The Ossiferous Fissures in the Valley of the Shode, near Ightham, Kent

W. J. Lewis Abbott

[*From the* Quarterly Journal *of the* Geological Society *for* *May* 1894, Vol. l.]

The Ossiferous Fissures *in the* Valley *of the* Shode, *near* Ightham, Kent. By W. J. Lewis Abbott, Esq., F.G.S.

Contents.

I. Introduction.

Doubtless there are many geologists in common with myself who have recognized the fact that, if the surface of the Wealden area has been subject to the oscillations claimed for it, then, considering the unyielding nature of the lime- and sandstones, we ought to find innumerable fissures, and by the law of chances these ought sometimes to occur in positions favourable to the preservation of those heterogeneous collections of objects that find their way into the drainers of a country. There are few, perhaps, who realize what a motley group of curiosities are to be found in large streams, unless they have spent some considerable time in walking between the tide-marks of a river in its lower reaches. It is not often conceived how large a portion of the life of to-day could be rescued from such a wreck. Here may be found bones of animals by the cartload, and the hard parts and fruit of vegetation, both terrestrial and aquatic. The principal non-marine mollusca are also represented, although the majority of shells are usually of aquatic species. To appreciate the profusion of these relics one need only travel for the same period over land-surfaces and note the difference of the result. I have frequently paced scores of miles over fields, foot by foot, chiefly in search of implements, without finding a single bone of an animal of either terrestrial or aquatic habits.

It is extremely important to bear these two conditions in mind when we try to account for the filling of fissures and caves with the materials that we now find in them. I have thought it absolutely necessary to draw attention to these important facts, because I regret that I am obliged to differ in opinion from so great an authority as Prof. Prestwich as to the manner in which caves and fissures have been filled. The successive faunas of the various strata, their stalagmitic sealing-down, the identity of the contents of fissures with river-débris, and their total dissimilarity to ordinary land-wash, together with other collateral characteristic features, to my mind render these deposits incapable of being the result of a *marine immersion*.

Unfortunately, the literature of the Weald would not encourage one to expect very much from the Kentish fissures; it is true that references to the ossiferous 'pipes' date as far back as the classic days of Buckland,[1] but from his time to that of Prof. Boyd Dawkins only 7 species of vertebrates have been recorded, and 5 species of mollusca. I have visited a number of these pipes in the neighbourhood of Maidstone and the Shode Valley, and have no hesitation in saying that they are altogether of a different nature from the fissures which will be described in the following pages. The former are surface-deposits, pure and simple, irrespective of the various depths and extensions to which they have cut into the underlying strata, bones and implements being distributed through them exactly as in an ordinary brick-earth.

II. Fissures in the South-east of England: History of the Shode Valley.

Fissures abound in the hard strata of the Wealden district[2] from the North to the South Downs inclusive; at times they are mere empty cracks, never having been brought into direct contact with either the surface itself or even surface-waters. At others they open more or less distinctly above, sufficiently to admit of being filled with land-wash or blown sand; or a river gets access to them and carries in and deposits its suspended material, or its flotsam and jetsam. Again, they are occasionally wide enough to admit of human habitation, some now containing tons of the relics of human occupation, terminating in the midden period. There are yet others which, so far as we can see, have never been open at the surface: their presence has only been revealed by the denuding action of rivers in excavating their channels into the rocks in which the fissures have existed, and, after having thus broken into their secret chambers, the rivers have deposited within them those heterogeneous masses characteristic of the burdens of a stream. At times situation has favoured an entire filling of the fissures; at others the height to which they are filled marks the limit of the power of the flood-waters at a particular period in the valley's history, leaving an empty chamber above. Into this latter meteoric waters subsequently enter, which, percolating through the limestone and hassock, dissolve out part of the lime, not only of the rocks, but of the bones, and redeposit it all over the chamber and for a certain distance into the fissure-deposit, in the various forms of arragonite, flos ferri, stalagmite, and stalactite, until at last the contents of the fissure become sealed down. In some other cases, where the fissures appear to have maintained a free surface-communication through practically the whole of their history, very nearly all the bones are dissolved out, and the lime is redeposited in the interstices of the filling and the adjacent rocks, like veins in serpentine.

[1] These pipes are described by W. Topley, F.R.S., in his memoir on 'The Geology of the Weald,' 1875, pp. 181–184. That author also gives copious bibliographic references to the subject, to which the reader is hereby referred in order to save repetition.

[2] I unsuccessfully worked a number of these before I located those here described, but upon enquiry I found that Mr. B. Harrison had already obtained bones from the latter, which he very kindly passed on to me, giving me at the same time an introduction to the quarry-owner. The latter has also taken great interest in my work, and kindly allowed his men to wheel away the débris for me, a service for which I am greatly indebted to him.

The description of the fissures near Ightham may be taken as a supplement or continuation of the paper by Prof. Prestwich on the drifts around that place.[1] It will, therefore, be unnecessary to recapitulate the description of the Shode,[2] upon whose banks these fissures occur; suffice to say that the stream now rises on the lower part of the face of the Chalk escarpment, about 1½ mile above Ightham, and after flowing over the Folkestone Beds in a general southerly direction, and receiving a westward branch, pierces the Hythe Beds in a picturesque gorge about 80 feet deep. It then winds round more to the east, and in about a quarter of a mile receives a tributary coming down from the N.E., past Borough Green. This latter stream has also carved out a deep valley, which, in wet weather, still carries water. A road has been cut into and along the old valley, exposing the old sandy brick-earth, the composition of which is very significant, owing to its similarity to the fissure-deposit. It also carries boulders of Ightham stone, chert, flint, and a few bones and other fossils.

