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NOTES ON THE VALE OF CLWYD CAVES, BY C. E. DE RANCE, F.G.S.,
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To realize the full significance of the facts lately discovered at Tremeirchion, on the east side of the Vale of Clwyd, and half-a-century ago at Cefn, on its western slope, it is necessary to review the evidence that has been obtained in other parts of North Wales, in Cheshire, in Cumberland, and especially in Lancashire, in which county a complete sequence of deposits can be determined from the commencement of the Glacial conditions down to the present time.

The upper portions of the Lancashire valleys are found to be what Professor Green has well called "valleys within valleys," the more ancient depression having been filled up with Glacial Drift, which has been re-excavated out, by the gradual denudation of the rivers running through them. The work of widening is effected by the outer bends of the "S"-like curves of the rivers, these slowly move their position in the direction of the flow of the stream, so that after a sufficient time has elapsed, the cutting bend of the "S" reaches the precise point which its predecessor occupied.

The Lancashire rivers have not only excavated wide valleys more than a mile across, like that of the Ribble at Preston, but have excavated them vertically to a depth of nearly 200 feet, the process

going on until the *negative gradient* was reached of that particular stream from its source to the sea, below which denudation ceases, so long as the levels of the land remain constant.

Thus it happened that when the cutting bend of the "S" occupied the position of the similar curve of its predecessors, the stream level was vertically lower by the amount denuded during the period of the seaward progression of the curve to its predecessors position, consequently the silt and other material thrown down during floods, forming the alluvium of the stream, was deposited successively at lower and lower levels; such portions of these alluvial flats that have escaped subsequent denudation form terraces fringing the sides of the valley, the varying height of which mark the successive stages in the process of deepening the valley. The lowest alluvial flat still in process of formation, consists of a bed of loam above a peaty horizon, resting on coarse gravel.

On the western margin of the glacial drift upland-plains, great marine denudation has gone on, and lowland plains continuous with the most modern alluvial flat of the Ribble have come into existence, here the sequence is Blowing and Blown Sand, and *Scrobicularia* clays resting on thick-beds of peat, which between the Mersey and the Ribble rests on an ancient Blown Sand, which I have named the "Shirdley Hill Sand"; and between the Ribble and Wyre, upon an ancient shingle bed, I named the "Presall Shingle."

Following the thick peat of the low-level plains into the Ribble valley, it is found to be continuous with the peaty horizon of the lowest alluvium of that river, proving that the valley had been excavated to its full width and depth before the growth of the peat out in the low-level plains.

Examination of the peat deposits on the coasts of North Wales, Cheshire, Lancashire, and West Cumberland point to the land standing at a higher level in regard to the sea than at present. At a boring at the Palace Hotel, Birkdale Park, Southport, the peat horizon occurred 69 feet below high-water mark. In Liverpool Bay the fishermen constantly bring up pieces of peat in the trawls, at Rossal, Crossens, and Hightown in Lancashire, at Leasowe in Cheshire, and at Llanderillo-yn-Rhos in Denbighshire, the peat beds are seen extending

down below high-water mark, and doubtless formerly passed beneath the level of low water, along which they have since suffered denudation ; borings also at Rhyl at the mouth of the River Clwyd in Flintshire establish the same facts, peat beds underlying Blown Sand and Estuarine Beds beneath the level of low-water.

Roman remains occur in the estuarine deposits overlying the peat beds of Leasowe, and near Fleetwood, and north of Rossal a large number of Roman coins were discovered in marine silt resting on the peat, which were probably lost by the Romans slipping about on the mud banks, at a period when the levels of land and sea were much as at present ; the position of the remains of a Roman Bath at Freckleton, west of Preston, points to the same fact, and no change of level appears to have taken place since Roman times.

The coarse gravels at the base of the Ribble Alluvium and the shingle in the plains between Garstang and Presall point to a period of considerable denudation, the sea wasting the Glacial Drift and forming the lowland plain which subsequently constituted an area of obstructed drainage, culminating in the growth of peat, and the rivers deepening and widening their main valleys to their present proportions.

The previous steps of fluviatile denudation and consequent fluviatile deposition of a small portion of the material denuded, appears to have proceeded along in similar lines, points to a recurrence of physical conditions, *first*, large gravel formed during a period of denudation, *second*, peaty beds with trunks of trees formed during a period of obstructed drainage, *third*, a period of tranquil deposition of fine loam. These conditions are marked in the sequence of deposits in the river terraces of the Ribble and the Irwell.

Reviewing the whole of the evidence afforded by the Post-glacial deposits, it will be seen that no geological work, or physical changes in level, or condition of the country appears to have taken place since the Roman era, but between the close of the Glacial episode, or at all events after the deposition of the latest glacial deposit and the advent of the Romans, the wide and deep valleys of Western Lancashire were excavated out of the Glacial Drift by fluviatile denudation.

