

“On the Causes of Art,” by John S. Phené, Esq., F.G.S., F.S.A.; from the Author.

“The Colossal Sculptures of the Celts in Sussex,” by John S. Phené, Esq., F.G.S., F.S.A.; from the Author.

The following were elected Members of the Association:—

William Nuttall, Esq.; J. M. Black, Esq., F.G.S.; Charles Campbell, Esq.; and B. Winstone, Esq., M.R.C.S.

The following Paper was read:—

ON THE VOLCANIC GEOLOGY OF ICELAND.

By WILLIAM LORD WATTS, Esq.

(Abstract.)

Iceland is still a *terra incognita* as regards its physical geology and geography, so large a part of it still remaining unvisited. The accompanying notes, which I have made during my visits to a portion of those hitherto untrodden districts, may contribute to a knowledge of the region, and of the vastness of the volcanic eruptions which have produced the present contour of a part of its surface.

Volcanic phenomena in Iceland appear, with some few exceptions, to coincide exactly with those of other parts of the world.

There are three aspects from which volcanic rocks can be viewed. Firstly as regards the phenomena of their production. Secondly, with respect to their geological age, and their effect upon adjacent sedimentary rocks. Thirdly, as mineralogical compounds, and their similarity to and difference from the products of volcanoes of other localities or periods.

In the parts of Iceland that I have traversed, however, the first and third aspects are unfortunately the only ones in which it is practicable to study volcanic products, for all the rocks I have met with in that country are either igneous in their origin or derivations from igneous rocks.

Iceland lies almost at the northern extremity of the great volcanic line which skirts the extreme west of the Old World. This line extends from Jan Mayan through Iceland, the Farões, Great Britain, the Madeiras, the Azores, Cape de Verdes, the Canaries, and breaking out along the West Coast of Africa, terminates at Tristan da Cunha.

Though not more than one-third larger than Ireland, it contains

more than 20 mountains which have been witnessed in actual eruption during historic periods, and its only parallel as a centre of volcanic activity must be sought upon the eastern or western shores of the Pacific Ocean. Along the coast there is great evidence of elevation, raised beaches and sea-worn caves occurring in some instances miles from the present coast-line, though I am inclined to think that they belong to a very remote period, for I have been unable to learn that there has been any variation in the soundings along the coast during historic times.

Upon landing at the capital of Iceland, Reykjavick, the contour of the country at once proclaims its volcanic character. The town of Reickjavick itself stands upon the borders of an ancient basaltic lava stream. Similar streams traverse the surrounding country in many directions, though direct volcanic activity for some centuries appears to have subsided in this section of the island, merely proclaiming its former existence by secondary symptoms, such as hot springs and solfataras. The former occur near Reykiness, the capital Reykjavick, and Rekil, from which circumstance those places derive their names—Rekil being the Icelandic for the verb “to smoke;” while the latter are at Krisuvick, a day’s journey to the south-east of Reykjavick. There are 80 or 90 of the solfataras, and they occur in a mountain of decomposed palagonite tuff, the sides of which are covered with fragmentary matter in all stages of decomposition, together with the products of the various gaseous emanations. The solfataras themselves are mere pits of siliceous and calcareous bluish-white mud, the result of the decomposition of contiguous tuff. This mud is of a very high temperature, and in many places in a violent state of ebullition, the principal gas exhaled being sulphuretted hydrogen, depositing great quantities of sulphur upon the surface, in crusts varying from an inch to a foot or more in thickness. The thicker crusts are very impure specimens of sulphur, being mixed with a considerable quantity of carbonate or of sulphate of lime.

The road from Reykjavick to Great Geysir runs through the far-famed Thingvalla, the chief geological features of which are the two large rifts in the lava, namely, Almanna Gjã to the west, and Rafvens Rift to the east. The largest of these is the Almanna Gjã, which is 7 or 8 miles long, 100 feet wide, and in some places 200 feet deep. A very superficial glance at the valley and these rifts—more especially when they are compared with similar

phenomena which occur in many other places on a smaller scale—at once explains their origin.

A large river of lava at some remote period entered the northern end of the valley, and nearly covered the whole of the depression, a thick crust soon formed over the surface of the stream, and when the supply ceased, the still liquid lava at the bottom of the stream flowed from beneath the crust into the deeper portions of the lake, which occupies a considerable area in the valley, leaving the unsupported crust to sink down in the middle, thus occasioning these large lateral cracks upon either side of the stream.