In about another quarter of a mile the Shode receives a second branch from the N.E., thus leaving the area between the two tributaries as a promontory, which, by the approach of the two streams to each other and the rise of the Greensand escarpment or counterscarp, is more completely isolated. In this the fissures now to be described occur. The Shode then continues its southerly course through the Plaxtol gap till it joins the Medway. Prof. Prestwich, in his graphic description of this river,[3] gives a map and four transverse sections, which are indispensable in the study of this district. But to fully understand the exact condition of things, attention had better first be centred on a section (see fig. 1, p. 174) from the Chalk escarpment up the counterscarp to Shingle Hill. Here we see the Gault, estimated at 150 to 200 feet,[4] rising up from below the Chalk on the lower part of the face of the escarpment, stretching over and forming the low part of the Holmesdale Valley; from beneath this rise the Folkestone Beds, about 110 feet[5] thick; these follow up the dip-slope of the counterscarp till they reach Bitchet

[1] Quart. Journ. Geol. Soc. vol. xlv. (1889) pp. 270–294.

[2] Mr. Topley calls this stream the Plaxtole brook, *op. supra cit.* pp. 185, 289. About Plaxtol it is called the Bourne.

[3] *Op. supra cit.* pl. ix. & p. 272.

[4] In 'The Water-bearing Strata of London,' p. 90, Prof. Prestwich refers to a well at Wrotham which gave 120 feet of Gault. Mr. Topley informs me that the thickness of the Gault in this district is greater than was formerly supposed. A well at Shoreham Place gave 226 feet. He estimates the clay in the line of section at a little over 200 feet.

[5] These figures and measurements are all estimated from sections in the neighbourhood and from the table given by Mr. Topley in his Wealden memoir, plate iii.

Fig. 1.—*Section from Cotman's Ash on the Chalk escarpment to Shingle Hill on the Greensand counterscarp.*

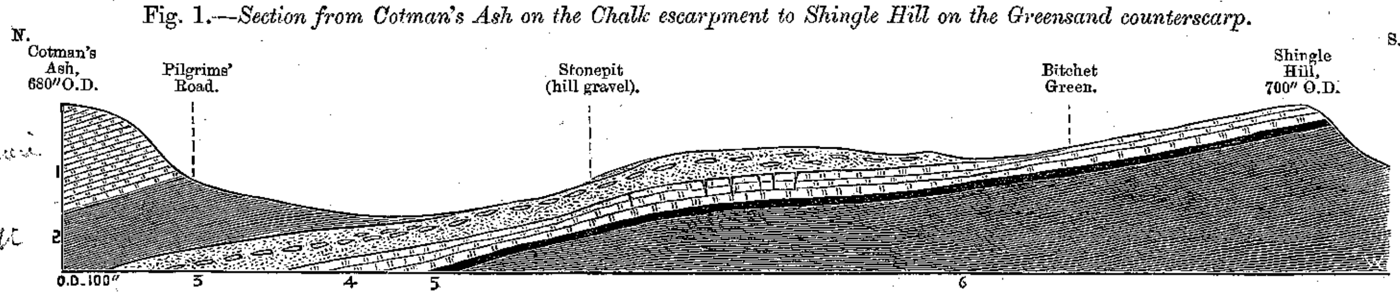


Fig. 2.—*Section across the Shode at Plaxtol, from Shingle Hill to Hurst Wood.*

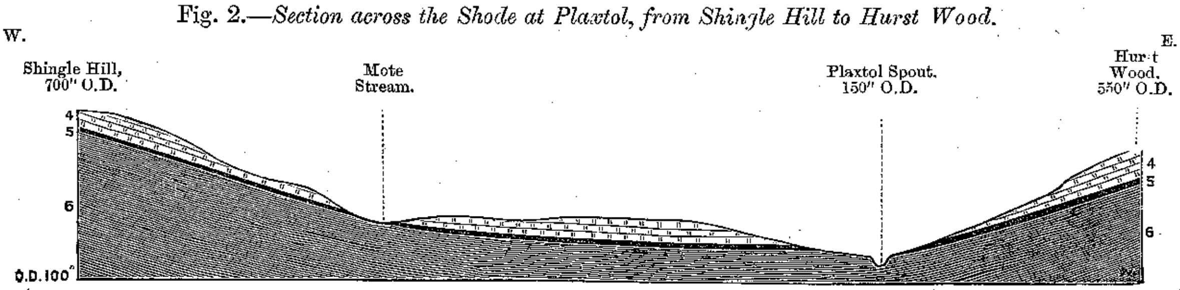
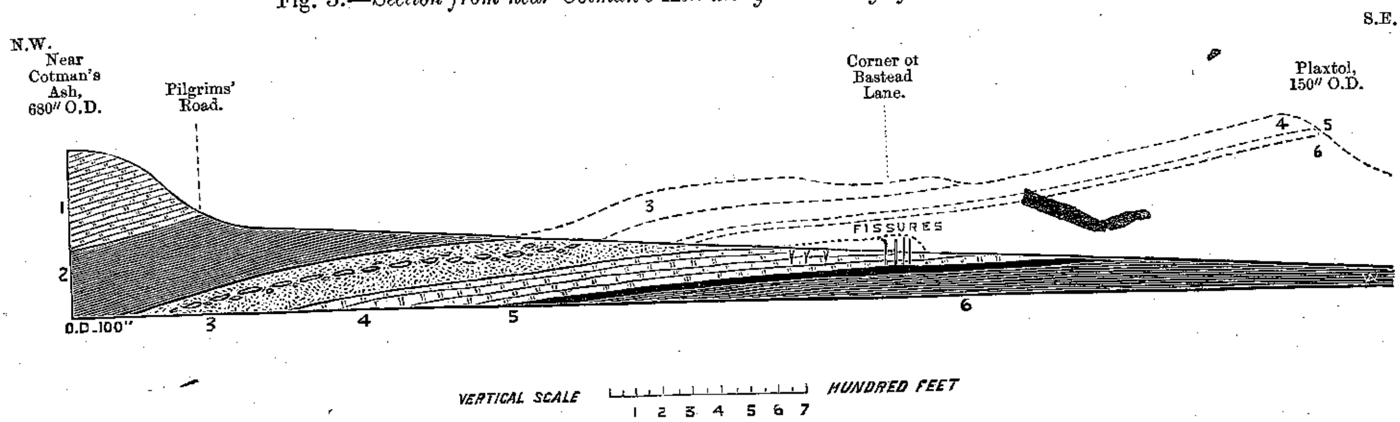


