

THE
GEOLOGICAL MAGAZINE.

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ORIGINAL ARTICLES.

I.—ON THE DISTRIBUTION BEYOND THE TERTIARY DISTRICTS OF
WHITE CLAYS AND SANDS SUBJACENT TO THE BOULDER-CLAY
DRIFTS.

BY GEORGE MAW, F.G.S., ETC.

(PART I.)

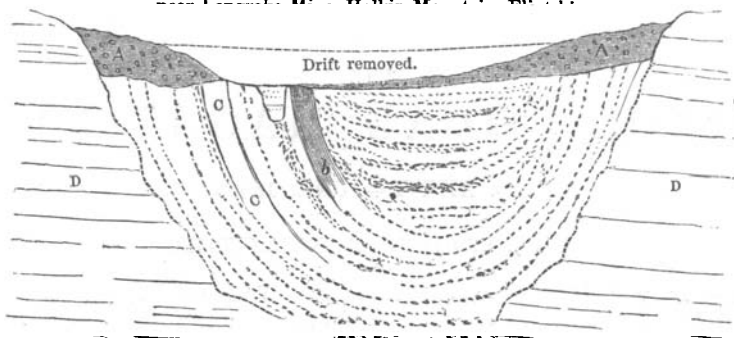
THE object of the following paper is to record some further observations on the distribution in North Wales of deposits of White Clays and Sands older than the Boulder-clay and its accompanying gravel drifts, similar to those in the neighbourhood of Llandudno, described in the GEOLOGICAL MAGAZINE of May, 1865, and also to give a condensed summary of what records I have been able to collect of the occurrence of similar deposits in other parts of the kingdom.

The well-defined and compact geographical disposition of the recognized Tertiary deposits of Great Britain renders the occurrence of beds of similar physical character inferior to the Boulder-clay, in outlying districts, a matter of no little interest, and with a view to a more exact comparison of these deposits in different parts of the kingdom with each other and with their possible analogues in the Tertiary districts, I have endeavoured to bring together in a condensed form all that has been hitherto observed of these singular formations.

North Wales.—Since publishing in the GEOLOGICAL MAGAZINE of May, 1865, a description of the Clay- and Sand-Pockets near Llandudno, I have learned from Mr. Binney that he made some observations on them several years ago, and published a short account in the Transactions of the Manchester Geological Society, but I have not yet seen his Memoir.

The only other locality in Carnarvonshire where I have observed similar deposits, is at a place called Werndow at the back of Conway Mountain, about a mile and a half from Conway, where white clay and sand are visible in several of the ditches. Some pits were opened a few months ago with the object of working the clay for pottery purposes, but there were no sections exposed at the time of my visit. The fundamental rock is here Lower Silurian, and it is the only instance that has come under my observation of these deposits occurring off the Mountain Limestone.

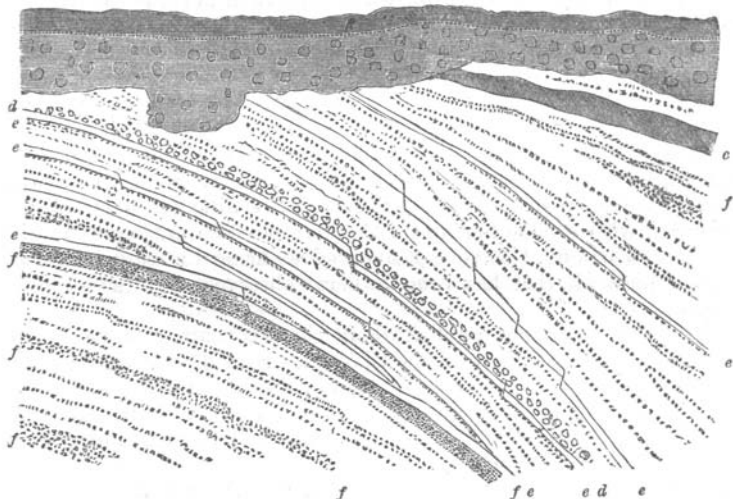
Fig. 1. Sand and clay pocket, about 180 feet in diameter, in Mountain Limestone,



A. Drift. B. Dark laminated clay. C. Tenacious light-coloured pipe-clay, interstratified with white and black sands with occasional layers of soot-like carbonaceous matter.

Passing to the eastward, several pockets containing white clays and sands occur in the Mountain Limestone of Halkin Mountain and the range of hills to the south of Holywell in Flintshire, sections of two of which are given in Figs. 1, 2, and 3.

