THE STREAMS OF THE NEW FOREST: A STUDY IN DRAINAGE EVOLUTION

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Introduction.

THE area to be discussed in this paper is somewhat larger than that ordinarily known as the New Forest. It extends from the Solent northwards to the River Blackwater, and from the Avon eastwards to Southampton Water.

The superficial gravel deposits of the New Forest have been the subject of much detailed morphological analysis in recent years (1, 2, 4, 5), and it has been shown that two 'flights' of gravel terraces exist (Figure 2), the larger descending southwards from the summit area of Black Bush Plain (420ft. O.D.) towards the Solent, and the other flanking the Avon valley. These terraces mark the main pauses in the uplift of the area from its low level in the late Pliocene and since that time the landforms and drainage pattern have been evolving concurrently, under the influence of the intermittently-falling base-level. The gravel-terrace stages make it possible to trace the former courses of the Rivers Avon and 'Solent'[1] across the New Forest and also the shore-lines of the estuaries which partly replaced them in the southern part of the area. The present New Forest streams are the much modified descendants of the tributaries of these major drainage channels. The tributaries were, in many cases, too small to produce terraces, but two lines of evidence may be followed in attempting to reconstruct their former courses. Firstly, the development of the tributaries is intimately connected with that of the major arteries, and much is already known about the evolution of the latter. Secondly, the present river pattern is itself a very delicate index of its own development. In the following pages this pattern is first analysed and then its evolution is discussed in relation to the denudation chronology of the Rivers Avon and Solent.

An Analysis of the Present Drainage Pattern.

The major watershed lies in the west, passing through Redlynch, Fritham, Burley and Highcliffe (Figure 1), and divides the New Forest into two unequal parts. The short, straight little-branched streams draining the western area are in striking contrast to those east of the divide, which are longer and more fully integrated.

1. The "Solent River" is the name given to a hypothetical extension of the River Frome across South Hampshire.

Western Drainage. The closely-spaced streams of the west drainage basin are remarkably parallel, particularly in their ' upland ' courses before they flow into the main Avon valley. The dominant trend is from north-east to south-west. The steeply-sloping upper reaches are deeply incised and, particularly near Fritham, cut the New Forest plateau into long winding ridges. The steep gradients are soon checked, however, and the streams and their valleys are of quite a different character as they flow across the low gravel terraces flanking the Avon. The northern streams of the area, the Ditchend and Huckles Brooks, for example, flow straight across the terraces to the main stream, but those to the south seem to lose their determination once the Avon valley is reached and, turning from their direct courses, they flow roughly parallel to the Avon for a few miles before finally entering it. An excellent example of a deferred junction of this type is that of the stream rising south-west of Picket Post. The upper valley is directed towards Moortown on the Avon, but the stream turns southward upon entering the main valley, and does not join the Avon until three miles below Moortown. The River Mude presents an even better example. The development of the more southerly trend is sometimes delayed until the Avon terrace has been partly crossed, for example, the Lindford Brook.

Eastern Drainage. The area draining to Southampton Water and the Solent is much larger than that tributary to the Avon, but the drainage is more integrated. Six rivers carry off the bulk of the surface water.

The Cadnam River, Bartley Water and the Lymington River rise to the east of Fritham, within a mile or two of one another, at about 300ft. O.D., and, like the nearby Avon tributaries, they dissect the country deeply. The Beaulieu River rises some distance to the south-east of this main centre of drainage dispersal, and its headwaters, which appear to be squeezed out by those of the other rivers, do not reach above 150ft. O.D. The River Blackwater rises near the foot of the prominent north-east facing scarp that extends from Redlynch to Bramshaw, and is wholly outside the area that is now covered with Plateau Gravel. The remaining stream, the Avon Water, is the shortest of the six and rises at about 175ft. O.D. on Holmsley Heath.

Tributary development on the Blackwater is fairly symmetrical, the feeder streams branching on either side of the gently curving main river. The pattern of the other rivers is irregular, and not without significance. The Cadnam River and Bartley Water receive most of their tributaries on their left banks, and show a very one-sided development. The Lymington River is served by several headstreams, but the Beaulieu River compares poorly in this respect. As was noted above, its headstreams appear to have

been squeezed out. Both rivers receive few tributaries in their middle and lower reaches, and both enter the sea *via* an estuary, but that of the Beaulieu River is about four times the length of that of the Lymington River. The Avon Water receives few tributaries and has no real estuarine section.

