NO. III.—NOTES ON THE GEOLOGY OF THE ISLAND OF EIGG.

By HENRY TAYLOR. With a Map [Plate III.]

[Read 13th December, 1894.]

AMONGST other striking features in the group of islands known as the Inner Hebrides, of which Eigg is a member, are the long level sheets or terraces of igneous rocks, which, rising in places, one above the other, to a height of 2000 to 3000 feet, overlies and preserve the sedimentary rocks from the action of the denuding agents from which they themselves have suffered so much. That these islands are isolated portions of a great series of plateaux which, in comparatively recent geological times, extended along the west coast of Scotland from Skye and Raasay to the north of Ireland, covering an area of probably from 7000 to 8000 square miles, but of which—owing doubtless to long continued denudation—the greater part has now disappeared, is, I think, quite evident. These remaining fragments of the plateaux themselves bear convincing evidence of the great amount of denudation which has taken place in the valleys—sometimes of considerable size—by which they are trenched, and to which other facts to be mentioned in the course of this paper bear additional proof. On this point there is not much, if any, conflict of opinion. As to the history of the volcanic action to which these old terraces or sheets of lava owe their formation, there is not, however, perfect unanimity amongst geological observers, except, perhaps, in so far as that the lavas flowed out on a land-surface and not on a sea-bottom.

Professor Judd, who has devoted himself to the elucidation of this subject for a number of years, maintains that there is conclusive evidence of the eruptions of molten matter having taken place from certain great centres, comparable to Etna and Vesuvius of our own day, of which he locates and describes five—Mull, Skye, Rum, Ardnamurchan, and St. Kilda. He also affirms that there were three distinct periods of volcanic activity, separated by long intervals of time, in which the products of one period were very greatly denuded and altered before the outflows of the succeeding one took place.* These are—

* This volcanic activity began to be manifested in early, and continued with these intervals probably to later, Tertiary times. Prof. Judd has more recently, I believe, modified his views as to the intervals.

THE ISLAND OF EIGG

(REDUCED FROM THE ORDNANCE SURVEY MAP)

(1) Eruptions of lavas of intermediate composition, which Professor Judd formerly called "felstones," but latterly after careful microscopic examination, "propylites," a variety of the andesites, accompanied by agglomerates and other fragmentary ejections, the whole surrounding and lying on the flanks of huge masses of granitic rock believed to be the cores of the ancient volcanoes.

(2) Eruptions of augitic or basic lavas, comprising the dolerites and basalts, evidently closely related to the more coarsely crystalline gabbros which penetrate the granite.

(3) Minor eruptions resembling those from the "puys" of Auvergne, the lavas from these being of more or less acid composition.

Sir Archibald Geikie, who has also closely studied this subject, vigorously opposes Professor Judd's views both as to the manner in which the lavas were poured out and as to the sequence of the acid and basic lavas. He asserts that there is no evidence whatever of the lavas having flowed out of great central volcanoes. He believes that the outpouring took place mainly from great fissures in the rocky crust, in a manner similar to that in which the enormous sheets of lava on the Pacific slope, and the Deccan "traps," are thought to have been produced, and he points to the great basaltic dykes underlying the plateaux, or some of them at all events, as probably occupying the fissures from which the lavas welled out. The felstones of Professor Judd he considers to be simply the older basalts much altered or metamorphosed, and the granitic masses or granophyres to have unquestionably disrupted both the gabbros and the plateau-basalt, and so to be younger than them.

The controversy on this part of the subject is evidently not yet closed, but in Eigg there is not so much cause for difference of opinion as in some others of the Western Islands.

