

Explorations in Iceland during the Years 1881-98

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tetrahedral, or tetrahedroid, deformation, are sufficient to produce the effects that Dr. Gregory has described.

The PRESIDENT: I think we shall all be agreed that this difficult subject, about which so few people seem inclined to give an opinion, has been set before us in a very clear and graphic manner and with great ability by our friend Dr. Gregory. I am sure you will all be ready to pass a vote of thanks for his most interesting paper. Although we are now almost for the first time realizing that the shape of the Earth is not what it is said to be in the text-books, we may remember that the first person who supported the theory that the Earth was the shape of a peg-top or a pear was Christopher Columbus, although he did not put the pointed end of the pear at the south pole, but near the region where the Venezuelan arbitration is going to take place. I now wish to ask you to pass a cordial vote of thanks to Dr. Gregory for his paper.

EXPLORATIONS IN ICELAND DURING THE YEARS 1881-98.*

By Dr. TH. THORODDSEN.

WHEN I was asked to write a brief account of my explorations in Iceland, together with a *résumé* of the geography of the island, I felt that in complying with the request I was undertaking a task which was anything but easy of fulfilment. To compress the results of seventeen years of observation and study into the compass of a short article is to lay one's self open to the charge of being superficial or sketchy, dry or dull. I therefore crave at the outset the reader's indulgence for merely touching upon several topics which, if only they could be treated at greater length, would almost certainly gain in clearness. For the sake of such as take an interest in the geography of Iceland, I will cite, in a series of footnotes, the sources which contain the accounts of my various investigations and journeys throughout the island. As those papers likewise give full information about both the geographical and geological investigations of other authorities, I trust that this present paper, although short, will serve as a sort of key to all that has been done in the field of Icelandic exploration. My own labours are scattered through many different periodical publications, some of them not readily accessible. Unfortunately, I have not hitherto been able to command the time to gather up my results into works of a more ambitious character. It will require several years for me to digest and work out properly the vast amount of scientific material of every kind which I have collected in the course of my journeys. I trust, therefore, I shall not be considered presumptuous if in this article I make bold to refer to those portions of my labours which I have been able to place on record in this or the other publication.

* Translated by J. T. Bealby, B.A. A new map of Iceland, from data supplied by Dr. Thoroddsen, will accompany the second instalment of this paper.

Although Iceland lies comparatively close to Europe, and although it possesses natural features which are in many respects remarkable, it cannot be said that the island is at all well known, certain relatively small portions of it alone excepted. Merely a fractional part has been visited by scientific inquirers. The majority of the visitors to Iceland follow the beaten tracks through the more accessible districts. Very few have enjoyed either time or opportunity to penetrate into the uninhabited and desolate interior. And there are many of the more inaccessible parts of the coast quite as much unvisited as the central region.

That Iceland has never previously been thoroughly examined is due to a variety of causes—its vast extent, its peculiar physical features, the sparse population, the unfavourable climatic conditions, the limited portion of the year during which it is possible to carry on investigations.

The uninhabited interior of the island, constituting more than one-half of the entire area, lies at an elevation of 1500 to 3000 feet above the level of the sea. The surface is covered by lavas, rocky *débris*, drift sand, and jökler, or ice-mountains. At such an altitude, so near the polar regions, the climate must necessarily be harsh. Vegetation is extremely scanty; for many miles on end there is not a blade of grass for a horse to pluck. It is also very difficult travelling in certain of the remoter portions of the coast, owing to its stern and rugged character. On the other hand, it is the easiest thing in the world to travel through the relatively thickly peopled districts of the south and the north; both are, in fact, visited every year by a respectable number of tourists.

Before we could say that this island was tolerably familiar to us two things were essentially necessary; first, a systematic geographical examination of the uninhabited interior; secondly, a geological reconnaissance of the entire island. It is true that several distinguished geologists have at different times visited Iceland, and published admirable accounts of what they have seen and observed; it is also true that certain particular districts have been examined again and again. Nevertheless, these inquirers have seldom spent more than a short time in the island, and consequently have gone away leaving vast stretches of it altogether unexplored. We possessed no general description of the geological structure of the island as a whole; nor, indeed, could we possess such, seeing that upon four-fifths of its surface no trained geologist had ever set foot. What was needed, then, was a general view of the physical geography and geological history of Iceland.

In the year 1881, I conceived the idea of trying to fill up piece by piece some of the biggest gaps in our knowledge of the geography and geology of Iceland. Considering the extremely modest resources I had at my command, I could scarcely hope to examine the entire island. The task I set myself was to go systematically to work, and, instead of

making a hasty survey of a large area, to confine myself to relatively narrow districts, examining one or more every year as thoroughly as I was able. By adopting this plan, I hoped, with patience, to gain a tolerably accurate knowledge of some of the less-known quarters of the island; and, time and opportunity favouring me, I might possibly go on, and in this way gradually lay the foundations for a general survey of the whole country.

The first nine years I was sadly hampered through lack of means; but as time went on, this hindrance was gradually removed. First, the Icelandic Althing made me a grant. After that the Danish Rigsdag and two private gentlemen—Mr. Oscar Dickson, of Gothenburg, and



DR. THORODDSEN AND MR. SIGURDSSON STARTING.

Mr. A. Gamél, of Copenhagen—generously provided me with the means to procure a better equipment; so that I was enabled to continue my work under much more favourable conditions than before. Thanks to this valuable support, I succeeded, during the years 1881-98, in travelling over and exploring the entire island.

My first object was to acquire a pretty accurate knowledge of the interior of the island. The coast was surveyed during the first nineteen years of the nineteenth century by various Danish and Norwegian naval officers. In the years 1831-43 Björn Gunnlögsson surveyed the inhabited districts, as well as took a few trips into the interior. The map of Iceland which he drew up, in four sheets, was an excellent piece of work; but the interior of the island, which was very little known, was laid down from mere observation and the reports of shepherds and others. Indeed, of the area represented on Gunnlögsson's map, some

17,500 square miles, representing the interior, had never been subjected to scientific examination, and certain other regions (including 3500 square miles of the ice-mountains) had never been trodden by human foot.

Amongst the latter I may especially mention a portion of Ódádahraun, the desert regions north-east of Fiskivötn, besides a few other places scattered up and down the island. The sources of several of the larger streams had never been seen, and the situation of some of the large groups of lakes was uncertain. My first immediate object then was to obtain a general and reliable view of the topography. At the same time there were also a number of geographical and geological questions urgently demanding solution. I intended, amongst other things, to collect materials for a geological map, on which I hoped to indicate with tolerable accuracy the extent of the several formations and species of rocks; in the next place, to attempt to trace out the broad lines of the structural history of the island; to examine and map the volcanoes and lava-streams, to study the history of the volcanic eruptions, as well as the origin, distribution, and geological relations of the warm springs, solfataras, and earth-tremors. In addition to these objects, it would also be desirable to make observations upon the modern glaciers, the altitude of their snow-line, their glacial changes and formations, the glacial scratchings, the marine deposits, marine terraces, and so forth. When I embarked upon this enterprise, I fully realized the magnitude of the task I was setting myself. I knew full well how audacious it was for a single private individual, with such limited resources as I possessed, to attempt the exploration of a country stretching over an area of 40,450 square miles, possessing an arctic climate, and being in many parts extremely difficult of access. But I took courage from the Horatian maxim—

“Est quadam prodire tenus, si non datur ultra,”

and counted upon the friendly consideration of my scientific colleagues over sea to extend to me that indulgence which is one of the brightest features of the modern scientific world. In a word, I hoped that generous allowance would be made for the difficult circumstances under which I worked. Iceland is destitute of scientific institutions and laboratories. For many years I never had opportunity to exchange a word with anyone who had an interest in geology. I am, therefore, all the more deeply grateful to those men of science in both America and Europe who have encouraged me by letters and helped me with presents of books.

