

either such as have been by common consent admitted to have been at work in former times, or such as can be seen in operation at the present day.

EXPLANATION OF SKETCH MAP (PLATE XVII.) OF LOUGH DERG.

A Portumna.	K Deepest sounding (119 feet).
B Terryglass Bay.	L Mountshannon.
C Cloondavaun Bay.	M Coolcoosaun.
D Woodford.	N Scarriff.
E Slieve Aughta.	O Scarriff Bay.
F Drominagh Point.	P Cornagnoe Valley.
G Coose Bay.	Q Slieve Bernagh.
H Illaun More.	R Rinnaman Point.
I Youghal Bay.	S Slieve Arra.
J Parker Point.	T Killaloe.

IV.—ON THE NORTHERLY EXTENSION OF THE OLD RED SANDSTONE TO LINLEY, AND OTHER GEOLOGICAL FEATURES OF THE VALLEY OF LINLEY BROOK.

By JOHN RANDALL, F.G.S.

TWO remarkable geological features present themselves in this little valley: one, the occurrence of the Upper Coal Measures of Bewdley, together with the well-known *Spirorbis* Limestone; the other, that of the Bone-bed, succeeded by the no less interesting Passage-beds, forming connecting links between the Old Red Sandstone and Upper Ludlow Limestone. The order in which these occur, taking both banks of the brook, appears to be this.

1. Upon the surface, beds of drift, with boulders, of various thickness.

2. The Permians may be seen dipping rapidly away from the younger Coal Measures, which crop out from beneath them, together with the *Spirorbis* Limestone, which occurs between the two coals.

3. Coarse sandstones, with "coal sheds," as the Shropshire sinkers term them.

4. Followed by Red clays, about six feet.

5. Light coloured grits, with plant remains, twenty feet.

6. Hard micaceous, gritty and flaggy sandstones, with fish remains, first discovered in collecting materials for my "Severn Valley," in 1860, and described as "The Upper Bone-bed" in a paper prepared by the late George Roberts, F.G.S., and myself, and read before the Geological Society by Professor Ramsay, January 21st, 1863.¹

The bed occurs on both sides the valley, and the spines, solid ribs, and solid bones it yielded are stated by Sir Philip Egerton to be the largest of the forms figured by him from the corresponding bed at the Paper Mill, Ludlow.

The sandstones of the "Upper Bone-bed," are altogether about seven feet in thickness, but the Bone-bed itself is not more than two inches; and—

7. Underneath it is a kind of flagstone, one foot nine inches thick, with very interesting and distinct impressions of current or ripple marks.

¹ See Quart. Journ. Geol. Soc., 1863, vol. xix. p. 229.

8. Followed by eleven inches of micaceous sandy grits, with *Lingulae*.

9. Greenish, irregularly laminated rock with conglomerate, one foot.

10. Hard calcareous grit, with thickly disseminated grains, and many broken *Lingulae*, twelve inches.

11. Succeeded by twenty feet of laminated light grey micaceous grit; and—

12. Lastly, about six feet of micaceous sandy clays coloured by peroxide of iron.

These are the lowest traceable in the glen or gorge, where the first Bone-bed occurs, and they are succeeded, I imagine, although the connexion is not to be very distinctly traced, by the yellowish sandstone seen beneath the yew-trees higher up the brook, which is probably of the Downton series. It contains *Beyrichia* and *Lingulae*, the former in abundance, and in one or two ferruginous bands may be found dermal scutes of *Thelodus*, with fragments of *Lingulae*.

The "Lower Bone-bed" then occurs in the bed of the brook, in conjunction with a hard calcareous rock containing numerous clusters of *Modiolopsis complanata* at its base; and to these succeed flaggy beds of impure limestone containing *Serpulites longissimus* and other Upper Ludlow forms, followed by the Aymestry series, which, however, become much better developed on the sides of the Caughley division of Darley Brook, a stream entering the Severn a few hundred yards higher up, and where characteristic fossils such as *Rhynchonella Wilsoni*, *Rhynchonella spherica*, *Chonetes lata*, with others, are to be found.

Among the fish fauna of these beds, Sir Philip Egerton has distinguished remains of *Onchus*, *Plectrodus*, *Ctenacanthus*, and I think others.

It is worthy of remark that *Plectrodus*, *Onchus* and *Ctenacanthus* abound most as characteristic of this zone, and that at Ludlow the Crustacean remains of *Pterygotus* predominate, while at Ledbury the Cephalaspid fishes seem to have been the chief inhabitants of the water.