Fig. 3.—*Section from near Cotman's Ash along the Valley of the Shode to Plaxtol.*



1. Chalk.
2. Gault.
3. Folkestone Beds.
4. Hythe Beds.
5. Atherfield Clay.
6. Weald Clay.

Green, by which time their upturned edges are cut through, thus exposing the underlying Hythe Beds, estimated not to exceed 100 feet. The latter are also much denuded, and a few hundred yards east of the section are cut through to the underlying Atherfield Clay, the thickness of which is estimated at 27 feet. Both the last-named beds appear on the face of the escarpment, where the Atherfield Clay is underlain by the Weald Clay.

The altitude at which the Shode now rises is 400 feet, and its level at Plaxtol is about 150 feet, the high ground on the summit of the banks of the valley at Shingle Hill being 550 feet higher; consequently, allowing the full thickness, 127 feet, for the Hythe Beds and Atherfield Clay, the stream ought to flow for the most part in the Weald Clay, and by the time it reaches Plaxtol it ought to have high clay-banks, exposing 423 feet of Wealden Beds. Such, however, is by no means the case. Fig. 2 (p. 174) shows a section from Shingle Hill, through Plaxtol to Hurst Wood, between figs. 3 and 4 of Prof. Prestwich.[1] Here the stream is seen, at 150 feet O.D., to have only just entered the Weald Clay, and one also notices that the high towering sides of its valley are composed almost entirely of 'Kentish Rag,' which extends to an altitude of 700 feet, although the deposit is only 100 feet thick. Moreover the Mote stream is seen to cut quite through the Hythe Beds at an altitude of nearly 400 feet, thus showing that the valley, instead of being one of simple erosion, is for the most part one of depression.

If we take a section along the Shode Valley (see fig. 3, p. 175) we find that such a depression really has taken place, approximately, from Plaxtol in a N.N.W. direction to below St. Clare. To this depression the yielding Gault Clay lent itself by forward progression, at right angles to the depression, by which the outcrop of the Gault is nearly doubled in width, as shown in the Geological Survey map of the district (Sheet 6). The Folkestone Beds, when made up of loose sand, also lent themselves to the stretch, but when more compact they cracked; the limestones of the Hythe Beds, on the other hand, became very much fissured.

For the purposes of this paper it is not necessary to enter further into the earlier geological history of the valley; of this, with the anthropological succession in the district, I hope to treat fully on another occasion. The exact date at which the depression took place has little, if any, chronometric value in connexion with the contents of the fissure: whether it was in the early stage of the Holmesdale Valley, when the Rag had 250 feet of Gault and Folkestone Beds above it, or whether it was after the river had actually pierced the former beds, is uncertain. One time-recorder remains, and that is, the amount by which the river has lowered its channel since its débris-charged waters first gained egress into the fissures, till the time when they were no longer able to do so.

An examination of the existing features of the surrounding country indicates that the Shode when it first entered the Hythe

[1] *Op. supra cit.* p. 272.

Beds,—or very shortly afterwards,—was flowing from N. to S. as now. Having previously cut through the Folkestone Beds it gained access to the fissures, and began to deposit its sediment in them; and it continued to do so during the whole period that its waters could carry materials into an unfilled space. Since this work of filling commenced, the river has cut its bed through about 85 to 90 feet of solid 'rag' at this spot. But deepening doubtless went on long after flood-waters reached for the last time the altitude of 300 feet, which was about the limit at which the fissures stopped filling.