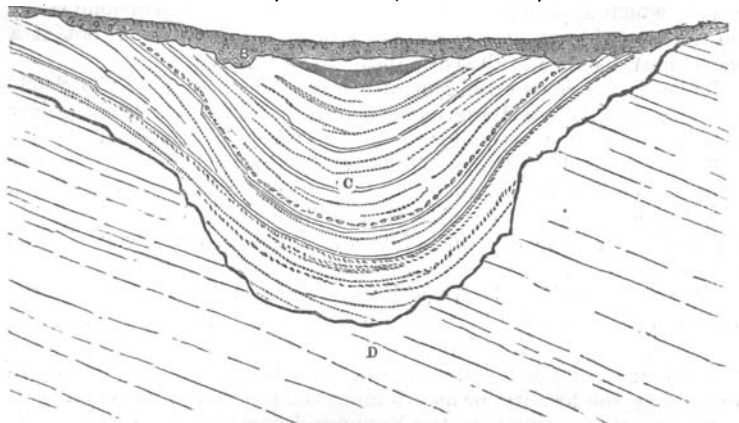
Fig. 2. Sand and clay pit, Bwlch Farm, near Nannerch, Flintshire.



A. Surface soil. B. Drift. C. Dark clay with much carbonaceous matter. D. Thin bed of small white pebbles. E. Thin layers of tough white pipe-clay. F. Dark sand coloured with carbonaceous matter interstratified with white and buff sands forming the bulk of the deposit.

No. 1 occurs about half a mile to the east of Longrake Mine at an altitude of about 900 feet above the sea. The cavity appears to be about 150 feet in diameter *judging from the position of the surrounding limestone on the surface*, though the walls are not visible. The superficial drift, now nearly all removed in working the sand, must have been from 20 to 30 feet thick, under which the contents of

Fig. 3. Supposed general arrangement of Pocket, containing sand and clay in Mountain Limestone, Bwlch Farm, near Nannerch, Flintshire.



A. and B. Surface soil and drift. C. White sand interstratified with grey buff and black sand and thin layers of tough pipe clay. D. Mountain Limestone.

the pocket consist of stratified white, black, grey, and variegated sands containing carbonaceous particles, also a layer about a foot thick of soot-like carbonaceous matter, and strata of dark grey laminated clays, and nearly white pipe clay: the contents of this pocket being but partially exposed, it is not easy to make out their general arrangement; in places they are very unconformable, perfectly horizontal sand beds terminating abruptly against almost vertical strata of tough plastic clay, and in another place a little pouch of level layers of sand lies in the midst of similar beds very much inclined. I have endeavoured to represent the arrangement in Fig 1. The great variety of gradual shiftings and slippings, which the contents of this singular cavity appear to have undergone, have produced a complexity of arrangement not easy to explain.

The section represented in Figs. 2 and 3, occurs at a height of about 850 feet above the sea on Bwlch Farm, between Nannerch and Longrake Mine, one mile to the south-west of the example just described. Fig. 2 represents in detail the portion actually exposed, and Fig. 3 what is most probably the general arrangement of the beds in the limestone cavity. The limestone is not visible in immediate contact with the sand; but as the sand and clay has been sunk through forty feet, and the limestone appears within a short distance on all sides, they must occupy a complete "Pocket," similar to those near Llandudno. The individual strata in this section quickly alternate, and are very thin, consisting of quite white, grey, yellow, and black sands, separated by layers of tough white clay, very regular and continuous, but not more than two or three inches thick.

The darker beds of sand and clay contain a great deal of carbonaceous matter, and here and there, in contact with the clay-beds,

are layers of very black carbonaceous earth. Some of the white sand-beds contain thin layers of small white pebbles, about the size of a pea, which appear to have been derived from the Millstone Grit: on the west side of the section the strata are nearly level, but at a very short distance to the east, they dip at a high angle.

There is a curious arrangement towards the bottom of the Sand-pit, in which the overlying inclined beds are cut off suddenly against some more level strata under them; the whole of the strata are also full of slight dislocations, faults, and slips, which irregularities appear to have been produced by restricted movements within a small area, and are disposed as though the beds had been gradually lowered *after their deposition* into the Limestone cavity during its slow excavation.