The geology of Eigg was described by Jameson, Macculloch, and Hay-Cunningham many years ago, but much has been learned regarding the island since their time. Hugh Miller's charming account of it in his "Cruise of the Betsey" will be familiar to all geologists. More recently it was examined by Sir A. Geikie with most interesting and instructive results, and his description, in the *Quarterly Journal of the Geological Society* for 1871, I have largely made use of in the following remarks:—

Eigg is about 5 miles long, by $1\frac{1}{2}$ to 3 miles broad, the highest point being scarcely 1300 feet above sea-level, and a hollow, running approximately north-west and south-east, divides it into two nearly equal portions. Hugh Miller not inappropriately compares its outline to that of two wedges placed point to point, with the Scur—presently to be described—perched on the thick end of the southern one. As already mentioned, it forms a portion of the Tertiary basaltic plateaux. In speaking of the plateau-basalts, I refer to the interbedded or contemporaneous rocks; distinct from these are the subsequent or intrusive sheets which I shall mention later on.

The whole series of rocks has been so tilted as to produce a slight southerly dip, and in consequence of this tilting a portion of the platform of sedimentary strata, upon which the basalts rest, has been exposed from the northern end to the middle of the island; their fossil contents show these strata to be of Jurassic age, belonging probably to the Middle and Lower Oolite. The lowest members are beds of limestone and shale, containing the teeth and bones of reptiles, teeth and scales of fishes, and molluscs. Above these lies a group of massive sandstones with plant and animal remains—these beds being in turn overlaid by another series of fossiliferous limestones and shales, notable amongst them the oyster bed at Laig. The highest member of the series is a soft clay, containing belemnites, ammonites, &c., which is found at the south corner of Laig bay, though, as the bed is almost entirely covered by the boulders of the beach, the former were the only fossils I could get out of it. Some of the sandstones exposed at Laig Bay are strongly calcareous, and contain huge concretions or “pot-stones,” from the degradation of which the well-known musical sand has been produced. The igneous rocks of the plateau rest unconformably upon these sandstones, limestones, and shales, as is clearly shown; for the basalts, having a much slighter dip than the stratified beds, are seen to lie across the edges of the latter. Failure to observe this fact partly led to the *basalts* being at one time considered of Jurassic age.

The southern half of the island is composed almost entirely of the plateau-basalts, which rise in more or less horizontal sheets to a height of about 1000 feet, and form a very fine example of the terraced slopes so characteristic of these Tertiary lava-flows. The

lowest lava-beds at this part correspond to the *topmost* beds in the northern half, consequently it is evident that the *upper* beds of the south end have been removed from the other end by denudation.

The rocks of which the plateau-beds are composed vary from a fine to a very coarse-grained texture. They belong principally to the basalt or dolerite group, and are often markedly amygdaloidal—the minerals commonly filling the cavities being natrolite, analcite, gyrolite, stilbite, pectolite, and chalcedony while others are porphyritic. One mass exposed on the shore, opposite the entrance to the well-known Frank's Cave—the scene of the massacre of Eigg—is of limited extent, and contains, in addition to crystals of labradorite, felspar, and little blebs of black olivine, very large crystals of a greenish plagioclase felspar, a variety intermediate between anorthite and labradorite, known as bytownite. It has been found by Dr. Forster-Heddlé in the gabbro at Hart o' Corry in Skye, but has not, so far as I know, been previously reported from Eigg. Another interesting rock is to be seen over- and under-lying a bed of rich analcite-bearing amygdaloid, adjoining the Scur, near Loch a Bhealaich. It is a heavy basic rock, and outwardly resembles picrite of which there are several examples in the adjacent island of Rum. A somewhat similar mass is to be seen underneath the eastern end of the Scur.

A notable feature of the plateau-basalts all over the island, but best seen, perhaps, along the eastern cliff of Beinn Bhuidh, is columnar structure, of which there are many beautiful examples, the columns varying from a few inches across to several feet. Sometimes they are vertical, at other times nearly horizontal, and often they occupy many curious intermediate positions. Intercalated bands or layers of a red clayey material—often very hard—are among the basalts, and vary in thickness from a mere parting common to several inches or even feet. They are considered to be the baked and hardened representatives of the soil which formed on the surface of the lava-beds in the interval between successive outflows. On the surface of some of the sheets exposed by the action of the sea at the south end of the island a very marked ropy-like structure is to be seen.

