

ON THE ESTUARY OF THE THAMES AND ITS ALLUVIUM.

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(Read July 5th, 1889.)

The estuary of the Thames lies in an old river-valley cut out of Eocene beds and the Chalk. It is bordered at high levels on either side by sheets of gravel, the intervals between which decrease as lower levels are reached. They are left as the result of the denuding action of the older river. These gravels, taken generally from about the contour-line of 300 feet above Ordnance Datum downwards, are of the kind which has received the title of Palæolithic, from the fact that they have embedded in them those types of early stone implements to which Sir J. Lubbock gave that distinguishing name. Yet there are among the lower patches of gravel some in which no extinct remains, nor stone implements have been found which are not clearly *remanié*. One such spread of gravel, which amounts to a distinct terrace, is found on either side of the estuary, between London and Gravesend. It often reaches the elevation of 20 feet, or a little higher above the adjacent marsh, and borders it. This terrace is apparently the result of the violent breaking up of the neighbouring older gravels by frost and floods, and is the direct continuation of the condition of that climate which produced the *Trail* and *Head*; which destruction lasted for so short a time that it did not suffice to imprison a special fauna or type of implement within it, if such existed. These banks of gravel, while covering here and there older gravels containing Palæolithic implements, graduate into a lower layer, which spreads across the whole valley of the Thames at its deepest excavation. This lowest layer of all lies beneath the alluvium, and differs in appearance from the older gravels. It is mostly grey in colour, though there are parts where it is black, a light and even a bright red; the grey and black being the result of deoxidation of the peroxide of iron by the vegetable matter from the overlying alluvium. It often contains incrustations of lime and iron-pyrites on the stones. This gravel presents the usual features of a river deposit, and passes from coarse to fine. It is covered generally with fine sand; and, near the shores, with loamy brickearth, which belongs to the warp produced by floods, constituting altogether a

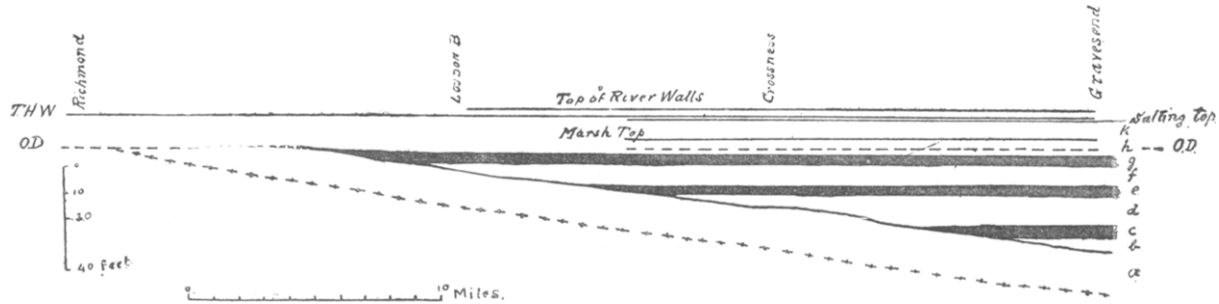


FIG. 1.—Diagram Section along the course of the Thames.

- a* represents the layer of old river sands and gravels, the upper and lower margins of which are shown.
- b* is tidal clay with sand.
- c*, peat.
- d*, tidal clay.
- e*, peat.
- f*, tidal clay.
- g*, peat, at the upper part of which lie Roman remains.
- h*, surface clay [tidal] of the marsh.
- k*, the clay now accumulating to form saltings.

distinct series. The older gravels at high levels do not admit of a satisfactory determination as to the amount of the fall in the river which produced them; but when we have reached the continuous sheet on which the Thames now runs an effort of this kind can be made with success. In the diagram Fig. 1, I have taken a line along the river, from Gravesend, where the Tilbury docks excavation enabled an excellent section across the river-bed to be made, from the lowest part of the gravel-bed there, to the lowest part of the gravel at Pimlico. The diagram shows the contact of the gravel with the older rocks. At Pimlico measurements were obtainable from the Engineer's published account of the foundation of the London, Chatham, and Dover Railway Bridge (Victoria). Intervening measurements have been made from several similar sources, such as the excavations of the late Metropolitan Board of Works, the works of the City of London, particularly those of the new Tower Bridge, and innumerable borings published and unpublished, together with much personal observation of excavations of all kinds. The general thickness of the whole layer of gravel and of the sand which lies conformably upon it along the whole distance is fairly uniform, and is distinctly shown in contrast with the superincumbent alluvium. If the lower plane of the old gravel-bed is carried up-stream it will rise to the Ordnance Datum about Richmond; the upper part of the bed being level with the adjacent shores there. At Gravesend the lower plane is between 60 and 70 feet below O.D.

