VI. *An Account of some Geological Facts observed in the Faroe Islands. By* Sir GEORGE STEUART MACKENZIE, *Bart.* Pr. PH. CL. R. S. EDIN.

[*Read Nov.* 2. 1812.]

THE singular appearances which were presented to my view by the Trap Rocks of Iceland, and the interest which they excited, made me resolve, as soon as I had given an account of that country to the public, to visit the Islands of Faroe. This expedition was undertaken, for the purpose of ascertaining, whether, in a Trap Country, where no traces of *external* volcanoes existed, any thing similar to the peculiar features of the rocks of Iceland was to be found. In the latter country were discovered a series of rocks, lying above the beds of Trap, which bore the most striking marks of igneous origin; in some instances having a perfect resemblance to ordinary Trap, and in others to the common Lavas of the country. The beds of Trap, and those above them, being separated by mechanical depositions of Tuffa (Trap-Tuff), led me to the conclusion, that the whole of the beds had been formed at the bottom of the sea, by successive eruptions of a submarine volcano.

cano. The results which I suppose may have attended a submarine eruption at a great depth, will be quoted in the sequel.

The following observations of LANDT, respecting the formation of these islands, contributed essentially to confirm the desire I felt to explore the country. It must be believed, that this clergyman had possessed some previous knowledge of the igneous theories. " It would form," says he, " a curious object of research to inquire, in what manner the Faroe hills have been formed, and how they attained their present elevation; whether above or under water? Whether they owe their height to volcanic explosions, which threw one stratum above another, or whether these strata were deposited upon each other under the water, and were afterwards raised to their present situation by a volcanic eruption, or some elastic force produced by subterranean inflammation; or whether these hills have been formerly covered by the sea, which has since retired back, in consequence of some convulsion of nature * ?"

Again; " But in examining the bottoms of the hills along the sea-coast, one will often discover indubitable marks of volcanic eruptions, or of some other convulsion of nature, which has acted a distinguished part in the formation of the singular phenomena which here present themselves to the eye of the curious observer. It is seen in many places close to the water's edge, that the matter of which the rock is formed has been in a state of fusion, and has become hard in its course. Sometimes this hardened matter is smooth on the surface, but has the appearance of the ice on a stream or rivulet, where the water rises above the first crust, and forms several strata, one above the other; but sometimes this hardened matter is rough, and

* LANDT, *Translation*, Lond. 1810, p. 5.

and full of holes and knobs, such as we may suppose would be seen in metal first fused, and then cooled in water *.'

Besides the desire natural to all travellers, to have a friend to partake their labours and enjoyments, the particular object I had in view, rendered it a matter of importance, that I should have a companion, of whose competency to judge upon the spot, of any new fact that might occur, there could be no doubt. On proposing to him to take a share in the expedition, my friend Mr THOMAS ALLAN, whose great experience in geological examination, and his intimate acquaintance with individual minerals, eminently qualify him for research, readily agreed to accompany me.

The islands of Faroe, or North Faroe as they are commonly called, are nearly midway between Shetland and Iceland; and lie between the parallels of latitude 61° 20′ and 62° 25′, extending north and south about seventy-five miles. The meridian of the seventh degree of west longitude divides the group into two nearly equal parts; the extreme points of land on the east and west sides including 1° 25′, or about forty miles. Besides a great many detached rocks, the islands are eighteen in number; the largest, viz. Stromoe and Osteroe, being in the centre. The extent of the former is twenty-eight miles long, and, on an average, six miles broad; that of the latter, about the same breadth, and twenty-two miles long.

The general aspect of the country is mountainous and precipitous; and, while the lofty rocks which frown over the ocean, inspire distrust in those who approach them for the first time, many excellent harbours are to be found, where ships of any size may ride securely.

The principal place is Thorshavn, situate on the east side of Stromoe. It is a small town consisting of wooden buildings,

* LANDT, p. 11.

ings, huddled together on a narrow tongue of land jutting into a bay, and forming two very commodious harbours. The country in the vicinity, though by no means flat, comprehends the greatest tract of comparatively low land to be met with in any of the islands; but it is exceedingly bleak and bare.

There are, in a few places, valleys of very small extent; the separation of the mountains being for the most part narrow glens, and, in many instances, merely the breadth of a small stream.

