IV.—The Older Deposits in the Victoria Cave, Settle, Yorkshire.

By R. H. Tiddeman, M.A., F.G.S.

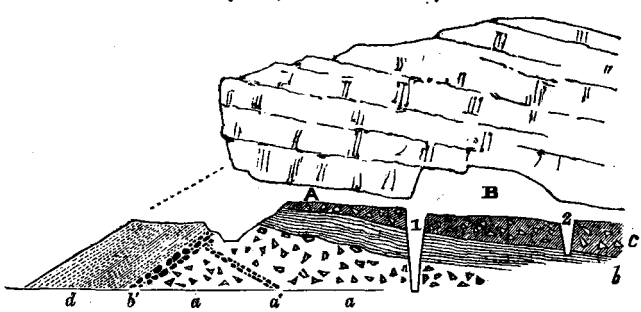
THE following remarks were written for the Settle Caves Exploration Committee in the spring of 1871. They were subsequently submitted to the British Association in 1872, and are, with additions embodying the result of the latest explorations, offered to the scientific public. First, I propose briefly to describe the beds with which we have become acquainted in the course of the explorations, their apparent range and superposition. Secondly, I will endeavour to show to what natural causes they probably owe their origin.

In doing so I need not give any description of the later deposits from Neolithic times to the present, they having been fully treated of by Mr. Dawkins.[1] I will merely remark that they are, so to speak, unconformable to the other deposits, and are mixed up with each of them in succession. In short, they form a floor or floors of occupation unconformable to older beds below.

1. The Cave is situated at the base of a vertical cliff of Carboniferous Limestone at the side of a dry valley, and the ground slopes away steeply from the mouth, and is covered with talus. It lies at about 1450 feet above sea-level, and consists of three principal chambers.

Victoria Cave, Settle, Yorkshire.

(Scale, 1 inch to 54 feet.)



A, Chamber A; B, Chamber B; 1, 25-foot shaft; 2, 13-foot shaft; *a*, lower cave-earth; *a'*, bone-bed containing the older cave-mammals; *b*, laminated clay; *b'*, glacial drift; *c*, upper cave-earth; *d*, talus, the dotted line showing its upper surface previous to the explorations.

A. the Central Chamber, about 40 yards long; its direction N.N.E.

B. branches off from it on the left, and has a smaller continuation, C., which is not yet explored.

D. lies on the right of A., and is entered from it near the mouth.

The Limestone in which the Cave is excavated is a whitish-grey massive rock; it dips to the N.N.W. A. is excavated in the bed which forms the roof of D., and B. in that which forms the roof of A. It is probable that all these chambers are really one great cavern, but filled with materials up to the inequalities in the roof which now separates the different chambers. Its floor has never yet been reached.

[1] Journal of the Anthropological Institute, 1871, and Report of the British Association for 1872.

(i.)[1] The débris at the entrance consists of a loose angular talus of Limestone, which at the surface has some clay and vegetable mould included in it, but lower down it is very clean. It is without doubt derived from the rocks above by the frosts of successive winters. It is a point worthy of notice, however, that though for the most part made up of loose, small, independent fragments, in many places you may see, on looking more closely, that very large blocks have fallen and become disintegrated by or after their fall, and their component pieces, although separated by chinks, are still lying in their relative positions. This shows that the rate of accumulation at any one spot is very irregular, and that any calculations with regard to absolute, or indeed relative, time, based upon the thickness of the débris, are very far from being infallible, especially where it is thin.

(ii.) The débris graduates below at the entrance almost imperceptibly into a yellowish-brown clay, with angular fragments of Limestone. This extends, so far as we can tell, over the whole Cave, but is thinnest near the entrance. In a shaft sunk to the depth of 25 feet at the junction of Chamber B. with Chamber A. this bed was 6 feet thick; and in a 13 foot shaft at the end of Chamber B. it shows a thickness of 10 feet, and is possibly greater. In the 25 foot shaft it contained a good deal of stalagmite, which was very soft and rotten; three beds, much harder, which had to be blasted, occurred in it in the 13 foot shaft. Very massive blocks of Limestone lie on its surface in several places, but more particularly at the further end of the Central Chamber (A.), where the form of their upper surface corresponds to that of the roof, and shows that they have simply fallen from above. But large and small masses of Limestone occur throughout its whole thickness. The fragments are nearly all angular, and do not show any signs of rolling nor of glacial scratches.