The Glacial Drift of the north-west of England and the coast of North Wales is generally made up of an Upper Boulder Clay, reddish or brown in colour, traversed by vertical joints, in the neighbourhood of which the colour of the clay is generally of a leaden hue, it is obscurely stratified, contains rounded and semi-rounded pebbles and blocks, that had been previously ice-worn and scratched, probably by the action of coast-ice, shells of recent mollusca occur occasionally, but generally in a fragmentary condition, and have probably been derived from the gravel generally found beneath these gravels, or rather shingle beds associated with thick beds of sand, have been called the "Middle Drift," from their overlying a Lower Boulder Clay, where seen in section, as in the Bispham and Norbreck Cliffs, north of Blackpool, the banks of the Ribble Valley at Red Scar, east of Preston, the cliffs near Egremont, in Cheshire, and Mostyn, in Flintshire. The pebbles in the Middle Drift are invariably derived from the underlying or immediately adjacent local deposit, and are made up of fragments of coal, coal measure sandstones, or millstone grits, if these rocks underlie it, or of erratic pebbles derived from the Lake District, if the Lower Boulder Clay forms the underlying deposit. The sands are extensively current-bedded, generally in a S.S.E. direction, or that now taken by the tidal current flowing past the Mull of Cantyre, on the coast of Cumberland, and that of Morecambe Bay, where this portion of the tidal current now meets that flowing through St. George's Channel, which during the glacial submergence was not the case. Shells of recent mollusca occur plentifully in pebbly seams, the shells are generally fragmentary, but at Macclesfield, Leyland, Preston and Blackpool they occur in a perfect condition, and probably lived at the site of the localities, where they are found, when covered by the glacial sea, the species of many are northern, and resemble those now living at the North Cape ;—in the peculiar thickening of the canal of the univalves, and the umbos of the bivalves, they resemble the shells of recent mollusca, brought back from Grinnel Land, by the late British Arctic Expedition. A similar assemblage of shells is found in the sands, occurring at very different levels, varying from that of the present high-water mark to 1,200 feet above it, it is probable that the deposits of the higher elevations are more modern than those of the

lowlands, by the time which it took for the land to subside that vertical amount, and that the deposits were thrown down in water of a similar shallow depth, in all the sections examined. There is however evidence in a large number of borings, especially in the Coal-fields of Flintshire, Wigan, and Manchester, that a repetition of conditions took place, and that more than two boulder clays exist, and that considerably more than one horizon of sand occurs.

In some sections near Brinscall, and in other parts of Lancashire, the oldest glacial deposit consists of a tough stiff clay, with local fragments, which in places is seen to be overlaid by Lower Boulder Clay of the ordinary type, in which obscure traces of stratification are to be seen. As I pointed out many years ago [Nature, 1870] the same sequence is seen in the glacial drift deposits off the coast of North Wales : a Lower Boulder Clay with northern erratics lying on the eroded surface of dark leaden-coloured clay containing local fragments ; Sands and Shingle Beds resting on the Lower Boulder Clay with erratic fragments. These Sands and Shingle attain a thickness of nearly one hundred feet at Holywell, in the valley between the station and the town ; near Mostyn also they were seen in extensive sandpits, and on the opposite side of the Clwyd Valley they are seen interstratified with red Boulder Clays between Colwyn Bay and the Little Orme's Head. In the neighbourhood of St. Asaph, in the centre of the valley, these middle glacial beds have been dug for sand, and contain the usual assemblage of shells found in the same beds at various Lancashire and Cheshire localities. Between Mostyn and St. Asaph these sands were described by Dr. Buckland in the *Reliquiæ Diluvianæ*, London, 1823. He gives the following section of the Talargoch Mine, shafts not named :—

| | Feet, |
|--------------------|--------|
| 1. Vegetable mould | ... 2 |
| 2. Clay | ... 78 |
| 3. Sand and Gravel | .. 204 |
| | <hr/> |
| | 284 |

He states that pebbles of lead and some pebbles of copper occurred in the gravel, and that horns, teeth, and bones of Mammalia occurred at from 40 to 70 yards from the surface, and also in the bottom bed

resting upon the rock. Mr. Trimmer,* in 1836, states that two bones found at Talargoch Mine in a bed of gravel at 63 yards from the surface, associated with marine shells, were presented by Mr. Thomas Harrison to the Caernarvon Museum, the bones were described by Buckland as the *astragalus* of a large deer, and the *humerus* of a smaller species, Two perfect specimens of *Purpura lapillus* were shown to Mr. Trimmer found in the eastern end of the works. The bones found at Talargoch have got scattered over the country, but one is preserved in the Chester Museum, and has been identified by Professor Boyd Dawkins, F.R.S., as the left *ilium* of a bison. The gravel beds were also described as being worked for the rolled fragments of lead at Gronnant Mine by Dr. Buckland, the Glacial Drift being 104 feet in thickness. The following table by Mr. Strahan, F.G.S.,† gives the level of the base of the Drift below the ordnance datum level :—

| | | Feet. |
|-----------------------------|--------|-------|
| At Talargoch Walker's Shaft | ... | 41 |
| „ Prestatyn bore-hole | | 54 |
| „ Foryd bore-hole | | 80 |

THE CAVES OF THE VALE OF CLWYD.