Notwithstanding that the waterway of the Thames is very irregular, it is clear that it has kept its present line of flow the same, within narrow limits, since it first became estuarine. The same broad masses of silt or marsh have remained, the bends of the stream have impinged on the same "hards," and apparently the same places have, with few exceptions, been the customary crossings or ferries from the time the sea first changed the character of the river. In modern times, as a consequence of the narrowing of the channel by bridging, embanking, and dredging, the river has been greatly deepened. Above London, for instance, the gravel is excavated to the surface of the London Clay, sometimes in the centre of the stream; but below London the stream runs in a shallow depression in the old river-gravel. There is nothing, in the evidence which we have, to lead us to suppose that the lower plane which I have been describing, if prolonged below Gravesend, will differ

greatly in its inclination for some distance, though of course the upper one may be expected to do so; nor, as the soundings on the charts of the Admiralty permit us to follow the direction of the channel by which the Thames enters the sea, can we have much hesitation in ascribing to the continuation of that channel off the coast of Kent, through the "Warp," the "Oaze," and the "Black Deep" in the North Sea, an indication of the former course of the River Thames when as yet the ocean was far away. The wide-spread Maplin sands, the shallows of the Nore, the Cant, and the Kentish Flats, the Margate sands, and the Girdler, &c., may represent the remains of high land now washed away; nor is there any improbability that a great extension of Sheppey itself, and other islands like Sheppey were once spread over the areas occupied by those waters. As for the former existence of inhabited land, where the Pan Sand and the Pudding Pan "Rock" stands or stood, 2000 years ago, I have no doubt of it. For further details concerning this, and many other like matters, I beg to refer to a paper on the antiquarian side of this question in the 'Journal of the Archæological Institute,' Vol. xlii, p. 269.

Upon the gravels I have been describing lie layers of blue (grey) tidal clay, with beds of peat between, though occasionally the peat is found lying on the gravel. In the highest part of the estuary the blue clay differs but little in its appearance and constitution from the flood-alluvium of the fresh water; but from Richmond eastward, evidence is found of marine influence in the presence of the tests of marine diatoms and the shells of brackish-water gasteropods.

In the upper part of the estuary such peat, or more properly black earth, as we find, is superficial. However, it occasionally dips into hollows to a considerable depth, as was found at Whitehall, where the Serpentine river joined the Thames. At the Surrey abutment of the Tower bridge this black earth is underlain by blue mud (upper layer). A little further down a layer of peat may be found covered with tidal clay (by which name I shall in future call the blue mud) lying at Ordnance Datum. Below this, at about Woolwich, other layers of tidal clay and peat come in, which succession is very marked at Crossness. Between Erith and Gravesend a third layer of peat commences, which is also covered with tidal clay, and which at Tilbury has beneath it slight signs here and there of tidal clay again. This overlies the old river-sand.

The diagram already referred to shows the layers of clay and peat lying horizontally on the inclined bed of gravel; it is much exaggerated vertically. The sections on which this diagram is founded—at Tilbury, Crossness, and numerous places in the marshes—have been so lately open that I excuse myself from giving them here in detail, the more so that Mr. W. Whitaker's 'New London Memoir,' soon about to appear, will, of course, contain many of them.

I take this opportunity of acknowledging Mr. Whitaker's kindness in permitting me to inspect some of his drawings, and otherwise assisting me with reference to the present paper.

The layers of blue clay are distinguished as tidal clay, because I consider that all these deposits shown in the diagram were spread under such conditions as the clay of the Saltings, *i.e.*, clay outside the river-walls, is being spread by the tide now, with the exception that in the older layers drift logs are often found imbedded.

The blue clay contains a large quantity of organic matter in a state of minute subdivision, to the deoxidating power of which its colour is due. In each layer seen at Tilbury, Crossness, or elsewhere shells of *Scrobicularia piperita* appear, generally accompanied by *Tellina bathica*, which distinctly separates it from the little lenticular deposits of mud or sand which lie under, in, or upon the layers of the peat (see Fig. 3), and which usually contain an abundance of land and freshwater shells, seeds and fruits, &c. Where the layers of peat rest on the tidal clay the clay presents a modification of its colour and consistency: it is redder, sometimes bright yellow from peroxidation of its iron; and it dries by breaking up into small dice-like masses, just as the dried surface of the present marsh does. This results from the loss of its organic matter by aëration or weathering, and it is evidence that it had been exposed and become a well-dried land-surface previous to the growth of the forest on it. Little freshwater streams have left their marks in the patches of mud containing land and freshwater shells. In the upper part of each layer of clay beneath the peat abundant roots and rootlets are found, those of trees meandering over the surface at little depth. The trees which constitute the larger part of the peat-beds are easily perceived to have been growing on the spot where found, and constitute with the other vegetation true forest-beds. At Tilbury none of the trees appeared to be of much importance as to size in any of the layers,

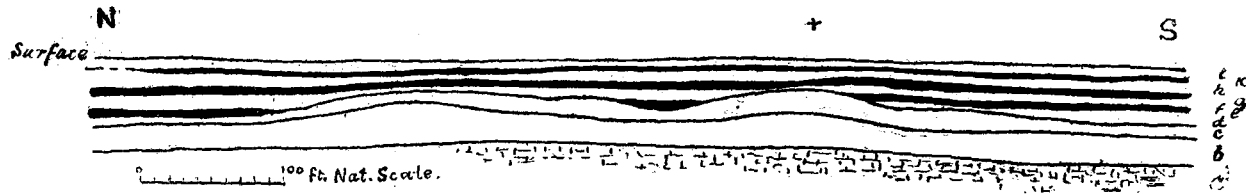


FIG. 2.- Section adapted from one belonging to W. Whitaker, F.R.S., in the Dock excavation, Tilbury.

