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ORIGINAL ARTICLES.

I.—THE VOLCANIC HISTORY OF IRELAND.¹

Being the Anniversary Address delivered to the Royal Geological Society of Ireland,
February 11th, 1874.

By Professor EDWARD HULL, M.A., F.R.S., President;
Director Geological Survey of Ireland.

I HAVE the pleasure of congratulating the Society on its prosperous condition after an existence of forty years, during which time it has numbered amongst its members men of the highest distinction in Science, and has been presided over by some of the most illustrious amongst the cultivators of Geology. In looking over the names of the first officers of the Society in 1833, I am rejoiced to see those of the Provost of Trinity College, Sir R. Griffith, and Professor Apjohn, who are still amongst us; and to myself it could not have been otherwise than a matter of high gratification to have been elected to an office which has been filled by such eminent men as the former Presidents of this Society.

But more honourable to the Society than even the names of its officers are the large number of excellent papers, bearing, though not exclusively, on the Geology of Ireland, which are to be found in the pages of its *Transactions*. It is the merit of the contributions which must stamp the character of a Scientific Society; and amongst all the Geological Societies—that of London only excepted—there is none which has produced so large a number of excellent memoirs.

Other Societies—especially those of Glasgow and Edinburgh—are now treading closely on our heels; and I would, therefore, venture from this chair to urge upon our members a little increase of industry in the preparation of papers founded on observations over various parts of the country. The geological questions and phenomena of Ireland are far from being exhausted, and still present materials for the industrious observer. I would, also, observe, that the arrangements recently effected by the Council with the Editors of the GEOLOGICAL MAGAZINE afford authors of papers read before this Society rare opportunities of extended circulation. By that arrangement, all papers of merit, after having been read before the Society, and approved by the Council, will appear in the pages of the GEOLOGICAL MAGAZINE, and subsequently in those of our *Transac-*

¹ Plate X., illustrating the Volcanic History of Ireland, will accompany the concluding part of Prof. Hull's Address in the next Number.—EDIT. GEOL. MAG.

tions; thus guaranteeing to them the advantages of almost a double circulation.

Amongst the papers which have been read during the year 1873-4, I may be allowed specially to mention those of Colonel Meadows Taylor "On the Coal-fields of Central India," that of Dr. Mackloskie "On the Fossil Wood of Lough Neagh," that by Dr. Macalister "On the *Charopsis Hibernicus*," that by Mr. Hardman "On the Occurrence of Zinc in the White Chalk of Tyrone," and by Mr. Meadows "On the Leinster Coal-field"; and I take this opportunity of acknowledging the gift to the Society of a mounted sheet of "Griffith's Geological Map of Ireland," presented by our valued member the Rev. Maxwell Close, F.G.S.

In addressing you this evening, I have ventured to select as my subject, "The Volcanic History of Ireland," but shall preface what I have to say by a few preliminary remarks on the general characters of volcanic phenomena.

The earthquake and volcanic history of individual countries is one full of interest to the physical geologist. This history has been ably written in the case of Scotland by Professor Geikie, and for our own country it seems to be a subject not unsuited to the present occasion. It is, perhaps, less difficult to decipher the characters in which are inscribed the volcanic, than the seismic (or earthquake) history of any special region; for earthquakes, although generally, are not exclusively, confined to volcanic districts, and often pass over without leaving any traces of their action. The existence of faults, or displacements of the strata, are not always to be relied upon as indicating former earthquake action; and owing to the rare cases which have come under actual observation of the production of faults and their connexion with earthquakes, we are not in a position to speak dogmatically regarding their relationship. If volcanic action, during any special geological period, were necessarily connected with, or accompanied by, earthquake movements, and these again with faults in the strata, it would be impossible to account for such cases as the Carboniferous volcanic district of Limerick, in which faults are comparatively rare; or the more recent case of the north-east of Ireland, where most of the lines of fracture are of later date than the consolidation of the great sheets of lava themselves. In a word, whether we regard the Lower Silurian volcanic region of North Wales, so ably illustrated by Sedgwick and Ramsay, the west of Ireland, the Carboniferous volcanic regions of the south of Ireland or centre of Scotland, or the Miocene volcanic districts of the north of Ireland and west of Scotland, we are equally impelled to the conclusion, that the main lines of fracture are totally unconnected with the volcanic products, and belong to periods either preceding, or subsequent to, those of volcanic activity.

In attempting to determine those periods in the past history of our globe in which volcanic phenomena have been prevalent, and the districts in which the products of volcanic action have been developed, we must guard ourselves against an error of observation

into which we might be liable to fall by observing merely the greater or less proportion of igneous rocks in each case. There may be formations penetrated by numerous sheets and dykes of trap rock, none of which can properly come under the head of "volcanic," and which, therefore, present no true marks of contemporaneous volcanic action. Dykes of trap of an irruptive (or intrusive) character may belong to a geological period different from that of the strata in which the dykes occur; and it is often exceedingly difficult to determine their true age. Even in the case of sheets of trap, unless very careful observations are made regarding their relations to the strata which inclose them, much caution is required in determining the question whether they are volcanic or plutonic, or as the late Professor Jukes used to say, "eruptive or irruptive." While no truly intrusive rocks can be properly called "volcanic," it is clear that all volcanic rocks are to some extent intrusive; for wherever they occur in sheets amongst the sedimentary strata, they must in some part of their extension pass vertically or obliquely through the strata which are in course of formation. Such truly volcanic lavas may therefore present evidences of intrusive action amongst the beds which underlie them; but we may feel sure that the beds which rest upon them, belonging to the same formation, will be not only undisturbed, but remain generally unaltered in physical constitution.