Professor Forbes calculated the age of Great Geysir, from the thickness of the siliceous sinter which surrounds its basin, at about 1000 years. There are numerous hot springs throughout the Island which owe their existence to earthquakes, which instantaneously called them into being. In 1339 a hot spring 60 feet in diameter suddenly appeared at Mosfelc, and during the earthquakes which preceded the great eruption of Skaptar in 1783, no fewer than thirty-five new hot springs made their appearance. The Great Geysir is surrounded by numerous other springs of all temperatures and sizes, whose deposits vary according to the character of the rocks through which they pass.

The most important geological features of Iceland are its volcanoes and their products. The traveller approaches Hecla from the N.W., his road lying across a plain which the eruptions of Hecla have from time to time desolated. As the mountain is approached from the N.W. its form appears to be that of an oblong cone. It is about twenty miles in circumference and 5000 feet in height, and is capped by three smaller cones, the product of more recent eruptions. Its craters are all upon the W. and S.W. sides, and most of the lava streams have flowed in the same direction. It has been in eruption no less than fourteen times since 1004. The ascent of the mountain really commences at 800 feet, where the climber passes the termination of an arm of the latest lava stream, the surface of this arm being very rough, and covered with masses of scorïæ; though masses of compact lava appear to have welled up through many interstices in the crust.

We ascended by the side of the lava stream over an undulating sandy slope, and, passing a fine specimen of a cinder cone upon our right, we left our horses; and clambering over the rugged surface of the latest lava stream and flanking the lava, we commenced

the ascent of the Ash and Cinder Cone, which forms the summit of the mountain. We now passed several masses of a grey stony variety of lava, but upon re-meeting this lava, at the height of 3,600 feet, the stream appeared to be very thin, and had cooled upon this steep incline in masses, passing almost into an obsidian. Further on the lava became of a more cindery nature. All the Hecla lavas that I have seen are basaltic or doleritic, and contain crystals of felspar and olivine. We were soon at the edge of the crater of 1846, as it is erroneously called. It is simply a circular opening, which topped a larger and more distant crater, from which, I believe, the eruption proceeded. This smaller collateral orifice was perfectly cold, but from the larger one steamy exhalations were rising. This larger crater was an elliptical depression about 300 yards across and 250 feet deep; its sides consisted of a series of terraced banks of many-coloured cinders, and of sulphurous clay. At the bottom was a little patch of indurated snow. Descending I found in some places the ashes and clay were too hot for the hand to bear, and wreaths of vapour were rising from amongst them, depositing a variety of sublimations upon their surfaces. Re-ascending and proceeding along a narrow saddle of the mountain, its two principal cones came into view. Crossing a snow slope which contained many miniature ice caverns, we ascended to the apex of the mountain, which surrounds a long, deep crater, breached towards the west, and nearly choked with snow. From one part of it a small body of vapour was rising. Upon the W. of the third cone we were informed that there was a fourth crater.

Two or three days' journey from Hecla brings us to the foot of Myrdals Jökull, which includes the much-dreaded volcano Katlugia. The hills immediately around Myrdals Jökull are mostly composed of palagonitic agglomerate, which encloses numerous fragments of basalt, many of which appear to have been subjected to the action of fire. A great deal of this agglomerate is doubtless formed by the huge debacles of mud and water that from time to time have rushed down the sides of these mountains into the plains beneath, caused either by the bursting of the basins of crater lakes or the sudden melting of the frozen covering of the volcanic heights. These have poured in a torrent of mud and ashes down the sides of the mountains, gathering up the pulverulent volcanic materials and other accumulations which they met with in their courses, and

mingling together the aqueous and igneous ejectamenta in the most extraordinary confusion, have hurled themselves in heterogeneous avalanches upon the lower elevations, forming banks of muddy agglomerate upon the plains, and filling the depressions in some instances with seething paste.

But some of these tuffs are formed without the terrible phenomena just described; the gentle and continual wash of the mountain streams have accomplished as much as the overwhelming debacle, bringing down atom by atom the volcanic ejectments, the constituents of disintegrating rocks, and piece by piece the fragments of basalt; yes, even in the very abode of convulsion do we find the constant and gentle forces of nature vieing with the terrible. In one corner amongst the hills, filling a depression, I found beds of black and almost impalpable sand, which perhaps were originated by the wind carrying the light volcanic dust (probably strewn over the country by the eruption of some neighbouring volcano) into the position in which I found it. Indeed we see the same thing going on every day upon the large sandy plains to the east of Myrdals Jökull. Having ascended the hills below Myrdals Jökull, on our way to Katlugia, we will glance back at the history of this terrible volcano, which has been in eruption no less than 15 times since the year 900.

