XX.—A German Professor's Views *of the* Geology *of* Arran, *translated from* Prof. A. von Lasaulx's "Aus Irland," Bonn, 1878, with Remarks, by Edward A. Wünsch, F.G.S.

[Read 5th December, 1878.]

First Part.

[A visit by Professor A. von Lasaulx, of Breslau, to the Glasgow meeting of the British Association in 1876 has resulted in a book entitled as above, recording chiefly the geological investigations of the author in Ireland, where he made a more lengthened tour under the guidance of our late Vice-President, the present Director-General of the Geological Survey of Ireland, Professor Edward Hull, to whom the book is affectionately inscribed; but the two last chapters are devoted to the geology of Scotland. In his introductory remarks under this head the author is full of graceful acknowledgments, and has a word of praise and thanks for every one from whom he derived information, printed or oral. In connection with the geology of the West Coast and of Arran, honourable mention is made most prominently of the members of the Geological Society of Glasgow, and Messrs. Armstrong, D. Robertson, Young, Thomson, and Wünsch are each quoted and thanked in turn for the information supplied. For general geology Professor Geikie's "Geology of the British Isles," so far as it relates to Scotland, seems to have been the author's chief guide, and the views of the Director-General of the Scottish Geological Survey are endorsed, or, at all events, not controverted in any essential point. In the first chapter, relating exclusively to the geology of the mainland, Professor von Lasaulx does not advance any special theories of his own; in the second chapter, however, devoted exclusively to Arran, the authorities are not so numerous, and the author seems to have carried out his personal investigations with peculiar vigour. Dr. Bryce is quoted here and there, but the author does not seem to have derived much satisfaction from his views, and is not long in brushing them aside, and in advancing a theory of his own in place of them. In this theory the chief interest of the book centres, so far, at least, as our Glasgow geologists are concerned, and I propose accordingly to give a careful translation of this portion, merely premising that the preceding

chapter contains a masterly review of the geology of the west of Scotland, a translation of which may be of interest at some future time.]

The island of Arran has been much visited and much described by geologists, and many English, French, and German travellers have investigated the district, so that it might be thought another visit would not readily disclose any facts not hitherto observed.

But Arran is in a certain sense inexhaustible, and thus also occurred to us, during a short visit to this beautiful island, various considerations as to its geological structure and outlines which might open up some new points of view, offering a more easy solution of its complicated and not yet readily understood geological details than has hitherto been presented. Arran may truly be described as a portal of honour placed at the entrance to the beautiful shores of the Clyde.

Starting from Rothesay, and sailing past the south end of Bute into the expanding estuary of the Clyde, the beautiful profile of Arran, stretching from north to south, lies right before us. At the first glance, this profile discloses to us a portion of the interesting geological structure of the island, upon which structure is also based the secret of its picturesque outlines. The island presents itself in two aspects, entirely different in their forms of relief—on the right, the high, sharp, serrated granite peaks, on the left, the lower, almost wall-like, elongated backs of the Old Red and Carboniferous formations, covered by the newer eruptive rocks.

The northern or higher part of the island has entirely the character of wild highland mountains, whose jagged peaks are surrounded by steep, almost perpendicular gullies. The whole region may be divided into two separate chains, running parallel north to south, separated to the south by the deep Glen Iorsa, and to the north by Glen Eais-na-Vearradh. The eastern chain is not so distinctly articulated as the western. It consists of an irregular group of granitic peaks, chiselled out of one massive granitic structure by powerful erosion. Amongst these the highest is Goatfell, the landmark of the island, raising its proud head 2866 feet above sea-level; the next highest peak is Caistael Abhael, lying to the north-west of Goatfell, and between the two the peak of Cior Mhor rises to the height of 2618 feet. The western chain has entirely the character of a regular mountain chain, but has no such considerable heights as the eastern one. Meal-nan-Damh

reaches only 1870 feet, and the heights rising from Glen Iorsa only 1500 feet.

