

Southern aspect. The details will be given in my paper "on the relation of the Boulder-clay of the North of England to the great Chalky clay of the South," when published in the Quarterly Journal of the Geological Society.

## VI.—ON THE MILLSTONE GRIT OF THE NORTH WALES BORDER.

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**T**HE Millstone Grit of the North Wales Border follows the eastern slope of the Carboniferous Limestone, from Crickheath and Sweeney, South of Oswestry, to the shores of the Irish Sea; it is also thrown up into the range of hills which the traveller by the Great Western Railway may see to the west of the line between Oswestry and Chester. This range serves as a natural boundary between this part of England and Wales, and forms a second line of natural fortification, strengthened on the English side by numerous outposts of low hills of clay, gravel, and sand, which give place, upon the Welsh side, to precipitous escarpments of Mountain Limestone, beyond which the change in the language, dress, and manners of the people is marked and sudden.

These hills are composed for the most part of an accumulation of sandstones, of very variable superficial breadth, affected as that breadth has been, firstly, by the area of their original deposition; secondly, by the amount of denudation they have since suffered; thirdly, by the extent to which they are covered by the Coal Measures; and fourthly, by the disturbances which have elevated the sandstones and the Coal Measures, leading to the subsequent denudation of the latter from off their surface. Thus, in the southern half of its course, say, from a point south-west of the town of Wrexham to Sweeney, the Millstone Grit presents the appearance of a continuous band of variable breadth, while, in its northern continuation, through a country crossed by numerous faults, it appears in disjointed patches, among the Coal Measures, as well as in a main band following the course of the Limestone towards Mold, Holywell, and the sea.

By the construction of a branch line from the Cambrian Railway, a most instructive section of the Grit has been exposed at Sweeney, perhaps the most complete hitherto obtained. By a reference to this section (See Woodcut, Fig. 1) it will be seen, that above the main body of Carboniferous Limestone there rests a deposit of coarse red and purple Sandstones, containing layers of pebbles; this is followed, in ascending order, by a considerable thickness of Calcareous Sandstones, containing in places thin layers of limestone, and these in their turn are overlain by a series of yellow, mottled, and brown beds; the whole being capped by a deposit of pinky-white sandstone, becoming in places pure white. Unfortunately, in this section the junction between the Grit and the Limestone is not seen, owing to a covering of drift, but if we travel a little towards the north-west we find, first, at Treflach, the deep red sandstone beds passing downwards into a purplish calcareous sandstone; and, in Craigforda

wood, we find the junction of this with the limestone proper (See Woodcut, Fig. 2). The section, however, which best illustrates this point, is seen in a small and comparatively unknown quarry at Carreg-y-big,  $3\frac{1}{2}$  miles north of Oswestry (See Woodcut, Fig. 3), where we have at the base the limestone proper, which is here burnt for Agricultural use, and at the summit thin sandstones of the Millstone Grit. It will thus be seen, that the change in the character of the deposits, while it was somewhat gradual, was, in the southern part of the area in question, marked and permanent. There were temporary cessations of the supply of calcareous matter, at various periods during the deposition of the Carboniferous Limestone, as is evidenced by four or five well-marked ferruginous shaly beds in the lower, and of bituminous shales in the upper portion of that formation; the supply of calcareous matter became subsequently less and less, and, with the exception of an unimportant outflow in the middle beds, permanently ceases. These remarks are however only applicable to the southern half of the area, as I shall have occasion to explain presently.

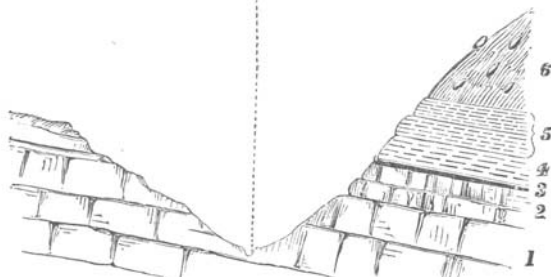
FIG. 1.—Section of Millstone Grit at Sweeney,  $2\frac{1}{2}$  miles South of Oswestry.