(iii.) Next below this upper Cave-earth wherever penetrated, we come to a thick bed of fine dark-brown and yellow laminated clay. The laminations are very distinct, tolerably regular, and for the most part very thin; and the clay, when pulled asunder, flakes off along the planes of bedding, the alternations consisting of excessively fine sand and tenacious clay. In section it has much the appearance of streaky gutta-percha. With acid it effervesces freely, about 8 per cent. of its weight being dissolved. This laminated clay is at the surface near the entrance of the Cave, but dips steadily, though not regularly, towards the inner part. It was well seen in two shafts sunk in Chamber A., in both of which it dips to the right towards Chamber D., and appears to underlie the whole of that chamber. On the left it dips towards and into Chamber B., and was ascertained by Mr. Jackson, the superintendent, to have there an inclination of 1 in 9, rather more than 6°. It shows a thickness of 12 feet in the 25 foot shaft, the lowest, 12 inches, consisting entirely of a pure yellow clay. The last foot and a half of the 13 foot shaft was in clay,

[1] Although the upper portion of this is necessarily recent, it has probably been forming ever since the Glacial Period, and therefore deserves to be classed with "The Older Deposits."

probably the top of this bed; but the water dripping from the roof prevented the shaft being continued, so that it could not be ascertained with certainty. The same angle of dip continued from the 25 foot shaft would just bring the top of this bed to where the pure clay was reached in the 13 foot shaft, so that it is highly probable that it is the same.

No organic remains whatever have been found in this bed. It is a deposit well adapted for preserving organic structures; and I have frequently searched it in hopes of finding something embedded in it, but hitherto without success. I have also examined it carefully with a microscope, but have not seen a trace of any animal or vegetable organism.

(iv.) The lowest set of beds to which we have as yet attained comes next in order of descent. It is in all respects, save the remains which it contains, similar to ii. Seven feet of it were shown in the bottom of the 25 foot shaft in Chamber B. It consists of large and small blocks of Limestone in a matrix of sandy clay. The stones are neither rounded nor scratched. No remains were found in it in this shaft, but at the entrance of the Cave, at a depth in this bed of about 16 feet from the base of the laminated clay, was a yellow layer, a floor of occupation dipping into the Cave, at an angle of 15° or 20°, full of hyæna coprolites, and containing the following remains, kindly determined by Mr. George Busk, F.R.S., in May and June, 1872:—

Elephas primigenius (milk molars).	*Hyæna spelæa.*
Elephas. Small size (fibula).	*Rhinoceros tichorhinus.*
Ursus spelæus.	*Bison.*
Ursus priscus.	*Cervus elaphus.*

2. I will now proceed to consider the probable origin of these deposits, and, with a view to that, will just glance at the position of the Victoria Cave. It burrows into the side of a cliff above the 1400 foot level on the east side of a lateral valley which forms a *col* between the comparatively narrow valley of the Ribble above Settle and its broad alluvial plain below that town. The Cave is situated on the watershed of the little valley, or rather what would be its watershed, were it not excavated in permeable limestone.

(i.) The origin of the talus is undoubted: it points simply to agents still in operation here, the disintegration of the cliffs by weather. It must certainly be Post-glacial, for any glacier passing in this direction would certainly remove it; and there are abundant proofs that ice did pass by here.