- a*, Chalk.
 - b*, gravel } River deposit.
 - c*, sand }
 - d*, tidal clay.
 - e*, peat.
 - f*, tidal clay.
 - g*, peat.
 - h*, tidal clay.
 - k*, peat (Roman surface).
 - l*, tidal clay.
- } Alluvium.
- + place where the man lay in sand.

constituting at the best what is called scrub in the mid-marsh section, though larger trees are obtained near the inland shores. In the lowest layer were birch and hazel (rooted), but portions of other trees in horizontal positions were not difficult to find, and some had been drifted. In the middle layer there was scrub in parts and trunks of small size, but the peat mostly consisted of reeds, *Phragmites*, *Sparganium*, &c., with layers of moss (*Hypnum*), and freshwater plants of various species. There was also a marked layer of *Sphagnum* of two species, and with this spores and portions of the fronds of ferns (*Pteris*?). Among the peat of the middle layer Mr. T. V. Holmes found "Horsetails and Heather" ('Trans. Essex Field Club,' iv, 135). In this layer also I found a wide spread of a very close-grained peat, perfectly homogeneous under low powers, consisting apparently of washings from an old peat-bed relaid. It was from three to six inches thick, and broke with an almost conchoidal fracture, which became more marked when dry; it was translucent at the edges. The upper layer of the peat was comparatively thin, and mainly consisted of a small growth of underwood, with spreads of grass resembling the growth on the marshes at the present day. I think it likely that this layer was much thinned in places in consequence of drought and by the rotting of the surface, due to clearing or agriculture, for on this level the Romans lived. I found the remains of a building in one place, surrounded by the rubbish remaining from a lengthy occupation. Since I wrote the archaeological paper to which I have already referred, I have met with several of the navvies who worked there, and have learned that the Roman relics were found over the whole area uncovered by the dock excavation, and that many were in such condition and of such excellence that some of the men were enabled to make a goodly harvest by their sale in London.

At Crossness, where in former years a great area was excavated, another great hole has been dug, and during the last year I have been able to work more carefully than usual there. The section, Fig. 3, gives a view in the centre of the cutting (considerably shortened, however), which applies to the whole area opened up—which is several acres in extent—and presents a state of the marsh soils similar to that visible in the more westerly area. This section, with the previous cuttings for the Metropolitan sewer and

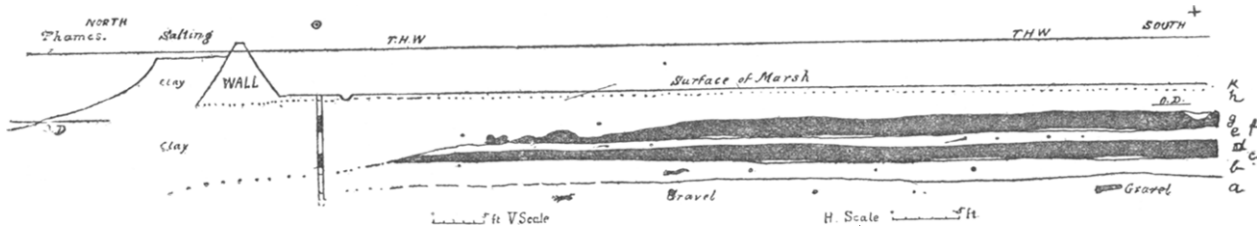


FIG. 3.—Section at Crossness. This section is much shortened, as the southward extension presents no peculiarities.

a, gravel, becoming sandy on the North.

b, sand.

c, lenticular thin beds of sandy clay full of fresh-water shells.

d, peat, lower.

e, tidal blue clay.

f, beds of sand and shells as above

g, peat, upper.

h, tidal clay.

k, arable soil and so-called brick-earth.

Alluvium.

The black marks represent drift-wood.

o, a boring 150 yards west of this point, showing the same layers of peat, etc.

works thereto belonging, enables me to give a good account of the marshes generally. The cuttings for a canal on the opposite side of the river, and the extensive excavations at Dagenham, Barking, and Becton, differ in no important particulars from those on the southern side, while the testimony of all of them concurs to show that the layers of the forest are confined to two, of which the figure is a good example. It has been said that the alluvial layers present a confused and irregular appearance here, which, however, I cannot admit, and my conclusions are drawn from a long-continued attention to the matter. At Crossness then, the gravel, further from the river, is comparatively coarse, but nearer to it the sandy and stony elements coalesce, and it becomes either a fine gravel or sand with stones. Occasionally logs of drift wood, mostly oak, and very hard and black are found in the gravel. Above this come lenticular sheets of sand containing land and fresh-water shells and seeds. There is no evidence that the tide reached here before the forest-bed was established as yet, but Mr. B. B. Woodward, F.G.S., from an examination of the objects washed out of the clay by me, has drawn my attention to the fact that the occurrence of *Hydrobia* indicates the near presence of brackish water. A small portion of *Membranipora* was also detected by him amongst this material. I washed a large quantity of these deposits, keeping the results obtained from the two layers separate. I have treated the layers containing shells and seeds as each belonging to the peat-beds in or under which they lie. The list of shells which have been identified by Mr. B. B. Woodward is given at the end of this paper.