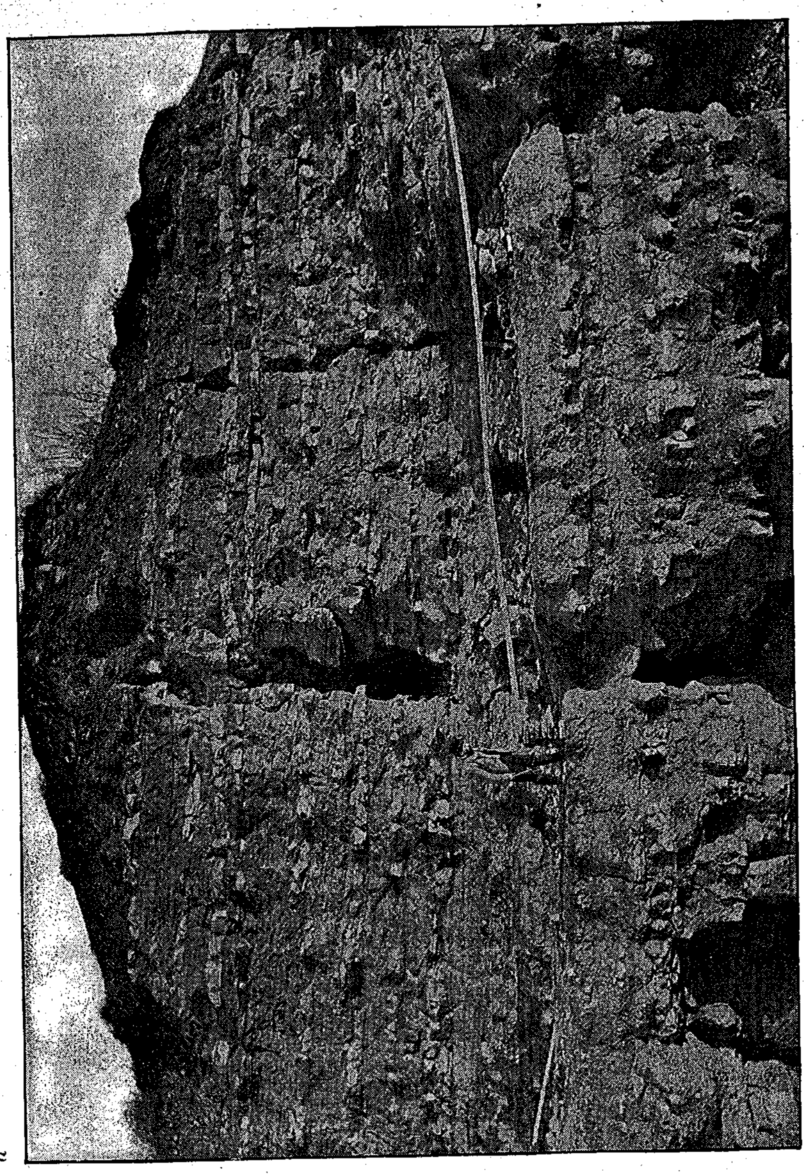
III. Description of the Fissures near Ightham.

Although there are numerous fissures in the Shode Valley, I shall confine myself to those on the western side of the promontory previously described. Here a quarry has been worked and a face 80 feet high exposed: the direction of the working is a little W. of N. by a little E. of S., thus revealing the fissures as seen in fig. 4, p. 178. The strike of these is practically at right angles to the direction of the downthrow of the valley. They are entirely in the Hythe Beds, which at this place consist of layers of exceptionally hard, slightly sandy, crystalline limestone—the Kentish Rag—alternating with friable, though often somewhat tough, beds of hassock; the thickness of the layers being from 1 to 2 feet for the rag, and $2\frac{1}{2}$ to $3\frac{1}{2}$ feet for the hassock. By the southward depression of the valley previously demonstrated, the beds are brought from a northerly dip to a horizontal position. There is a slight downthrow of about 18 inches to the south, the mass between *b* and *c* forming a miniature trough fault—a feature characteristic of the kind of earth-movement here undergone, the overlying hassock bending over and thickening in accommodating itself to the new conditions. A little farther down the valley the limestones are shown with a decided reversed dip.

The beds at the top have been very much altered, weathered, broken up, and decomposed for about 4 or 5 feet, and trailed down in the direction of the fall of the surface. It is still visible how the upper parts of fissures *a* and *d* have been bent and trailed down the hill; *d* towards the Shode, and *a* into the valley of the tributary. As these two fissures, and also *c*, had obviously been in contact with the surface, I confined my attention chiefly to *b*; of this fig. 5 (p. 179) is a generalized vertical section. The width of this fissure is from $1\frac{1}{2}$ to 5 feet: when I first saw it, it did not reach the surface by about 4 feet; there was a ceiling of stalagmite about 12 inches thick; flocculent lime has also been redeposited into the cracks, crevices, and interstices of the grains of the adjacent rocks (shown in the figure by the wavy lines). Below the ceiling was an empty chamber (*b*) some 4 or 5 feet in height; the walls and floor were covered by a continuous deposit of lime, chiefly in the form of flos ferri at the sides; while white, with a slightly yellowish-brown tinge, granular stalagmite covered the bottom, some 3 or 4 inches

