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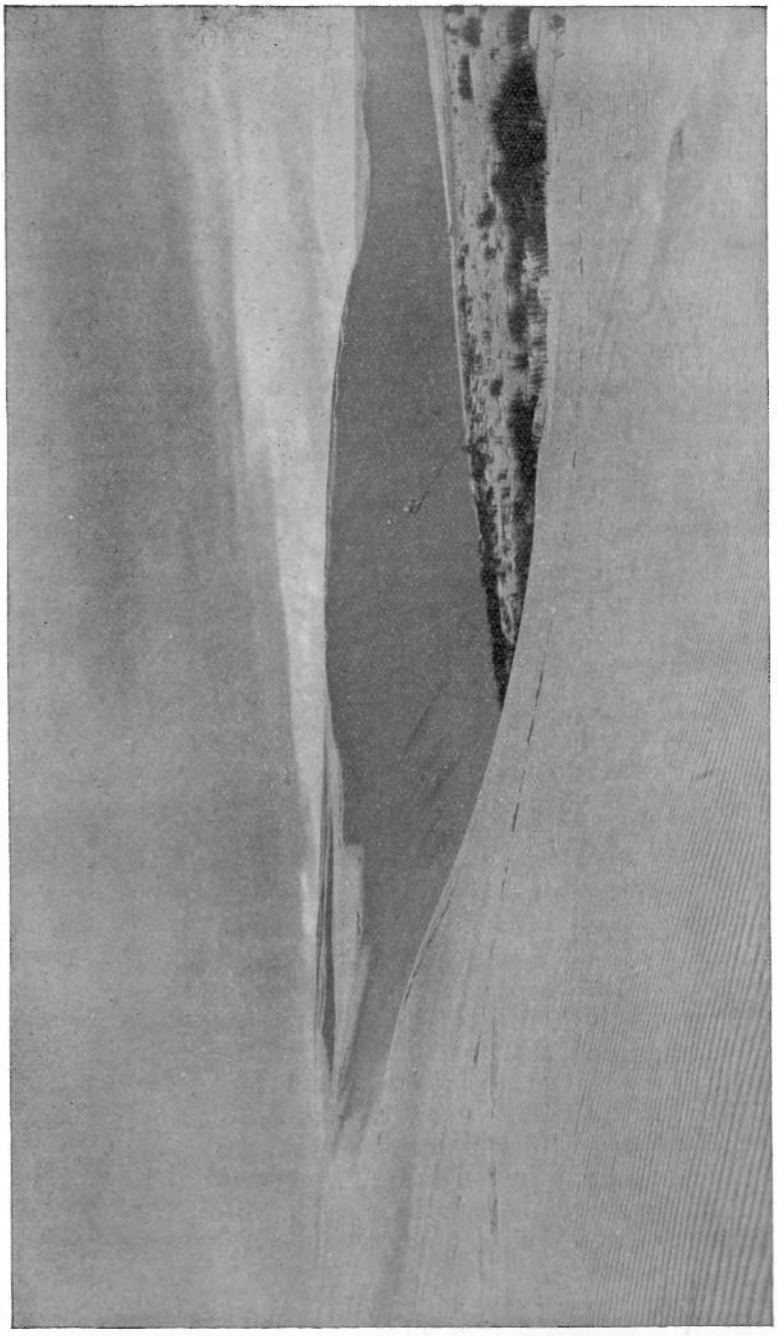


THE CULBIN SANDS: SHOWING THE ORIGINAL CULTIVATED LAND SURFACE DOWN TO WHICH ALL THE LARGER OBJECTS

ON SOURCES OF ERROR IN ASSIGNING OBJECTS FOUND IN SANDS AND GRAVELS TO THE AGE OF THOSE DEPOSITS, WITH SPECIAL REFERENCE TO THE SO-CALLED EOLITHS.[1]

By Professor T. McKENNY HUGHES, M.A. F.R.S.

The attempt to trace man back into the remote past has always had a great fascination for both the scientific and the unscientific world. The data upon which theories as to his age and origin have been built up appear to be so easy of apprehension that most people feel that they are competent to form an opinion upon the subject. When, however, one comes to examine the details the fact is forced upon one that there are sources of error in the observations which may vitiate most of the wide reaching inferences which have been drawn.

