ice-flow to the west —striæ and *roches moutonnées* on the south side of the bay pointing distinctly in that direction.

I have some additional remarks to make upon the subject of glaciation, but these I shall defer to a subsequent paragraph.

3. *Till or Boulder-clay.*—The till or boulder-clay of the Færöe Islands closely resembles the similar deposit which occurs in the hilly and mountainous districts of Scotland. We found it in a great many places, generally as little local patches, sheltering in the lee of *roches moutonnées* and projecting rocks; at other times spreading more continuously over low ground, and covering the beds of gently-sloping and wide valleys. Not infrequently it occurs along the margins of fiords, where the hills retire, and the coast-land is low. It varies much in thickness, but seldom exceeds 15 feet, and generally it is much thinner. In the neighbourhood of Thorshavn, it is a hard, tough, dark brown deposit, stuck full of blunted stones and boulders, some of which were well-striated. This was the case especially with some of the bigger stones. The same deposit of till showed here and there an irregular layer of earthy gravel of the usual character. The clay ranged in thickness from a few feet up to six yards; and here and there contained blocks of basalt that measured 10 and 12 feet across. Along the shores of the bay it rests upon a glaciated surface, and the same is the case with the till at Höÿviig, which is of a dark brownish blue colour. I noticed till also in Kolfaredal and at Westmannshavn and Saxen. Thin sprinklings were observed at various places between Eide and the foot of Slattaretind; and at Andafiord the low cliffs along the shore are formed of a very hard, dark greyish blue till with angular and blunted stones—some of the larger ones showing striæ. This till rests on a striated surface of dolerite.

Another good exposure of till occurs on the shores of Boröevig fiord, close to Klaksvig. It contains intercalated lenticular beds of fine tough brown stoneless, laminated clay and sand, as shown in Plate XV. fig. 19. The till is of the usual character, but very few of the included stones show faint striæ; they are of the common blunted subangular shape. At Giöthe there is a good deal of till, and irregular sheets of it appear here and there along the course of Skaalefiord, as at Siov, Strendre, and Glibre. Again in Sandöe considerable depths of till fill the bottom of the valley that opens into the sea at Sand. The deposit in this valley is more than 20 feet thick, and is well exposed along the course of the stream. We noticed till in Suderöe in many places, but more particularly in Trangjisvaag valley, and at Ordevig. In the former it occupies the whole bottom of the valley, and it also shows in various places along the northern shores of the fiord. Intercalated lenticular beds of gravel, clay, and sand occur here and there.

The distribution of the till and the mode of its occurrence harmonised completely with the appearance presented by the glaciated rocks ; it lay either upon low undulating grounds, or was closely packed together behind rocks, whose abraded and ice-worn faces were quite destitute of any such covering. All the stones and boulders in the till were of local origin, and in the many exposures which we examined we never saw a single fragment which might not have been derived from the islands themselves—all consisting of basalt-rocks and tuff, and chiefly of the former. This till, we had no doubt whatever, represents the ground-moraine, or *moraine de fond* of the old ice-sheet that covered the islands. On steep slopes and in situations which must have been exposed to the full force of the ice-flow not a scrap of till appeared.

4. *Erratics and Morainic Débris.*—Large angular blocks of basalt-rock are of common occurrence throughout the islands, but in some districts they are more conspicuous than in others. In the vicinity of Thorshavn they are specially numerous, and many of them attain a large size, measuring occasionally upwards of 20 feet across. They occupy positions which preclude the possibility of their having fallen or rolled down from the hills, and as they are now and again associated with coarse morainic débris, I do not doubt that they have been deposited in their present positions during the melting of the ice-sheet. An excellent exposure of morainic débris, consisting of earth and angular fragments of all shapes and sizes up to large blocks, may be seen on the road that leads out of Thorshavn on the way to Kirkeböe. Large blocks are frequently seen dotting the hill-slopes in greater or lesser numbers throughout all the islands, and not a few may have had a glacial origin, but in many cases such isolated blocks and morainic débris can hardly be distinguished from the loose fragments which are disengaged even now by the action of frost, and rolled down from the upper parts of the hills. It is noticeable, however, that while perched blocks are quite absent from hill-tops which give no evidence of glaciation, they are yet often scattered abundantly over the surface of high ground which has been glacially abraded. This is well seen upon the ridge between Giöthe and Skaalefiord, where isolated erratics are sprinkled about upon the moutonnée surface. But even in the valleys I found true morainic débris less plentiful than might have been expected. In Kolfaredal, for example, only a slight sprinkling occurred, and in many cases this débris might quite well have resulted from the shattering by frost of the rocks *in situ*. This was particularly well seen in Saxen valley, where immediately below the lake the bottom of the valley is filled with what appear at a first glance to be hummocks of morainic matter. I found, however, that many of those hummocks were mere knobs and bosses of basalt-rock screened and masked by their own ruins. Whether some of the

débris and loose blocks that were scattered about might not have had a true morainic origin, it was impossible to say, but from the presence of some blunted and evidently glaciated stones, this seemed highly probable. True terminal moraines, however, were noticed in the valley that leads down to Westmannshavn, on the way over from the head of Kolfaredal. At Andafiord in Österöe, I found the till overlaid by true morainic débris and shingle, and all the low ground was sprinkled with large erratics which could not have rolled to their present positions, but are of unquestionably glacial origin (see Plate XV. fig. 20). At Klaksvig also may be seen erratics and morainic gravel and sand overlying till (see fig. 19). In Suderöe, as in the northern islands, numerous loose erratics appear, but morainic débris seems to occur in mere superficial sprinklings, and never, so far as I saw, formed definite mounds. So far as my observations went, well-marked terminal moraines appeared to be quite exceptional, but much of the loose angular débris and earth which are scattered over the bottoms of the valleys and the lower grounds are doubtless of morainic origin. It is needless to add that not a single erratic or loose fragment of rock foreign to the islands was observed.

5. *Lake-Basins.*—All the lakes, with one or two exceptions, occupy true rock-basins. None, as I have already mentioned, attains a large size. They are somewhat numerous, and were formerly more abundant, for not a few appear to have been silted up, and are now represented by little sheets of alluvium and cakes of peat. As all the lake-basins we visited present the same kind of features, a few only need be specially referred to.

The *col* between Kolfaredal and the valley that takes down to Leinum is only 259 feet (79 mètres) above the sea. In the Leinum valley, a short distance below the water-parting, occurs a little lake (Mjavatn), and about half a mile or so further down is a second and larger lake (Storevatn). Mjavatn is divided by a *cône de déjection* of detritus brought down into the valley by a torrent escaping from the hills on the north side. The surface of the lake is only 12 or 13 feet lower than the water-parting—the height over the sea being 75 mètres. The lake is about quarter of a mile or so in length, and it appears to be shallow. Yet it is a true rock-basin, since the stream at its lower end flows over rock.

Storevatn is three-quarters of a mile or more in length, and half a mile or so in breadth, and seems to be deeper than Mjavatn. At its lower end it is hemmed in by rock, over which the stream flows. The height of this lake we found to be 63 mètres, or 207 feet. *Roches moutonnées* occur at the foot of both lakes, but only a thin sprinkling of angular débris is scattered over the valley. There are no true moraine mounds. Storevatn lies at the base of tolerably steep hills—the one on its north-west side being glaciated all over. The lake originally extended up the valley to the north-west, and must at one time have been nearly two miles in length.

Storevatn evidently owes its origin to the grinding action of the ice that flowed from the heights between Qvalvig and Leinum. This ice was deflected by the mass of the hill called Saaten, and would necessarily erode a hollow where the opposition to its flow was greatest. I think it is also highly probable that in late glacial times this hollow, which had been excavated at a period when the ice was thickest, would be occupied by a local glacier. Mjavatn appears to be likewise due primarily to the excavating action of the ice-sheet. It lies quite close to the low *col* or water-parting at the head of Kolfaredal, which, when the ice first began to stream down the slopes of the island, was probably a more marked feature than it is now. The water-parting may then have formed a rocky barrier against which the ice that flowed across into Kolfaredal would press with great force. Here then another rock-basin would be formed, which, however, would tend to become obliterated as the rock-barrier continued to be lowered by the grinding of the strong ice-current that passed across it. In late glacial times the hollow may have been to some extent modified by the action of a small local glacier.

Another interesting rock-basin is that in the valley of Saxen. The surface of this lake is 22 mètres or 74 feet above the sea. The valley in which it lies is wide, and comparatively flat-bottomed—the position of the lake being shown in Plate XV. fig. 21, which is a diagrammatic longitudinal section of the valley. The present stream has cut deeply into the old valley-bottom, and now flows some 140 feet or so below its general level. The lake-basin appears to have been excavated in the bed of the old valley which rises some 60 feet or so above the surface of the water. I saw no trace of old water-levels, which would indicate a former greater height for the lake. But its borders are strewed with so much débris fallen from the heights above, that any such traces might well be obliterated. I think it most probable, however, that the lake-surface was never much higher than it is, but that the deepening of the outlet went on contemporaneously with the excavation of the rock-basin, and consequently that the deep gully in which the stream now flows is not entirely of post-glacial origin. It is worthy of note that the water-parting of the valley in which the Saxen lake-basin occurs is a mere flat *col* like that of Kolfaredal. The glacier to which it owes its origin did not therefore head in lofty, steeply-inclined valleys and corries, but was rather a thick flattened mass of ice that gathered deeply over the low-lying *col*, and seems to have flowed both to north-west and south-east.