This peat is a true forest-bed in which the roots of most of the trees remain in place, but many have fallen over and lie prone in different directions, without, so far as I have seen, any one direction predominating. (This remark applies to the whole length of the forest-beds of the Thames.) Mossy and grassy patches occasionally appear. In this lower layer a whole skeleton of a beaver was found lying under a big tree stem. This bed is covered with tidal clay, *Scrobicularia* being occasionally found in it, together with a fresh-water shell here and there. The roots of *Phragmites* and other plants growing on this mud have penetrated to, and through the trees which lie buried beneath them. Above this clay recurs in the same manner the upper forest-bed with spreads

of shells at its lower part. The trees, so far as their mode of growth and thickness goes, are like those of the lower layer, but the majority are not so softened by decay, and many pieces of timber have been obtained of great hardness and unrotted except at the circumference. The species of trees in both layers taken as a whole are nearly the same, but in the upper layer the proportion of yew trees and their size are greater than in the lower layer, in which latter *Alnus* and *Fraxinus* are predominant. Many specimens of wood from each layer were preserved for examination. Some fairly fine oaks occurred in both layers, the largest I saw being 33 inches in diameter about five feet above the divergence of the roots from the stem. The trunks of yews were very abundant. In the lower bed three yews were to be seen, the roots of each having covered those of its predecessor; they constituted a distinct mound. The stem of the lowest had rotted away, that of the next had fallen and sunk into the peat; it had 298 rings. The one above, which occupied its place, had also been blown down; it had 187 rings. I counted the rings of many yew trees, and the largest I saw appeared to have at least 500 rings, and was a big tree. It was "hollow" on one side, and rotten at the circumference. The horns and bones of red deer were very abundant in both peat-beds; and in the upper, a nest of moss was found with winter store in it, consisting of half-a-pint of the seeds of the yew, which may have been a squirrel's nest.

The upper surface of the upper layer of peat was much weathered and was strewn all over the area with abundance of Roman pottery—red, black, yellow, white—and well-figured Samian. Some of these sherds lay in masses. Indeed, a little streamway marked * on the section, Fig. 3 was choked with them. I also found over the whole area bones of oxen, goat or sheep, and pig, with plenty of oyster shells. A long stone, flattened at one end by art, such as was used for grinding or pounding, was found; and portions of *mortaria* were abundant, fragments of these utensils of different kinds, with a whole one, having formerly been obtained at Crossness. If I had collected the pottery I could have filled a couple of carts with it. The major part was freshly broken and sharp; very few whole pieces being seen. Close to the little streamway was a layer of tree-trunks, apparently placed to serve for a platform. I also saw some polygonal logs of black oak,

from which the outer parts had been riven, apparently to make shingling. Bricks and roofing-tiles were found. In great contrast to what I have observed (in the paper already mentioned) with respect to the Roman relics lower down in the Swale marshes, it is likely that the Roman occupation of this district was more leisurely terminated, and no ruins of value left behind. When the tide water regained superiority and washed the surface of the forest soil it destroyed some depth of that surface altogether. It also washed about some of the sherds, leaving them with rounded edges, resembling those now found in like condition on the shores and saltings lower down at East Tilbury or Upchurch. These sherds lay mixed with the lowest part of the clay on the peat. The tide also washed away parts of the peat-beds here, in bay-like hollows, so that portions slid away from the mass and were seen, as the cutting proceeded, standing isolated in the blue clay, just as is now happening in other places, while above and below this spot the two layers can be found intact close to the water's edge. The tide-way of the river in various places on both sides below Woolwich, especially about Erith and Purfleet, at low water, shows broad strips of forest-bed, the upright stubs of trees being surrounded by a dense and complicated network of roots. Fallen trunks of trees also lie awash. From these old surfaces are obtained now and then vases of Roman ware, some of which, as at Erith and elsewhere, have formed part of burial deposits.

A slight alteration in the current of the river having permitted a redeposition of mud off the Crossness shore, the layer which covers the Roman remains, and which now serves for agricultural purposes, was extended into the stream. The figure (Fig. 3), very well illustrates the growth of the modern fresh marsh; the level from which the present wall was raised; and the accumulation outside it called "salting," which has continued in certain situations ever since the Romans abandoned the spot.

