

THE VOLCANOES OF ICELAND. BY TEMPEST ANDERSON, M.D., B.SC.

The author visited Iceland in the summer of 1890, with the especial object of examining and photographing the volcanic phenomena with which the country abounds.

Iceland is an island about the size of Ireland, situated just outside the arctic circle. The inhabited, or habitable, portion is confined to a narrow belt round the shore, the centre portion being occupied by volcanic mountains, extensive lava deserts, sandy plains, and snow mountains mostly flat-topped, called "Jokuls." The interior is traversed by a few desert tracks, seldom used, and becoming less so since the establishment of a regular service of steamers round the north coast. The north coast is much broken up into promontories and fjords, or deep bays, at the ends of which most of the villages—they scarcely deserve the name of towns—are situated. The south coast, on the contrary, does not boast a single harbour where a steamer can lie in safety, between Reykjavik and Hafnafjord on the west, and Berufjord on the east, for, though it is true that the small trading station of Eyra Bakki is situated here, and small sailing vessels find some shelter from the Atlantic swell behind a reef of rocks, the entrance is narrow and dangerous for any ordinary craft in which a landsman would like to trust himself. Add to this, that many large rivers, quite disproportionate to the size of the island, come from the desert interior and here flow into the sea; that they are mostly broad, swift, and icy cold, and often with quicksands in their bottoms; and we see at once the reason that this part of the island is seldom visited by travellers, and that the inhabitants enjoy fewer of the necessities, to say nothing of the luxuries of life than in other parts. Yet in this part are situated the great volcanoes of Kotlugiá and Skapta Jokul, which it was the author's object to explore on his visit to the island in 1890.

Reykjavik, the capital of Iceland, is a straggling village or small town of 2,500 inhabitants. The chief buildings are the governor's house, a plain whitewashed building apparently of about a dozen small rooms, a Church or Cathedral, also whitewashed, capable of

holding probably 400 people, and the parliament-house, a building of very moderate dimensions, yet accommodating a free library on the ground-floor, the Parliament Chamber on the first floor, and the National Museum in the attics. The Latin school, and one or two Elementary schools complete the sum of the public buildings, except the gaol, which has twelve cells, generally empty.

In the more remote parts, such as the Skaptadair, many articles of bone and stone are still in use, which, in more accessible districts, have been replaced by metal or earthenware. The inhabitants still use a wheelbarrow with a stone wheel, a steelyard with a stone weight, a hammer with a stone head, and a net with bone sinkers. At the same farm a quern, or stone hand mill, was in use, also horn stirrups, and harness fastenings of bone instead of metal buckles, to say nothing of bone pins and rude bone dice. At a neighbouring farm was a basin formed of the cup joint of a basalt pillar. Truly we still have a survival of the Stone Age. Less remote than this is the meeting place of the County Council of the district, consisting of a spacious cave in the lava. It would be difficult to find anything more appropriate to such a primitive land.

The roads, such as they are, are merely bridle tracks. Where they traverse stony moors and lava streams, they are mended by taking off the largest stones, leaving the smaller to be trodden down; where they cross bogs they are occasionally carried on artificial embankments. Bridges are almost unknown. In the few cases where new roads have been made, they have evidently been laid out by unskilled persons, and the work has often been begun in the middle; then, before the road has been finished, the plan has been changed, and the whole abandoned. I saw several large pieces of road out in the wilds leading nowhere, and which will never be used. It is only fair to say, however, that near Reykjavik there is about twenty miles of new road beautifully engineered by men who have recently returned from learning road-making in Norway. Even in these roads, however, there are gaps left unmade at intervals. This, I was told (let us hope falsely) is to prevent people spoiling them by using wheeled carriages or carts on them.

The numerous hot springs constitute one of the chief wonders

of Iceland. They are very numerous, and as various in their volume as in the composition of their waters and the products deposited from them. The great Geyser, which has been so often described, spouts its mighty volume of water, only slightly charged with silica, and deposits a silicious sinter called Geyserite; and several other springs, such as at Reykjanæs, deposit similar formations; others are so charged with ferruginous and sulphurous mud, that they appear like boiling cauldrons of red and blue paint. Some of the Reykjanæs springs, and many of those at Krisuvik, are of this kind, as are the more celebrated mud Geysers of Krabla, in the north of the island.