When investigating the occurrence of man's handiwork in various deposits we soon find that the enquiry falls under two heads. (1) Are the objects undoubtedly the work of man, and (2) do they really belong to the age of the deposit from which they are said to have been procured ?

These questions may be approached from several different points of view. The biologist will ask what may be inferred from the character of the bones of man and other animals found associated with him in ancient deposits, and how far we may expect him to have remained almost unchanged in comparison with the variations which are observed in the lower animals during the period in question.

The archaeologist will endeavour to establish some criteria by which sticks and bones and stones may be recognised as trimmed by man and distinguished from others whose form is due to natural agents.

The geologist investigating the age of the deposit from which the bones or handiwork of man are said to have been procured will enquire whether they cannot have

[1] Read before the Institute, 6th December, 1911.

been introduced into it by artificial or natural means long after the original deposition of the formation in which they occur.

It is this last point that I propose to discuss in this paper, as I believe it contains the statement of a source of error which has not hitherto received the attention it deserves and yet is certainly of supreme importance in speculations as to the age of some of the earliest forms of chipped flints which have been referred to the agency of man.

I will first take some of the simpler cases. A very obvious one is where burrowing animals have made holes in sand and gravel into which implements or other objects bearing upon the question before us have worked their way.

I have already placed on record[1] a very interesting case which came under my notice some years ago. Among the remains brought to me by workmen from the gravel of Barnwell near Cambridge were the bones of sheep, an animal which has never been found in beds of the age of those gravels. They appeared to be in exactly the same state of preservation as the bones of extinct animals from the same locality. I went to the pit to examine the spot in which they were said to have been found and ascertained that they occurred along a well defined stratum of more sandy incoherent material than the beds above or below. I followed this a short distance, and as I scraped it away I detected what had once been a hole somewhat oval in shape but now filled with the material of the bed in which it occurred. I found fragments of bone on the floor of it, and on the sides and roof the marks of the claws of the burrowing animals that had made it. Subsequently I procured from it the skulls and other bones of badgers, foxes and dogs. This was therefore clearly a badger-earth afterwards occupied by foxes, while dogs, which followed them in, got suffocated and left their bones there also, as we not infrequently find in caves. The hole being entirely filled by sand and gravel which had worked down into it, it was not at first sight obvious that this had taken place at a much later time than the date of original formation of the beds of sand

[1] *Geol. Mag.* Dec. ii, vol. x, no. 16, p. 454, Oct. 1883.

and gravel, while the state of the bones, which had lain there so long under conditions similar to those affecting the rest of the deposit, did not arouse any suspicion. It was only the close examination of the section, immediately upon the finding of the bones of species not expected to occur there, that led to the discovery of the true explanation.

In a country over which deposits resulting from sub-aerial denudation have long been in process of formation, sometimes continuously through long ages, and sometimes with local or widespread interruptions, we continually have older river terraces and surface soils used up in later times and even the less destructible parts of bones, and still more the practically insoluble flints, handed on from one level to another and from age to age without being transported very far from their original position. This is going on apace in " dry chalk valleys " and in pipes.

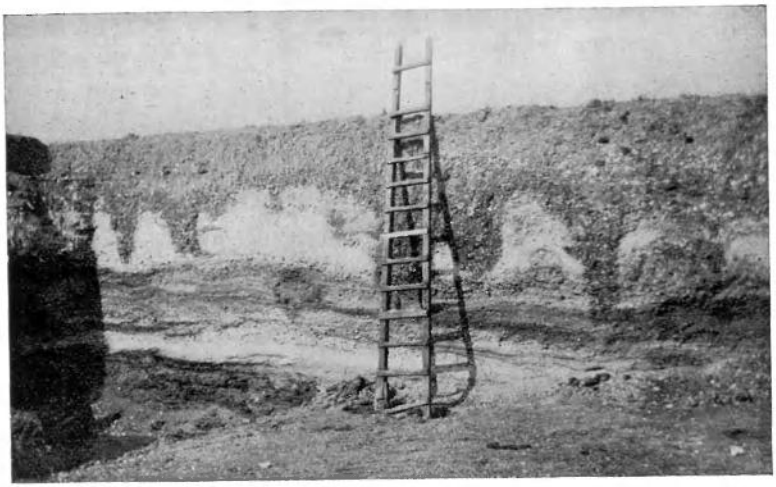
For example I think it probable that the bone of musk ox found by Lord Avebury in the gravel below his residence is a weathered and worn lump of the most massive part of the skull drifted down into one of the potholes which have swallowed up and are still receiving, in a deep depression in the soft and rapidly perishing surface of Kent, the varied débris from the surface soil and from ancient terraces.

