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of the past, more precious than any hitherto obtained, remain to reward the labours of future observers. I would also remark, that the fact of so long a period as nearly thirty years having elapsed between the first discovery of detached teeth, and of a portion of the jaw of an *Iguanodon* with teeth in place, notwithstanding diligent and constant research, is worthy of especial consideration, as a striking proof of the little reliance that ought to be placed on what is termed negative evidence; and it suggests the salutary caution, that we should not hastily infer the non-existence of any forms of animated nature in the earlier ages revealed by geology, simply because no vestiges of their organic remains have been detected.

2. *On the Position and General Characters of the Strata exhibited in the Coast Section from CHRISTCHURCH HARBOUR to POOLE HARBOUR.* By JOSEPH PRESTWICH, JUN., Esq., F.G.S.

I HAVE on former occasions described the eocene strata of White-cliff Bay and of Alum Bay*. The sections of these two localities show in a remarkable manner the changes there undergone, in the comparatively short distance of twenty miles, by the series of sands and clays forming the Bracklesham Bay beds, and included between the London clay and the Barton clay. I also gave the commencement of the section of the Barton clays at Barton, to show their connection with the upper part of the section at Alum Bay. I have recently had the opportunity of further examining the coast-sections from Barton Cliff to Poole Harbour, with a view to continue the sequence of superposition lower in this more westward portion of the series. This part of the coast was described by Sir Charles Lyell in a paper read before this Society in March 1826. I need not therefore enter into a detailed description of the strata, but will confine myself to the question of the exact position which they bear with reference to the Barton clay, and to a few general observations on their physical conditions. The progress made by the sea in the destruction of the cliffs has also, I believe, brought to light some new features.

In the first place I have, I think, obtained evidence of the existence of the Barton clays to the westward of Christchurch Harbour; consequently the section downwards from them, which I had discontinued at Muddiford, can now be taken up and continued uninterruptedly to Poole Harbour.

Mr. Webster and Sir Charles Lyell have both noticed the sands which underlie the Barton clays at the end of the Barton Cliff near Muddiford. After leaving this cliff, Christchurch Harbour, with its dunes, intervenes for the space of a mile and a half before we reach the cliff at Hengistbury Head. The relation of the strata at this point to those of the Barton cliffs is thereby obscured, and the sequence rendered apparently incomplete.

It may be necessary here again to mention briefly the general characters of the lower part of the Barton clays as exhibited in the cliff east of Muddiford. The extreme abundance of fossils in the upper

* Quart. Journ. Geol. Soc. vol. ii. p. 224, and vol. iii. p. 408.

part of the Barton clays near Hordwell is well known, but in descending lower in the strata they become much scarcer, and almost entirely disappear at the base of these clays. The strata also become generally more mixed with sand, much of which consists of greensand. At the end of the cliff near High-cliff House, nearly one mile east of Muddiford, we have the following section, fig. 1.

Section near the West end of Barton Cliff.

If the strata at the Barton cliffs and those at Hengistbury Head were on the same line of strike, and no fault intervened, we might expect to find at the latter place beds lower in the series than those we left at the former; but it will be perceived that Hengistbury Head projects south in advance of the general line of coast, and consequently is not in the same bearing of the strata as the Barton Cliffs. At Hengistbury Head the strata are more in the trough of the synclinal line of which the anticlinals of the Isle of Wight and Isle of Purbeck form the southern edge. This may, I think, account, without any disturbance, for the reappearance of the Barton clays on the other side of Christchurch Harbour at Hengistbury Head. I have little to add to Sir Charles Lyell's description of the cliffs at this place, and beg to refer to his paper for fuller details than I purpose entering into. I would venture however to introduce the grouping shown in the section fig. 2.

In examining this section we find a near lithological resemblance to the cliff east of Muddiford. The difference is no greater than is common at like distances in any beds of this varying series. The same general characters are preserved, but some slight details vary. The sands at the base of both sections are exactly alike in appearance, and present in both places the same peculiar fragmentary and carbonized appearance in their imbedded vegetable remains. Then we

Section of the Cliff at Hengistbury Head.

Fig. 2.

have the same well-marked bed of black flint pebbles, varying in size from a marble to a swan's egg, and imbedded in white and yellow sand and forming a perfect gravel-bed. Above these are the clays, rather more sandy, it is true, at Hengistbury Head than in Barton cliff and the septaria more ferruginous, but with no character of any value as indicating difference of origin. In further corroboration we have the evidence, scanty though it be, of organic remains. In the lower part of the clay at Hengistbury Head they are extremely scarce: I only found one cast of a small *Modiola* and some teeth of the *Lamna*. Rather higher in the section, and at a short distance west of the Head, I however found very friable, but abundant remains of Barton clay species of *Panopæa*, *Solen*, *Cytherea*, *Pectunculus* and *Venericardia*. Of themselves these few fossils would be insufficient to determine the age of these clays. Several of them equally mark the Bracklesham beds, though on the whole they probably more resemble those of the Barton clays; but this fact being supported by a superposition and by lithological characters, agreeing with the lower beds of the Barton clay at Barton, it follows that the weight of evidence is in favour of their belonging to this series. I had not time to work out more fully the organic remains of this bed, but a further search would, I am convinced, bring many more to light. There is a brick-pit recently opened immediately on the eastern side of the headland, at which I requested the men to collect any specimens they might meet with.

