ON THE ORIGIN OF THE OSSIFEROUS DEPOSITS IN THE ORESTON CAVES.

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In the course of his "Notes on Recent Notices of the Geology and Palæontology of Devonshire," published in the *Transactions of the Devonshire Association* for 1877, Mr. Pengelly, F.R.S., has done me the honour to comment at considerable length upon my paper on the "Geology of Plymouth," published in the *Journal of the Plymouth Institution* for 1876. There is no reason why I should review the whole of the ground therein traversed by Mr. Pengelly; but upon one matter the difference between us is so great, and the particular point so important, that some reply seems necessary. I refer to the question of the origin of the ossiferous deposits in the Oreston Caves. Before passing to that special subject, I may however be permitted to express my regret that by what is evidently a looseness of statement, since it led Mr. Pengelly to draw a different conclusion from my words than I meant them to convey, I have been understood to state that the "amount and direction of the dip of the Cleavage [of the slates at and near Plymouth] coincide commonly with those of the Bedding." When I wrote that "the bedding and cleavage [of those rocks] have a general coincidence," I certainly did not mean that they were generally *identical*, but simply that they generally dipped in nearly the same direction, and to nearly the same amount. I intended resemblance; not identity.

It is unnecessary to describe in detail the character of the Oreston caves and their contents. The fullest account of both will be found in Mr. Pengelly's cavern literature, published in our *Transactions*. It is sufficient for my present purpose to note that there are fissures in the limestone rock at Oreston, near Plymouth, which have from time to time been found to contain the bones of the mammoth, rhinoceros, bear, lion, hyæna, and other animals. In the limestone rock on the opposite side of the Cattewater, on Plymouth Hoe, there are also fissures, for the most part filled with clay, sand, and stones of undoubted Dartmoor origin—at least I understand that in this assignment I have the support of Mr. Pengelly himself. In my paper on the "Geology of Plymouth" the following passage occurs: "These deposits are by no means isolated phenomena in connection with the Hoe. Sand was found in digging the foundation of Elliot Terrace adjoining; but that was largely mixed with pebbles. At the south-eastern corner of the Hoe, near the little cavern which is used as a tool-house, the fissures in the rock contain pebbles precisely similar in character to those above. In such fissures we have the authority of Dr. Moore for saying that bones were found representing with tolerable closeness the Oreston fauna, including remains of the elephant, rhinoceros, and bear. Then again 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 vertebra 9¼ inches by 4½."

Hereon Mr. Pengelly joins issue; and having examined abstracts of the papers of Dr. Moore describing one set of discoveries, and an account of the discovery of 1808, comes to the conclusion that I was in error when I quoted Dr. Moore as saying that bones were found in these fissures "representing with tolerable closeness the Oreston fauna." For this conclusion three reasons are assigned.

A. That Dr. Moore "makes no mention of fissures at all;" but describes two sets of deposits, the higher identical in its constituents with the fissure accumulation described by me; the lower a raised beach.

B. That although Dr. Moore describes "his Raised Beach fauna" as similar to that of the Devonshire caverns, "we are not informed by whom the identifications were made, and also that only the genera, but not the species, are named." Moreover, before Dr. Moore's statement of the similarity can be unhesitatingly accepted, an "explanation must be given of the fact that the hyæna, the most prevalent *genus* of Kent's and Yealm Bridge Caverns, did not occur on the beach on the Hoe, and of the companion fact that the ox found in all the caves named by Dr. Moore was also absent; and even then a trustworthy identification of the *species* as well as the *genera* will be required."

C. That even if the Hoe species were identical with the cavern, and found in the fissures, it would be unsafe to "infer thence that the fissure and cavern deposits were contemporary, for the remains were found *in* the Cave-earth, but . . . *on* the accumulations on the Hoe. They were coeval with the Cave-earth, but more modern than the Raised Beach."

