The Evolution of the Beaulieu Drainage-system in the Southeastern New Forest (Hampshire)

by W. E. TREMLETT

ABSTRACT. Mapping of geomorphological features and drift deposits in the southeastern New Forest reveals that the present Beauleiu drainage-system has arisen from a large number of river-captures. An essentially eastward-flowing drainage-system towards the Southampton Water persisted until after the 70-foot erosion cycle, and it was only in the interval between 70-foot times and 35-foot times or in the early part of the 35-foot erosion cycle that capture by southward-flowing streams diverted the drainage towards the south coast.

INTRODUCTION

RESEARCH on the evolution of the Beaulieu river-system was undertaken because the extensive drift deposits of the Nature Reserve in the Matley and Denny area, south-east of Lyndhurst (Tremlett 1961) yielded information which did not agree with published views on the evolution of the drainage-pattern (Everard 1957). It was, however, necessary to increase the area of investigation before the history of river-development could be completely understood, and mapping was extended to cover the area east of gridline 290 and south of gridline 110.

The information discovered in this extension of area accords with conclusions expressed in the author's previous work—that much of the topography of this area was moulded in erosion-cycles that correspond to the 70-foot and 35-foot sea-levels recognised by Everard (1954B). Following the development of a mature valley-system in 70-foot times, extensive sheets of gravel (some of the Higher Gravels of the Matley-Denny area[1]) were deposited within the valleys (and on the neighbouring wave-cut surface Everard 1954B, Fig. 1). Later, with the sea-level at 35 ft. O.D., there was formed a lower series of mature valleys containing abundant alluvium (the Older Alluvium of the Matley-Denny area), and still later, more gravel sheets (the Lower Gravels) were deposited on top of the alluvium within these valleys. The accumulation of the Lower Gravels is thought to have occurred during the glacial phases of the Last Glaciation (Tremlett 1961, pp. 6–7), when the resultant low sea-levels also caused a series of deep narrow channels to be cut through the widespread Older Alluvium. These channels have since been largely infilled by the Newer Alluvium.

In addition to the geomorphological features observed in the Matley and Denny area, there is present in parts of the lower courses of the valleys of the southeastern New Forest a terrace which appears to correspond to the 15-foot sea-level recognised by Everard. This occurs within the more extensive 35-foot terrace (the Older Aluvium) but outside the narrow strip of Newer Alluvium filling the overdeepened valleys up to the present floodplain level. Study beyond the confines of the Nature Reserve has also allowed some conclusions on the geography of 100-foot times, the period which preceded the 70-foot erosion cycle, the first

1. Not all of these, however: see p. 49.

mentioned in the description of the drift deposits of the Matley-Denny area. In fact some of the gravels in that area which were thought in 1961 to rest on the 70-foot erosion-surface are now recognised as having been deposited earlier, on the 100-foot surface. The reason for this error was the absence of any obvious break in the level of the surface of the gravel sheet between the Shatterford and Beaulieu rivers, 2¾ to 4 miles west of Applemore Hill. This is fairly uniform at about 108 ft. O.D. (base of the gravel about 104 ft.) over all of the northern part but in the southeastern part slopes down to about 78 ft. O.D. (base of gravel about 75 ft.). Further experience has revealed the solution to this common problem in the gravels of this region—the absence of any obvious break in a gravel which shows a large range of height. After the deposition of an earlier sheet of gravel within the mature part of a valley and a later fall of sea-level (in this case by about thirty feet), the area is much further from the coast. Consequently the longitudinal and transverse gradients of new valleys graded to the lower sea-level result in bluffs only a few feet in height between the previous gravel and the valley floor. Later deposition of gravel within the new valley together with some solifluction of the earlier deposit have almost completely hidden this break of the underlying surface. The gravel previously mentioned is now recognised as containing 100-foot and 70-foot parts, and the Matley Heath gravel (a further ½–1¼ miles to the west) is divided into a 150-foot marine portion (with its base at about 130–140 ft. O.D.) and a 100-foot valley portion (base at about 105–120 ft. O.D.). In both these sheets the division is made on the basis of elevation.

The method used to describe the main geomorphological features of the area and the development of the drainage-system will be a stage-by-stage consideration commencing with the 100-foot stage. The correlation of these stages with the erosion-chronology of other areas of dated Pleistocene events, such as the Thames Valley, is beyond the scope of this work, and it is sufficient to say that all the events which this paper describes are believed to have happened in Middle Pleistocene and later times.