What has chiefly made Arran interesting to and famous amongst foreign geologists are its trap dykes, and still more so its pitchstones—that vulcanic glass in which the most wonderful formations of slags (glassy slags) of our furnaces are foreshadowed (typified) in such a manner—but rarely repeated in such perfection in other rocks—that these analogies lead to the irresistible conclusion as to the plutonic origin of this rock. Numerous descriptions have made known to us the beautiful fern-like tufts, the brocoli-like bunches, and the neat snow-crystal-like groups in which embryonic crystalline spikelets of augite are aggregated in these pitchstones. The geological position of these pitchstones is of great interest, too, and their study was the chief object of our excursion to Arran. The most favourable appearances of pitchstones, which are everywhere in close local connection with quartz porphyry, and hornstone-like dense felsite, are, on the east coast of Arran, near Clachland Point, and on the west coast, south of Tormore, at Drummadoon Point—also in dykes on the shore near Brodick. To the first of these points, which can be visited from Brodick comfortably in two to three hours, we now turn, and with it can be combined usefully on the return journey a ramble along the coast, which is crossed by dykes in every direction.

Ascending the road at the back of Brodick pier, we reach the terrace leading to the heights of the Dundhu range, a rounded, elongated range of hills, averaging 600 to 700 feet in height, superimposed upon the sandstone terrace which bears the fruitful fields and pastures of Corriegills. The highest point of this range is Dun-fion hill, and the northernmost end of the ridge projecting steeply into the sea is Clachland Point.

And here we are at one of the points at which the classical pitchstones of Arran are to be seen to the greatest advantage.

Proceeding at the back of the Corriegills farms, along the Dundhu range, towards Dun-fion, a series of rocks is traversed, the profile of which has already been given by Dr. Bryce, although in a somewhat greatly-idealized diagram. [See "Arran," page 80.]

Nethermost are the conglomerates and sandstones of the Upper Old Red. The highest layers of these sandstones appear at first sight to be separated by conformably intercalated beds of quartz porphyry and pitchstone, so that, according to Bryce's profile,

counting from below, the following almost horizontal beds overlie each other:—Sandstone, quartz porphyry, pitchstone, sandstone, pitchstone, and uppermost, basaltic trap, so that we might in effect believe to have before one's eyes a regular mass of strata made up of a series of sandstones and pitchstones.

[This view is controverted by the author at greater length than it may be convenient to give it here, so I omit it.]

The two pitchstone dykes, of about equal thickness, of from 13 to 14 feet, can be followed pretty far down the cliffs. The appearance of this rock must be familiar to all; but what is striking about it is a very plainly-marked parallel, sometimes slatey, fracture, which makes it difficult to get good hand specimens out of the brittle material. This thin-plated fracture is, however, not the same in all places. Following the southernmost dyke in its downward course, it can be traced, with some interruption where it is covered by vegetation, down to the sea-shore.

Descending now from the upper sandstone terrace of Corriegills down to the conglomerate beds which form the sea-cliff proper, a walk along the foreshore, bounded by the massive walls chiselled out of the sandstone, and extending as far as Brodick, affords an excellent opportunity of obtaining an idea of the almost innumerable dykes which here everywhere intersect the strata of the Old Red. In the short space of about 4½ miles from Clachland Point to Invercloy hotel about 60 may be counted, mostly greenstone and basalt; but the microscopical examination of which will probably disclose further petrographic differences. Interspersed between them there also appear very massive dykes of quartz porphyry and of dense felsite, as well as the dykes of pitchstone already referred to.

At the edge of the terrace the (trap) dykes are seen rising like chimneys. On the level shore they mostly form straight massive furrows or wall-like prominences, according as the rock may weather more quickly or more slowly than the surrounding layers of Old Red. The dykes can be followed by the eye below sea-level, and at low tide there is a matchless geological exhibition prepared by the waves themselves with an infinity of toil. And still this richness in dykes is not peculiar to Arran. It is only a repetition of the same occurrences which we noticed in Ireland at Belfast, and in Scotland along the shores of the Clyde; but the grander exposure in Arran conveys a stronger impression of the picture.