The different cuttings, as they are followed westward, exhibit the two layers of peat separated by clay, which is more and more filled with drift wood until the junction of the Thames with the Lea and the Ravensbourne is reached. At this part of its course the amount of drift wood is so great as to obliterate almost completely the distinctions I have laid down between the clays and peats. At the Albert Dock excavation big trees interlaced at

various angles in such a way as practically to make the peat-beds one, and not a forest-bed, except at its upper level, where the advent of quieter times enabled the forest to re-establish itself and to present a more regular surface. Here also were found Roman remains, but, as might be expected, less in quantity, from the inconveniences of the floods originating with the River Lea.

In certain places in the alluvium, and notably near Gravesend, the peat presents wavy outlines in section. These, there can be no doubt, are the result of changes which have for the most part occurred subsequently to the deposition of the layers of clay and peat. The streamways from the land would be freshwater streams when the forest or land surface was above reach of the tide, and they would be *fleets* when the tide overflowed the low lands. When the clay was deposited the level would be, like it is now, at a uniform height, but there would be still a slight disposition for the beds of clay, especially during dry periods, to flow into the lower gullies. This, though very slight, becomes perceptible in the lapse of ages. When the clay slips or flows, the peat does not stretch, it therefore breaks and the clay flows into the break or crack, usually from the layer above which is more plastic than the lower one. (See Figs. 4 and 5.) An apparent case of incipient or extra peat-surface was well shown at Tilbury at a considerable distance from the river in consequence of a slip of the clay having carried a thin layer of the peat (middle) away with it, leaving it dissociated from the parent mass and apparently an independent layer.

There are clear instances also in which the flow of underground streams has abstracted by dissolution, calcium carbonate and organic materials from the gravel, and others in which the peat has been dissolved along certain lines by oxygenated water flowing down them; these causes would likewise produce the gentle waviness seen in a section. There are cases, too, in which the water has found its way through the gravel within the bank where a fleet has at one time weakened the layer of clay sufficiently to enable the water to rise through it; and then, when the tide has fallen and so withdrawn its support to a bank, the weight behind, aided by land floods, has burst the bank outwards. Such a reason, I suppose, may account for the continual recurrence of breaches in particular

places—those of Dagenham and the great and lesser breaches of the Erith marshes being cases in point.

Hitherto it has been the rule to speak of the forest-beds as *the forest* and *the peat*, with indefinite divisions of peat in it at the most.

On the other hand, a section compiled from borings and hasty notes is liable to present an appearance of irregularity in the deposits, for frequently it may happen that a stray drift log in the clay may be recorded by the engineer as a layer of peat and so the layers be unduly multiplied, not to say mixed, by the effort of imagination required to connect them.

But I find the relative positions of the various layers in the alluvium to each other very constant, and the variations from the order in which I have described them as occurring, to be all explicable by ordinary events and accidents of a kind which in no way confuses.

Near the edge of the river at Tilbury there was disclosed on a sudden an increase in the layers of peat, all horizontal in position. These I found had been caused by pressure from the side towards the river. Portions of peat had been dislocated from the main mass, which, rising vertically in the manner of steps, presented the appearance so well illustrated by Mr. Marr's models of Stresses. In another case, at the river's edge at Tilbury, the main peat layer was to be seen thrown into a fold with vertical sides in such a way as to show a great thickening, which measures taken through it for purposes of a section would misrepresent. The upper part of the fold had subsequently suffered denudation horizontally, and clay and peat could be seen lying normally over it (Fig. 7). Another fold was seen less distorted near the same place (Fig. 8). Doubtless all these cases were connected. I can only account for the appearances by the supposition that once on a time ice blocking up the river had exerted so much lateral pressure that the soft ground began to crumple and give way. Even in historic times the Thames has been blocked by ice at Gravesend, as has been recorded to have happened in 1281, if not later.

As all the layers of peat before-mentioned were distinctly dry land surfaces, while the layers of clay represent salt-marshes subject to the tide, the alternate layers of alluvial peat and clay

represent interrupted subsidence of the land beneath the sea-level. That this was very gentle during the deposition of the clay is obvious from the fact that, at various levels in it, there are sometimes found signs of roots and a thin peat formed of brackish-water plants with *Phragmites*, such as now grow in similar situations; but it is not certain whether there was a mere arrest of subsidence or a positive rise in the land which allowed the forest to occupy the bottom lands and fringe the comparatively narrow stream. From the moment when the gravel was laid on the bed-rocks of the river until now there has been no break in the continuity of the deposits, the only difference being that of kind with a gentler display of force—thus, river-gravel, sand, clay, and peat. The last layer of clay is being deposited at this moment over old gravels in spots which have never been covered by it before. Even the latest layer contains concretionary masses, somewhat pappy on the outside, consisting of calcium carbonate mixed with arenaceous and argillaceous particles with a little iron and phosphoric acid, which I take to be an incomplete form of such masses as are known by the name of *Race*. For the rough analysis of these masses I am indebted to Mr. W. H. Hudleston, F.R.S. I procured some of these in the Sheppey marshes seven feet below the salting top and about four feet above the layer of Roman remains and burnt clay flooring.

