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THE GEOMORPHOLOGY OF PART OF THE BASIN OF THE RIVER TEME IN WORCESTERSHIRE AND HEREFORDSHIRE.

Thesis submitted for the degree
of Master of Philosophy, at the
University of Southampton, 1972

Brian Howard Adlam.

THE GEOMORPHOLOGY OF PART OF THE BASIN OF THE RIVER TEME IN WORCESTERSHIRE AND HEREFORDSHIRE.

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FACULTY OF ARTS

GEOGRAPHY

Master of Philosophy

THE GEOMORPHOLOGY OF PART OF THE BASIN OF THE RIVER TEME IN WORCESTERSHIRE AND HEREFORDSHIRE

by Brian Howard Adlam

The lower courses of the River Teme and its tributary the Leigh Brook cross at right angles the main axial line of the Malvern Axis fold and fault complex. In addition, the Shelsley Reach of the Teme occupies part of a major depression west of and parallel to the Malvern Axis. Here, both the main stream and its tributaries are deeply incised. [The well-developed sequence of terraces of the Teme must further be related to the terrace sequence of the main trunk river, the Severn. [Since the lower Teme basin was free from ice during the last (Devensian) glacial advance of the Pleistocene period, it can only have been affected by periglacial and meltwater action. However, earlier glacial advances may have had some effect upon the development of the present landscape.]

It is here proposed that the Teme has never occupied the whole of the broad valley west of the Malvern Axis, and that its present course is primarily the result of normal fluvial processes. Following initial superimposition west-to-east, the process of adjustment of drainage to the emerging Malvern structure has proceeded. Glacial interference is proposed as being limited to one major pro-glacial lake overspill during Devensian times which has resulted in:

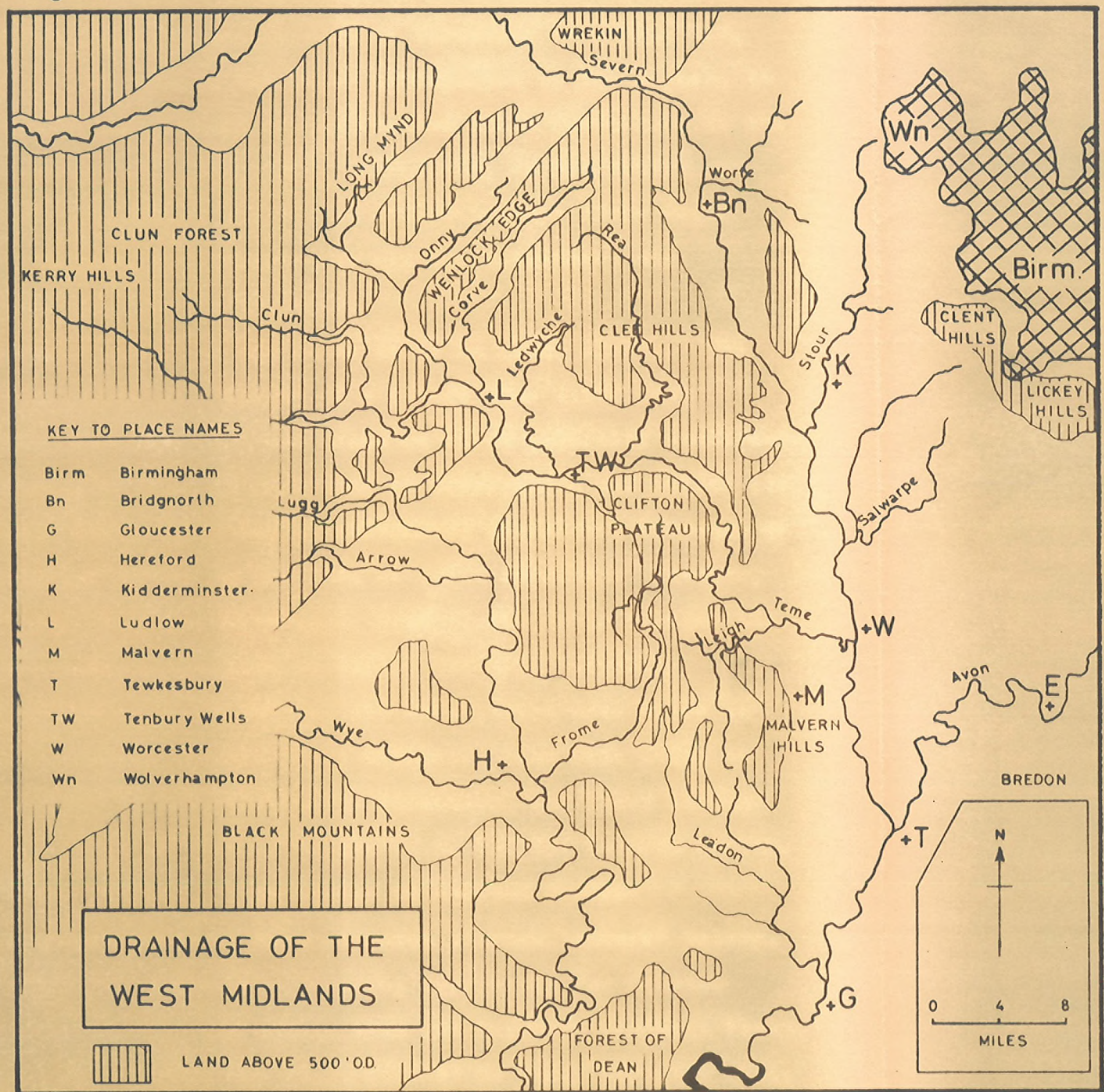
i) the reversal of drainage in the Tenbury Reach

ii) the creation of the valley-in-valley form of the Shelsley Reach

iii) the consequent incision of tributaries downstream from the site of overspill.

The Teme and Leigh Brook gaps through the Malvern Axis ridge are interpreted as the results of superimposition of drainage, though temporary blockage by ice during the Gippingian period is suspected. The terraces of the Teme indicate a connection with the River Severn which dates back at least as far as Wills' Bushley Green times.