The "Upper Bone-bed" is interesting as connected with the extreme northerly extension of one great section of the Old Red Sandstone, which, following an uninterrupted course from South Wales, through Herefordshire and South Shropshire, and attaining a thickness of several thousand feet, here dwindles down to the compass indicated, and speedily disappears altogether.

Similar "Bone-beds," with Devonian and Silurian passage shales, have been found in Herefordshire, Worcestershire, and Gloucestershire, the latter at Pyrton Passage, a point about 70 miles distant from Linley.

Whether these beds, which are never more than a foot in thickness, and more frequently are not more than one or two inches, are absolutely continuous or not over all the intervening spaces between the points indicated, there is no evidence to show. In either case they point to a uniformity of conditions over large areas, and indicate

that were such depositions took place, they must have been of precisely the same character.

The two beds, here separated by the grits, and rock and shales described, comprising about forty feet of strata altogether, become highly interesting when considered as the connecting links between two great formations, and as prolific in the remains of those forms of ichthyic life now engaging so much of the attention of palæontologists. In his second edition of "Siluria," Sir R. Murchison, describing rocks occupying similar positions, says, "Fourteen years have now elapsed since I proclaimed that these fishes of the Upper Ludlow rock appeared before geologists for the first time as the most ancient beings of their class; and all the subsequent researches in the various parts of the world over which Silurian rocks have been found to extend have failed to add to or modify this generalization. In other countries, indeed, besides our own, as in America and Bohemia, one or two ichthyolites have been discovered within the pale of Silurian rocks; but there, as with us, they are merely found on the outer threshold of the system, and very sparingly."

Whether such beds are evidences of sudden destruction of the finny inhabitants of these early waters, or merely indicate conditions favourable to fish life—like modern feeding grounds on shallow shelving shores—I cannot say; but leaving the question as to the cause of this accumulation, nothing is more easy than to read by aid of the light which such remains afford the conditions under which these passage-beds themselves were formed.

First, there was the period of clear water, when lime alone was thrown down; next, that during which rivers came down charged with sand containing iron, so fatal to fish life; but with intervals when clear water prevailed, as evidenced by the Corn-stones. Speaking of these sandstones, Sir H. de la Beche, in the Memoirs of the Geological Society, says, "In the country of which Herefordshire forms the chief portion, extending to Shropshire in one direction, to Monmouthshire and Glamorganshire in another, and into Brecknockshire, Caermarthenshire, and Pembrokeshire in a third, we have an unbroken exposed surface of 2100 square miles of Old Red Sandstone; the whole, making due allowance for vertical differences between the upper and lower beds, of the same general character. Taking the average thickness of the mass as it appears from measuring the beds vertically to their out-crop, we should have more than 1500 cubic miles of chiefly red-coloured detrital matter, for such it appears, with the exception of a slight amount of the limestones termed Corn-stones. We have hence in this area alone a large amount of detritus accumulated under conditions very different, as regards the admixture of ferruginous matter, from those which preceded it during the Silurian epoch. It is difficult to obtain a clear view, in the present state of our knowledge, of the causes which produced such a mixture of peroxide of iron with the accumulations formed during the lapse of time apparently required for the deposit of this amount of Old Red Sandstone. After a few sandstone beds with *Lingula*, and perhaps some other shells—the last struggles, as it

were, of the molluscs of the time to keep their ground in the waters covering this area—there would appear to be few other traces of animal life than the remains of fishes, and these chiefly in the Cornstones, or limestones, associated with the red or variegated marls and sandstones. Fishes could readily swim freely without injury in the waters from which the peroxide of iron was thrown down, so long as they did not disturb the substance at the bottom, while at the same time molluscs would be incapable of crawling upon or living in the sand or mud intermingled with the peroxide, as we have found by experiments; so that at any intervals when the waters might be relieved by deposit from their load of mechanically suspended peroxide of iron, the fish could readily enter the area exposed to this kind of red accumulation." Seeing that there is no break or unconformity in these two sets of rocks, the Upper Ludlow and the Old Red rocks, but that the physical passage from one to the other by these stratigraphical beds is uniform and complete, it is difficult to account for the life break which takes place in passing from one formation to the other, excepting on the ground that great changes in the relative positions of land and water must have taken place, causing the marine condition of an extensive area most probably to have become one of fresh-water, seeing that the remains found belong to the latter, and that marine forms did not live on beyond the limits of these passage-beds. The marine Silurian sea must have been slowly and gradually changing at the time these beds were formed by elevations and oscillations of the land over an oval basin-shaped region, extending from this northern point to Haverford-West and Milford Haven, in South Wales, on the one side, and along the Abberley and Malvern ranges, and the eastern margin of the Bristol Coal-field on the other. Over this large area during long intervals of time fresh-water conditions, estuarine or lacustrine, with slow but continuous elevation of land, are supposed to have continued, for no form of invertebrate life appears to have lived on beyond these beds,¹ which form the confines of the two systems.