The scientific exploration of caverns appears to have sprung from the search after the ‘*ebur fossili*’ or unicorns horn, in the deep caverns of the Hartz, Franconia and Hungary. So far back as 1603 Dr. Gesner had noted that this supposed specific for many diseases, was in fact the elephant's teeth, tusks, and other fossil bones. In 1672 Bauman's Hole in the Hartz was described in the Philosophical Transactions. In the following century the caves of Franconia engaged the attention of numerous German observers, and bones were identified by Baron Cuvier. The most important of these was the cavern of Gailenreuth, from which vast quantities of bones of hyenas, lions, and other animals were obtained. The year 1816 appears to have been the moment when public interest in these matters was greatest, and the experience of cavern exploration in Germany fully matured, which was the time chosen by Dr. Buckland for his visit to

* On the Diluvial or Northern Drift of the eastern and western side of the Cambrian Chain by Joshua Trimmer, 1838, pp. 32-33.

† Geology of Rhyl, Abergelle and Colwyn. Memoirs Geol. Survey, 1885.

this remarkable cavern, in which he learned those methods of research which subsequently laid the foundation of all scientific cavern exploration in Britain. It was in this county, in the cave of Kirkdale, in the Vale of Pickering, 25 miles north-east of York, that Dr. Buckland first applied the knowledge he acquired at Gailenreuth, and proved by the most conclusive evidence that the cave had been inhabited by hyænas, who had gnawed the bones of their prey in the manner he had observed the modern hyæna of the Cape of Good Hope, gnawing bones of an ox in a menagerie.

The Victoria Cave, near Settle, was discovered by Mr. Jackson, in 1837, in a limestone scar 1,450 feet above the sea, and subsequently explored under his superintendence, by a British Association Committee, in 1870, 1871 and 1872. The section near the mouth was found to be as follows, according to Professor Boyd Dawkins* :—

| | | | Ft. | In. |
|---|-----|-----|-----|----------|
| Post-Roman Talus | ... | ... | 3 | 0 |
| Romano-Celtic Stratum | ... | ... | 2 | 0 |
| Talus, with Neolithic horizon at its base | 6 | 0 | | |
| Grey Clay | ... | ... | 4 | 0 to 6 0 |

The Grey Clay occupies the entrance and inside of the caves to an unknown depth, a shaft sunk to a depth of 25 feet near the entrance proved the following sections, in descending order :—

| | | | Ft. | In. |
|--|-----|-----|-----|-----|
| Stiff grey clay, with stalagmite layer | ... | ... | 6 | 0 |
| Finely laminated calcareous clay | ... | ... | 12 | 0 |
| Stiff grey clay | ... | ... | 6 | 0 |

A second shaft further in the caves failed to find the base of the clay at 12 feet, but a third shaft still further in the cave proved 4 feet of reddish loamy cave-earth to underlie about 5 feet of it. The cave-earth contains the bones and teeth of the same group of animals that occur at Kent's Hole, Wookey Hole, and other places, and that reached Europe before the commencement of the glacial episode.

Mr. Tiddeman, F.G.S., describes certain portions of the grey clay as being laminated like the boulder clays of Ingleton, and Clifton, near Manchester, where it was first described by the late Mr. Binney,

* Cave Hunting, p. 87, London, 1874.

F.R.S., under the expressive name of "book-leaves." Professor Dawkins states that they occur at all horizons, and even under the cave-earth, in interstices between the large blocks of limestone underlying the cave-earth.

The Victoria Cave in many respects resembles the Caves of the Vale of Clwyd, in the Yorkshire Cave certain deposits alleged to be glacial rest upon the Bone-earth, but their age has been disputed in the Clwydian Caves, also the Bone-earth is overlaid by glacial deposits, the presence of which has been referred to Swallow-holes, and to a wash from older deposits. After careful study of the Welsh Caves, and all that has been written upon them, I think there is no doubt that they were inhabited by hyænas, and were visited by man before the submergence, during which the local glacial deposits were thrown down.