At Craig Vraddoc, between Bwlch Farm and Nannerch, on the southern margin of the Mountain Limestone range of Flintshire, similar sand is also found of a character different from that of the Glacial drift of the neighbourhood, but I had not an opportunity of examining the locality, or ascertaining the position of the beds.

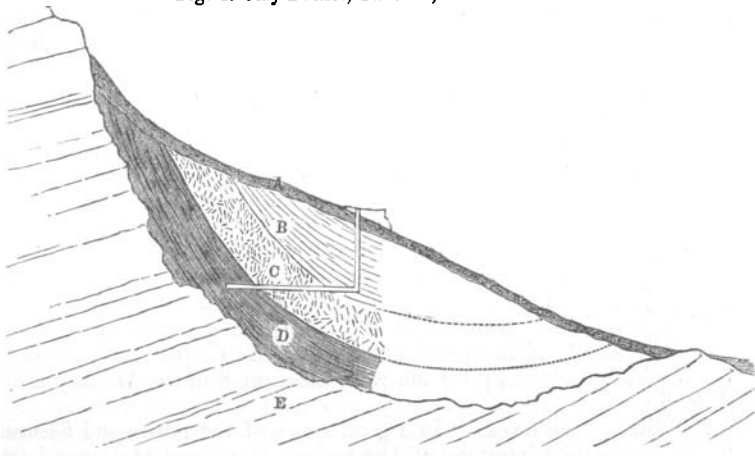
Two or three cavities in the Mountain Limestone have been partly emptied of sand and clay at Ty Coe, near Fridd Garreg Wen, $1\frac{3}{4}$ miles due north of Caerwys. One that has been abandoned for some time appears to be about 150 feet in diameter; I was informed that it contained, with the sand-beds, a considerable proportion of white clays, which were sufficiently tough for the manufacture of tobacco pipes. I also observed a small exposure of dark laminated clay strata near the circumference of the pocket, dipping at a steep angle towards its centre.

A little to the south-east of Langynhafal, in the vale of Clwyd, an adit driven for the purpose of working Hæmatite, exposed a deposit of dark laminated clay, filling up a fissure in the Mountain Limestone, of the same character as the clays on Holywell and Halkin Mountains, and in mineral aspect closely resembling some of the Eocene Clays of Dorsetshire, and the Miocene beds of Bovey Tracey, in Devonshire.

Another example in North Wales, of which I have obtained a section (Fig. 4) occurs at Pant du, near Llanferris, Denbighshire, five miles to the south-west of Mold, at an altitude of about 900 feet above the sea. It appears to be a lodgment that has been protected from denudation in the angle of a sort of amphitheatre of Mountain Limestone rocks, one side being open to the main valley. The clay has been worked for pottery purposes from a shaft sunk into it seventy-five feet deep. The upper five feet is through limestone débris and drift, succeeded by a mass of tough white clay, the base of which was not reached, and consequently the position of the fundamental limestone is uncertain. A head driven from the bottom of the shaft towards the Mountain Limestone escarpment, intersected horizontally 21 feet of white clay, 84 feet of soft chert breccia, similar to that on the Great Ormes Head (described in *GEOLOGICAL MAGAZINE* for May, 1865), and 27 feet of black laminated Clay, the limit of which was not reached. All these beds dipped at a high

angle towards the north, and from the general lie of the ground and the position of the Limestone rock to the south and north of the pit, appeared to occupy a large pocket as represented in the accompanying diagram.

Fig. 4. Clay Pocket, Pant du, near Llanferris.



A. Drift and Limestone Débris. B. White Clay. C. Breccia of Decomposed Chert.
D. Dark Laminated Clay. E. Mountain Limestone.

The bed D closely resembles the dark clay at Llangynhafal and Fridd Garreg Wen, and appears to occupy the same position in relation to the pocket and its contents, as in the latter locality.

At Maes y Safon Mine, about one mile and a half to the north of Pant du, a similar bed of white clay was found in digging the foundation for a windlass, but the depth and extent was not ascertained.

I am informed by Captain Cooke, of Colomendy Hall, that about a mile further to the north, near his house, a shaft was sunk many years ago, and said to have penetrated white clay for more than forty yards without reaching the limestone; but exact particulars are wanting. The probable existence of the clay is rendered evident by a sinking of the ground, below the general level, on all sides—a phenomenon almost invariably accompanying these deposits. A shallow pit sunk on the spot a few years since proved the existence of the clay on the surface, though the full depth was not ascertained.

