

fossil is demonstrated, however, by the few remaining vertebræ, which seem to belong to the posterior cervical or dorsal region. There are well-marked transverse processes, anchylosed to the centrum, such as have already been mentioned in connection with the Cretaceous *Protostega*; and "the great development and height of the neural arch" are, likewise, quite extraordinary.

With the Austrian Pliocene fossil, the palæontological history of the Leathery Turtles, for the present, ends. It is obviously a most imperfect and fragmentary record, and such as it is frequently the lot of the student of past life to be compelled to accept with contentment. It may even be suggested that the various scattered allusions to the subject have proved scarcely worthy of collation. But the task has not been altogether in vain, if the foregoing array of facts tends in any measure to emphasize the morphological importance of the group of Leathery Turtles, which have rarely been given sufficient prominence in any but technical memoirs; and the series of bibliographical references may possibly be of some slight service to the next fortunate discoverer of fossils of this character, in the all-important preliminary search through the writings of his predecessors.

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#### ON SOME FURTHER RESEARCHES IN BONE-CAVES IN NORTH WALES.

BY HENRY HICKS, M.D., F.R.S., F.G.S.

Since I read my paper 'On some Recent Researches in Bone-Caves in Wales,' before the Association, on Nov. 7th, 1884, I have, in conjunction with others, carried on some further explorations in the Ffynnon Beuno and Cae Gwyn Caverns, which were described for the first time in that paper. The results obtained have been given in papers to the Geological Society\* and to the British Association for the Advancement of Science.† The caverns have been worked by the aid of grants from the Royal Society and from the British Association.

They are situated in a Carboniferous Limestone escarpment, forming the north side of a ravine near Tremeirchion, on the east side of the Vale of Clwyd, and are about two miles from the

\* 'Quart. Journ. Geol. Soc.,' Feb., 1886.

† 'Brit. Assoc. Reports,' 1885 and 1886.

Bodfari Station, on the Chester, Mold, and Denbigh Railway. The heights of the caverns above sea level are about 380 and 400 feet respectively, and they are about 42 and 62 feet above the stream in the ravine.\* The ravine was evidently excavated in pre-glacial times, but was afterwards filled up during the Glacial period with sands, gravels, and boulder-clay. Since then these deposits have been gradually removed by subaërial denudation, but the stream has not as yet reached the original floor of the valley. At different points along the valley, the boulder-clay, with its associated sands and gravels, is left in miniature terraces at various heights, some being above the horizon of the caverns. Fragments of shells occur in the sands and gravels, usually in too imperfect a condition for determination. Ice-scratched boulders, many of large size, one Arenig boulder being several feet in diameter, may be seen on the hill-side to the east of the caverns, and are very plentiful wherever sections have been made in the clay. The majority of the boulders are of local origin, but there are felstones and other rocks from the Snowdonian and Arenig areas, and granitic and gneissic rocks from northern sources. Attempts have been made to sub-divide the glacial deposits of this area, but Mr. Strahan, of the Geological Survey, in his recently-published memoir on the geology of this area, says† “that no detailed classification applicable to the whole area” has been found possible, and that “the passage from the one boulder clay into the other is gradual, nor can it be said that one under or over-lies the other. They were, no doubt, formed contemporaneously, differing only in the source of supply of material.”

The Ffynnon Beuno Cavern is partly a fissure and partly a tunnel-cavern. From the entrance inwards for a distance of about 40 feet it is a true tunnel-cavern, and there is a branch tunnel extending from this for a further distance of over fifty feet, ultimately opening out on the hill-side above the main entrance. Another tunnel communicates with an extensive fissure cavern, which had evidently been disturbed at some time by mining operations (though I could obtain no information as to when). In the undisturbed part of the cavern, at a distance of about 20 feet from

\* In my former paper, by mistake, the height of the Ffynnon Beuno Cavern above sea-level is given at 280 feet.

† ‘The Geology of the Coasts adjoining Rhyl, Abergelle, and Colwyn,’ pp. 28 and 31.

the entrance, the following deposits were recognized: 1. Surface soil. 2. Stalagmitic breccia with some charcoal. 3. Reddish cave earth with bones of Pleistocene animals, and a flint implement. 4. Gravel consisting mainly of local materials with angular blocks of limestone. There was an open space at this point, above the deposits, of from five to seven feet. This being for some extent an open cavern, had probably been inhabited also in Neolithic or perhaps later times. The material below the stalagmitic breccia, it was clear, however, had not been disturbed since Pleistocene times, and the flint implement and the bones must be classed as of that age. Several other flint implements were found at different points in this cavern in association with bones of the mammoth, rhinoceros, &c. Worked bones and others apparently broken by man were also found. The bones were exceedingly plentiful in the cavern, and showed indications of having been freely gnawed, evidently when in a fresh condition, hence proving clearly that they had been conveyed into the cavern soon after the animals had died. Some *album græcum* was also found, therefore the evidence points conclusively to its having been a den occupied by beasts of prey. The materials found in the inner tunnels, which were completely blocked up, must have been rearranged in Pleistocene time by water-action, as a considerable amount of a sandy material occurred there distributed throughout. It is perfectly certain that these deposits had not been disturbed by man, and the evidence obtained seems to point unmistakeably to the conclusion that the bones, which occurred plentifully in them from the base to the roof, must have been carried there from some other part of the cavern by water-action; or that a rearrangement of the materials previously in these tunnels had taken place by water-action, and at the same time that sands and gravels like those to be seen at this horizon in the valley at present, were forced in through the mouth of the cavern to be mixed up with the cave-earth and bones.