Before beginning my real work of exploration, I deemed it essential to make myself familiar with the labours of my predecessors, and with all that had been written about my native island. There exist a good many books about Iceland, written in both ancient and modern times, besides a number of separate papers, scattered through Icelandic, Scandinavian, and other periodicals. These, of course, vary greatly in

value. In addition to these printed sources, there also exist in Icelandic and Danish libraries a large number of little-known manuscripts, containing a good deal of information about matters of interest relating to Icelandic geography, national life, and means of subsistence in ancient times and in modern. I have made it my duty to unearth all these sources whilst carrying on my own investigations. But seeing how vast is the material, and how widely different its constituents are in character and value, as well as how extraordinarily inaccessible a good deal of it is to ordinary inquirers, I have deemed it advisable, in the interests of future students and investigators into the geography and *kultur-historie* (social history) of Iceland, to gather them up into one collective publication,* which is now in process of being published in Icelandic and German.

I will first enumerate briefly the several exploring journeys which I made through Iceland during the period already mentioned, referring to the accounts of them published in divers periodicals.

As I have already remarked more than once, my first object was to explore the interior. Now, as the interior consists for the greater part of deserts, lava-fields, and glaciers, and as it is almost entirely destitute of vegetation, exploring trips in that direction obviously demand both time and patience,† as well as a good equipment of tents, provisions, horses, instruments, and so forth. Most of the earlier attempts to explore the most difficult parts of the interior failed from want of grass for the horses. To carry sufficient fodder to last over a prolonged stay in the high-lying desert regions is an absolute impossibility. The large expedition which was sent out in 1840, under the leadership of T. C. Schythe, in order to explore the southern part of Odáðahraun, was unsuccessful from that very cause—want of grass, coupled with snowstorms. Nearly all the horses died, whilst the members of the expedition barely struggled back to the inhabited districts alive.‡ Others which followed had no better fortune. With the view of avoiding a failure from the same cause, I went to work on a plan which had not previously been attempted. I never carried hay with me from the settled districts. Scattered round the outer border of the interior plateau there are a few small oases yielding scanty supplies of grass. These are known to certain shepherds and others, who in autumn have had occasion to follow straying sheep into the desert wilds, and I got them to tell me where these spots were situated. The knowledge thus obtained proved

* ‘*Landfræðissaga Islands*’ (Reykjavik and Copenhagen, 1892-98). ‘*Geschichte der isländischen Geographie*,’ German translation by Aug. Gebhardt (Leipzig, 1897-98). Two volumes are already published. The third and last volume is not yet printed.

† “Icelandic exploration is ‘chancy’ as Central African, and the traveller must expect to be the sport of circumstances far beyond his control, unless, at least, he can afford unlimited time” (Richard F. Burton, ‘*Ultima Thule*,’ vol. ii. p. 325).

‡ *Kröyers Naturhistorisk Tidsskrift*, iii., 1841, pp. 331-394.

extremely useful to me in my expeditions. Although frequently not greater than a few score chains square, these patches of grass served for camping-grounds, and temporary centres from which to make flying excursions to this or the other point of interest in the immediate vicinity. I used to take a scythe and rake with me, mow the grass, pack it into sacks, and in that way carry it as food for the horses whilst journeying from one oasis to another. As a rule, the desert wastes between the oases could be traversed in from two to three days. My equipment was in nearly all respects typically Icelandic, although during the first nine years, owing to lack of pecuniary means, extremely primitive and inadequate. I and my attendants lived upon the plain ordinary food of the Icelandic peasant. During our tent life in the interior we drank large quantities of coffee, but no alcoholic liquors. Surveying in the interior of Iceland is wont to be frequently interrupted by bad weather—rain, fogs, storms of sand and snow. Owing to fog, I often had to ascend the same mountain several times before I was able to get a proper observation for measurement. In fact, the principal *desiderata* for successful exploration work in the interior of Iceland are a thoroughly good equipment and an unlimited stock of patience.

In the year 1876, I took part in Prof. Johnstrup's expedition to the northern parts of the island, to study the volcanoes at Mývatn and the volcano of Askja. My own independent investigations I began five years later, in 1881, when I made a hurried journey obliquely across the island, working in with it trips to the south-west corner, where I studied the volcanoes and warm springs near Celfus and Thingvallavatn.* I made my first long exploring journey in the summer of 1882, and with it began the execution of my plan, my former expeditions having partaken more of the nature of trial trips.† That year I went from Akureyri to Mývatn, and thence to the fjord districts of Eastern Iceland; besides which I made two or three excursions into the interior—for example, to the east side of Hofsjökull, which no traveller had previously visited. Amongst other work which I accomplished on that journey, I investigated the well-known "double spar" quarry at Reydarfjord, in the vicinity of Helgustadir, mapping it and taking drawings of it in profile.‡ But the year 1882 was for several reasons unfavourable for travel. The whole of the north coast was blocked by the Greenland drift-ice until the very end of August. The summer was so cold that

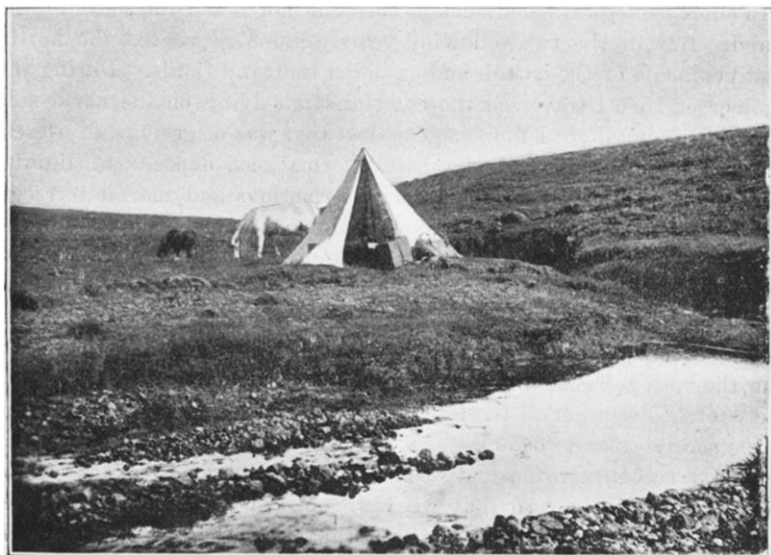
* Th. Thoroddsen, "En Udflugt i det sydvestlige Island," in *Geografisk Tidsskrift*, vi. pp. 135-139.

† Th. Thoroddsen, "En Undersøgelse 1882 i det østlige Island," in *Geogr. Tidsskrift*, vii. pp. 95-112, 129-140. Translated into German in *Die Natur*, 31ten Jahrgang (Halle, 1885); *Petermanns Mittheilungen*, 1884, pp. 422-426; *Andvari*, ix. pp. 17-96.

‡ Th. Thoroddsen, "Nogle Bemærkninger om de islandske Findesteder for Dobbelspath," in *Geol. Fören. Förhandl.* (Stockholm), xii. pp. 247-254. German translation in *Himmel und Erde* (Berlin, 1891), iii. pp. 182-187.

very little grass grew, and some of my horses broke down. In addition to these drawbacks, the entire island was ravaged by an epidemic of measles, which carried off nearly two thousand people. Wherever I went there were sick folk, so that but little assistance was to be procured. Before the end of the journey my own men fell ill, and I was obliged to bring my summer's work to an abrupt termination.