The septaria, although containing almost exclusively carbonized fragments of plants and imperfect vegetable impressions, also showed traces here and there of shells. The "*Teredo antenauta*" was far from uncommon in some of the large fossil stems of trees which are found both in the clays and in the septaria. I would also call attention to the occasional occurrence, in a tolerably perfect state, of the

seeds of plants amongst the mass of fragmentary vegetable remains in the septaria.

The cliffs range westward about half a mile without any lower strata outcropping. For a distance of nearly a mile we then find nothing but low cliffs of sand and gravel, which interrupts the sequence of stratification. When the cliff rises again it consists of gravel underlaid by whitish and yellow sands regularly stratified, but with no characters sufficiently definite to indicate to what exact part of the series they belong. After a continuation, however, of this section for about half a mile, we luckily meet with a slight throw-in of an overlying stratum, which enables us to resume the plan of superposition in descending order. The section is as follows.

Fig. 3.

Here we evidently have in a small depression the base of the Barton clays. The peculiar appearance of the clays "a" and of the bed of pebbles "b" cannot, at this short distance from its last appearance, be mistaken, and this structure and order is peculiar to this part of the series.

After this slight reappearance the Barton clays are not seen again. As we proceed westward the cliffs rise in height, and range uninterruptedly to the entrance of Poole Harbour, a distance of six miles and a half; but, as observed by Sir Charles Lyell, the section is continued "so precisely in the line of bearing of the strata that no new beds rise up;" the whole consisting of the sands which immediately underlie the Barton clays.

Notwithstanding, however, the want of fresh outcrops, there is much to interest in the illustration which these strata afford of rapid changes of condition within short distances.

To commence with the pebble bed "b." This at first sight might appear to thin out, whereas it in reality forms the upper part of the cliff for a considerable distance westward; but, from the circumstance of its immediately underlying the common surface-gravel in this part of its course, it may readily be confounded with it; a closer examination will, however, distinctly show the difference between the two. The one is a confused mass of angular, with a few round, flint pebbles in clayey ochreous sand; the other consists uniformly and solely of perfectly rounded smaller or larger flint pebbles, mixed with more or less sand, and always, when the latter predominates, showing distinct though rough stratification.

At Alum Bay we have seen this bed of pebbles about six inches thick (see Section of Alum Bay, stratum 28), and consisting of pebbles about the size of an egg.

At the end of Barton Cliff the pebbles are generally larger, and the bed is about a foot and a half thick. At Hengistbury Head its

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thickness has increased to about three feet; two miles westward of this headland it is four feet thick. Thus far it has increased in thickness very gradually, and its character has not materially changed, the proportion of pebbles and sand and the size of the former not varying much. At this point however it begins to be rapidly developed, as represented in fig. 4.

Fig. 4.

The pebbles now become larger; irregular and false stratification with beds of sand sets in, and in the range of fifty yards this stratum attains a thickness of fifteen feet. So rapidly does the change proceed, that by the time we have reached within two miles of Bournemouth, or three miles westward of Hengistbury Head, this conglomerate bed, which at the latter place we have seen to be only three feet thick, is developed to a thickness of about forty feet. This forms, for its limited extent, the most important conglomerate-bed in the English tertiaries.

Below this bed is a series of laminated and impure sands. Indications of the variations they present we have already perceived at Barton Cliff and at Hengistbury Head; there however their development is confined both as regards thickness and range, but in the Bournemouth cliffs they are exhibited, as we have before said, in perfect continuity for a range of six miles, and with a thickness of probably, as Sir Charles Lyell estimates, about 150 feet.

The sands are at one spot white, at another yellow, then light red, sometimes coarse, at other places very fine; the clays are here very carbonaceous and compact—there they are interlaminated with sand; elsewhere they consist of fine pipeclays; all these changes are not changes in different parts of a vertical section, but changes in the same bed and on the same levels, with incessant passages from one to the other state of things. In one part of the cliff, as near Boscombe for example, nothing can appear more tranquil and regular than the arrangement of the beds. The upper part of the cliff consists of well-marked, horizontal and uniform, fine white laminated sands, passing downwards into yellow sands, the whole having a ribboned appearance at a distance, and reposing upon horizontally-deposited and laminated fine dark grey clays.

At a short distance east from this we find these clays almost entirely replaced by sands; they then reappear again with strongly-marked false stratification. Further still they again disappear, and then they not only reappear as before, but the sands above and below them assume the same lithological characters, and the whole cliff presents a face of laminated clays. And thus it continues from

beginning to end; clays replacing sands and sands clays, horizontal lamination giving way to oblique lamination, and then changing again, with extreme frequency. So great are the changes, that if the country were only exposed, here and there along the line of cliff, by pits, it would hardly be supposed that the sections were in one and the same stratum.