Fig 1.1


WREKIN
Severn
LONG MYND
Wn
Worfe
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CLUN FOREST
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Clun
Ledwyche
CLEE HILLS
CLENT HILLS
Stour
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L
LICKEY HILLS
KEY TO PLACE NAMES
Birm Birmingham
Bn Bridgnorth
G Gloucester
H Hereford
K Kidderminster
L Ludlow
M Malvern
T Tewkesbury
TW Tenbury Wells
W Worcester
Wn Wolverhampton
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CLIFTON PLATEAU
Salwarpe
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Arrow
Teme
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MALVERN HILLS
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Frome
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DRAINAGE OF THE WEST MIDLANDS
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Chapter One - Introduction.

The River Teme rises in the Kerry Hills of Radnorshire and thence flows in a generally southeasterly direction for some 70 miles to its confluence with the River Severn near the city of Worcester (see Fig. 1.1, P. 1). One of the major tributaries of the Severn, it drains large areas of the central Welsh Borderland in the counties of Radnorshire, Shropshire, Herefordshire and Worcestershire, and in its course crosses three major geological divisions - the Old Red Sandstone, the Silurian and the Triassic.

The course of the river is by no means simple. The Teme rises at a height of a little over 1,500 feet (457 metres) O.D., and flows at first generally southeastwards, in what is described by Dwerryhouse and Miller (19) as a steep-sided valley containing occasional evidence of glacial action in the form of drift deposits. However, below Brampton Bryan (G.R. 370725) the river changes its characteristics most markedly, becoming intensely meandering as it crosses the broad, flat area known as the Vale of Wigmore (G.R. 413691). From this area, it changes to a northeasterly direction, and flows through the gorge at Downton Castle (G.R. 430735) towards Ludlow. (G.R. 513750). From Ludlow to Ashford Bowdler (G.R. 515706) the Teme occupies a broad 'mature' valley, and flows southwards, heading apparently for Orleton (G.R. 494670) and thence into the Lugg-Wye drainage basin. But near Woofferton (G.R. 518686) it turns abruptly east, past Tenbury Wells (G.R. 580680) and towards the line of the Malvern Axis, a structure of Carboniferous age (see Chapter Two, P. 21). In this section, the river is flowing wholly upon rocks of the Old Red Sandstone group and its course is not related either to lithology or to structures within the rock. From Stockton-on-Teme (G.R. 716673), the river turns southwards again to flow parallel to the Malvern Axis for some eight miles, its position being perhaps influenced by the geological boundary between the Old Red Sandstone to the west and the Silurian to the east, and also by the position and alignment of the fold-fault structure of the axis. At Knightsford Bridge (G.R. 734558) a further sharp change of direction causes the river to cross the Malvern Axis through a fault-controlled gap, and the lower nine miles or so of its length is in an easterly direction to the confluence with the River Severn below Worcester.

The area to be considered in this dissertation comprises that part of the drainage basin of the River Teme which lies downstream from Stockton-on-Teme, although some reference to higher parts of this drainage basin must of necessity be made. In addition to the features of the valley of the main river, this work is also concerned with the valleys of the major tributaries in this section - namely the Whitbourne Brook, the Sapey Brook, the Leigh Brook, the Cradley Brook and the Laughern Brook (see Fig. 1.2, P. 4).

Downstream from Stockton-on-Teme, the drainage area can be sub-divided, for convenience, into three sections (see Fig. 1.3, P. 5).