THE 100-FOOT STAGE

Some conclusions on the geography of 100-foot times can be deduced from the few remnant patches of the gravels which were deposited on the 100-foot erosion-surface. The height of the base of the gravel at Applemore Hill and ½ mile to the northwest, and in the south-eastern part of the Long Down patch, at exactly 100 ft. O.D., and a height of only about 103 ft. O.D. for the gravel between 2¾ and 4 miles west of Applemore Hill indicate deposition in a very mature valley-system not far from the mouths of the rivers. On the other hand the position of the present 100-foot contour southeast of Applemore Hill and the evidence for a watershed well to the northeast of Long Down in 100-foot times (see below) both indicate a coast at least as far northeast as that shown in Fig. 1. Hence it seems probable that in 100-foot times in the area of Applemore Hill there was an estuary causing an indentation in the coast-line.

The Long Down gravel is not sufficiently extensive to give any information on the longitudinal gradient of the valley in which it was deposited, but there is clear evidence of a transverse gradient since along its notheastern limit the gravel sheet rises to a height of 120 ft. O.D. Northward from the edge of the gravel a mature land surface can be traced up to about 140 ft. O.D. around the remnant patch of 150-foot gravel and to 144 ft. O.D. some 300 yards further north. It is evident that the Test watershed of 100-foot times must have been situated still further north. Evidence to the east of Long Down also indicates a watershed well to the northeast in 70-foot and 35-foot times (p. 52).

The river which deposited the Long Down gravel is thought by the author to have been the southeasterly-flowing one (best called the Woodlands river) which was eventually captured by the northeast-flowing Bartley Water. The present wide, flat-topped ridge at about 103 ft. O.D. extending between 345096 and 348117 appears to be part of the terrace of this river linking the present confluence of the Woodlands river and Bartley Water with the Long Down gravel. The change of direction of the river which this indicates might be the result of an earlier river-capture, achieved before late 100-foot times, the period illustrated by Fig. 1.

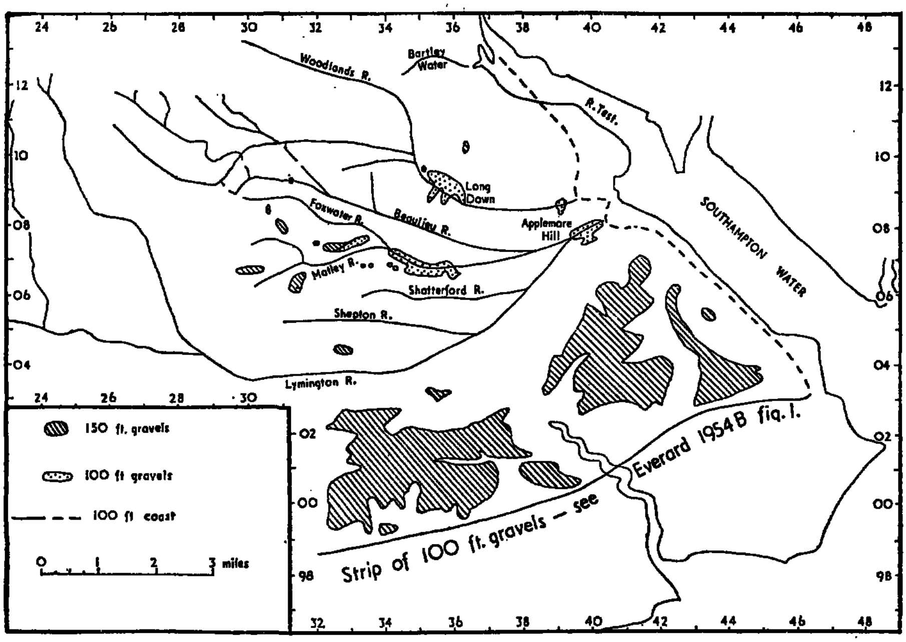

FIG. 1. The probable drainage-system of the southeastern New Forest in late 100-foot times, showing the distribution of present 150-foot and 100-foot gravel patches to the east of grid-line 290 and to the south of grid-line 110. The 100-foot southern coast-line, some of the boundaries of the southern 150-foot gravels, and the probable courses of the Lymington headwaters are based on Everard 1954B and 1957.

It appears that in 100-foot times an eastward-flowing tributary of the Woodlands river captured the headwaters of the Beaulieu and Foxwater rivers in the manner indicated in Fig. 1. This is the only satisfactory explanation for the drainage-pattern of later times, for although in 35-foot times we find the drainage of these captured headwaters flowing through the Ashurst gap, it is difficult to believe that the arrangement indicated in Fig. 2 could have been achieved by the Ashurst tributary of the Beaulieu cutting back by a long circular course to capture the more important headwaters of that river. On the other hand if these captures were effected by the Woodlands river-system, the later diversion of drainage through the Ashurst gap can be easily explained (p. 52). Everard (1957) believed the captures were effected by the Bartley Water, but it will be seen later that the waters of the original upper parts of the Beaulieu and Foxwater rivers were flowing southward through the Ashurst gap in 35-foot times and it was not until late in that period that this drainage was captured by the Bartley Water (p. 54).

