

4. NOTES on the CORRELATION of the DEPOSITS described in
Mr. C. J. GILBERT'S paper with the HIGH-LEVEL GRAVELS
of the SOUTH of ENGLAND (or the LONDON BASIN). By
GEORGE BARROW, F.G.S., M.I.M.M. (Read January 22nd,
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THESE deposits being clearly post-Eocene, the question arises, what is their true age, and with what other similar deposits within or near the London district can they be correlated? Their height above sea-level—550 feet—suggests that they form part of the series of High-Level Gravels, described by various authors under various names, often that of the locality at or near which they occur.

Under the heading of 'Pebble Gravel,' Mr. Whitaker has given a short but good description of these¹ deposits, followed by a list and a brief account of the numerous occurrences of pebble-gravel. Unfortunately, the term has been applied by many of the observers, whose notes he quotes, to deposits that have no connexion with the particular gravels to which he personally restricts the use of this name, so that much of the account is either of no value or misleading. The late Prof. T. McK. Hughes grasped the significance of their extent and mode² of occurrence, being especially impressed by their uniform level in the area surveyed by himself in Hertfordshire, a little over 400 feet above sea-level. He called them the 'Gravels of the Upper Plain,' and considered that they must be marine.

On the north side of the Thames, the most extensive spread of these gravels occurs on the Tertiary Ridge, about Stanmore Common, Shenley, Barnet, Potters Bar, etc., and these are taken by Mr. Whitaker as the type occurrences. Recently these occurrences have been re-examined and re-mapped by the officers of the Geological Survey, mostly by Mr. R. W. Pocock, under the supervision of the writer. Brief summaries of the results have been published in the 'Summary of Progress of the Geological Survey.'³

These occurrences are especially interesting, and were selected by me in my Presidential Address to the Geologists' Association (1918),⁴ as giving the key to the study of the High-Level Gravels on the north and north-west of London, which I believe are of Pliocene age. They illustrate the fact that there are present in this area two distinct types of gravels, other than river-gravels, that contain stones foreign to the district. The best known are the fluvioglacial gravels, which contain abundant pebbles and

¹ Mem. Geol. Surv. 'Geology of London' vol. i (1889) pp. 290-96.

² Q. J. G. S. vol. xxiv (1868) pp. 284-85.

³ Mem. Geol. Surv. 'Summary of Progress for 1913' 1914, pp. 32 *et seqq.*

⁴ Proc. Geol. Assoc. vol. xxx (1919) pp. 1-48.

small blocks of foreign material, such as Bunter pebbles (liver-coloured quartzite, etc.), vein-quartz (often in large angular or subangular fragments), Carboniferous Limestone, sandstones of various ages, waterworn fossils (especially *Gryphaea*) from the Lias, Oxford Clay, etc., special types of rock such as Red Chalk and Spilsby Sandstone, many igneous rocks, and in a few localities, fragments of Scandinavian rocks. Now, these foreign components have obviously come from a considerable distance; they are far-travelled.

But the gravels on the Tertiary Ridge, selected as the type of High-Level Gravels, contain no far-travelled material. The chief pebbles foreign to the district consist almost exclusively of small pebbles of white quartz and of lydite; Lower Greensand chert is fairly common in part of the area. These small pebbles have been derived from the Lower Greensand. They can be seen pouring out of the end of water-sieves or screens in operation at Leighton Buzzard, where the incoherent Lower Greensand is sieved for commercial purposes on a considerable scale. There are certain points in these pebbles that help to establish their identity. Many are slightly translucent, and also they have almost a dreikanter form. It is often stated that these Stanmore-Barnet gravels contain quartzite: it is possible that some of the small pebbles from the Lower Greensand may be quartzite, though apparently none have been recorded. The material called 'quartzite,' which is not common, is sarsen, derived from the Reading Beds, and of local origin. Thus, these gravels contain foreign material, often in great quantity, but it is derived from the area beyond the Chalk escarpment, not far removed, but neighbouring, and the pebbles may be described as 'neighbouring.'

Thus there are two types of gravel containing foreign material to be dealt with:—

- (1) Those containing far-travelled stones, and
- (2) Those containing only 'neighbouring' stones.