Or, to give another example from the gravels north of Cambridge, I exhibit a fragment of a molar of Elephas meridionalis, an ancient form not found in any of our river gravels or anywhere with palaeolithic man. This is from the gravel pit near Kennet station, where, according to so good an observer as Mr. A. G. Wright, it was found associated with Rhinoceros and palaeolithic implements. But it is only a pebble of elephant molar washed in from no one knows where, and has no more value in determining the age of the deposit than the fragments of secondary and palaeozoic rocks which we find so commonly among the flints. The further north we go the more likely we are to find débris from the Forest Bed and other preglacial deposits which crop out along the coast of East Anglia. These are not likely to have been confined to that narrow belt and we are sure by and by to find them preserved in hollows much further south.

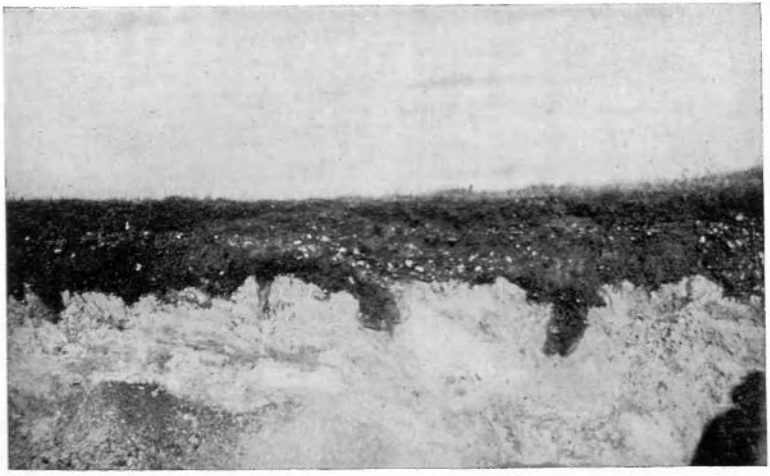
The very various conditions, colours and mode of fracture of the flints, and the variety in the implements, where such occur, point to the explanation that we have in our gravels the later sweepings of remnants of ancient terraces and of old surface soils of many different ages, while derivative fossils and rocks tell the same tale. We find implements with one side weathered white and the other side remaining dark, a difference of condition not seen in deep buried flints, but due to surface action. This is well shown in the broken implements strewn over the sands of Egypt, where one half of the same implement is often dark, the other light, according to which way up the two pieces fell.

In North Britain, near Nairn, on the coast of the Moray Firth there is a most interesting group of dunes known as the Culbin Sands (plate 1). Local history tells us of rapid overwhelming of houses and lands and also of slow encroachments on field and forest. What concerns us now is the manner in which this sand moves, and how it deals with the larger and heavier objects that accident lays upon it. It does not travel forward uniformly, producing a level waste of sand, but any obstacle which diverts the path of the wind causes more lifting here, more dropping there, so that the sand soon acquires the form of steep rounded hills, and between these are deep troughs and pits out of which the eddy and swirl of the confined wind lifts the sand and hurries it away, till the diminished velocity in the more open spaces allows it to settle again.

The wind, however, lifts only the sand, and therefore any heavy object gravitates down the slopes and finds a resting place on the solid ground over which the sand originally encroached and which is from time to time exposed between the shifting mounds. We find accordingly lying together at the bottom of these hollows, dressed flints which have been left by early man, shells which have been blown up the steep slopes of sand, and the coins and buttons of later times. Had these sand dunes been ancient enough there might have been eoliths, palaeoliths, and neoliths as well, all mixed together at the bottom of the hollows. What has been going on is shown by the effect of the blown sand in etching and polishing the various objects which lay in its path.



