

25. *The GLACIO-MARINE DRIFT of the VALE of CLWYD.* By T. MELLARD READE, Esq., C.E., F.G.S., F.R.I.B.A. (Read April 7th, 1897.)

[PLATE XXV—MAP.]

In a paper on the Drift Deposits of Colwyn Bay, I pointed out that the bulk of the materials of the sands and clays forming the Colwyn drift had been derived from the Vale of Clwyd.¹ In January, 1896, I had the opportunity of tracing the deposits farther westward past Llandulas and into the Vale itself. These later observations quite bear out my original statement.

(1) Boulder Clay from Craig, west of Llandulas, to the Vale of Clwyd, south-east of Abergelw.

Immediately east of Craig, between Llandulas and Colwyn Bay (No. 1 in the Map) the Boulder Clay stands out in vertical cliffs about 30 feet high, and so compact that it is undercut by the waves, in a manner similar to that often seen in rock-cliffs. A closer examination shows that it is very full of angular fragments of limestone, derived from the Carboniferous Limestone-rock against which it lies. Several large blocks of Welsh felstone and blocks of slate-rock—showing banding or original bedding—occur on the shore, and I found a small boulder of Eskdale granite in the clay. At one place the clay appears to be foliated in a vertical direction. It does not appear that there are many shell-fragments in the clay, as I found only one example. All the Boulder Clay described in this paper is of a brown or reddish-brown colour, containing northern erratics, and is similar to the low-level Boulder Clays of Lancashire and Cheshire, excepting where it is mixed with the waste of the hills against which it may happen to lie.

A microscopic examination of a specimen of the clay by Mr. Joseph Wright, F.G.S., for foraminifera yielded negative results.

The following is a mechanical analysis showing the constitution of the clay; specimen taken about 5 feet above the shore:—

Weight before washing = 1·000 = 5 oz.	
Caught in $\frac{1}{16}$ -inch mesh.....	0·191
„ $\frac{1}{8}$ „	0·033
„ $\frac{1}{4}$ „	0·075
Passed do. & deposited by subsidence	0·208
	<hr/> 0·507

This leaves 50 per cent. of clay, if we count as clay all the material washed out in the operations.

¹ Quart. Journ. Geol. Soc. vol. xli. (1885) pp. 102-107.

Immediately west of the West pier at Llandulas, there is a spur of extremely fine Boulder Clay standing out from the cliff; out of this I took one granite-pebble. Notwithstanding its freedom from stones, the clay is extremely hard where unweathered.

Mechanically analysed, the specimens taken (No. 2 in the Map) yielded 80 per cent. of clay. Between 4 and 5 lbs. troy of the Boulder Clay yielded to Mr. Wright the following foraminifera¹:—

- W. *Miliolina seminulum* (Linn.). Very rare.
- W. " *subrotunda* (Mont.). Rare.
- C.W. *Bolivina dilatata*, Rss. Rare.
- C.W. " *plicata*, d'Orb. Common.
- C.W. *Cassidulina crassa*, d'Orb. Common.
- C.W. *Lagena sulcata* (W. & J.). Very rare.
- C.W. " *hexagona* (Will.), var. Very rare.
- C.W. " *levigata* (Rss.). Rare.
- C.W. *Uvigerina angulosa*, Will. Rare.
- C.W. *Globigerina bulloides*, d'Orb. Common.
- Patellina corrugata*, Will. Very rare.
- C.W. *Discorbina rosacea* (d'Orb.). Rare.
- C. " *Bertheloti* (d'Orb.). Very rare.
- C. " *Wrightii*, Brady. Rare.
- C.W. *Truncatulina lobatula* (W. & J.). Rare.
- C.W. *Nonionina depressula* (W. & J.). Very common.
- C.W. *Polystomella striato-punctata* (F. & M.). Rare.
- " *macella* (F. & M.). Rare.

One hundred specimens of *Nonionina depressula* were obtained from this gathering, while the other 17 species numbered in all only 69 specimens.