Similar white clay has been found in sinking mine shafts in several localities near Mold, in each case, as far as could be ascertained, resting on the limestone under a considerable thickness of Boulder-drift and limestone débris, and generally at a height of from 800 to 1000 feet above the sea. At a pit a little to the west of Trinity Church, three miles to the west of Mold, under 93 feet of drift and loose limestone boulders, 45 feet of white clay similar to that at Pant du, was penetrated; and at Vron Hall Mine, at a depth of 140 feet, a layer of white clay was found under the limestone débris.

All the examples of these white clays and sands in North Wales, though varying much in the relative proportion of sands and clays, bear an unmistakeable affinity in mineral character. To the west, in the neighbourhood of Llandudno, sand strata predominate with but slight traces of clays. In the neighbourhood of Holywell the proportion of argillaceous strata is larger, though the sand beds are still in the ascendancy, and in the most easterly examples about Mold the sand strata are almost absent, and replaced with considerable masses of white clays, with occasional layers of dark laminated clays.

Derbyshire and North Staffordshire.—For the followings facts I am indebted to Mr. E. W. Binney, F.R.S., of Manchester, and Mr. E. Brown, F.G.S., of Burton-on-Trent. Mr. Binney has placed at my disposal his notes of several years' observations on the distribution of white clays and sands, similar to those in North Wales—over the Mountain Limestone district of Derbyshire and North Staffordshire; and Mr. Brown permits me to print a portion of his paper "On the Drifts of the Weaver Hills," read before the British Association at Nottingham—the result of independent observations in the same district; and has obligingly supplied me with the section of the Weaver Hills (Fig. 6).

Mr. Binney observes: "In a good many of the mines and fissures of the Mountain Limestone of Derbyshire, clay, sand, and gravel are found; at Bolsover and Lindric common, near Worksop, beds of clay of a light colour occur on the top of the Magnesian Limestone, but they contain no sand or gravel."

The earliest notice of the white clays, in the Mountain Limestone district of Derbyshire, appears to be in Farey's "General View of the Agriculture and Minerals in Derbyshire," published in 1811. In Vol. i., page 249, he says: "Faults, as before observed, range along and have broken the vein stuff and rake and *pipe* veins, and introduced rounded Quartz pebbles, gravel and *alluvial clay*, and other extraneous mineral matters below the Tick holes, *which connect with the surface*, and such are often called soft veins or are said to be filled with 'softs.'" These "*Tick holes*," connected with the surface, would appear to be analogous with the "Pot holes" or Pockets of the Mountain Limestone district of North Wales. Farey gives a list of mines in which, what he terms "*Alluvial clay and other extraneous matter*" derived from the surface have been met with; but in many cases it is difficult to distinguish whether the white clays and sands resting on, and contained by pockets in the limestone, are referred to. The following mines taken from his list appear to be the localities of the white clays, sands or gravels underlying the Glacial drift:—

"Bald Mare," in Brassington, is given as the locality of China clay and gravel.

"Bonds Vein," North-West of Wirksworth; in 3rd Lime—gravel.

"Clay-pit Dale," near Hartington—China clay, and gravel.

"Dale Top," in Wirksworth—Gravel.

"Green Linnet," West of Brassington—China clay.

- "Hill Top," South of Middleton, by Wirksworth—Gravel.
- "Leas Vein," North-West of Wirksworth—Gravel.
- "Lime Kilns" and "Drake," in Winster—3rd Lime—Gravel.
- "Mossey Meer," in Winster—Ochrey clay.
- "Nursery," North of Hopton in Dunstone—Soft clay.
- "Portaway Pipe," in Elton and Winster—Gravel.
- "Sand-hole Pipe," South-West of Wirksworth—Gravel.
- "Seven Rakes," near Matlock Bridge—Gravel, bones, and teeth.
- "Solms," in Wirksworth and Middleton—Gravel.
- "Suckstone," in Brassington—China clay.
- "Upper Field," in Brassington—China clay.

In speaking of China clay, at page 447, the same author says : "China clay of a most beautiful white colour is procured in small quantities in Bald Mine, Green Linnet, Suckstone and Upper Field Mines ; in the 4th Lime at Brassington ; in Clay-pit Dale Mine in Hartington, etc. ; in a lum or fissure in the 4th Lime, a quarter of a mile east of Newhaven House ; also in a similar lum at Milk Hill Gate, one mile and a half east of Caldron in Staffordshire ; and perhaps in other places in this stratum."