The soil, in almost every part of the islands, is chiefly peat. No trees are to be seen, excepting one or two stunted mountain-ashes in the governor's garden. This deficiency of trees may be attributed, perhaps, more to the wetness of the soil than to the climate. The whole country abounds in springs; no part of the soil being naturally dry, while, at the same time, it is very shallow.

There are two lakes of considerable size in the island of Vaagoe. One, called Sorvaags Vatn, is about three miles long, and about half a mile broad. The waters of this lake approach very near the coast, which is lofty and precipitous; and, after a short course, fall into the sea, forming a magnificent cascade about eighty feet high. The other lake is on the north-west side of the island, and is about a mile long, and a quarter of a mile broad. It is not named on the chart, nor by LANDT.

In Stromoe there are several small lakes, the most considerable being that near the village of Leinum.

There are but few in Osteroe; the only one of note is that called Tofte Vatn, at the south-east end.

The streams are in general merely brooks; that which issues from the lake of Leinum being the only one which can be considered as a small river. The variety of cascades which these streams form, is endless: and some of them, when swollen

swollen by rain, are exceedingly picturesque. Many of them fall from such a vast height, that they are completely dispersed into fine spray long before they reach half-way down the precipice.

The mountains present a variety of forms, but tend chiefly to assume that of a cone at their summits, which are often very sharp and rugged. The Northern Islands, Kalsoe, Kunoe, Bordoe, and Videroe, consist of long sharp ridges, the summits being broken into many fantastic shapes. The highest land is in Stromoe and Osteroe, which are separated by a narrow channel, which in one place is scarcely a quarter of a mile broad. The state of the weather prevented our ascending the highest mountain, called Skellingfell, in Stromoe: but we succeeded in reaching the summit of one of the highest mountains in Osteroe, called Slatturtind, near the village of Eyde. By barometrical observation, this appeared to be 2825 feet above the sea. Skellingfell * cannot be less than 3000 feet high, and is probably somewhat more.

The western coast of Stromoe presents an extent of twelve miles of the most sublime rock-scenery that can be conceived. Every part of the Faroe group has its romantic beauties; and there is scarcely a promontory which does not exhibit a scene calculated to excite the most lively admiration. The general elevation of the precipices on the west side of Stromoe, varies from 1000 to 2000 feet. There is a cliff called Kodlen, forming the north-west promontory of Osteroe, which did not strike us so much by its elevation, (for it sunk far beneath the neighbouring rocks of Stromoe), as by the circumstance of its being exactly perpendicular. Mr ALLAN measured its height by

* The name of this mountain, and some other names, are variously spelled; but the mode adopted in this memoir conveys the pronunciation.

means of a line, and it was thus ascertained to be 1134 feet high.

Greatly as our admiration was excited by the stupendous exterior of these islands, their internal structure did not fail most powerfully to arrest our attention.

The Faroe Islands are composed almost entirely of Trap, the most common characters of which are amygdaloidal and porphyritic. Beds of coal occur in Suderoe, and, it is said, also in Myggenæs, neither of which islands we could visit, on account of the unfavourable state of the weather, at the time we were about to make an attempt to land upon them. The beds of Trap are inclined at a small angle, about 4° or 5°, and dip towards the south-east *. Their thickness varies; in some, it is but a few feet; and LANDT states that of some columnar beds, which we did not reach, to be from 100 to 300.

The first striking resemblance between the rocks of Faroe and those of Iceland, we observed in the separation of many of the beds of Trap by thin layers of Tuffa, resembling red sandstone. In both countries, this tuffa occurs of a greyish and of a yellowish colour; and sometimes assumes the small columnar form, and then it has a tendency to the texture of Wacke. In Faroe it occurs also of a green colour †.

The

* We had a view of Myggenæs, near enough to distinguish that it was composed of beds, which rose at an angle considerably greater. The coal is probably in the same position as that found in the Isle of Skye, near Talisker, where it occurs between beds of trap.