The principal phenomena attending the eruptions of this volcano are stupendous floods of heated water and the prodigious quantities of sand ejected. It has, I believe, never been known to produce lava; but upon the base of the mountain I found numerous ancient lavas, proving that Myrdals Jökull at one time was no exception to its neighbouring volcanoes. These lavas are mostly felsitic, and some of them, despite their porous nature, are almost obsidians. The floods from Katlugia during eruptions have often submerged a district of 280 square miles, continuing sometimes for days in spite of the rapid outflow to the sea. These floods are produced not only by the sudden melting of the snow on the Jökull at the time of eruptions, but in all probability by the bursting of large cavities in and underneath the mountain in which water might have been for years accumulating. This aqueous phenomenon is, however, by no means peculiar to Katlugia, although it occurs there upon much the larger scale, for during the 13th and 14th centuries all the volcanoes in the south of Iceland erupted water.

But to return to Katlugia. Upon the base of the mountain I

encountered some masses of compact basalt that split with the hammer into thin laminæ, presenting the conchoidal fracture of a flint. The rocks, a short distance from the glacier, were much scratched and furrowed by glacial action, and I found two or three large masses of ferruginous lava many tons in weight, that when struck with a hammer sounded perfectly hollow, doubtless owing to their cellular nature, the multiplied echoes from the numerous small cavities producing a precisely similar effect to that produced by one large cavity, as pointed out by Mr. Scrope in relation to the solfataras of the Italian volcanoes.

Upon the S.E. side of the Jökull, in a line with the mountain Aruna-stakka, is a black cone of volcanic sand and ash, with a base of tuff protruding through the ice which, upon closer inspection, proved to enclose a perfectly formed crater about 300 feet in diameter. This crater was reached towards the S.E. At the bottom was a deep pool of turbid water, into which several small streams emptied themselves, but none ran out, this is possibly one of the reservoirs in which the dreaded waters of Katlugia accumulated in the bowels of the mountain. Standing at the summit of this cone the eye wanders over a vast accumulation of *débris* and sandy moraine which is borne by the blackened ice of the glaciers towards the broad dark sandy waste of Myrdals Sandr from a horse-shoe-shaped valley which leads right into the heart of Myrdals Jökull. This valley, which is filled with an immense glacier, is surrounded by steep banks and slopes of indurated snow, from which protrude several cliffs of felstone and banks of sand. It is none other than the barren crater Katlugia. Upon exploring it we found in one or two places considerable depressions partially filled with water. The only indications of its destructive nature were the black desolate plain of sand to the east and the inky waves of the discoloured glacier below us.

Leaving Katlugia, we cross Myrdals Sandr (the greater part of which has been erupted by Katlugia), and pause for a few moments beside the huge lava stream of Skaptar which flowed from Skaptar Jökull (the S.W. corner of Vatna Jökull) during the memorable eruption of 1783. This produced two streams, one 50 miles long and 15 wide, and the other 40 miles in length and seven broad, being in some places 500 feet in depth. It has been computed that the entire mass exceeds in bulk that of Mont Blanc.

This lava is highly ferruginous, and strongly impregnates the waters of the river Eldvatn which flows through it.

To the Vatna Jökull (of which Skaptar Jökull is but a small part), together with the unknown country which lies immediately to the north of it, the volcanic forces of Iceland seem at present to have retreated. The Vatna Jökull is a tract of ice and snow which rests upon a nest of volcanoes, many of which have been in eruption during historic times; the peaks of many of these protruding through the frozen covering. The Vatna rises from a series of basaltic terraces to a large "rolling" snow-covered plateau 5,950 feet above sea level.

While investigating this remarkable district last year I came upon a cluster of conical eminences which rise from a larger pit or crater upon the mountain. This showed a complete transition from highly vitreous obsidian to a banded semi-obsidian then to a pearlite which again passed into a grey stoney variety of lava which so much resembles the alum stones of Hungary. Upon the unexplored north of the Vatna Jökull I believe there may be permanently active volcanoes, for, from time to time, eruptions have been witnessed in that direction, and yet no one has penetrated to where they occur. Gaseous emanations, that I am sure cannot come from anything but a body of cooling lava, are frequently experienced upon the south of the Vatna Jökull when the wind is in the N.N.E. And I have found that they increase in pungency of odour the further north I have advanced upon the mountain.

ORDINARY MEETING, MARCH 5TH, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., F.L.S., F.G.S., President,
in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," Vol. xxxi., part 1; from that Society.

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Transactions of the Manchester Geological Society," Vol. xiii., parts 6, 7, 8; from that Society.

"Researches in the Roman Castrum at Richborough," by Geo. Dowkar, F.G.S.; from the Author.