An examination of the area south of Cadnam and east of the main watershed shows that a three-fold division of the drainage pattern may be made. The first zone is one of close drainage texture, and includes the headwaters of the Beaulieu and Lymington Rivers, and Bartley Water. South-east of this is a belt of country passing through Brockenhurst, Beaulieu and Hythe, which contains few streams apart from the three main ones. Finally, in the coastal belt bordering the Solent, surface drainage is again more common, for between the main rivers are many small sub-parallel streams flowing directly to the sea, all rising within three or four miles of the shore.

The eastern drainage basin shows several dominant trend lines. An approximate north-west to south-east trend is perhaps the most common. It can be traced in (i) the lower River Blackwater continuing into Southampton Water, (ii) the estuaries of the, Beaulieu and Lymington Rivers, (iii) the Highland Water branch of the Lymington River, (iv) the Avon Water and (v) the numerous small streams, referred to above, that flow into the Solent.

A trend more easterly, or east-south-east, occurs consistently in the headstreams of the Cadnam River, Bartley Water and Beaulieu River, and in the Black Water and Ober Water branches of the Lymington River.

The remaining dominant trend (north to south) is to be found on the Beaulieu River between Ipley Manor and Beaulieu, on the Lymington River from Brokenhurst Park to Lymington, and on the lowest mile of the Avon Water. The genetic significance of these trend lines will be discussed in a later section.

The Evolution of the Drainage Pattern.

In a general sense the drainage pattern is not out of sympathy with the geological structure. The north-west to south-east trend of certain rivers was noted above, and the rocks of the New Forest are tilted in a similar direction. The structure is complicated by two synclines pitching to the south-east, their axes passing near Hordle and Lyndhurst respectively. The Avon Water and the Lymington and Beaulieu Rivers might appear to be guided by this structure, but a study of the Miocene-Pliocene denudation chronology (6) shows that these rivers could not have arisen as consequents on a folded and tilted surface of Tertiary rocks. Although there has been no overall structural guidance in the stream pattern, there has been some adjustment to structure as the rivers have cut

their way into the underlying rocks. The Beaulieu River, just north of Matley Heath, follows, for a mile or two, the Bagshot Clay—Bagshot Sand junction, with possibly some uniclinal shifting. The relief is inverted, as is shown by the hill-top sites of the synclinal axes at Lyndhurst Hill and Castle Hill, Burley, and the anticlinal-axis course of the lower Lymington River.

In the western drainage basin the Avon tributaries, as far south as Sandford, flow parallel to the strike, whereas south of that village they flow across it. The streams are all sub-parallel, and structural control does not therefore appear to be significant.

The morphological terraces into which the drift gravels may be divided cut indifferently across the various rock outcrops, and something of the late Pliocene-Pleistocene denudation chronology may be deduced from their study. It is to these geologically-late phases that the evolution of the New Forest drainage pattern can be related.

The initiation of the present New Forest drainage cannot be placed earlier than the Pliocene. Much of south-east England was covered by the sea at this time (6), obliterating any existing river systems, and the land was gradually exposed by its intermittent retreat. Remnants of the marine plain now lie at about 550ft. O.D. There is increasing evidence (2) to support the view that much of south Hampshire was still covered by the sea at the 420ft. O.D. level and that it was upon the newly exposed surface of this lower marine plain that the streams which now cross the New Forest commenced to flow.

The morphological gravel terraces below the 420ft. level are related to the still-stands that occurred during the overall fall in base-level in the late Pliocene-Pleistocene. Figure 2 shows clearly that there has been a south-easterly migration of the strand-line across the greater part of the New Forest, particularly across the eastern drainage basin. Each movement exposed a narrow strip of land, extending south-west to north-east, and sloping south-eastwards, across which streams could prolong their courses. In the west drainage basin a much more limited aerial movement, although involving nearly as great a range in altitude, has occurred, bringing about an overall shift in the strand-line from east to west.