1. Carboniferous Limestone: *Productus*, *Lithostrotion*, and usual fossils of the top beds.
2. Covering of Drift, hiding the junction of the Limestone with the Grits.
3. Yellowish ferruginous sandstones, massive dark red ditto with coarse pebbles. Fossils in some of these beds; Corals, uncertain species; *Rhynchonella*, *Sanguinolites*, *Metoptoma*, *Chonetes*, *Productus semireticulatus*, *P. cora*, etc., etc.
4. Calcareous sandstones, about 60 feet.
5. Soft, white, buff, mottled, and striped sandstones, with thin beds of marl and shale. *Schizodus* in some of these beds.
6. Fine-grained hard pale sandstones, with occasional layers of pebbles, and, in the fine beds, reticulated plant and annelide-markings.
7. Beds of friable sandstone, passing upwards into solid beds of pinky-white sandstones, with lateral pockets, capped with thin beds dipping under the Coal Measures. *Productus semireticulatus* in great abundance, large *Orthoceratites*, *Calamites*, and fucoid remains. Total thickness of Grits between the Carboniferous Limestone and Coal Measures, 282 feet.
8. Coal Measures.

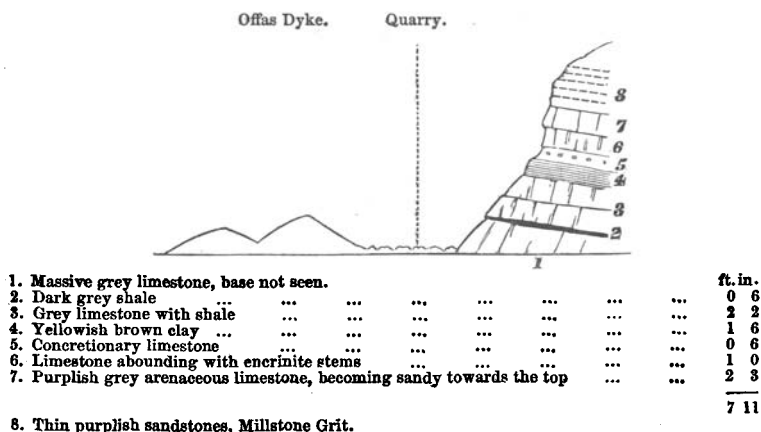
FIG. 2.—Section showing the junction of the Millstone Grit with the Carboniferous Limestone, in Craigforda Wood, 3 miles N.N.W. of Oswestry.

River Morda.



1. Carboniferous Limestone, covered by,
2. Light grey limestones, with brownish markings and stems of *Encrinures*.
3. Thin bed of dark red marl.
4. Calcareous sandstones with purplish markings.
5. Thin beds of brownish sandstones with cavities—casts of concretions or fossils.
6. Steep slope covered with sandstone blocks from the upper beds.

FIG. 3.—Section showing the junction of the Millstone Grit with the Carboniferous Limestone, at Carreg-y-big, 3½ miles N. of Oswestry.



As might be expected, the sandstones are of various degrees of texture, ranging from fine to coarse-grained, whilst layers of pebbles—varying in size from a pea to an egg—are present in both the lower and upper portions of the group, the calcareous sandstones in the middle being most free from them. All this I need scarcely say is owing to, and denotes the different depths of water in which the whole series was deposited,—from the strong current (tidal or otherwise)—and shallow water in which the pebbles were rolled, to the still depths in which the fine grains of sand quietly sank. Both the larger pebbles and the finer sand are of quartz, in its different varieties; and although I have examined many blocks of sandstone for the purpose, I have been unable to detect a fragment of limestone, and but rarely any traces of the older slaty and porphyritic rocks of Wales. Both pebbles and sand are, as stated by Sir R. Murchison, in his “Silurian System,” cemented together in a paste of felspar, but the distribution of the felspar is very unequal. Thus, in the uppermost beds of the section at Sweeney, we find considerable layers of feldspathic clay, succeeded by thick beds of sand, in which it is scarcely present, and some even from which it is totally absent, the sand simply cohering from surrounding pressure, and when this is removed becoming loose sand (white generally), which can be dug out, as it is sometimes, and used in mortar. The various beds are also coloured by metallic oxides, peroxide of iron being largely present in the deep red beds, manganese in the speckled, and copper here and there giving a greenish tinge, as at Sweeney and Trevor.

In the 8-foot bed, near to the top of the Sweeney section, there are some curious “Pockets,” which illustrate both this unequal distribution of felspar, and the varied colouring of the rock. These Pockets differ from all those I have hitherto observed or seen described, in that they are horizontal, and not perpendicular, extending laterally into the rock, not simple vertical cavities on its surface. I

give a representation of some of these (See Woodcut, figs. 4-7). At first sight they bear some resemblance to the concretions which are so abundant in the Wenlock Shale of North Wales, but there is this difference, that whereas the Wenlock Shale examples are concretions of a harder nature than the surrounding rock, and are formed around a crystalline central nucleus, or cavity, filled with crystalline matter, these in the Grit are cavities with no perceptible outlet or inlet, filled with loose brown sand, gathered around a nucleus of white or yellowish clay, the surrounding rock being nearly white. Around the outer margin, as in figs. 4 and 7, there are dendritic markings; and sometimes, as in figs. 6 and 7, dark lines of mineral matter enter the surrounding rock.<sup>1</sup>

Pockets in the Millstone Grit at Sweeney, near Oswestry.