To each of these objections there is, I think, a sufficient answer.

a. It is perhaps one of the inevitable dangers of an argument which is based on the assumption of the proof of a negative, that Mr. Pengelly should have formed his opinion as to Dr. Moore's views on insufficient data—the papers of Dr. Moore, and the papers only. I grant that the Raised Beach deposit, so-called, was really a raised beach, and so described by that gentleman. But this was by no means the only discovery of a similar kind made in connection with the Hoe, quite apart from those which Mr. Pengelly cites. The museum of the Plymouth Institution contains a number of specimens deposited there by Dr. Moore himself, and by him labelled as from the Hoe Raised Beach *and Fissures*. This is conclusive evidence then, on the authority of Dr. Moore, though it finds no mention in his papers, that the Hoe fissures were ossiferous, as stated by me. Since then bones of a similar character have occasionally been found in fissure pockets in the limestone of Cattedown.

b. Dr. Moore is of course responsible for the identification of the genera of the remains found. His general accuracy can however be tested by the examples preserved in the museum. Moreover these dispose at once of the crucial test applied by Mr. Pengelly to the theory of the similarity of the (so-called) Raised Beach and cavern fauna—the absence of relics of the hyæna from the remains found on the Hoe. The hyæna is amongst them. In other words, "the fact that the hyæna, the most prevalent genus of Kent's and Yealm Bridge Caverns, did not occur . . . on the Hoe" (I simply omit the words "on the beach") "is not a fact." So also with the ox.

c. The argument against the contemporaneity of the fissure and cavern deposits is to a certain extent met by the proof that the fissures were really ossiferous; because whatever the position of the Raised Beach remains to that deposit, those from the fissures must have been embedded *in* the deposits therein. And this brings us to a further objection to my argument. Mr. Pengelly says, "The period during which the Raised Beach was formed was certainly not subsequent to the Cave-earth era, for the species of mammals found *on* the beach were either identical with those of the Cave-earth, or they belonged to an earlier fauna; the latest known British elephant and rhinoceros being the *E. primigenius* and *R. tichorhinus* of Kent's Hole." To my mind nothing can be clearer than the fact that the remains being found *on* the beach proves the beach to be of that subsequent origin which is essential to my theory, and which Mr. Pengelly denies. That the date of their deposition in that place was later than the formation of the Beach requires no argument; but to hold that the remains were either contemporaneous (in part) or subsequent seems to me akin to a contention, for example, that the Liassic fossils which bestrew the beach at Lyme Regis are the remains of animals inhabiting our present seas. I account for the presence of these bones *on* the beach by their having been washed out of an ossiferous fissure or fissures. The presence of the whale would create no difficulty.

Mr. Pengelly declines "very decidedly to accept the fluviatile hypothesis" which I thus expressed: "I hold it to be capable of demonstration, that the level wall-like character of our limestone—and this is no mere local phenomena, but may be observed in Torbay—is due to the action of water; that our limestone 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, though it is quite possible that ice may have aided in producing this result." He holds that "an agency is required that would apply to several and widely separated localities—from the confines of Cornwall to those of Dorset and Somersetshire, and to heights varying from the one hundred feet level of Plymouth Hoe to the eight hundred feet of Haldon; that was capable of transporting the wreck of Dartmoor rocks as far as its levelling action has been traced, and that would allow the formation of lithodomous perforations at a height more than double that of the Plymouth plateau. In short, I see no reason for abandoning the opinion I expressed in 1864, as already stated, that 'the grinding action was that of the breaking waves,' and that the various terraces, from the level of Haldon to that of the now submerged forests, 'are indications of . . . . . periods of intermittence in a long series of upheavals.'"

That *something* must be allowed to marine action in the production of the phenomena which Mr. Pengelly describes all must admit; but I, like him, see no reason to depart from the opinion I have already expressed. Such distinctive Dartmoor detritus as we find on the Hoe can have but one origin, and that directly fluviatile. Moreover, the hypothesis that the Tamar was the agent has been greatly strengthened since I wrote by the discovery therein of a pebble of basaltic character, which can only be attributed to the rocks in the vicinity of Brent Tor. At the present moment Dartmoor detritus is being deposited by Dartmoor streams at all levels in the county below that of Dartmoor itself; and this process must have been in progress ever since Dartmoor had existence. For the assumption that a "geologically very modern river" transported Dartmoor detritus to Haldon I am not responsible.

Finally, my hypothesis with regard to the introduction of the osseous remains in the Oreston caves and the Hoe fissures was thus stated: "And now to return to the bone caverns. Their contents must have been carried into them by waters which flowed at a much higher level than those of the Tamar and the Plym, or by waters which flowed when the land was at a much lower level. Here then, is my hypothesis. The similarity in character and method of occurrence of the two classes of deposits leads me to hold that the caverns are in the main contemporaneous with the surface formations which I have described, and date back to a time when the limestone rocks which enclose the fissures were but slightly raised above the waters, and when therefore nothing was easier than the introduction into the caverns of bodies of animals swept down the stream, probably in time of flood; just as they are commonly swept down the rivers of tropical countries in the present day. This view has the double advantage of reconciling difficulties, and of agreeing with the generally observed facts." Mr. Pengelly's objections to this are five-fold.