Farther east, between the East and West piers, the cliffs of drift are well developed. A very shelly clay occurs here, and I picked out *Turritella terebra*, *Trophon truncatus*, *Cardium edule*, etc. The lower part of the cliff is grass-grown, but in a good exposure about 30 feet above the shore I took a specimen of the clay (No. 3 in the Map). Mechanically analysed, it yielded 35 per cent. of clay, showing, curiously enough, a smaller proportion of that material than the strong clay to the east of Craig already described, but this arises from the preponderance of sand-grains having a diameter between $\frac{1}{100}$ and $\frac{1}{10}$ inch, together with the flour of rock deposited in the washing. This specimen is interesting from the numerous foraminifera it contained. Mr. Wright examined 1 lb. 1 oz. troy, and found the following species:—

¹ For purposes of comparison I have marked those species that occur in the Boulder Clay of Great Crosby with a C (see 'Foraminiferal Boulder Clay at Great Crosby,' Proc. Liverpool Geol. Soc., Session 1895-96, vol. vii. pt. iv. pp. 388-390), and those that occur in the Boulder Clay of Wirral, Cheshire, with a W (see paper by Davies & Reade, Proc. Liverpool Geol. Soc., Session 1894-95, vol. vii. pt. iii. pp. 334-335 & pp. 342-344).

- W. *Miliolina seminulum* (Linn.). Very rare.
W. " *subrotunda* (Mont.). Frequent.
C. " *tenuis* (Cz.). Common.
Ammodiscus gordialis (J. & P.). Very rare.
C.W. *Bulimina pupoides*, d'Orb. Rare.
C.W. " *fusiformis*, Will. Very rare.
C.W. *Bolivina dilatata*, Rss. Frequent.
C.W. " *plicata*, d'Orb. Very common.
C. *Cassidulina levigata*, d'Orb. Very rare.
C.W. " *crassa*, d'Orb. Very common.
C.W. *Lagena sulcata* (W. & J.). Very rare.
C.W. " *Williamsoni* (Alcock). Rare.
C.W. " *lineata* (Will.) var. Very rare.
C.W. " *hexagona* (Will.) var. Very rare.
C.W. " *squamosa* (Mont.). Very rare.
C.W. " *Orbignyana* (Seg.). Very rare.
C.W. " *levigata* (Rss.). Rare.
Rhabdogonium tricarinatum, d'Orb. Rare.
Polymorphina lactea (W. & J.). Very rare.
" *myristiformis*, Will. Very rare.
C.W. *Uvigerina angulosa*, Will. Frequent.
C.W. *Globigerina bulloides*, d'Orb. Very common.
Sphaeroidina bulloides, d'Orb. Rare.
W. *Pullenia sphaeroides* (d'Orb.). Very rare.
Patellina corrugata, Will. Very rare.
Spirillina vivipara, Eliz. Very rare.
C.W. *Truncatulina lobatula* (W. & J.). Common.
Pulvinulina Menardii (d'Orb.). Rare.
C. " *Karsteni* (Rss.). Very rare.
C. *Rotalia Beccarii* (Linn.). Very rare.
C. *Discorbina Wrightii*, Brady. Common.
C.W. *Nonionina depressula* (W. & J.). Very common.
C.W. *Polystomella striato-punctata* (F. & M.). Frequent.
" *macella*¹ (F. & M.). Very rare.

About 650 specimens of *Nonionina depressula* were obtained from this gathering, while the other species numbered in all 235 specimens.

Mr. Wright observes that some of the forms from this sample are extremely rare as British specimens. *Rhabdogonium tricarinatum* and *Sphaeroidina bulloides* have been met with at a few places only off the west coast of Ireland; *Pullenia sphaeroides* has been recorded only from off Dublin and the estuary of the Dee, and *Pulvinulina Menardii* from the Isle of Man and from off the coast of Dublin.

These drift-cliffs continue at a lower elevation to the River Dulas, at the mouth of which is a pebble-ridge, forcing it to the eastward. The valley of the Dulas has been drift-filled and since then denuded, the gravels in it being of later date.

Beyond the Dulas to the east is a low bank of drift grassed over. The same kind of Boulder Clay as that hitherto described may be seen in a section at the large limestone-quarries at Llandulas, at a level of 150 feet above O.D., lying upon the irregular surface of the Carboniferous Limestone.