In the summer of 1883 I explored the peninsula of Reykjanes. Although lying so near to Reykjavik, the greater portion of this remarkable volcanic peninsula had never been visited by a geologist. Except for a few fishing-stations along the coast, it is almost entirely



DR. THORODDSEN'S TENT.

buried under lava, an uninhabited and barren waste. Although it was no easy matter to use horses in that region, owing to the uneven surface of the lava and the numerous rents in the ground, I nevertheless managed to cross it backwards and forwards sufficiently to examine its remarkable geological conditions. I counted some thirty volcanoes, with over seven hundred craters of different sizes, as well as a great number of volcanic fissures, out of which the lava had flowed. I estimated that the lavas thus ejected covered an area of 730 square miles.*

The following summer I spent the time at my disposal in investigating the vast lava desert of Odádhraun and the adjacent parts of the

* "Vulkanerne paa Reykjanes i Island," in *Geol. Fören. Förhandl.* (Stockholm), vii. pp. 148-177; *Andvari*, x. pp. 1-76; *Globus*, vol. lxix.

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interior plateau, ranging at altitudes of 1500 to 3000 feet above the level of the sea. The country was difficult to travel through; besides which we had to contend against a deficiency of grass, glacier streams so swollen as to be actually dangerous, and unfavourable weather. In spite of these obstacles, I was successful in ascending the greater part of the mountains, in crossing the desert backwards and forwards, both on horseback and on foot, and in covering it with a network of trigonometrical triangles drawn from mountain to mountain.* That same year I made a trip to the little island of Grimsey, lying off the north coast,† immediately above the arctic circle.

In the year 1885 I undertook no long journey, but contented myself with short geological excursions in both the north and the south of the island. But in the two following years, 1886-87, I visited the north-west peninsula of the island, and explored its many fjords. During the summer of 1886 I traversed the coast districts lying on the north side of Breidifjörðr, where I found a good deal that was of geological interest—well-marked profiles of the basalt formations, deposits of lignite, petrified vegetation, as well as glacial formations and marine terraces. In August of that same year I travelled along the north-east coast of the peninsula, through the so-called Hornstrandir, as far as Cape North (the Horn). The southern portion of that coast had not been visited since the year 1754, when it was traversed by E. Olafsson; the northern portion had never been visited by any traveller. My journey along that coast was the most toilsome of any I have ever undertaken in Iceland. We had wretched weather all the time. The drift-ice had penetrated close in to the shore. The fjords and glens were shrouded in the cold fogs which generally accompany the drift-ice. All August it snowed and rained without intermission; so that we were obliged to quit the tent, and take refuge in the miserable huts of the peasantry. We used up all the provisions we had brought with us, and for several weeks had to live upon half-decayed sea-fowl, shark's flesh, and such like delicacies of the native inhabitants of the region. When we stumbled upon an occasional bowl of porridge, it came as a veritable feast. We got wet through every day, and had no opportunity to dry our clothes. No wonder, then, that we looked thin and wretched when we returned home.

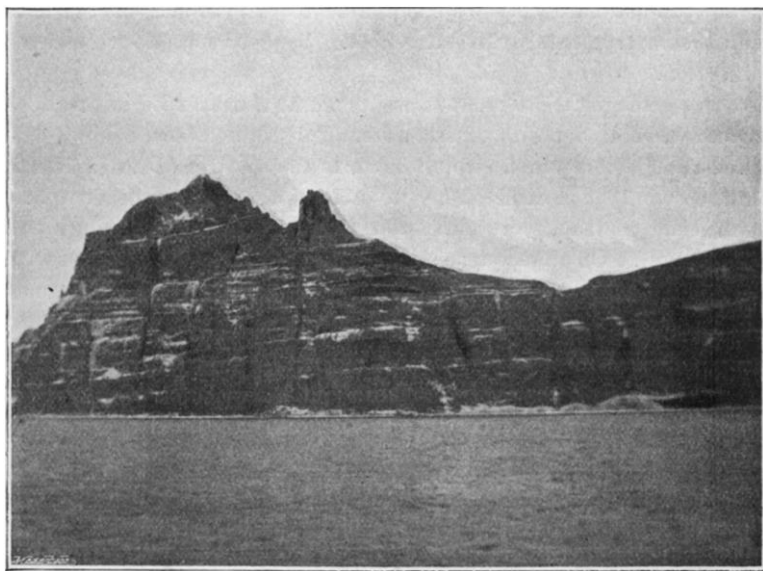
The inhabitants of those parts of the coast dwell at vast distances apart. The mountain spurs which divide fjord from fjord are lofty, narrow, and very steep, and to climb up and down them entailed severe labour upon both horses and men. In many places the only means of getting up is along mere ribbons of footpath, that wind up the faces

* "Eine Lavawüste im Innern Islands," in *Petermanns Mittheilungen*, 1885, pp. 285-294, 327-339, with map; *Globus*, vol. xlvii. pp. 183-188; *Nature*, vol. xxx. Nos. 780, 781, and vol. xxxi. No. 791. *Andvari*, xi. pp. 20-108; xii. pp. 125-161, with a map.

† *Nature*, vol. xxx. No. 770.

of the precipices, and demand the utmost caution in moving along them, whilst the surf rolls in with a thundering roar several hundred feet below. At other times the horses had to scramble over slippery blocks of stone down on the very edge of the sea, both horses and men constantly drenched by the bursting waves. At the most dangerous places we were obliged to unload the horses and carry their loads on our own backs, whilst the horses were led across one by one after us. In the valleys it rained without ceasing. On the tops of the mountains it snowed so heavily, that the snow often lay knee-deep, and the horses kept sticking fast in the snow-drifts.

The people who inhabit those tracts have a terribly hard struggle to



CAPE HORN.

live. During one-half of the year the drift-ice lies wedged up against the coast, or drifts close to it. So much of the summer's warmth is consumed in melting the ice, that it is always cold and raw during that season, and nearly always excessively damp. For this reason the people experience very great difficulty in drying the small quantity of hay they require for their few domestic animals. Their principal means of subsistence is wild-fowling, a dangerous occupation, frequently costing human lives. It would scarcely be possible to conceive anything more lonely and desolate than a cottage on the Hornstrandir. The wretched hut clings like an eyrie to the face of the steep sea-cliffs, several hundred fathoms above the water. No stranger ever shows his face within sight of it. Often the nearest neighbour lives an entire day's

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journey distant. The inhabitants are almost entirely ignorant of what goes on in the world, for it is extremely seldom that an odd number of an Icelandic newspaper finds its way into those remote regions.*

I devoted the summer of 1887 to the exploration of the north-west fjords of the same peninsula. Travel on that side of the peninsula is beset with well-nigh the same difficulties as on the east side, especially towards the northern extremity, round about Adalvík, west from Cape North. In that part we were unable to take our horses, but were obliged to make our way entirely on foot. That summer those remote northern districts were suffering from famine, and a malignant form of typhus and scurvy. In the widely separated and poverty-stricken huts, where we spent the nights, there was scarcely any food to be had; and unfortunately we were not able to carry much else with us beyond the instruments we needed most. By good fortune we escaped the infection.

To the geologist that coast presents many features of interest. I discovered several deposits of *surtarbrand*, or lignite (see below), and explored the glaciers which stretch down to the sea from Drangajökull.†

In the year 1888, I directed my investigations to the southern parts of the interior plateau, more particularly the tracts around Langjökull and Hofsjökull. On that journey I was for the most part favoured with fine weather, and in the districts which I visited there were adequate supplies of grass. My first excursion was to the so-called Thjórsárdalur, where the ruins of twenty homesteads remain as melancholy witnesses of a destructive volcanic outburst in the fourteenth century. Here too there was much to interest a geologist. Thence we travelled beside the Hvítá (White river), up into the interior, where I spent several weeks, for I soon perceived that the existing maps of the districts I was visiting needed considerable revision. Whilst examining the liparite mountains of Kerlingarfjöll, I had the good fortune to discover some exceptionally fine solfataras—in fact, the finest in all Iceland.‡ I also explored the glaciers around Lake Hvítárvatn, the lava-fields of Kjalhraun, and the warm springs at Hveravellir. I made my way home by the north and west roads, and was so fortunate as to discover some hitherto unknown places with fossil plants.§

The next year, 1889, I explored the portion of the interior which was least known, namely, the tracts west of Vatnajökull, including the

* "Fra Islands nordvestlige Halvö," in *Geog. Tidsskrift*, ix. pp. 31-50; *Andvari*, xii. pp. 99-203. "Eine Reise nach Nordkap in Island," in *Petermanns Mitteilungen*, 1888, pp. 113-120; *Das Ausland*, 1887, pp. 181-186.