1. <u>The Shelsley Reach</u> - from Stockton-on-Teme to

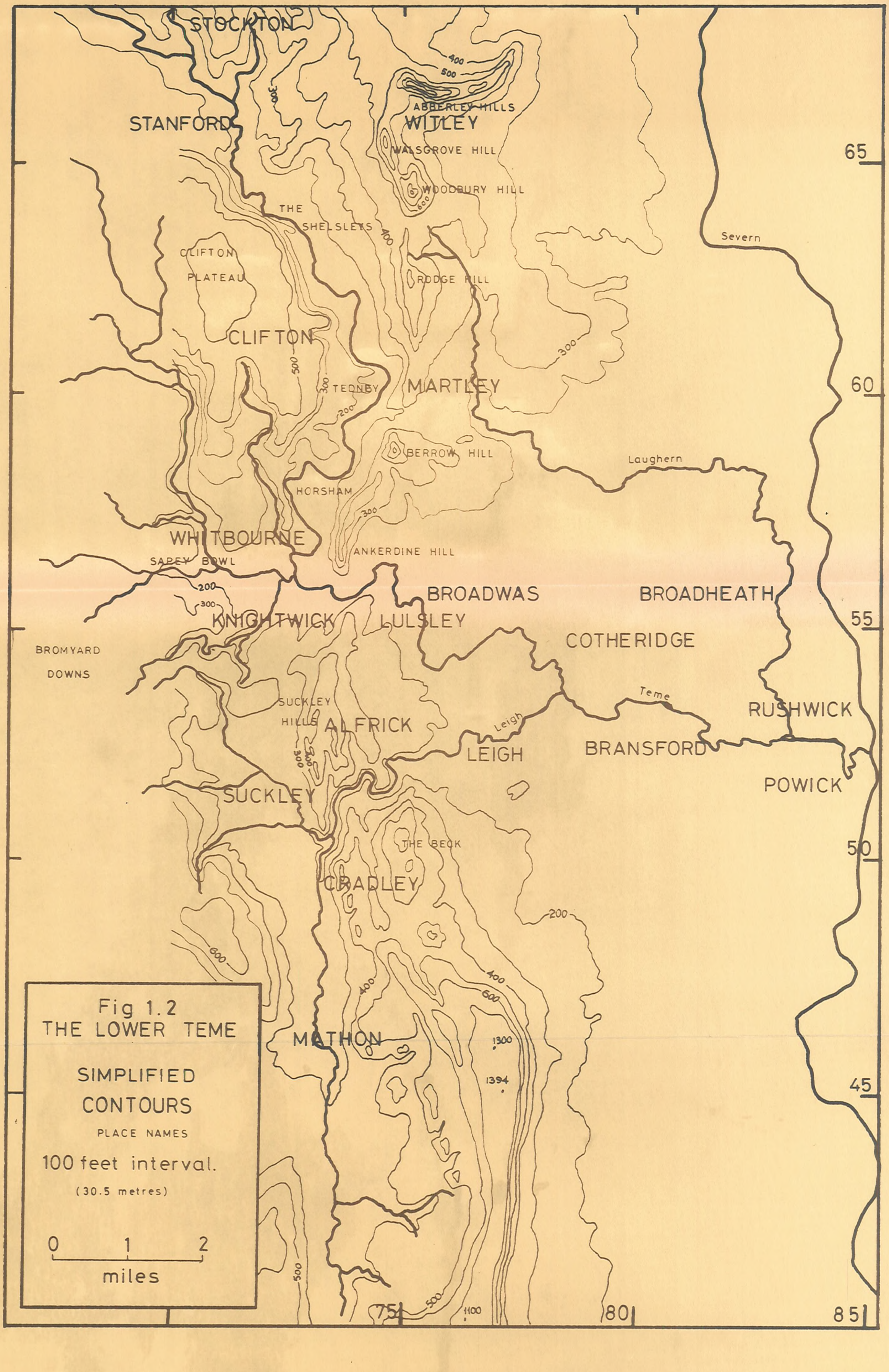


Fig 1.2
THE LOWER TEME

SIMPLIFIED CONTOURS
PLACE NAMES
100 feet interval.
(30.5 metres)

0 1 2
miles

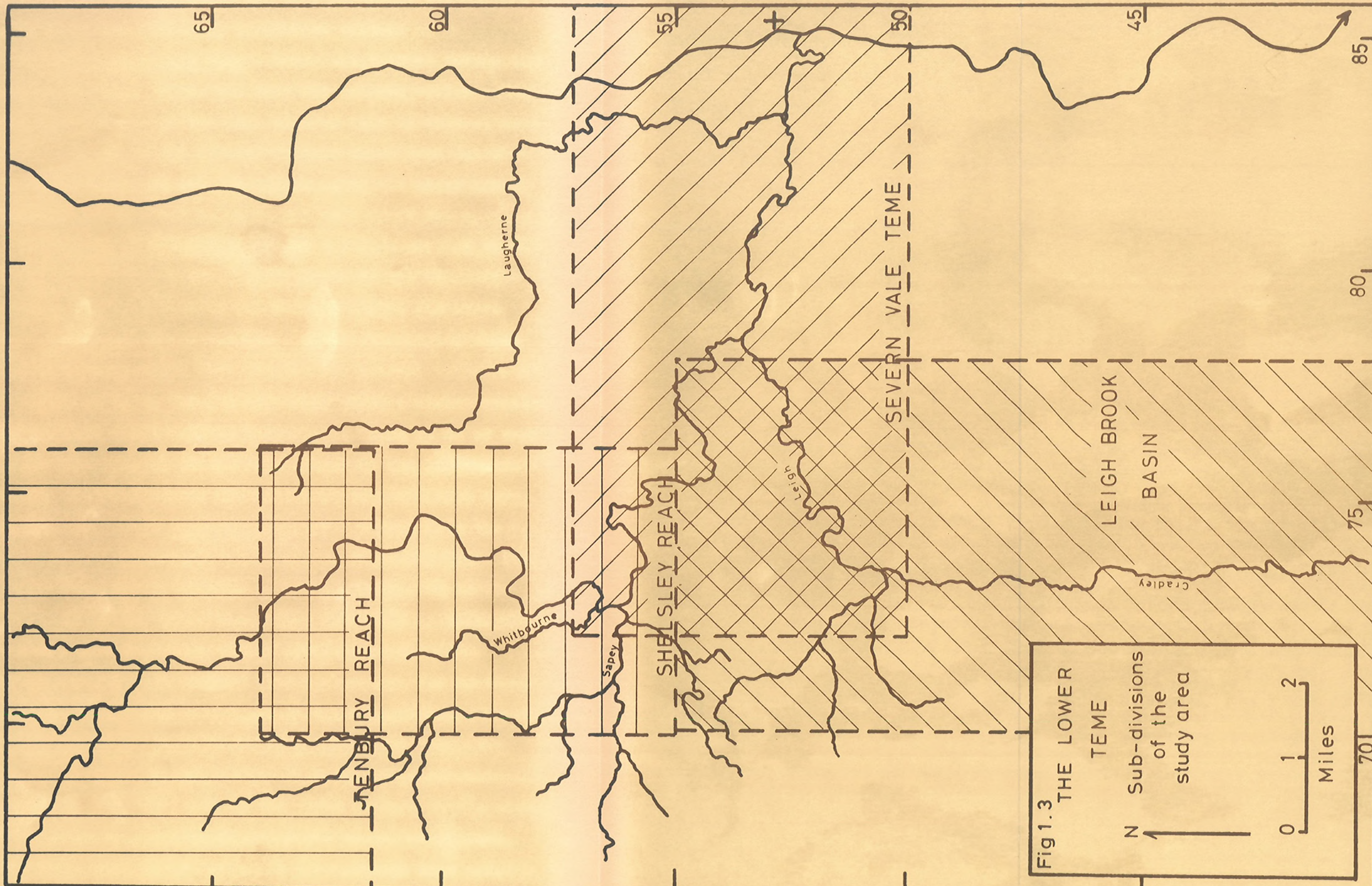


Fig 1.3 THE LOWER TEME Sub-divisions of the study area

Knightsford Bridge, where the Teme parallels the Malvern Axis in an asymmetrical, gorge-like valley.

2. The Severn Vale Teme - below Knightsford Bridge and across the axis, where the Teme has cut its valley across the western side of the much broader Vale of Severn; here the valley is an ill-defined feature which cuts across the north-to-south aligned landforms of the major trunk river.

3. The Leigh Brook Basin - the drainage area of the Leigh and Cradley Brooks, tributaries of the Teme which rise in the area west of the Malvern Hills, and which cross the line of the Malvern Axis in the Longley Green gap (G.R. 735505).

Although lying outside the study area, a fourth section of the Teme basin must be considered, since it is of very great significance in the development of the lower Teme - namely that section of the valley between Stockton and Woofferton. This Tenbury Reach has recently been the subject of a geomorphological investigation by Cross (8).

Considerable attention has already been paid to the landscape of the Upper Teme basin - notably by Dwerryhouse and Miller (19), Cross (7&8), while Wills (60&62), Tomlinson (54) and Shotton (47) are perhaps the most important of the many workers in the Severn area. However, a gap exists in the literature on the lower Teme, the valley of which displays many features of geomorphological interest.

