The Relief and Drainage Evolution of the Blean.

Coleman, A

Proc. Geologists Assoc. 65 (Part 1), 1954

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The Relief and Drainage Evolution of the Blean

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Received 11 September 1952

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ABSTRACT: The Blean plateau is of morphological interest because it exhibits two features which are unusual in clay country. Firstly, there is a great regularity of direction in its drainage pattern, and secondly, as a regional unit, the Blean has proved relatively resistant to erosion. Each of these characteristics can be explained by reference to the denudation chronology of the area. The Blean has been completely traversed by the River Stour which has migrated laterally across it. The minor streams owe their parallelism to a common origin as left bank tributaries of the Stour, although they are now isolated from it. Their capture history also follows logically from this origin. The preservation of the Blean as an upstanding plateau is related to the extension of the minor streams parallel with the coast in the wake of the migrating Stour. Long portions of their courses thus remain higher than those of streams which run directly to the coast, and this extra height is reflected in the altitude of the Blean as a whole.

1. STATEMENT OF THE PROBLEMS

THE BLEAN lies on the north coast of Kent between the Isle of Sheppey and the Isle of Thanet. It is a roughly rhomboidal tract of London Clay fringed narrowly and incompletely with Lower London Tertiaries. It is contrasted with the areas immediately to the east and west, since there the London Clay has been eroded and the Eocene consists chiefly of the irregular outcrops of Thanet Sand.

The relief map (Fig. 1) shows a longitudinal alternation of ridge and valley with a strong east-north-east grain. The interfluves are flat and the general appearance is of a plateau declining gently from a height of about 400 ft. in the south-west corner. The chief exception to this simple pattern is the Herne Depression, a low-lying rectangular area in the north. This is open to the sea between Whitstable and Herne Bay, and on the other three sides is bounded by sharply rising ground. Within this depression the streams flow north-north-east instead of east-north-east.

There can now be recognised two peculiar features of the area. The first is the compactness of the Blean as a unit, leading us to ask why the

London Clay has been preserved as an upstanding plateau here but entirely removed to the east and west. The second characteristic is the constant presence of two dominant directions in the relief and drainage-pattern.

This paper is an attempt to explain these two problems. Each of them is the type of feature which can often be accounted for in terms of structure, and accordingly an attempt has been made to elucidate the local structure by means of a stratum-contour map of the Eocene base (Fig. 2). This shows two parallel anticlines with complementary synclines occupying the western half of the Blean and pitching towards its centre, where there is an arcuate trough. This trough is flanked on the north-east, first by the end of the Thanet anticline, and beyond by a short north–south monocline. The combined result of these structures is to depress the London Clay stratum in relation to the Tertiary tracts to either side, so rendering it less vulnerable to erosion. This is a partial explanation of the first problem—the preservation of the Blean as a unit—but it is not the whole solution, as will be shown presently. The second problem—the origin of the regional grain—is clearly *not* solved by reference to structure, but a more comprehensive statement of it is now possible.

2. DRAINAGE DIRECTION

The streams follow the structural axes for an aggregate length of seven miles, which is $10\frac{1}{2}\%$ of the total drainage-length of the Blean. Over most of the area, however, they are markedly discordant with the structure, as is generally the case in the London Basin. For example, the Stour crosses the main Blean trough at Upstreet, and the Sarre Penn behaves similarly at Chislet Park; the Wantsum crosses the Thanet anticline, and the other small streams of the northern Blean pursue their paths to the sea following both dip and strike directions locally, but often accordant with neither. It seems unlikely, therefore, that the seven miles of harmony between the drainage and the disposition of the strata represent anything more than adventitious agreement.

Nevertheless one cannot dismiss the stream-pattern of the Blean as simply dendritic. A comparison with the irregular river net of any typical tract of clay immediately throws fresh emphasis upon the two recurring directions already noted in the Blean streams. Quantitative analysis shows that the east-north-east direction accounts for 41.5% of the total sixty-six miles, while the north-north-east reaches account for 26.6%. Only one third falls outside these two categories, and this is composed only of insignificant tributaries.

