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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

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evidently the equivalent of the Corncockle Muir sandstones. It probably covered the district to a certain extent, but has been afterwards largely denuded away, the portions now remaining having been protected by their peculiar situation. Great quantities of the sand, formed by the disintegration of this rock, are found in many places, and are used for building purposes.

In this red sandstone are found embedded large and small fragments of older rocks which have been deposited in the strata while they were still in a soft and pasty condition. Its greatest exposure is to be seen on the way up to Hartfell, on the side of the burn which has cut through it, but it is also found in many other places, as on the Well burn, Frenchland burn, Beld craig, &c. It is soft, shivery, and brittle in character, and apparently unfit for any economic purpose whatever; its appearance being as if it had not received sufficient pressure, or wanted some cohesive ingredient to give it solidity. In some places it is stained with white circular markings, having a small central nucleus similar to those common in the Old Red Sandstone. Its equivalent at Corncockle Muir is an excellent building material, and is largely used for the dressings of buildings, and for foot pavements.

These specimens of upper graptolitic black shales are from Dobb's Linn, and are crowded with graptolites. This rock is soft and aluminous, does not split freely in many places, and is generally more folded and contorted than the lower shales. A fine section of one of these foldings may be seen from the head of the long arm of Dobb's Linn. The burn passes through it as through a broken archway, the top having been denuded away, possibly by some great flood. A short way further up there is another example of a similar folding which the burn runs through, the top having been also broken away, and the bed of the stream drops about 15 feet just at the spot, forming a small cascade, so that the effect produced is very fine.

This specimen of upper shale is taken from the extreme end of one of these foldings, and is full of fossil remains. At the same point the shales are in vertical bands of about three feet across, and are all jointed at right angles to the plane of lamination, but these joints occur at irregular distances of from 1 to 8 inches or so. Here there is found between each of the 3 feet bands a layer of light-coloured clay from 1 to 2 inches thick. In places where this becomes freed from the shale, it washes down, and, mixing with the

rock *débris*, forms a hard breccia, found in some places in considerable quantity.

The fossils in the upper shales belong to the genera *Mono-graptus*, *Rasterites*, *Diplograptus*, and *Retiolites*, with some crustacean remains, and one or two Brachiopoda I got lately, also *Serpulites dispar* (Salter), and all in a beautiful state of preservation. I mentioned in a former paper that I had observed a number of small faults in the cleavage joints, so that, when a slab is split, one part of a graptolite may be seen, while the other portion is on another plane either above or below.

As may be seen from the specimens on the table, the lower shales are very much harder than the upper ones, and are usually not so much contorted or folded. Slabs of a much larger size can be obtained from them, and they split much more freely at any thickness of layer down to the 1-16th of an inch. They are also generally quite free from the aluminous matter so abundant in the upper shales. Curiously enough they give off a very pleasant odour when closely shut up—as in a cabinet drawer—for any length of time. Whether this is due to the great quantity of organic matter they contain or not, I am not prepared to say.

The finest section of the lower shales to be found near Moffat is at Hartfell, on the north side of the burn, opposite the Spa—or, in other words, on the left-hand side, looking up the corrie. A low cliff about eight feet high, of the same rock, runs along the top of the section to the end of the corrie, nearly a quarter of a mile long, and about 40 feet below the upper crag. There is another parallel to it, and then a talus of *débris* to the bottom. From the bed of the burn to the top is fully 300 feet. The principal fossils of these shales are the branching forms—*Pleuro-graptus*, *Diplograptus*, *Retiolites*, and portions of *Eurypterus*, &c. One bed of shale associated with these rocks does not split up, but, as I have mentioned before, falls into small tabular pieces—a characteristic caused, doubtless, by metamorphism, probably through the action of hot vapours.

The physical characters of such localities as Dobb's Linn must alter very much in the course of a few years, owing to the shattered state of the black mud-stones. From the action of the rains and frosts upon their numerous jointings they are being split up and thrown down into the stream below, and then washed away by the floods. When up at Hartfell last summer I noticed that at the

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head of the corrie a fall from the side of the mountain of from 100 to 200 tons had lately taken place. The mass which came away consisted of a similar breccia to that already mentioned. It lay right in the bed of the stream, ready to be acted on, and carried away by the flood-waters in the winter months.

In this slab from Hartfell you will find about 30 Retiolite forms, which I have not yet identified. I believe they are the first of the species got in the locality. This other Retiolite I brought before the Society last year. The frond is lancet-shaped in form, 1-4th of an inch broad, and from 3 to 4 inches long, having a delicate central axis, with about 20 to 22 cells per inch. It is covered with a beautiful ringed network, which had, probably, at one time some protective covering. The cells are slightly alternate, and inclined at an angle of about 40°. Mr. Lapworth, of St. Andrews, to whom I sent this form for examination, has named it *Retiolites Daironi* (Lapworth).*

Here are examples of several branching forms of graptolites from the lower shales of Hartfell, many of them being extremely complicated in form. Little has as yet been done in the investigation of this class of graptolites in the Moffat shales—their ravelled and confused appearance being well calculated to deter any one from attempting to work out their original forms. Patience and perseverance may, however, yet reward us with perfect specimens, and we shall then be able to arrive at the true appearance of these interesting organisms. Doubtless they were beautiful objects, with their outspread branches floating around them; and only when they fell to the sea-bottom and died would their filaments assume the twisted and complicated appearance they now possess.

I may mention that in the Lower Llandeilo series of Wales and their equivalents of Skiddaw and Point Lévis, Quebec, the branching forms are obtained in a perfect state, which shows their original forms to have been quite different in character from those of the Upper Llandeilo of the south of Scotland.

* Prof. Lapworth, now of the Mason College of Science, Birmingham, has described and figured this species in the *Proc. Belfast Nat. Field Club*, 1876-7, p. 136, pl. VI., fig. 30.