(ii. and iv.) The similarity of the deposits ii. and iv. is so great that there can be little doubt they were made under similar conditions, and are due to similar causes. (The bed of laminated clay between them is quite different, and must be referred to quite a distinct state of things.) The angularity of the fragments and the absence of any appearance of rolling forbid us to refer them to the sea; with this may be coupled the absence of distinct bedding, save where layers of stalagmite or of bones occur, and the irregularity with which the blocks are dispersed throughout the mass without reference to coarseness and fineness of material. Nor can they be

referred to a river or brook, for any stream which would be of sufficient strength to bring the blocks of stone would infallibly have sorted the materials. It is not likely that they are glacial, and have been pushed into the Cave from the side of an advancing glacier, for then they would be almost sure to exhibit scratches, which is not the case. Every condition is satisfied by the supposition that the stones have fallen from the roof, and that the clay and fine material have been introduced by water in small volume coming down through crevices in the limestone, and depositing its impurities on the irregular surface below, and forming occasionally, when circumstances were favourable, layers of stalagmite.

(iii.) In direct contrast to the beds above and below, the laminated clay shows the greatest regularity of structure. How was it formed? It is not very likely, if it were a marine deposit, that we should find no organic remains whatever; some small fragments or fibres would be sure to be thrown up, and the clay is of the best possible nature for preserving them, which increases the strength of this negative evidence. Also, it is not likely to be a sea deposit, because, if it were, against so rocky a beach it would not be made of such very fine materials, and coarser beds would certainly occur in it. Also, the beds would not dip away from the sea, but be either level or dip towards it; whereas the reverse is the case. Neither have we at any spot in the district for many miles round any indisputable evidence of the sea having been at so high a level either during or since the Glacial Period. On the other hand, it is difficult to conceive of an ordinary stream of sufficient power to bring so much mud, and also to deposit it at so high an angle as that at which it lies. Any brook flowing through the Cave at that angle would not deposit fine mud, but remove it. There is only one way in which I can conceive of its having been formed. Let us imagine a glacier, or an ice-sheet, passing by the mouth of the cave, and partly blocking the entrance with its rubbish. The former existence of one or both is proved by the glacial scratches and till on the rocks hard by, and by numberless other ice phenomena in the neighbourhood. The glacier melts by day, and *usually* (though not always) freezes by night. The moraine rubbish hinders the coarser débris from entering the cave, but gives passage to glacier water charged with fine mud. The glacier, by its grinding, keeps the water charged with mud; and the frequent change from daily flow to nightly inaction gives rise to that close lamination which is its characteristic feature.

In the summer of 1872, since the above was written, in a shaft sunk for coal at Newfield House, Ingleton, a few miles to the N.W. of Settle, I came upon the following section:

4. Reddish stiff till, containing large and small scratched and beautifully polished boulders ... ... 39ft.
3. Laminated clay undistinguishable from that in the Victoria Cave, but containing a few small well-scratched boulders ... ... 6ft.
2. Red clay, containing a few very small semi-angular scratched stones... 3ft.
1. Laminated clay, like No. 3 ... ... 3ft.

Coal-measure rock.

Although in specimens of the laminated clay only a few inches

broad no distinction could be drawn between that here and that in the Cave, in larger specimens in the coal-shaft it was seen to have been much crumpled, as if by lateral pressure. It seems highly probable that the laminated clay in the coal-shaft was the result of glacier water in some quiet hollow beneath the edge of the ice-sheet, or its waning representative, and that it was squeezed after deposition by the ice which left the till upon it. In the Victoria Cave the deposit would have been protected from any such subsequent disturbance. In the coal-shaft the scratched boulders show that it was a glacial deposit. They may have been dropped into the mud from the ice above. In the cave the limestone roof would prevent such an occurrence.

Since the British Association grant was made (1872), further excavations have brought to light beneath all the talus at the mouth of the Cave a bed of tenacious clay with scratched Silurian and other boulders *resting on the edges of the beds containing the older mammals*, and dipping outwards at an angle of 40°. Mr. T. M'K. Hughes has suggested that we must bear in mind the possibility of this Boulder-clay not being in its original position, but having fallen from the cliff. It will be seen in the section that all the talus, and that of considerable thickness, lies above it. Nor is the whole of the talus which has fallen from the cliffs, and so represents a rude measure of their disintegration, here shown, a much greater quantity lying lower down the slope. If we were to *remove* all the talus, it would be barely possible *now* for the Boulder-clay to fall vertically from the cliff into its present position. But were we to *restore* to the cliff all the fragments of Limestone which it has lost since the deposition of the Boulder-clay, it would, I think, be quite impossible for such a fall to occur.