Besides these larger lakes, which occupy nearly the whole breadth of the valleys in which they occur, very many lakelets lie in cirques. The great cirque of Howe, for example, is studded with lakelets. I counted upwards of twenty, varying in breadth from 50 or 60 feet up to several hundred yards. They are all true rock-basins—the bed of the great cirque in which they lie being also abundantly covered with well-marked *roches moutonnées*. In the numerous smaller cirques that occur in Suderöe and the northern islands, lakes are of almost invariable occurrence. Now and again, however, such lakes have become silted up, and are replaced either by flats of alluvial detritus and peat-moss, or by quantities of rough débris which have tumbled from the surrounding precipices. All these cirque-lakes are unquestionably of glacial origin—the cirques themselves having been originally formed by the action of springs and frost, and subsequently deepened and excavated by small local glaciers and *glaciers remaniés,* as I shall describe more fully in the sequel.

The rock-basins visible in the islands themselves have thus been excavated under varying conditions. Some, as we have seen, have been hollowed out when the ice was at its thickest. They belong to the period of general glaciation, while many are due to local glacial action, which has likewise in some cases modified the results produced by the erosion of the ice-sheet. In the great amphitheatric cirque of Howe, we see how innumerable small rock-hollows may be scooped out by the action of one and the same ice-flow. Doubtless, most of these little basins owe their origin to some accidental circumstance. In some cases, perhaps, the rock has yielded unequally, owing to more abundant jointing or to differences in mineralogical composition and petrological structure. In other cases the basins may simply indicate localities where the ice, owing to the form of the ground, was enabled to exercise greater intensity of erosion.

VI. Origin of the Valleys and Fiords: Subaerial and Glacial Erosion.

1. *Forms of Valleys.*—I have already made brief reference to the various forms assumed by the valleys, and must now describe these a little more fully. For this purpose I shall select one or two examples which may be taken as typical of all the others.

The great cirque-valley of Howe in Suderöe is one of the finest to be met with in any of the islands. It opens upon Howe Bay on the east coast of Suderöe with a breadth of nearly one mile. Its bottom is gently undulating, being studded with clustering *roches moutonnées.* Following the stream upwards we are suddenly brought to a cliff or wall of rock at a distance of rather more than a mile from the sea. This wall circles round the valley, and appears to form its head. But when it is surmounted we find a second broad cirque-like valley bounded in like manner by steep cliffs, above which other cliffs rapidly succeed, rising tier above tier to the summits of the bare rugged mountains. This upper cirque-valley is wider than the lower one, and its bottom is covered with *roches moutonnées,* in the hollows amongst which occur the numerous lakelets of which I have already spoken. What chiefly impresses one is the great width of the valley relative to its length. From the sea to the head of the upper cirque is just some three miles; yet the width of the valley at its upper termination, at the base of Borgaknappan, is nearly one mile and a half (see Plate XIII. fig. 1).

The geologist, crossing from Saxen to Tiörnevig in Stromöe, will traverse two very characteristic valleys. The stream which comes from the north falls into Saxenfiord down a succession of steep cliffs. When we ascend these cliffs, which are perhaps 400 or 500 feet high, we find ourselves in a flat-bottomed valley bounded by encircling cliffs of dolerite, above and beyond which another similar but shorter cirque-valley appears. Between this upper plateau and the valley of Tiörnevig the water-parting is reached at a height of 1693 feet (516 mètres). From this point the ground descends rapidly towards the north-east into another cirque-shaped valley, the sides of which consist of a succession of narrow plateaux, so that the stream descends by leaps from one stage to another till it reaches the sea at Tiörnevig (see Plate XIII. fig. 2).

Similar features characterise nearly all the valleys. They descend in a series of platforms, which vary in number, breadth, and relative height, but invariably present the same features. Those I have now described agree in this respect that they all have well-defined water-partings ; to get from one valley over into the other we must ascend and descend several hundred feet. But there are other valleys, the heads of which coalesce, as it were, so that we pass from the one into the other over a low flattened *col* or water-parting. Such valleys form the great hollows which I described in a previous section as crossing some of the islands from sea to sea. The lofty rock-barriers which must at one time have separated the heads of these valleys have been demolished. The measurements we obtained in Kolfaredal will illustrate the general character of those remarkable hollows. From Kollefiord we found that the valley rose to the water-parting (259 feet) with a mean inclination of 13° or 14°. The water-parting itself is low and flat, and it was hard to distinguish any culminating point. The descent on the other side of the water-parting is very gentle, the fall being only some 50 feet or so for the first two miles. After this the sea is reached at Leinum in less than a mile—the fall being of course more than 200 feet in this short distance.

2. *Fiords.*—The soundings upon the chart prove that the long fiord which separates Stromöe from Österöe, occupies the bed of two submerged valleys with a low separating *col,* over which there is shallow water. This *col* occurs in the narrow part of the sound between Nordskaale and Öre, and the soundings show that from this point the water deepens both towards north-west and south-east. The fiord is shallower at its mouth near Eide, where there are 5½ and 9 fathoms of water, than it is at and above Haldervig, where we get depths of 18 to 30 fathoms. The southern part of the fiord has not been sounded, but it is probably the deeper of the two sections. Many of the other sounds between the islands are apparently of the same nature as that just described—

such as Qvanna Sund, Svinöefiord, Harald Sund, Kalsöefiord, Leervigsfiord, Westmannsfiord, &c. An elevation of 200 or 300 feet would probably suffice to run the sea out of all these fiords and sounds and convert them into valleys, communicating with each other across low level *cols.* They would, in short, resemble the long hollows that have already been described as crossing the islands from shore to shore. Conversely, were the islands to be submerged for 200 or 300 feet, new sounds and fiords would make their appearance, and Stromöe would be cut up into three separate islands, Österöe into two, Boröe into two, and Suderöe into three, while the present fiords would then cover all the low grounds at their origin, stretching back into those broad amphitheatric cirques which are so prominent a feature in the configuration of the Færöe Islands.

Although the fiords are never very deep, they yet, as we have seen, resemble those of Scotland and Norway in this respect, that they are shallower at or near their mouths than somewhat further up. Unfortunately, the soundings indicated upon the chart are not numerous, and reliable details are thus wanting. But the fishermen assured us that it was certainly true that the fiords were deeper above than below their entrances. The soundings between Österöe and Stromöe show that Sundene at least has this character; and it is interesting to observe that the deepest portion of that fiord occurs just where it should if the depression owed its origin to the grinding action of the ice that flowed towards the north. There appears also to be a deep excavation in the sea-bottom to the north of Naalsöe, comparable to the deep hollows that are met with along the inner margin of the Outer Hebrides and many other islands off the Scottish coast—hollows which I have elsewhere shown must be attributed to the erosive action of glacier-ice.*

3. *Trend of Valleys and Fiords: Main Water-parting.*—One sees at a glance that the Færöe Islands are only the more mountainous parts of a region which has been submerged within comparatively recent geological times. And it is not difficult to account for the north-west and south-east trend of so many of the valleys and fiords. If we draw a somewhat undulating line from north-east to south-west between Svinöe and Waagöe, we traverse in so doing the main water-shed of the islands, and what must likewise have been the chief water-shed when the land stood several hundred feet higher. Now, if we suppose the original surface of the land to have been gently undulating, there can be little difficulty in accounting for the trend of the valleys and fiords. What is now the main water-parting will represent the low undulating water-shed of the old table-land—the ground to north or north-west of the line having a gentle fall in that direction, while to the south of the line the inclination would be to

* The Great Ice Age, p. 289; Quart. Journ. Geol. Soc., vol. xxxiv. p. 861; Trans. Geol. Soc. Glasg., vol. vi. p. 161.

south and south-east. In addition to that main line of drainage, there would of course be subsidiary water-partings, such as that which runs down through Stromöe between Saaten and the heights that lie to the south of Thorshavn. From this water-shed streams would flow east in the direction of Kollefiord and Kalbaksfiord, and west into what is now Hestöefiord.

4. *Origin of Main Water-parting, &c.*—To what the original superficial undulations of the old table-land were due it is not so easy to say. Evidence is not wanting, however, which seems to show that in some cases the direction of a valley may have been determined by the dip of the strata. Thus in Fundingsfiord the dolerites dip approximately in the same direction as the fiord or E.N.E., and similar appearances were noted in Andafiord, where the beds incline to north-east. Again, on the south side of the main water-parting nearly all the fiords and valleys run towards the south-east, or approximately in the same direction as the dip. On the other hand, it will be noted that some of the valleys and fiords trend at right angles to the dip, particularly in Österöe and Suderöe, while others run in a direction exactly opposite to the inclination of the strata. It is possible, therefore, that the coincidence of the dip with the trend of certain valleys and fiords may be to some extent at least accidental, and that the configuration of the original surface may have been determined only in part by the inclination of the bedding. It seems not unlikely, indeed, that mere irregularities in the deposition and accumulation of the youngest or latest of the trappean strata may have had much to do in producing the primeval water-sheds of the old table-land; so that, while the original streams would in many cases flow with the dip of the rock, they might in other cases frequently be compelled to run in some different direction. It is even quite possible that the strata may have been slightly tilted since the streams first began to carve out the hollows which are now land-valleys and sea-lochs. For example, the dolerites in the north of Österöe and Stromöe may have been approximately horizontal or even had a slight dip towards the north-west when running water commenced to carve out the now submerged valley between Nordskaale and Eide. If the subsequent tilting were slowly effected, the erosion of the valley might have kept pace with the elevatory movement; the direction of the drainage need not have been reversed. But we see now such a very small portion of the ancient volcanic plateau that it is almost useless to speculate upon the various causes, for there may have been many not now apparent, which determined the principal water-sheds of the now fragmentary table-land. MACKENZIE was of opinion that the narrow channels that separate the islands might have originated in the destruction of large basalt-veins, removed by denudation in the same manner as those smaller veins and dykes which are seen giving rise to caves and hollows along the shore-line. The fiords, however, are as we have seen simply submerged valleys, and there is nothing to show that the valleys

of the land have been hollowed out along the course of large dykes. Many of the small veins which are now exposed to the action of the weather certainly crumble rapidly away, and so give rise to more or less deep gullies. We have no reason to believe, however, that any dykes actually reached to the original surface of the old plateau. And if they did break through that surface they must have overflowed, and cooled under circumstances which would necessarily produce a rock differing considerably in character from that of the dykes which we now see, but probably approaching to that of the dolerites which they intersect.