Contrary to a statement by Everard (1957, p. 248), the captured streams have left well-marked gaps at 315098 (105 ft. O.D.), 300096 (130 ft. O.D.), and 294092 (140 ft. O.D.). The first of these may have been modified slightly by subsequent competition between the remnant and reversed streams (p. 52), but its height agrees reasonably well with that of a small gravel with a base at 112 ft. O.D. at 312092; both these features appear to approximate to a mature 100-foot surface. The other two captures appear to have been achieved by the same pirate stream at a later date, but the gaps are not graded to the 100-foot level and the well-marked nick-points down-valley from these gaps are apparently a feature of the 100-foot landscape, virtually unchanged since the diversion of the waters which flowed over them.

The exact course of the Beaulieu Water is not known, downstream of the small gravel-patch mentioned above, but it may well have followed approximately its course of later periods, not joining the Foxwater until a little to the west of Applemore Hill. The large gravel area between 2¾ and 4 miles west of Applemore Hill reveals the course of the lower Foxwater river, while the 100-foot part of the Matley Heath gravel indicates a course for the Matley river very similar to that of the present, and a moderate transverse gradient in its valley (see p. 49.)

There are no 100-foot gravel areas preserved to show the course of the lower Lymington river, but the positions of remnants of 150-foot gravel together with the records of the courses of this river and its tributaries in later times suggest the picture shown in Fig. 1.

Although in 150-foot times the drainage of this area appears to have been approximately at right angles to the coast (Everard 1957, Fig. 3c), it can be seen from Fig. 1 that the main drainage in 100-foot times was nearly parallel to the existing south coast. This unusual state of affairs arose partly from a change of coastal configuration, but also partly because the extensive spread of gravels on the 150-foot wave-cut surface of the south coast formed a resistant barrier parallel to the 100-foot southern coastline (still marked by a broad heathland plateau broken only by fairly narrow valleys).

It is clear that the effects in this area of the river-system of 100-foot times were the erosion of large parts of the gravel-capped 150-foot wave-cut surface, the formation of a mature valley-system with very little longitudinal gradient in the lower few miles of the valleys, and the deposition of a continuous spread of gravel within the lower parts of these valleys.

THE 70-FOOT STAGE

One of the most striking features of the geomorphology of the southeastern New Forest is the absence of any 70-foot terrace along the lower courses of the Beaulieu and Lymington rivers. These streams at the present day cut through an east-west ridge of high land (which is largely capped by 150-foot marine gravels—see Fig. 1) in comparatively narrow gaps where only the 35-foot and 15-foot terraces exist. In contrast the extensive lower areas to the north of this ridge, where 150-foot (and some 100-foot) terraces and gravels have been removed by fluviatile erosion, link with the wide 70-foot gap in the Southampton Water–Beaulieu river watershed just southeast of Applemore Hill (402073). It appears that in 70-foot times the Lymington and Beaulieu rivers passed eastwards through this gap towards the Southampton Water. The course by which the Lymington river flowed towards the Applemore Gap in 70-foot times is well-marked by the gap at 80 ft. O.D. at 336036 between present-day westward-flowing tributaries of the Lymington river and eastward-flowing tributaries of the Beaulieu river (see Figs. 2 and 3).

Other features of the drainage-pattern of 70-foot times are revealed partly by the contours of the base of the gravel-sheets which were deposited in this valley-system, and partly by the system of rivers existent in later times. From these considerations it is found that the most important change between late 100-foot times and late 70-foot times was the disappearance of the lower part of the Woodlands river. This appears to have been achieved firstly by the Bartley Water effecting a capture at about 342118. The remnant stream, which presumably still had an estuary independent of the Beaulieu–Lymington system, was weakened by this piracy and so could rejuvenate its lower course only slowly compared with the more active combined Beaulieu–Lymington river. As a result the Beaulieu river now had an advantage over the eastward-flowing tributary of the lower Woodlands river which had previously captured the headwaters of the Beaulieu and Foxwater rivers, and it was able to recapture this drainage at about 328104 by means of its tributary the Ashurst river. This more active rejuvenation of the Beaulieu system may also have caused some attack on the gap at 315098, but in view of the small catchment area of this tributary this is not likely to have caused much lowering of the level of the gap (see p. 51).