At Krisuvik, and some other places, but connected with the springs, are fumaroles, from which some sulphurous vapour and steam escapes. This has given rise to deposits more or less extensive of sulphurous earth or mud, on the top of which a crust forms on which it is possible to walk; care is however necessary, for if the traveller should happen to go through the crust, he will be precipitated into a mass of boiling sulphurous mud. It has been proposed to work these deposits for shipment to England, and a company was formed which came to an untimely end. We visited the house built for the manager at the springs; it was built of galvanised iron. Could any one have conceived a material less likely to resist sulphur fumes? There were many difficulties which operated to prevent success. The natural idea would have been to burn the crude sulphur in *calcaroni* or kilns, like those used in Sicily. The heat produced by the burning of part of the sulphur melts the remainder, and runs out in a refined state into moulds. But in Sicily the deposit is dry, here it was liquid mud; there was no means of drying it. Krisuvik is near the sea, and this was conspicuously marked on the map published at the time; but the coast is rocky, and there is no landing-place. In reality, the sulphur had to be carried on ponies for many miles over the mountains to Hafnafjord. We were told that about seventy horses died one year, and the attempt was then abandoned. No wonder the venture was unprofitable to the shareholders.

The rivers of Iceland are large and out of all proportion to the island, and are especially large and dangerous in the southern part, as

it is here that most of the great rivers draining the desert interior of the island, and especially the glacier streams proceeding from the Myrdals, Skapta, and Vatna Jokuls discharge themselves into the sea. They constitute, in this district at any rate, a most serious hindrance and occasionally a positive danger to the traveller. Most of the worst are broad and swift rather than very deep, a common size being a quarter of a mile or more wide, the depth in the fordable parts perhaps four feet, and the rapidity sufficient to make the icy cold water surge and foam up against the traveller's saddle and water boots. It is no wonder that a stream of these dimensions, flowing over a sandy and gravelly bottom, constantly shifts its course, and that quicksands are common. A place may be safely fordable to-day, and deep water next week. Hence the necessity of always taking a local guide from the nearest farm. Where the river comes from a lake the water will be pretty clear, so that the bottom is partly visible; but if from a glacier it will be loaded with mud, which prevents a view of the bottom, and this with its icy coldness adds greatly to the difficulty and danger of crossing. Deaths occur not infrequently from horse and rider being carried away. Sometimes a river spreads itself out into many parallel arms, and the guide in search of a ford seeks by preference such a part. If the river is not fordable at present he must seek a ferry at a narrow part where the banks are good. This is always a tedious undertaking. First the ferryman must be found, which is sometimes difficult even if he lives on the near side of the river, but the difficulty is much worse if he and the boat are on the opposite. Then all the horses are unsaddled, and the saddles, pack boxes, and gear are put into the rickety boat, and the horses, with much shouting and cracking of whips, are driven unwillingly into the stream. As soon as they are well swimming and too far out to turn back, the travellers and guides hurry across in the boats as quickly as possible. By the time they are across the horses have all landed, and feeling cold have started off at a canter. A guide runs after them, and with some trouble catches one which he mounts and pursues the others, and eventually drives them all back to the ferry. Then the whole cavalcade has to be resaddled and the packs adjusted, so that before the caravan is fairly on its way again at least an hour, but

often more, has been wasted. What wonder that the guide always prefers to ford if possible.

The main object of our visit was to examine the great volcanoes of Kotugiá and the Skaptá Jokul, the former of which appears not to have been visited this century, while the crater of the latter had, we were assured, never been reached since its formation in 1783.

The crater of Kotugiá is a vast fissure situated high up among the glaciers of the Myrdals Jokul, and is now so filled with snow and ice that our distant view of it did not promise much from a nearer inspection. Moreover, the weather being abominable, and the snow in bad condition, we were reluctantly compelled to abandon the attempt. One peculiarity of the eruptions arises from its position under a glacier of snowfield, viz., that when the incandescent gases and lava escape, the snow and ice are suddenly melted, and a vast outpouring takes place of mingled boiling water, ice, volcanic mud, pumice stones and ashes. This rushes with great velocity to the sea, devastating everything. We rode across a plain about twenty miles wide which marks the track. The last eruption took place in 1866. Scarcely a blade of any kind of vegetation has yet begun to appear on all this vast area. Certainly the volcano deserves its name of Kotugiá, the Kettle crater.

The second main object of our journey was to explore the lava fields of the Skaptá Jokul, mentioned in all the books on vulcanology as being among the largest known. The great eruption of this volcano in 1783 is well described by Lord Dufferin in his "Letters from High Latitudes," and especially by Henderson, a missionary who visited the island in 1814, when the facts were fresh in living memory. Two great streams of lava issued from the desert interior of the island, one descending the valley of the Skaptá River, and another, that of the Hervisflot, the first being about fifty miles long, and the latter perhaps forty. Both appear to have issued from the same great fissure on which a line of craters has been thrown up. We determined to endeavour to reach the craters by the former valley. We slept at the last farm in the valley, and were fortunate in obtaining the old farmer as guide. He at once told us that, though he had taken several parties of travellers far up the course