In the latter, the local pebbles are nearly all Tertiary, mainly from the Reading Beds; fragments of flint are distinctly uncommon in the Stanmore-Barnet area.

The eastern occurrences on this Tertiary Ridge are all at approximately the same level, a little more than 400 feet above sea-level, and it was to these occurrences that Prof. Hughes referred, when he claimed them as marine. So long as they remain at this level, the quartz-pebbles are abundant, and the associated Reading pebbles are on the whole comparatively small. But, on approaching Stanmore Common, the gravels gradually attain a greater elevation, at one point 500 feet. As the height above sea-level increases, so does the size of the Reading pebbles: thus, when the highest point is reached, these pebbles are, on the average, much bigger than those at Barnet, and many of them still show the original beach-hammering (nodding) of the Reading pebbles.

The course of these deposits has been traced from the neighbourhood of London, both on the east and on the west sides of the Misbourne, near Chalfont St. Giles; and at Hampstead Heath they rest upon the Bagshot Beds, while at Barnet and Stanmore they are on the London Clay. Recent work has proved the presence of these beds between Chorley Wood (north-east of Rickmansworth) and the Misbourne valley. At Chorley Wood they rest on the upper part of the brilliantly-coloured marl near the top of the Reading Beds, while farther west, at the Vache, they rest on a slightly lower horizon. It was a little to the north of this that the locality was found where they rested on the 'sarsen' of the Reading Beds. Mr. J. F. N. Green and the writer had the rare good fortune to find a large block of sarsen with the base of these high-level gravels firmly cemented to its upper surface. The gravel here consisted mainly of the typical small white quartz-pebbles. A little farther north the gravel occurs near the base of the Reading Beds, and it was pointed out that these gravels must occur still farther north, resting directly upon the Chalk, but that the outcrops were probably concealed under Drift of some kind.

The gravels of Little Heath, Berkhamsted, described above, are clearly an example of the occurrences predicted; they are typical of the deposits containing the 'neighbouring' small pebbles of white quartz and lydite from the Lower Greensand, but no far-travelled stones. Moreover, the deposit occurring at a higher level, the local stones in the gravel are much bigger than in the area at a lower level and farther south.

It has now been clearly proved that the small quartz-pebbles entered the area about Chorley Wood, and Chalfont, through the Wendover gap, the old floor at 500 feet above sea-level being in part still preserved beneath a thick coating of material mainly composed of large fragments of unworn flint. It is more likely that the quartz-pebbles at Little Heath came either through the gap at the head of the Bulbourne valley (near Tring), or through that at the head of the Gade, probably the former.

A point of especial importance in connexion with these gravels resting on the Chalk, is that the High-Level Gravels north of the Thames are now brought into line with those occurring in a similar position south of the Thames. This leads to the conclusion that these deposits are really allied to the Lenham Beds, but possibly are somewhat younger.

DISCUSSION ON THE TWO FOREGOING PAPERS.

Dr. R. L. SHERLOCK congratulated Mr. Gilbert on bringing before the Society this account of a remarkable section. Mr. Gilbert had devoted much time to a thorough investigation of his subject, and deserved the Society's thanks for a plain statement of facts.

In the five years 1910-1914 the speaker surveyed, on the 6-inch scale, some 300 square miles of the counties of Buckinghamshire

and Hertfordshire, including Mr. Gilbert's district. Owing mainly to the war, that work has not been published, except the very brief abstracts which appear in the Summaries of Progress. There exists in manuscript, however, a complete new survey of the Beaconsfield and Aylesbury sheets, with descriptive memoirs. If those memoirs had been published, Mr. Gilbert would have had the opportunity of criticizing the speaker's account of the deposits at Little Heath.

Mr. Gilbert claims for these deposits an extension of a mile and a half: it is an underestimate, for they are scattered over some hundreds of square miles of the Chiltern plateau. In 1911 the speaker read to the Society a joint paper, by Capt. Noble and himself, on the Glacial origin of the superficial deposits covering that plateau; a paper which caused a warm discussion. Mr. Barrow, among others, opposed the ideas expressed, and it was therefore gratifying to find that he now spoke of the 'Glacial' deposits, as if their age were a matter of common knowledge.