Patently, the drainage-system has been subject to guidance, and since this guidance is not structural, some alternative cause must be sought. The present topography offers no clue as to the nature of this cause; it is,

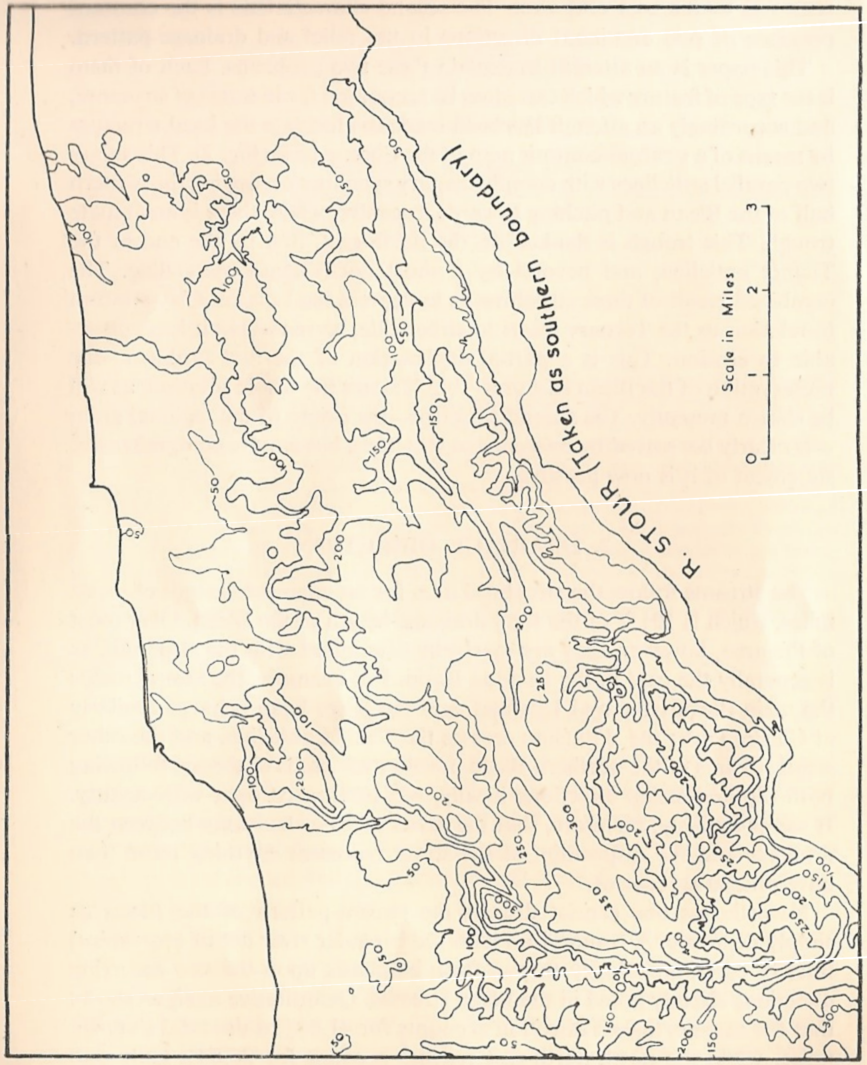

Fig. 1. Relief. Note the Herne Depression, marked out by the 50 ft.-contour

therefore, necessary to adopt the genetic approach and reconstruct, as far as possible, the evolution of the drainage-system. River-terraces must be examined in order to discern the former positions of the streams. The physical map alone is inadequate for this purpose: it presents the oversimplified picture already drawn, and allows the more delicate detail to slip through the coarse mesh of the contour-interval. Close field scrutiny has been carried out, and upon this a denudation chronology of the area has been based.

A brief reference must be made to Coleman (1952) to which this paper is the sequel. The field evidence was there reproduced in map form, and it was demonstrated that the Stour had persistently migrated eastward from the western summit of the Blean to beyond its eastern margin. In its passage it produced a flight of broad north–south terraces at very close vertical intervals. These surfaces are now preserved upon the interfluves and are the cause of the general plateau-like character. They are related to old sea levels at 400 ft. (approx.), 350 ft., 300 ft., 265 ft., 205 ft., 160 ft., 125 ft. and 100 ft., and also to two lower stillstands which are termed the Upper and Lower Reculver stages. The surfaces have been transversely dissected by the minor, east-north-east, streams which are responsible for the detailed modelling of the area, and have themselves left small terraces. The terrace evidence is here presented in the form of a block-diagram (Fig. 3).