Turning now to the evolution of the drainage pattern, we may endeavour to reconstruct its growth from the early stages to the present (Figure 3). The restricted area of the uppermost terraces indicates that little of the New Forest was exposed until the 300ft. stage (Figure 3A). At this time, the first emergence of the New Forest as a distinct land mass, a narrow peninsula projected southwards between the valleys, or estuaries, of the proto-Avon and proto-Test. The 370ft. terrace preserves the Avon flank of the peninsula, and upon this south-west sloping surface must have

originated part of the New Forest western drainage. The eastern flank of the peninsula, now destroyed, was probably drained by short west to east streams, of which the upper River Blackwater may be a much enlarged remnant. Of greater importance to the history of the eastern drainage basin was the truncation of the end of the peninsula by the Solent River at the 300ft. stage. It flowed from south-west to north-east, and gave rise to small south-east flowing tributaries on the southern part of the peninsula. This trend has persisted as the drainage has grown. The essentially "local" origin of the New Forest drainage can thus be demonstrated, arising in the small brooks draining the early peninsula to the west, east and south-east. There can be no question of the Beaulieu and Lymington Rivers being the lower trunks of larger rivers, beheaded by river capture, that rose beyond the confines of the present area. The main drainage parting was early defined, and the only subsequent development has been its extension southwards as the land surface has been exposed.

The Western Drainage Basin. The Avon has not deviated greatly from its present path during its evolution. K. R. Sealy (5)[2] has stated that the Avon has followed a very similar course at all stages subsequent to his VIIIth terrace stage, which is about 250ft. O.D. at Ringwood.

The terrace sequence shows that the Avon migrated westwards, with successive falls of base-level, during the following stages : 370ft., 300ft. (Everard), and the VIIIth (250ft.), VIIth (225ft.), VIth (197ft.) and Vth (140ft.) of Sealy (in the last four stages the heights given are for the Ringwood area). During Sealy's Vth stage, the Avon apparently reached its maximum westward encroachment in this district, later moving eastwards. This oscillation about a mean position, coupled with the fact that the main watershed was early defined, has prevented the western New Forest streams from ever developing very lengthy courses. Recurrent downcutting on the part of the Avon has steadily increased the height range between the sources and mouths of these small streams and so has maintained their youthful features, namely, straight, sub-parallel courses, few tributaries, and deeply incised valleys This constant rejuvenation has been accentuated at certain stages by vigorous lateral corrasion of the bluff defining the western edge of the New Forest. This occurred, for example, during the formation of the Bransgore Terrace (Sealy's IIIrd terrace), south of Ringwood, and in the lowest terrace stage (Sealy's Ist terrace), north of Ringwood. The courses of the streams were thus shortened and their gradients further steepened.

