THE RIVERS OF THE HAMPSHIRE BASIN.

BY HENRY BURY, M.A., F.G.S.

The great synclinal fold, to which we owe the preservation of the Eocene Beds of the Hampshire Basin, has determined the main features of the river system of this district; for although the Solent River, which formerly occupied the trough of the syncline, has been breached by the sea between the Isle of Wight and the Purbeck Hills, its course is still traceable in the Solent, while its upper part survives in Dorset as the river Frome. Into this synclinal river, which ran eastwards, a number of tributaries flowed from either side, but, owing to the asymmetrical development of the fold (a feature common to all such folds in the south-east of England), the tributaries on the right bank were comparatively short and steep, while those on the left bank were far longer and more important. On the right bank, too, the dip is almost everywhere towards the north, and the outcrop of the Chalk from under the Eocene forms a nearly straight line from west to east; but on the left bank the dip changes from about south-east in the western region to south-west in the east, and a basin-like structure arises, which not only gives a curved outline to the Chalk outcrop, but also affects the course of the principal rivers: for, although these do not always closely follow the dip, they are ranged round the basin in a more or less radiating fashion—the Trent and Stour bearing in from the west, and the Meon and Itchen from the east, while the Avon and Trent run nearly from north to south.

But while the principal rivers are, to this extent, guided by the tectonic structure, they pay practically no attention to the numerous minor anticlines and synclines which, running for the most part east and west, traverse the basin, especially in its northern half. Thus, not only do the Avon, Test, Itchen, and Meon cut right across such anticlines, but they often do so at or near points where the folds attain their greatest development; and this behaviour justifies us in regarding them, provisionally at least, as "consequent" streams—that is to say, as primitive streams arising on a coastal plain as a direct consequence of the uplift which raised this area out of the sea. This is the view adopted by Clement Reid,[1] but it is opposed by Mr. Osborne White,[2] who believes that there have been two cycles of subaerial denudation, the synclinal tributaries belonging to the first cycle; while the second cycle, initiated by a further uplift, produced some, at least, of the transverse rivers.

[1] *Mem. Geol. Surv.*, "Ringwood," 1902, p. 29. The hypothesis of marine planation is also advocated by Codrington (*Quart. Journ. Geol. Soc.*, vol. xxvi, 1870, p. 547), Hull (*Geol. Mag.*, Dec. v, vol. ix, 1912, pp. 100-105), and Hooley (*Proc. Hants Field Club*, vol. ix, 1922, pp. 151-172), but without any special reference to river evolution.

[2] *Mem. Geol. Surv.*, "Winchester," pp. 64-65. And *ibid* "Shaftesbury," pp. 75-79.

It is difficult to obtain satisfactory evidence on this subject, but such complete subaerial planation on a Chalk soil is unusual, and might be expected to give rise to more meandering than we see in this area: and for this and other reasons I am more inclined to regard the longitudinal streams as of "subsequent" origin, developed in the strips of soft Eocene strata, which lingered in these folds after they had been removed by marine planation from the anticlines; and perhaps some support for this view can be derived from the distribution of the tributaries themselves.

The Meon and Itchen, though transverse throughout most of their length, start as longitudinal streams, flowing westwards in synclines, and they receive no other important tributaries. The main tributaries of the Avon, on the other hand, run in from the west, the only exceptions being some small streams in the Eocene region (New Forest), which, as will be shown later, are of very recent origin, being due to a shifting of the main river towards the west, while, finally, the Test is joined by several streams (mostly synclinal) flowing in impartially from either side. Thus we have three practically unilateral rivers, with their minor streams flowing, in each case, towards a bilateral river lying in the centre; and this can, perhaps, be best explained in the following way. Let us suppose that the marine plain followed (though at a much slighter angle) the basin-like curve already alluded to: we may then regard its slope as compounded of two factors, an inclination southwards towards the main synclinal fold, and an inward slope towards the centre of the basin-like curve—that is to say, towards a north and south line in the neighbourhood of the Test. Then the consequent rivers followed an oblique course, the resultant (if we may so express it) of the two forces; but the subsequent streams, developed in the synclines, were blocked off from the south by anticlinal ridges, and could only flow inwards—westwards, that is to say, if they lay to the east of the Test, and eastwards if they lay to the west of it.