5. *Atmospheric Erosion.*—From the appearances presented by the land-valleys there can be no doubt that these hollows owe their origin to the action of the usual atmospheric agents, aided by the subsequent erosive powers of glacier-ice. To make this clear, a few notes on the nature of the subaerial denudation now going on seem desirable, and these I shall supplement with some remarks on the effects that have been produced by former glacial action.

Although the basalt-rocks of the Færöe Islands, when freshly exposed, are hard and tough under the hammer, yet their composition and structure render them peculiarly liable to more or less rapid denudation. Not only are they frequently decomposed by the chemical action of the atmospheric forces, but their abundant jointing enables frost to act most effectively upon them, while the work of demolition is still further aided by the horizontality of their bedding. I have already mentioned the fact that some of the basalts weather more readily than others, and that even in one and the same bed there are often great differences in this respect. Thus certain basalts show rough irregular surfaces —the wacké-like portions crumbling to earth and sand—while the harder parts weather less rapidly, and thus amorphous hollows, and ruts, and shapeless humps, knobs, and ridges come to diversify the faces of the rocks in many localities. These appearances, however, are best seen in the sea-cliffs. In the inland valleys the hollows in the rock are often masked by the fall of débris from the ledges above, and are only conspicuous upon very steep cliffs where the loose material finds no angle of repose. As some basalts weather more rapidly than others, their demolition often leads to the destruction of the harder masses that overlie them. The latter are undercut, and by and by large segments split off and fall away. But the undermining of the rocks is carried on in the most marked manner by springs which frequently issue in abundance all along the outcrops of certain beds, particularly when more or less impermeable tuffs alternate with the basalts. This action results in a more or less steep cliff, broken by little sloping ledges which are often thickly carpeted with bright green mosses, in striking contrast to the bare walls of brown rock above and below them (see Plate XV. fig. 23). Not only are the basalt-rocks undermined by the mechanical action of the springs, but they are of course abundantly subject to the action of frost, and immense quantities of débris are thus showered down the precipices. One can see that the denudation is going on rapidly in many places, and thus gradually destroying the glaciated aspect of the ground.

The low dip of the bedding greatly aids the frost and springs in their work of destruction, and now and again considerable landslips take place in consequence. At Tiörnevig in Stromöe we saw the cultivated grounds to a large extent buried under masses of débris and large blocks which had fallen suddenly only a year or so before our visit, and the evidence of similar landslips having occurred in many of the higher valleys of the islands was abundant and conspicuous. So rapid, indeed, is the destruction of the mountains that one is apt to wonder that the valleys are not more plentifully covered with débris; for the streams are insignificant, and hardly able to carry seaward any large proportion of the débris showered down the slopes by springs and frosts. Nevertheless, some of the streams during floods would seem to overflow wide areas, and probably carry seaward no inconsiderable amount of material. They are fast silting up the lakes, and many of these have already been obliterated. And the same silting-up process is going on in the fiords. Thus Saxen Fiord, which was once a good harbour, and could be entered by sloops and other vessels, will now hardly admit a small boat. It was not quite low tide when we entered, and yet our boat grounded several times, and was only brought to shore by dint of vigorous pushing. I have little doubt that could the quantity of material carried down by the streams be fairly estimated, we should find it considerably in excess of what might have been supposed.

It is evident that springs and frosts have been among the chief agents in widening the valleys. When the streams first cut down into the basalt-rocks, they doubtless flowed in more or less deep trenches—the walls of which, undermined by springs and riven by frost, would gradually recede. Moreover, owing to the regularity of the bedding, and the low dip of the strata, the retreat of the opposing cliffs would be tolerably uniform, so that each valley would tend to retain a somewhat equable breadth throughout. But as the streams in their course traversed a series of beds—some of which would yield to denudation much more readily than others—the waters would descend in a succession of runs and leaps. Each hard bed of trap, which happened to be underlaid by a more or less thick band of soft tuff or decomposing earthy amygdaloid, would give rise to a waterfall, the crest of which would gradually retreat up the valley as the trap continued to be undermined by the rapid wasting-away of its pavement. It would rarely or never happen, however, that all the waterfalls in a valley would retreat at the same rate, and thus one would in the course of time overtake another, with which it would coalesce, as it were, to form a higher fall.

This heightened cascade would in like manner gradually retreat up the valley, and perhaps would merge with others before it finally reached the steeper slopes in which the stream originated. The retrocession of the rock-walls however, would not be entirely due to the action of the stream—for the undermining process would be carried on at the same time across the whole breadth of the valley by the action of springs and frost. In short, the rock-face would recede up the valley in the very same manner as the loftier lateral cliffs, between which the water flowed. The Færöe Islands afford numerous examples of every stage in this kind of valley-formation. In Kolfaredal we find the valley-bottom rising from the sea-level with a gentle acclivity to the watershed —the rock-walls and cascades have disappeared. In other valleys, again, we have the bed rising with the same low inclination until it is hemmed in, as it were, by a rock-wall over which the water pours from an upper platform. This latter in like manner slopes gently upwards until it is suddenly cut off by a similar rock-wall, above which a third flat-bottomed course succeeds, terminated by another steep face of rock, and so on. The steeper the gradient of a valley the more numerous do the transverse cliffs and waterfalls become, which of course is only what might be expected from the comparative horizontality of the strata.

Valleys, excavated in the manner described, are necessarily more or less cirque-shaped at the head, and similar but usually smaller lateral cirques open upon them at various levels throughout their course. These lateral cirques have been formed by the locally rapid recession of the valley-cliffs. Here and there some particular bed, perhaps pretty high up in the cliff, is more quickly undermined than the strata below it, and the upper section of the cliff therefore tends to recede more rapidly than the under. In this way small lateral cirques are formed which collect the tribute of the springs and send down their cascades to the main stream.

6. *Former Greater Rainfall.*—Now the recession of all those rock-walls and cliffs results in the production of enormous quantities of débris, the accumulation of which, if it be permitted, must in the course of time bank-up the precipices and retard their waste. And this is precisely what is taking place. The streams are unable to carry away all the loose material which is brought down the slopes by the action of springs and frost. It is evident, therefore, that the time must arrive when these slopes will become more or less masked or concealed under their own ruins. Even now one may see the process far advanced in many mountain-valleys —great curtains of débris hanging from the higher parts of the hills, and sweeping in long trains down to the low grounds, where they gather upon the bottoms of the valleys, and are often left undisturbed by the streams, confined as so many of these are to narrow post-glacial trenches. It is clear, then, that there must have been a time when the rainfall in the Færöe Islands was more considerable

than now—a time when the streams flowed in sufficient body to flood their valleys, and to prevent the undisturbed accumulation of débris-banks at the base of their cliffs. It is quite impossible that the valleys could have been excavated to their present breadth by the small streams of to-day—even with all the aid of springs and frost. These streams are now busied in digging narrow trenches in the flat bottoms (as shown in Plate XV. fig. 22), forming as it were valleys within valleys.

7. *Glacial Erosion of Valleys, &c.*—There are many appearances, however, which cannot be explained by aqueous erosion even on the supposition that the rainfall was formerly more excessive. The width of many of the cirques, the form of the valley-bottoms, the presence of rock-basins, and other phenomena all testify to powerful glacial erosion. The rounded and somewhat undulating contour of the valley-bottoms, and the smoothed and bevelled appearance of the cliffs are conspicuously glacial. The valleys have been glacially deepened and widened, and the harsher features which the cliffs must have presented in preglacial times have thus been softened down. The demolition of the rocky *cols* between two valleys is also unmistakably the work of the ice. As with the valleys so with the amphitheatric cirques, large and small alike, and whether forming the head of a valley or opening abruptly upon a valley from a mountain-slope—all have been considerably modified by glacial action—many containing rock-margined lakelets. When local glaciers occupied these cirques, the recession of the cliffs by which they are surrounded would proceed at a rapid rate—the débris, instead of gathering at their base and forming a protecting mantle, being carried outwards and drifted over the rock-ledges to some lower glacier, or *glacier remanié,* upon the surface of which they might be carried down to sea.

8. *Weathering of Glaciated Surface.*—But throughout all the islands the features impressed by former intense glacial erosion are now, as I have said, being more or less rapidly effaced. *Roches moutonnées* are breaking up and disappearing; ice-worn cliffs are being chipped and shattered by frost; great taluses of débris are accumulating at the foot of scaur and precipice; rock-basins are being tapped and silted up; streams are digging deep gullies in the flat glaciated bottoms of cirques and valleys; and thus erelong the characteristic ice-worn outlines will vanish, and those features which must have characterised the islands in early preglacial times will come more and more prominently into view.