NO. I. PIT IN LOW-LEVEL GRAVEL, MILTON ROAD, CAMBRIDGE.



NO. 2. PIT IN PLATEAU BEDS, WANDLEBURY, CAMBRIDGESHIRE.

If now we turn to another area where we have to deal with vast extents of sand and gravel left in past ages by the sea, as I believe, we see how, *mutatis mutandis*, the same process which we have observed in operation on a large scale but over a limited area in the Culbin Sands has been going on in detail all over the undulating plains of East Anglia, where there is a very variable deposit of sand, gravel and clay, sometimes one sometimes the other being exposed. Where sand is at the surface it is of course blown this way and that way by the shifting wind, it fills hollows and is heaped up against natural or artificial banks. It is searched out from among the interstices of the gravel, and covers beds of clay which were once at the surface, till large tracts of Norfolk and Suffolk are covered with blown sand forming the interesting region of the Brecks, with its peculiar fauna and flora. This shifting sand formed the soil which was the object of enquiry by the traveller, and the amusing reply by the man who was driving him through the country, "To whom does the soil mostly belong about here?" "Why, you see, sir, it's this way. When the wind be from the east it mostly blows the soil on to squire So and So's land, but when it be in the west, it blows it on to my lord's property."

This has been going on for ages and is going on still, and that dry country, with its abundant supplies of flint, its numerous rivers and its patches of woodland, has from palaeolithic times been a happy hunting ground where primeval implements have been lost and exposed to changing temperature and moisture on the surface, or been buried under the sand or in the moving subsoil, or at last been caught and sorted in the deposits of the rivers.

In the drifts exposed on the cliffs of Norfolk and Suffolk and extending inland far from the coast, we see not only clay, gravel and sand, but enormous masses of transported chalk and chalky material mixed up with the gravel and sand and clay. This gives rise to many difficulties when we come to examine these deposits in their extension inland, and trace them over the surface of the East Anglian plateaux, and, it seems to me, furnishes an explanation of the occurrence of palaeoliths and eoliths together in the similar though differently formed deposits which lie on

the terraces and tops of the chalk hills south of the Thames. The subterranean decomposition of the chalk, whether in place or occurring in transported masses, produces complications which affect the surface soil, and is the chief source of error in the reference of objects found in the gravels and other superficial deposits in the east and south of England to the age of those deposits. This then is the principal point to which I invite attention.

I do not know of any formation the top of which presents such a variety of form as does the chalk. In one place we see a very thin uniform layer of chalk rubble covered by an almost imperceptible surface soil. This is where the weathered surface and the vegetable mould are creeping rapidly down hill and where there are no local circumstances causing the rain water to be collected into runlets. No age can be assigned to this soil or subsoil.

In another area we find a surface-covering derived from other deposits at a higher level, and this directly affects the carrying away of the rain water, which runs into gravel, or runs off clay, and is thus brought irregularly into contact with the chalk. Upon the chalk it acts both chemically and mechanically, eroding the surface into pans and pipes, and into these pans and pipes the superficial deposits sink. One can see that they have so sunk because the layers, which were laid down horizontally, are looped into the hollow, and the flints along the margin are dragged down with their longer axes vertical, a position which they could not have assumed during the deposition of the bed. The walls of chalk generally stand firm and are besides held up by the packing of superficial deposits which nature rams into the hollow as it is being formed.

Supposing, however, that this action takes place in a gravel bed, itself composed largely of chalk. The rain water, often collected into runlets by local circumstances, sinks into the gravel, carrying away the carbonate of lime in solution and leaving only the insoluble residuum. The conditions here are different. The surrounding gravel does not present a firm wall as in the case of the chalk and the gravel falls in irregularly, but chiefly from the top corners.

This is well seen in a pit at the Cambridge end of the Milton Road near the Victoria Bridge, in which pipes

NO. 1. GRAVEL PIT, HARE PARK, SIX MILE BOTTOM, CAMBRIDGESHIRE.