† I have preferred the term *Tuffa* to that of *Trap-tuff*, because I wish to employ a generic term, and one that has no allusion to theory. *Trap-tuff* is, no doubt, used as generic by the Wernerians; but it is in reality a specific term. It is a question whether the specific terms should be derived from

The first example we had an opportunity of examining, of that species of tuffa, immense beds of which form so remarkable a feature of Iceland, was observed forming part of a very curious rock on the west coast of the island of Vaagoe, called Tindholm. We saw the same sort of tuffa in different places; particularly at the bottom of the promontory called Niepen, in Stromoe. It may also be seen on the beach, near the village, in Naalsoe.

from the basis or the included masses. As it is not in any case easy, I may say possible, to determine to what specific substance we ought to refer the basis, which varies in several respects, it may perhaps be best, when there is any uncertainty, to describe both it and the included masses; for prolixity is, in every description, preferable to want of perspicuity. *Trap-tuff* implies, either that the basis is derived from Trap, or that the included masses are Trap, or that both have the same origin. Now, as the rock in question often contains sandstone, and sometimes wood; and as in Iceland and other volcanic countries, it contains lava and other volcanic substances; the term Trap-tuff conveys none of these important particulars. Correctness seems, therefore, to demand some reform. I would propose that the basis should be understood generally, as Professor JAMESON has described it, to be "rather a loose, spongy, "clayey basis," and that we should relinquish the term *trap*, and use, as a general term, the word *tuff*, or the original and more harmonious Italian *Tuffa*, and describe the included masses. Thus, in Iceland, I met with tuffa, the component parts of which were so minute, that it resembled red sandstone; tuffa including rounded masses of trap, from a size very minute, to many feet in thickness; tuffa including masses of trap, lava, slags, and mineralized wood. Here the description appears to be absolutely necessary to prevent misapprehension; and instead of being at all offensive, it affords perfect satisfaction: whereas, were I to use for them all merely *Trap-tuff*, many important particulars would be omitted.

Objections also arise to the term *Calc-tuff*, which may be understood to mean a calcareous basis, cementing together substances, the nature of which we are left to imagine. The included masses being sometimes entirely calcareous, and sometimes heterogeneous, the term, by itself, conveys nothing satisfactory. For fragments connected by a solid basis, the old term *breccia* seems to be unobjectionable, when qualified, as circumstances may require, by a description of the basis and the included masses.

The Society will no doubt recollect the fact which I described, of the under-surfaces of many of the beds of Trap in Iceland, bearing unequivocal marks of their having been in a state of fusion, of which there are various specimens in our cabinet. On finding the red tuffa separating the beds in Faroe, I expected to meet with some indications of heat in that country also; and I was not disappointed, though their occurrence was not so frequent in Faroe as in Iceland. Near Kirkeboe, we observed a considerable degree of roughness on the bottom of a bed of rock, which resembled some that occurred in Akkrefell in Iceland so much, that the specimens differ only in a shade of colour. At Kirkeboe, such marks of fusion were in many places quite apparent; but I did not succeed in my attempts to procure a mass of a size sufficient to exhibit, in a satisfactory manner, the general feature which is so remarkable. The most perfect I could procure on a small scale, of that slagginess which was so conspicuous in Iceland, was found on the hill of Leinum in Stromoe. I had to regret that heavy rain, and the risk incurred in wandering among high precipices, while surrounded by thick fog, prevented my exploring this mountain so completely as I wished.

But whatever degree of doubt might have been left on my mind by the appearances just described, it was entirely dissipated by a new and most important fact, in relation to heat having operated in the formation of trap, which first presented itself to our notice in the island of Naalsoe, where almost every circumstance of importance in the geology of Faroe is to be seen, and where the greatest variety of the individual minerals which occur in trap are to be found. This island lies opposite to Thorshavn, being separated from Stromoe by a channel about five miles broad. It consists of one mountain, rising to an elevation of

1500 feet; and receives its name, which signifies *Needle Island*, from a perforation in a rock at the south end, thought to resemble the eye of a needle.

The surfaces of many lavas which I passed over in Iceland, were not unlike coils of rope, or crumpled cloth; an appearance which we should expect to be assumed by any viscid matter in motion. On our first visit to the Island of Naalsoe, we observed the surface of a bed of amygdaloid, which had been exposed to a considerable extent by the removal of the bed above, exhibiting an exact picture of the lavas I had seen in Iceland. At first sight, this discovery forced instantaneous conviction on the minds of those who were with me, none of whom had ever seen lava, that heat must have caused the appearance before us. We brought away a number of specimens, which are now before the Society, and which speak a language not to be misunderstood. (See Plate I.)