9. *Limited accumulation of Till upon Land.*—When the islands were enveloped in their ice-sheet, the action of frost would be confined to such ridges and hill-tops as projected above the *mer de glace,* while severe glacial abrasion would go on below. This abrasion, carried on doubtless during a prolonged period, resulted in the more or less complete removal of all great banks of débris

that cloaked the valley-slopes,—in the bevelling and rounding-off of basalt-cliffs and ledges,—in the deepening and widening of cirques and valleys, the levelling of valley-bottoms, the reduction of low-lying water-partings or *cols,* and the excavation of rock-basins. It is in accordance with all that we know of the glacial phenomena of Scotland, Norway, and Switzerland, that the material produced by glacial abrasion should not have collected in any great quantity under the ice. The gradients, as a rule, are too steep, and comparatively little till, therefore, was accumulated in the valleys, the great mass having doubtless been rolled out to sea, and spread over the sea-bottom—part of it probably being carried away by the icebergs that broke off from the terminal front of the ice-sheet.

10. *Direction of Ice-flow and Extent of Ice-sheet.*—The undulating lines which I have described as indicating the primeval water-shed of the old table-land also mark out the centres from which the *mer de glace* flowed. The long sound that separates Österöe from Stromöe brimmed with ice which flowed in two directions. North of Nordskaale the movement was northerly, while south of the shallow part of that sound the ice held on a southerly course. So thick was the *mer de glace* that its upper strata flowed across Kollefiord and Kalbaksfiord, and even overwhelmed Naalsöe. All Stromöe south of Kalbaksfiord appears to have been smothered in ice flowing to south-east, and I believe that the direction of the flow in Hestöefiord was the same. Sandöe was also overwhelmed, nor can there be any doubt that the ice which covered it was continuous with that which cloaked all the islands to the north. Of these last it is enough to say that so far as our observations went, they appear to have been glaciated invariably in the direction of the principal fiords. A glance at the map, indeed, will show that the ice streamed outwards everywhere from the dominant high grounds.

The appearances in Suderöe are extremely interesting, inasmuch as they prove that the ice of that island, although for the most part strictly local, and flowing east and west from the chief heights, was yet connected with the *mer de glace* of the northern islands. This is shown by the fact that glacier-ice has passed up Qvalböefiord across the island to the west coast. That ice could not have come from Suderöe itself, but from a thick glacier-mass occupying the bed of the sea between Suderöe and Sandöe. In other words, the ice-sheet of the northern islands must have coalesced with that which covered Suderöe. This is not astonishing when we remember that the *mer de glace* of Stromöe must have reached a thickness, at what is now the sea-level, of 1500 or 1600 feet. So thick a mass could not have floated off in the shallow water (20 to 40 fathoms) that separates Suderöe from the northern islands. But the ice that streamed south from Stromöe and Österöe was thicker even than these depths imply. To the north of Naalsöe we get a depth of 120 fathoms which must have been filled up of course before the ice could overflow that island. This indicates a mass of ice not less than 2200 or 2300 feet in thickness. In Suderöe, again, the upper surface of the ice attained a height of 1400 feet, which we may take as the thickness of the stream that flowed out of Trangjisvaagfiord and Howebugt. We cannot wonder then that the shallow seas which separate the Færöe Islands were completely filled up, nor that the outflow of ice from Suderöe should have been controlled by that coming towards it from the north. The direction of the striæ and *roches moutonnées* at the head of Qvalböefiord agrees with that of the glaciation in the west of Sandöe, and seems to point to a general movement of the *mer de glace* towards the south-west. Probably all the ice that lay to the west of Skuöe and the two Dimons flowed in this direction, while that which lay to the east of these islands participated in the south-easterly movement.

How far out to sea the ice-sheet extended can only be conjectured, but judging from the thickness it attained upon the islands, and in the sounds and fiords, it may well have reached what is now the 100-fathoms line, where it would break away in bergs. Like the greater *mers de glace* of Europe and North America, it tells a tale of excessive evaporation and precipitation, and one ceases to marvel at the thickness attained by the ice-sheets of those vast continental regions when one sees the indisputable evidence of a very considerable sheet of glacier-ice having covered even so limited an area as that of the Færöe Islands.

11. *Origin of Erratics and Morainic Débris.*—The large erratics which are scattered over hill-tops and hill-sides were doubtless deposited by the *mer de glace* during its final dissolution; and the erratics and loose morainic débris that occur in the valleys mark out, in like manner, the gradual disappearance of those local glaciers that still occupied the hollows of the islands after the higher grounds had been relieved of their icy coverings. I have mentioned the fact that valley-moraines are much less numerous than one might have expected, when the shattery character of the igneous rocks is kept in mind. It is true that considerable quantities of loose morainic-like débris are frequently scattered over the bottoms of the valleys, but well-marked mounds of morainic origin appear to be of rare occurrence. We saw some in the valley leading down to Westmannshavn, and some of the mounds in the Saxen valley may be moraines, but such of them as were exposed in section proved to be *roches moutonnées* buried under their own ruins. It is difficult to account satisfactorily for this scarcity of moraine mounds, more especially when we remember that in other countries, such as Scotland, North of England, Wales, Ireland, Norway, Switzerland, &c., where the rocks as a rule are less easily acted upon by the weather, distinct valley-moraines are yet more or less abundantly met with. The following considerations, however, may help to explain the apparent anomaly.

1*st.* Long after the general *mer de glace* had become reduced to a series of small isolated glaciers, it is probable that snow and névé may have continued to cover the land so as to protect the rocks from the excessive waste which they now experience. The superficial moraines, therefore, need not have been very extensive.

2*d.* Again, we must remember that the conformation of the ground, unlike that of the Alps, would not favour the preservation of large valley-glaciers after the snow-fall had become less, and the snow-line had retreated to a higher level. The ice which formerly occupied all the valleys of the Færöes could only have been sustained by the copious precipitation of snow over the whole land-surface. But when the line of perennial snow had risen to 1000 feet or thereabout, only a few local glaciers would probably exist at the heads of the valleys, while *glaciers remaniés* would be distributed along the flanks of the valleys at all those points where torrents and cascades presently appear. There would be no large trunk glaciers formed by the union of considerable lateral glaciers, as in the valleys of the Alps. Thus there would be a general absence of terminal moraines in the middle of a wide valley, for the superficial débris would be distributed chiefly along the flanks of the glaciers and in front of the small *glaciers remaniés.* Moreover, the moraines thus formed would tend to become obscured by the gradual accumulation upon them in post-glacial and recent times of rock-rubbish detached by the weather from the cliffs above.

3*d.* But the principal reason for the apparent scarcity of valley-moraines was probably the continuous and comparatively rapid dissolution of the ice after the snow-line had retreated several hundred feet above the sea level. The ice would appear to have made no long pauses in the valleys, as the ancient valley-glaciers of Britain did, but melted gradually and continuously away. The distribution of the morainic material in sheets over the beds of the valleys seems to point to the destructive action of water escaping from the dissolving glaciers. The detritus thus formed has much the character of that loose aggregation of coarse shingle, earthy grit, and boulders, which is known in Switzerland as " Alpine diluvium."

VII. Marine Erosion.

The erosive action of the sea is admirably exhibited along the shores of the islands, and more especially upon those parts of the coast-line that face the open ocean. Everywhere the cliffs are undermined and eaten back, the rate of erosion varying according to the character of the rocks at the sea-level. The rapid recession of the cliffs is aided not only by the soft and decomposing character of so many of the basalt-rocks and tuffs, but also by the abundant jointing of the rocks; and springs and frost are evidently as actively engaged along the sea-cliffs as they are upon the steep slopes that overlook the valleys. But the influence of jointing upon denudation is certainly most marked in the sea-cliffs. Nowhere can this be seen to better advantage than along the magnificent shore-line of Stromöe between Westmannshavnfiord and Myling. The cliffs there are nearly vertical, and show broad, bare, plane faces, that look often as if they had been only freshly fractured or sliced. Towards the top they are more rugged, and grass grows on all the little ledges, giving the appearance to the cliffs of having been sprinkled with green tufts. The upper parts of the cliffs are often riven by the frost into peaks, spikes, and spires. This great rock-wall, I may add, ranges in height from 1200 feet or so up to 2277 feet. Between Muulen and Saxen occur some splendid stacks called the "Drangar" (isolated or lonely ones). Some of these are not less than 400 feet in height. They taper upwards to sharp pinnacles, and one of them, called "Toskuradrangar," which forms a long wall running parallel to the cliff, is pierced by a lofty portal. Long vertical master-joints are conspicuous in the cliffs at irregular intervals, and give rise to hollows and caves. All the caves we saw between Muulen and Saxen were worked out either along the lines of such joints or in vertical dykes of basalt. They occur in all stages. Here one sees the process just beginning,—a little cleft only a foot or two in width, and a few feet in height. There again one observes another which shows a somewhat greater breadth and height, the height almost invariably exceeding the breadth. Sometimes as many as twenty caves can be counted in the space of a quarter of a mile or less, varying in extent from a few feet in height and breadth to large caverns 20 to 50 feet in height, and somewhat less in breadth, which penetrate the cliff for some considerable distance. The master-joints just referred to seem to cut the cliffs at right angles to their trend, and they are crossed by another set of great joints which have the same direction as the coast-line. Thus when the sea has undermined the cliff to a certain extent, the strata eventually give way and great segments are sliced off along the lines of jointing that run parallel to the shore. These joints are, of course, not so conspicuously visible as those which cut them at right angles. Nevertheless, they were seen again and again on the sides of projecting headlands, and the clean fracture presented by the faces of the cliffs themselves clearly indicate their presence. The large sea-stacks or "drangar" seemed to me to owe their origin to the destruction of caves which had been hollowed out along both lines of jointing, the long wall-like sea-stack called "Toskuradrangar" being evidently defined by joint-planes. This well-marked cross jointing has also given rise to the remarkable indentation in the cliffs which occurs a little south of the "drangar," where the cliffs retire so as to form a kind of marine amphitheatre about 60 or 70 yards in diameter, and surrounded by nearly vertical precipices rising to some 1200 or 1400 feet.