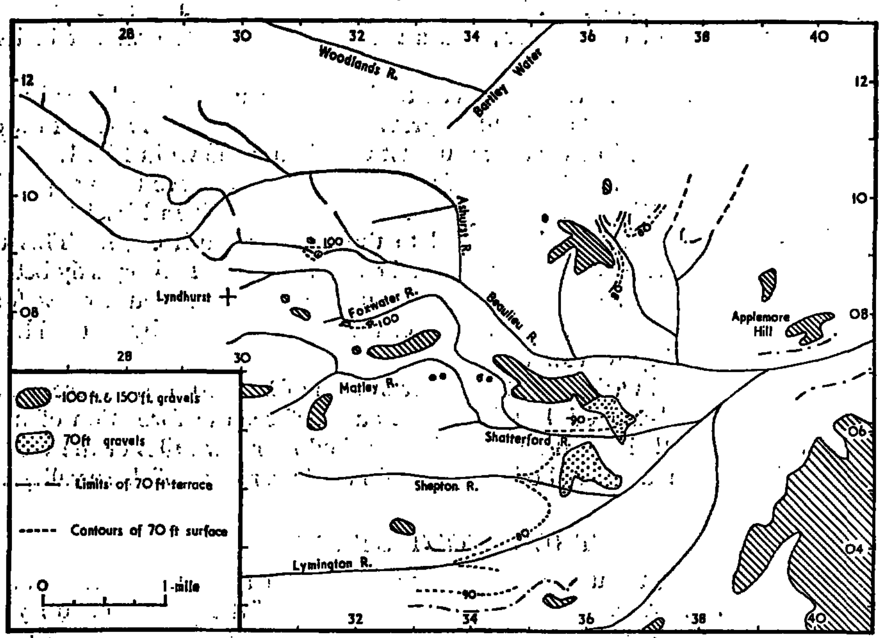

FIG. 2. The probable drainage-system of the Lyndhurst–Beaulieu area in late 70-foot times, showing the present distribution of 70-foot and earlier gravels to the east of grid-line 290 and to the south of grid-line 110.

These captures by the Bartley Water and the Ashurst river resulted in the virtual disappearance of the Woodlands river from this area. A stretch of stream for ½ mile southeast of 370080 may have been a remnant of this river, but in general a southward-flowing river-system developed and produced a moderate area of mature 70-foot surface to the east of Long Down. The northerly extent at this time of the eastern headwaters of this drainage is unknown, since the valleys at present end in a gap at 373093 (75 ft. O.D.) graded to the 70-foot level, and a gap at 381093 (60 ft. O.D.) graded southwards to the 35-foot level. The prominence of these gaps, however, suggests a fair flow of water through them, and the well-developed 15-foot surface along parts of their valleys suggests that much of the loss of headwaters to the Test is a fairly recent event (particularly in the eastern stream).

Presumably in 70-foot times the Foxwater and Matley rivers flowed southward into the Shatterford river along the courses for which there is good evidence in 35-foot times (p. 54), southward-flowing tributaries of the Shatterford having captured first the Matley river and then the Foxwater river. It is probably the southward diversion of this drainage which preserved the patch of 100-foot gravel to the east, previously deposited by the combined Foxwater and Matley rivers.

From these considerations the overall picture of the geography of 70-foot times appears to be as shown in Fig. 2. It is possible in places to indicate the contours of the 70-foot erosion-surface where it has been preserved through later changes of drainage or under the capping of the 70-foot gravels. The alluvium of this period has been found only on the 70-foot terrace of the Applemore Gap, and its deposition appears to have been confined to the eastern parts of the area. Similarly the widespread accumulation of gravels on this surface appears to have occurred only in the lower parts of the valleys, and in the upper parts its distribution appears to have been confined to narrow belts along the watercourses.

The drainage-pattern indicated in Fig. 2 differs considerably from that shown by Everard for 70-foot times (1957, Fig. 3E). The reasons have been given above for postulating that the Ashurst drainage flowed south into the Beaulieu system and not into the Bartley Water, and that the Lymington and Beaulieu rivers flowed eastward into the Southampton Water and not at this time southward into the Solent. The geomorphological evidence shows that the essentials of the present drainage pattern did not become established until 35-foot times, and were not existent in 100-foot and 70-foot times, as suggested by Everard (1957, Figs. 3D and E). The inherited eastward-flowing river-system of 70-foot times was somewhat less anomalous than in 100-foot times (see p. 51) due to migration of the coast southwards accompanying the drop of sea-level (compare Fig. 2 with Everard 1954B, Fig. 4), but was still not a normal geographical arrangement.