Not less interesting than this southward wandering is an excursion from Brodick hotel to the north.

Long before the terrace on which the castle stands is reached, a whole series of dykes has been traversed, amongst which must be mentioned the pitchstone dyke at the schoolhouse at Brodick—possibly a continuation of the Corriegills dykes.

But the special interest of an excursion farther north along the coast is connected foremost with the appearance of a rich series of beds of the coal formation, and of beds of volcanic ash included in these. Especially north of the "Fallen Rocks"—an old massive slip of a mountain side of blocks of Old Red—have these beds chiefly become known by the investigations of Messrs. Wünsch, Young, and Thomson.

[And here I may be allowed to skip a certain portion of the original text as relating to myself, and in fact taken—of course with full acknowledgment—from the *Transactions* of our Society.]

From Lagantuin Bay forward to the north end of Arran—the Cock of Arran—where the red sandstone, formerly considered New Red, occurs again, there is laid open a series of beds, consisting alternately of layers of limestone, calciferous sandstones, shales, thin seams of coal, so-called ash-beds, and variously composed breccias and conglomerates, in which the fossils of the various stages of the Coal formation are found. The ash-beds—which, according to their petrographic character, we should prefer to designate diabasic tufa—lie everywhere intercalated conformably between the sandstone and shales of the series, and are in part distinguished by the numerous remains of plants, and also of fish, contained in them.

One of the best points for their study lies somewhat south of Lagan, in the neighbourhood of which large slate quarries are laid open. This is the point to which, in particular, Mr. E. A. Wünsch's discoveries have lent interest. Here he found, in the year 1865, in these greenstone-like ash-beds—to retain his own expression—numerous stems and branches of trees. The more particular botanical definition and description have been afterwards supplied by Mr. Binney, of Manchester. The beds—alternately sandy shales, thin seams of coal, and peperino-like tufa—are inclined at an angle of 30° to 60°; the trunks, of which 12 to 14 have been found, stand horizontally upon the plane of the beds, and are rooted in the earthy layers of the shale, several series of trees overlying each other. The branches and leaves are excellently

preserved. We saw the finest of the specimens in the collection of Mr. Wünsch in Glasgow. They are *Sigillaria*, *Lepidodendron*, *Halonia*, *Sphenopteris* and other ferns. A new species of *Lepidophloios* has, in honour of the discoverer, received the name of *L. Wünschiana*.

Undoubtedly the beautiful geological profile presented by this portion of the shore offered an excellent illustration of the alternation of geological events by which these strata were formed. To quote the words of the discoverer, "Slowly the volcanic ashes enveloped the plants growing in low marshy ground." Such occurrences were repeated throughout the whole immeasurable time of the Coal formation—for the alternation of sandstones and limestones, some of them containing the thoroughly characteristic and extremely well-preserved fossils of this formation, as well as the intercalated volcanic ash, extends, as already stated, from Lagantuin Bay to the Cock of Arran—so that from this the thickness of the Coal formation of Arran, chiefly of the lower series, may be estimated as exceeding 6000 feet. But numerous elucidations will not be required as to the connection and true position of the many single series extending along the north coast of Arran. And here it will be of special importance to remain mindful of the probability of various faults, or upthrows and downthrows, which, according to the views we have developed as to the general structure of Arran, are extremely probable. Thus, already the red sandstones of the Cock of Arran, formerly held to be New Red—Bunter-sandstein—as they appear to overlie the Carboniferous strata, have been recognised as true Old Red, and are marked as such on Geikie's new map of Scotland. Therefore this spot affords a clear example of an apparently reversed succession of series, for the strata underlying these red sandstones are by their fossil remains very decidedly characterised as Lower Carboniferous limestone. Thus, the whole west coast of Arran—at which only a short peep was allowed us—as also to a certainty the whole island, offers still a rich field for geological labour and investigation.