At page 298, Farey observes : "In large open fissures in this rock (Toadstone), most beautiful white china clay is found, and many coarse sorts mixed with quartz pebbles, and other alluvia, near Newhaven House, in Hartington, and at Milk Hill Gate, near Caldron, in Staffordshire ; good fire-clay being also procured at the latter place, and used at Whiston Copper Works." Again, at p. 279 : "Just by (The Harboro Rocks in Derbyshire) the Yellow Dunstone seems to produce pits of scouring sand, and near them excellent clay for brick and tile making."

Mr. Binney observes in his notes : "I have many years since seen a good bed of potter's-clay in the Millstone Grit at Spitewinter, near Stannage, on the west side of the turnpike-road leading from Chesterfield to Matlock. This may be only of one of the fire-clays of the lower coals, or it may be like that at Caldron ; I cannot say positively."

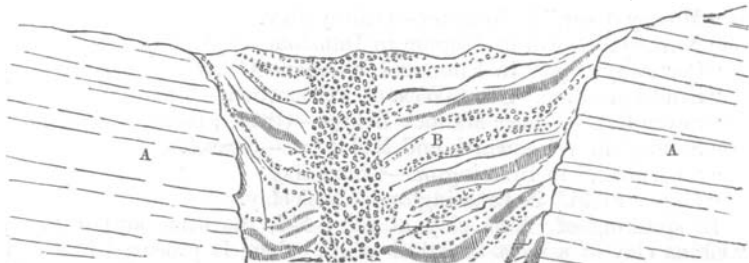
"The whole of the Mountain Limestone district of North Derbyshire and the Millstone Grit and Coal-measure strata are free from foreign drift. I have never seen Till or Boulder-clay in the district."

Mr. Binney has furnished me with the following sketch (Fig. 5) of the Fire-clay "pocket," at the Caldron Hill Limestone Quarry, and observes—"The vertical bed of rounded pieces of grit and white Quartz pebbles mixed with sand proves that the whole of the Clay and Sand now found in the hollow of the limestone was the débris of the Millstone grit formerly lying above them ; but there must have been some strange commotion to account for the position of the bed of pebbles. It is about five feet wide, and the diameter of the pocket about thirty feet. The fine sand is used for the iron furnaces, and the clay, when mixed with sand, for the manufacture of fire bricks."

The following description of the distribution of this deposit on the Weaver Hills, which form the southern extremity, in Staffordshire,

of the Pennine Chain, is from a paper read before the British Asso-

Fig. 5. Sand and Clay Pocket, Caldron Hill Limestone Quarry, Weaver Hills.¹



Scale about 16 feet to 1 inch.

AA. Mountain Limestone. B. Vertical mass of White Quartz Pebbles lying in the midst of contorted layers of black and light coloured Clay mixed with Sand.

ciation at Nottingham, by Mr. Edwin Brown, F.G.S., to whom I am indebted for the section of the locality (Fig. 6).