We afterwards discovered varied examples of this crumpled surface in different parts of the country. In the vicinity of Eyde in Osteroe, there were many instances, in which the matter appeared, as if, in a viscid state of fusion, it had flowed and spread itself out. Of this a specimen is before the Society, sufficient to explain the fact, though it does not afford so good a display as we could have wished: our attempts to raise large masses entire having failed. (See Plate II.) We found that one bed was exactly moulded on another, and had every appearance of the lower one having become hard before the next had flowed over it. This was observed at various elevations. Near Waii in Bordoe, we saw several examples; some at the height of 1000 feet above the sea. It is to what has been described, no doubt, that LANDT alludes in the passage quoted in page second.

It has been observed to me, that what has been remarked on the *upper* surfaces of the beds of Faroe, cannot be reconciled with the ideas I had formed respecting the manner in which the slagginess of the *under* surfaces had been produced. Though all I wish to contend for, in either case, is, that heat had operated, I request the indulgence of the Society, while I shortly endeavour to show, how a lava, flowing at the bottom of the sea, might also assume the marks of fusion on the upper surface.

The effect of water on the surface of metals in a state of fusion, is well known to be the production of wrinkles. This is the case also when any viscid substance, whether fluid by fusion or otherwise, becomes gradually solid while in motion. In the case of water applied to the surface of a hot body, the phenomena are familiar to most persons. When, for instance, brass is in fusion, a few drops of water poured upon it remain suspended almost without motion; but as the heat diminishes, the water approaches nearer and nearer to the hot surface, and at length coming into contact with it, violent ebullition and quick evaporation take place. In the case of a lava erupted at the bottom of a great depth of sea, a stratum of steam must be produced, continuing, while the heat exceeds a certain degree, to keep the water and the hot mass separate. In the operation of boiling the mercury in a barometer tube, an event analogous to this takes place, and we see the column of mercury raised up by the vapour occupying the lower end. As the heat of a stream of lava flowing under the sea is reduced, and the lava itself becomes viscid, its motion, combined with the action of the water coming into contact with it, will infallibly produce a surface full of wrinkles; and therefore we should expect to find the upper surfaces

surfaces of submarine lavas uneven and rough, as in the examples before the Society.

In considering this subject, it ought to be observed, that steam is not like permanently elastic fluids, which, when they escape, overcome any pressure of water, and rise quickly to the surface. In the case of water above a greatly heated surface, there is a constant production, as well as a constant condensation of steam; and the water itself may, to a considerable extent, become greatly heated. But steam produced under the lava, by its flowing over a wet, and, if tuffa be present, over a spongy surface, would act in a very different manner, as I have shown in my account of the Mineralogy of Iceland. It will have a tendency upwards, and will act upon the hot mass, rendering it more or less vesicular, according to its degree of fluidity *.

Thus

* "When the lava is very hot, and consequently very liquid, the steam will have less difficulty in penetrating it than when it is viscid. We may conceive cases in which the lava burst forth in such a high state of liquidity, as to permit the whole of the moisture to pass through it in the form of steam; in such a state of viscidity, as to admit of its escaping very slowly, so that the lava may become solid, and, by confining the steam, more or less vesicular †; and, lastly, so tough, that the exertions of the elastic vapour shall be confined entirely to the lower surface of the lava. In the first case, a compact mass of stone would be formed, having no appearance of the action of heat; in the second, on account of the pressure of the superincumbent water being sufficient to prevent the escape of carbonic acid and other volatile ingredients, a vesicular and amygdaloidal mass would be produced; and from the last would result a mass entirely compact, excepting at the under surface."—*Travels in Iceland*, chap. IX.

To this passage of the text the following note is subjoined:

"In such a case, it is possible that the steam, when condensed, would, in some instances, remain confined in the stone in the form of water; and thus the

Thus it appears, that the marks of fusion, exhibited by the upper, as well as the under surfaces of the beds, are equally reconcileable to the supposition of their having flowed in a state of fusion at the bottom of the sea.