† "Fra Vestfjordene i Island," in *Geog. Tidsskrift*, ix. pp. 149-168; *Andvari*, x. pp. 46-93.

‡ 'Neue Solfataræen und Schlammvulkane in Island,' in *Das Ausland*, 1889, pp. 161-164.

§ "En Reise gjennem det indre Island i Sommeren, 1888," in *Geog. Tidsskrift*, x. pp. 10-29; *Petermanns Mitteilungen*, 1892, pp. 25-31; *Andvari*, xv. pp. 56-119.

lakes which bear the name Fiskivötn. In that journey I travelled over long distances which had never before been trodden by human foot. Before visiting them, I believed that the lakes of Fiskivötn, like other similar groups in the interior of Iceland, were of glacial origin—depressions lying between ancient moraine ridges. I was, therefore, not a little surprised to discover that the greater part of them were crater lakes, and that they lay ensconced among a large cluster of volcanoes with extensive lava-fields, forming a link of connection between the volcanic regions of the south and the north of the island. To the north and east of these lakes there was nothing but deserts of sand and lava, utterly destitute of vegetation. We had to carry with us every blade of fodder we needed for the horses. I made several long excursions through those deserts, visiting, amongst other places, Lake Thorisvatn, which I found to be a little over 25 square miles in extent. In the course of another excursion I touched Vatnajökull, discovered the sources of the (river) Tungná, and also a long narrow lake, to which I gave the name of Langisjór (Long lake). On my return journey I came across some extremely interesting currents of obsidian lava.*

The exploration of the peninsula of Snæfellsnes and the districts at the head of Faxaflói claimed my attention in 1890. There was plenty of scope for geological work. I opened up several fresh fields, discovering, amongst other things, some new beds of liparite, extensive deposits of *nagelfluh*, numerous groups of craters which had never previously been examined by any geologist, warm springs, carbonic acid springs, and similar features.† The summer of the following year was occupied with short excursions to the west side of the island, more especially to the neighbourhood of Borgarfjörður, where I completed certain investigations which I began in 1890; for instance, observations of warm springs and different glacial deposits and rock-striations.

In 1892 I did no exploring work in Iceland. An illness compelled me to go abroad for the summer. The rest and change, however, restored me to good health.

Next year I worked the county of Vester Skaptafell and the little-known parts of the interior plateau which fringe the south-west slopes of Vatnajökull. Travelling was anything but easy in that quarter, because of the great irregularities of surface of the lava-streams, the broken and rifted character of the mountain ridges, the want of grass, and the drift-sand. In spite of these drawbacks I was successful in penetrating to the sources of the two streams—the Skaptá and the

* “Fra Islands indre Højland,” in *Geog. Tidsskrift*, xx. pp. 149-179, with a map; *Petermanns Mittheilungen*, 1892, pp. 189-196, with a map; *Andvari*, xvi. pp. 46-115.

† “Snæfellsnes i Island,” in *Ymer* (Stockholm, 1890), pp. 144-188. “Geologiske Iagttagelser paa Snæfellsnes og i Omegnen af Faxeflugten i Island,” a supplement to *K. Svensk. Vetenskaps Akademiens Handlingar*, 1891, vol. xvii. II. No. 2, 96 pp., with map and illustrations; *Andvari*, xvii. pp. 27-118.

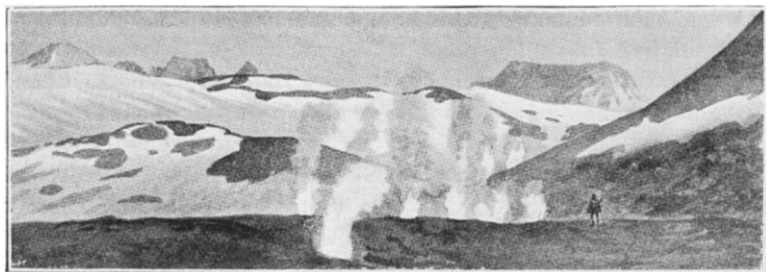
Hverfisfjót, which had never previously been visited. I also was the first explorer to examine the mountainous country north of Fljótshverfi. All these districts, and especially the stretch of country between the Tungná and the Skaptá, are amongst the most interesting in Iceland. I investigated the border glaciers of Mýrdalsjökull and the western side of Vatnajökull, and discovered thirteen hitherto unknown glaciers, as well as took the altitudes of the snow-line and of the edges of the glaciers in many places. But the features of greatest interest were the volcanoes. Amongst other notable discoveries I made in that quarter was a gigantic volcanic fissure (Eldgjá), which ran to a length of nearly 20 miles, with a depth of 400 to 650 feet. This fissure has in three different places ejected streams of lava, which now cover a combined area of 268 square miles. Later on in the summer I explored the chain of craters at Laki, amounting to about one hundred in number. They were the scene of a violent eruption in 1783, which left behind it a lava-stream 220 square miles in extent, and having a volume equal to a cube measuring 3 miles along each of its sides. These gigantic outflows of lava have occasioned great changes in the appearance of the country, altering the coast-line and the channels of the rivers. I made a close study of the geological development of this part of Iceland, and embodied the results in a series of maps.*

The summer of 1894 was devoted to an examination of the southern flank of Vatnajökull and that part of the plateau which borders upon the north-east side of the same glacier tract, as well as a portion of the northerly fjords on the east side of the island. For the most part the mountains in the latter region consist of basalt, but there are also a good many dykes of liparite and granophyr. I discovered close upon fifty new deposits of these eruptive rocks. At Lón I studied the gabbro mountains and their relations to other species of rocks. The only places in Iceland where gabbro occurs are the districts adjacent to the south-east corner of Vatnajökull. A great number of large glaciers radiate from the southern flank of Vatnajökull, and the narrow sandy belt of coast between the mountain and the sea is traversed by numerous rivers, conveying considerable volumes of water. I studied the physical conditions of the glaciers, and found that some of them have sensibly increased in dimensions within historic times, as well as moved nearer down to the sea. On the plateau to the north-east of Vatnajökull I investigated other glaciers, as well as discovered some new lakes and surveyed certain of the less-known districts.†

* "Reise i Vesterskaptafells Syssel paa Island i Sommeren 1893," in *Geogr. Tidsskrift*, xii. pp. 167-234, with a map and illustrations; *Andvari*, xix. pp. 44-61; *Verhandl. d. Gesellsch. f. Erdkunde zu Berlin*, 1894, pp. 289-295.

† "Fra det sydøstlige Island," in *Geogr. Tidsskrift*, xiii. pp. 3-37, with a map; *Andvari*, xx. pp. 1-83, xxi. pp. 1-33; *Verhandl. d. Gesellsch. f. Erdkunde zu Berlin*, 1895, pp. 185-192; *Petermanns Mittheilungen*, 1895, pp. 288-290.