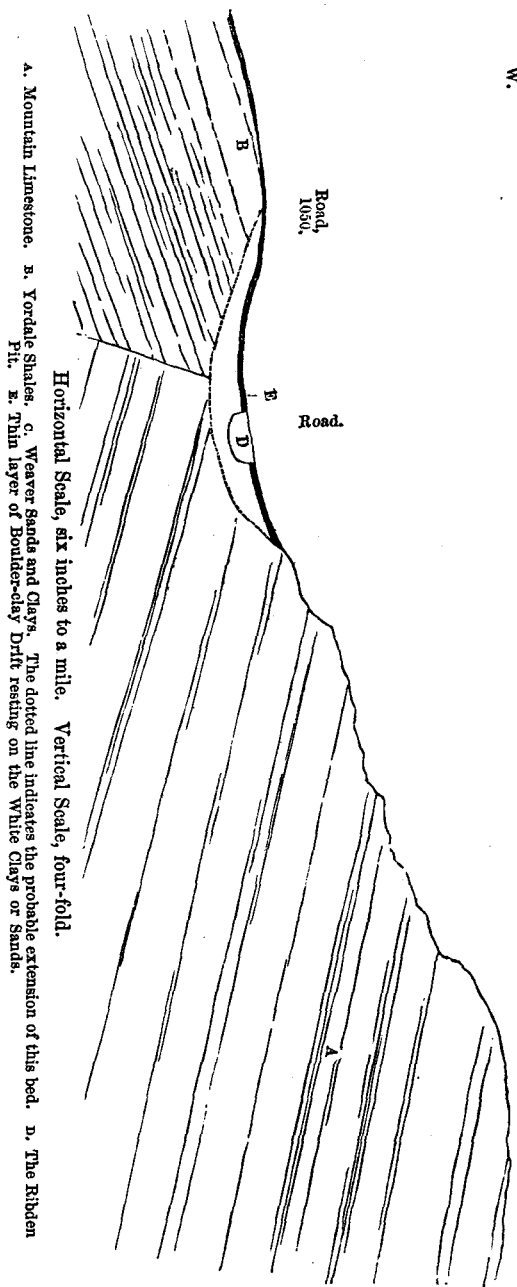
"The Weaver Hills have an elevation of 1200 feet above the sea level. Now it so happens that, owing either to a roll in the strata or to a fault, there exists in front of the Weavers, and at a distance of about a mile from their summits, a ridge of Yoredale rocks, stretching north-west and south-east. This ridge maintains an elevation of about 1050 feet above the sea, and between this ridge and the limestone-hills there is a shallow valley. In this valley, in a trough as it were, there have been preserved the remains of what I cannot but think is the most ancient Drift of the district. It consists of white sands and clays in a roughly bedded condition—nearly the whole substance of this drift appears to have been derived from the denudation of the Millstone Grit and other beds that lie to the westward; it is mostly composed of very fine white silicious sand, the grains of which are so far cemented together, that it may in some parts be cut from the pit in blocks, whilst in others the sand is loose and incoherent. Here and there the bed consists of fine white clay, which has much the aspect of pipe clay, or impure Kaolin. There are interposed also, irregular layers of quartzose pebbles, and in some parts angular blocks of Millstone Grit, Bunter Conglomerate, and Keuper Sandstone are to be found."

"The area of this bed, owing to subsequent extensive denudation, has a very irregular outline: it extends more or less over a stretch from N.W. to S.E. of two miles, and is found in the folds of the limestone valleys at a lateral distance of a mile and a half from the principal bed: its upper surface varies in elevation above the sea level from 1000 feet to 1050 feet, its depth has only been tested in the outlying portions. At one pit or quarry at Ribden, a perpendicular face of some 30 feet has been worked without reaching the bottom, and the bed is here so white and pure that the pit looks singularly like a freshly opened Chalk quarry.

¹ From an error in this engraving, the sand beds interstratified with the clays are represented as pebbles.

"The commercial value of the material has only lately been discovered. It is now extensively worked for various purposes. The best sandy varieties are used for building and lining smelting furnaces, the coarser, for the making of fire-bricks, and the plastic clay when carefully selected will probably be found applicable to the making of earthenware. It is well adapted to these various purposes and is composed almost exclusively of silica and alumina.

"Below Caldon Low this deposit betrays its existence by deep sinkings on the surface of the ground, or by 'Swallows,' as the inhabitants of the neighbourhood term them. These are miniature valleys that converge towards deep central depressions in which, without any apparent hole, the surface water disappears suddenly into the ground. This is, no doubt, owing

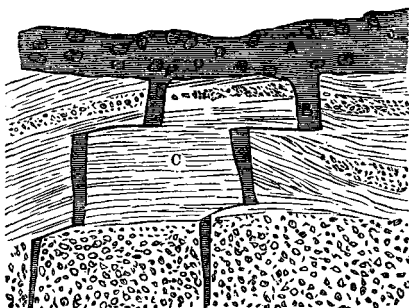


to the existence of fissures in the subjacent Limestone rock, and down which the water is carried mixed with particles of clay. A curious instance occurred a few months ago, shewing the insecurity of this material to build upon. The landlord of the village inn had been entertaining some guests in his best parlour until a late hour on a Saturday night, when on the following Sunday the room fell into an unsuspected chasm in the foundation."

