ALLUVIAL DEPOSITS ON PLYMOUTH HOE.

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FROM time to time traces of alluvial deposits discovered on the Hoe, at Plymouth, have occasioned considerable controversy, especially as they are in some measure associated with the remains of what are commonly held to be raised beaches. Within the past few months fresh discoveries have been made, and it has been suggested that the whole of the phenomena indicated, alluvial deposits and raised beaches together, are really part of the northern drift. I purpose giving my reasons for holding a contrary opinion.

The Hoe is part of a ridge of Devonian limestone, which, in the words of the late Mr. J. Prideaux, "though intersected in several places," extends "from Mount Wise to Oreston quarries, almost as level as the top of a wall."* The highest point of the Hoe, which has a plateau of some width, is 110 feet above mean tide level, and the average height of the plateau is about 100. Midway on the Hoe extensive excavations are now in progress for the foundations of an hotel, in course of construction by Mr. Pethick, and these have revealed the existence of the deposits which I desire to describe.

Below the ordinary turfy soil there is a bed of earth more or less clayey in character, through which are scattered numerous pebbles. This varies in depth up to four or five feet, and contains patches of white and red clay appearing to graduate, partially at least, into the less distinctively clayey soil by which they are surrounded. With the clay are small veins of sand tending downwards to larger arenaceous deposits, which have not yet been bottomed. Where the rock has been reached, except on the seaward or southern side of the excavation, it is the ordinary limestone. On the south the

* Trans. Plym. Inst., vol. i. p. 40.

rock is what is locally called "hardhead," an arenaceous limestone of a reddish hue, which appears to rest unconformably on the common limestone, here dipping southward at a high angle.

I take the different constituents of the deposits here described in order.

The matrix of the pebbles, which I have termed clayey in character, differs in no respect from the ordinary alluvium of an ordinary river valley; unless in the occurrence of the patches of clay.

The pebbles scattered through it range from a very small size up to boulders a dozen pounds or more in weight. They are chiefly quartzose, some apparently a mixture of quartz and schorl, others granitoid in character, though rather resembling an elvan than a true granite; with a few of a dark hard slate. There are likewise fragments of limestone more or less waterworn; but the pebbles are unquestionably travelled.

The clay occurs in patches rather than beds, these occasionally assuming a lenticular shape. The white clay in exterior character exactly resembles the ordinary clays of the Bovey Heathfield, and at once suggests a similar origin in the decomposed felspar of the Dartmoor granite. This clay contains very few pebbles. The red clay, as a rule, is not so free from them. It may have been derived from the decomposition of a granite with a reddish felspar; but the probability is that it owes its colour to the direct action of iron. Fragments of iron ore have been found in association. The white and red clays occur in close juxtaposition on the same level; and probably therefore the origin of both is the same, and the difference in colour is due rather to local causes of an accidental character.

The sand is the chief peculiarity of the series of deposits. It varies in colour from white, to drab, cream-colour, and red; is very fine and unmistakeably siliceous—precisely such a sand as would be produced by the degradation of a quartzite rock—such a rock, in short, as that from which the quartz pebbles already spoken of came. In mass it occupies a position distinctly subordinate to the clays, and evidently fills a large fissure in the rock, as yet of unknown depth.

These deposits are by no means isolated phenomena in connection with the Hoe.* Sand was found by Mr. Pethick in digging the foundations of Elliot Terrace, adjoining; but that was largely mixed with pebbles.

• At our first meeting Mr. C. Spence Bate, F.R.s., described deposits of sand at Bovisand, which have unquestionably a like origin.

In 1808 a deposit of sand was found on the Western Hoe, fifty feet above high water mark, which contained the jaw of an animal with teeth two inches long, and a large vertebræ $9\frac{1}{4}$ inches by $4\frac{1}{2}$, doubtless that of a whale.

Mr. Bellamy, in his Natural History of South Devon, published in 1839, states* that the height of the ancient beach on the Hoe was generally about 30 feet above highwater mark; and describes a patch as it then existed, 20 feet in depth, and fifty feet above high-water. It rested on a shelf of smoothened rock which sloped gently seawards, and consisted of regularly "superposed or stratified" layers, varying from extremely fine sand to moderately sized pebbles. As traces of pholades were discovered in the rock on which these deposits rested, there can, I think, be no doubt that they were what they were taken to be, a raised beach.

These beaches are from fifty to seventy feet lower than the clays and sand which I have been describing; and the interval is, or has been, more or less filled up by the occurrence of deposits somewhat similar, in which we have the authority of Dr. Moore for saying that bones were found representing, with tolerable closeness, the fauna of the Oreston caves, including remains of the elephant, rhinoceros, and bear.† These may have been taken from portions of deposits which filled fissures in the limestone, under conditions very nearly analogous therefore to that of the cavern at Oreston.

And now for my reasons for distinguishing between what I have called the alluvial deposits and the raised beaches; and my disbelief in their drift origin.

I hold it to be capable of demonstration that the peculiar wall-like character of the great ridge of Plymouth limestone is due to the action of water—that the ridge is, in short, a platform of denudation, formed by a great river which probably followed in the main the course of the present Tamar, but whose debouchure must have been some distance further seaward. That being admitted, the whole of the phenomena described are to be accounted for by a gradual elevation of the land, such as we know to have taken place in geologically recent times. The range of limestone must have been exposed to the denuding action of the waters for a period of great duration, ere the platform could have been levelled as we now find it. While this process was onward, either no deposits were thrown down, or they were only harboured in sheltered

* Page 115.

⁺ Vide report of Geological Section, Plymouth meeting of British Association, 1°41.

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spots. I am inclined to think that the deposition did not commence until the crest of the Hoe had been raised nearly to the level of the waters. Such fine sand could not have been deposited by either a rapid or a deep stream, at any rate at the actual site of deposition; and so with the clay. We see deposits of precisely analogous character formed in the present day by the streams which flow from china clay works. In the ordinary alluvium and the pebbles intermixed, we have evidently the work of a still later period, when the Hoe had begun to peer above the waters, and was only liable to occasional overflow, the river meanwhile busily eroding the present channels by which it passes the rocky barrier, possibly in the track of some pre-existing fractures and fissures. The raised beaches are probably more recent, and may, to a certain extent, be taken to mark pauses in the upheaval, which pauses must have been of long duration to permit of the formation of the shelves of rock upon which these beaches rested.

I trace, therefore, the whole of the phenomena of which I have been treating to a single cause, or rather, perhaps, chain of similar causes: upheaval in conjunction with the action of water, at first fluviatile only, but subsequently both fluviatile and marine, since concurrently with the upheaval the volume of water in the river would appear to have gradually diminished, and tidal action to have assumed greater power.