of the lava, none had ever reached the crater ; but he was quite willing to make the attempt. We therefore started next morning, keeping at first some distance from and then close alongside the lava. At last we found it necessary, in order to get to a set of cinder heaps which promised a passable road, to cross the main stream, and had some difficulty in getting our clever little nags across ; but perseverance prevailed, and going further on we encamped in the evening at the last patch of grass at the edge of the desert. Next morning, after a hard frosty night, the weather proved good, in fact, the only good day for many days, and by riding as far as possible into the desert and then leaving the horses and going forward on foot, the craters, the objects of such a long journey, were at last reached. They extend in a line for several miles along a great fissure, which is still in many places clearly visible. At the lower end are two or three dwarf craters, then the two or three main orifices from which most of the lava has poured out in billows of fire, now solid and black, it is true, but retaining their shape perfectly ; and, further on, several others from which the gases and steam evidently chiefly escaped.

The higher craters, from which the steam and vapours escaped, are roundish or oval ; and the fissures can still be seen along their bottoms in places of a width of several feet. Traces of it are also visible going under the heaps of scoriæ which separate adjacent craters, and here constitute their walls. The outer slopes of the craters are gentle, the inner nearly precipitous, this conformation being apparently due to the scoriæ having been ejected in a pasty condition, so that they stuck where they fell ; and thus, while those which fell again directly into the fissure would be blown out again, those which fell out of the direct line attached themselves and did not roll back to fill up the vent, as we so often see in ash cones. These craters also illustrate most strikingly the fact that water, except as running streams, has scarcely any eroding power. Though they have been erupted over 100 years their edges are as sharp and perfect as the day they were formed, the explanation being that the scoriæ are so porous that the rain as it falls, and the snow as it melts, instantly soaks in, and never appears on the surface as a stream.

The lava near the craters is almost all of the corded or "*paho-
heoe*" type, while lower down the valley immense fields of scoriaceous lava, or "*aa*," of the most bristling character are seen. The most probable explanation being that the lava, at the commencement of the eruption, contained much imprisoned steam and vapours which escaped in fiery froth, and solidified into the rough "*aa*," and was carried down the valley on the surface of molten lava, which, in places, is as much as 600 feet thick. The eruption was a prolonged one, and consequently the later lava had a prolonged simmering in the chimney or fissure during which it parted with most of its vapour, and when finally it flowed out it had little left, not sufficient to form a layer of froth, but only a few "giant's children" or blow-holes, of which some very fine examples occur near the craters. This sequence of events does not appear always to obtain. Near Hekla we saw a stream of lava, scoriaceous on the steep slope near its point of eruption, but corded with most beautiful regularity in parts where it had flowed tranquilly on the plain after parting with most of its vapour, and escaping from under the crust higher up.

We returned from the Skapta by way of the Fjallabaksvegr, a desert route of about ninety miles from the last house on the one side to the first on the other, and thence by Hekla, the Geysir, and Thingvalla; but these have often been described, and space is wanting.

It is currently believed in Iceland, and was stated in some of the public prints at the time, that a volcanic eruption or earthquake had taken place at Cape Reykjanæs in October, 1887, by which a large new *gíð* or chasm had been formed, separating a large rocky promontory, almost deserving the name of a mountain, from the main cape on which the lighthouse stands. This chasm, at least fifty feet wide, was pointed out to the author from a passing steamer, the captain declaring that he remembered the rocks before they were rent asunder. Here, then, appeared to be a case of the formation of one of the *gíás* or chasms which form such a characteristic feature of Icelandic geology. There are several such on the Reykjamæs peninsula, huge chasms several feet wide and of unknown depth, stretching for miles across the lava desert of which the district is composed. In this district they usually, though not always, have a throw of a few feet

or yards, but one of these at Thingvalla, more in the centre of the island, the Allmanagiá, has a throw of about 100 feet. In this case, the author is satisfied that the *giá* is due to the unequal settling of a crust of lava formed on the surface of a still fluid mass, which had found an outlet and flowed out after the solidification of the surface. He is not prepared however to say that this explanation will hold good in the case of all the rifts on the Reykjanæs peninsula. It certainly would not in the case of the great fissure from which the Skapta lava was erupted. Consequently any clear case of the formation of a new *giá* in strata long cooled and solidified would have been well worth investigation.

From a careful examination of the locality it appeared that no fresh formation of a *giá* has taken place, but that certain small portions of the rock on which the lighthouse stands had been loosened partly by ordinary denudation and partly by earthquakes, which are frequent here, and had fallen on to the beach. The strata of partly consolidated volcanic ashes and lava are quite continuous at the end of the small cove or recess between the two large rocks above referred to.