Possibly, too, evidence in the same direction can be derived from the course of the Nadder, which joins the Avon near Salisbury, after flowing in an easterly direction along an anticline. When hard strata are removed from the summit of an anticline in such a way as to expose a core of softer beds, subsequent streams are commonly developed in the latter; but since the first appearance of the inlier is usually at, or near, the point of greatest upheaval, these streams generally flow towards the latter[1]; but this is not at all the case with the Nadder, which runs towards the end of the anticline, and, where that dies away, passes out on to the Chalk. Such a course is very remarkable,

[1] The branches of the Avon, in the Vale of Pewsey, may have arisen in this way; but this, as we shall see later, has been disputed.

and difficult to understand, but it is conceivable that the river may have originated in the soft beds underlying the Chalk after the latter had been removed by marine planation.

Since the publication of Prof. W. M. Davis's stimulating paper on "The Development of Certain English Rivers,"[1] many ingenious attempts have been made to discover cases of river-capture in this country; and one of the latest of these attempts is Mr. W. D. Varney's hypothesis,[2] that the Hampshire Avon originally rose in the Welsh mountains, and entered the Vale of Pewsey by the gap at its western end: that it was beheaded by the Severn; and that the Bristol Avon is an "obsequent" river resulting from this capture—that is to say, that it has developed along the course of the old river, though with reversed drainage. In support of this thesis, he adduces certain high-level plateau-gravels near Bath, which he thinks came from the north-west; and also the slope of the valley floor at the western end of Pewsey Vale, which, if continued, reaches the plateau above Bath. The latter argument can be dismissed at once, for the gradient (17ft. per mile) is far too great for a river of the length and importance postulated; but the gravel requires further attention. Mr. Varney finds in it many quartz pebbles, fragments of Palæozoic shales, and occasional pieces of coal; and since similar pebbles (with the exception of the coal) are present in the plateau gravels of the New Forest, he regards them as marking the course of a river coming from South Wales in Pliocene times. Flints, however, are also numerous in the Bath gravel, and these compel him to postulate a great westward extension of the Chalk (including, of course, the Upper Chalk); but this would connote an amount of denudation and retreat of the Chalk escarpment since Early Pliocene times, which few, I think, who have studied the Lenham Beds and their apparent equivalents all along the North Downs, would be willing to grant.

It is curious that it does not seem to have occurred to Mr. Varney that the Bath gravels may be, as Prestwich long ago suggested,[3] marine, and may have derived their materials from various directions. Moreover, Clement Reid expressly ascribes the quartz and Palæozoic pebbles found on the New Forest Plateau to Eocene strata,[4] which certainly yield them in fair abundance in the neighbourhood of Dorchester,[5] and it does not seem impossible that westward extensions of these beds may even have contained coal as well.

In connection with this question, attention may be called to the watershed in the north-west quadrant of our area, which,

[1] *Geog. Journ.*, vol. v, 1895, pp. 127-146.
[2] *Proc. Geol. Assoc.*, vol. xxxii, 1921, pp. 189-205.
[3] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 143.
[4] *Op. cit.*, p. 30.
[5] *Mem. Geol. Surv.*, "Dorchester," 1899, pp. 27-32.

allowing for local irregularities, forms a fairly even curve, roughly parallel to that of the Eocene margin. This is, no doubt, in part due to the outcrop of certain hard strata at the head of the Stour; but that does not apply to the Wylye and the Avon, and I believe it to be an expression of the fact that this curve represents, approximately, the original limit of the Hampshire Basin, as determined by the marine plain. As has been clearly shown by Sir Aubrey Strahan and Mr. Osborne White,[1] there is no reason to assume that the Stour has ever extended very far to the west of its present watershed; and if the Bristol Avon has been developed as an obsequent since the formation of the Bristol Channel, how is it that rivers like the Brue and the Yeo, which, *ex hypothesi*, must be at least as old as the Bristol Avon, and which, so long as the Solent River survived, had a much shorter course to the sea than the Stour, have not encroached more on the territory of the latter river? It seems, therefore, highly improbable that the Avon alone, of all the rivers in our system, should have extended so far beyond our area, and have undergone such profound changes, while the others have kept within, or very near to, the limits of the present drainage basin, and suffered but little alteration since their initiation. It may be added that the assumption of an obsequent origin for such a large and complex river as the Bristol Avon is, having regard to the hardness of the rocks, and the small size of other streams of known obsequent origin in the south of England, a very doubtful proposition, and requires much more evidence in its favour than either Prof. Davis or Mr. Varney have produced.