FIG. 4.

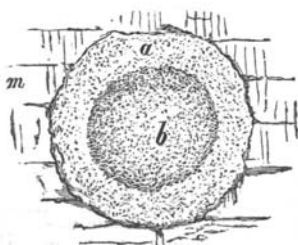


FIG. 5.

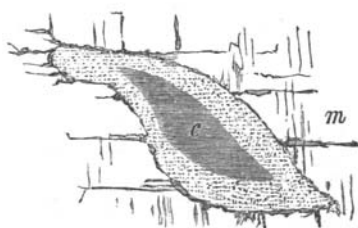
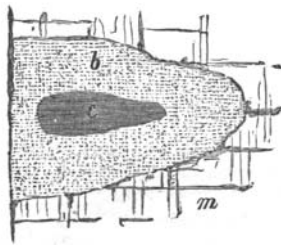


FIG. 6.

FIG. 7.

FIG. 4. Front view of Pocket, 2 feet 6 inches in diameter, with marginal rim (a) of dendritic markings of manganese, and centre (b) of yellow sand.

5. Side view of the same Pocket, showing the comparative depth to which it penetrates the rock m, (c) central nucleus of felspathic clay.

6. Front view of another Pocket, with end section of central nucleus of yellow clay (c) and radiating lines of manganese.

7. Front view of irregular shaped Pocket, with ochreous centre (c) and dark variegated margin with dendritic markings. (m) matrix of pinky-white sandstone, bed No. 7 of Fig. 1.

My description of the beds so far has been drawn principally from the sections south and west of Oswestry, but in many respects

<sup>1</sup> It is difficult to account for the origin of these Pockets, and it is with diffidence that I venture to offer the following suggestion, viz.: That in the centre, where we now find the clay, there was originally a concretion of mineral matter; next, by electro-chemical agency, such as is supposed to have aided in the formation of some mineral veins, this mineral matter was disseminated around to the boundary of the present pocket, and the felspathic clay—the cementing matrix of the rock—concreted into the central cavity thus made by the dispersion of the mineral base, leaving the sand, which had become discoloured by the dispersion of the mineral matter, simply cohering by the force of the surrounding rock.

it holds good of the formation generally. There are, however, local variations, as might be expected, arising from local causes, which affected the original mode of deposition; as, for example, the degree of intensity of the currents, and the nature and amount of the materials. It may therefore be interesting to note a few of the local changes that occur as we follow the formation northwards from Sweeney. At the southern end of Cynr-y-broch, north-west of Oswestry, the beds corresponding to the upper 26 feet of the Sweeney section are changed in colour to yellow, and become in their upper portion very cherty and splintery. The uppermost beds, seen in a quarry on the right of the road from Oswestry to Llansilin, near the Racecourse, become flaggy, and are covered with well-defined ripple marks. In the Forest quarry, on the north-west side of the Oswestry Racecourse, there is a bed corresponding with the pale hard fine-grained sandstone of Sweeney, which becomes very coarse and pebbly, and contains in its finer portions well-defined crystals of felspar. Over this there is a bed, one foot thick, which is literally an agglomeration of pebbles, covered by an irregular deposit of sand, pebbles, and sandstones, about 3 feet thick.

## Section of Millstone Grit at Trevor, near Llangollen.

[This section was kindly given to me by the Messrs. Roberts, of Garth Quarry, Trevor, from a record of borings made below their quarry, in the 78ft. of Sandstone at the head of the section.]

Thin seam of Coal.—Base of the Coal Measures.

Thickness.

Compact Sandstone, with crystals of felspar, varying in texture from a coarse conglomerate to fine grained sandstones used for building purposes ...	ft. in.
Dark grey clayey shale ...	0 9
Grey flinty stone ...	4 0
White shale ...	1 3
Dark grey shale, with iron pyrites ...	9 3
Hard white sandstone ...	16 0
White clay and chert ...	6 0
Black shale ...	0 3
Hard cherty rock; decomposes into rotten stone ...	5 0
Black shale ...	2 0
Hard rock ...	2 4
Black shale ...	0 3
Hard rock ...	2 0
Fire-clay ...	2 0
Ditto and sand ...	1 8
Rock ...	0 10
White Rock ...	0 2
Brown ditto ...	0 10
Dark shaly rock ...	0 10
Black shale ...	0 3
White rock ...	0 4
Shale ...	3 0
Limestone (metalliferous). [N.B.—Broke my chisel]	1 3

138 3

Section taken along the outcrop of the beds to the junction of the Grit with the Limestone. The figures must be regarded as approximately correct.