2. The writer acknowledges with thanks permission to refer to this thesis.

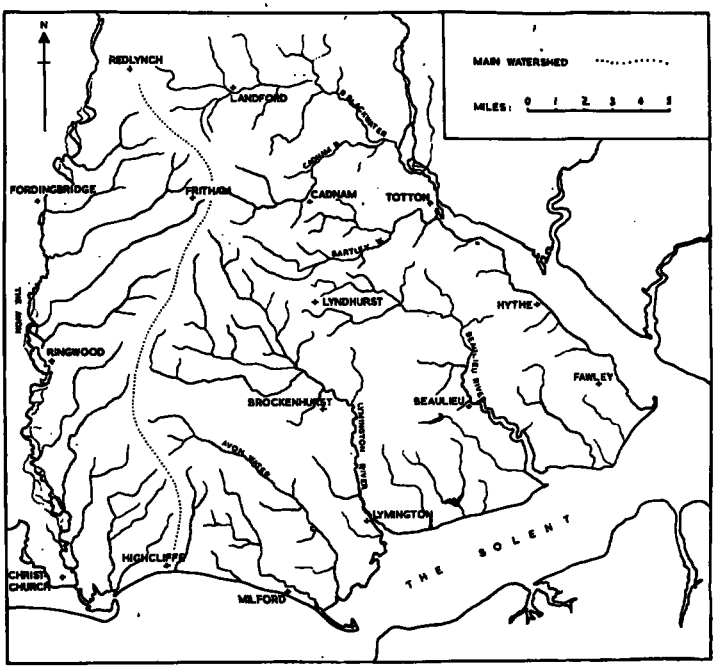

FIGURE 1 The drainage pattern of the New Forest
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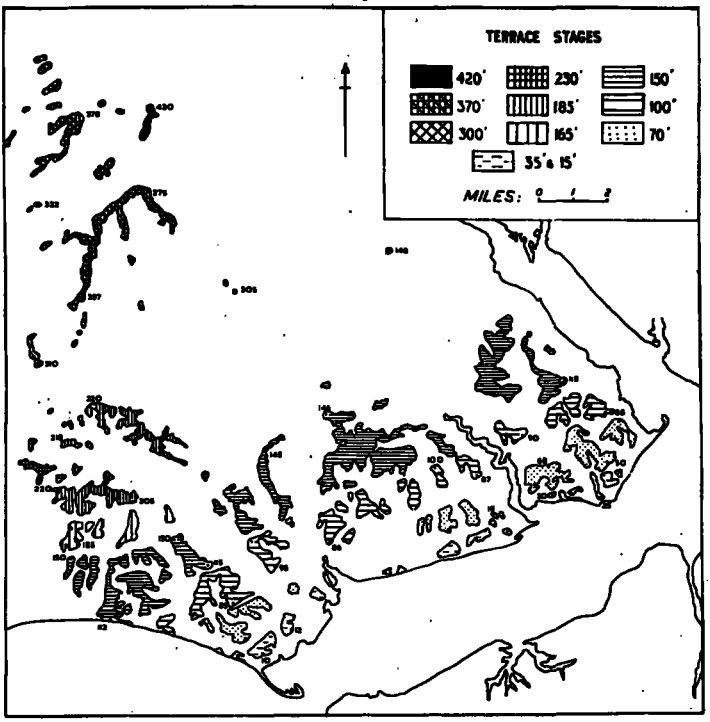

FIGURE 2 The gravel terraces of the New Forest

The influence of the Avon is to be seen also in the actual courses followed by these streams. Each time the Avon retreated westwards (down to Sealy's VIth terrace) and began downcutting, because of a fall in base-level, a low terrace was exposed, across which the New Forest streams extended their courses. This fresh surface, being a former river flood-plain, would have sloped both towards the main river (westwards) and downstream (southwards), that is, it would have been slightly inclined to the south-west. Streams extending across it, seeking the steepest slope, would have flowed in the same direction, and it is believed that this factor has played a large part in determining the marked north-east to south-west trend of these streams.

In the case of the last major terrace to be exposed, the transverse slope appears to have been so gentle that a simple south-eastward extension across it has not always occurred, and the downstream (southward) gradient of the surface has had a profound influence on the New Forest streams, resulting in the deferred junctions noted above.

The Eastern Drainage Basin. The sequence of gravel terraces has been likened to a stairway, descending to the south-east from the summit area of Black Bush Plain to the Solent shore. It makes abundantly clear the migration of the strand-line towards the Solent as base-level fell.

The 300ft. and 230ft. terraces are poorly preserved, and are found for only short distances east of the watershed. Their reappearance at Southampton strongly suggests that they formerly continued, a little east of north-east, across the New Forest. The initiation of the south-easterly drainage trend at the 300ft. stage has already been discussed.

Little can be said of the 230ft. stage, except to note that a high wind-gap is found north-west of Burley Street, at 235ft. O.D. This marks the probable diversion of the headstreams of an Avon tributary into the Upper Ober Water, the only transfer of this type so far discovered. The capture was probably initiated at the end of the 230ft. stage, for reasons similar to those given for later captures.

Below the 230ft. stage the gravel terraces are better preserved, and the map (Figure 2) shows that these lower stages run approximately parallel to the Solent shore until abruptly terminated by the steep bluffs bordering Southampton Water. Discussion of the 185ft. and 165ft. stages, which have only a limited extent, is deferred until after the drainage patterns of the lowest stages have been examined.

In the New Forest the terraces below the 185ft. stage slope transversely towards the Solent, but are horizontal when traced

along their length. It has been shown (2) that they are a special form of marine terrace, formed on the shores of two estuaries which, from the 185ft. stage to the 15ft. stage, occupied very roughly the position of the present Solent and Southampton Water. At each successive fall in sea-level the estuaries shrank in size, in such a manner that, in the New Forest, the proto-Solent shore retreated towards the south-east, exposing a succession of narrow coastal plains, each covered with gravel and slightly lower than its predecessor. The present terraces are the dissected remnants of these surfaces.

It is clear that rivers flowing into the proto-Solent estuary would prolong their courses across each freshly exposed strip of land. The coastal plains had no slope in a direction parallel to the shore, and so the prolonged courses would, in most cases, have been determined by the transverse slope. Had there been no subsequent modifications a series of sub-parallel rivers would have evolved flowing roughly from north-west to south-east. It is significant that this trend is well developed in a number of New Forest rivers.