On the other hand, if the sea extended in Miocene or Early Pliocene times over most of our area, stretching perhaps from the North Sea to the Bristol Channel—and there is a fair amount of evidence in support of such a suggestion—then the hypothesis here supported of the origin of the rivers of the Hampshire Basin (and perhaps the Bristol Avon as well) on a coastal plain from which the sea gradually retreated is not an extravagant one. The lowering of the strand-line, judging by the remarkable constancy of level of the North Down deposits, seems to have been mainly eustatic—that is to say, due rather to a general fall of the sea level than to a local uplift of the land; but there may well have been some small differential movements along older tectonic lines, determining the limits of the basin, and the flow of the new rivers to the English and Bristol Channels respectively; and even apart from such movements, it is well to remember that the floor of the sea is at best but a peneplain (an unnecessary word, really, for absolute plains were never postulated by geologists), and that very small factors—winds,

[1] Strahan, *Quart. Journ. Geol. Soc.*, vol. lviii, 1902, pp. 207-221; O. White, *Mem. Geol. Surv.*, "Shaftesbury," pp. 75-79.

currents, etc.—must often determine the direction of flow on a rising coastal plain.

Another case of alleged river capture, which has been widely accepted, is Clement Reid's attempt to show that the Hampshire Avon has been formed by the union of two originally distinct rivers, an Upper Avon, joining Southampton Water (Southampton River), and a Lower Avon, which, growing up from the south, captured the former near Downton[1]: and, owing to the prestige attaching to Clement Reid's name, and the complex nature of the evidence for and against his hypothesis, it is necessary to devote a good deal of space to its examination.

None of the ordinary symptoms of river capture is present. There is no "elbow of capture"; no narrowing of the valley below the point of capture; no obsequent stream arising out of the change; and no notch in the hills, or marshy tract leading to the remnant of the beheaded river. In fact, it is difficult to say which is the beheaded river; for while a general study of the geography seems to point to the Blackwater (a small tributary of the Test, joining it near its mouth, see Fig. 2), Clement Reid represents it as entering Southampton Water much further south, and crossing several minor valleys in its course; in which case the whole drainage system below the point of capture must have undergone a radical and, to me, inexplicable change. Yet, in spite of these facts, and although the author of this hypothesis admits that it "ought not to be lightly postulated," the only arguments he adduces in support of it are (1) the existence of a gravel-capped ridge from Woodfalls (near Downton) to Picket Corner and Long Cross, which, he says, marks the course of the old river, and connects "in a direct line the Salisbury rivers with Southampton Water"; and much stress is laid on a pebble of Purbeck chert, attributed to the Nadder Valley, which was found not far from the summit: (2) the impetus which "must" have been given to the Lower Avon by the irruption of the sea into the Solent River valley to the west of the Isle of Wight.

Of the four "Salisbury rivers," only one (the Wylye) runs at all nearly in the direction of Southampton Water; and two (the Avon and the Bourne) line up equally well with the Lower Avon; while if we consider the Avon as a consequent stream following the main direction of the dip, we should expect it to come out somewhere near Lymington, or about half-way between its actual mouth at Christchurch, and that assigned to it by Clement Reid in Southampton Water. Obviously, then, no serious argument can be founded on the mere question of alignment.

The so-called "ridge" is really the edge of a much-dissected plateau, which ends abruptly to the north-east in an escarpment

[1] *Op. cit.*, pp. 29-32.

overlooking the Blackwater valley, but falls gently away towards the south for several miles, with lateral slopes to the east and west as well. Clement Reid believed that he could distinguish on this plateau a "High Plateau" belonging to his Southampton River, and several terraces belonging to the Lower Avon; but the distinction between the High Plateau and the Highest Terrace is, to say the least, hard to follow, and I, personally, am disinclined to admit its existence. In Fig. 2 an attempt has been made to show the former dimensions of the plateau by omitting the dissecting valleys and smoothing its contours; and it will be seen (from details supplied by Clement Reid himself) that the High Plateau and Highest Terrace are in contact for over six miles (from Woodfalls to Broomy Walk) along a line about half-way between the course of the Lower Avon and that of the hypothetical Southampton River. How this is to be reconciled with the capture of one area by the other, and in what direction the capturing river advanced that it should have effected this prolonged contact, I am at a loss to understand.