In the following summer I bent my steps towards the extreme north-east of the island, the peninsulas of Melrakkaslétta and Langanes, and the portions of the plateau which lie immediately behind them. These districts had never previously been surveyed; and they revealed several features of geological importance. For instance, I ascertained that the more recent volcanic formations of Iceland extend very much further to the east than had hitherto been supposed. Here again I discovered and measured some new volcanoes and lava-streams. In the interior I found several chains of tuff hills, as well as rivers and lakes, which had never been shown on any map. Towards the end of that summer's journey I fell ill of typhus, and had to stay some time in a peasant's house. By the time I had recovered and got back my normal strength, autumn was come, and the snow and frost made it



SOLFATARAS IN KERLINGARFJÖLL.
(After a sketch by Captain D. Bruun.)

impossible to continue my work. However, I had pretty nearly done all I had planned to do that year.*

I next directed my attention, in the summer of 1896, to the northern parts of the island, namely the mountainous peninsulas between Skjálfandi and Húnaflói, and undertook a longer excursion to Arnarfellsjökull (or Hofsjökull), in the interior, for the purpose of exploring districts there which were but little known, including the glaciers. In that quarter the plateau consists for the most part of stony deserts without a vestige of grass, so that we were obliged to carry all the hay for the horses with us.†

In the summer of 1897 I laboured in the southern lowlands of the island, in especial in those districts which were the scene of the violent seismic disturbances of the preceding autumn. My principal object was to gather details that would serve as a basis for a general view of the geology of that region, in the hope that I might thus trace out the

* "Fra det nordvestlige Island," in *Geogr. Tidsskrift*, xiii. pp. 99-122, with a map; *Petermanns Mittheilungen*, 1896, pp. 269-275; *Andvari*, xxii. pp. 17-71.

† "Fra det nordlige Island," in *Geogr. Tidsskrift*, xiv. pp. 7-28, with a map.

cause of the earthquake tremors, and ascertain their connection with the fundamental structure of the island, as also to collect materials for a descriptive account of the disturbance itself. Towards the close of the summer I made an excursion to the north of the island, and travelled through the *sysse*l (county) of Húnavatn, studying its geology, especially its glacial deposits.* In the last summer, 1898, I explored the interior plateau north-west of Langjökull and the mountains behind the Borgarfjörð.

From all this it will be seen that I have pretty well travelled over the whole of Iceland—the interior plateau, the inhabited and cultivated parts, the promontories, peninsulas, and fjords, and I have carried through my original plan of making a geographical and geological reconnaissance of the entire country. But seeing that Iceland possesses so many geological features of exceptional interest, I hope, if life is spared to me, to make further special studies of some of the more interesting regions.

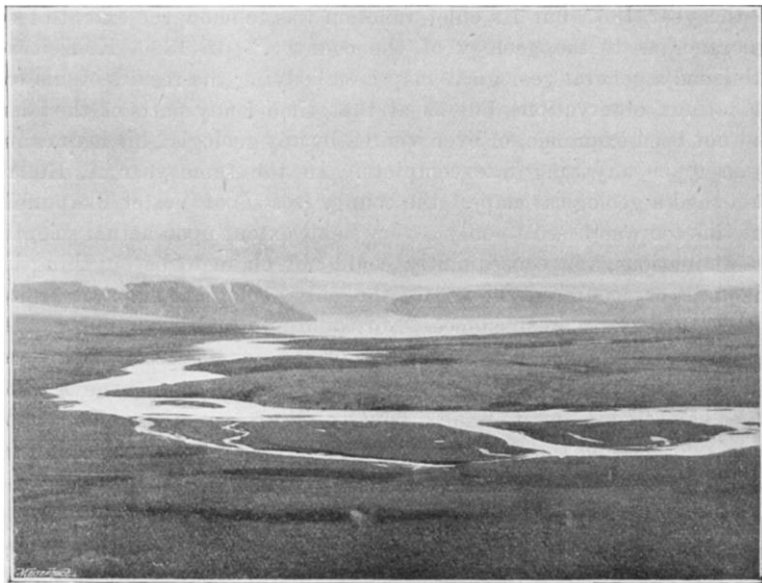
Exploration work in Iceland can only be carried on satisfactorily during the months of June to September. On the plateau you can hardly travel much before July. It is only then that the scanty supplies of grass are available; earlier than that the ground is still soft and wet, owing to the thawing of the snow-wreaths. After the middle of September the weather is as a rule rainy and stormy, at any rate in the southern districts, so that travelling becomes difficult on that account.

During the years 1880-84 I was teaching in the “modern” school (*realskole*) at Mödruvellir, near Akureyri, on the north side of the island, and one of my pupils from there, Ogmundur Sigurdsson, who has accompanied me on most of my subsequent journeys, has been of great service to me. Since the latter year I have held an appointment in the grammar school of Reykjavík. The schools in Iceland are closed for holidays from three to four months every summer; these months I employed in travelling about the island. Then by an economical arrangement and employment of my spare time between and after my daily duties (which occupied from six to seven hours) during the winter, I have found time to write the accounts of my several journeys—my books and articles on the geography and geology of Iceland. The last two years I have been allowed to engage a substitute to do my school work. Icelandic scholars have hitherto devoted their attention almost exclusively to the study of Iceland's past, her language, literature, and history. But during the last few years an interest has been awakened in the natural sciences, and some of our younger

* “Jordskjælv i Islands sydlige Lavland deres geologiske Forhold og Historie,” in *Geogr. Tidsskrift*, xiv., with map; *Société de Géographie de Paris—Comptes Rendus des Séances*, 1897, pp. 330-333.

students have trained themselves in those branches of knowledge at the university of Copenhagen. There is, therefore, every reason to hope that in the future native Icelanders will be able to make contributions towards a thorough knowledge of the physical conditions and phenomena of the island which has given them birth.*

As I have already remarked, one of my principal objects was to sketch a more accurate geographical picture of the plateau regions of the island, based upon surveys of the less known tracts, than we hitherto possessed. The coasts were surveyed in the early part of the nineteenth century, at which time the positions of a number of mountain summits



HVÍTÁRVATN AND HVÍTÁ.

in the vicinity of the coast were trigonometrically determined. These determinations I took as fixed points for my own surveying work. In the interior I linked the more prominent mountain peaks together by means of triangles measured with the theodolite, whilst the details between were filled in by means of the surveying compass. The maps embodying the results of my surveying operations are published in various periodicals.† Up to the present I have, unfortunately, through lack of

* With the view of awakening an interest in the natural sciences in Iceland, I wrote in my mother-tongue, 'Jardfræði' (Geology) (Reykjavik, 1889); 'Lýsing Islands' ('Description of Iceland,' translated by A. Helland) (Christiania, 1883); besides several papers in Icelandic periodicals.

† I may perhaps be permitted to add a list of the sources in which maps, based on my surveys, have up to the present been published. "Odáðahraun," in *Petermanns*

time, had no opportunity to collect and publish them all together, but I hope to do so shortly.

Another important task which I set myself was to determine the heights of as many mountain peaks as possible all over the island. I have measured about eight hundred peaks, but the results in the case of only a relatively small portion of them are as yet published. I hope, however, eventually to make my measurements the groundwork of a hypsometrical map of all Iceland.