Thus, when we stepped on board the magnificent screw-steamer "Arbutus"—which had brought many hundred guests of the Meeting of the British Association to Arran, and by the return of which we profited—and when the evening sun showed to us in splendid illumination the curious shapes of the Paps of Jura wrapped in distant purple glow, and as we gave a last look at the

lovely island, as it was gradually veiling itself in its evening mists; then, in bidding it farewell, we united with our adieux the wish and hope of *au revoir*, for no one would like to think that he shall have seen Arran for the last time.

Second Part.

[I have somewhat transposed the order of contents of the original chapter, and I have reserved for the Second Part the specially-interesting remarks of the author respecting the granitic, and, indeed, the general structure of Arran—the First Part being merely descriptive and introductory, and what now follows being intended as the kernel of my paper. The author, literally translated, writes on this subject as follows, p. 222].

What has most occupied English geologists, and has appeared to them as most striking and remarkable in the structure and distribution of the rocks of Arran, was the abnormal, one might say the eccentric, position of the granitic masses in the northern portion of the island. In connection with this it was always assumed as though the granite, breaking through, had been the upheaving cause—the force that had uplifted the island on its shoulders. We have already seen by examples in Ireland, following the indications of Continental mountain chains, that this upheaving force is not in any sense to be understood as a radial force, working from below upwards. If here also, in place of this protrusive raising force, we assume a sideward pushing tangential effect of pressure, then the eccentric position of the granite in itself has no longer any meaning; and that the peculiarities of mountain structure in Arran fit into the assumption of elevation produced by tangential pressure is brought out more particularly when we consider this island not as an isolated unit by itself, but in connection with the rest of Scotland and the opposite coast of Ireland. The remarkable and uniform direction of the mountain chains and of the strike of the strata from S.W. to N.E., which we have found everywhere prevailing in Ireland, is also continued in like manner in Scotland. A line drawn from Belfast Lough to the Scottish coast, exactly in the bearing of S.W. to N.E., will strike straight upon the boundary line between the massive beds of Silurian strata and the old crystalline schists which extend from Money Head, on the peninsula of Rhinns of Galloway on the west coast, to St. Abbs Head on the east coast. North of this zone lies the district of the sedimentary

formations from the Old Red downwards, principally the Carboniferous formation and its associated massive trap rocks, which reach from the neighbourhood of Glasgow to the hills around Edinburgh. In Ireland, north of the Silurian strata in Lagan Glen, lie the basaltic formations of County Antrim. According to their position these could therefore be held to be the equivalents of the beds between the Firths of Clyde and Forth—that is to say, they correspond in direction to one and the same area of depression. If we now again draw a line across to Scotland, farther north-west from the boundary of the old crystalline schists and the younger formations at Lough Foyle, this takes us exactly to the boundary of the sedimentary strata of the Old Red of the neighbourhood of Glasgow, and abutting against the northern-lying Silurian formations. The old crystalline schists of Donegal, lying north-west of Lough Foyle, in which may also be included the portions in the north-west corner of County Antrim, correspond therefore to the Silurian formations of Kintyre, Argyllshire, and the Grampian mountains, which they almost literally touch in the N.E. point of Antrim.

Thus we obtain a tolerably clear view of the connection of geological structure between the north of Ireland and Scotland. It shows to us that the two countries correspond perfectly—that from south to north there is an even succession of the gigantic folds of the old surface dividing the country into ridges and valleys. Thus the level plain of the Carboniferous limestone in the centre of Ireland corresponds to the Carboniferous limestone of Northumberland. The zone of the Silurians and of the granites of the Mourne mountains corresponds to the zone of the Upper Silurians between Money Head and St. Abbs Head. The series of the Antrim beds, with its eruptive rocks overlying here also the Carboniferous formation, corresponds to the whole series of formations between the Clyde and the Forth; and finally the Silurian schists of Donegal, described as metamorphic schists, correspond to the Lower Silurians of Kintyre and of the southern Highlands of Scotland. With regard to these latter, it certainly may be inferred that the crystalline schists of Donegal and 'Derry, marked in the map of Jukes as metamorphic series, may also belong in part to the Lower Silurian, although this has not yet been so definitely fixed as has been possible on the opposite coast of Scotland. If we then distinguish these two zones of Silurian rocks and of old crystalline

schists, on which we here lay particular stress, and which, to adopt a compound geographical name, we might call the *Donegal-Argyllshire* folds or ridges, and the *Lagan-Dumfriesshire* ridges, we find that within these two zones there are embedded in a remarkably uniform manner large masses of granite.