The natural parallelism of the minor streams can only spring from a simple uniformity of origin. Though they now reach the sea independently of the Stour, they were formerly its left-bank tributaries. As the parent river migrated eastward it exposed a series of abandoned flood-plains. These acted as initial surfaces across which the young family of left-bank affluents extended themselves in unison. They were not absolutely at right angles to the trunk stream, being directed slightly downstream. Eventually, they became superimposed through the alluvia on to the London Clay beneath.

Each tributary was compounded of a series of segments added stage by stage as the Stour migrated. The age of each segment can be determined within very narrow limits. The maximum limit is controlled by the fact that no reach can be older than the particular terrace of the Stour which it traverses, for no pre-existing stream could have survived the relentless passage of the Stour as it swept the landscape clean and laid down a fresh gravel carpet as a datum-plane for later dissection. In many cases a minimum age can also be set, on the evidence of the small terraces formed by the tributaries themselves. At first the streams were not large enough to cut such features, but, as they lengthened, their power and volume increased and they were able to cut and build small flats, especially near their confluences with the Stour. The 205-ft. stage is the first at which such evidence is normally found.

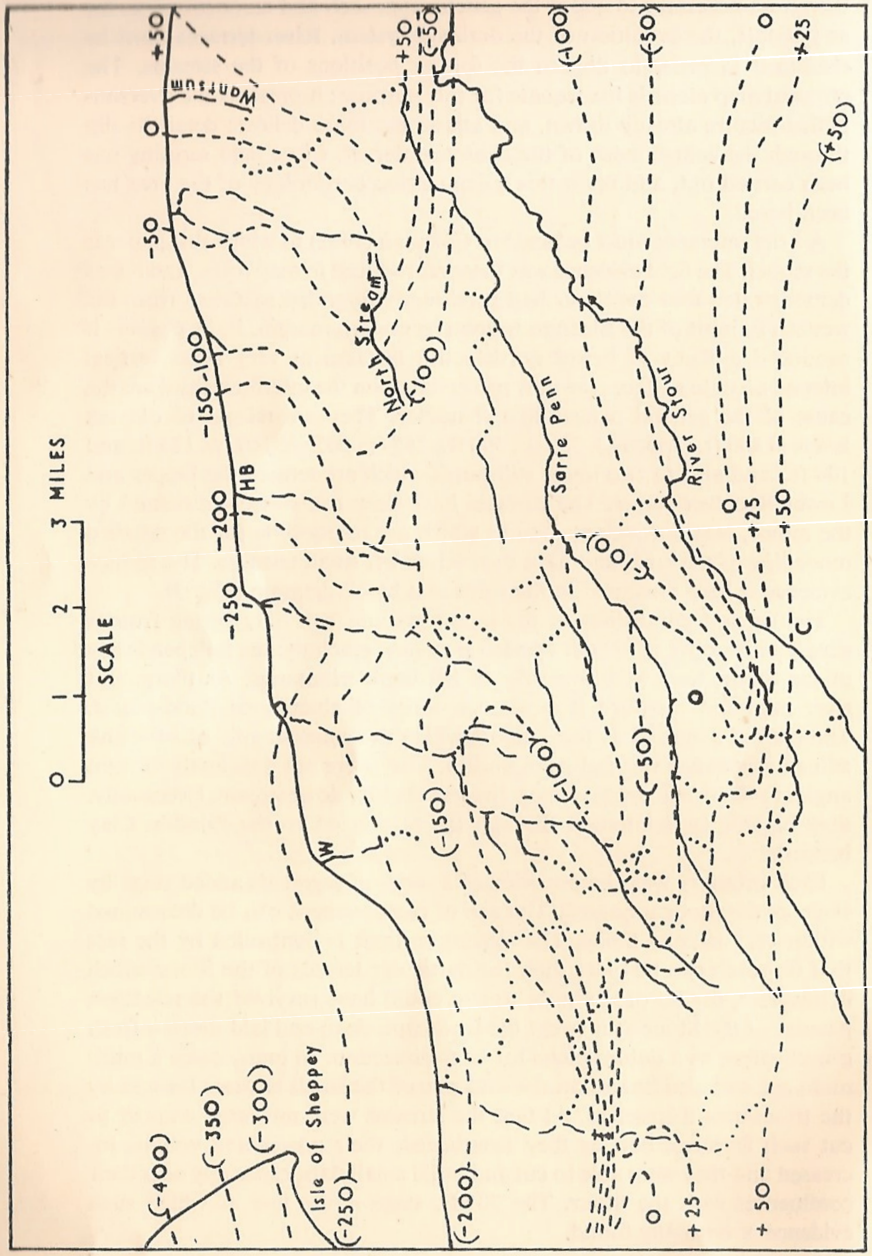

Fig. 2. The relations of drainage-pattern and structure
— — — Sub-Eocene stratum contours (Heights in ft. O.D.)