It is further to be noted that the ridge runs *uphill* from Woodfalls (370ft. O.D.) to Picket Corner (419ft. O.D.), so that in this part of its course (nearly three miles) it cannot possibly be the bed of a river flowing south-eastwards; and that its principal gradient all the way along is towards the south-west, parallel with the watershed, but exactly at right angles to the supposed course of the river, there being a fall of almost 80ft. from Picket Corner (419ft.) to the spot on Hampton Ridge (340ft.), at which Clement Reid professes to find its point of contact with the "Highest Terrace."

Before accepting a hypothesis which involves so many difficulties, it will be well to inquire how much of this gravel-capped plateau it is possible to attribute to a single river, flowing, as the Avon does now, from Salisbury to Christchurch. It is clear, on Clement Reid's own showing, that the Lower Avon must at one time have swept in a curve which carried it, at some points, five miles to the east of its present position, and that it has since, while lowering its bed, retreated westwards, giving rise, in so doing, to the tributaries already mentioned; and a similar extension eastwards to the north of Fordingbridge would bring it to Long Cross, and enable us to attribute to it all the gravel which lies to the west of the watershed. The curve thus introduced into the course of the river need not trouble us, for a very similar curve is seen in the case of the Test, which starts in a south-westerly direction, but enters Southampton Water from the north-west; while a lesser one occurs in the Stour, which makes a decided bend just above Wimborne; and it is a curious fact that in each case the change in direction begins not far from the spot at which the river enters the Eocene area, while in two cases (Avon and Stour) an exten-

sive sheet of gravel occurs close to this point. The attribution, therefore, of a large portion of the New Forest Plateau to a single river Avon meets most of the facts, its principal drawback being that it leaves a not inconsiderable area of gravel to be ascribed to another, and unknown, source; but while neither of the hypotheses so far considered completely explains all the Plateau Gravel, this one seems, on the whole, to offer fewer difficulties than the other. But there is another possibility which Clement Reid never even considered, namely, that the "High Plateau" and "High Terrace" gravels (down to about the 300ft. contour) may be marine. I do not at all assert that this is so, though I have elsewhere drawn attention to certain suggestive features,[1] but it is at least a possible alternative, and as such is sufficient to prove that Clement Reid's conclusion was not so logically complete as he supposed. On this view, the gravel may represent a bar formed near the mouth of the Avon, and marks a stage in the retreat of the sea from the Basin, before the Lower Avon had come into existence. At any rate, this would do away with the difficulty of so much gravel lying to the east of the watershed, and, incidentally, would slightly assist in explaining the presence of a Purbeck pebble, which might have been carried by the sea several miles from the actual river mouth. But no argument either way can be founded on this pebble, which Clement Reid is content to derive from the Nadder, while Hooley[2] imagines it carried by the sea from the Purbeck Hills: but as such pebbles are found in the Eocene, at any rate in the neighbourhood of Dorchester,[3] yet another origin is possible.

It remains for us to examine the second half of Clement Reid's hypothesis, in which he assumes that the breach of the Solent Valley by the sea gave a great impetus to the Lower Avon, the mouth of which was more or less opposite the gap. In order to appreciate this problem, we cannot do better than study first of all the conditions prevailing at the present time in the Isle of Wight. There we find that the destruction by the sea of much of the territory formerly belonging to the Western Yar has split up that river into a number of separate portions, some of which have evidently received a fresh impetus in lowering their valleys, though it has not enabled them to advance any further inland; but the main trunk, which passes through the wall of Chalk, lies at so low a level that the sea is constantly threatening to force its way through from Freshwater to Yarmouth. Much the same situation is repeated in the Eastern Yar, near Bembridge; in fact, but for the interference of man, the Isle of Wight would before now have been split up into three

[1] *Proc. Prehist. Soc.*, "E. Anglia," vol. iv, 1923, pp. 27-29.
[2] *Proc. Hants Field Club*, vol. ix, 1922, p. 158.
[3] *Mem. Geol. Surv.*, "Dorchester," 1899, pp. 28-29.