The re-survey was for three years under the superintendence of Clement Reid, and among the occurrences especially looked for were Pliocene deposits. Reid had an unrivalled knowledge of Pliocene beds, and came direct from Cornwall hoping to find a representative of the Pliocene 400-foot platform that he had mapped there. He came to the conclusion that there was no evidence for its existence. Mr. Barrow had seen newer sections, but the speaker would like him to remember that the idea of a 400-foot Pliocene platform had occurred to his predecessors.

The chief point in the papers seemed to be the age of the deposits called Pliocene. No fossils have ever been found. Mr. Barrow seemed to rely mainly on the presence of pebbles of vein-quartz, which (he says) are never found in the Reading Beds of the London Basin. The speaker was not convinced that these quartz-pebbles never occur in Reading Beds, and saw no reason why they should not do so: for, as one proceeds from the Thames Valley towards the Chilterns, there are changes in the character of the Reading Beds: for instance, there appear the Hertfordshire Puddingstone and beds which produce sarsens, and also flint-pebbles that are but partly rounded and sometimes large, instead of the perfectly-formed ones so numerous in, say, the Croydon area. These features indicate that the margin of the deposits is being approached. Good sections may be said to be non-existent; such as occur show signs of disturbance, and so it is open to anyone to say that the pebbles have been introduced later. Quartz-pebbles have been recorded by Mr. Osborne White as extremely abundant in Reading Beds in the Lane End outlier, west of High Wycombe, where he says London Clay caps the deposit, proving it to be in place. He also records lydite-pebbles and subangular flints, which characterize the deposits that Mr. Barrow regards as Pliocene.

It is established that the Reading Beds rest on a plane cut across the gently-folded Chalk. Thus at Taplow, near Maidenhead, Reading Beds rest on the *Marsupites* Zone; farther north, at High

Wycombe and Amersham, they rest on *Micraster-coranguinum* Chalk. Still farther north, there is evidence that the Reading Beds rest on even lower horizons; for example, near Markgatestreet they seem to come down to a little above the Chalk Rock.

The plane on which the Reading Beds rest is the same as the plane regarded as of Pliocene age. This coincidence seemed to the speaker to weigh heavily against Mr. Barrow's conclusion that the plane was cut in Pliocene times.

Mr. H. DEWEY objected to the Authors' suggestion that the plateau-gravels of West Surrey were of Pliocene age. The reasons adduced in support of their contention are the presence in those gravels of white quartz-pebbles and the supposed marine origin. As to the mode of origin, it should be remembered that existing conditions of subaërial denudation are forming two plateaux, a higher and a lower one, separated the one from the other by sloping lands. Bagshot Beds form the surface, and are divisible into an upper and a lower series of sands and an intermediate group of clays and loams. The sands form wide flat tracts, heath-covered and often swampy, whereas the clays give rise to gently undulating ground. Precisely similar features occur at the Chobham Ridges, but these great spreads of gravel envelop the underlying solid formations and mould themselves to the pre-existing topography. There is, therefore, no reason to invoke marine erosion when subaërial denudation locally produces similar peneplains.

The Authors infer from the presence of white quartz-pebbles in these, the Chobham Ridge gravels, their origin from the Lower Greensand deposits lying to the north of the Chiltern escarpment; but a more likely source of these quartz-pebbles is surely to be found in the local pebble-beds. Such are found at many localities at the base of the Barton Sands and in the Bagshot Sand, and contain many white quartz-pebbles, although fewer than do the gravels described by the Authors.

When mapping this district for the Geological Survey the speaker came to the conclusion, after weighing all the available evidence, that these gravel-spreads are analogous to the outwash fans of Glacial regions.

He did not, however, consider that the Weald had ever been glaciated, but that its heights had collected on them many years of snowfall, which on thawing liberated torrential floods carrying the frost-splintered rock-débris of the district to the lowlands. The gravels contain up to 50 per cent. of Greensand chert, which must have been brought through the present-day 'dry gap' of the Blackwater. Many large sarsens and blocks of abraded and battered flint are common in the gravels, while the upper beds show contortions and gnarled structures.