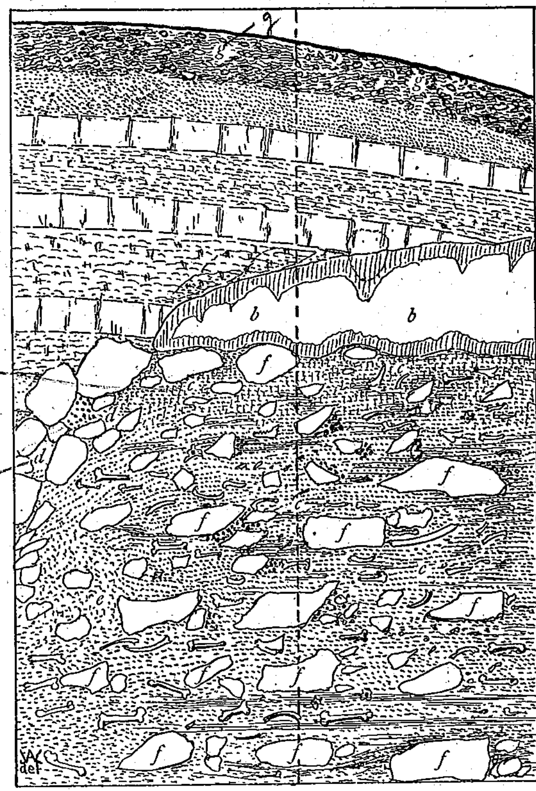
Fig. 4.—*View of the fissures near Ightham.* (After a photograph by Essenheigh Corke, Sevenoaks.)

a b c d



thick. Occasionally the stalagmites were crystalline. There was also a beautiful variety of arragonite, whiter and finer than the finest cotton-wool. The third inset, made by the quarrymen, that I saw, was about 80 yards from the present representative of the old stream, and showed the height of the fissure to be rapidly diminishing, and the top bending down in an arch, so that the two sides met the top in an angle, and the arragonite chamber formed a *cul-de-sac.* The deposition of flocculent lime extended 5 or 6 feet

Fig. 5.—*Generalized vertical section along fissure* b.



[The dotted line shows the present face of the quarry.]

into the underlying fissure-material, from which it appeared that the meteoric waters, which entered the chamber above, acted upon the fissure-earth, dissolved out the lime from both rock and bones, and redeposited it: the occurrence of bones increasing as the secondary deposition decreased. Owing to the decrease in the height of the fissure, this deposit quite sealed down all that was below it. Below this, towards the back, the fissure-material *d* (fig. 5) was more friable and loose, presenting a washed-out appearance, probably due to the inability of the water-power to carry thus far anything but the lighter materials. The chamber-floor was about 300 feet O.D., and from this to the bottom of the working (which was only a very few feet from the present water-line or clay) it was full of a deposit (*c*, fig. 5) which might be described as an ordinary brick-earth, similar to that exposed in the valley, with the addition of lime and other materials of the mother-rock, not only of the friable hassock, but of blocks of rag varying in weight from a few ounces to nearly half a ton. These blocks (*f*) occur at all levels throughout the deposit, large ones frequently being tightly wedged in, and impossible to move without blasting. There are frequent boulders of Oldbury stone and chert, and occasionally a flint, the latter sometimes in the form of flakes; but up to the present no implements have been discovered in the fissure. The field (*g*) above was probably an encampment in Neolithic times, as neoliths occur in large numbers on the surface. One of the higher gravels was deposited upon the Folkestone Beds above the fissure; remains of the former still exist on the higher part of the field. There is also a patch of bleached white flint-gravel about 100 yards square, which I have just been able to trace home. These gravels were worked by Neolithic man, as often were similar deposits, but I have found no trace of man in the fissure—except a stray flint or two—and not a single neolith! The latter fact is very important in deciding whether the fissure has been reopened in more recent times than the period generally associated with *Rhinoceros*, *Elephas*, *Hyæna*, etc., or even whether it ever did open upon the surface. It is certain that in the early history of the filling of the fissure gravel covered the ground above it, but I have been unable to find any trace of it, even when the fissure was excavated to the lowest depths penetrated, which could only have been a very few feet from the underlying Atherfield Clay. On the other hand, the upper part of fissure *d* is full of a breccia similar to that seen on the surface at *g*.

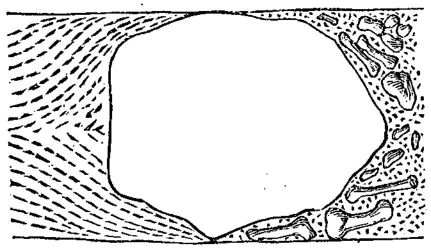
In places horizontal stratification was very distinct, fine layers of clay alternating with more sandy ones; but whether this was due to original stratification, or to the subsequent circulation of underground waters I should not like to say; a fissure a little lower down the valley still gives out water. In many places there were evidences of the levels at which the water stood at a particular time, by the adhesion in great profusion of calcified stems of *Chara* in a horizontal line upon the sides of the walls. The delicate scales of the slow-worm (*Anguis fragilis*) were also found adhering to the sides of the fissure for a distance of 20 feet, quite horizontally.[1] Very frequently on the stream side of a big block there would be an accumulation of the large bones, and in a similar position a few years ago a considerable number were found. On the inner side of such obstructions, unless either above or below them, it was useless to look for anything but the very smallest organic remains. As the

[1] These were about 60 feet above the present water-level.

quarry was worked in platforms from the top to the bottom downwards, I had a good opportunity of noting these features, which unmistakably pointed to the introduction of the débris-charged waters from the side and not from above. Those cases to which I particularly refer were about 30 feet from the top.

Fig. 6 shows a view from above of one of these 'keyed blocks.'