THE 35-FOOT STAGE

The drainage-system of 35-foot times in the southeastern part of the New Forest is known with a high degree of accuracy since it was responsible for the formation of extensive terraces and the deposition of large areas of alluvium. It will be seen from Fig. 3 that the pattern of drainage differed in many important respects from that of 70-foot times (Fig.2). These differences are the result mainly of numerous river captures, which, since their relative ages cannot always be fixed, will be described from the south working northwards.

During the drop of sea-level from 70 ft. to 35 ft. and the long period of stability at 35 ft., the following changes occurred in the drainage-pattern of this area:

(1) The Lower Beaulieu river cutting back northwestwards (a direction presumably resulting from the slope of the 150-foot wave-cut surface) effected the capture of the most southerly of the northeast-flowing streams at 377034; and by means of a southeast-flowing tributary captured the beheaded remnant of the Lymington river (see 3 below) at about 360046.

(2) The upper part of the Shepton river was diverted into this drainage by a southward-flowing tributary effecting a capture at 353051.

(3) The Lower Lymington river (another consequent stream of the 150-foot marine bench) cut back northwards to capture the eastward-flowing river at two places, about 308031 and 318035. Continued downcutting of the eastern branch caused progressive piracy of the remnant, probably as far east as the present watershed at 336036.

(4) The eastern branch of the Lymington river continued to cut back northward and eventually captured the headwaters of the Shepton river at 320052.

(5 and 6) The confluence of the Shatterford and Lymington rivers had already been short-circuited by a southeast-flowing tributary of the Lymington effecting a capture at 361060 before this drainage was diverted into the Lower Beaulieu system by an eastward-flowing tributary at 373054.

(7) One of the headwaters of this Lower Beaulieu river captured the former eastward-flowing drainage at 381071 and reversed the direction of flow for a considerable distance to the east—as far as 402073 along the previous main river-course, while by means of its present tributaries this drainage rises as far east as 412072.

(8) An unimportant capture in the Shatterford system at 343065 caused the abandonment of a section of alluvium-filled valley for some 250 yards southwest of that point.

(9 and 10) A tributary of the middle reaches of the Beaulieu river cutting back to the west effected captures of the Foxwater at 337075 and the Matley at 334072. The more rapid downcutting of the Beaulieu valley would result from its greater flow (including a large amount of drainage coming through the Ashurst gap) compared with the limited catchment area of the Foxwater–Matley–Shatterford system. The Matley river must, however, have already prior to its capture abandoned its course through the gap at 337067 to achieve a confluence with the Foxwater at about 340072, for the former valley is comparatively narrow and has no alluvial infilling for some 150 yards through the wind-gap, while the valley (now dry) below the supposed confluence of the Matley and Foxwater rivers shows a continuous wide spread of alluvium.

(11 and 12) An eastward-flowing tributary of the Ashurst river captured one of the headwaters of the Beaulieu river (itself a misfit from a previous capture) at about 318093. This probably occurred before the capture by a southward-flowing stream at 326095, for the gap to the east of this point is a much wider and more important feature than that to the southeast of 318093. Moreover the capture of Beaulieu headwaters by the Ashurst river would be related to the abundant flow of the latter prior to its capture by the Bartley Water (see 13 below), while recapture of drainage by the Beaulieu system would follow the loss by the Ashurst river of most of its water.

(13) The Ashurst river was captured by the Bartley Water (a tributary of the Test system) at 326104. This capture probably occurred fairly late in 35-foot times, for the wide Ashurst Gap is well-graded to the 35-foot surface of the Beaulieu system, but piracy took place before the deposition of much alluvium in this gap which is largely floored by Barton Clay.

The recognition of this large number of river captures during 35-foot times results partly from the more complete record of drainage-evolution in this cycle than in previous erosion cycles, since no subsequent periods of erosion have been very effective in modification of the 35-foot landscape, which still forms large parts of the area. Nevertheless the changes of drainage-pattern were more striking than those achieved during the preceding cycles; this suggests possibly longer duration of this cycle and/or heavier rainfall within the catchment area giving more abundant surface drainage to effect rapid erosion. These possibilities are suggested also by the large width of the 35-foot terrace in many parts of the area, as indicated in Fig. 3. In general landscape-evolution of this area suggests more abundant water during the Pleistocene Period (certainly from 100-foot times on) than at present, but this is most striking in the picture which emerges of 35-foot times. Then moderate-sized rivers with abundant tributaries flowed across a very mature landscape, effecting frequent captures and changes of drainage-pattern.