Those in Ireland are the extensive granitic mountains extending from Gweebarra Bay on the west coast to the outflow of Lough Swilly, and to these in Scotland correspond the numerous granitic masses which succeed each other from the Firth of Lorne across to Kinnaird Head, and have their greatest extension in the east in Aberdeenshire. In the southern zone it is in Ireland the granitic mountains of Mourne, and in Scotland those of Kirkcudbright.

All these granites come to the surface in more or less elongated elliptical patches, and adjoin each other in a direction parallel to the general strike of the large mountain folds (the large $\wedge$ ridges and $\vee$ troughs of the mountains). In other words, the granites lie upon lines at right angles to the lateral pressure which has produced these folds.

Thus the appearance of these granitic masses at the surface is probably to be accounted for (simply) by the violent compression of the old Silurian strata covering the granites, and by their extraordinary folding, and the complete shattering and bursting open of the folded domes—thus laying open the underlying granites. Later on, by means of powerful and long-continued erosion, the granite became more and more detached from its surrounding envelope and was laid bare in high pointed peaks. Nowhere can the granite be looked upon as the lifting power, but it was itself pushed and raised up along with other rocks.

All these considerations may be summed up in a few words to the effect that a force pushing in a north-westerly direction, and meeting with resistance in a direction from the south-east, induced an upward and downward folding (or undulation) of the surface. The upraised parts (or $\wedge$) are seen in the Silurian districts which have not been covered by later formations, while the depressed or sunk parts ($\vee$) were filled up subsequently, more or less completely, by the whole series of sedimentary formations, which in two distinct repetitions are seen spread out in tolerable uniformity between these two uprising Silurian folds from the south of Ireland to the north-east point of Scotland.

Thus one could easily sketch a profile of the characteristic wave-

lines common to both kingdoms, the one-half of which would be represented as near as may be by the profile [p. 202].

These considerations, then, prepare the way for the understanding of the mountain structure of Arran. Right through the centre of the island runs the boundary line between the old elevated fold, or ridge (anticlinal axis), which we have designated as the Donegal-Argyllshire ridge, and the sunken area (or synclinal trough), which has received the sedimentary formations between Clyde and Forth. In the northern part of Arran a mighty mass of granite has been laid bare from between the shattered Silurian schists that lay round about like a cloak. Hence the position of the granitic mass in the northern part of the island is not "abnormal," and has nothing to do with the shape of the island. Hence the granite is not a "mineral axis" [*vide* Bryce's Arran, p. 6]—a designation to which I cannot attach any correct meaning; it is only the projecting portion of the ridge which extends uniformly over the whole of Scotland as far as the east coast. Thus also the structure of the southern part of Arran is entirely in conformity with the opposite district of Renfrewshire, where the Old Red and Carboniferous series follow each other from north to south precisely as they can be followed between Loch Katrine and the Campsie fells. The line, which may be drawn as the boundary line between the raised and the depressed portions of Arran, begins opposite in the Mull of Kintyre, goes straight through Glen Iorsa, and thence bending somewhat northerly to the Cock of Arran, cuts straight across to Rothesay, which likewise is situated on the boundary between the Silurian schists and the younger sedimentary formations, consisting here of the Old Red Sandstone. Thence the boundary line runs in a north-easterly direction almost straight across Scotland as far as the bay of Stonehaven.