In the Cae Gwyn Cavern all the deposits were, when we commenced our explorations, entirely undisturbed, except by burrowing animals. The deposits, in descending order, may be described generally as consisting, first, of a reddish clayey earth, varying in depth from two to four feet; below this, a more compact deposit, about 18 inches in thickness, made up of thin layers of fine marly clay; and, under this, the material containing the bones. This material consisted of a reddish clay with sand in places, and con-

tained a few small boulders similar to some of those found in the boulder-clays of the district. Large fragments of a stalagmite floor and of stalactites occurred also in it, showing that the water-action which disturbed the original materials had also broken up the thick stalagmite floor in the cave, and therefore that it must have been of a violent nature. Under this was found a gravelly deposit, containing fragments, mainly from the hills above, and no bones. All the deposits in the main tunnel of this cavern, except the lowest, have now been cleared out, and another entrance has been reached, which was completely buried under some glacial deposits. It was found necessary to dig a shaft through these deposits, from the field above, in front of the entrance, and by this means an excellent section, 20 feet in depth, was exposed. The upper part of the section was made up of a tolerably stiff boulder-clay containing many ice-scratched boulders and narrow bands and pockets of sand. Below this there were about seven feet of gravel and sand, with here and there bands of red clay, having also many ice-scratched boulders. The next deposit met with was a laminated brown clay, and under this was found the bone-earth, a brown, sandy clay, with small pebbles, and with angular fragments of limestone, stalagmite, and stalactites. On June 28 of this year (1886), in the presence of Mr. G. H. Morton, F.G.S., of Liverpool, and myself, a small but well-worked flint-flake was dug up, by one of the workmen, from the bone-earth on the south side of the entrance. Its position was about 18 inches below the lowest bed of sand. Several teeth of hyæna and reindeer, as well as fragments of bone, were also found at the same place, and at other points in the shaft teeth of rhinoceros and a fragment of a mammoth's tooth. One rhinoceros tooth was found at the extreme point examined, about six feet beyond, and directly in front of, the entrance. It seems clear that the contents of the cavern must have been washed out by marine action during the great submergence towards the close of the Glacial period, and that they were afterwards covered by marine sands and by an upper boulder-clay, identical in character with that found at many points in the Vale of Clwyd and in other places on the North Wales coast. The glacial deposits here are undoubtedly in an entirely undisturbed condition, and are full of smooth and well-scratched boulders, many of them being of considerable size. The animal remains found in these caverns, as identified by Mr. W.

Davies, F.G.S., of the British Museum, comprise teeth of eleven genera and sixteen species, viz. :—Lion, wild cat, spotted hyæna, wolf, fox, bear, badger, wild boar, bovine, great Irish deer, red deer, roebuck, reindeer, horse, woolly rhinoceros, and mammoth.

The palæontological evidence shows that these caverns, like most other Pleistocene caverns, contained many of the animals found in the Norfolk forest-bed, admitted by all to be of pre-glacial age. The absence of other forms may only show that they had probably not migrated into this area, hence this cannot be relied upon as evidence of important difference in age. I am perfectly convinced by the evidence found during the exploration of these caverns that they must have been occupied by man and the animals, before the climax of the Ice age ; also that the thick stalagmite was formed some time during that age ; that this was broken up by marine action during the submergence ; and that the caverns were afterwards completely covered over by materials deposited from floating ice. There seems, therefore, to be every reason to suppose that man and the so-called Pleistocene animals arrived in this country in advance of the Glacial conditions, and that their migrations were mainly from northern and north-western directions.

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## ORDINARY MEETING.

FRIDAY, JANUARY 7TH, 1887.

W. TOPLEY, Esq., F.G.S., Assoc.Inst.C.E., President, in the Chair.

The donations to the library since the previous meeting were announced, and the thanks of the Association accorded to the various donors.

The following were elected members of the Association :—H. W. Burrows ; F. Chapman ; C. Fox ; C. R. Griffiths ; J. N. Johnston ; J. H. Leonard ; E. Locke ; Rev. W. Spiers, M.A., F.G.S. ; and Rev. R. S. Tabor, M.A.

Mr. H. H. French and Mr. S. H. Needham were elected Auditors for the past year's accounts.

The following lecture was then delivered :—‘ On Crinoids and Blastoids.’ By Dr. P. H. Carpenter, F.R.S.

The lecture was illustrated by slides, exhibited with the sciopticon, by Mr. Wm. Lant Carpenter, B.A., B.Sc.