Clearly, an entire change took place in the marine fauna as we follow through this series of beds from the Ludlow Limestone to the conformable Lower Old Red Sandstone, when the few fish and crustacea common to them almost, if not entirely, disappeared; for the vast accumulation of these sandstones in this district marks an epoch and an era almost barren of life; only two or three species, and these land and fresh-water, being found, and they only in the upper portions of the Old Red.

In supposing this section of Old Red Sandstone to have been piled up under fresh-water rather than marine conditions, I have adopted the views of Mr. Robert Etheridge, F.R.S., who holds that an extensive coast-line or barrier existed south of the Mendip Hills, separating it from the fossiliferous marine Devonians, which he divides into a middle, lower, and upper series.

¹ We assume the author means life *in this particular area*; he does not of course imply that no form of invertebrate life passed from the scene of the older into that of the newer deposit.—EDIT. GEOL. MAG.

No such passage-beds here conduct us from the Old Red Sandstone to the Coal Measures, and even in cases where they do, as in North Devon, of the 383 species of Devonian fossils known in Great Britain and Ireland, only 56 are common to it and the Carboniferous series, which contain 1748—a fact which would seem to indicate either very varied conditions or a wide difference in point of time. The abruptness and suddenness of the change in passing from the Old Red to the Coal Measures is all the greater from the fact that here we rise from the former formation into the upper members of the Coal Measures; and the question naturally arises as to whether the old Coal Measures ever here rested upon the Old Red Sandstone, now capped by the New. Facts occur which indicate that they did; and supposing the Old Red to have been the result of the silting up of the wide area indicated, it will occur to the mind that conditions were preparing for the growth of vegetation, by the formation of land.

It is worthy of remark, too, that on the high ground at Linley, by the road-side, traces of the old or Lower Coal Measures occur, as well as on the high ground before descending the hill at the Dean, where an anticlinal fault brings up the Aymestry Limestone. Still stronger evidences are furnished by the facts that at Shirlot and the Brown Clee Hills the connexion between the two is distinct. The evidence is equally conclusive that they have been swept away altogether here, partially so to the north, at the Dunge, where the 'Little Flint Coal' crops out above, and the 'Lancashire Ladies,' the lowest coal of the series, occurs a little below the road. At Caughley, in the Deep pit, and in other shafts on that side, the younger coals, together with the *Spirorbis* Limestone, overlap the lower measures of the old coal-field. At Caughley the *Spirorbis* Limestone appears on the surface, and is found in several old shafts in the neighbourhood, about 180 feet above the Crawstone, the lowest Ironstone of the series; thus showing that the Coal Measures up to the top coal have been destroyed. The extent to which these were reduced, and the point at which denudation ceased, is marked by what is called 'calamincar' and the rough rock, the latter very uneven and irregular in thickness, but a complete conglomerate, having above it the usual brick and tile making clays of the neighbourhood, with a clunch, and one, or sometimes two, thin seams of coal above. The order in which these coals disappear, as we gather from practical men connected with the district, is this:—At the foundry, midway between Broseley Town Hall and the church, what is known on this side the river as top coal terminates, whilst the bottom coal extends thirty yards further, and then terminates too. The Pennystone then runs two hundred yards beyond, and terminates at the Foresters' Arms, on the road to Ironbridge; the Vigor coal five yards further on, and the Ganey coal a hundred yards beyond the latter. The Clod coal extends thirty yards further than the Best, the next in succession, and the Little Flint coal sixty yards further still. This would represent about a hundred and fifty-two feet of vertical, and 1575 feet of lineal strata, giving a slope of one in a little over ten, as the old

coast-line. Towards the bottom of the Estuary the slope appears to be less, for at Caughley, over a mile from the last point named, the Clod coal, and the Little Flints, occasionally are found; but no trace of them, as we have seen, is to be found at Linley Brook. How far the extension of the Clod and Little Flint coals to Caughley, beyond where we might naturally expect them to terminate, may be due to a downthrow fault which intervenes, we cannot say; but a great fault crosses the road which lets down the brick and tile clays which are on the surface, by Mrs. Thorn's brickworks, so that at the deep pits near they are worked at a depth of ninety yards.