That the structure of Arran and the position of its granites is to be taken in this sense may perhaps be further best evidenced if we take one of these granitic masses lying near the southern edge of this Silurian zone, and look upon it as a detached insular mass. We then have an island, the structure of which is in conformity with that of Arran. North-east of Comrie lies the granitic peak of Ben Chonzie, 3048 feet high. If we draw around it an ellipse, extending southward into the Old Red district, and imagine this to be an island, it would show us the exact structure of Arran; like it, there would be an elevated northern granitic portion, sur-

rounded by Silurian schists, and in the south the sedimentary basis of the Old Red, with its superimposed eruptive rocks. The position of Comrie, on the boundary of the southern area of depression, is of particular significance, inasmuch as the neighbourhood is subject to numerous and quickly-recurring shakings of the ground, which prove the continuance of the movements of the earth's crust upon this line up to our time. Thus the great variety in the geological positions in Arran is not a peculiarity, as has been hitherto maintained in all descriptions of it; for if the variety is an effect of the boundary line between the raised and the sunk areas running across the centre of Arran, it cannot be admitted to be the effect of a peculiar abnormal position of the granitic nucleus. It does not correspond in the remotest degree to the assumption which attributes the structure of the island to the breaking out of a massive body of eruptive rock, such as the granite is said to be, along the line of junction of the older schists.

In fact, in Arran are repeated the same circumstances (or geological positions) which have been observed along the boundary lines of sunk areas in other districts; hence, along this boundary line the steep and partially-upturned position of the sedimentary rocks, as observable in the northern part of Arran; hence, also, the great mass of younger eruptive rocks which abound in the sunken area of Arran in every direction.

Thus Arran, surrounded by the sea, has in a manner remained as a connecting link between Scotland and Ireland to show that, geologically speaking, no rolling channel separates the two countries. And, as thus it proves most effectively its geological connection with the opposite shores of St. Patrick's Channel, so, on the other hand, the peculiarities of its structure can only be understood when the island is taken, not as a separate, independent area, but is looked upon as an integral part of the whole geological structure of North Britain.

Third Part.

[In making a few remarks upon the foregoing subject, I would beg of you to bear in mind that, with the exception of some introductory remarks of my own, every word of the foregoing—descriptive and explanatory of Arran and its granites—is a translation of Prof. von Lasaulx's paper, purposely kept as literal as possible to do every justice to the author.

Throughout his paper Prof. von Lasaulx never once propounds any theory of his own as to the origin of the granites, nor any mineralogical or chemical theory in connection with such origin. He confines himself strictly to describing the stratigraphical position of the granite, and the only theory he advances is what may be called the physical or mechanical one—namely, that the present surface appearance of the Arran granites is not to be taken as an isolated occurrence, but is only one example of a series of appearances extending over a great portion of Scotland, and across and under the Irish Channel into Ireland, in the shape of gigantic ridges or folds—wave-like swellings of the earth—with alternating elevated crests or anticlinals, and correspondingly depressed troughs or synclinals, running in parallel lines from N.W. to S.E.—the upper surface mostly covered by Silurian rocks, but the granite laid bare here and there in large elliptical patches, a typical example of which is offered to us by the group of the Arran granitic mountains. Now, when we look at the geological maps of Scotland and Ireland, we are bound to admit that, so far as external appearances are concerned, the author's description is correct, and that he has succeeded in bringing before us a splendid generalisation, supported by close reasoning and by reference to actual positions on the map, and the whole more clearly and more powerfully expressed than has been done by any previous writer. In fact, the stratigraphical position of the granites, as laid down by the author, is unassailable, and, like a prudent general in advancing into the open field, he lays himself open to the least possible attack by advancing only one single theory—which is, that the present appearance of the granites, and of the overlying schistose rocks, running across the country in enormous parallel waves, *is due to lateral pressure.* Had Prof. von Lasaulx confined himself to this statement, no one, looking at it in a general way, could have denied it; but in connection with this theory he also introduces the question of time, and infers that these enormous plications took their origin so far back that, while the ridges formed mighty domes to be hereafter sculptured into separate mountain systems, the corresponding depressions were so vast and deep as to admit of the deposition of sedimentary strata during the Old Red Sandstone period; and there he certainly lays himself open to attack. We cannot advance against him a theory more comprehensive than his own, or one corresponding better to the

apparent stratigraphical position on Prof. Geikie's map; but we can show that his theory in its integrity is untenable, because it is irreconcilable with facts, of which ocular demonstration can be given.