But the most reliable phenomenon to guide the observer in determining the question whether or not true volcanic action has left its traces upon any formation, is the presence of beds of ashes, agglomerates, or other volcanic *ejecta*, which have been blown out of submarine or sub-aerial vents, and have subsequently become interbedded with the strata. For, while it is true that such accumulations may not necessarily be present at all times amongst volcanic rocks of different formations, they are, doubtless, very general accompaniments; and whenever they do occur, we may safely conclude that we are in the presence of truly contemporaneous volcanic rocks; that is to say, rocks which have been ejected in a liquid or fragmental state during the period of deposition of the strata in which they are found.

But, before entering on the consideration of the successive periods of volcanic activity in Ireland, one or two observations regarding the use of the term "volcanic" may not be unnecessary, in order to guard against misconception of my meaning. The term is generally exclusively applied to designate those rocks, consisting of various kinds of lava, ashes, scoriæ, etc., which are now from time to time being poured forth or blown out of active volcanos, or those which, like Auvergne and the Eifel, have become extinct in Post-Tertiary times. We have, therefore, *active* volcanos and *extinct* volcanos, with their respective lavas, etc.; but there seems no good reason why the term should not also be applied to those products of internal igneous action which have been erupted during the formation of Cainozoic, Mesozoic, and Palæozoic rocks, and which are found interstratified with them. And as there are at the present day both sub-aerial and submarine volcanos, so, doubtless, there were in the past;

and geologists are now becoming familiar with such expressions as volcanic rocks of Silurian, Carboniferous or Permian periods, and which, from the necessity of the case, must chiefly be the representatives of the sub-marine or sub-lacustrine classes of volcanos.

Guided, then, by such principles of determination, let us endeavour to review in the order of succession the periods which in this country present us with unquestionable evidences of volcanic activity, and we shall consider them under the three great divisions of geological time, the Palæozoic, the Mesozoic, and the Cainozoic or Tertiary.

Palæozoic Epoch.—The oldest rocks represented in Ireland—the Cambrian beds of the east coast—present us with no evidences of contemporaneous volcanic activity; but when we ascend into those of the Lower Silurian period, we have numerous examples of volcanic rocks in several parts of our island where these formations occur. Throughout the range of these beds in the counties of Wicklow, Wexford, and Waterford, there are numerous sheets of felstones and porphyries accompanied by beds of ash and volcanic breccia, interstratified with the slates and grits which for the most part make up the Lower Silurian rocks of those districts. These contemporaneous traps are referable to the acidic felspathic, or highly silicated felstone group; and amongst them are outbursts of hornblendic rocks, or diorites, as well as a few melaphyres, which are of intrusive origin and later date than the felspathic rocks themselves. The districts of Stradbally and Kill, near Waterford, seem to have been foci of volcanic action. Similar beds of porphyries, felstones, ashes, and agglomerates are of frequent occurrence in the Silurian district north of the valley of the Boyne, but become less frequent in the districts of Down, Armagh, and Cavan. As all the fossils yielded by these Lower Silurian rocks are of marine origin, we must suppose the whole series to be marine; and we may therefore infer, that the volcanic rocks of the period were erupted from vents sporadically breaking out over the sea-bed of the period, and either pouring forth sheets of liquid lava, or vomiting out masses of fragmental materials which were strewn over the bottom, and were in turn covered over by fresh sediment.

It is interesting to observe that these rocks are the representatives of those great sheets of felstone and porphyry which rise into the lofty escarpments of North Wales, and which have been so ably described by Sedgwick, Murchison, and Ramsay; and I am informed that the late Professor Jukes, when engaged with Mr. Du Noyer in mapping out these beds over the Silurian district of the south-east of Ireland, was constantly struck by the marked resemblance of the old volcanic rocks of this district to those with which he had become familiar amongst the mountains of Snowdon, Moel Wynn, and Cader Idris.

Contemporaneous trap-rocks being so abundant amongst the Lower Silurian rocks of the east of Ireland, where they are generally unaltered, it can scarcely be doubted that they are also represented

amongst the beds of the same great series in the west and north-west of the island, where they have undergone, for the most part, various degrees of metamorphism. In the Galway district, Mr. Kinahan considers that such rocks may be recognized amongst the hornblende schists of the metamorphosed districts;¹ but while the general conclusion may be admitted, the great amount of alteration which these rocks have undergone, together with their structural complications, renders actual determination in special cases somewhat uncertain.