To assist examination of the individual streams the drainage may be divided into three basins (Fig. 4). In the south is the Harbledown Stream which was influenced by the proximity of the Stour. In the north is a group of streams which have been influenced by the proximity of the sea. In the centre is the Sarre Penn system. The Sarre Penn is one of four streams which flow east-north-east from the summit of the Blean, and is alone among the four to maintain this same direction across the whole width of the area. The flats upon which its reconstruction is based all lie close to the river, indicating that it has not roved far from its present line during the whole period of its development. Its tributaries also show four short east-north-east reaches.

The growth stages of the Sarre Penn form a complex sequence which can be most simply described as a logical 'chain-reaction' of stream extensions and diversions. Essentially, three parallel streams traversed the central Blean and two of them underwent dismemberment to the profit of the third, the Sarre Penn itself. The middle member is now divided into two parts, and the northerly one into three, of which one no longer feeds the Sarre Penn system. The disintegration has been progressive: the streams' upper courses were broken before their lower extensions were formed and it is easy to see why this must inevitably have been so. The streams were so close that they could co-exist only so long as none of them had cause for strong lateral corrasion. Extension at the lower end meant, in due course, incision in the middle and upper reaches when the tributaries had adjusted themselves to the lower base-level at their entry to the Stour. With such incision came the development of valley-side gullies, and competition between these would give opportunity for capture. In the earlier stages the northern member was diverted northward, but after this the Sarre Penn assumed the rôle of master stream and now provides the sole outlet for the integrated drainage system. Five captures can be detected within the basin, and each is witnessed by an elbow of capture, a beheaded stream and a windgap or equivalent feature which allows the episode to be dated. Fig. 4 illustrates the capture-sequence which can be built up in detail, stage by stage.

The last two maps in Fig. 4 depict changes in the northern Blean also. Both the Longreach and the North Streams must have had very similar histories, but the evidence pertaining to the latter is more abundant, and this only will be discussed here. The stream itself is now no more than a shrunken remnant on the eastern margin of the Blean, but terraces of the 100-ft. and certain earlier stages can be traced west of its present source for several miles, through a windgap at Herne, along the southern edge of the Herne Depression, and then through a large and conspicuous windgap in the western boundary of the Blean. It follows that the original source was well to the west of that boundary: in fact, the Blean must have formerly