Another point of resemblance between Iceland and Faroe remains to be noticed. LANDT, in his description of Faroe, (which, as far as I had the opportunity of judging on the spot, is a very faithful one, though his translator does not always do him justice), mentions great fissures which can often be traced from one island to another. We found that these fissures had been originally entirely filled with veins of basalt; and in those only did that rock occur to our observation. Being columnar, and the columns being perpendicular to the walls, the basalt is easily broken down; and water-courses being formed, the veins are soon worn away. On examining the sides of the veins, we found, though not in every instance, a vitreous coating, similar to what was observed on those of Iceland.

Thus, the perfect resemblance between the trap rocks of Faroe, and those of Iceland, seems to be completely established. The beds are separated by the same substance, viz. layers and beds of tuffa. They present indications of fusion; and Faroe has afforded some of a new and very decided character. I have heard that similar appearances exist in Norway; and it is not improbable, if geologists take the trouble of looking for them, that such will be found in every country wholly composed of trap; and that the igneous origin of that genus

the fact of water being found in the vesicles of basalt and other rocks, may be accounted for. It must be observed that the steam, in such circumstances, must have been very much condensed, so much, indeed, as to be almost in the state of water greatly heated; much more so than in the familiar experiment made with Papin's digester."

genus of rock will be established beyond a doubt. The discovery of submarine lavas, the idea of which first struck the celebrated DOLOMIEU, serves as an additional illustration of the magnitude and various exertion of that power, which, when subjected to the control first conceived by the ingenious HUTTON, explains almost every phenomenon of the mineral regions.

While the great point, the action of heat in the formation of trap rocks, seems to be demonstrated, forming a theory of the manner in which heat has operated in particular cases, is, in a general view, perhaps not absolutely necessary in the present state of geology. Yet it is satisfactory to the mind when any explanation, consistent with the laws of nature, is suggested. The theory of submarine volcanoes is not meant to be extended to the appearance of beds of trap interspersed between strata of sandstone and other rocks. These have been thrust among the strata from below, and have probably been the cause of the strata being elevated above the sea, in which they were formed. The succession of beds of trap, one above another, is the fact which the theory of submarine volcanoes is intended to explain; and though it may not be thought to afford grounds for conviction, yet, in a case where the agent employed is of unlimited power, the imagination is led, by this theory, into a scene on which it can dwell with some degree of satisfaction. Some affect to view geological theory in the light of idle speculation; while others, of whom I am one, consider it the main spring of research, and the direct road to discovery. There are three descriptions of geological facts of importance to theory; those which support it, those which are difficult to account for, and those which can be explained by the operation of agents opposite in their nature, as fire and water. In proportion as the first accumulate, the second present fewer

obstacles; and the last, which may be called neutral, are associated with the first. Difficulties remain to be overcome both in the Huttonian, and in the Wernerian system; and unless the partizans of each were zealous in applying their doctrines to the facts which they discover, the face of nature would cease to be referred to for those steps by which alone we can hope to arrive at a perfect system: and our progress would be so slow and heavy, that prejudice might take possession of our minds, so as to shackle, if not to exclude, the free exercise of reason.

Rocks such as those of which the Faroe islands are formed, are very liable to destruction by the operations of the atmosphere. The great abundance of springs, which is characteristic of a trap country, aid the action of frost. Accordingly, the whole of Faroe exhibits extensive marks of the constant and destructive operation of these agents. The sea, too, rapidly undermines the precipices, large masses of which are daily buried in it. As all the narrow channels which separate the islands, lie in the same direction, and as veins of basalt are sometimes seen as if branching from them through the adjacent islands, I am induced to suppose, that the separation of the islands has originated in the destruction of large veins, subsequent to the land being elevated above the sea, and caused in the same manner as that of other veins or dikes, now going on. The support of the walls being removed, decomposition, and the effects of moisture and frost, would operate in gradually destroying the beds, and at last the sea, breaking through (as it is constantly doing in various parts of the islands), these channels might in this manner have been formed. In the same way, the position, in some instances, of those huge masses which now stand separated from the coast may be accounted for. Indeed, in several places, we saw the separation actually proceeding, by the removal

val of veins, particularly near the village of Tiornevig in Stromoe.

An account of some other geological facts, of the varieties of the trap, and of the various minerals contained in them, I leave to my friend Mr ALLAN, whose great accuracy in such descriptions is well known to the Society.

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B. Mitchell, Sculp.t