The tidal clay, which in suitable places is still being accumulated, is kept up to the regular height far down the estuary, although the washing away of the land by the sea is destroying the area of the saltings, and even of the enclosed marsh, the efforts to preserve which often exceed the profits derived from its use. I have mentioned that the embankment and confinement of the river to a narrower channel has deepened the streamway, and it is obvious that, were the embankments not kept up, even at a loss, the spreading of the tide would rapidly produce shoals and a general shallowing of the water. If we carry our minds further back to times when the tide was absent, the marshes covered with loosely-rooted trees and only the comparatively small freshwater (or perhaps sometimes brackish) stream filling the channel, we can well picture to ourselves the great banks and shoals which made a passage of the river by fords and boats an easy matter. When further we consider that the accumulation of stranded trees combined to

aid this it will not be difficult for us to picture nature assisted by art, and even bridges and causeways jutting out into such a stream as the present estuary of the Thames was when the Romans first came here. It is, I think, not too much to suggest that the tidal water, such as now reaches London, might then have been full five-and-twenty miles away.

The only skeleton of man which has been investigated from the estuary of the Thames is that of the "Tilbury man." It was found in the bank of sand shown in Fig. 2, under the mark +, covered by twenty inches of sand. This sand I followed vertically to the gravel, of which it constituted a part. A few shells of *Bythinia* and *Succinia* were also obtained from it. On the surface of the sand lay a few stray valves of *Scrobicularia* and of *Tellina*. The skeleton was not that of a well and equally formed man.

Sir R. Owen has described the skeleton and its situation (Sir R. Owen, 'Antiquity of Man') and has pronounced that it is a Palæolithic man. Mr. T. V. Holmes ('Trans. Essex Field Club,' iv, 135) has examined the situation in which it was found and he pronounces the man to be Neolithic. Prof. Prestwich ('Geology,' ii, 522) says that he was "a very ancient, but not Palæolithic man" which taken with the opinion he gives that there is a distinct break between the two "*lithic*" ages, clearly marks him as Neolithic.

No implements were found with the skeleton, nor in the excavation in which it was found. I may be pardoned, therefore, if I examine the value of these opinions.

As yet no Palæolithic implements have been actually found in the gravel series to which this man belongs, and which, on Fig. 1 is marked (*a*). Neither have any been dredged up from the river, nor have any Neolithic remains been found in place in the gravel. All this is not very surprising seeing the difficulty of examining or even of getting a good view of these deposits. It is altogether from the operation of dredgers that we have at present any stone implements from the deep gravels of the Thames, and these are exclusively, so far as I know, Neolithic. Very many rude as well as polished implements have been obtained by this means, but no series of implements forming a peculiar type has been got from this situation.* By Palæolithic deposits is understood

* After this paper had been sent in I received a letter from Mr. G. F. Lawrence, of Wandsworth, telling me of some flint implements he had lately obtained from the Thames. These implements were brought to Wandsworth

FIG. 4.

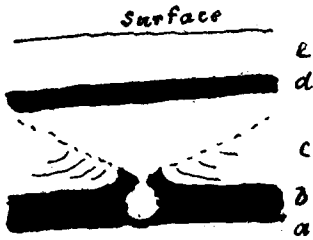


FIG. 5.



FIG. 6.



FIG. 7.

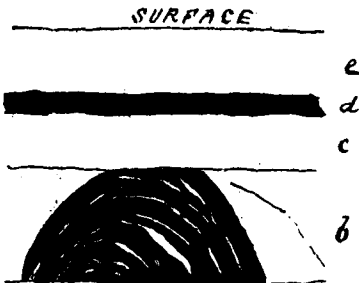
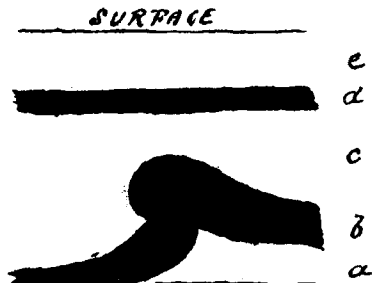


FIG. 8.



FIGS. 4-8. Figures representing the peculiarities in peat at Tilbury. The lettering in each signifies the same layers, *b* in each case being the middle or main peat. They are sketches approximately to scale.

those in which implements having that title are found, and in which they have a contemporaneous place. A similar statement will define Neolithic deposits, but the presence or absence of extinct Mammalia does not affect these definitions. There is no doubt that Palæolithic implements, taken as a whole, may be separated from Neolithic implements similarly considered; but it would be a mistake to deny that there is a distinction to be made in the types of each class which points to variation in a certain direction. To say that there is no passage between the two leading classes of implements is to say too much; and it is assuming still more if this necessitates the supposition that man was absent altogether during the very time when that amelioration of the climate was in progress which resulted in the gradual improvement which has continued from Palæolithic times until now.

It is obvious then that between the two kinds of implements there must be an approximation somewhere, and if the question is unsettled it is merely for want of investigation. From what has already been advanced I see no reason why the evidence of this approximation or transition should not be discovered in the deposits of the estuary I have been examining.

On the whole, it appears to me that the man of Tilbury holds a middle or transitional position.