Fig. 6.—*Plan of one of the keyed blocks, seen from above.*



In this will be seen not only the stoppage of the large bones, but the direction of the waters as they deposited their sediment. It will also be obvious that, since the deposition of the fissure-material around these blocks, the position of the latter in regard to the former has not been changed. To my mind the wedged-in state of these blocks is very significant, for had they fallen from above during the filling of the fissure the deposit would have formed a bed for them, and so obviated the keying action; and seeing that after they fell they were covered with fissure-deposit, if the opening action had been continued after a stone had become keyed, we should not find a single stone so nipped to-day; whereas there are numbers in that condition all through the fissure, thereby showing that the process of opening was not a continuous one, and that the fissures have been stationary since their first filling.

IV. The Fossil Plants and Invertebrata found in the Fissure.

In working down the face of the quarry for the first time I kept all the fossils from the various levels separate, expecting to find a Cave-like succession; but on comparing them with my notes taken while work was progressing I could see nothing to warrant a separation either in the state of preservation of the specimens or in the occurrence of species—a conclusion simultaneously and independently arrived at by Mr. E. T. Newton. In some places certain species were naturally more plentiful than others; sometimes frog-bones were more numerous than all the rest of the bones put together, at others they were in the minority. I have seen a large wall of the deposit cleared on one side for a considerable distance, and throughout its whole extent it was perfectly solid; it is certain that water could not have transferred the fossils from one part of the deposit to another or re-arranged its constituents. Occasionally, under large stones or in peculiarly situated spaces, the material was more friable and loose, or even a space left; but, so far as I could see from careful observations during nearly three years (in which time I handled, sifted, or washed scores of tons of material), I could see no possibilities of communication from one part of the fissure to another *to any great extent.* At the last inset, and as I worked the fissure farther back, the deposit was far less solid, more carbonaceous, and showed more cavities, and I quite expect this phase to increase as one works inwards.

It is the vertebrates, of course, that are the most important fossils of the fissure; but having stated the conditions under which they were found, I leave their description to far more competent hands than mine. I might, perhaps, remark that many of the bones are peat-stained, as though they had lain upon a peaty river-bank before entering the fissure, which colouring they never lost; they occurred irregularly all through the fissure in juxtaposition to the unstained bones. The same remarks apply to the gnawed bones. In a few instances, in the case of a bat, a vole, a mole, and a slow-worm, the creature entered the fissure very nearly or quite whole, and their bones occurred near each other; but it was usually otherwise, the bones being single and isolated.

List of Fossils other than Vertebrates.

Plantæ.

Corylus avellana (nuts).
Quercus robur (acorns).
Hypnum prælongum.
Chara.

Insecta.

Iulus.
Cynips, sp.
Otiorhynchus, sp.
Chrysomela, sp.
Porcella scaber.

Ostracoda.

Candona candida, Müll.

Mollusca.

Limax maximus, Linn.
Hyalina cellaria, Müll.
„ *alliaria*, Miller.
„ *crystallina*, Müll.
„ *fulva*, Müll.
Helix (*Patula*) *rotundata*, Müll.
„ *hispida*, Linn. (including Jeffreys' *concinna*).
„ *nemoralis*, Linn.
„ *ericetorum*, Müll.
Pupa muscorum, Linn.
Vertigo minutissima, Hartm.

Succinea oblonga, Drap.
Cyclostoma elegans, Müll. (top).
Unio, sp.? (minute fragments).

Helix (*Vallonia*) *pulchella*, Müll.
Cæcilioides acicula, Müll.
Cochlicopa (*Zua*) *lubrica*, Müll.
Carychium minimum, Müll.

Remarks on the Plants and Invertebrates.

[*Plants.*—The stems of the *Chara* were in a state of calcic casts, and at first were very puzzling, and thought to be small annelid-tubes; but when submitted to W. Carruthers, Esq., F.R.S., he at once recognized their vegetable nature, and referred me to a collection of specimens in the Natural History Museum of the same description. Upon submitting them to Mr. R. B. Newton, F.G.S., he immediately identified them as similar to a large mass of *Charæ* from Northampton described in the Geological Magazine for 1868, p. 563. On comparison of the specimens from the fissure with these, their identity became at once established. In the latter both nucules and globules are very plentiful in the entangled mass, but in those from the fissure I have only once or twice recognized the spiral structure of a nucule. Upon dissolving some of the stems under the microscope Mr. E. M. Holmes, F.L.S., revealed sufficient structure to assign them to *Chara* and not to *Nitella.*

Throughout the whole of the deposit nuts in a good state of preservation occurred. In the case of the acorns, the inside was a black, spongy, carbonaceous cast, but the outside skins were fairly well preserved. There are other vegetable remains which have not yet been identified.

At the back of the fissure exposed since the reading of the present paper there is far more carbonaceous matter, and I hope to be able to obtain more plants from it.

Insects.—Recently I have obtained upwards of a hundred tiny little globular bodies from ·75 to 1 millim. in diameter, usually single, but occasionally in clusters of three and four, which Mr. C. O. Waterhouse, F.Z.S., has identified as the galls of *Cynips.* To the same gentleman I am also indebted for identifying the insects. To Prof. T. Rupert Jones, F.R.S., I am indebted for naming the Ostracod.