I may here refer only very briefly to a paper which was read at the Glasgow meeting of the British Association in 1876, on the junction of the Old Red and the granite at Arran, its purport being to show that the hitherto assumed bands of slate entirely surrounding the granitic nucleus were imaginary, and that there was a direct and unbroken succession from the Old Red into the granite, as could be clearly shown to even a geologically-untrained observer, by leading him up from North Sannox Burn in the direction S.W. as indicated by my map (enlarged from the Ordnance Survey map), showing the Old Red Sandstone rising to the height of more than 800 feet in one unbroken series of stratifications, until it is clearly seen to gradually merge into and assimilate with the great mass of granite forming the central part of the island. All theories and statements to the contrary notwithstanding, I assert that the granite facing east on both sides of Glen Sannox, and in the adjoining corries south, *retains traces of stratification with the same general strike and dip as the adjoining beds of Old Red which supplied the material now metamorphosed into granite.*

There is therefore clear proof that the Arran granite, such as appears on the eastern coast, is *posterior* to the deposition of the Old Red Sandstone, and the sweeping generalisation of Prof. von Lasaulx becomes untenable in point of time. An additional and overwhelming proof that the Arran granite in its present position cannot be *anterior* to the Old Red, is furnished by the well-known fact that at the N.E. end of Arran the whole of the Carboniferous series, and the underlying Old Red, are upheaved on the flanks of the granitic nucleus, some of the beds (as near the Saltpans) at a very steep angle, and to the height of more than 600 feet. In controverting this point, and meeting it successfully, as I hope, the question raised for discussion, so far as Prof. von Lasaulx's paper is concerned, is disposed of, and we are thrown back upon the almost untouched and still unsolved question as to *the origin of granite.*

I may be allowed, in conclusion, to express my admiration of Prof. von Lasaulx as an accomplished geologist and author, and

to add the hope that he may be induced, at no distant time, to re-visit the scene of his labours in Arran; and that we ourselves, as members of the Geological Society, may, by further investigation and study, be prepared to meet him once more, and show ourselves "foemen worthy of his steel."]

XXI.—*On the* Rocks *and* Graptolitic Shales *of the* Moffat District. By James Dairon, V.P.

[Read 16th January, 1879.]

Having on several occasions described the rocks of Moffatdale to the Society, I shall confine my remarks to-night to a few minor details connected with them, aided by a number of hand specimens I have brought for illustration.

It may safely be asserted that few other stratified rock formations have undergone such an upheaving, crushing, and contorting, as the Silurian, for its strata are to be found tilted from their original level at all angles—up to the perpendicular, and even inverted. Occasionally the folds take many strange and fantastic forms, as is more particularly the case with the black mud-stones or graptolitic shales.

The prevailing rock of the district round Moffat is Silurian grit or grauwacké, the whole of the hills being chiefly composed of it, and its accompanying thin flaggy grits and graptolitic shales, which crop out frequently at certain points along the valleys. These rocks also stretch right across the country, from an anticlinal axis at Birkhill to the Irish Sea on the one shore, and to the German Ocean on the other.

The hills built up of these rocks are all verdure-clad to their summits, except where they are scored and cut into by the mountain streams.

The grauwacké is largely used in the neighbourhood for building. I exhibit a specimen from Wellhill quarry, which is said to be the best in the district for such purposes. It is crystalline in texture, and is of a fine grey colour, but varies according to locality, being sometimes of a reddish or purplish tint. It is hard, tough, and durable.

Here is a red sandstone, said to be of Permian age, and