¹ In the Brit. Assoc. Report on the 'High-level Shell-bearing Deposits of Kintyre,' (L'pool) 1896, p. 397, Dr. David Robertson states that, so far as he knows, *Polystomella macella* has not been found in recent deposits in the British Isles, and in Scotland it is only found in the shelly deposits of Kintyre.

A walk of about a mile along the St. Asaph road from Abergele shows drift banked up against the limestone-cliff on the west side of the Vale of Clwyd: it is conterminous with that of the shore-cliffs just described.

East of the St. Asaph road, and at a level of about 140 feet above O.D., is a disused brick-pit, showing a plastic red Boulder Clay, very like that in the cutting of the Wirral Railway at Seacombe.¹ In it are a good many shell-fragments, mostly very rotten, among which *Cardium*, *Turritella*, and *Tellina* are distinguishable.

A mechanical analysis of this clay (No. 4 in the Map) showed that the matter separated by the sieves was mostly sand, the larger part of which passed the $\frac{1}{100}$ -inch mesh. The sand consists to a great extent of most beautifully rounded and polished quartz-grains. The proportion of clay was very high, amounting to 82 per cent.

Three lbs. of this clay were submitted to Mr. Wright, in which he discovered the following species of foraminifera:—

- C.W. *Bulimina pupoides*, d'Orb. Rare.
- C.W. " *marginata*, d'Orb. Very rare.
- C.W. *Bolivina dilatata*, Rss. Rare.
- C.W. " *plicata*, d'Orb. Frequent.
- C.W. *Logena lineata* (Will.). Very rare.
- C.W. " *hexagona* (Will.). Very rare.
- " *Nodosaria* (*D.*) *communis*, d'Orb. Very rare.
- C.W. *Globigerina bulloides*, d'Orb. Frequent.
- C.W. *Discorbina rosacea* (d'Orb.). Very rare.
- C. " *Wrightii*, Brady. Rare.
- C.W. *Truncatulina lobatula* (W. & J.). Rare.
- C.W. *Nonionina depressula* (W. & J.). Very common.
- C.W. *Polystomella striato-punctata* (F. & M.). Rare.

Ninety specimens of *Nonionina depressula* were obtained from this gathering, while the other 13 species numbered in all only 34 specimens.

On the east side of the St. Asaph road, a short distance up the road, immediately N.W. of Parc-y-Meirch, is a limestone-quarry about 280 feet above O.D., and it is seen here that the drift runs up and chokes the valley. It is full of Wenlock Shale, mixed with limestone and much rounded shingle. Following the valley upwards, it is evident that the whole is drift-filled, and not only so, but the drift sweeps over the hills, giving them their rounded outlines. Parc-y-Meirch is an old entrenched camp on a drift-covered hill. At a level of about 555 feet above O.D. I found a large boulder of nodular volcanic ash, which looked to me very like Arenig. I submitted the specimen to Mr. Thomas Ruddy, of Palé, who is very familiar with the volcanic rocks in this part of North Wales, and he says that he considers it to be the nodular ash described by Ramsay at p. 93 in vol. iii. Mem. Geol. Surv. He has found boulders of it near the village of Cerrig-y-Druidion. At the road crossing the

¹ Davies & Reade, Proc. Liverp. Geol. Soc., Session 1894-95, vol. vii. pt. iii.

St. Asaph road, north-west of Parc-y-Meirch, 220 feet above O.D., a stream has cut into the drift, over which it falls for a few feet as a waterfall, and here is disclosed a well-stratified sandy deposit.

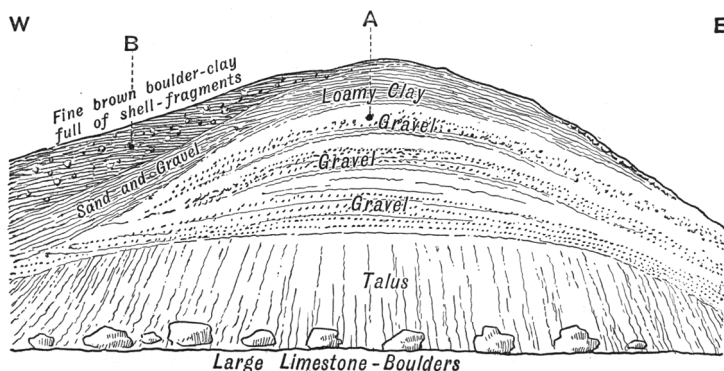
My observations generally go to show that the drift here described represents a shore sloping up gradually from the lowland of the Vale of Clwyd, until it is backed up at a greater angle against the limestone-cliffs forming the west side of the Vale.