Between Stockton-on-Teme and the Severn confluence, two major changes of direction have already been noted (see P. 2,3) - changes which are associated with changes of valley form. Dwerryhouse and Miller (19) have described the valley above Stockton-on-Teme as a 'reversed' reach, narrowing downstream instead of opening out, and with a cross section which steepens in the same direction. Where the river parallels the Malvern Axis (the Shelsley Reach) the valley becomes gorge-like, with a relatively broad and flat floor lying at approximately 135 feet (40 metres) O.D.; to the west rises the Clifton Plateau at over 600 feet (183 metres) O.D., whilst to the east the summits of the Malvern Axis reach heights of over 700 feet (213 metres) O.D. Downstream from Knightsford Bridge, the valley becomes broader and much less distinct as the Teme crosses the terrace sequence of the River Severn; the 'summits' here reach little more than 200 feet (60 metres) O.D.

To the south of the Shelsley Reach of the Teme lies a broad 'mature' valley, aligned north to south, and lying to the west of the Malvern Hills (see Fig. 1.4, P. 8), which has attracted the attention of Groom (26&27), Wills (62) and Hey (31&32). At the present time this valley is occupied in its northern part by the Leigh and Cradley Brooks, tributaries of the Teme, and in its southern part by the Glynch Brook, tributary to the River Leadon. The valley appears to be much too large and mature to be the product of the present small streams, while its position and alignment is such that the suggestion has been made by the three authors listed above that it may be a 'natural' continuation of the present Shelsley Reach of the Teme. It is envisaged that a large river once flowed southwards, parallel to the Malvern

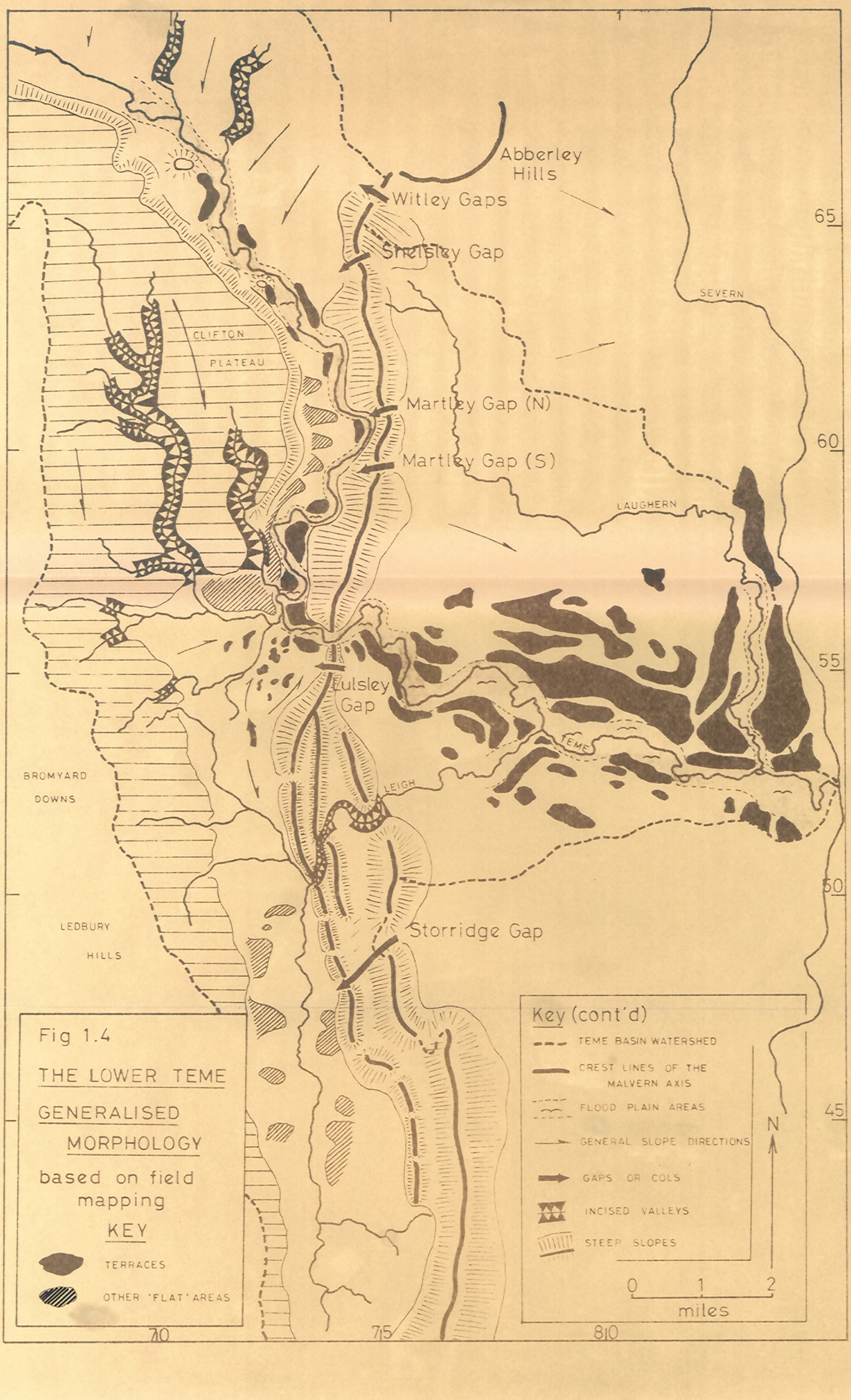


Fig 1.4

THE LOWER TEME

GENERALISED MORPHOLOGY

based on field mapping

Axis, from a source somewhere in the vicinity of Stockton-on-Teme, to a forerunner of the present River Leadon, and thence into the Severn near Gloucester.

In this southern area, the courses of the Leigh and Cradley Brooks are of interest. The Leigh Brook rises on the eastern slopes of the Bromyard Downs, and is joined at Longley Green (G.R. 735505) by the Cradley Brook, which rises in the south near Eastnor (G.R. 735373). From Longley Green the combined stream crosses the Malvern Axis at right angles to the geological boundary between the Old Red Sandstone and the Silurian, and across the crest of a small anticline in the Silurian rocks. Hey (31) concludes that this discordance may be the result of glacial interference during the Pleistocene, and that the valley across the Axis may represent a glacial overspill channel. However, since such channels tend usually to be straight or gently curving features, the meandering nature of this crossing would seem to be problematical. Moreover the meandering valley is deeply incised across the structure, so that the possibility of superimposition at an earlier date seems worthy of some consideration.