The Southampton Water shore of the New Forest does not show the same succession of terraces. Scattered remnants of the 150ft. terrace suggest that formerly it bordered Southampton Water (Figure 2), but for much of its history this flank of the New Forest has been undercut. The terrace sequence on the opposite side of Southampton Water supports this view. The short streams which flow into Southampton Water below Marchwood at one time probably possessed much longer lower courses, now cut away.

The present complex river pattern in the New Forest is the result of modification and integration chiefly by the agency of river capture. Evidence for this is usually based upon the alignment of river courses and wind-gaps. Numerous aligned courses are traceable in the New Forest, but wind-gaps are uncommon, only one obvious example having been found, and frequently the aligned reaches lie on either side of an even-crested ridge, or, in the extreme case, of a small isolated hill. These anomalies may be attributed to two factors. In the first place the captures occurred at the end of prolonged still-stands (see below), when the valleys were only slightly below the general surface level. They would not therefore give rise to deeply notched wind-gaps. Secondly, consideration of the rock lithology shows that a wind-gap need not be the only criterion for tracing a former river valley across what is now a ridge. The gravel along the now abandoned stretch of the beheaded river acts as a pervious, and protective, capping to the underlying soft Tertiary rocks of the valley floor. The unprotected ridge on either side is soon reduced to the level of the old valley floor, producing a level-topped ridge, or in the extreme case, to below the level of the old floor, leaving it as a gravel-capped summit.

A reconstruction of the 150ft. stage drainage pattern is shown in Figure 3C. The movement of the strand line to a position five miles south-east of that at the 300ft. stage had been accompanied by the extension of several sub-parallel streams. The Beaulieu River is shown as having more headstreams than at present, while the Lymington system is shown to be less extensive. The river captures believed to have been imminent towards the close of this long still-stand are discussed below.

(*a*) BEAULIEU RIVER. The alignment of the three main Bartley Water headstreams with the upper four miles of the Beaulieu River suggests that formerly they were the headwaters of the latter river, the diversion having occurred just north of Lyndhurst (Figure 3C). Their former course below the elbow of capture was across the ridge between Foldsgate Hill (150ft. O.D.) and Ironshill Inclosure (135ft. O.D.). No wind-gap can now be traced, and the presence, particularly near Foldsgate Hill, of several gravel-capped summits a few feet above 150ft. O.D. is taken as marking the level at which the Bartley streams crossed the ridge, the former valley-floor gravel now acting as a protective capping on the small hills.

(*b*) LYMINGTON RIVER. Figure 3C illustrates the imminent capture of the Blackenford Brook by the Black Water tributary of the Lymington River in the region of Burley Lodge. The Blackenford River probably continued across the ridge at Burley Old Inclosure into the short north-west to south-east reach of the Ober Water, near Rhinefield Lodge, the composite river being conveniently termed the "Rhinefield River". The elbow of capture (near Dogkennel Bridge) is well developed, but no wind-gap exists in the even-crested ridge. It was probably crossed at *c.* 150ft. O.D., at which level there are several low gravel-capped summits in Burley Old Inclosure.

In both the above cases the captures occurred after the rivers had cut down to about 150ft. O.D., as at this level they were still continuous with the now beheaded lower courses. The rivers would have been grading to the 150ft. base-level and it was this long still-stand which gave time for the pirate streams to work headwards towards the points of capture, and yet, because of the reduction in longitudinal gradients, made such headward erosion progressively slower. The captures were therefore maintained in the imminent stage for some while. The fall to the 100ft. base-level provided the necessary stimulus, and the captures were complete before the rivers had incised themselves far into their 150ft. flood-plains. This view is supported by the limited number of streams now crossing the 150ft. (Solent) terrace (Zone 2 of the division noted above). The drainage must have been concentrated into the Beaulieu and Lymington rivers before the terrace was

exposed. The pirate streams had slight advantages in that the Bartley Water had a slightly shorter route to the sea than the Beaulieu River, and the valley of the Black Water, being a tributary of the relatively large Lymington River, may have been at a slightly lower level than that of the " Rhinefield River ".

The 100ft. stage shore-line lay about a mile to the south-east, and the main rivers extended their courses across the freshly exposed 150ft. stage coastal plain. It is believed that towards the end of the 100ft. stage further captures were imminent, for reasons similar to those noted above.