Similar joints are well seen along the coast of most of the other islands.

They are finely displayed in those of Waagöe, Österöe, Sandöe, Skuöe, and Suderöe, and I have no doubt that they have played a most important part in determining the trend of the coast-line where that faces the open ocean. In the quieter fiords the action of the sea, although frequently well-marked, is of course not so conspicuous.

Basalt-dykes almost invariably give rise to caves. This is due not so much to the decomposition of the basalt (which is generally a harder and less easily decomposed rock than the bulk of the bedded strata) as to the minutely fissured or jointed character of the intruded rock. The dykes are traversed by many long joints parallel to their direction, and by innumerable cross joints, so that they fall an easy prey to frost and the battering of the waves (see Plate XIV. section fig. 14) One of the most beautiful dyke-caves is that to which I have already referred, the "Hole under Kjetle" (Plate XV. fig. 16).

From the fact that caves occur solely at the sea-level and are nowhere seen inland, we gather not only that they are of purely marine origin, but also that no part of the Færöe Islands has been submerged within any late geological period. We searched everywhere for evidence of the former presence of the sea, but failed to find the slightest proof that the islands were ever smaller than they are now. This is in keeping with what my brother and Messrs Horne and Peach have observed in Orkney and Shetland, and with what I have noticed in the Outer Hebrides. The belief amongst the inhabitants, indeed, is that the land is sinking, but the facts mentioned by them in support of this view do not appear to be satisfactory. Thus the shallowing of Saxen Fiord might be entirely due to the action of the Saxen stream, aided by the tide itself. There are several considerations, however, which lead me to believe that the islanders are probably right in their conjecture. The present coast-line does not appear to me to be very old. Had it been of long standing I should have looked for more evidence of excessive marine erosion. We know that along the present coast-line of Scotland a terrace of marine erosion is frequently visible. Our land has stood so long at its present level, that the waves have cut back the cliffs for some distance, so that at low tide a platform or terrace of rock is more or less exposed at their base. Now the rocks of the Færöe Islands are being denuded much more rapidly than those parts of the Scottish coast-line to which I refer; and had the land remained at its present level for any prolonged period, we might certainly have expected to meet with such rock-platforms in the Færöe Islands more or less abundantly. But the cliffs seem generally to shoot down at once into deep water, and only in a few places were sea-stacks in any number. A submerged rock-platform diversified with numerous stacks, some of which peer above the sea-level, occurs along the west coast of Suderöe, but this is apparently the only island which is thus reef-fringed. And even these reefs are perhaps too deeply submerged to have been cut down by the waves at their present level. I should infer that, if the islands are not now sinking, they have within recent times experienced some degree of depression.

VIII. Peat and Buried Trees.

The low grounds and gentler slopes in the islands are often coated with thick turf or peat, which is extensively dug for fuel. It varies in thickness from two to six or eight feet; and here and there, in what appear to be the bottoms of old lakes, it may possibly be thicker. So far as my observations went, the *Sphagnaceæ* appeared to form a smaller proportion of the peat than is the case in Scotland. At the bottom, roots and twigs of brushwood are frequently present, and in some places they are quite abundant. The largest pieces we saw were not more than an inch thick, but we were informed by the people, who were digging the turf in Österöe, Stromöe, Sandöe, Suderöe, and other islands that sticks as thick as one's wrist were common; and at Eide in Österöe, the merchant there told me he had seen them taken from the peat near Eide Vatn as thick as his leg. I could not determine the species of wood with any certainty, but the pieces I saw were probably juniper and birch. No brushwood now exists anywhere in the islands, except in the private gardens and enclosures at Thorshavn, yet the evidence supplied by the peat makes it certain that the lower parts of the Færöes must formerly have been pretty well clothed with brushwood and small trees. This was of course in post-glacial times, when the islands were probably of considerably greater extent, and enjoyed a climate more suited than the present to the growth of arboreal vegetation.*

* I have elsewhere endeavoured to show that the Færöe Islands were connected with Scotland in post-glacial times. See Prehistoric Europe, p. 518.

IX. EXPLANATION OF PLATES.

Plate XIII.

Fig. 1. Represents a horizontal section, drawn along the line A.B., upon the map, across the Island of Suderöe. The horizontal and vertical scales are the same. The horizon of the thin coal got at Dalbofos is shown by a thick line; but it must be understood that the coal itself has been found only at one place. The beautiful columnar basalt of Frodböe is shown at *b*.

Fig. 2. This is a diagrammatic representation of the form of the ground between Saxen and Tiörnevig in Stromöe.

Fig. 3. Is a similar diagrammatic section across Österöe, between the sea at Eide and the head of Fundingsfiord. These sections illustrate a very common feature in the valleys of the Færöe Islands, many of which descend in successive platforms.

Fig. 4. Is a horizontal section, drawn to same scale as fig. 1, across the north end of Suderöe along the line C.D.

Fig. 5. Sketch-section of an exposure of strata at the coal-workings of the Præstefield (Suderöe), at a height of 147 mètres above the sea. The coal occurs in two layers, and is separated by 4 to 6 inches of shaly clay. The shales overlying the coals are interlaminated with lines and thin seams of glance coal, which are sometimes as much as 3 or 4 inches thick. There is a good deal of iron pyrites in the shales and coal-lines above the coal. The reference letters are as follows:—

- *d*. Tumbled blocks and superficial débris.
- *t*. Till or boulder-clay.
- *i*. Nodules of coarse grey arenaceous clay-ironstone; 1 to 3 inches in diameter.
- *s*. Dark shales and clays with lines and layers of glance coal and common coal; about 8 feet thick.
- c^1. Glance coal; 8 inches.
- *d*. Dark shaly clay or clunch; 2 to 8 inches.
- c^2. Coal; 2 feet.
- *g*. Space covered with grass and débris; tufaceous shales.
- *a*. Dark anamesite.

The dip is north-east at 5°.

Fig. 6. Sketch-section of strata at Præstefield (Suderöe), near the place shown in fig. 5. The spot is 161 mètres above sea-level; the dip of the strata is towards north-east at 3°. The reference letters are as follows:—

- *t*. Till or boulder-clay.
- *s*. Shales and clays, about 12 feet thick, with layers and seams of coal, as in section fig. 5. The coal-lines are lenticular, and are most abundant in the shales immediately overlying the thick coals; towards the top of the section they are less plentiful.
- *i*. Ironstone nodules in shales.
- c^1. Coal; 8 inches.
- *d*. Shale or clay; 4 inches.
- c^2. Coal; 1 foot 2 inches.

Fig. 7. Sketch-section of strata at Dalbofos (Suderöe); 607 feet above sea-level:—

a. Anamesite; earthy and decomposing into rude spheroids below.

s. Fine grained greenish tufaceous shales, with fine mudstones.

s i. Nodules of coarse ironstone in greenish tufaceous shales.

b. Tufaceous, agglomeratic, scoriform upper surface of anamesite.

c. Probable position of thin coal seam (3 inches) described by Forchhammer; not now seen in place.

Fig. 8. Section of upper part of sea-cliff at Syd i Hauge, on west side of the Præstefield (Suderöe). Height of coal about 440 feet above the sea. From mouth of mine to top of overlying anamesite 50 or 60 feet.

a^1. Dull, dark blue, fine-grained anamesite; showing amygdaloidal band towards middle of the bed; decomposing spheroidally below.

s. Shattery dull green tufaceous shales with streaks and lines of coal.

c. Coal, about 3 feet; seamed with layers and streaks of clay or shale.

a^2. a^3. Anamesites of same character as a^1.

t. Line of red palagonitic tuff.

PLATE XIV.

Fig. 9. Diagrammatic sketch-section of part of sea-cliff at Frodböenÿpen (Suderöe).

a^1. Bed of anamesite, 50 or 60 feet thick, showing lines of amygdaloidal cavities.

s. Brown shales and clay; 15 or 20 feet thick.

e. Coal, about 1 foot 6 inches; with parting of shale or clay.

s i. Shattery brown mudstones resting on brown ferruginous shales, with some nodules of ironstone; 20 to 30 feet thick.

a^2. Anamesite, decomposing spheroidally.

Fig. 10. Sketch-section of basalt-veins; northern shore of Qvalböefiord, near Qvalböe.

d d. Basalt-veins.

t. Red tuff.

Fig. 11. Sketch-section, sea-cliff, Stromöe, near the Drangar.

a. Red tuff.

b b b. Amygdaloidal bands or zones in dolerite.

c c. Non-amygdaloidal dolerite.

d. Overlying bed of dolerite.

Fig. 12. Sketch-section; sea-cliff near Eidevig, Fundingsfiord.

d^1 d^2 d^3. Beds of dolerite.

a. Zone of wacké-like amygdaloidal rock, forming part of bed d^2.

t t. Beds of red tuff.