The gaps occupied by the Teme and the Leigh Brook are the only two water gaps across the Malvern Axis. There are, however, other cols which interrupt the continuity of the ridge (see Fig. 1.5, P. 10). As the following list will show, these dry gaps are higher in the north, as also are the intervening summits;

1. Great Witley (G.R. 745665) at 600 - 625 feet (182.8 - 190.5 metres) O.D.

2. Shelsley Beauchamp (G.R. 746636) at 475 feet (144.8 metres) O.D.

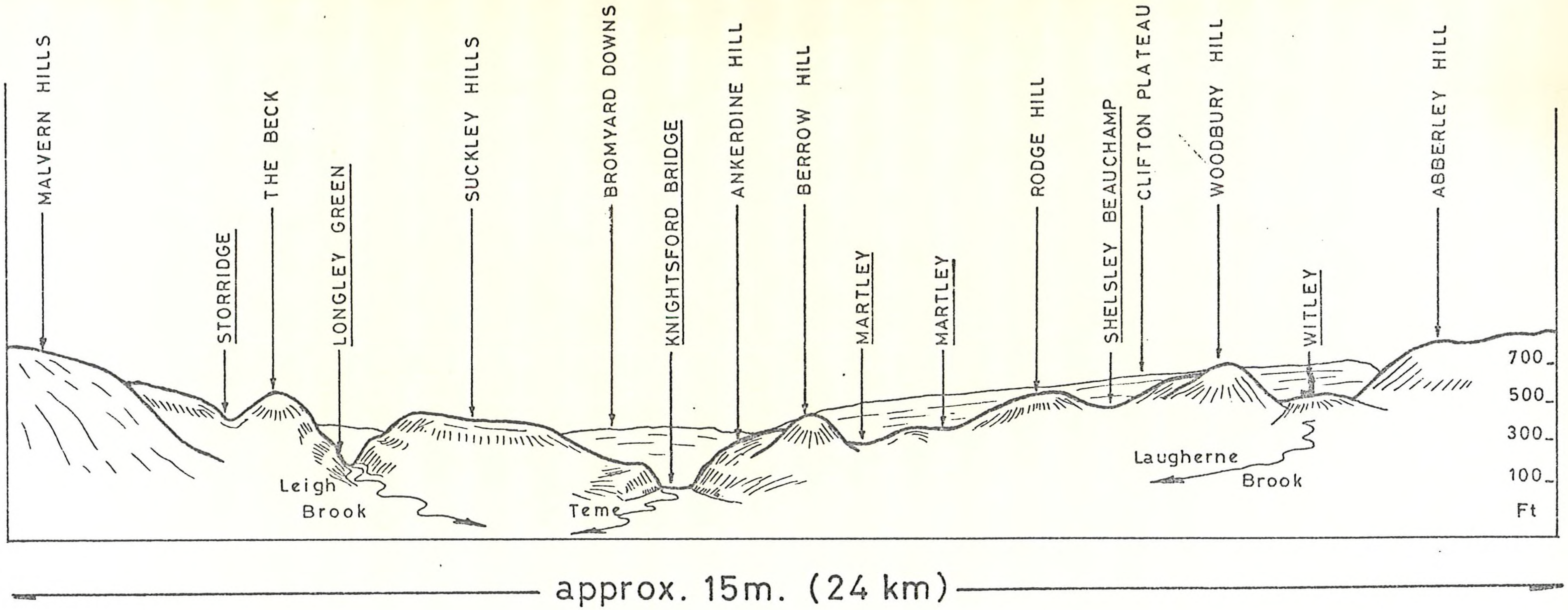


Fig 1. 5 DIAGRAMMATIC SKETCH TO SHOW THE RELATIVE HEIGHTS AND POSITIONS OF THE COLS ACROSS THE MALVERN AXIS.

3. Martley (G.R. 748606) at 315 feet (96.0 metres) O.D.

4. Martley (G.R. 745595) at 275 feet (83.8 metres) O.D.

5. Lulsley (G.R. 738554) at 230 feet (70.1 metres) O.D.

6. Storridge (G.R. 750486) at 430 feet (131.1 metres) O.D.

The water gap occupied by the Teme is at 84 feet (25.6 metres) O.D. and that occupied by the Leigh Brook is at 200 feet (61.0 metres) O.D. This sequence of cols, and its relationship with the development of the Teme valley, presents a further problem in the study area.

The valley of the River Teme downstream from Woofferton, although ill-defined in its lower part below Knightsford Bridge, contains a number of terrace fragments and 'flats', most of which support gravel deposits. Cross (8) has mapped and surveyed these remnants as far downstream as Ham Bridge (G.R. 738611) in his considera- tion of the geomorphology of the Ludlow district. In the present study, the author has mapped remnants between Stockton-on-Teme and the Severn confluence near Worcester. Some at least of these remnants of former valley floors should relate to the terraces of the Severn, as set out by Wills (62), since the Severn - Teme confluence has served as local base-level for the Teme for at least part of its geomorphological history. In this context, it is the higher terraces which may prove to be the more significant in that they may not relate to terraces of the Severn, but give support to the earlier mentioned suggestion (P. 7) of a major river flowing west of the Malvern Hills (Hey, 31&32).

A further area for investigation is that of the valleys of the Whitbourne and Sapey Brooks. These two streams are nowhere more than six feet (2 metres) in width even in their lowest parts, while in their upper reaches they are little more than 'ditches', one foot or so wide. Yet both occupy deeply cut, broad valleys on the southern side of the Clifton Plateau, the valley sides exhibiting generally convex profiles (see Fig. 1.4, P. 8). The incised sections appear to begin at around 400 feet (121.9 metres) O.D.; this height roughly coincides with the 'top' of the walls of the Teme gorge in the Shelsley Reach. Since the confluences of these two streams must have served as local base-levels, an incision of the tributary should reflect an incision of the main trunk valley. Moreover, terrace fragments here might provide some evidence relating to the evolution of the Teme valley, and any possible connection between the Shelsley Reach of the Teme and the valley west of the Malvern Hills.