In the year 1832, the Rev. Edward Stanley, Vicar of Alderley Edge, afterwards Bishop of Norwich, and father of the late Dr. Stanley, Dean of Westminster, visited what was then called the Cefn Cave, a perforated arch through which the road is carried, in which he describes the occurrence of the bones of animals, stags' horns, and a human skull pierced with some sharp instrument. After examining this natural tunnel he heard that a new cave had been discovered 100 feet higher up on the hill, and about 40 or 50 feet below the summit, it was discovered in cutting a very extensive series of walks, by the owner Edward Lloyd, Esq., he found the new cave to have two entrances, the western being full of bone-earth, made of comminuted fragments of bone with numerous large bones of mammals, gnawed and crushed by hyænas, whose teeth were plentiful. He visited the cave in February, and again in April, and found the fine loam in it to fill up the cavern nearly to the roof, which he considered was formerly entirely sealed, he described the laminated appearance of the loam, and the occurrence of bones and broken pieces of hazel or birch.*

In 1836, Mr. Bowman† inferred from the presence of sand and gravel within 18 inches of the roof, that the cavern must have been a water-course.

* Edinburgh New Philosophical Journal, Vol. XIV, p. 40-53.

† J. E. Bowman, Cefn Bone Cave, Brit. Assoc. Report, 1836.

The section he describes as consisting of :—

1. Impalpable mud laminated, 1ft. 6in. to 2ft. 0in.
2. Marl, or clay, with angular limestone waterworn pebbles, passing down into pure bone-earth, with hæynas, rhinoceros, 2ft. 0in.
3. Diluvial clay, pebbles of clay-slate, splintered bones and stalactites, 2ft.
4. Coarse and fine sand, loam, and clay, no bones or shells, 3ft. 0in.

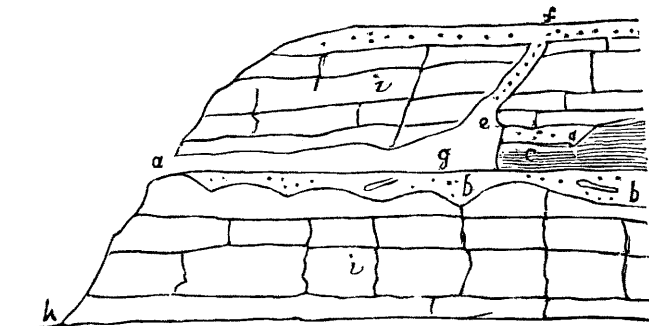


Figure 1. Cefn Cave [Trimmer.]

- a. Level of Cave entrance.
- b. Mud, with rounded pebbles of grauwache, limestone or wood, covered with stalagmite.
- c. Mud, bones, and angular fragments of limestone.
- d. Sand, silt, with fragments of marine shells.
- e. Fissure.
- f. Northern Drift.
- g. Cave cleared of mud.
- h. River Elwy 100 feet below cave.
- i. Limestone rock.

Mr. Joshua Trimmer* in 1838 correctly described the position of the Cefn Caves, as being in a locality in which the local Cambrian Drift met with that derived from the north. He states the beds nearly filled the cavern to the roof, which communicated with the surface by fissures, and describes the Northern Drift as occurring both on the surface and in the fissures. He describes the sedimentary deposits

* Trimmer. Cefn Bone Cave. Brit. Assoc. Report for 1838-1839. *Also* Practical Geology and Mineralogy, London. John W. Parker, 1841, p. 400 etc.

filling the cavern as consisting in descending order of sand and marl, containing fragments of marine shells like those dispersed near the neighbouring district. He mentions that the sediment is very finely laminated, and that the bone-bearing loam was separated into two beds by a crust of stalagmite. The lower bed he states "was below the level of the entrance from the face of the cliff, and contains bones and teeth enveloped in sediment, and mixed with smooth pebbles like those of the adjacent river, and fragments of wood." The authors point out that the lower bed must have been formed by the river when it flowed at a different level, and the marks on the bones show that it was the home of carnivora; and he points out that it must have been sub-aerial for a time, allowing the stalagmite to form.

Dr. Falconer visited Cefn Cave on August 27th, 1859. His notes appear in the "Palæontological Memoirs and Notes," edited by Dr. Murchison, London, 1868. Vol. II. p. 541-2, in which he gives a ground plan of the cave which I have verified on the ground. The tunnel on entering turns to the left, almost parallel to the face of the cliff, it then turns at right angles to it; to the right is a steep side branch running a considerable distance upwards, with many sub-branches, which probably almost reach the surface. Further on the main tunnel divides, and afterwards again unites, a column or island of limestone being left in the centre, beyond which the tunnel ascends very steeply, and eventually reaches daylight on the other side. Of this opening Dr. Falconer says, "it appears to me to have been the *flue* through which most of the materials were injected and washed into the cave. The main tunnels have their floors covered with very slippery yellow loam. The injecta have been washed down chiefly into the left hand tunnel, where bones are found on the upper side of the insular irregular cylinder, around which the cave passage turns, and which forms a complete circular communication.