separate islands, though obviously such breaches through the Chalk ridge could have no effect on the mainland rivers. But it is, at least, a possibility that the breach of the Solent River to the west of the Needles may have occurred under very similar conditions; that is to say, at a time when there was little or no difference in level on the two sides of the Chalk ridge. We know that there were frequent changes in the strand-line in Pleistocene times, and that, during periods of depression of the land, the sea advanced a certain distance up the valley (from the region of Spithead), turning it into an estuary: and if, as the analogy of the Isle of Wight renders probable, the breach in the southern bank of the river occurred at such a time, it could produce practically no effect on the Avon and other rivers.[1]

The exact date at which this change took place is not known with certainty. Clement Reid originally supposed that it happened in the Pliocene, when his "Southampton River" ran 300ft. above the present alluvial plain of the Avon; but later he realised that this was against the weight of evidence. At various points along the Sussex coast are found boulders of granite and other rocks foreign to the district, which can only be explained as having been dropped by floating ice, drifted up the English Channel during the Glacial Period; and since they are found again at Portland, as well as in the eastern part of the Solent (as far as Lee-on-Solent), but not in its western part, or in Poole or Christchurch Bays, Clement Reid admitted that these bays could not have come into existence till after the first great glaciation, and probably not till the second. Sir Aubrey Strahan suggests an even later date: at the close of the Pleistocene there was a somewhat abrupt rise of the land, during which the river valleys of the south of England were cut about 80ft. lower than at present, followed, at about the beginning of the Holocene or Recent Period, by an equally rapid fall almost to present level; and since these are just the conditions under which the sea would be most likely to break through, perhaps in more places than one, it is quite conceivable that this breach occurred not more than about 10,000 years ago, that being the date generally assigned to the close of the Pleistocene Period. But even so early a date as the "second Glacial Period," or to be more precise, the formation of the 15ft. raised beach at Lee-on-Solent (in which the erratic boulders occur), has a very serious effect on Clement Reid's theory of river capture, though, strangely enough, he utterly failed to perceive it: for at that period a simple calculation of gradients shows that the Upper Avon must already have carved out its valley nearly, if not quite, 200ft. below the summit of the New Forest Plateau; and since there is no valley connecting it with

[1] *Cp.* Strahan, *Proc. Geol. Assoc.*, vol. xiv, 1896, p. 407; and O. White, *Mem. Geol. Surv.*, "Lymington and Portsmouth," 1915, pp. 48-49.

Southampton Water of anything approaching that depth, it follows that, if the alleged capture ever took place at all, it cannot possibly have been the result of the breach of the Solent Valley. But with this removal of the last argument in its favour, the whole hypothesis of a double origin of the Avon breaks down altogether.

SUMMARY.

The principal conclusions arrived at may be summed up as follow :—

(1.) The main rivers of the Hampshire Basin were formed as consequents on a coastal plain, and when the sea had retreated sufficiently, joined the Solent River.

(2.) Their synclinal tributaries probably arose as subsequents, in remnants of the Eocene strata.

(3.) There is no good ground for supposing that either the Avon or any other river ever extended far beyond its present limits.

(4.) The belief that the Upper Avon formerly joined Southampton Water, and was captured by the Lower Avon, is not justified either by the actual facts at the alleged point of capture, or by theoretical deductions from the supposed effects of the breach of the Solent River.

(5.) The capture of the Solent River by the sea took place either very late in the Pleistocene or early in the Holocene.