Mollusca.—Of these the most plentiful species is *Hyalina cellaria*, which occurs all through the deposit; I obtained considerably over half a pint of specimens. The next in numbers is *Hyalina alliaria*; the whole of these are of a beautiful translucent pearly white, similar to those in the Portland fissures; there is not the slightest trace of animal matter or coloration in them. The Helicidæ come next, *Helix* (*Patula*) *rotundata* topping the list, in which species, as is usually the case in Pleistocene specimens, the colouring is still visible. The same remarks apply to *H. nemoralis* and *H. ericetorum.* The latter species was represented by only two or three specimens. *Succinea oblongata* was fairly common, and reached a length of 17 millim. The *Cyclostoma* was represented by an apical fragment of a spire. I also obtained several dozen molluscan eggs of various shapes and sizes, from 3 to 5 millim. in their major diameter; about half were pierced, but the rest were not, and when broken open showed no trace of any colouring. These have not yet been determined.

Vertigo minutissima calls for special notice, owing to its unusual size, reaching a length of 6 millim. This species, I believe, had not been discovered in Pleistocene deposits until I obtained it from the New Admiralty section,[1] associated with *Betula nana*; in this deposit also the species attained a similar size, from which it would appear that the species has greatly dwindled in size since Pleistocene times. I also found on several occasions small fragments of a pearly, flaky shell which I have no doubt is *Unio*. The *Limaces* were represented by six specimens.

I handed the whole of the shells to Mr. B. B. Woodward, F.G.S., with whom I have had the honour of working for many years, without telling him whence they came, and asked him to kindly name and report upon them. In reply he said:—"Judging by its frequent occurrence in late Tertiary deposits, *Succinea oblonga* was far more common formerly than it is to-day. Its presence seems to indicate the proximity of very marshy ground. The *V. minutissimæ* are perfect giants! All the species are living at the present day, and the state of preservation is not such as to suggest any great antiquity."

The best estimate of their age can probably be made from their comparison with the fauna of a remarkable land-wash which exists in the neighbourhood. From this latter I obtained some 24 species belonging to 10 genera, and from the bottom of the deposit Neolithic flint-flakes, and pottery; but there are no signs of *Succinea oblonga*, nor is the general facies that of so water-loving an assemblage as that of the fissure. Still, with the exceptions of the fragments of *Unio* in the latter, no truly *aquatic* forms occur, although all of them are found in river-deposits elsewhere. In contrasting this land-wash, which is some 12 feet thick, with the fissure-deposit, I might observe that it contains scarcely a single bone, thus adding further, in my opinion, to the improbability of the fissure-deposit being a land-wash; while the absence of *album græcum* and path-trodden surfaces, the occurrence of single whole bones, unaccompanied either by fragments or foreign matter, is prejudicial to the idea of the bones having been carried in by, or as having made a passage through, carnivorous beasts or birds.—February 6th, 1894.][2]

[1] Proc. Geol. Assoc. vol. xii. (1892) pp. 346–356.

[2] [The last four species (see list on p. 182) have been added to the mollusca since the reading of the paper. Of these, *Helix pulchella* and *Cæcilioides acicula* are represented by a single specimen; of *Cochlicopa lubrica* there is also a single example, which is immature; none of these presents any features of special interest. The two specimens of *Carychium minimum*, on the other hand, call for some remarks, as they differ greatly from the type, and would no doubt be regarded by many as a new species, or at least a new variety. Seeing, however, that this species varies greatly, both Mr. B. B. Woodward and myself consider it inadvisable to found either a new species or variety on the material to hand. We have compared it with several hundred Pleistocene and recent examples, and find the following features and differences:—In outline it is altogether more slender than the type; it is fully 2·6 mm. in height, its width not exceeding ·75 mm. The whorls are six in number, more closely coiled, and consequently longer, and increase more gradually all through, so that the spire is higher and more tapering. The body-whorl is much less in proportion. The mouth is more rounded, and not at all constricted at the outer tooth; on the other hand,

V. Conclusions.

It is a little difficult to sum up the questions raised by the Ightham fissures and their contents until one has read Mr. Newton's paper. Still I think there are certain points which must be settled before a correct estimate can be made of the palæontological significance of these discoveries. They appear to me to be these:—

1. Was the filling up of the fissures effected by (*a*) a marine submergence, or even (*b*) were the contents washed in from a land-surface above? or

2. Were the fissures filled by the action of a river from the side?

3. Was the opening of the fissures a continuous and recurring one, after the first introduction of fissure-material, and the heretofore recognized Pleistocene mammalia; thus making the contents of the fissure belong to *any* age since the first opening? or

4. Did the river, when it first entered the fissures, find them of practically the same width as now? Was the filling confined to one period, and therefore the fossils all of one geological age?

The answers that suggest themselves to me are the following:—

1. (*a*) The fact that we have raised beaches extending a long way inland, left as relics of submergence, suggests that, had such an action taken place in the Ightham neighbourhood, with its land-locked depressions, some vestiges of it at least would have been left; and of all things in the world no traps would have been more fitted for the purpose than empty fissures. Yet I must admit that I have been unable to find a single particle of an obviously marine deposit. On the other hand, the whole of the contents are of terrestrial origin; and this, with the detached and gnawed condition of the bones, is to my mind hopelessly fatal to the hypothesis of a marine submergence.