NO. 2. GRAVEL PIT, HARE PARK.

of non-calcareous soil and subsoil are seen infolded into horizontally bedded chalky gravel (plate II, no. 1). This deposit belongs to a low-level terrace in the Cambridge valley gravel.

This superinduced structure is conspicuous also in the irregularly bedded and contorted sand, gravel and chalky boulder clay of the plateaux, as may be seen in the pit on the golf links near Wandlebury, Cambridge (plate II, no. 2). Here pipes of decalcified soil and subsoil are seen penetrating the remanié chalk and chalky sand which close over and enfold the pipes. This is an interesting section in connexion with our present enquiry, as these beds are the equivalents of the plateau beds of Hare park, while in character and association they more closely resemble some of the sandy beds of the Norfolk coast, of which I believe them to be the inland extension.

If in addition to the chalky gravel we have large masses of included chalk and extensive beds of chalky boulder clay, such as may be seen on the East Anglian coast, the compilation is greatly increased; and if further the whole complex mass is contorted by ice action, and perhaps also rests on chalk which is being rapidly removed by subterranean denudation, the intwisting of ancient surface soils is a fact of which we must take account.

Now we are in a position to ask and answer the question, What is the value of the evidence for the discovery of palaeolithic implements in the plateau gravels of East Anglia and the high level[1] deposits of the north downs? One was found by Mrs. Hughes near Hare park in the top of the gravel of the lower plateau north of Cambridge. There is no doubt about its being the work of man but there is great doubt as to its being of the age of those deposits.

In a gravel pit in these plateau beds, in the top of which the palaeolithic implement was found not far off, the whole mass of gravel is let down by the decomposition of the underlying chalk (plate III, no. 1). It is obvious that the surface soil and any object on it would be engulfed by the agencies which produced such folding.

Another section (plate III, no. 2) close by that illus-

[1] See *Nature*, vol. 30 (1884) p. 632; *Cambridgeshire* by T. McKenny and Mrs. Hughes, Camb. Univ. Press, 1909, pp. 134, 135, fig. 2.

trated by the preceding photograph but at right angles to it, shows large included masses of chalk and chalky boulder clay not seen in the other section. These are only remnants of an enormous quantity of chalk transported and spread over East Anglia, and we may imagine what movement and crumpling of the superficial deposits must have accompanied its solution through the long ages which have elapsed since it was dropped here. The bearing of this on the subject we are discussing is that throughout much of it man was occupying each area as it became suitable.

The deep gravel deposits north-east of Hildersham occur under very similar conditions. They are on a similar terrace or lower plateau some 150-200 feet above sea level and show all the various causes of complication mentioned above. The chalk is deeply pierced by pipes, the superficial deposits contain large masses of chalk, and more or less comminuted chalk pervades most of the original gravel. So we see on one side surface flints dropped into a large swallow hole, further on patches of chalk still remaining in the gravel and loam, though showing signs of great and probably rapid waste, and, everywhere, evidence of contortion in the superficial deposits as they have sunk into the hollows formed by the solution of the chalk.

A flint implement was found by Dr. Marr[1] in the marginal part of a similar deposit on Furze Hill east of the road between Linton and Hildersham in a loop of rusty sand and gravel out of which all the chalky material had been dissolved.

In the superficial deposits of Kent the same difficulties arise, though there we are dealing with beds probably formed under somewhat different conditions. The character of the deposit teaches us that we must be prepared to find objects such as palaeolithic implements, which were not so long ago on the surface, now engulfed and buried deep in loam, sand and gravel by those soil movements which I have been describing.

I have avoided the discussion of the question whether eoliths must be considered as the work of man. It is sufficient for my present purpose that implements referred to the palaeolithic age have been found sometimes

[1] *Geol. Mag.* vol. vi, Dec. 1909, p. 534.

associated with eoliths in the superficial deposits of the high ground of East Anglia as well as south of the Thames.

To sum up, let me sketch the downward course of a flint implement or any other object dropped upon the surface of such a deposit as that which constitutes the plateau gravel of East Anglia or the chalky superficial deposits of the north downs of Kent.