A third object was to collect materials for a general geological map of the island. The earliest geological map dealing with Iceland was the map by Paijkull, published on an exceedingly small scale (1:1,920,000) in the year 1867, but its chief function was to show the extent of our ignorance as to the geology of the country.* In 1886, K. Keilhack published a general geological map,† embodying the results of his own and others' observations, but as at that time many parts of the island had not been examined, or even visited by any geologist, his map cannot claim to be anything like complete. In the same year A. Helland published a geological map of the county (*syssel*) of Vester Skaptafell,‡ but this too was based to only a very small extent upon actual scientific determinations, and consequently could not claim to be anything like adequate or accurate. These are the only geological maps of Iceland which there were in existence. Nor could any really reliable maps be made until the whole of the island had been systematically visited and studied, and its geological structure investigated. The journeys I have taken have enabled me to issue gradually one after another some thirteen maps,§ delineating the results of my geological surveys. At the present

Mitteilungen, 1885, plate xiv.; "Fiskivötn and the Neighbourhood," in *Geogr. Tidskrift*, x. plate iii.; "Map of a Portion of the Interior of Iceland," in *Petermanns Mitteil.*, 1892, plate iii.; "The County of Vester Skaptafell," in *Geogr. Tidskr.*, xii. plate ii.; "South-Eastern Iceland," in *Geogr. Tidskr.*, xiii. plate i.; "North-Eastern Iceland," in *Geogr. Tidskr.*, xiii. plate iii.; "A Part of Northern Iceland," in *Geogr. Tidskr.*, xiv. plate i.

* *Svenska Vetenskaps Akademiens Handlingar*, vii. No. 1 (Stockholm, 1867).

† *Zeitschrift d. deutsch. geolog. Gesellsch.*, 1886, plate viii.

‡ *Lokis Kratere og Lavaströme* (Kristiania, 1886).

§ My geological maps include: "South-West Iceland," in *Geolog. Fören. Förhandlingar*, vii. plate v.; "Odáðahraun and Neighbourhood," in *Mitteil. d. k.-k. geogr. Gesellsch. in Wien*, 1891, plate vi.; "Snæfellsnes," in a Supplement to *Kongl. Vetenskaps Akademiens Handlingar*, vol. xvii. II. No. 2, 1891; "The County of Vester Skaptafell," in *Geogr. Tidskr.*, xii. plate ii.; "North-West Iceland," in *Geolog. Fören. Förhandl.* (Stockholm), xviii. plate i.; "A Portion of the Interior," in *Petermanns Mitteil.*, 1892, plate iii.; "South-East Iceland," in *Geogr. Tidskr.*, xiii. plate i., and *Peterm. Mitteil.*, 1895, plate xix.; "North-east Iceland," *Geogr. Tidskr.*, xiii. plate iii., and *Petermanns Mitteil.*, 1896, p. 269; "A Portion of Northern Iceland," in *Geogr. Tidskr.*, xiv. plate i.; "Geolog. Sketch-map of Landmanna-afsjettur," in *Geol. Fören. Förhandl.*, xiii. p. 614; "The Southern Lowlands," in *Geogr. Tidskr.*, xiv. plate iv.; "Direction of Glacial Striations," in *Geogr. Tidskr.*, xi. plate ii.; "Marine Terraces and Marine Deposits," in *Geogr. Tidskr.*, xi. plate vi. In addition to the above, several smaller sketch-maps of limited localities.

time I am engaged upon a map of the whole of the island, which will, I trust, be able to appear in a year or two's time, at the expense of the Carlsberg Institute of Copenhagen.

After this long trial of the reader's patience, I will now pass on to a brief description of the physical geography of Iceland. In such a short *résumé* there are of course many matters of interest which I can only touch upon in the most transitory fashion. I cannot venture to do more than state results, referring for fuller particulars to the articles and works cited under the text. I pass over my observations on the flora and fauna,* together with the inquiries I have made about the national life and the means of subsistence. The notes exist for the most part in manuscripts only; I hope to publish them on another occasion. Our knowledge of the vegetation of Iceland has been greatly increased during the last few years through the investigations of the native Icelanders, S. Stefansson and H. Jonsson, pupils of the well-known botanist, Prof. E. Warming, of Copenhagen. Indeed, the study of the geographical distribution of plant-life in the island dependencies of Denmark—Greenland, Iceland, and the Færoes—has in recent years made great advances, in consequence of Prof. Warming's energy and initiative. To him and his many gifted pupils the domain of arctic vegetation is indebted to a very considerable extent.

Iceland, which has an area of 40,450 square miles, may be broadly described as a plateau land, built up of volcanic rocks of both older and newer formation. Compared with the elevated portions of the island, the lowlands are almost a negligible quantity; they embrace only about one-fourteenth of the entire area. Nevertheless, the districts which possess most importance are the lowlands, the coasts, and the dales. With but few exceptions, they alone contain all the inhabitants of the island. All the rest, by reason of its elevation above the sea, and its climatic conditions, is almost entirely uninhabited. Along the outer borders of the plateau grass grows in summer sufficient to graze some sheep. In the interior there are only a very few patches of grass, at wide intervals apart, where a stunted vegetation grows for about two or two and a half months in the year.

The deep, wide bays of Breidifjord and Húnaflói divide the island into two separate plateaus. The isthmus, which connects the two, the north-west peninsula and the main mass of the island, is only $4\frac{1}{2}$ miles across, and rises to an elevation of 750 feet.

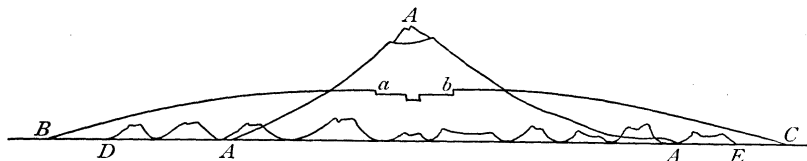
* The phanerogams, mosses, and lichens, which I have collected, are described in several papers by Prof. Chr. Grönlund, in *Botanisk Tidskrift*, and in *Meddelelser fra Naturhistorisk Forening*. (Copenhagen). Dr. Mörch has studied the fresh-water molluscs of my earlier journeys; Dr. H. J. Hansen, the insects I collected on the interior plateau.

Turning our attention first to the smaller or peninsular plateau of the north-west, we may liken its general shape to that of a deeply incised leaf. Deep, narrow fjords penetrate inwards from every direction, but in largest number from the north-west. The area of the peninsula amounts to about 3610 square miles, but the coast-line measures some 1120 miles. The fjords are shut in by dark walls of basalt, which in many places rise perpendicularly, or with a very slight inclination, straight from the sea, to an elevation of 2000 to 2500 feet. The several strata are so disposed as to form a number of steep steps or terraces, mounting up to the verge of the mountains which overtop them, though sometimes they tower upwards like black vertical walls. Their faces are beribboned with torrents, great and small, which tumble down, by waterfalls and cascades, from step to step, till they reach the fjord below. Here the geologist has a splendid opportunity to study the progress and development of the processes of erosion in the many small dales, glens, and clefts, which meet the eye in every direction. If you go up the fjords, and then ascend to the plateau through the glens, you invariably find that glen and fjord form regular constituent parts of the same deep trench cut down through the solid mass of the plateau. Once on the top, you get wide, sweeping horizons, and glens and fjords disappear from sight, or look merely like insignificant crevices. Inland, the prospect consists of a monotonous plateau, strewn with loose fragments of rock, and streaked with immense snow-wreaths. But travelling is difficult, because of the sharp-edged blocks of basalt, the pebbly detritus, and the clay, softened by the thawing of the numerous patches of snow. While the mountain-sides and the bottoms of the glens, close down next the sea, produce grass of tolerable luxuriance, together with heaths and belts of scrub, the only sign of vegetation to be seen on the plateau is an occasional Alpine plant, struggling hard for bare existence in the shelter of the larger boulders. On the highest elevations (2000 to 3000 feet) the snow drifts and consolidates into *firn* pinnacles and domes, e.g. Gláma, in the south-west of the peninsula; Drangajökull, in the north-east. The former of these has an area of not less than 90 square miles, but, so far as is known, possesses no glaciers. The latter, which stretches over 135 square miles, sends off seven glaciers, down as many glens, almost to the margin of the sea. On Drangajökull the climate is colder and damper than on Gláma, and the snow-line runs 800 or more feet lower, namely, at the absolute elevation of 1300 feet.