Fig. 13. Sketch-section; sea-coast near Qvitenæs, Stromöe, showing thinning out of red tuff *t*, between beds of dolerite *d*.

Fig. 14. Sketch-section; sea-cliffs west coast of Stromöe, a little south of entrance to Saxen Fiord. *b b* Dykes and veins of basalt traversing beds of dolerite, with separating layers of red tuff. Dykes are much jointed both longitudinally and transversely. Their thickness varies from a mere thread up to 12 or 14 feet. *j j* are joints traversing the cliffs and giving origin to caves c^1. c^2 shows a cave excavated in the line of a dyke.

PLATE XV.

Fig. 15. Ground-plan of a dyke with veins, near Saxen, Stromöe.

Fig. 16. *a*. Diagrammatic ground-plan of cave ("Hole under Kjetle") at southern entrance to Saxen Fiord. *c a* shows the south opening into the cave, and *c b* the north entrance. The arcade is excavated along the lines of cross dykes which are represented in the engraving by the cross hatching.

Fig. 16. *b.* shows the appearance of the dyke as seen in the roof of the cave.

Fig. 17. Sketch-section of dyke; sea-cliff, west coast of Skuöe. The cliff shown in the sketch is about 600 feet high.

Fig. 18. Hill-slope near Westmannshavn, to show glaciated contour—the sharp edges of the basalt-beds being smoothed off.

Fig. 19. Sketch-section, sea-shore, near Klaksvig, Boröe.

p. Peat.

m. Boulders, shingle, gravel, and sand.

t. Tough hard dark blue till, with subangular glaciated stones.

c. Tough brown laminated clay and sand, with no stones.

Fig. 20. Sketch-section; sea-coast, Andafiord, Österöe.

a. Coarse unstratified shingle, and rough earthy grit with large boulders. Morainic débris.

b. Very hard, dark greyish blue till, with subangular, angular, and blunted stones and boulders—some of the larger ones showing striæ. The deposit rests on a striated pavement of blue dolerite; the striæ point out to sea or E. 40° S.

Fig. 21. Diagrammatic longitudinal section of Saxen Valley. *l* lake; *v* bottom of old glacial valley; *s s* level of present stream (Giogværaa); *F* level of fiord.

Fig. 22. Diagrammatic section across Saxen Valley; *v* bottom of glacial valley; *s* bed of present stream; *d* débris from subaerial waste of cliffs.

Fig. 23. Diagrammatic section to show denudation of basalt-rocks, *d*, caused by springs creeping between these and intercalated layers of tuff, *t*. Talus of débris forming at base of cliff shown at *r*.

Plate XVI.

Geological Map of Færöe Islands. The general features of the geology of the Færöe Islands are correctly indicated upon the map which accompanies Dr Forchhammer's paper ("Om Færoernes geognostiske Beskaffenhed," *Kongl. danske Vidensk. Selsk. Skrifter*, 1824), of which the present is almost a reproduction so far as the delineation of the coal-crops is concerned. The dips of the strata, the dykes and veins, and the direction of striæ and *roches moutonnées* are from my own observations. The coal-crops also differ somewhat from the lines given by Forchhammer, and from those on the more recent map of Suderöe by Professor Johnstrup.

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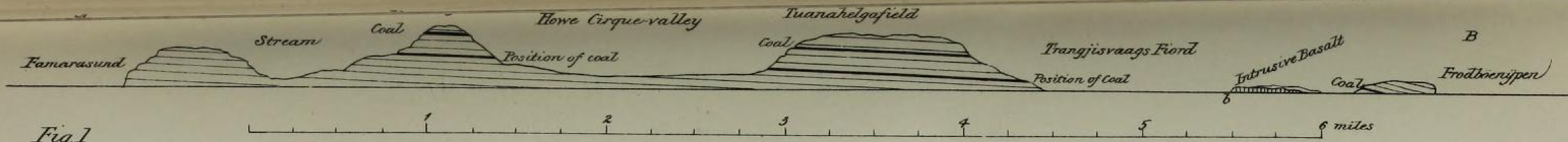

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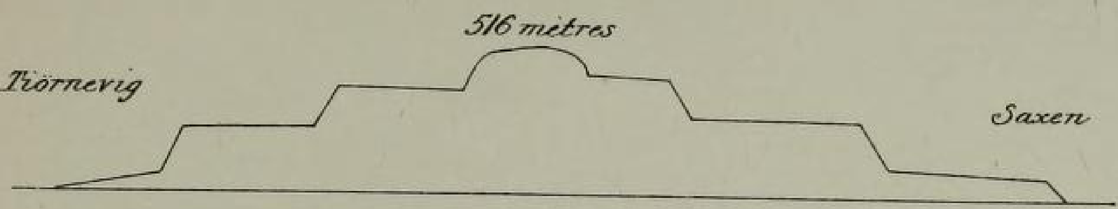

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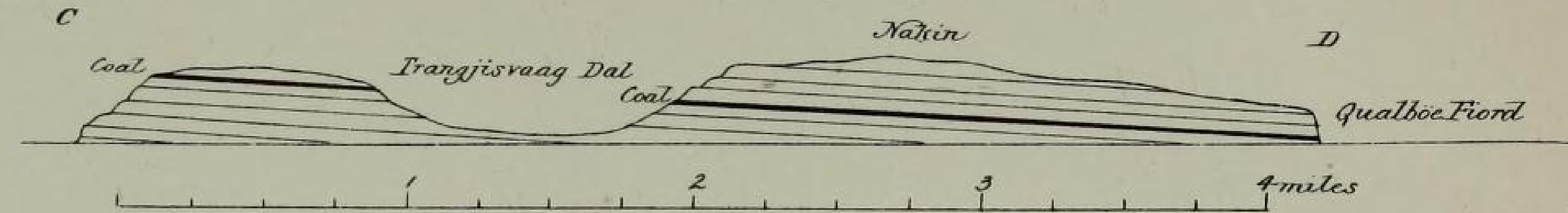

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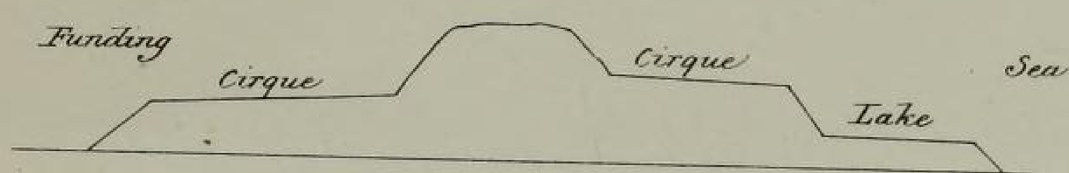

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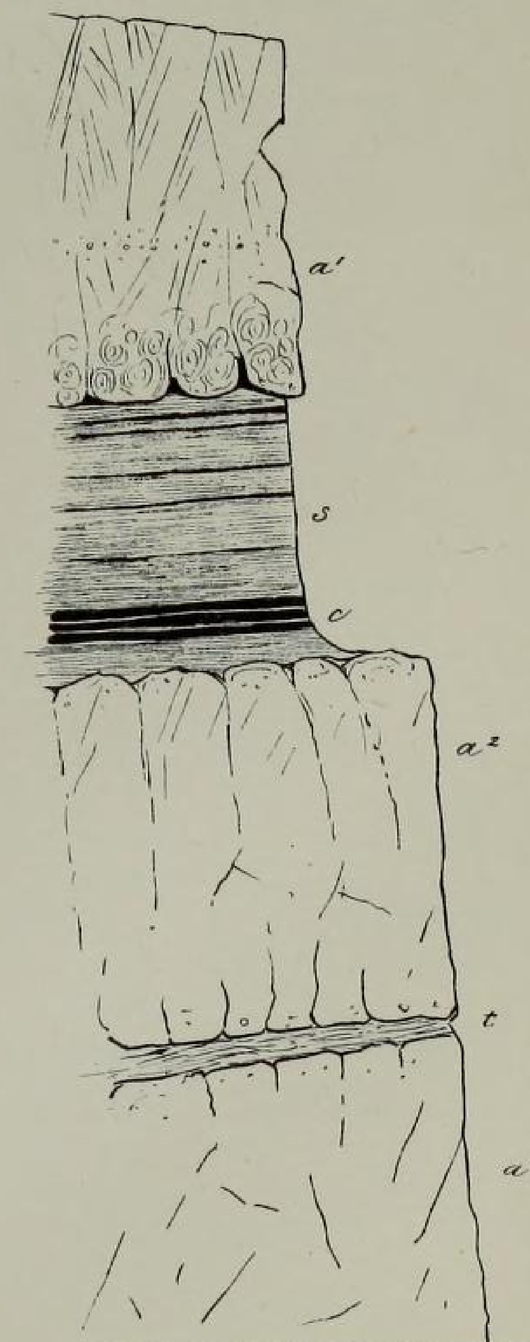