Interbedded with the basalts of the north end, and readily to be distinguished from them by its colour, is a thick sheet of pale

grey rock of more acid composition than the basalts, and which has been classed with the andesites, one of the groups of rocks of intermediate composition. This bed is well exposed along the eastern cliff of Beinn Bhuidh, and it emerges from underneath the overlying rocks about the middle of the island, consequently occupying a portion of the central hollow. Professor Judd mentions that he found other similar beds in the island. These rocks are of interest as showing that during the period of eruption of the basic lavas there were occasional outflows of more acid material.

There is a scarcity in the island of fragmentary volcanic rocks such as breccias, agglomerates, and tuffs, a fact referred to by Sir A. Geikie in one of his arguments against the theory explaining the outflow of the plateau-rocks through volcanic craters.

Of later age than the interbedded or contemporaneous lavas of which we have been speaking, but belonging, doubtless, to the same period of volcanic activity, are the numerous *intrusive* sheets or sills of similar rock which pierce alike the sedimentary strata and the overlying volcanic masses, and which are found most abundantly near the base of the interbedded series. The sandstones and shales at the north end of the island are greatly split up by these intrusive rocks—a marked alteration of the sandstone along the line of contact being observable, one of the principal tests by which we recognise an intrusive sheet. The material composing these sheets is on the whole finer-grained than that of the plateau-rocks, and the edges are more finely crystalline than the inner portions. Both series have, doubtless, been derived from the same fluid magma—the intrusive sheets being such simply because, owing to the great and increasing weight of the overlying masses, the liquid lava could not force itself to the surface so easily as it could make its way along the weaker planes of the various strata.

Numerous basalt-dykes run throughout the island, approximately in the same direction, *i.e.*, north-west and south-east. In many cases they are clearly younger than either the plateau-basalts or the intrusive sheets, as they often cut through both from top to bottom. They can be observed traversing the cliffs at various places, being beautifully displayed at Laig Bay, where they run out to sea in long straight lines. Frequently the sandstones through which they cut have, for a short distance from the line

of contact, been so baked and hardened as to resist weathering better than the dykes themselves, with the result that deep vertical gulleys have been formed; while occasionally, and generally where they are more or less closely crystalline, the dykes stand up prominently above the stratified rock. As a rule the dykes are more finely crystalline than the intrusive sheets, the contact edges often showing black glossy tachylite.

While speaking of dykes, I might say that, though the evidence which Professor Judd has brought forward to prove the former existence of great volcanoes in the Western Isles seems convincing, it does not appear to me unreasonable to suppose that, if the hundreds or thousands of fissures which exist in this area reached the surface at the time they were injected with the molten material now consolidated in them, enormous quantities of it may have been poured out thus.

The next series to be described contrasts strongly with those previously mentioned, the rocks belonging exclusively to the acid group, and being of later date than the basalts which they disrupt. Included in it are three intrusive masses now called by Sir Archibald Geikie "granophyric porphyry," a rock approaching the granophyres and granites found in the other islands. The largest exposed mass, which is at the north end of the island, is partly columnar, and is traversed by basalt veins, showing that all the latter are not of the same age. Another mass is to be seen near Laig road in a line with the farm, and with it occurs a vein of pitchstone, but, although there is apparently some relationship between the two, what it is is not clear. A third mass rises through the plateau-rocks below the Scur near Grulian.

At Rudh an Tangairt a very regular vein, or dyke, of material very similar in outward appearance to some of the masses just mentioned is seen traversing the dolerites of the plateau for a short distance. Where it stops a pitchstone takes its place, the junction being somewhat irregular. The portion of the fissure occupied by the former rock contrasts very strikingly with that occupied by the pitchstone, the one being very regular and the other quite the reverse. Another vein of pitchstone ascends the cliff a few feet west of the one already noted. These veins look at several places as if they had been fractured and then slightly displaced; and where this seems to have been the case, the partially

truncated ends have assumed a platy and somewhat friable structure. This structure is also seen in pitchstone occupying a cavity above one of the veins, of which it is quite clearly a detached part. Another pitchstone vein, very similar to the others, occurs near the harbour.