The limits of the 35-foot terrace indicated in Fig. 3 give some indication of the relative importance of the various rivers during and after the evolution of the drainage-pattern by the various captures listed above. The wide extent of this terrace either side of the present-day Beaulieu river to the east of grid-line 310 confirms the large volume of its drainage in 35-foot times (at least until after the beheading of the Ashurst river). The significance of the wide Ashurst Gap linking in both directions with the 35-foot surface has already been noted. The continuous wide spread of alluvium between the Foxwater and Beaulieu rivers presumably indicates considerable variation of their courses and possibly at times extensive flooding below the points where they emerged onto the plain. It will be noted, however, that, at the end of 35-foot times, compared with its wide flood–plain further northwest, the Beaulieu river southeast of its confluence with the Shepton river still flowed in a comparatively narrow valley through the 150-foot gravels. The wide valley in the northwest may be the result not only of the greater antiquity of the drainage there but also to some extent of its location on the outcrop of the Barton Sands. By contrast, the Shatterford valley, cutting across this formation, is comparatively narrow and its 35-foot terrace is only preserved in a few small patches outside the limits of the Newer Alluvium; this is clearly due to the loss of most of its headwaters to the upper part of the Beaulieu river long before the end of 35-foot times (captures 9 and 10 above).

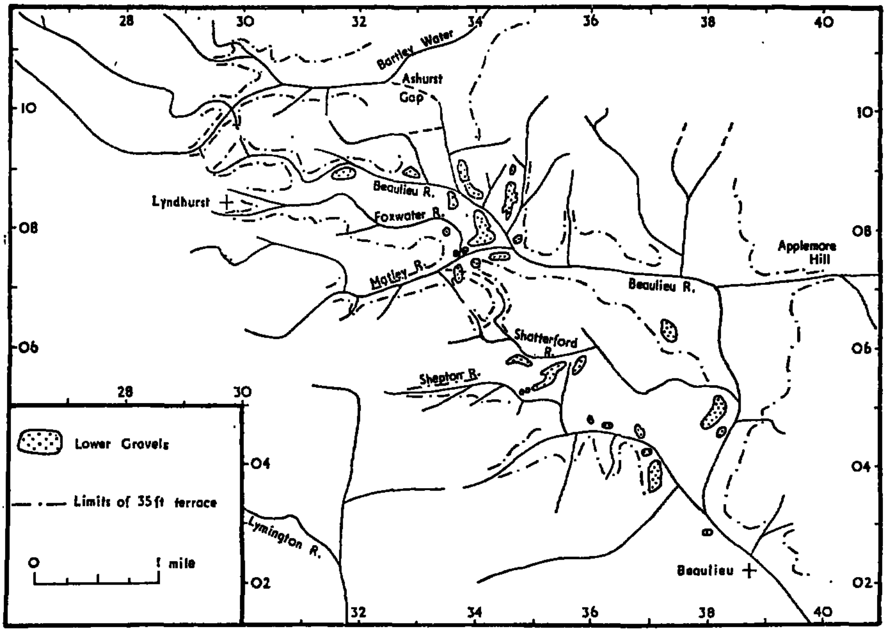

FIG. 3. The probable drainage-system of the Lyndhurst–Beaulieu area in late 35-foot times, and associated geomorphological features.

The most important effect of the captures of 35-foot times was the diversion of the former eastward-flowing drainage into the Lower Beaulieu and Lymington rivers, and this to some extent removed the anomalous arrangement of earlier times (see p. 51) and produced a drainage-pattern more in accordance with the existing coastline. These rivers were presumably initiated on the exposed gravel-covered wave-cut 150-foot surface and flowed southwards towards the retreating coastline of 100-foot and 70-foot times. Their headward extension, however, would be delayed by the resistance to erosion of the extensive gravels and by initially the short courses and small catchment areas of the rivers. The rate of headward erosion would be increased by enlargement of catchment areas through the gradual retreat of the coastline between 100-foot and 35-foot times, and the amalgamation of some of the initially independent streams.

POST-35-FOOT TIMES—THE LOWER GRAVELS, THE 15-FOOT TERRACE, AND THE NEWER ALLUVIUM

The sequence of events in post-35-foot times is complicated. This period is represented by three features—the Lower Gravels, the 15-foot terrace confined to the lower parts of the drainage-system, and the Newer Alluvium, a heterogeneous infilling of clay, silt, gravel and peat deposited within narrow deepened channels of most of the rivers of this areas (Fig. 4).