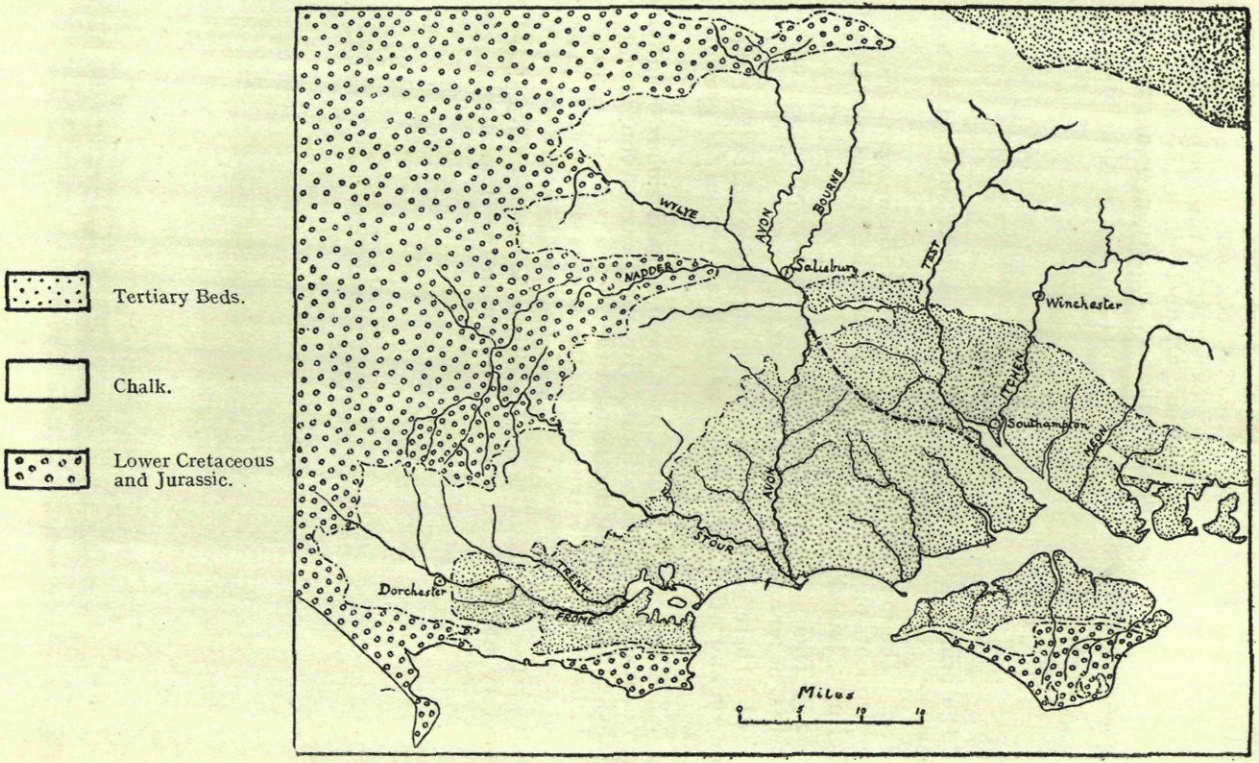

FIG. 1.—THE RIVERS OF THE HAMPSHIRE BASIN.

THE BROKEN LINE INDICATES, ACCORDING TO CLEMENT REID, THE FORMER COURSE OF THE UPPER AVON.

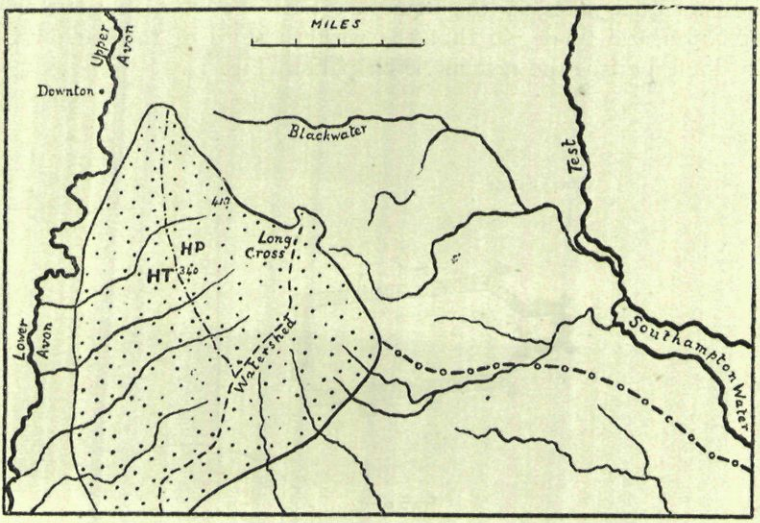

FIG. 2.—MAP SHOWING THE LIMITS OF THE NEW FOREST PLATEAU AND ITS WATERSHED.

H.P.—High Plateau. H.T.—Highest Terrace.