(*a*) The Bartley Water, having enlarged its drainage basin at the expense of the Beaulieu River was itself about to be beheaded by the Cadnam River (Figure 3D). The site of the capture lay near the village of Cadnam.[3] Three small streams (Shepherd's Gutter, King Garn Gutter and Coalmeer Gutter) unite a mile above the village, and flow westwards towards a broad gap between Castle Malwood (353ft. O.D.) and the summits rising just above 150ft. O.D. at Copythorne and Tachbury Mount. The floor of the gap is much dissected but its former level must have been about 115ft. O.D. (*cf.* Brick Works Hill, Rockram, *c.* 115ft. O.D.). Just before reaching the gap the Cadnam turns north-east, forming the characteristic " elbow of capture ". Within the gap rises a small " misfit " branch of the Bartley Water.

(*b*) A second impending capture concerns the Ober Water (or the " Rhinefield River ") which was about to be dismembered near Hinchelsea Moor. The river clearly once continued to the sea *via* the wide valley of Milking Pound Bottom, but has been diverted by a north-eastward flowing stream which is now the lower Ober Water. The former course is traced by the patches of gravel between 90ft. and 100ft. O.D. on Whitefield Moor, Furzy Hill and the golf course,[4] leading to the gap, which must have been carved by a much larger river than the little " misfit " which now drains it. The capture must have occurred when the " Rhinefield River " had cut its flood-plain to about 95ft. O.D., for this is the present level of the Milking Pound Bottom valley, and was probably initiated by the rejuvenation at the end of the 100ft. stage. The bend by which the Milking Pound Bottom stream now enters the Lymington River is an original feature, the river having turned at the foot of the old cliff bounding the 70ft. terrace.

In addition to the above captures, the retreat of the strand-line to the 70ft. stage saw the birth of the numerous small sub-parallel streams which drain to the Solent. Many of these are at present

3. The gravels at Cadnam post-date the capture. The new outlet may have been constricted at first, causing accumulation of river and solifluction gravels, later re-worked by the stream into two terraces.

4. The gravels at Brockenhurst are re-deposited material derived from these beds, plus re-sorted solifluction material.

eroding headwards into the 150ft. terrace, but none has yet cut across it.

The relation between the trends of the strand-line and those of rivers having been established, it is instructive to return for a moment to higher levels. The trend of the 185ft. stage is more northerly than that of the terraces below it, and it is significant that the streams which rise near the terrace (the headwaters of the Avon Water, and the Ober Water and Black Water) have easterly courses, in sympathy with the trend of the terrace, instead of south-easterly.

Base-level continued to fall intermittently until, at the maximum of the last glaciation, it was many feet below the present level. Across the floors of the two estuaries the proto-Test and Solent Rivers prolonged their courses and deeply incised their valleys (3). Similarly, the Beaulieu and Lymington Rivers were incised in their lower courses. The post-glacial rise in sea-level has flooded these deepened valleys, converting them into the present estuaries. The Beaulieu River entered the Solent River a little downstream of the Lymington River and might conceivably have cut down lower and therefore might now have a slightly longer estuary, but its length compared with that of the Lymington River is too great for this to be a likely explanation. It is suggested that the reason lies partly in the early loss of the Beaulieu River headstreams. The Lymington River estuary has been silted up much more rapidly because of this river's undiminished drainage basin, and the large amount of material excavated from the deeply cut Fritham plateau area. The Beaulieu River, on the other hand, has a much reduced headwater system, which drains very low ground, and has probably done so since the 150ft. stage.

The north to south reaches of the Beaulieu and Lymington rivers remain unexplained. The solid geology seems to have little influence, for in this reach the Beaulieu River is flowing obliquely to the dip on Barton Sand, whereas the Lymington River is crossing Headon Beds, albeit aiming for the anticlinal axis. The most that can be gleaned from this at present is that it provides corroborative evidence for the absence of a longitudinal slope on the 150ft. stage.