(2) Glacial Sands and Gravels, east side of the Vale of Clwyd.

The country between Rhyddlan and Diserth is mostly covered with red sand, evidently derived from the Trias, which is the bottom rock of the Vale.¹

South-east of Diserth Castle, near Prestatyn Branch Railway, is a striking grass-covered mound of sand and gravel (No. 5 in the Map),²

Esker south-east of Diserth Castle.



the structure of which may be investigated where it is broken into by the excavations for gravel. The axis of this mound has a north-easterly trend, and it forms a spur from the hill on which it lies. Orographically it resembles an Irish esker. The excavation shows that the bedding of the sand and gravel largely follows the external form, the flank, where exposed, being covered with a layer of Boulder Clay, as illustrated in the above diagram. In the

¹ Between Abergele and Rhyddlan the Glacial beds are masked by post-Glacial deposits, but borings seem to show that Boulder Clay and Sands alternate. There are good sections of the Marine Drift on the river-bank at Rhyddlan, and these have been described by Prof. M^cK. Hughes, 'Geol. of the Vale of Clwyd,' Proc. Chester Soc. Nat. Sci. 1884, no. 3. See also remarks on Drift in 'Trias of the Vale of Clwyd,' Proc. Liverpool Geol. Soc., Session 1890-91, vol. vi. pt. iii. p. 285.

² See 'Geology of Rhyl, Abergele, and Colwyn' (p. 32 & map), by Aubrey Strahan, Mem. Geol. Surv.

gravely sand that runs loosely down the flanks of the excavated portion were marine shell-fragments of the usual type.

The pebbles are preponderatingly of Carboniferous Limestone. There are too a great many boulders of the same rock lying about that have been taken out of the mound. Boulders and pebbles of a fine-grained felstone also abound, and these may have come from the Snowdon range. There are, moreover, other rocks which both Mr. Ruddy and I consider to be from the Arenig.

At A (see diagram, p. 345) I took a specimen of the sand and gravel, at a level of about 350 feet above O.D. The result of mechanical analysis was as follows:—

Weight before washing = 5 oz. = 1·000.

Caught in	$\frac{1}{20}$ -inch mesh	0·700
"	$\frac{1}{30}$	"	0·083
"	$\frac{1}{60}$	"	0·100
Passed	$\frac{1}{60}$	"	0·050

Clay ? = 7 per cent. 0·933

The $\frac{1}{20}$ -inch material contained some extremely rounded and beautifully polished pebbles, measuring from $\frac{1}{2}$ inch on the longer axis down to $\frac{1}{8}$ inch, of very hard, green, igneous rock; there were also pebbles of limestone, sandstone, vein-quartz, and a few shell-fragments. None of this material was striated, but it had a beach-worn appearance.

The material from the smaller meshes consisted, as is generally the case, of a larger proportion of quartz-grains as the material became smaller. Many of them were rounded and polished, but mixed with irregular quartz-splinters. The material is largely calcareous, as shown by its bubbling up strongly on the application of acid.

The Boulder Clay on the flanks of the mound, although it was seen on the ground to contain small shell-fragments, did not yield foraminifera to Mr. Wright, who examined a specimen from B (see diagram, p. 345). The stones, he reports, were more or less rounded.

The Boulder Clay appears to cover the surrounding country, being seen in the cutting of the Prestatyn Branch Railway, according to Mr. Strahan, so that the gravel-mound must rise up through it. On the road to Newmarket, at a level of about 500 feet, a sand-pit (No. 6 in the Map) shows yellow stratified sand, with frequent shell-fragments.