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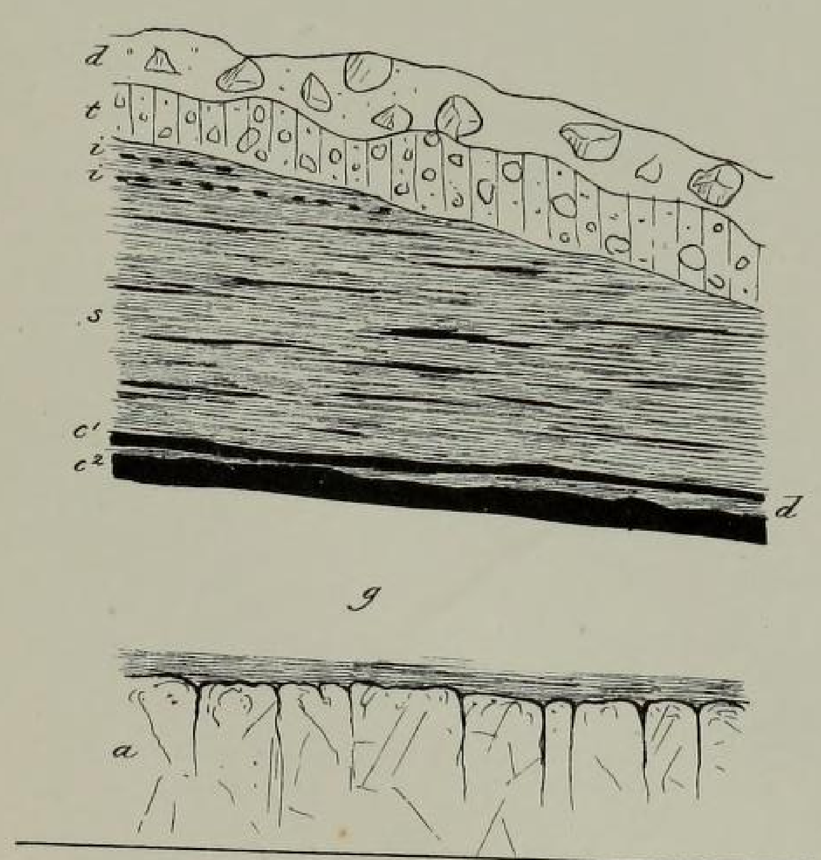

Fig. 5.

Fig. 6.

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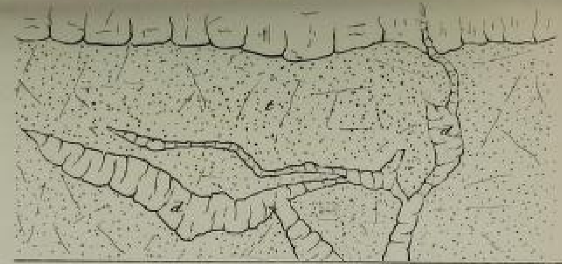
Fig. 9.



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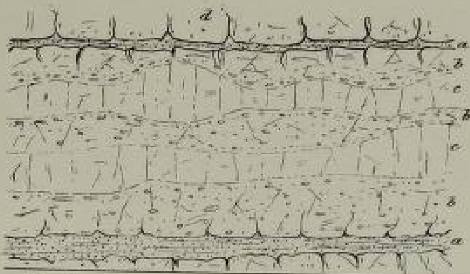

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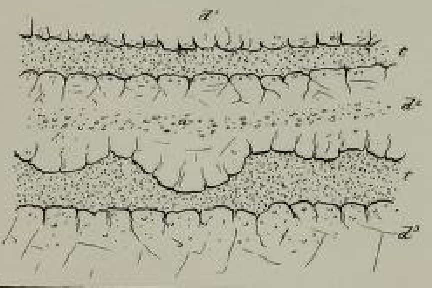

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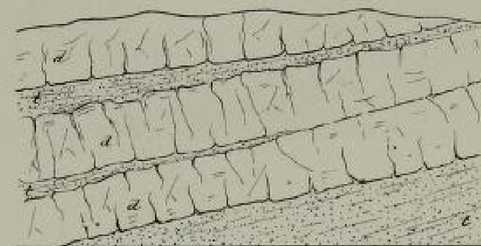

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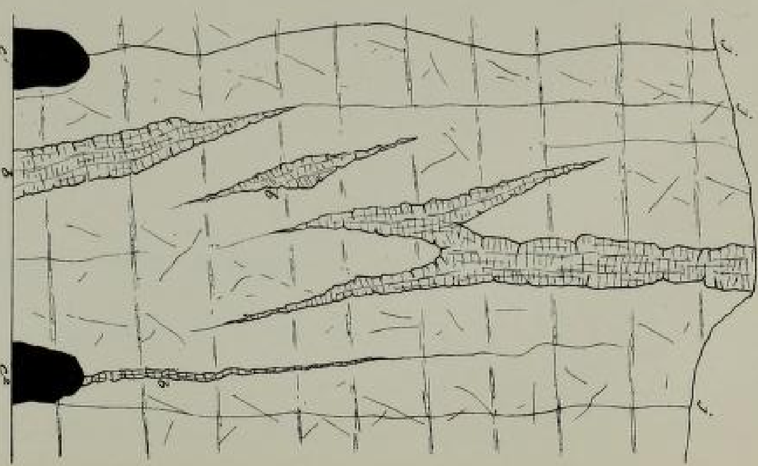

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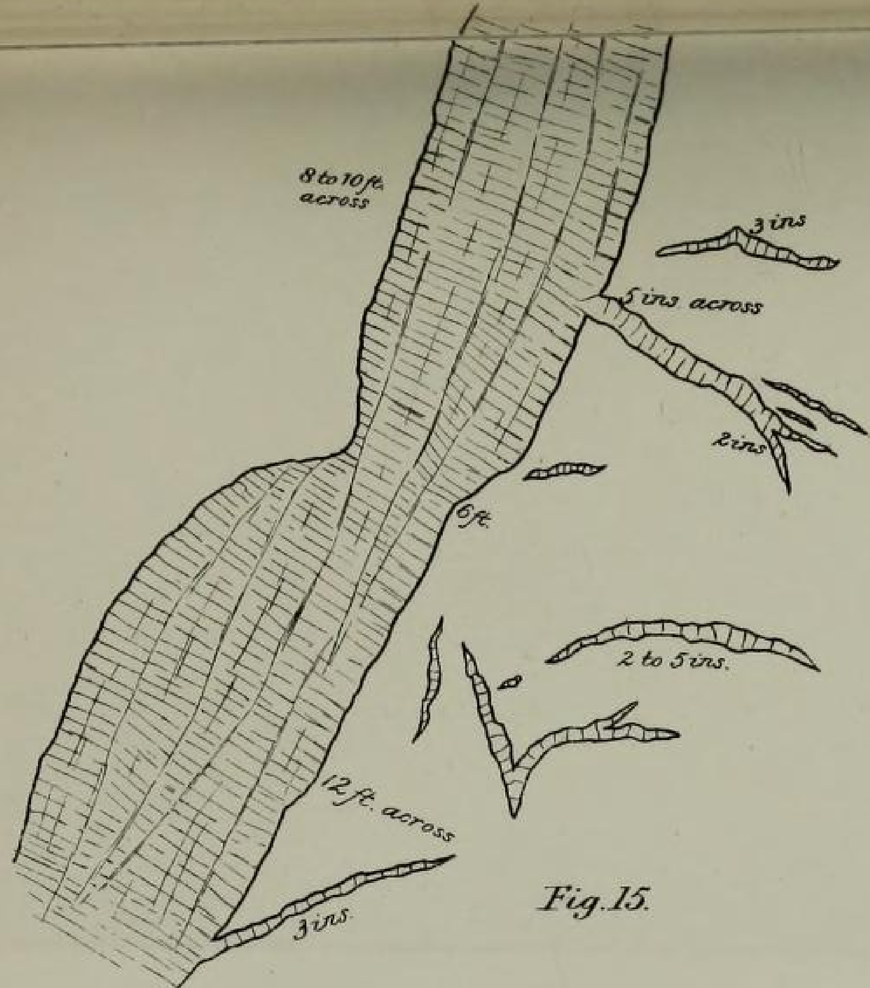

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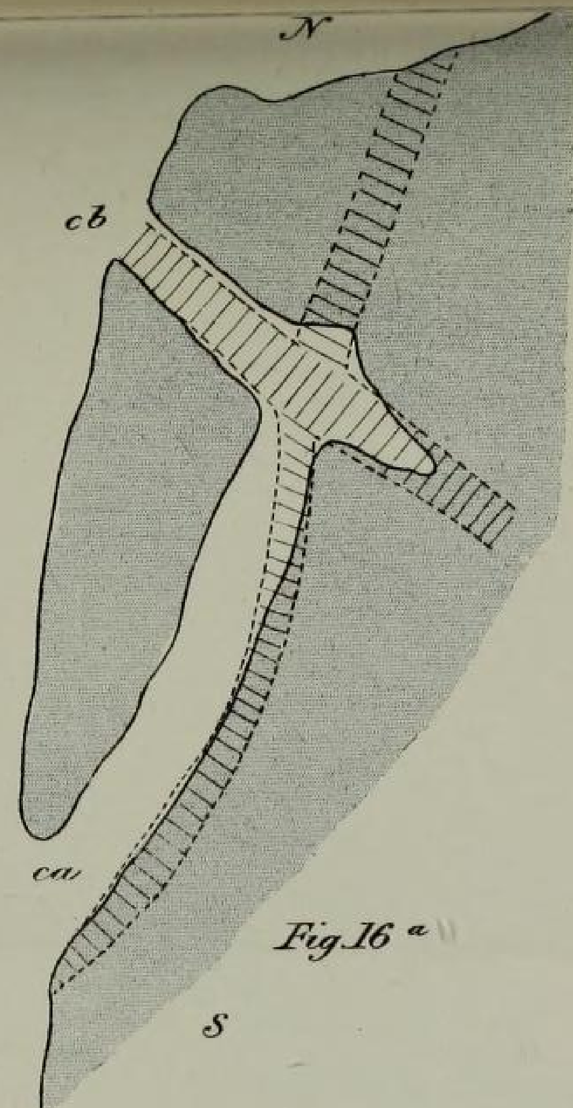
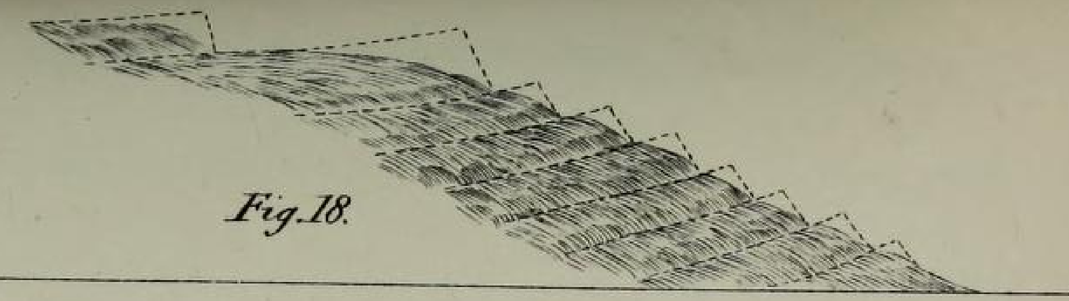