In the case of the extinct Mammalia with which he is to be considered, we find that a few species, including the Elephant, continued to live through the period of deposition of the gravel and sand to its junction with the Alluvium, and some are found high up in the latter. I think, too, the Tilbury man may have been a contemporary of the Mammoth.

The teeth of the Mammoth have been found by dredgers not

with gravel which had been dredged off Erith, or somewhat to the eastward of that place, in the autumn of 1888. On visiting the writer I found that two implements in particular which had been found at some little distance of time and place from each other were well worthy of notice. If in some points they resemble Palæolithic types, in others they are like Neoliths. Their workmanship is good, they have received no recent injury, and their mineral condition, marking, and colour are in perfect keeping with the appearance of the gravel of the place whence they came. Their most remarkable feature is that they resemble no implements from the neighbouring Palæolithic deposits, nor any others yet discovered in this part of the country; they appear to confirm my views expressed in this paper that there is a transitional type.

unfrequently when working in the Thames, but it is to be regretted that comparatively few specimens have been preserved. I have a good one, obtained off Price's Oil Works at Erith, which I propose to present to the British Museum. The dredge was at work very close in shore when the tooth was brought up, and it could only work at high-water, resting on the dry mud and forest-bed long before the ebb. The tooth evidently lay partly in sand and partly in peat, and when it was brought to me it was covered with the latter. It is markedly of the Arctic type. I also have a portion of a large tusk from (off) Dartford. This evidently lay in contact with peat on a layer of gravel, which adheres to one side of it. It is very black on the outside, and within are blue patches of iron phosphate. In Jermyn Street Museum is a molar marked "Dartford." It is in excellent condition. The matrix is at one part sand, and at another blue clay. It is very deeply stained with peat, and evidently dredged from the Thames off the parish named. Another in the same Museum, marked "Erith," has a great similarity to the Dartford specimen as to colour and adherent matrix. Two teeth were obtained from a navvy by Mr. Davies, and placed in the British Museum, Catalogue No. 40,081. They came from excavations apparently connected with the West India Docks in the Isle of Dogs. The matrix is sandy, and they are deeply peat-stained. Another in the British Museum, No. 37,248, was obtained from Millbank; is black and unworn, and was apparently dredged or obtained from a cutting in the peat. Last autumn Mr. E. R. Pearce wrote to tell me that he had a molar of elephant which had been dredged off Greenwich. I found it to be in a similar condition to those above mentioned. All these teeth are remarkably well preserved and very dark. They seem to belong to the Arctic type of Mammoth. They are very heavy, and seem to still retain some portion of gelatine. The matrix in every case shows that they laid near the peat or in it. Dr. H. Woodward has recorded the finding of elephant molars in and upon the gravel below the peat at Walthamstow, and there is one tooth in the British Museum, No. 40,559, in a sandy matrix and black, from the Medway.

It has been suggested to me that these teeth have been "derived." Had I thought so I should not have gone into details. The specimens are not rolled, and the laminae of cement

in some instances are very thin. Their physiological condition also is so similar to other remains from the same horizon, such as the *Homo* of Tilbury, *Cervus tarandus*, and other animals, that I see no cause, apart from theory, why one or another should be separated by calling it derived.

The remaining animal-remains are a few of those which I have been able to collect or to hear of.

Arvicola, sp.

Bos longifrons.

Bos primigenius, "Urus," Albert Dock.

Canis lupus, common.

„ *vulpes*, ditto.

„ sp. "Dog," ditto.

Capreolus capra, Albert Dock.

Castor fiber, Albert Dock and Crossness.

Cervus alces, in peat near the junction of the Lea River.

„ *elaphus*, most abundant.

„ *tarandus*, not infrequent, and extending to the upper level of the peat.

Equus caballus, Crossness.

Sus scrofa.

The following list of plants is constructed from their leaves, wood, and seeds. I procured the seeds by an exhaustive method of washing, and think it probable that it represents the larger proportion of those recoverable. I am indebted to Mr. Clement Reid, F.G.S., for kindly looking over and identifying those here given; but I still possess some which are undetermined. I collected from the separate beds at Crossness between 30 and 40 specimens of wood, from trees whose diameters ranged between 10 inches and 2 feet. Prof. H. Marshall Ward, F.R.S., kindly undertook to examine my mounted sections of these, and though the kinds were few, *Pyrus* and *Salix* were added to the list, the majority proving to be *Fraxinus* and *Alnus*.

LIST OF PLANTS.

L = lower. U = upper beds at Crossness. A = lower part of alluvium of Albert Dock, North Woolwich. T = base of main layer of peat at Tilbury.