We now come to one of the most interesting rocks—the porphyritic pitchstone—of which that striking and scientifically-famous landmark, the Scur of Eigg, is mainly composed. This peculiar mass extends along the highest part of the plateau at the south end of the island in a nearly east and west direction for about $2\frac{1}{2}$ miles, and at its eastern extremity rises sheer from the plateau to a height of nearly 400 feet, presenting the appearance of a huge wall or dyke, which, indeed, some of the older geologists believed it to be. Professor Judd classes this pitchstone porphyry with the glassy form of the andesites. It contains large porphyritic crystals of sanidine, and also of plagioclase with small crystals of augite and magnetite. It corresponds in petrographical characters, according to Judd, with the rocks of the Tertiary dykes traversing the south of Scotland and the north of England. It is wholly columnar, and the different sets or beds of columns, arranged sometimes vertically, sometimes horizontally, and in many intermediate and curious ways, show, without doubt, that there were several flows. Associated with it are several bands of somewhat similar but much paler-coloured rock, which has been named felstone-porphyry, and is probably an example of the pitchstone devitrified. It sometimes contains much magnetite.

The rocks of the Scur are the latest examples of volcanic material in this area. They belong to Professor Judd's third period of volcanic activity, and are believed by him to have flowed out from a minor vent or "puy" similar to those of Auvergne, probably situated on the flanks of the great volcano of Rum. Evidence, however, to which I shall allude immediately, seems to prove that the position of this particular vent must have been elsewhere than in the island of Rum.

Between the last outflow of the basic lavas of the plateau and the first one of the acid pitchstone-porphyry of the Scur a vast interval of time must have elapsed, for the latter occupies the site of an old river valley hollowed out of the plateau. This is shown

by the fact that, in several places underneath the brecciated base of the pitchstone, gravelly material consisting largely of water-worn pieces of basalt, sandstone, quartzite, and clay slate, together with fragments of coniferous wood (*Pinites Eiggensis*) and larger masses of drifted material, is to be found.

There must therefore have been sufficient time between the outflows of the different classes of lava for the erosion of this old river valley to a considerable depth. The existence of the river-gravel under the Scur, first mentioned by Sir A. Geikie, is of great interest, not only in itself, but also from the bearing which it has on the time since the last of the lavas preserved to us flowed over these islands, a period geologically quite recent. The interval between then and now must be enormous, for when the pitchstone flowed into the old river valley the latter would be bounded on both sides by rising ground, as all valleys are, but this state of things has been entirely changed. The once higher ground on the south side of the old valley has been denuded away down to the base of the Scur, and from there, owing to the same cause, it now descends to the sea with a comparatively steep slope; on the north side the ground now gently slopes towards the central hollow. The Scur itself remains only because of the much greater resistance of its component material to the weathering influences. It should also be mentioned that the Scur is situated on the side of sloping ground, not exactly on a flat summit, and consequently at one place about 100 feet *higher* from the ground on the southern side than on the northern. This fact itself proves that there must have been much higher ground bounding it when the lava flowed out, which otherwise would not have remained in its present position.

As to the direction in which this old river flowed, the fact that the base of the Scur is much higher at the eastern than at the western end, and further, that a similar rock has since been found at a much lower elevation in the small island of Hysgeir, about 20 miles to the west of Eigg, leaves no doubt, I think, that it, as well as the lava which subsequently filled up the valley, flowed from the east, and not from the west. This is confirmed by the additional fact that pebbles of various rocks, which are found *in situ* only to the north and east, are present in the

gravel under the Scur. Here, then, is a further proof of the great denudation which has taken place, for the land, which once united what is now the island of Eigg to that from which the pebbles and blocks found in the bed of the old river have been derived, has been entirely removed. In short, to use Sir A. Geikie's own words *—"What were once hills have disappeared, and what used to be a valley is now the crest of a lofty hill. The pitchstone which, when it rolled down that ancient water-course, sought the lowest level it could find, rises to-day into one of the most conspicuous landmarks in the West of Scotland."

* "The Scenery of Scotland viewed in connection with its Physical Geology." [Sir] Archibald Geikie, LL.D., F.R.S., 2nd ed., 1887, p. 153.