The following is a list of the species identified by Dr. Falconer amongst the fossils from Cefn Cave :—

| | | |
|---|------------------------------|-------------------------|
| { | Elephas antiquus. | Rhinoceros hemitaechus. |
| | Hippotamus major. | „ tichorhinus. |
| | Equus, teeth and astragalus. | „ Species undetermined. |

| | |
|---------------------------|-------------------|
| { Strongyloceros spelæus. | Cervus Guettardi. |
| { Bos, molars. | „ eurycerus. |
| { Felis spelæa. | Hyæna spelæa. |
| { Ursus spelæus. | Canis lupis. |

No reference is made to shells in the note of Dr Falconer, published by Dr. Murchison, but in the “Geologist” for 1863,* it states that the bones examined by Dr. Falconer, were in the possession of Colonel Watkin Wynn, and that Falconer and Professor Ramsay together discovered fragments of cockles and other marine shells in the clay, and amongst gravel and stones, with which the cave is filled.

Sir Andrew Ramsay referring to this discovery, states the Cefn Caves “were below the sea during part of the glacial epoch, for the Boulder Clay beds reach a higher level, and with Dr. Falconer I found fragments of marine shells in the cave overlying the detritus that held the bones of elephants and other mammalia.”

Mr. Mackintosh, F.G.S.,† in 1876, gave the following sequence of the deposits at Cefn Cave :—

1. Coarse sand charged with minute fragments of sea-shells, still found adhering to one side of a rising branch ascended by steps.
2. Clay with angular and subangular fragments of limestone, likewise a few pebbles of Denbighshire sandstone, grit, and felstone. This deposit contains bones of a number of the usual cave mammalia, is horizontally continuous with the Upper Boulder Clay of the district.
3. Stalagmitic crust from less than an inch to 2 feet in thickness. Very little is described as left in Cefn.
4. Loam with rounded and smoothed pebbles, bones, teeth, and fragments of bone and wood.

The author agrees with Mr. Trimmer, that the sand with shells was introduced by the sea.

On the 22nd of May last, I made, in company with Mr. Bouverie Luxmoore, F.G.S., a careful examination of the cave, and we found portions of the sand-bed still adhering to the wall of the cavern near the upper steps, containing numerous small fragments of shells, one of which is believed to be referable to *Tellina Balthica*, the fragments

* Geologist, Vol. VI, p. 114, 1863.

† Quart. Jour. Geol. Soc., Feby. 1876, Vol XXXII, p. 91.

were examined by Mr. Clement Reid, F.G.S., but no others were capable of determination.

To Dr. Hicks, F.R.S., is due the great interest which now attaches to the caves of the Vale of Clwyd. This investigator visited St. Asaph in 1883, and after visiting the well-known Cefn and Plas Heaton Caves, in the carboniferous limestone of the western side of the Valley, he "was struck with the dissimilarity in the character of much of the materials which had apparently filled these caverns before they were explored," with that which he was conversant in South Wales, to the exploration of which he had previously given much attention. Mentioning this to Mr. Luxmoore, F.G.S., of St. Asaph, and enquiring for caverns on the eastern side of the Vale of Clwyd, he was taken by the latter to a cavern situated in a ravine at the back of Ffynnon Beuno, near the village of Tremeirchion, four miles to the east of Cefn. The cavern was subsequently explored by them. The floor was found to be 42 feet above the stream, and 380 feet above the sea, the slope between being covered with a reddish Boulder Clay, containing Silurian pebbles. The stream has not yet cut down to the original floor of the valley, while high up the valley, sand and gravel is seen containing fragments of sea-shells, on a level slightly above the highest cavern. Similar gravels occur in the gorge east of the Oratory, in the grounds of St. Beuno's College, at a height of over 500 feet. The Ffynnon Beuno cavern, on investigation, was found to consist of a main tunnel with entrance to the south, a small parallel tunnel to the west, also facing south, and a fissure cavern to the east, between which and the inner termination of the tunnel caverns is a considerable chamber, probably partly of a late and artificial origin, and connected with mining trials carried out through the fissure to the east, which has, or has been expected, to bear lead-ore.

A section of the main tunnel, about twenty feet from the entrance, disclosed the following section ;—

1. Surface soil or loam about a foot thick, containing bones of domestic fowls and sheep.
2. Stalagmitic breccia with charcoal, &c., possibly of extremely modern origin, about six inches.
3. Reddish undisturbed cave-earth, about 2 feet in thickness

lying horizontal, and but slightly inclined, at the base was a more coherent yellowish bed, but not stalagmitic, with flint implements.