That much of the study area was affected, both directly and indirectly, by the Pleistocene glacial advances has been extensively argued and demonstrated by Wills, Tomlinson and Shotton, amongst many others. The broad concensus of opinion is that while much of the area was beneath the ice sheets of the third advance, the fourth glacial phase did not bring active ice into the area, which was instead affected by various periglacial processes (see Fig. 1.6, P. 13); indeed it is probable that not even the highest parts of the Malvern Hills were under permanent ice and snow. The glacial history of the area will be discussed more fully in Chapter Three. (P. 50)

Fig 1.6 GLACIATIONS OF THE MIDLANDS, after L.J.Wills.

Limit of Devensian ice (4th advance)
Limit of Gipping ice (3rd advance)
Retreat stages of Gipping ice to show ice sources.
Present drainage lines

The purposes of this dissertation are:

1. To measure and record the landforms and landform assemblages of the area as defined.

2. To investigate further the possibility of a major stream flowing southwards, west of the Malvern Hills.

3. To relate, if possible, the terrace fragments of the lower Teme with those of Cross in the Tenbury Reach, and with Wills' sequence of the River Severn.

4. To attempt, through the interpretation of these features, a reconstruction of the evolution of the present landscape of the study area.

The methods of field investigation have involved the covering of the entire area for the purpose of mapping the landshape (Waters, 57), and to produce morphological maps of the four sub-divisions of the study area (see P. 3) For this purpose, a simple key of symbols was devised, so that relief forms might be easily identified. Since the focus of attention throughout is upon the features of the valleys, the maps are intended to show generalised slope form - concave, convex or rectilinear - and the positions and extents of the various 'flat' elements in the landscape. For those areas other than the main valleys, the generalised direction of slope has been shown, without attempting to indicate any further detail which, in the nature of this study, does not appear to be required. In many areas, initial investigation was carried out from stereo-pairs of air photographs which are mostly on a scale of about 1:10,000. The object of this study was to attempt to identify and delineate the 'flat' areas and the breaks of slope on the basis of the three-dimensional viewing, and then to transcribe this work onto Ordnance Survey maps on the scale of 1:25,000. Field checks and investigations were then carried out on these maps as bases, prior to any form of more accurate measurement.

It is appreciated that this method of mapping is subjective, and that the location of any landform boundaries on such a map is often a matter of personal judgements, liable to considerable operator variance. However, in such an extensive area, this variation and inaccuracy is deemed to be relatively unimportant when attempting to pick out the general characteristics of a landscape.

Once the landscape had been mapped in this way and so classified, field investigation involved more accurate mapping of the 'flats', the method used being that of Hare (29) in his work on the middle Thames. Breaks of slope were sighted against the skyline, against hedgerows, or against any other convenient features of the present landscape. Where a bluff is indistinct, the boundary has been drawn at the expense of the 'flat', so that 'flats' shown on the maps are to be interpreted as minimum areas. In other cases, the bluff is so indistinct that it was deemed inappropriate to attempt to suggest a clear boundary. Here, general slope arrows are employed, and the delimitation of the 'flat' is left equally vague. The field mapping was carried out mainly on the Ordnance Survey, 1:25,000 maps, but in the more complicated areas such as the Severn Vale Teme area (see Fig. 1.3, P. 5), maps on a scale of 1:10,560 were used.

In the identification of terrace remnants, deposits of gravel were sought, and since there are very few exposures, pits had to be dug to determine the presence or otherwise of such materials. These pits were always dug to a depth of more than one foot, or beyond the depth of normal agricultural activity, and the assumption is made throughout, that any deposits found below that depth are 'in situ' materials. The only 'flats' which have been included in the discussion are those where a significant proportion, or a layer, of pebbles was found, although it must be stated that not all pits revealed a distinctive pebble layer. A further reason for the digging of these pits was that over almost the entire surface of the Vale of Severn, the surface soils contain rounded pebbles, even beyond the strict valley confines, and on most summits. This fairly uniform spread of gravels over the surface below 250 feet (75.9 metres) O.D. is presumed to be the product of all forms of slope transportation, including periglacial processes, which have been operative in the area since at least the third glacial advance.

No attempt was made to establish the heights of the bases of the terrace deposits, although these heights might be seen as a more accurate means of assessing former valley levels and positions. A recent private 'megger' survey of a large sand and gravel extraction concern at Grimley (G.R. 830618) has shown that the base of the deposit of Severn gravels is extremely irregular, with a variation of up to 49 feet (15 metres). This suggests that the gravels were deposited upon a very irregular surface which may not have been a valley floor, and that the heights of deposit bases may therefore be of little value in attempting to determine pre-deposit surfaces. Thus the morphological evidence is used in the interpretation of the terraces, and it has to be assumed that these 'flat' surfaces approximate to the level of formation, and that subsequent surface lowering and modification have been only slight.

The altitude of terraces was determined by use of a surveying aneroid barometer. Traverses were based upon local bench marks as starting levels, so that heights were measured in feet O.D. (Metric conversions are also given in the tables, Figs. 4.2, 4.3 and 4.4, Ps. 85, 86 and 87). In all cases, traverses were of less than 90 minutes duration - as short a time as was practicable - to try to minimise errors which might be occasioned by changes of atmospheric pressure and temperature (Sparks, 51, and Powers, 42). All readings were later checked against a barograph trace and a thermograph trace, and pressure and temperature changes were then distributed over all the readings accordingly. The instrument used was a Short and Mason aneroid barometer, corrected for pressure and temperature, with a Vernier scale giving a nominal accuracy of plus or minus one foot.

The aneroid barometer was preferred to an abney level or other clinometer, since it is a more convenient instrument and giving a much greater total of measurements in any given time. Furthermore, it is felt that since the height of the terrace surface has been subjected to processes of denudation, the accuracy of an abney or clinometer survey is not justified. King (35) suggests that an accuracy of plus or minus five feet is sufficient for this kind of study of river terraces.

The section diagrams which are used are constructed from Ordnance Survey maps on the scales of 1:25,000, with further detail of shape being added from field measurements and observations. Angles were measured by using a Suunto clinometer. This method was adopted as a time-saver, and also because close and accurate detail of slope form was not deemed appropriate to this study.