The symmetrical pattern of the River Blackwater suggests that this river has not been subjected to the same evolutionary processes as the other rivers of the eastern drainage basin. H. Bury (1) put forward the suggestion that the New Forest gravels never extended beyond their present north-east limits, *i.e.* that the bulk of the Blackwater drainage basin was never so covered. It is probable that the river originated on a terrace on the east flank of the early peninsula. By headwater erosion it then made tributary to itself the broad, gravel-free, belt of Tertiary rocks that lay north of the New Forest gravels and south of the chalk of Dean Hill. It has

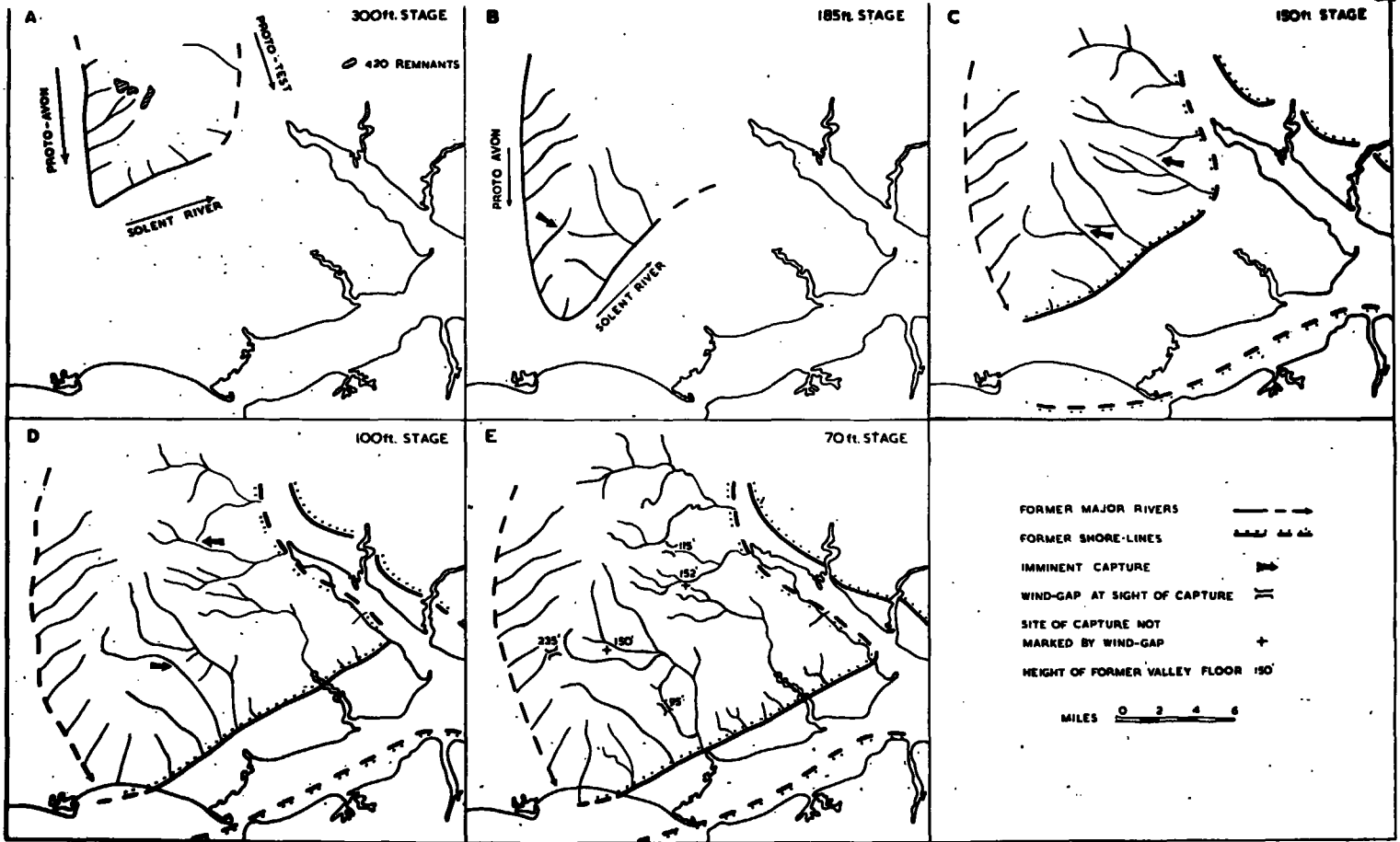

FIGURE 3 Stages in the evolution of the New Forest drainage pattern

carved a broad vale between these more resistant formations, and the fortuitous axial position of the main stream, aided by uninhibited headwater erosion of it and its tributaries, has permitted a fairly symmetrical pattern to evolve.

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