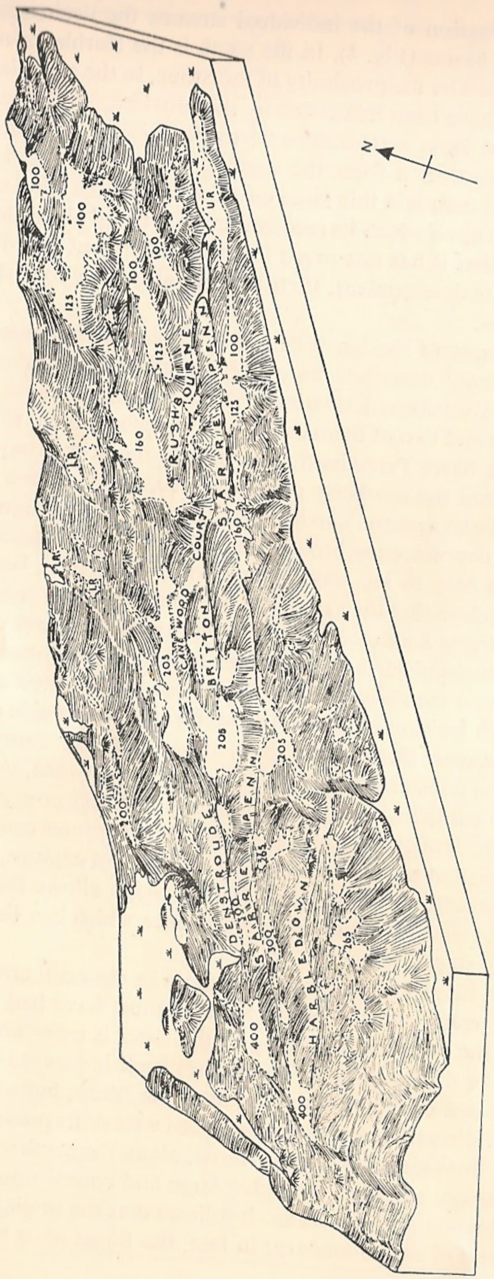

Fig. 3. Block diagram showing erosion-surfaces

possessed a considerable wing of high territory adjoining its north-west quadrant. Its severance from the kindred clay-tract of Sheppey could hardly have begun.

Up to and including the 100-ft. period the North Stream continued to extend itself in the wake of the retreating Stour, but the Reculver period witnessed a complete reversal in this trend, and stream dismemberment became the dominant form of change. The Herne windgap at 90 ft. indicates a first diversion, but this is far from a simple case, as one searches in vain for an elbow of capture, or indeed for any trace of the diverted reach. The little Herne Bay stream is in the right position to have effected this capture, but it no longer retains the spoils of piracy. It is, in fact, hardly more than a trickle, yet it must formerly have possessed a sufficient volume to have carved the eastern wall of the depression, and such extra volume is evidently reconcilable with the hypothesis of capture. As the stream cut back headward at the stimulus of coastal retreat, it could not avoid intersecting the line of the North Stream and thus diverting it. While this pattern of drainage lasted (Fig. 4F) the southern and eastern walls of the depression were undercut, and its floor roughly flattened at the Upper Reculver level. This floor has since been dissected by the north-north-east streams, but relics of it are preserved as small flats along the modern interfluves.

Resembling the Herne Bay Stream in their late origin and rapid headward erosion, all of these north-north-east streamlets were as well fitted as the latter to intercept the North Stream, and it appears that each in turn did, in fact, act as pirate. When reinforced by this additional supply of water, they were able to carve out broad Lower Reculver terraces which are much too large to be their unaided work in their present condition. Once the stream at Whitstable had effected a similar interception, the North Stream could no longer enter the Blean at all. Its surviving headwaters were confined to the Swale basin, and the broad windgap, noted above, was left abandoned. But meantime the normal ridge and valley character of the northern Blean had been destroyed and replaced by the present marked depression with its north-north-east streams.

It is now clear that these north-north-east streams are simply the normal right-bank tributaries of those flowing east-north-east. The coastal ones must have originated as the affluents of a river which lay offshore of the present coast, and so fall into pattern, despite their greater size. The rapid recession of the coast, which locally exceeds three feet per annum, indicates that room for such a stream must have existed in the quite recent past, and in more remote times there may have been several. Their valleys would have been progressively washed away as the sea advanced southward, and their right-bank affluents brought into direct contact with base level, with consequent rejuvenation and headward erosion. The Bishopstone