White cherty limestone, in thin splintery beds, below a solid bed of limestone, 1ft. 6in.

thick, corresponding with the base of section above	...	...	...	...	16	0
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Massive white sandstones with pebbles, forms two ridges ...	...	...	...	40	0
forming a lower ridge				27	0

"	"	"	"	forming a lower ridge	...	...	...	27	0
Brown sandstones,	a little calcareous,	passing downward into a lighter colour of			...			8	0

[illegible]

Pink and white variegated sandstones	...	...	...	...	...	...	20	0
Calcareous sandstone	...	...	...	...	...	...	25	0

Calcareous sandstones	...	...	...	...	...	\$5	0
Yellowish white, with darker coloured ditto	with purple calcareous spots					\$	0

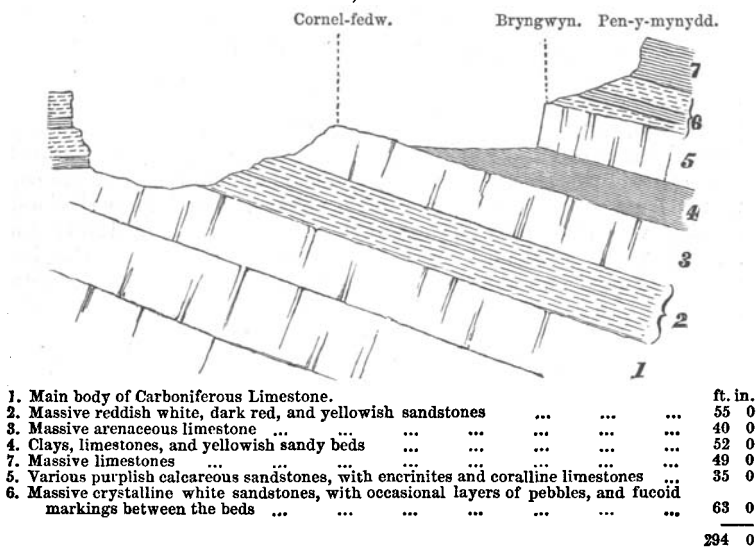
Thin flaggy buff and yellow sandstone beds, in places honeycombed by decomposition of

mineral matter, as at Cragford and Bronygarth...	...	...	...	...	3 0
resting on					

294 3

Pale limestone, few fossils, near the junction, but passing downwards into an encrinital and coralline limestone. Top of the main body of Carboniferous Limestone of the Eglwseg Rocks.

FIG. 8.—Section of Millstone Grit, with interstratified limestones, 3½ miles west of Mold, Flintshire.



(Measurements to be taken as approximately correct.)

Passing on to Trevor, three miles east of Llangollen, we have the upper beds made up (as shown in the accompanying Trevor section) of compact sandstone, with crystals of felspar, ranging in texture from a coarse friable conglomerate to a fine-grained sandstone. This character it maintains (omitting the friable conglomerate) to Mold, in Flintshire, where it forms the topmost sandstone of the Mold section (see Woodcut, Fig. 8). The basement beds at the two extremities of the formation differ considerably: at the southern end they are red and purplish sandstones; at the northern termination, on the Ormes Head, we find the main body of the limestone immediately succeeded by a succession of cherty beds. The middle beds preserve their calcareous character throughout the entire area, becoming more decidedly calcareous in their passage northwards; for example, taking three points at about equal distances, we have—

	(South.) At Sweeney (1 mile).	Trevor (15 miles).	Mold (30 miles).	(North.)
	Calcareous sandstones, with occasional thin layers of limestone.	1ft. 6in. limestone, 16ft. cherty ditto, calcareous sandstones.	About 120ft. limestone.	
Total thickness of each section. }	282ft.	294ft.	294½ft.	

So rapid is the increase of calcareous matter, in the last fifteen miles, that it is difficult, when looking at the Mold section, to say whether we have, as shown on the Government Survey maps, Millstone Grit with bands of limestone, or, limestone interstratified with beds of grit.

(To be concluded in our next Number.)