	L	U	A	T
<i>Ranunculus sceleratus</i> , L.	x	...	...	...
<i>Ranunculus repens</i> , L.	x	x	...	...
<i>Oxalis Acetosella</i> , L. ... ..	...	x	...	...
<i>Prunus communis</i> , Huds., several different forms, } perhaps including <i>Bullace</i>	x	x	...	...
<i>Prunus spinosa</i> , L.	x	...	...	...
<i>P. Cerasus</i> , L.	x	x	...	...
<i>Rubus fruticosus</i> , L.	x	x	...	...
<i>Rosa</i> , sp.	x	x	...	...
<i>Pyrus communis</i> , L.	x	x	...	...
<i>Cratægus Oxyacantha</i> , L.	x	x	...	...
<i>Ilex Aquifolium</i> , L.	x	x	...	...
<i>Viburnum Opulus</i> , L.	x	x	...	...
<i>Hippuris vulgaris</i> , L. ... ..	...	x	...	...
<i>Oenanthe Phellandrium</i> , Lam. ... ..	...	x	...	...
<i>Hedera Helix</i> , L.	x	x	...	...
<i>Cornus sanguinea</i> , L.	x	x	x	...
<i>Sambucus nigra</i> , L.	x	x	...	x
<i>Fraxinus excelsior</i> , L.	x	x	...	...
<i>Polygonum Hydropiper</i> , L.	x	...	...	...
<i>Mercurialis perennis</i> , L.	x	x	...	...
<i>Salix</i> , sp. ... ..	...	x	...	...
<i>Betula alba</i> , L. ... ..	...	x	x	x
<i>Alnus glutinosa</i> , Gaertn.	x	x	x	x
<i>Corylus Avellana</i> , L.	x	x	x	x
<i>Quercus Robur</i> , L. <i>sessiliflora</i> ... ..	...	...	x	x
" " <i>pedunculata</i>	x	x	...	...
<i>Acer campestre</i> , L.	x	x	...	...
<i>Taxus baccata</i> , L.	x	x	x	...
<i>Iris Pseudacorus</i> , L. ... ..	...	x	...	...
<i>Sparganium ramosum</i> , Huds.	x	x	...	x
<i>Scirpus lacustris</i> , L.	x	...	...	...
<i>Carex</i> , sp. ... ..	...	...	...	x
<i>Phragmites communis</i> , Trin.	x	x	x	x
<i>Pteris aquilina</i> , L. ... ..	...	...	...	x
<i>Sphagnum</i> , two species ... ..	...	...	...	x
<i>Hypnum</i> , spp.	x	x	...	x
<i>Hypoxyylon concentricum</i> ... ..	...	x	...	...
<i>Polyporus hispidus</i> , Fr. ... ..	...	...	x	...
<i>Puff-ball</i> , species undetermined ... ..	...	x	...	...

LIST OF SHELLS.

L = lower peat. U = upper peat, Crossness. A = Albert Dock. T = Tilbury main peat.

	L	U	A	T
<i>Pisidium amnicum</i> , Müll....	×	...
„ <i>fontinale</i> , Drap....	...	×	×	...
<i>Sphærium corneum</i> , L.	×	×	×
<i>Unio tumidus</i> , L.	×	×	...
<i>Neritina fluviatilis</i> , L.	×	×	...
<i>Valvata piscinalis</i> , Müll....	...	×
„ <i>cristata</i> , Müll.	×
<i>Bythinia tentaculata</i> , L.	×	×	...
„ <i>leachii</i> , Shep.	×	×	...
<i>Hydrobia ventrosa</i> , Mont.	...	×	...	×
<i>Planorbis fontanus</i> , Lightf.	...	×
„ <i>contortus</i> , L.	×	×	...
„ <i>spirorbis</i> , L.	×
„ <i>marginatus</i> , L.	×	×	×
„ <i>crista</i> , L.	×	...
<i>Limnæa truncatula</i> , Müll.	...	×	...	×
„ <i>palustris</i> , Müll.	×	×	...
„ <i>peregra</i> , Müll.	×	×	×
<i>Ancylus fluviatilis</i> , Müll....	...	×	×	...
„ <i>lacustris</i> , L.	×
<i>Carychium minimum</i> , Müll.	...	×	×	×
<i>Succinea elegans</i> , Risso.	×	×	×
<i>Clausilia laminata</i> , Mont.	...	×
„ <i>rugosa</i> , Drap.	×
<i>Balæa fragilis</i> , Drap.	×
<i>Vertigo pusilla</i> , Müll.	×	×	×
„ <i>substriata</i> , Jeff.	×
„ <i>edentula</i> , Müll.	×
<i>Pupa umbilicata</i> , Drap.	×
<i>Cochlicopa lubrica</i> , Müll....	...	×	×	...
<i>Helix nemoralis</i> , L.	×	×	×
„ <i>arborum</i> , L.	×
„ <i>lapicida</i> , L.	×
„ <i>rufescens</i> , Penn.	×	...
„ <i>concinna</i> , Jeff.	×
„ <i>hispida</i> , L.	×	...
„ <i>pulchella</i> , Müll.	×	...	×
„ <i>rotundata</i> , Müll.	×	×	...
Ova of <i>Helices</i>	×	...
<i>Hyalinia nitida</i> , Müll.	×	×	...
„ <i>fulva</i>	×
„ <i>nitidula</i> , Drap....	...	×	×	×
„ <i>crystallina</i> , Mull.	×	...	×
„ <i>cellaria</i> , Müll.	×