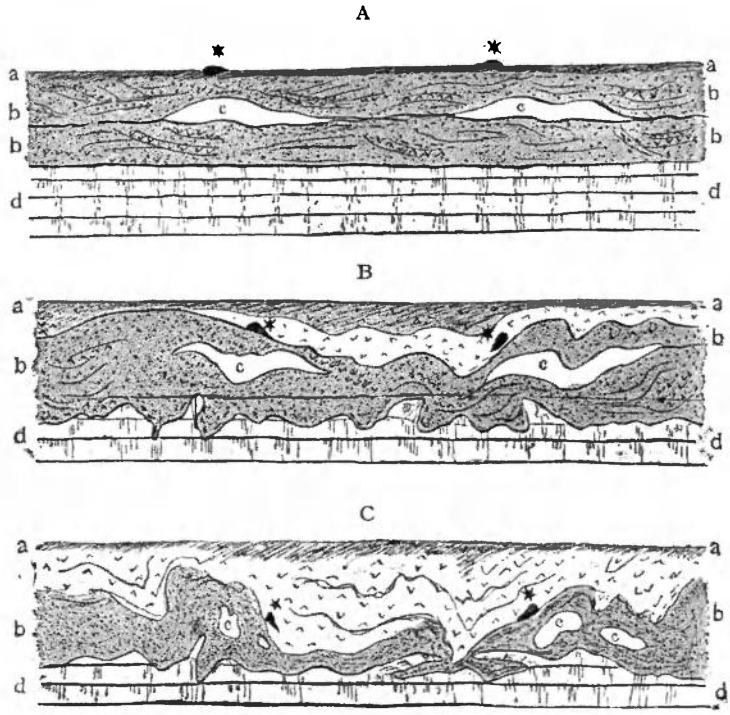


FIG. 1. (a) is the surface soil upon which two flint implements (marked by an asterisk) have been dropped; (b) is the false-bedded sand and gravel, full of fragments of chalk; (c) represents large masses of chalk, often associated with chalky clay; (d) is the chalk in place.

Section A in fig. 1 is an ideal restoration of the beds when undisturbed by subterranean denudation.

There are in the deposits referred to three different modes of occurrence of chalky material, any one of which would be by itself sufficient to account for the depressions and complications of the strata by which I am explaining the inclusion of implements in them. There is the solid

chalk (d) at the base, worn into pipes and pinnacles; there is the comminuted chalk (b) forming a large part of the sand and gravel, before it has been acted upon by the acidulated water; and there are the large masses of chalk (c) relics of the chalky boulder clay, or it may be, sometimes broken-down pinnacles of solid chalk.

In section B we see the result of the subterranean removal of the chalk in place. The surface soil (a) and implements (*) sink into the depressions and are covered over by new deposits of gravel and earth brought by the soil creep and rain from the surrounding surface. In places we see the usual result of surface action on a large scale; the fine earth and sand has been removed from the flints, which indicate by their condition that they have been long exposed to the agency of surface changes of temperature, moisture, etc. These masses of flint resemble those found in "dry chalk valleys" where they are collected by gravitation into the hollows of a sinking subterranean trough and commonly occur far beyond the limits of the chalk with flints.

Section C represents a further stage in the process. The characteristics of the surface soil have been destroyed, but the fact that each part has been at the surface may be inferred from the condition of the flints, and from the processes still going on around.

In applying these observations to the country south of the Thames we must bear in mind that there the chalk appears to have been exposed to the action of subaerial agents for a much longer time than has the lower area of East Anglia and that there we must more frequently explain the inclusion of masses of chalk in the superficial deposits by the breaking down of pinnacles and partitions between the pipes and troughs.

Those who believe in the human origin of eoliths may receive comfort from these observations, as they explain what has been a stumbling block to many, namely the occasional association of palaeolithic implements with the eoliths; and those who do not believe in eoliths will learn of a constant operation of nature by which stones, which have received a recognisable form and exterior condition on the surface of the ground, have been subsequently engulfed in ancient deposits of sand and gravel.