4. Gravel consisting of local materials, with angular blocks of limestone below.

The flint implement was discovered close to a large portion of the jaw with teeth of a rhinoceros, and close to it large fragments of limb bones of mammoth. The fissure cavern communicated with an opening to the surface, under this large masses of limestone and surface soil were found, which when removed, exhibited undisturbed earth, with many bones, and a few broken flint implements. In the line of the fissure undisturbed stalagmite was found, under which was cave-earth, mammoth teeth, and a well-worked implement. The implements were examined by Dr. J. Evans, F.R.S., who stated

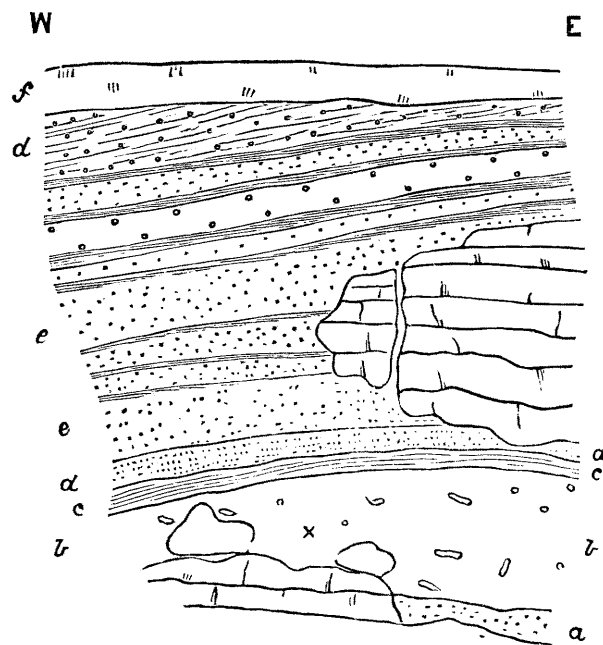


Fig. 2. Section across shaft, and western entrance of Cae Gwynn cave.

Scale. 8 feet to 1 inch.

- | | | |
|---------------------------------|---------------------|--------------------|
| a. Local Gravel. | b. Bone Earth. | c. Laminated Clay. |
| d. Banded Sand. | e. Sand and Gravel. | f. Soil, &c. |
| x Position of Flint Implements. | | |

they resembled those found in Kent's Cavern, he states they have every indication of being used and have now a white porcellanous appearance.

When I examined the cavern with Dr. Hicks, the work of exploration was drawing to a conclusion, I found the fissure to have been extensively mined at some period, and with a rope followed it down some 40 feet below the level of the floor of the cavern.

The western small undisturbed tunnel was discovered by Dr. Hicks, and searching for still another entrance, he found the entrance into the cavern now called Cae Gwyn, this he discovered in 1884, he considered a portion of the entrance had been originally quarried away, and filled up with débris, on this being removed, a cavern was seen filled up with loam, to within $2\frac{1}{2}$ to 4 feet of the roof, a small chamber, with a turn to the right hand was reached, and a trial made at 45 feet from the actual entrance, here under the loam, and underlying laminated clay, occurred bones belonging to Rhinoceros, Horse, Reindeer, and Red Deer, and a well-worked Flint-scraper, resembling those of the French Caves of the Reindeer period, according to Dr. Evans. The work in this cave was resumed in 1885, much débris had to be removed, and large masses of limestone had to be blasted that were found resting upon the gravel beneath.

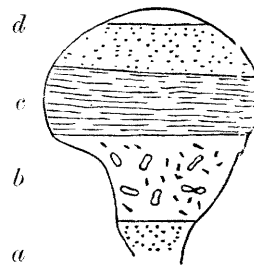


Fig. 3. Section in cavern near new entrance. Scale. 6 feet to 1 inch.

- a. Local Gravel.
- b. Bone Earth.
- c. Laminated Clay.
- d. Banded Earth.

At the time of my visit in the autumn of 1885, the Cae Gwyn Cavern had been worked back as far as the supposed chamber marked

“B” in the plan of the cave published in the Quart. Jour. Geol. Soc., Feb., 1886, which plan I assisted Dr. Hicks in constructing, unfortunately, we did not connect it with the surface, and we were totally unaware that the cavern, by trending westwards, was upon the point re-emerging into daylight, not the slightest traces of subsidence was visible either in the roof of the cavern or on the surface of the field above.

The various deposits at the working face of the cavern filled it up to within 5 or 6 inches of the crown of the roof, consisting of:—

| | | | | Ft. | In. |
|----|---|-----|-----|-----|-----|
| 1. | Fine washed yellow sand | ... | ... | 1 | 0 |
| 2. | Laminated clay, &c. | ... | ... | 1 | 6 |
| 3. | Red Bone-earth (fragments of stalagmites) | ... | ... | 2 | 6 |
| 4. | Local gravel | ... | ... | 1 | 6 |

The Sand resembled that seen in the Drift Sand Pit, 400 yards distant up the valley. On my next visit, 5th June, 1886, and on subsequent days, I found that the removal of material from below had caused a subsidence to take place, beyond what turned out to be a wall of limestone, in which the cavern terminated, and against which a mass of glacial drift formed a slope masking the limestone behind it. The subsidence was accelerated by the heavy snowstorm of the previous winter, the melting snow percolating into the sands, and along the plane between the rock and the drift.