Westward of Bournemouth the division into layers of coarser sand and fine clays is more marked; pipeclays become more frequent. It was in one of the latter subordinate layers, a short distance west of Bournemouth, that the Rev. P. B. Brodie discovered the impressions of leaves*: they are beautifully preserved, and in one or two seams are most abundant, but the species are not numerous. At the end of the cliff, towards Poole Harbour, there are indications of the appearance of an underlying bed, consisting of a dark grey clay with numerous flat masses of iron pyrites; without seeing it, however, in greater extension, it would be difficult to say whether it is or is not subordinate to the sands of Bournemouth Cliff.

As a whole, this stratum may be considered to consist of whitish and yellow sands, occasionally very coarse, irregularly laminated with subordinate dark carbonaceous clays, which latter are however chiefly developed in the middle part of the stratum. It represents probably the strata Nos. 27 and 28 of the Section of Alum Bay Cliff, and consequently the fossil plants of Bournemouth occupy a higher position in the series by 300 to 400 feet than those of Alum Bay, which occur in stratum 17†. Compared with the strata around London, these beds would form part of the Upper Bagshot sands, or the upper part of the Bracklesham Bay series of Hampshire. The clays worked within a mile or two of Poole I believe also to belong to the same series, but I am not yet in possession of data sufficient to establish a continuance of the series downwards. The sections are numerous; but they are not connected, and the want of fossils, and the rapid changes which we know to take place in the same stratum on the same level, and of which I have further seen some interesting examples in the railway-cuttings between Poole and Wimbourne, together with the frequent repetition of very similar characters in the different vertical parts of this series, render it necessary to proceed in the study of the relative superposition of the strata in this part of the country with much caution.

As a study of a peculiar physical tertiary structure, this is a district of considerable interest. In the east of the Isle of Wight we observe the portion of the eocene series between the London clay and the Barton clay to consist of clays and fine sands repeated with but little variety and in considerable thickness. The absence of strong drifts is denoted by the abundant fossils and by the beds of shells in their normal position, uninjured as at the moment of their entombment, whilst vegetable remains are scarce. At Alum Bay, on the contrary, the remains of drifted vegetables are common; the strata are strongly marked,—fresher, as it were, from their source; exhibit

* Proc. Geol. Soc. vol. iii. p. 592.

† Journ. Geol. Soc. vol. iii. section p. 408.

the action of stronger drifts, and do not contain a single fossil to represent the 200 species abounding in the synchronous strata at so short a distance eastward. Continuing the examination still further westward, we see every indication of an approach to those waters which transported into the then seas the materials of which this series is formed. Extreme irregularity prevails; the coarser portions have here been left. In strong contrast with the coarse grits and sands are the fine white clays, the result probably of intermediate action so quiet as to carry but little of such sediment beyond this threshold; whilst, on the contrary, silt, which here under the stronger aqueous action remained in small proportion and with few subdivisions, became, as it were, by its longer transport, sorted and sifted. We thus have at Alum Bay a succession of clearly-defined and well-marked strata, the representatives of which from Christchurch to Dorchester, there is reason to believe, are fewer, less distinct, and much entangled. I here merely allude to these questions to show the interest which ground, apparently geologically barren and unattractive, may possess when viewed in its larger bearing of ancient physical conditions. To enter upon them fully would require a far more complete survey of this district.

3. *On Ingleborough Cave.* By J. W. FARRER, Esq., F.G.S.

I VENTURE to lay before the Society a plan of the Ingleborough Cave in Clapdale. In Mr. Phillips's paper "On a group of Slate Rocks, &c." published in the Transactions of the Geological Society, second series, vol. iii. part i. p. 12, under the title "Clapham-dale," the dale or valley, of which the cave forms a feature, is described. The "broad depressed cavern" mentioned by him is a little beyond the mouth (A) of the "Old Cave," immemorially known, the extent of which is shown upon the plan. At that time a curtain or barrier of stalactite (*a*), descending from the limestone roof, was supposed to be rock, but in September 1837, a passage being cut through it, the several galleries and chambers marked upon the plan (fig. 1) were discovered. This series of galleries and chambers has at some distant period been the course of the *beck* or stream which Mr. Phillips notices, but the great accumulation of stalagmite on the floor has diverted its course and forced it to work out another channel, and to issue generally through "the broad depressed cavern."

The rock in which these caves are situated is on the line of the Great Craven Fault, and is the Great Scar Limestone described by Prof. Sedgwick in a paper published in the same Transactions (second series, vol. iv. part i. p. 69). In floods, the "broad depressed cavern," called in the country "Little Beck-head," is not sufficiently large for the body of water, which rushes from the hills above through the fissures and hollow interior windings in the rock; and it then forces itself a passage through the larger (supposed to be the original) mouth. The cave described on the plan is in its extent wet. On its floor are numerous basins formed of stalagmite from one foot to four