If we follow the course of the Severn to the south, and examine the rocks laid bare in the valley, and in channels cut by tributary streams on either side, we not only find all traces of the older Coal Measures disappear, but we find the younger members come in and supply their place.

If we cross the 16 miles area, consisting of the usual divisions of the Permian, the Bunter, and Keuper sandstones, which separate the coal-fields of Coalbrookdale and South Staffordshire, we find no indications of the existence of the Coal Measures underneath; on the contrary, the experiments made at Enville, Shatterford, and other places, demonstrate their absence.

That the Shropshire and South Staffordshire coal-fields are fragments of one mineral tract would appear from the position which that important and persistent measure—the Pennystone Ironstone—occupies in the two fields, as well as from the similarity of its organic remains. The authors of the memoirs of the Geological Survey, in their "Iron Ores of Great Britain," say that the lower beds of the Coal Measures in South Wales and Shropshire (and the same is true for Lancashire) contain a set of marine fossils, some of which are Mountain Limestone species, and the rest peculiar to the Coal Measures. Also, that there seem to be good reasons for supposing the Rosser veins of South Wales equivalent to the Pennystone and underlying ironstones of Coalbrookdale; that the flat coal bass has at least a very strong resemblance in its fish-remains to the bottom vein; and that the Darran Pins exactly resemble the white flats of Coalbrookdale; whilst the Ellea Balls Mine is the counterpart of the ball stone of the same field. If the various beds of these coal-fields can be correlated, and if it is reasonable to suppose that the mineral seams originally extended over the greater portion of the intermediate tracts where we know they no longer exist, the extent to which they have been denuded is amazing.

Still, when we look at the island-like form of the Brown Clee Hills, rising above the sea of Old Red Sandstone, and bearing on its summit a narrow patch of the Lower Coal Measures—a mere wreck saved by the protecting barriers of trap and other rocks from that utter destruction which befell the coal-seams spread over tracts where now no trace exists—the mind is the more disposed to believe in the destruction of the Coal Measures from the eastern side of the Shropshire field to the western side of that of South Staffordshire and East Worcestershire.

We know that deposition and denudation are inseparable correlatives, and that the amount of destruction done upon the older rocks is measured by the sedimentary deposits derived from their materials; but the recognition of these facts gains more than ordinary significance when we come to consider of how much of those hidden mineral treasures we prize so highly, and the extension of which we seek so earnestly, as the means of perpetuating our national prosperity, we have been deprived by the former agency.

Along the line of ground marked by the barrier before referred to as separating the marine Devonians from the fresh-water Old Red Sandstones of this district, Palæozoic rocks are described as crumpled and contorted for a breadth of many miles, and along a length of 800 miles, tilting and turning the Coal Measures back upon themselves, squeezing and folding them, so that the crown of the anticlinal is sometimes four or five miles above the level of the reversed synclinal arch to which the bottom Coal Measures descend in Belgium. One of these anticlinals presents itself at Linley, on a small scale it is true, but bearing the unmistakable impress of the forces to which it is due, and betraying to the experienced eye the direction in which denudation has done its work. All such tilted beds must have had broken edges somewhere, and those edges once exposed to the waves, the work of denudation would commence along the line of fracture.¹

V.—NOTES ON THE BRITISH GRAPTOLITES AND THEIR ALLIES.

By CHAS. LAPWORTH, F.G.S.

I.—ON AN IMPROVED CLASSIFICATION OF THE RHABDOPHORA.

PART I.

IN the following communication I intend to give a very brief outline of some of the chief results of my investigations among British Graptolites in those departments of inquiry which are more especially connected with considerations of classification. I shall content myself with offering a concise statement of the main conclusions at which I have arrived, reserving all detail to the future, when I hope to adduce decisive evidence in support of the views here advanced. The special subjects to be noticed in this place are—the development, structure, classification, and geological distribution of that section of the *Rhabdophora* in which the complete polypary can be proved to be composed of one or more polyparies essentially similar to that in the unilateral and uniserial forms to which the name Graptolites (*Graptolithus*) is commonly applied. Those *Rhabdophora* supposed to be similar in structure to the genus *Retiolites* will be considered in conjunction, but no pretension is made to anything like the same certainty in this section. In an outline paper like the present, which may be looked upon simply as a registration of new discoveries and opinions, it becomes possible to dispense with that constant reference to the collateral labours of other investigators which strict justice demands

¹ Read before a Field-meeting of the Dudley Geological Society, held at Linley near Bridgnorth, on 17th September, 1873.