The Lower Silurian period may, therefore, be considered as having been one of great volcanic activity in this country, as well as in Wales and Cumberland; the products being, for the most part, felspathic and highly silicated, and such as were erupted at various points over the bed of the sea.

Upper Silurian Period.—The Upper Silurian rocks are not very largely represented in our island; nevertheless, they present unmistakable evidences of contemporaneous volcanic action. Nothing can be more conclusive on this head than the phenomena observable in the mountainous region of West Mayo and Galway. Here, on ascending the flanks of Muilrea from the north shore of Killary harbour, we cross over the edges of great beds of grit, slate, and conglomerate, alternating with others of quartz-porphyry, each bed capped by its covering of volcanic ash; as if showing, that after each successive outpouring of lava, there had been a grand eruption of fragmental materials from the volcanic vents. In all probability these vents, like those of the Lower Silurian period, were submarine, nor is there any very marked distinction in the general character of the volcanic products.

Another district of volcanic action of this period is that lying along the western shores of Lough Mask, where beds of felstone, quartz-porphyry, felspathic ashes, and agglomerates are associated with fragmental strata, supposed to belong to the Upper Llandoverly series, but which may also represent the earlier stage of the Muilrea volcanic rocks.²

The Promontory of Dingle, where it projects into the Atlantic Ocean, together with some of the Blasket Islands, affords evidence of having been another district of volcanic action during the Upper Silurian period. Great beds of ash, agglomerate, and a few of trap form the coast from Clogher Head southwards, for a considerable distance, and again are found at Beginish, Young's, and Inishvickillane Islands, and have been carefully laid down on the maps of the Geological Survey by the late Mr. Du Noyer.³ The thickness of these volcanic products has been estimated by the late Professor Jukes at 2,500 feet, and they are interstratified with sedimentary strata richly stored with marine fossils of the Wenlock stage. As the beds of felstone and ash of Muilrea probably correspond to this

¹ Mem. Geol. Survey, Explanation Sheets, 105 and 114.

² See Geological Survey Map, Sheet 85.

³ Sheet 171. See "Explanation" of Sheets 160, 161, 171, etc., by Messrs. Jukes and Du Noyer, pp. 12, 46, etc. (1863).

period, we have evidence of at least two centres of volcanic activity in the west of Ireland during the Upper Silurian period, which, for all we know to the contrary, may be but representatives of vastly more extended volcanic regions spreading either beneath the ocean, or beneath formations of more recent age on the land.

Old Red Sandstone Period.—The Old Red Sandstone presents us with several examples of contemporaneous volcanic rocks, both in the northern and southern districts. In the neighbourhood of Boyle, in Co. Roscommon, there occurs one or more beds of consolidated ash, interstratified with the red and purple sandstones and conglomerates of that formation.¹ In the southern district, one of the most remarkable and well-known cases is that which occurs amongst the Killarney mountains, south of Lough Guitane, and which has been admirably illustrated by the pen and pencil of Mr. Du Noyer, under the direction of Professor Jukes. Here, at Benaunmore, a bold rock reaching an elevation of 1,490 feet, a mass of columnar felstone indicates the position of an old "neck" or volcanic throat, from either side of which stretch, for considerable distances, beds of felspathic ash and agglomerate, with large "balls" of felstone, often hollow in the centre, which were probably bombs, shot out of the vent at various stages of eruption.² These beds of ash re-occur at Lough Garagarry, Lough Managh, and the Devil's Punch Bowl, to the west of Benaunmore, and rise into the summit of Crohane (2,162 feet), and the southern slopes of Killeen mountain on the east.³ To the south of this, there is another district, containing contemporaneous trap-rocks, forming the cliffs of Cod's Head and Dursey Island, at the mouth of the Kenmare river.³

The shores of Lough Kay and Valentia Harbour present to us another striking instance of a volcanic centre of eruption during this period. Beds of greenstone, felstone, ashes, and agglomerates are here associated with those of Old Red Sandstone, and pierced by numerous dykes.⁴

(To be concluded in our next Number.)

II.—ON THE TERTIARY BRACHIOPODA OF BELGIUM, ETC.

By THOMAS DAVIDSON, F.R.S., F.G.S.

(PLATES VII. AND VIII.)

IN the seventh volume of the GEOLOGICAL MAGAZINE I gave a description, accompanied by illustrations, of all the Brachiopoda then known to me from the Tertiary formations of Italy. I would now offer some notes and figures relative to those that occur in Belgium.

In order to be able to do justice to the subject, Messrs. Dupont and Nyst kindly forwarded me for examination the best examples preserved in the Museum of Brussels, and I am likewise indebted to

¹ Messrs. Jukes and Foot, Journ. Geol. Soc. Ireland, vol. i. part 3, p. 249.

² Maps of the Geological Survey, Sheets 184, 185, with "Explanations."

³ *Ibid.* Sheet 198, with "Explanations," pp. 8, 17, etc.

⁴ *Ibid.* Sheet 182, with "Explanations," p. 26.