A vertical shaft had been dug 20 feet in depth on the east, or cavern side, and 19 feet on the western side, 9 feet across at the top, and about 5 feet 6 inches at the bottom. I measured with Dr. Hicks the beds exposed in the shaft on all sides by means of a ladder. I placed the point of a knife at the intersection of each bed, and the measurements were written down, and checked by him. The section published in the British Association Report 1886, is the result of these observations. The dip was westwards from the rock, both above the cavern mouth and below it, as shown in the section. The whole of the material in the cavern was not then removed, and the fine grained yellow sand, resting on laminated loam overlying bone-earth, was then seen extending into the cavern to a distance of fourteen feet. Water was still coming in freely at the extreme north-east corner of the shaft, along a line of joint ranging north, to an unknown

distance into the hill. But the yellow sand with oblique lamination, came right up to the rocky ridge overhanging the north of the cavern, and extending northwards beyond it, the sand-bed not only abutting against the rocky ledge but filling up hollows and inequalities in its surface ; the overlying beds of boulder clay, associated with seams of sands, also abutted against the rounded mass of overhanging rock, as did the succeeding bed of fine sand a few inches in thickness, that could then be followed round the four sides of the pit, as could the boulder clay resting on it.

On my next visit June 17th, 1887, my colleagues, Messrs. Tiddeman and Reid, were present, the northern face of the shaft was boarded up ; the shaft was carried westward to 11 feet from the inner wall of the cavern ; no new phenomena were observable ; the materials of the cave were almost entirely excavated out, and the north joint had become dry. I again visited the cavern on October the 3rd and on the 8th, in company with Mr. Shone, F.G.S. The timbering had been removed, and the north side of the shaft re-exposed. Professor Hughes was present, and had a small east and west cut made into the west bank of the shaft, which showed a slight trace of oblique lamination to the S.S.E., the direction so often met with in the Middle Drift Gravels of Lancashire and Cheshire. The joint was slightly yielding water ; no new phenomena were observable.

On October 10th I again visited the cave, accompanying the Director-General of the Geological Survey, and Professor Hughes. Messrs. Hilton Price, F.G.S., Luxmoore, F.G.S., and E. Morgan were also present. Very heavy rains had fallen, and the pit was unfortunately in a soft and somewhat obscure condition. A large block of limestone was pointed out to Dr. Geikie, and he was correctly informed that others occurred at the mouth of the cavern, but he was not told that similar blocks occurred throughout the whole tunnel. A vertical band of sand or sand pipe was shown to him on the west face of the "tumbler" block before referred to.

The visit led to the following letter being addressed to Dr. Hicks by Mr. Archibald Geikie, L.L.D., F.R.S., Director General of the Geological Survey of the United Kingdom, which is of considerable interest :—

“The question on which my opinion was asked with reference to this cave, was, I understand, the following :—Whether the glacial beds lie undisturbed upon the bone-earth at the end of the cave, or whether their present position is due to the fall of the roof or wall of the cave, and their consequent descent upon the cavern floor.

Accordingly I visited the cave on the 10th inst., and examined the section laid open in the pit that was dug in the glacial deposits. The conclusions I formed may be summarized.

1. The bone-earth projects beyond the present limits of the cave, but it probably never did so originally, hence I have no doubt that the roof or wall of the cavern has given way. The large masses of limestone lying at the bottom of the pit no doubt represents a portion of the fallen material.

2. These fallen blocks lie on the bone-earth. The material resting upon them has, of course, been removed in the excavation of the pit, but I observed that the block nearest the northern wall of the pit passed under the base of the undisturbed glacial beds.

3. Against the lower part of the face of limestone on the northern side of the pit there is undoubted evidence of slipping, the lower layers of pebbly sand and clay being vertically against the end of rock. This disturbance however I could trace only a few inches outwards from the rock boundary. It does not affect the main mass of glacial deposits, and is referable I think to solution of the limestone along its outer surface. The various layers of gravel, sands and clays were traced by me continuously across the pit, I could see no evidence that they had ever subsided into a cavity, caused by the fall of the limestone into the cavern.

4. From the data presented by the pit section, I would infer that the fall of the roof or wall of the cave took place before the deposition of the glacial deposits, and that during a period of subsidence, these marine strata were subsequently laid down against the limestone bank, so as to conceal this entrance to the cavern.

16th October, 1887. (Signed) ARCH. GEIKIE.

Mr. Morgan, the lord of the Manor, having kindly promised to delay the process of filling up the pit until I had attended to make a last examination and sketches for Dr. Hicks, I again visited the

cave on the 11th of October. Three sketches were then taken, showing successive stages of removal of the blocks. The north joint in the limestone is seen in Fig. 4, on the west side of it are masses of

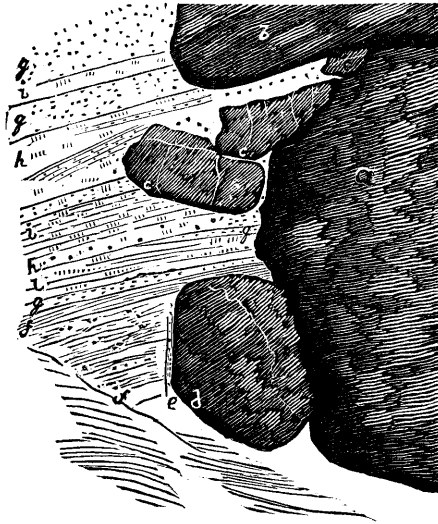


Fig. 4.