It was noted in the introduction that although the Lower Gravels rest largely on the 35-foot floodplain, their transport was probably associated with the low sea-levels which caused the overdeepened channels subsequently infilled by Newer Alluvium. From theoretical considerations the polycyclic nature of this gravel transport and deposition had previously been emphasized (Tremlett 1961, p. 7) and its relationship to the three gravel-covered terraces below sea-level in the Southampton Water (Everard 1954A) postulated. The existence of more than one period of gravel deposition can now be illustrated by the patches 1½ miles north of Beaulieu on the west bank of the river. Here the higher sheet rests largely on the 35-foot terrace, its western edge coincident with the western limit of the terrace at 50 ft. O.D., but towards the river sloping to 30 ft. O.D. where it ends against the cliff of the 15-foot terrace. The lower gravel rests on the 15-foot terrace and ends in a low bluff against the floodplain of Newer Alluvium. These relationships indicate that sea-level had already dropped from the 35-foot level and the valley had already been eroded below 35 ft. O.D. before the first period of gravel deposition; then cutting of the 15-foot terrace occurred before deposition of the second gravel, which was followed by a further period of erosion. While the composite nature of the Lower Gravels can be illustrated here, it must be appreciated that further inland, where no 15-foot terrace is found, Lower Gravels resting on the extensive 35-foot terrace represent more than one period of gravel transport—two demonstrable from the locality just described, but probably three, coincident with the three glacial phases of the Last Glaciation and the three drowned gravel-covered terraces of the Southampton Water.

The extensive 15-foot terrace, often alluvium-covered, cut after one period of fluviatile gravel transport but before another such period, would appear to require the long-continued stable sea-level of an interstadial phase and can most probably be correlated with the Lower Floodplain terrace formed in the Thames valley during the first interstadial of the Last Glaciation (Zeuner 1959, p. 171). The limits of this 15-foot terrace in the Beaulieu area are shown in Fig. 4. There is also, however, between ¾ and 1½ miles S.W. and W.S.W. of Applemore Hill, an area of very irregular surface where the 35-foot surface is breached by numerous channels which are largely graded to the 15-foot surface.

The differences between the drainage-pattern of post-35-foot times and that of 35-foot times can be seen by comparing Figs. 3 and 4. It will be noticed that the modifications of drainage since 35-foot times have generally been minor. The stream which had in 35-foot times captured the Shepton river at 353051 and had already cut further back to the north (Fig. 3), continued to extend in this direction and eventually captured the Shatterford river at 355057. The greater erosive power of the Shepton system came from its greater volume of water, compared with the remnant Shatterford river (beheaded in 35-foot times) but the capture did not occur until the abandoned valley to the east had already been over-deepened and infilled with alluvium. The capture at 369084 in a northern tributary of the Beaulieu system was similarly effected after overdeepening of the abandoned channel, which is infilled by Newer Alluvium. This at first sight unusual type of capture can be explained by the relative volumes of water in the two branches of the drainage-system above their original confluence at 377078. The eastern branch has been noted to have had sources considerably further north than those of the present-day (p. 52), and the larger flow in this branch allowed an eastward-flowing tributary to cut back westward and capture the western stream.

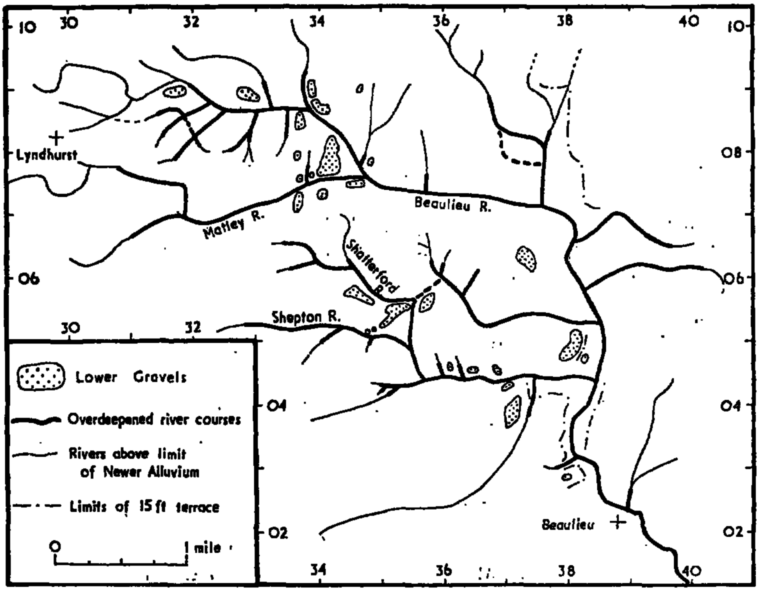

FIG. 4. The Beaulieu drainage-system and associated geomorphological features of post-35-foot times.