Maps on the same scale were used as the basis for the construction of generalised contour maps, which attempt to reconstruct the whole landscape before dissection took place. The subjectivity of the method is again a distinct limitation, and in this sense, these maps are used more as illustrations of points made rather than as the basis for an hypothesis. The construction of such generalised contours in this area is rendered more difficult by the degree of dissection which has occurred, and the joining up of spur end contours across intervening valleys becomes a somewhat subjective technique.

Altimetric frequency analysis was not used as a method of research since for the most part, the 'flats' form only a very small proportion of the landscape, and there are no other extensive erosion surfaces for this method to demonstrate. Such a resulting histogram would merely illustrate the range of heights to be found within the area, with perhaps two concentrations of values to represent the surface of the Clifton Plateau, and the so-called flood plains of the two major rivers, the Teme and the Severn.

The interpretation of terrace data in Chapter Four and

Chapter Five is illustrated on the series of diagrams, where heights are plotted both against long profile of the present flood plain and also by means of height above flood plain. A height-range diagram is also used. The problem here has been to attempt to group the terraces, and thereby to suggest former valley levels. Since there is no generally acceptable objective method of achieving this end, several subjective methods are employed, and points of comparison between these diagrams form the basis of the conclusions.

Field identification and the groupings of the terraces would probably be more accurate and reliable had it been practicable to collect, analyse and relate deposit samples. However, it was observed in the field, from the pits and few exposures, that the pebble content of most of the terraces was remarkably similar, as is that of the lower terraces of the Severn (39), and 'suites' of pebbles relating to any one group of terraces are probably impossible to define without the use of thin sections of constituent rocks, and the tracing of such materials back to their points of origin. However, if the Teme valley terrace material is derived either from local sources or from glacial deposits, any clear distinction between levels may not even then emerge.

Other methods of terrace correlation, such as fossil study, the degree of dissection, and the weathering and degree of decomposition of 'marker' rocks, are likely to be similarly unrewarding since the time lapses between the various terrace stages of the river were so short that differentiation on any of these bases is likely to be equally tenuous.

For these reasons, terrace correlations suggested in this study are derived from field observations and measurement and morphological evidence alone, and the limitations of such a method are apparent.

Since the instrument involved in the field measurement of heights was graduated in feet, all heights quoted in the study are given as feet, and the metric equivalent is given to the nearest tenth. For reasons of consistency, distances are therefore given in miles rather than in kilometres.

Chapter Two - Geology.

1. The Rocks. (see Fig. 2.1, P. 22)

In terms of solid geology, the study area may be divided into five main areas:

a) The Pre - Cambrian granitic rocks of the Malvern Hills.

b) The Silurian rocks of the Malvern Axis.

c) The Old Red Sandstones, lying to the west of the Malvern Axis.

d) The Carboniferous rocks which occur in the north of the study area, together with a number of outlying occurrences along the Malvern Axis.

e) The Triassic rocks of the Vale of Severn, to the east of the Malvern Axis. (see Fig. 2.2, P. 24)

a) The Pre - Cambrian Rocks.

The Malvern Hills form a north-south range about 7½ miles long, rising like a wall from the southwestern approaches to the Midlands, and forming a marked boundary zone between the Trias of the east and the Devonian of the west. The materials of the Malverns are varied, and include granites, gneisses, schists, syenites, dolerites, diorites and many other intrusives, which have been discussed in great detail by Holl (33), and Groom,(26&27), amongst many others. Butcher (6) considers the structure to be of Carboniferous age, traceable from the South Wales Coalfield area, through into north Staffordshire. In plan, the range shows a curious dislocation which has resulted in the southern part lying further to the west than the northern part - a dislocation which was long believed to be the result of a great thrust-fault movement

FIG. 2.1

GEOLOGICAL FORMATIONS OF THE DRAINAGE AREA OF THE LOWER TEME

PLEISTOCENE AND RECENT	River terrace gravels, glacial tills, solifluction deposits, alluvium.
TRIASSIC	Keuper Marl Lower Keuper Sandstone
UNCONFORMITY	
CARBONIFEROUS	Clent / Haffield Breccia
UNCONFORMITY	
	Highley Beds, Sulphur Coal. Old Hill (Etruria) Marl
UNCONFORMITY	
DEVONIAN	Dittonian Psammosteus Limestone Red Downtonian Marls Temeside Beds Grey Downtonian Marls Ludlow Bone Bed
SILURIAN	Upper Ludlow Shales Aymestry Limestone Lower Ludlow Shales Wenlock Limestone Wenlock Shales Woolhope Limestone Llandovery Sandstones
UNCONFORMITY	
PRE - CAMBRIAN	Malvernian

N.B. Also a dyke at Brockhill (G.R. 725638) composed of dolerite, which is believed to be of Carboniferous age, and a syenite at Martley (G.R. 745595), surrounded by Carboniferous rocks.

from the southeast, known as the "Cheltenham Drive". This movement was also held responsible for the formation both of the eastern fault scarp, the fault dipping at angles of up to 45 degrees beneath the Trias to depths of over 5,000 feet (1,500 metres) (Dreghorn, 11&12, Butcher, 6), and also of the fold structures further north in the Silurian rocks of the Malvern Axis. Butcher also suggests that the Malvern rocks had been folded by some pre - Cambrian orogeny, and that this denuded fold-range was exhumed by late-Carboniferous events. (see Pp. 40 to 44 for further discussion of the structure of the Malvern range).

b) the Silurian.