- a. Limestone wall, joint face.
- b. Overhanging solid limestone.
- c. Loose masses in Drift.
- d. Large block.
- e. Pipe of sand, against block d.
- f. Bone earth.
- g. Sand.
- h. Gravelly Boulder Clay.
- i. Boulder Clay.

fallen limestone, now separated from it by a vertical pile of dark chocolate-coloured clay, with pale green fragments, about 4 inches in width. Examining the blocks more closely with Robert Williams, who was foreman of the workmen through the whole of the investigation, we very cautiously removed several, and found them to be imbedded in the ordinary brick red clay, with occasional erratics ; further removal of the large blocks disclosed a band of washed yellow sand, which could be traced round from the north joint westwards, over the large "tumbler" before referred to, and over the vertical sand pit also

alluded to, cutting off its upward or vertical prolongation. The sand band now described is about 5 inches in thickness, and ranges horizontally when in contact with the north joint, but dips westwards along the northern face of the pit up to the next bank, where in common with the other beds at the lower part of the section, it dips southwards. Between this sand bed and the "tumbler" is a bed of red clay 6 inches thick. So far as I could ascertain this clay passes down behind the "tumbler," but we considered it dangerous to remove it and ascertain, as the whole bank might have been brought down on our heads.

The red clay up to a certain height contained bone fragments, and the teeth of a hyæna from the north, or clay joint up to and over the "tumbler" fragments of stalagmite were numerous, but I saw none above 2 inches in length, I observed no fragments of stalagmite or bones in the red clay above the laminated sand-bed. The sand pipe adjacent to the "tumbler" appears to owe its origin to percolation of water in the 5-inch sand-bed, which has carried the sand, filling up the fissure between the side of the block and the adjacent red clays, these latter are obviously the flow which arrests and throws out the spring at the north, or "clay joint," which has been similarly filled by the passage of water carrying Boulder Clay from above. The "saturation plane" in the rock beneath, I found by observations in the Fynnon Beuno Cave in 1885, to be but slightly above the stream level, the dryness of the tunnel-cave is due to the cap of Boulder Clay which overlies the hill, but the clay is not wholly impermeable, water traversing joints in it, to which process is probably due the infilling of the north joint with clay, as described.

I undermined the western bank of the Cae Gwyn pit for about 2 feet, the red bone-earth continued as far as we went, containing fragments of stalagmite and bone, there is no evidence to show how far westwards this deposit extends, traces of bone occurred at a point 5 feet from the overhanging ridge of the cave, and I think it a matter of great regret if the extent of its western prolongation be not settled.

From the facts observed during the past half century, it would appear that the following conclusions may be considered definitely settled.

That the caves of the Vale of Clwyd were inhabited by hyænas and other animals at a period, when man existed in the Vale of Clwyd, before the deposition of the middle and upper glacial deposits, but whether before the oldest glacial deposits, there is no evidence to show.

That the Vale of Clwyd like the valleys of the Ribble and the Mersey was deeper before the deposition of the glacial deposits than at the present time. That the valleys and plains of Lancashire, Cheshire, and the coast of North Wales were filled up with various Drift deposits.

That the existing valleys of Lancashire, Cheshire, and the coast of North Wales, have been excavated by the action of running water since the deposition of the Upper Boulder Clay.

That the great peat beds fringing the coasts of these districts are later than the period of denudation of those valleys in the Glacial Drifts.

That the period of the Roman occupation of Britain was later than the growth of the peat.

NOTES ON THE CLASSIFICATION OF THE PALÆOZOIC POLYZOA.

BY GEORGE ROBERT VINE.

The classification of Palæozoic Polyzoa, whether as Cyclostomata, Busk, Cryptostomata, Vine, or Trepostomata, Ulrich, is still incomplete. This arises from two causes, it may be from more causes still, but I wish to confine my remarks specially to two points only :—

- I. The want of a suitably definite nomenclature, descriptive of the structural elements of the Zoarium, Recent and Fossil ; and
- II. The want of ready agreement on the part of Palæontologists, as to what should, and what should not be admitted as Polyzoa, or Bryozoa.

Within the last few years the Palæozoic Bryozoa have been critically studied, both by means of the mass, and by sections of the species described, and at the present time we are in a better position to judge of the possibilities of future research, than we were at the beginning of the decade that is now drawing to a close. Since the