The other changes in the drainage-pattern resulted from the piecemeal disruption of the remnants of the Foxwater river by northeast-flowing tributaries of the Upper Beaulieu river. The first captures resulted in the diversion of the drainage through Whitemoor Bog to join the Beaulieu at 330086 and in piracy of the Foxwater headwaters at about 307086, and both these occurred before any rejuvenation had spread thus far upstream. Later a northeast-flowing stream, ½ mile west of Whitemoor Bog, captured the Foxwater at 321082 and cut back further to capture a tributary at about 318079. Later the same process occurred again with a stream a further ¼ mile to the northwest effecting a capture at 318086.

The large number of patches of Lower Gravel give some information on the transport of this deposit across the 35-foot terrace and through the incised lower river channels. Since transport and deposition (and some erosion) took place over a long time and were effected partly by the drainage-system indicated in Fig. 3 and partly by that shown in Fig. 4, the positions of the present patches of gravel have been shown in both these figures. Their widespread distribution across the 35-foot terrace must indicate extensive flooding during periodic melting of local snow accumulations of the glacial phases, as well as possibly migration of meandering or braided streams. This flooding could occur if the deepening of the river channels resulting from the associated low sea-levels had not extended thus far upstream and the deepened channels of an earlier glacial phase, having become infilled by the alluvium of interstadial times, were no longer effective in dealing with the rush of water. Under periglacial conditions flooding would also be helped by a frozen subsoil, and at times could have resulted from an upstream thaw occurring before the lower parts of the river were melted. The broad extent of gravel to the northeast of the confluence of the Matley and Beaulieu rivers indicates widespread flooding there. Similarly the extensive deposits between the Shatterford and Shepton rivers suggest that in times of flood there was a flow of water and transport of gravel through the generally abandoned earlier river-course between the Matley and Shatterford rivers and over the low interfluve between the Shatterford and Shepton rivers (the gravel here being deposited directly on Barton Sand, outside the limits of the alluvium).

Finally, concerning the Lower Gravel it should be noted that not all of the gravel found in this area need have been transported far during the period of the Last Glaciation, for much may have originated by the erosion of local 70-foot, 100-foot, and 150-foot gravels. The position of the patch around 357057 immediately beneath a 70-foot gravel area was previously noted by the author (1961, p. 5), and the probable importance of solifluction in this relationship noted. This process of cannibalism of earlier-formed gravel terraces in the Hampshire Basin was of course an important feature of erosion-deposition relationships throughout the Pleistocene period.

In the polycyclic alternation of cut-and-fill of post-35-foot times the present cycle shows abundant signs of deposition in this area, with downstream the extension of the floodplain into the drowned estuary of the Beaulieu river and upstream the influx of some clastic sediment as well as the accretion of peat in the bogs of the scoured-out channels.

CONCLUSIONS

It is seen from the land-forms and the distribution of drift deposits in the southeastern New Forest that the present Beaulieu river-system has arisen from a large number of river-captures resulting in a gradually evolving pattern. It is clear that the river systems of 100-foot and 70-foot times were essentially eastward-flowing and that the outlines of the present pattern were only established by numerous captures in 35-foot times. While later events have considerably modified the form of the valleys and the appearance of the New Forest, through the formation of extensive valley-bogs, only minor modifications of the drainage-pattern of the Beaulieu river-system have resulted. Evidence is given that the 15-foot terrace was formed between periods of gravel transport which are thought to represent the glacial phases of the Last Glaciation, and the reasons are provided for believing that this terrace is of interstadial age.

The palaeoclimatic implications of the land-forms, the drift deposits and the changing pattern of rivers are considerable. It is clear that large volumes of coarse gravel were transported during abnormal (in general probably periglacial) conditions, but even at other times the rapid headward erosion by the rivers resulting in frequent capture, and the wide extent of some of the erosion surfaces and alluvial deposits, especially those of the 35-foot cycle, appear remarkable (even in an area of such soft strata) when compared with the present insignificant flow of the streams. In some cases this can be partly explained by the loss of headwaters, particularly to the Test drainage system, but this explanation would never appear to be adequate and in many instances is not applicable. It is clear that in general, surface-drainage must have been considerably greater in amount during the latter half of the Pleistocene Period than at the present, not only during the sporadic flooding of the peiriglacial phases but also during the warmer conditions of non-glacial phases.

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