These flanking deposits on either side of the Vale of Clwyd bear all the appearance of marine clays and sands, and are, as I have shown in detail, full of the remains of marine organisms. Similar deposits, in this case consisting mainly of the red sand of the Vale of Clwyd, can be traced up the River Wheeler into the valley of the Alyn and down to its junction with the Dee. Farther up the Vale of Clwyd this marine drift gives place to a more local drift, which has come, as shown by Mr. Strahan, from

the south-west. We have also seen that the Arenig rocks are to be found at various localities, even among the marine deposits of the mouth of the Vale.

It is not my object here to attempt to explain these phenomena, but to place on record the results of a more minute examination of the nature of the clays and sands found at the entrance of the Vale of Clwyd than appears to have been hitherto made. It is interesting, however, to observe from the lists and localities given that the Marine Boulder Clays of Lancashire, Cheshire, and Denbighshire contain more frequently, and in a much greater profusion than was suspected, the tests of foraminifera. As a rule, these are found in the finer and more plastic brown or red Boulder Clays, which often contain intensely-striated erratic stones, and they occur in just the sort of deposits in which they are mostly found at the present day. It is certainly remarkable that they are so well preserved, when frequently large boulders of dolerite and other originally hard rocks have crumbled to sand in the same beds.

PLATE XXV.

Geological Map of part of the Vale of Clwyd on the
scale of 2 miles to the inch.

DISCUSSION.

MR. STRAHAN drew the attention of the Author to Prof. Hughes's exhaustive papers on the drifts of the Vale of Clwyd. The occurrence of foraminifera was to be expected in clay so similar to that of Cheshire, in which they had long since been recorded by Mr. Shone. One of the most interesting points in the drifts of the Vale was the meeting of drift from the north with the local drift of North Wales. He congratulated the Author on the result of his careful examination of the clay.