"The question now presents itself, at what time was this bed deposited? To this I can only answer, that it is my belief it was deposited before the first glacial action took place, and that it may be possibly coeval with some of the later Tertiaries, as, for instance, the Norwich Crag. It occurs beneath all other drifts; it is unmixed with Boulder mud. The fragments of contained rocks are mostly angular, and although I have bestowed much time in the search for indications of glaciation, yet, in so far as I can see, the blocks are unmarked by striæ or groovings. I further consider this deposit to be a very ancient one, from the circumstance of the absence of calcareous matter from its composition, for it can scarcely be imagined that a marine deposit of this character could have been formed upon and among calcareous rocks without embedding some fragments of limestone in its substance. Yet I have failed to find any limestone at all amongst the pieces of rock that are scattered through it; and the clay and sand yield only the most infinitesimal trace of lime, when exposed to the most delicate of all tests—oxalate of ammonia. I infer that there was a very long period after the deposit of this bed, and prior to the deposit of the Boulder-clay, during which rain-water permeated it in all its parts, and gradually carried off all calcareous matter. It is owing of course to the absence of lime that this clay is so capable of being used as a fire-clay. I need not remark that I have not found any shells in this bed; as if they ever existed there, which is not

very probable, they would have been long since dissolved and carried away."

Fig. 7. White-clays, Sands, and Pebble Beds overlain by Glacial Till, Ribden Pit, Weaver Hills.



A. Boulder-clay Till. B. Ditto filling up a crack in (C) White-clay Sands and Pebble-beds subsequently shifted.

Under the direction of Mr. Brown, I have recently had an opportunity of examining some of the pits on the Weaver Hills, and was much struck with the close resemblance of the deposit, both in position and mineral character, to the white clays and sands of the Mountain Limestone district of North Wales. Some of the complications of arrangement were very remarkable. The sand and clay strata occupying the limestone cavities being

sloped and twisted into strange contortions, here and there standing

almost vertically, and nearly level beds ending abruptly against those steeply inclined. The superposition of the Boulder-clay was invariably evident, and in one or two places I observed thin layers and seams of the dark Till running in amongst the subjacent lighter deposit, as though it, at the time of the deposition, had contained open cracks on its upper surface, as in Fig. 7.

In one case it was evident that the deposit had moved after the deposition of the Till, the continuity of the thin dark lines being abruptly broken by what appeared to be small slips in the white sand and clay beds containing them. This is a point I shall have further occasion to refer to in the latter part of the paper.

Mr. Brown informs me that—"Somewhat to the east of the Ribden Pit" (from which the example in Fig. 7 was taken) "is another exposure of the white clay, superimposed by several feet of Boulder-clay Till: the locality is known in the neighbourhood as the Wredon or Sally-Moor Pit; leading up from this past the Ribden Pit, towards the Red House, are several other interesting pits in this deposit. At the south-west base of Caldon Low, and close to the road leading to Caldon village, are two or three pits of rather impure deposit. From the top of Caldon Low you may trace by the eye the extension of the bed as marked by the sinkings mentioned in my paper. North of Caldon Low are two or three other newly opened excavations."

[To be concluded in our next Number.]

II.—ON A BED OF PHOSPHATE OF LIME, N.W. OF LLANFYLLIN, NORTH WALES.

By D. C. DAVIES, Oswestry.

AT the meeting of the British Association held in Birmingham in 1865, Dr. Voelker directed attention to the discovery of a bed of Phosphate of Lime in North Wales, and entered into particulars concerning its chemical composition, and economical value.

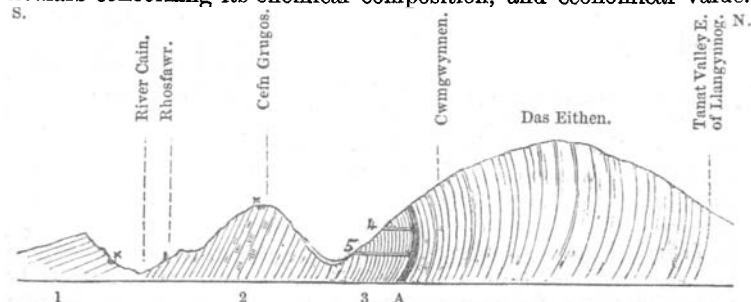


Fig. 1. Section showing the general structure of the country near the Phosphate bed, north-west of Llanfyllin.

1. Rubbly shales, passing upward into soft sandstone, containing *Retepora*, *Favosites*, *Orthis elegantula*, *O. parva*, *Leptæna simulans*, *L. tenuicincta* (Llandoverly beds).
2. Schists, in centre of the hill, passing into impure limestone (Uppermost, or Hirnant band, of Bala limestone).
3. Blue rubbly schists, passing into solid limestone, with bed of Phosphate, A.
- 4 and 5. Levels driven into the hill, the lower one (5) showing the return of the beds to their natural position. x Quarries.