The geological data prove that this north-western peninsula was formerly larger than it is at the present time. It is, in fact, the last surviving fragment of a gigantic plateau which in Tertiary times extended right across to Greenland. This mass of basalt is built up of several faulted or dislocated segments, the faults or dislocations coinciding with the first cleavages of the larger fjords; erosion has done the rest of the work necessary to give the peninsula its existing contour and

shape.* There are no lowlands, with the exception of a narrow ribbon of strand, due to the action of the surf when the sea had a permanently higher level than it has now. But it is only on these low, narrow shelves of coast that human settlements are found. Their principal dependence is upon the sea. The people make excellent seamen, and carry on with energy, and on a relatively large scale, fishing for cod, especially in Isafjardardjup. In places where the coast strip widens out a little, and the glens produce more grass, as, for instance, along the north side of Breidifjord, the people find their chief occupation in breeding and keeping sheep. On the other hand, in places where the fjords are short, the sea-cliffs steep, and the coast-belt disappears, as it does at Hornstrandir, to the south of Cape North, the population exist almost exclusively from and upon the catching of wild-fowl.

The other and larger plateau, of which the bulk of Iceland consists, attains its highest elevation, namely 6000 to 6250 feet, towards the south-east, where the vast snowy masses of Vatnajökull cover an area of 3300



VOLCANIC TYPES IN ICELAND: A A A, TUF AND LAVA-CONE (VESUVIUS-TYPE); B C, DOME-SHAPED LAVA-CONE, WITH A TERRACED PIT-CRATER A B (KILAUEA TYPE); D E, A ROW OF SMALL CONES (FISSURE-ERUPTIONS).

square miles. The axis of maximum elevation stretches from the head of Hvammsfjord, in the north-west, to Hornafjord in the south-east. It does not, however, consist of one continuous ridge, but of a chain of snow-covered, dome-shaped mountains, separated by broad stretches of leveller ground; for instance, Langjökull, Arnarfellsjökull, Tungnafellsjökull, Vatnajökull, and others. These ice and snow-clad domes are properly so many smaller plateaus, rising some 2000 to 3000 feet above the general level of the plateau base upon which they stand, and attaining an absolute elevation of 4500 to 6250 feet. All of them are built up of tuff and breccia, and appear to have once formed integral portions of one continuous mass of tuff, which covered the middle of Iceland. The island seems to have assumed the broad contoural features which it at present exhibits long before the Glacial age, in all probability towards the close of the Miocene period.

The average mean elevation of the plateau is 2000 feet. Where it consists of basalt, it sinks at a very steep angle towards the coasts; but in those parts where the principal petrological constituents are tuff and breccia, it falls with a gentler inclination. These two species of rock

* Comp. Th. Thoroddsen, "Nogle Iagttagelser over Surtarbrandens geologiske Forhold i N.V. Island," in *Geolog. Fören. Förhandl.* (Stockholm, 1896), xviii. pp. 114-154.

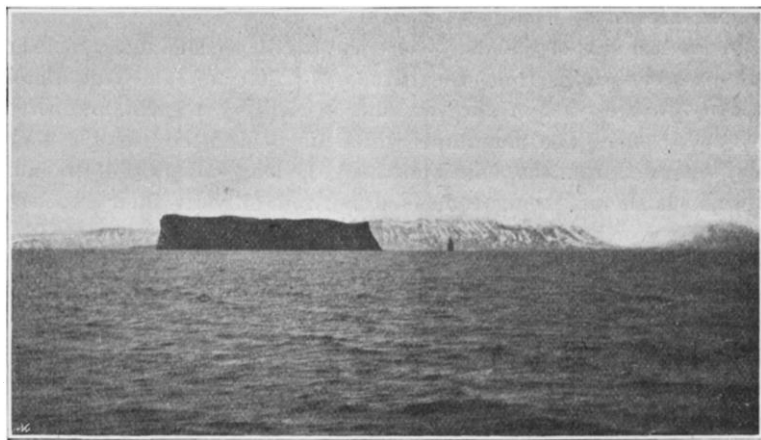
stretch across the island in a kind of belt; and it is with this belt that the modern volcanoes stand in close association. The Tertiary basalts have throughout a slight inclination from the coasts inwards to the belt of tuff, and are frequently higher next the sea than the plateau mass behind them. The interior plateau is seamed by a number of valleys, more especially towards the north and east. The spaces between the valleys are filled up with long mountain spurs, the skeletal ribs of the plateau, left behind by erosion, ramifying outwards towards the ocean. The largest tracts of level lowlands occur towards the coasts on the south-west and south of the island; although even they are crossed by a sort of promontory ridge, which projects southwards from the main plateau till it reaches the sea, and is surmounted by the vast ice-mass of Mýrdalsjökull.

As already stated, the elevated interior consists for the most part of barren deserts, but the surface varies in character in accordance with the geological constituents and formation of the underlying rocks. Where the substratum consists of basalt, or its coarser crystalline variety dolerite, the surface is strewn with a "stormy sea" of sharp-edged boulders, split and rent by frost. Where tuff and breccia form the foundation, the surface is generally covered with pebbly *débris* and fragments of scoriaceous lava, often with crusts of tachylite. These fragments are integral elements in the breccia, and have become exposed through the action of weathering and the wind sweeping away the softer rocks in which they were embedded. But more than one-half of the interior plateau is overlain by quite recent formations, such as lava, drift-sand, ancient ground-moraines, and erratic boulders. Vast areas are simply desolate lava-fields, utterly destitute of the smallest vestige of vegetation. In fact, it would hardly be possible to conceive a drearier prospect than the boundless lava-fields in the interior of Iceland. For example, the view from the summits of Odádhraun is the weirdness of desolation itself. As far as the eye can see, the surface of the earth resembles a gigantic stiffened corpse, petrified, black as the night. The only breaks in the grim monotony are a few scattered reddish mounds of slag, brown hills of tuff, and sporadic snow-drifts. Looking southwards, you get glimpses of the glittering snow-fields of Vatnajökull; whilst towards the east the sky is obscured by the yellowish-brown aerial banks of dust, which have risen off the vast expanses of drift-sand that border upon the plateau. Nowhere a vestige of life. An oppressive silence weighs upon the entire landscape.*

Extensive areas in the interior are smothered under drift-sand,

* Mr. E. Delmar-Morgan, speaking of the lava-wastes of Askja says, "I have been in many lonely places in my life, the great pine forests of Northern Russia, the immense plains of Central Asia, the watery wastes of the Atlantic, the arid deserts of Persia, but none to equal the desolation and absolute lifelessness of that scene of Askja" (*Proc. Roy. Geog. Soc.*), 1882, p. 143.

which, when the wind is stormy, often raises serious hindrances to the progress of the traveller. You are enveloped in an impenetrable darkness, the horses become unmanageable, sand and gravel are hurled into your face with great violence, and the finer particles of dust search through every pore and opening in your clothes. The drift-sand has various origins. Examined under the microscope, the greater part of it appears to consist of nothing but minute particles of pelagonite, which has been broken off the mountain masses and weathered down through the agency of the atmosphere and the wind. Dense clouds of this fine dust, and of great extent, are frequently carried to distant quarters of the island, and there deposited in the river valleys and on the patches of grassland, thus initiating the formation of a kind of loess, which the Icelanders call *móhella*. In several valleys—for example,



DRANGEY, AN ISLAND IN SKAGAFJORD.

Land and Rangárvellir in the south—there are wide stretches covered with yellow-brown deposits of this character, held together by the roots and fibres of plants, and frequently attaining to a considerable thickness.

A good deal of the drift-sand consists, further, of volcanic ashes of recent date, in some cases mingled with glacial clay and dust, weathered to the consistency of powder. To the south-east of Askja there are immense deposits of drift-sand of a peculiar constitution, namely, crumbled and comminuted liparitic pumice, ejected from Askja during the eruptive outburst of 1875.