(*b*) The description given in the Introduction (p. 171) of the absence on land-surfaces many miles in extent of the relics found in the fissures, and the extremely limited area of the little promontory in which the latter occur, dipping on all sides and covered with materials not found in the fissure, render it impossible for the filling to have been effected simply from above. We may be sure that, whatever might have been the agencies by which the Holmesdale Valley was scooped out, the soft Gault Clay would have given way before the harder Folkestone Beds (as is evinced by the lie of the older gravels), so that a northward extension of a gathering land-surface was truncated. The stream, however, extended over the Gault, and from this source derived the clay which forms a constituent of the fissure-material, both disseminated and as water-rolled

the tooth itself is almost wanting, and is represented by a mere thickening of the labrum. The columella-teeth are not more than one-third the size of those in the recent species, and occur down inside the whorl so as to be invisible when the shell is viewed obliquely. The peristome is more reflected and less thickened, and consequently less 'toothy,' altogether presenting more the outline of *Paludestrina marginata*.—March 20th, 1894.]

pebbles, none of which exists in the sandy beds above the fissure; and from the Gault Clay pools were derived in times of flood the large quantity of *Chara*-stems. It thus appears impossible for the filling in to have resulted from marine submergence, or for the material to have been introduced in the form of a land-wash from above.

2. That the deposit was introduced into the fissures by a river is to my mind evident, from the fact that the material itself is exactly similar to that deposited in other sequestered spots in the valley, and the additional fossils constitute just such a heterogeneous mass as is to be found in the burdens of a river when preserved, and *nowhere else*. That water was present during deposition appears evident from the horizontal stratification of the sand and clay, and the scales of slow-worm and *Chara*-stems adhering in a straight line along the walls of the fissure; while the manner in which the fissure-material was forced upwards into blind veins and crevices from below is explicable on no other than an aqueous hypothesis. That the river was entering at the sides of the valley during a long period in the history of the filling of the fissure is absolutely certain from the damming action of the keyed stones, and the deposition of the material in passing round such large blocks.[1]

Coming to the mollusca, *Helices*, *Pupæ*, and the others are always found in river-deposits, and such forms as *Succinea* are never found far from water, but usually in it, while *Unio is never found elsewhere*. The preponderance of frog-bones over everything else, the large number of water- and bank-voles, the presence of *Chara* in such profusion, entomostraca, and *Triton* unmistakably point, in my opinion, to the fissure-deposit having had a river origin.

3 and 4. In the keyed stones, as it appears to me, we have an absolute answer to the question of the reopening of the fissures. We have seen that the keyed stones occur all through the deposit, into which position they were let fall, by the fissuring of the strata (or some may have been dislodged from the mother-rock by the entering of the water during the process of filling). It was in this keyed condition that they were when the deposit successively reached them. As the fissure filled the material became packed closely all round and over them, the inward transport of larger burdens being intercepted by these obstacles; and just as the material was originally deposited, so we find it to-day. Had a subsequent widening set in every stone originally keyed would have been loosened from the grip, and a keyed stone would have been practically an impossibility. It might, however, be urged that, by an unprecedented series of coincidences, every stone was so placed that when its hold was broken it ploughed through the solid material until it again became keyed, or fresh ones got into that condition. But if this were the case, and the stones moved out of their original position, all former

[1] Very careful and protracted observations lead me to consider that the downthrow of the valley did not occur till just immediately after the river had entered the Hythe Beds.

relations of stratification and filtration would have been obliterated; this, however, we know was not the case.

Attention might also be called to the fact that the bank on the top of the fissures became an old Neolithic settlement, neoliths being scattered over the surface literally in hundreds, yet not one of these was found in the fissure.

It is true that the mollusca might have borne a more aquatic facies, and not much can be said from a solitary entomostracon, but I have worked for many months at a river-deposit in which there were myriads of these little creatures, and only found one gasteropod, nor do any of the more aquatic forms occur in any deposit which I have worked in the valley outside.

We have, however, I think, far more evidence both positive and negative than we could reasonably have expected under the circumstances, that the fissures have never been reopened since they were first closed by the materials introduced into them by the river; and although it is within the bounds of possibility that in some unknown and incomprehensible manner some stray modern relic has been introduced, and in each case by some remarkable modification of chemical laws has been changed into a condition indistinguishable from those upon which the same forces have been operating for countless ages, there is still the great balance of probabilities that the whole of the contained fossils belong to one and the same geological period.

I am fully aware that there are many remains found here which have not been found before in recognized Pleistocene deposits; but that has been my experience with other sections at which I have worked for a long time. The increase in species is only such as to support the suggestions made by Mr. Clement Reid in connexion with the Forest Bed fauna,[1] namely, that late discoveries tend to show that it is the larger Pleistocene mammalia that have become extinct, and that the more we discover of the smaller creatures of this age, the more they approximate to those of our own time.

Even if we were to exclude from the lists all the species not previously found fossil elsewhere, we still have an extensive assemblage of the older Pleistocene forms which must have lived during the filling of the fissure: this therefore limits the filling operation to Pleistocene times.

In conclusion I have to express my hearty thanks to the officers of the Geological Survey, especially Messrs. Clement Reid, H. B. Woodward, and W. Topley, for the very great assistance which I have received from their invaluable advice, while it is unnecessary to remark that the chief value of the paper hinges upon the work bestowed by Mr. E. T. Newton upon the vertebrates. I have also to thank Mr. B. B. Woodward for his kind assistance in the determination of the mollusca, and Mr. C. O. Waterhouse for naming the insects.

[1] Mem. Geol. Surv. 1890, 'The Pliocene Deposits of Britain,' p. 182.