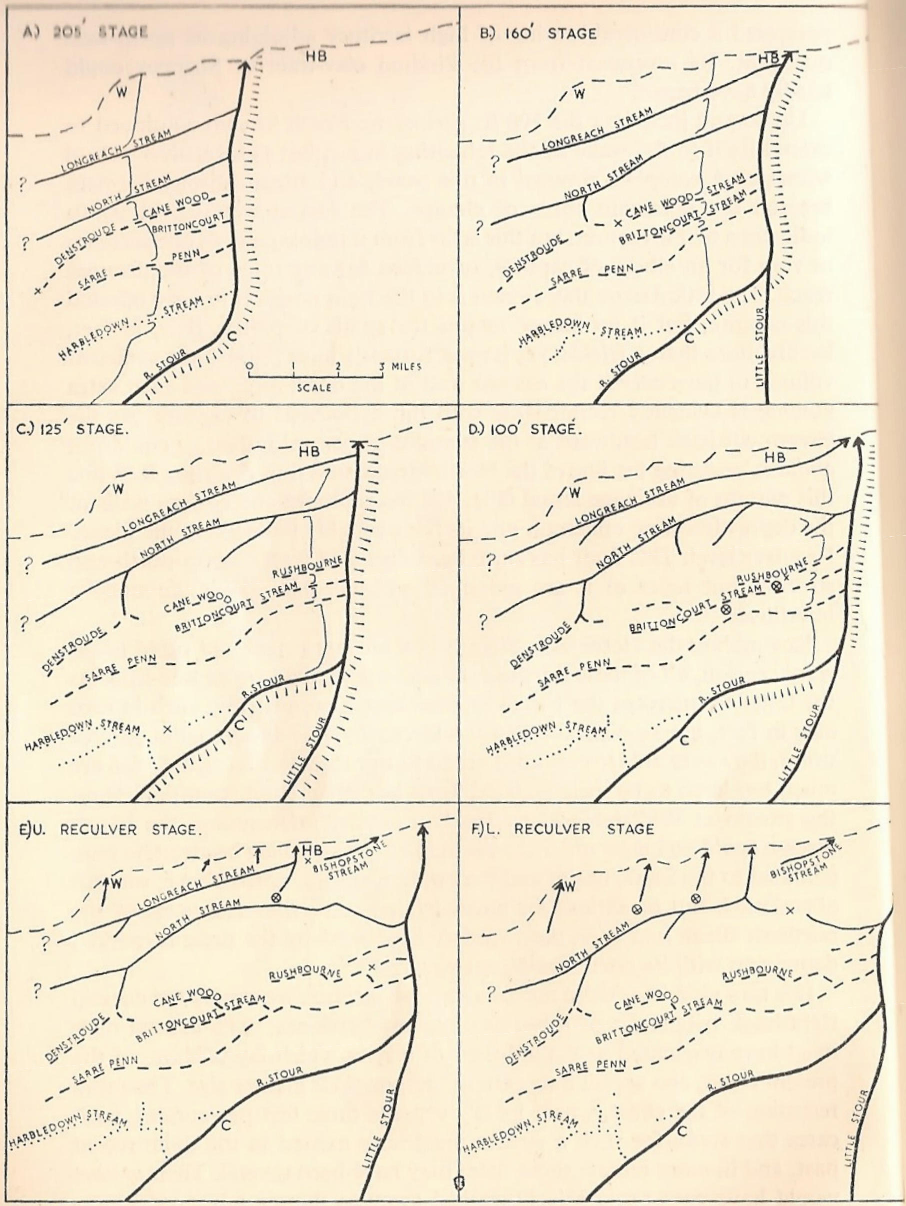

Fig. 4. The growth stages of the drainage-system

———— Streams of the northern Blean system
– – – – – – Streams of the central Blean, or Sarre Penn, system
. . . . Streams of the Harbledown system
× Site of windgap
⊗ Site of incipient capture
C. Canterbury W. Whitstable H.B. Herne Bay

ravine, a classic Eocene locality near Herne Bay, is a modern example of similar rejuvenation, which convincingly indicates how the formerly tiny tributaries could be endowed with the power to effect the captures described.

The two dominant valley-directions in the Blean have now been shown to be an integral part of a coherent pattern of drainage development. The same facts also have an illuminating bearing on the other problem under consideration, namely the preservation of the Blean as a compact plateau.

3. THE PRESERVATION OF THE BLEAN AS A PLATEAU

Fig. 5, a section running along the Sarre Penn and the interfluve to the south of it, demonstrates that the progressive eastward extension of the streams has in general restricted their depth of incision, and so allowed the preservation of the clay-cover, which has not been preserved to the east or west. The clay is left white and the underlying beds shaded, in order to portray more clearly two height comparisons which the diagram is designed to make. Firstly, it compares the east-north-east streams (exemplified by the Sarre Penn thalweg) with the simple dip-streams to the west. The change in valley-direction at the watershed between the two brings the high source reach of the former into juxtaposition with the low middle reach of the latter. They are, therefore, separated by a topographic break, and it is the coincidence of this break with the structural pitch that makes the western boundary of the Blean so distinct.

The second comparison is between the existing east-north-east streams, and the theoretical dissection which would have occurred if the Stour had not migrated. Had the Stour remained in its earliest position, it would have incised its valley vertically down to present base-level. It would have cut through the London Clay and have removed it from the interfluves on either side. In that case there would have been no homogeneous clay-plateau, even despite the local structural depression of the clay. We may take another theoretical case in which the Stour migrated only half-way across the Blean, and cut down to present base-level in that position. It would again expose the Lower London Tertiaries, as the diagram shows, and furthermore the east-north-east streams would have been shorter and steeper than they are in fact. They, too, would have cut down to Lower London Tertiaries, and again there would have been no continuous unit of clay. But in actuality the migration of the Stour has drawn out these tributaries for several miles. Their gradient is therefore considerably lessened: their courses lie too high to penetrate the clay-cover. Thus the process of tributary extension is intimately related to the present conformation of the Blean's surface.