The exposed rocks of the interior plateau exhibit plain evidence of the power of the violent storms which sweep across it with such appalling frequency. Not only are marks of wind-abrasion and pyramidal blocks of stone common everywhere, but the general contour-lines

of the whole country show conclusive proof of the constant disintegrating action of the wind. Glacial formations are neither so prevalent nor yet so great in mass as might perhaps be expected. The larger part of the constituent materials of the moraines have been transferred into the valleys and fjords. Nevertheless, the *residua* of the ground-moraines of the Glacial epoch are pretty general in the depressions all over the plateau. In many places the erratic blocks lie heaped up by thousands together. In fact, immediately north of Hofsjökull, and in many other districts on the plateau, you could almost imagine that the *jökler* (ice-mountains) of the Glacial epoch had only quite recently melted away.

It would carry me too far to describe, at greater length and in fuller detail, the several minor subdivisions of the plateau. I must therefore content myself with a few disconnected remarks about one or two of the more interesting localities.

On the east side of Iceland, where the basalt predominates, the edge of the plateau drops from an altitude of 2500 to 3500 feet almost vertically to the level of the sea, and is cleft by a great number of fjords and glens. The mountains which lie behind the east fjords are almost separated from the main plateau by the long valleys of Jökuldalur and Fljótsdalshérad, being connected with it only at their southern extremity. Northwards from Vatnajökull the plateau falls away from the altitude of 2500 to 3000 feet at a gentle regular slope right across the island, till it reaches the coast between Langanes and Skjálfandi. Throughout that part it is principally composed of tuff and breccia and other rocks of younger volcanic origin. My geological surveys go to prove that all that portion of Iceland has subsided, there being well-marked lines of faultage going down to the bases of the mountains. At Lake Mývatn the altitude is not more than 1000 feet, and both there (Mývatnssveit) and east of Jökulsá there are several scattered farms lying at altitudes of 1250 to 1600 feet above sea-level. In the district east of Jökulsá, *e.g.* Fjallasveit, the surface consists for the most part of drift-sand. The inhabitants, who subsist principally by the breeding of sheep, feed their animals on the sandwort, or arenaria (*Elymus arenarius*), and dwarf willows (*Salix glauca*), which grow on the sand. These are the only two settled districts upon the plateau; but the extremely inclement climate renders life there anything but enviable. On the west of the stream of Skjálfandafjót the plateau suddenly shoots up again, turning a steep escarpment towards the river, and sending off northwards three broad, lofty spurs between the large fjords which there indent the coast. These ridges are built up of basalt, and in many places next the sea rise considerably higher than the plateau behind them. The highest elevations occur between Æfjörð (Eyja-fjörð) and Skagafjörð (*e.g.* Vindheimajökull, 4810 feet), and on them minor glaciers are not at all uncommon.

The mountains on the northern side of Iceland are furrowed by a great number of valleys and glens, all of which appear to owe their origin to erosion. All the same, the beginnings of these Icelandic valleys are, no doubt, of older date than the Glacial epoch. In the south-west of the island I have found that streams of doleritic lava, which themselves show glacial markings, have flowed down into the valleys; so that these must have been formed anterior to the outflows of lava. But I have nowhere found moraine *débris* or glacial striations underneath the ice-marked streams of lava; from all which the conclusion was forced upon me, that the lava was in all probability ejected anterior to the Glacial epoch. The valleys of Iceland are often very deep, being cut far down through the basalt. The *jökler* (ice-mountains) of the plateau, during the Glacial epoch, filled them up with huge moraines, which subsequently melted, leaving masses of gravelly *débris* behind; and this has since been banked up into terraces by the rivers which flow down the valleys. During and after the Glacial epoch, large lakes were dammed up in several of the valleys. Clear evidences of this exist in the Fnjóskadalur on the north side of the island, where, towards the close of the Glacial period, there was a lake 24 miles long and from 250 to 300 feet deep. The elevations of these former glacial lakes are still apparent in the beach-lines marked on many of the valley-sides. The valleys of Iceland offer exceptionally favourable opportunities for studying the forms which basalt assumes in the process of being worn down by erosion. All the various stages of disintegration exist together side by side; there are not only a great number of collateral glens, there are also many deep dells and cauldron holes (*botner*).

The western portion of the plateau, which lies north-west of Langjökull, is considerably lower than the remaining parts, the mean altitude not exceeding 1500 feet. In this quarter there are many lakes, moraine formations, and wide stretches of marsh and moor. South of Langjökull and Arnarfellsjökull the plateau consists exclusively of a barren and desolate country, especially along its eastern margin towards Vatnajökull; there lava and drift-sand reign supreme. The region lying between Tungná and Skaptá is unlike any other part of the plateau, in that it is crossed from south-west to north-east, from Mýrdalsjökull to Vatnajökull, by several parallel mountain chains of tuff, all remarkably torn and ragged in outline. The plateau east of Fljótshverfi is entirely covered by the snow and ice masses of Vatnajökull. The only exceptions are a few promontories of tuff and basalt along the outer borders of this giant among the ice-mountains of Iceland.

On each side of the wide bay of Faxaflói two ridges run out westwards from the plateau, forming the peninsula of Reykjanes on the south of the bay and Snæfellsnes on the north. Of the two Reykjanes is both broader and lower in elevation, and is built up of tuff and

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breccia, as well as divided by a number of transverse faults, disposed in a south-west to north-east direction, into several step-like minor plateaus, which decrease in altitude from east to west. These fissures have been the "springs" of immense lava-streams, which now overlie the greater part of the peninsula. Of larger volcanoes there are but few; on the other hand, there are several "strings" of craters of no great elevation.* The ridge which constitutes the backbone of Snæfellsnes is both higher and steeper, but at the same time narrower, than that which traverses Reykjanes. At the extreme end of the peninsula there is a large ancient volcano, Snæfellsjökull (4710 feet), capped with glaciers. There has been no eruption during historic times, although the surrounding country exhibits abundant evidences of both ancient and modern outflows of lava. Some of the lavas have been scratched by the passage of ice over them, proving that the volcano was active prior to the Glacial epoch. All along the ridge there are craters from which lava has issued and flowed down upon the lower-lying tracts, as well as alkaline and carbonic acid springs.†

(To be continued.)

A TRIP ON THE THA-ANNE RIVER, HUDSON BAY.‡

By the Rev. J. LOFTHOUSE.

ON July 7, 1896, I left Churchill in a small Peterborough canoe, accompanied by two Chipewyan Indians, to explore the "Tha-anne" and Fish rivers, which empty themselves into Hudson bay about 100 miles north of Churchill. These rivers had never before been traversed by white men, and one of them, the Tha-anne, was but little known even to the Indians. The ice had cleared off early from the coast (I have been fast in ice on August 1), and I felt sure we should have no difficulty in reaching the "Tha-anne." The day was beautifully fine, and quite calm; but the mosquitoes were in myriads, and very fierce.

We paddled across Button bay on to North river, when, a fair wind springing up, we hoisted our sail and stood right across the Seal river bight, a terrible place for canoeing around the coast, as the tide runs out so very far, at times leaving one high and dry out of sight of land. We camped that night about 10 miles south of Long point, which we reached early next morning. This point is really a sand-ridge about 100 feet high, and forms the western side of the Churchill bight as Cape Churchill forms the eastern, each point being about 40 miles from the mouth of the river. After rounding the point, we were met

* "Vulkanerne paa Reykjanes i Island," in *Geolog. Fören. Forhandl.* (Stockholm), iii. pp. 148-177.

† 'Geologiske Iagttagelser paa Snæfellsnes og i Omegnen af Faxebugten i Island' (Stockholm, 1891), 98 pp.

‡ Map, p. 336.