A. He asks for instances of bodies being engulphed in fissures traversing the *bottoms* of rivers. I simply refer to the washing of the bodies into the fissures in times of flood. We all know that at such times *débris* of various kinds collects in the land hollows, especially as the waters subside, and where they have neither power enough nor depth sufficient for the further transport of bulky bodies.

B. It is next stated that it is not "easy to see why the Oreston fissures should receive such a number and variety of osseous remains, whilst those on the Hoe should receive absolutely none." I have shown that this is an error.

C. Mr. Pengelly remarks that "the Raised Beach era must have been contemporary with or prior to that of the cave mammals; hence at that time the country might have been from thirty to forty feet, but not anything like one hundred feet, lower than at present," and argues that, without making "a lofty cataract a part of the machinery," the Plym or the Tamar could not have had the plateau of the Hoe as its rocky bottom, when the sea was cutting a platform in the cliff of the plateau, or depositing a beach "on such a platform at from sixty feet to seventy feet vertically below the stream itself." If the Raised Beach era was *subsequent* to that of the cave mammals, this objection has no force.

D. Mr. Pengelly denies the similarity of the deposits in the Hoe fissures and the Oreston caves. "Whilst the prevalence of Dartmoor detritus was the most striking fact in the fissures on the Hoe, there was no such material in those at Oreston." There are several points at which it would be difficult to decide with certainty that the contents of the Hoe fissures were of Dartmoor origin, if the enquirer stopped there; for the dissimilarity existing at different localities on the Hoe is quite as remarkable as any that I can imagine between the Hoe and Oreston. And, with all deference to the high authority of Mr. Pengelly, I cannot see in this dissimilarity any adequate reason for abandoning a conclusion to which so many other arguments seem to point. That one set of causes may produce deposits of very different character may be seen at the present moment on the shores of the Sound, and even in localities quite as closely adjoining each other.

E. Pointing out that my hypothesis assumes that "the time represented by the Oreston fossils was not long enough to produce any such changes in the physical conditions of the district as would affect the machinery by which the caverns received the organic remains," Mr. Pengelly cites the opinions of eminent palæontologists that the Oreston cave mammals belonged to distinct faunas, and therefore probably to such very dissimilar conditions of physical geography as would absorb more time than would be consistent with the preservation of this machinery. But does it necessarily follow that this variation in the character of the components of the fauna involves this extension of time? We may have all the conditions necessary for such variation absolutely coexistent within a comparatively limited area, where difference of level induces variation of climate. The great mountain chains of the present day afford all the proof of this that we can need; and it singularly happens that in the section of his Fauna of Devon which includes the mammals, in our last year's volume, Mr. Parfitt illustrates this very point by a reference to the Altai Mountains.

In conclusion, Mr. Pengelly utterly fails "to see what *difficulties are reconciled* by the author's hypothesis, or the *observed facts* with which it *agrees;*" nor does he "see the least occasion for supposing anything more than a series of gaping fissures traversing a table-land above the reach of flooded rivers—though not necessarily or probably of great elevation—into which some animals fell and were killed, and others retired to die; where perhaps a few were dragged or pursued by beasts of prey; whilst the rains of Devonshire washed in at least some of those which died near at hand on the adjacent plateau."

The "observed facts" I have endeavoured briefly to indicate. The main difficulty to be reconciled is the difficulty of believing that contemporaneous and similar deposits in fissures so closely correspondent as those on the Hoe and at Oreston were due to causes so utterly dissimilar as fluviatile action in one case, and casual falling into open fissures on the other; for I am unaware of any evidence that the Oreston caves were ever the resort of living animals, or at all approached the character of dens. Did such evidence exist, it would indeed be a strong argument against my hypothesis; but in its absence I know of none. That water did play some part in depositing the Oreston bones in the position in which they were found is not denied; and I think that the cautious conclusion of Mr. Pengelly, as the result of his visit to Oreston in 1859, when he declined to say "whether animals fell or were dragged in, or whether the bones found there were wholly or partially the remains of dead animals washed in," far safer, and far more in accordance with the teachings of modern geology, than his return to the antediluvian theory of Buckland, minus the deluge.