Taking all the circumstances together, it seems more likely that the drift here is the remnant of a *moraine* (lateral or *profonde*) which dammed up the mouth of the Cave, and prevented anything but water charged with fine sediment from entering it during the Glacial Period. It is a rather significant fact that all the deposits below this till are charged with mud, whilst those above it, consisting entirely of fallen talus of great thickness, are, except quite at the surface, completely free from it. Also many of the limestone fragments close beneath the drift appear to have lost much of their surface from the solvent power of water and carbonic acid; for they are rounded to some extent, but not rolled. Perhaps one of the strongest pieces of evidence that the older cave mammals mentioned at p. 13 lived in this district only at a time previous to the great ice-sheet is, that so far as we know the remains of none of them (except of *Cervus elaphus*, which ranges from the Forest-bed to the present day) have been found in any of the Post-glacial deposits of this district. Though so common in the river-gravels in the Midland and Southern counties, they are never found except in caves until we get much further south or east. Leeds, I believe, is the nearest locality where they occur. This would seem to imply that their remains were wiped off the area by the great ice-sheet which occupied what is now the

Irish Sea and its tributary river-systems, and only left in the shelter of caves to which it could have no direct access. Brown bear, horse, red deer, reindeer, megaceros, the more modern bovidæ, and other more recent forms are not uncommon in the Post-glacial beds; but the older cave mammals seem conspicuous only by their absence.[1]

V.—On the Occurrence of Copper and Lead Ores in the Bunter Conglomerates of Cannock Chase.[2]

By William Molyneux, F.G.S.

THE district known as Cannock Chase is, at the present moment, the scene of a series of extensive mining operations which, if even moderately successful, will open up a very considerable area of valuable coal-seams, computed at not less than 200,000,000 tons, and push outwards a distance of upwards of five miles the nothern apex of the South Staffordshire Coal-field. This apex, as is well known, now rests on Brereton, where the Coal-measures are thrown down on the east by a fault of considerable range and influence, and on the west they are overlapped unconformably by Bunter conglomerates. From this point the conglomerates are continued in a broad unbroken tract over the Chase to within about four miles of the town of Stafford, up to which point the mining investigations, to which I have alluded, will be extended.

A little south of Brereton, in the Old Park at Beaudesert, some of the shallow coals, known as the Old Park coals, and also some bands of ironstone, were worked upwards of *300* years ago, and in all probability, judging, not only from the authenticated condition and value of the works in the time of Edward VI., but also from the size and age of numbers of oak trees which now stand on the old pit banks, both the coals and ironstone were worked even hundreds of years previously. And it is interesting to note, in connexion with these old coal workings, that until the year 1852 they represented a distinct and isolated coal area, no coals having been up to that time worked within a distance of four miles, although, geologically, there is no severance of the coal-seams of the Old Park and those of the other portions of the field situated to the south and west.

The Cannock Mineral Railway from Cannock to Rugeley occupies a valley which runs nearly north and south, and unquestionably marks a line of fault of considerable importance. This fault is laid down in the maps of the Geological Survey, and has long been held as determining the western boundary line of the workable coal seams of South Staffordshire. West of this valley, from a point a little south of the town of Cannock, as far as Brocton and Milford, ranges the old surface area of a large portion of Cannock Chase, the greater part of which is at the present time in a state of nature.

[1] I am pleased to find in a Settle Caves Exploration "prospectus," just issued with a view to collecting subscriptions, Mr. Boyd Dawkins has adopted my views on these important questions.

[2] Read before the British Association, Brighton, August, 1872.