Fig. 16 a



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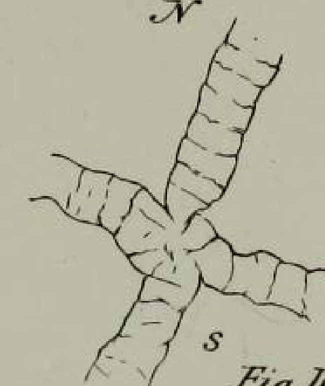

Fig. 16 b

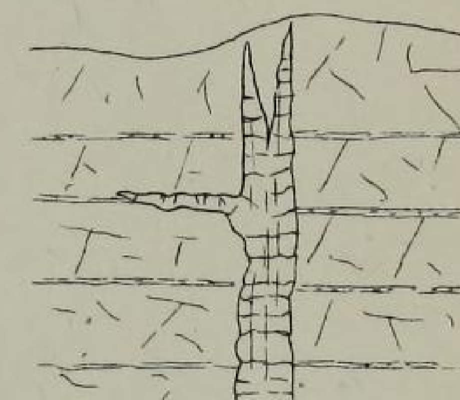

Fig. 17.

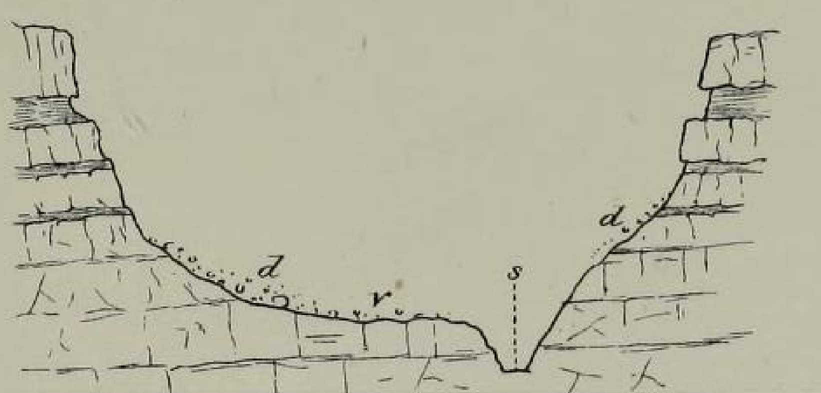

Fig. 22.

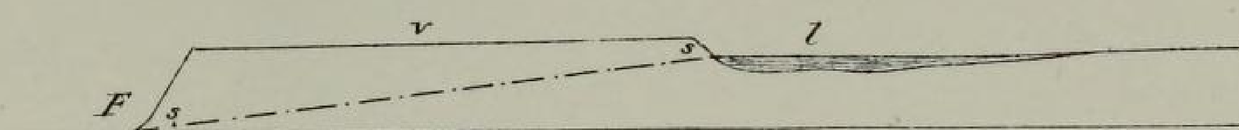

Fig. 21.

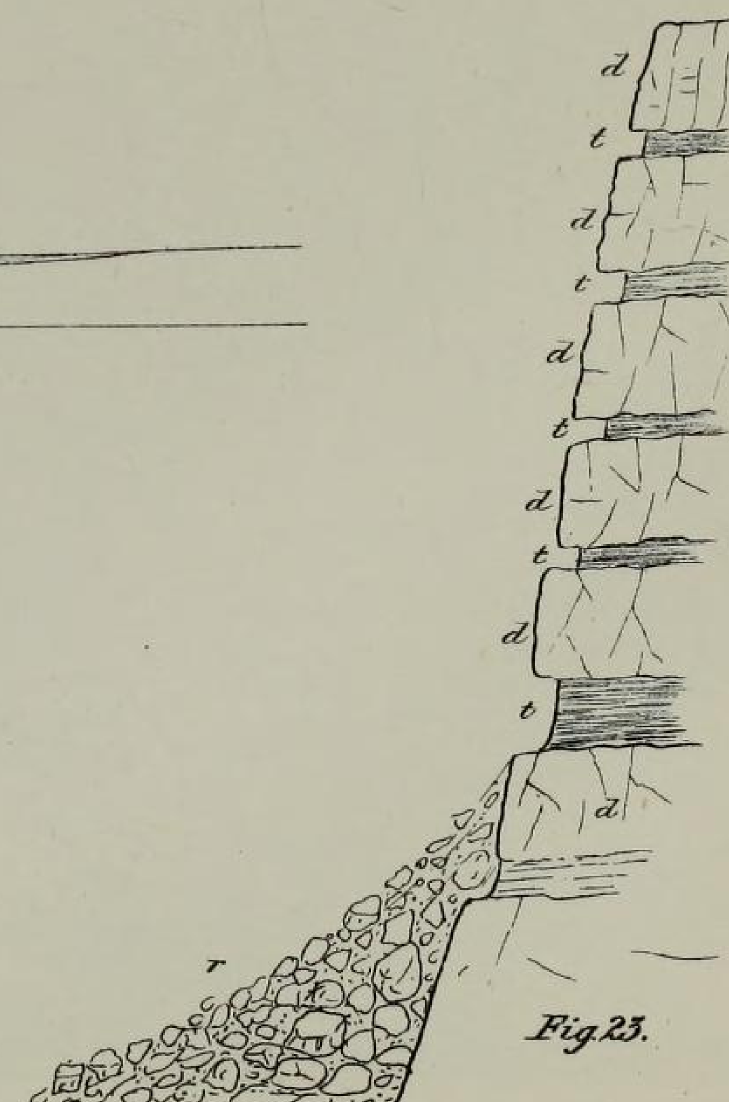

Fig. 23.

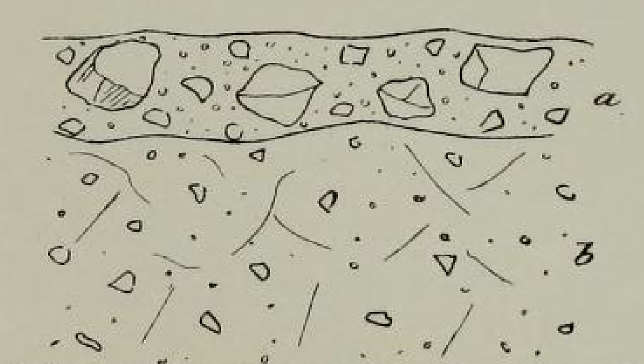

Fig. 20.

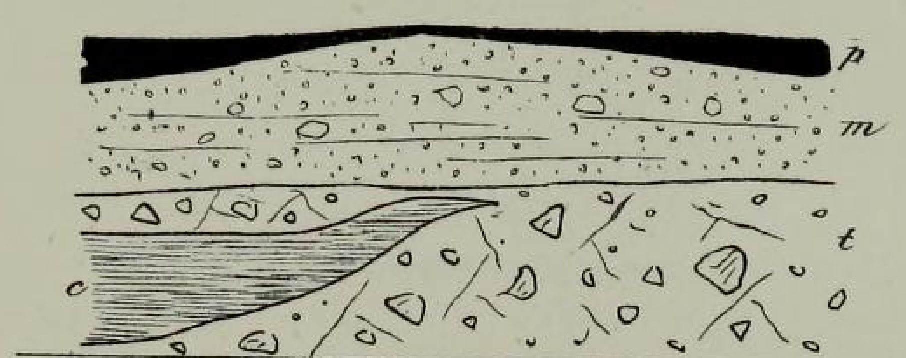

Fig. 19.


MAP OF THE
FÆRÖE ISLANDS
Reduced from the
KAART
OVER
FÆRÖERNE
TRIGONOMETR.SK OPMAALET AF CAPITAINE BORN
udgivet fra
Det Kongelige Söe Kaarte Archiv
1806
British Statute Miles
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To Geological Colours and Signs.
Basalt-rocks & Tuffs above Coal.
Basalt-rocks & Tuffs below Coal.
Intrusive Basalt
Dip of Strata
Crop of Coal
Direction of Glacial Striæ
Direction of Roches moutonnées.
KALSÖE
WIDERÖE
FUGLÖE
SVINÖE
MYGGENÆS
THORSHAVN
NAALSÖE
KOLTER
HESTÖE
Skaapenfiord
SKUÖE
STORE DIMON
LILLE DIMON
Suderöefiord
Qvalboe Fiord
Waags Fiord
Longitude West From Greenwich