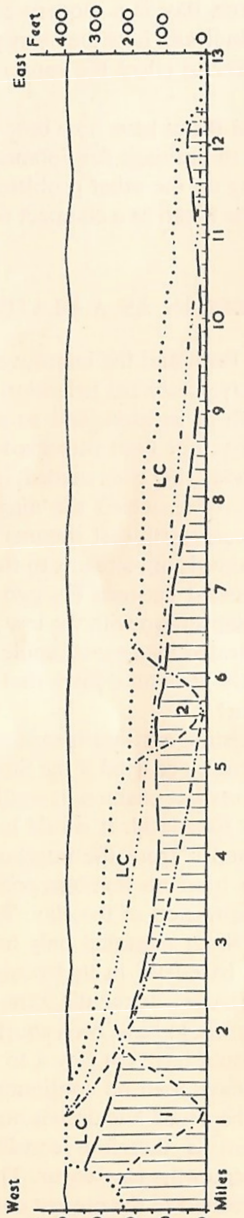

Fig. 5. Diagram to explain the preservation of the London Clay cover in the Blean

- Initial surface at 400 ft.
- Base of London Clay
- Lower London Tertiaries
- Surface of interfluve south of Sarre Penn
- Thalweg of Sarre Penn. London Clay breached only in extreme east
- First theoretical transverse profile of Stour Valley. In this case it is supposed that no migration occurred and the London Clay is deeply breached
- Second theoretical transverse profile of Stour Valley. Migration is fixed at half the true distance, and the clay cover is breached
- Theoretical longitudinal profile of Sarre Penn in the second case, steeper than at present and breaching the clay throughout almost its entire length

4. CONCLUSION

This analysis of the relief and drainage of the Blean has been based upon the evidence contained within the minor stream-valleys themselves. Its conclusion is that an orderly sequence of stream extensions and integrations occurred, and is competent to explain both of the problems which the area presents to the geomorphologist on first examination. It is quite independent of the evidence afforded by the main terraces of the parent Stour: it is, however, more fully intelligible in relation to the latter, and at the same time provides complementary testimony to the history of migration which has been traced out elsewhere.

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The Annual Report of the Council of the Geologists' Association for the Year 1953

THE NUMERICAL STRENGTH of the Association on 31 December 1953, was as follows:

Honorary Members	20
Ordinary Members:	
Life Members (compounded) ...	175
Annual Subscribers	1765
	1960

During the year ninety-three new members were elected, and the Association lost 147 members through death, resignation and removals under Rule XI for failure to pay subscriptions.

Thus, the membership has suffered a net loss of fifty-four.

The list of deceased members is as follows: A. C. Ballard, Miss Grace Bigby, A. Bigot, W. N. Croft, R. E. R. Evans, C. Green, I. F. Harrison, F. N. Haward, J. Jack, J. Johnstone, F. D. Jones, E. Lawrence, Miss Mairet, E. Nuttall, W. Rivers, E. W. Skeats, L. B. Smyth, Miss Elsie White, J. N. Woodhead and A. Wrigley.

Obituary notices will be published in the PROCEEDINGS.

FINANCE

Our accounts for 1953 are presented in a simpler form than previously and it is hoped that members will therefore be encouraged to look at them carefully and so appreciate the real position of the Association financially.

On the revenue side our income from subscriptions and admission fees has increased to £1727 10*s*. 0*d*. against £1488 10*s*. 0*d*. in 1952. The arrears outstanding at the end of 1952 have realised £75 more than was expected but our arrears position is still a cause for anxiety, at £691 10*s*. 0*d*. it is even higher than at the end of 1952.

Our expenditure generally has increased although the cost of the PROCEEDINGS is slightly less than for 1952. The greater part of the item for Accountancy and Secretarial services was due to the temporary difficulty in finding a successor when Mr. Wrigley had to relinquish the treasurership owing to illness. (The anticipated cost of this item in 1954 is approximately £35.)