Nothing that the speaker had heard that evening had modified the opinions which he had formed and afterwards published in the Windsor & Chertsey Geological Survey Memoir.

Mr. LL. TREACHER suggested that the small quartz-pebbles described by Mr. Barrow, although doubtless ultimately derived

from the Lower Greensand, had also passed through a Reading-Bed stage. Mr. Osborne White (in a paper published in the *Proc. Geol. Assoc.* vol. xix, 1906, p. 371) had described a section in the Reading Beds at Lane End (Bucks) which yielded these pebbles in abundance, and it was quite possible that from strata of this age once existing farther north but now destroyed, the small quartz-pebbles so common in the Drift-gravels north of the Thames had come. This might also explain the presence of the quartz-pebbles forming part of some sarsens. Sarsens, being portions of the Reading Beds hardened in their original position, would naturally partake of the character of the strata at the spot where the hardening process took place.

Sir HENRY HOWORTH expressed the opinion that Mr. Gilbert's paper contained a large store of facts carefully observed and of inferences. Substantially the paper describes a section on the Chiltern plateau, in which two beds of stratified sand and gravel respectively are overlain by a bed of heterogeneous and unstratified clay with pebbles. In regard to the former beds, he considered that a very good case had been made out for their Middle or late Tertiary age, and for their correlation with similar deposits of similar partly-denuded beds north of the Thames. The absence of fossils is a common occurrence at this horizon; the so-called 'barren sands' of the Red Crag are well known, many stretches of gravel of that date are without shells, and it was difficult to suggest any age for the beds in question other than Tertiary. The speaker had discussed similar beds south of the Thames at some length in his 'Ice & Water,' vol. ii, pp. 159-75. In regard to the unstratified clay-with-pebbles, he objected to the use of the term *glacial* as applied to this and similar beds. There was not a single glacial feature about them. All the pebbles belong to the locality, and are clearly traceable to the Greensand and to the Reading Beds. There are no travelled stones from the far north and east, and, if they were brought by ice, it must have been local ice; further, there is no adequate gathering-ground for a glacier in this district. There are no angular stones, but all the pebbles are rounded and much weathered, nor are there any scratches on them. Furthermore, a large number of the stones are upright in the beds, showing that they dropped through water by gravitation. It is impossible to conceive their dropping through ice in this fashion, or retaining this position when ice was passing over them. Nor is there any trace of a subglacial stream, but the deposit is clearly a widespread mantle thrown down violently and suddenly, thus accounting for its heterogeneous character. The speaker considered it a pity to qualify the value of observations so interesting by the use of the ambiguous term '*glacial*' where its application is so clearly illegitimate. Mr. Barrow had questioned the name of 'quartzite' as given to some of the pebbles, and had suggested that the stones were coloured pebbles from the sarsens. He thought that this was an important suggestion, and one easy of proof.

Mr. R. W. Pocock remarked that, when mapping the gravels of
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the Shenley-Barnet ridge, he had found the occurrence of Lower Greensand chert in these gravels to be limited in a north-westerly direction by a fairly well-defined line crossing the area from south-west to north-east. This seems to confirm, to some extent, the view that the gravels came from the south and not from the north, and that they are of earlier date than the Thames Valley.

Mr. GILBERT, in reply, remarked upon the practical absence of criticism upon the essential points of his paper, namely, the origin and the age of the beds. That the gravels were not Glacial was abundantly clear, alike from their composition, uniformity, and situation. Regarding their age, that there was a Pliocene submergence during which certain beds south of London were deposited was beyond dispute. It was highly improbable that such submergence should have failed to reach this district. These beds conformed in every respect to the theory of marine deposition, and linked themselves up naturally with the High-Plateau Gravels and the South London beds. This was all that could be said, as only the discovery of contemporaneous fossils could place the matter beyond controversy. Unfortunately, the nature of the deposits did not afford ground for very confident hope that this evidence would be obtained.

Mr. BARROW, in a brief reply, stated that he quite accepted Mr. Dewey's remarks on the area about Chobham Ridges.