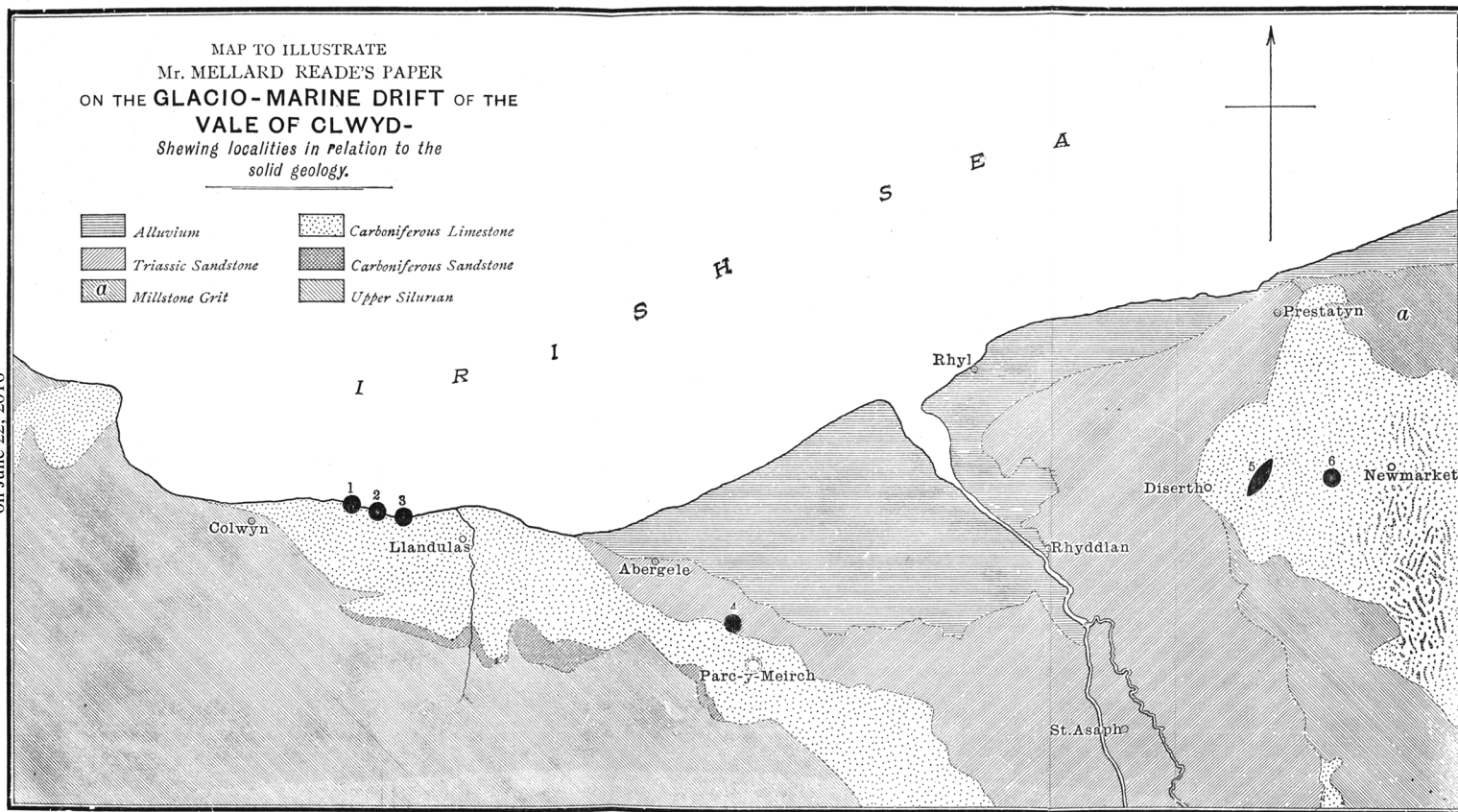
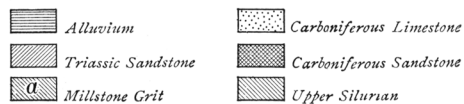
Prof. HUGHES said that he had laid pretty fully before the Society his views as to the origin and classification of the drifts of the Vale of Clwyd (*Quart. Journ. Geol. Soc.* vol. xliii. 1887, p. 73); and he gathered from the too short exposition of Mr. Mellard Reade's recent observations in that area, that the foraminifera which he had obtained all occurred in the newer or St. Asaph Drift. This had all the characteristics of the shore-deposits on that coast at the present day. It contained boulders washed out of pre-existing Boulder Clays, thus commingling the products of the land-ice from the Welsh mountains with the northern boulders rolled in the shore-deposits. There were lumps of the older clay which had been trundled along the shore, so that the outside was covered with gravel, sand, and shells which had stuck to it. There were fragments and rarely whole specimens of shells thrown up from various habitats, just as they occur in the shore-shingle at the present day; and in some of the gasteropods foraminifera were found washed up from sea-bottoms of various character and depth, as at the present time.

The shells in the St. Asaph Drift were, with few exceptions, of the same species as those which now occur on that coast, and the exceptions were Scandinavian, not Arctic.

Mr. P. F. KENDALL also spoke.

The AUTHOR, in reply to Mr. Strahan, said that Mr. Shone obtained his foraminifera from the material in the interior of *Turritellæ*, and not from the clay-matrix in which they were embedded. The late Dr. Robertson examined Boulder Clay from the Atlantic Docks, Liverpool, for the Author; and the list of foraminifera is given in his paper on the 'Drift Beds of the North-West of England,' published in the Society's Journal. It was not, however, until the Boulder Clays in the Wirral Railway-cutting, Cheshire, were examined by Mr. Wright and found to be rich in foraminifera, that the Author realized the importance of the subject. Since then many samples of clays from Great Crosby, Lancashire, Blackpool, the Vale of Clwyd, and Ayrshire have been examined by Mr. Wright with the same result. The organisms occur most plentifully in the finer clays and are well preserved, the facies being very similar from all the localities in England, Wales, and Scotland—jointly pointing to the conclusion that they are not derived fossils, but have lived and died where they are found. The Boulder Clay of the Vale of Clwyd here described is identical with the Low-level Marine Boulder Clay of Lancashire and Cheshire.

MAP TO ILLUSTRATE
Mr. MELLARD READE'S PAPER
ON THE GLACIO-MARINE DRIFT OF THE
VALE OF CLWYD-
*Shewing localities in relation to the
solid geology.*



Scale of 0 1 2 3 4 5 6 Miles

[The black spots indicate the localities at which the specimens described in the text were taken.]