There are no deposits of either the Cambrian or the Ordovician periods occurring on the surface in the study area, implying long periods of contemporary erosion. The Silurian period, however, was a time when the sea spread progressively across the Midlands and ultimately as far east as the Baltic Sea, from the Welsh geosyncline (Wills, 63), the succession of rocks being complete in Wales, but less so further east. The sequence reveals a rhythmic sedimentation probably related to varying depths of water, and resulting in alternating layers of shales and limestones, after the initial deposition of basal sandstones which are indicative of coastal conditions. Not only do these beds rest unconformably upon pre-Cambrian and other rocks, but individual beds show marked changes in lithology from one area to another. In the study area, the Silurian rocks occur as a narrow 'band', never more than two miles wide, extending from the area west of the

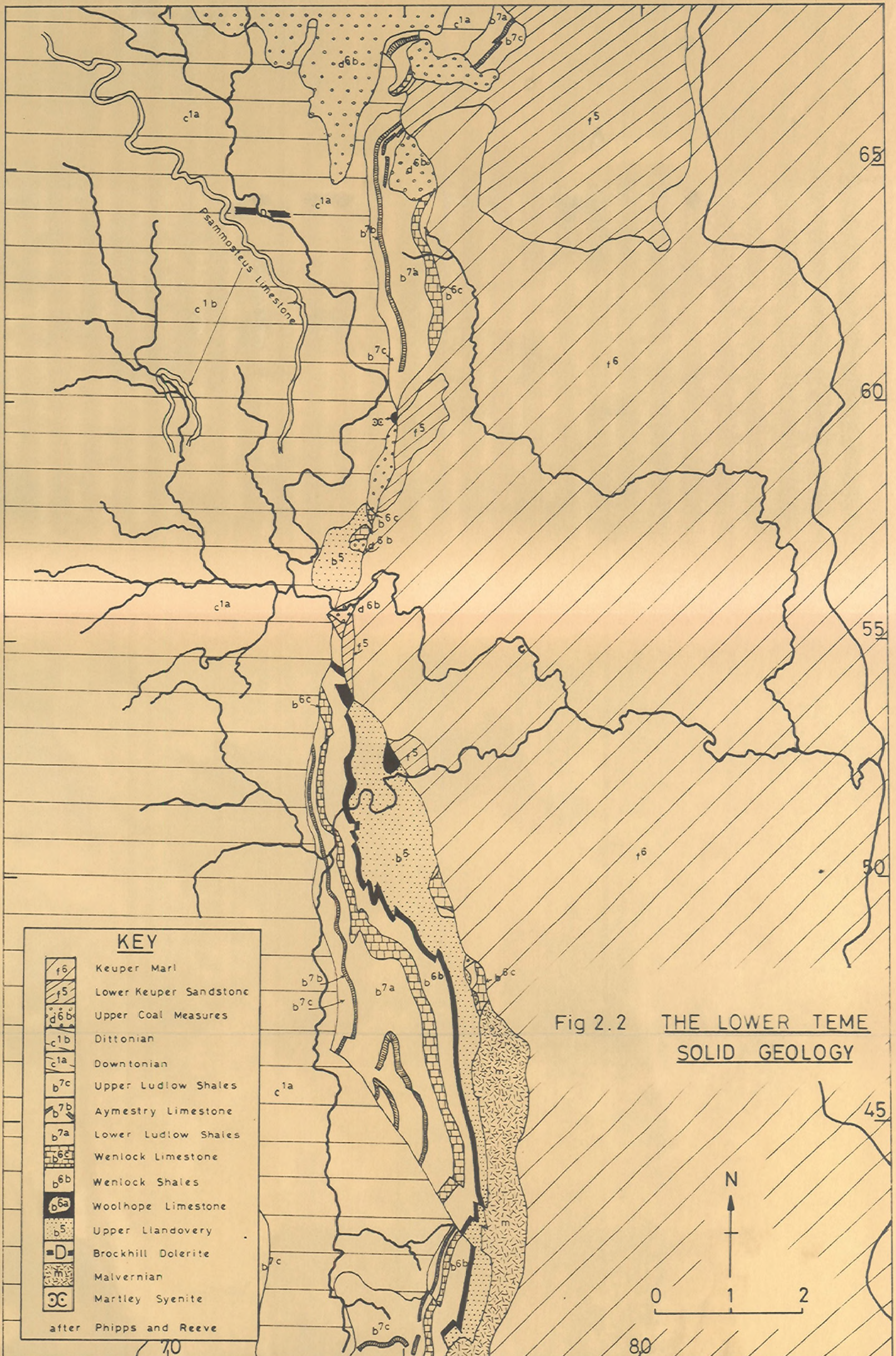


Fig 2.2 THE LOWER TEME SOLID GEOLOGY

Malvern Hills, northwards to Great Witley (G.R. 750660) and Abberley Hill (G.R. 762670), and form part of the line of disturbance known as the Malvern Axis (33). The main structure of the Malvern Axis is a great overfolded anticline, but with considerable and complex faulting, so that the rocks dip at varying angles up to 50 degrees. Thus differential erosion has resulted in the development of a scarp-and-vale landscape, in which the limestones stand up as prominent ridges, often of a 'hog's back' nature, separated by the shale-based valleys.

The Silurian sequence ranges from the Upper Llandovery group through to the Ludlow Bone Bed, which with its organic remains of fishes and crustacea forms the boundary between the Silurian and the succeeding Devonian. In the Table, Figure 2.1, P. 22 , the Bone Bed is listed as the lowest bed of the Devonian. The rocks of the Silurian are common in most of the superficial deposits of the area. Although the shales are generally soft and easily disintegrate, the limestones, both massive and flaggy, are more resistant and have survived.

The shales are generally olive grey in colour, and are more accurately siltstones and silty sandstones, with occasional bands of more calcareous material. The limestones are generally of the same colour as the shales and are essentially silty limestones. The rocks which exert the most important influence on relief in the area are the more massive sub-divisions of the Wenlock and the Aymestry Limestones, The upper part of the Wenlock series consists of a hard, nodular material which derives from coral colonies in the position of growth (known as 'ballstones'), while the Aymestry limestone is a flaggy, nodular, rather yellowish crystalline limestone. These two rocks form the core of the Malvern Axis north of the Teme gap at Knightsford, and give rise to two sub-parallel ridges of the 'hog's back' type, south of the gap.

Holland, Lawson and Walmsley (34), in their complete description of the Silurian in the Ludlow district, have further sub-divided and renamed the rocks of the Ludlow group, but the alternating sequence remains, and the older, more familiar terminology will be used in this study.

c) <u>the Devonian</u>.

Devonian rocks occupy a large part of the surface of the study area, and are also present in a high proportion in all the superficial deposits. Lying to the west of the Malvern Axis, they form a generally southwards sloping surface from the highest part of the Clifton Plateau north of Clifton-on-Teme (G.R. 715615). The scenery of the Devonian is characterised by rounded summits and broad, gentle vales.

At the close of the Ludlow period, the seas grew progressively shallower, the Bone Bed apparently representing estuarine or delta-lagoon conditions which persisted into the early Devonian. Some of these beds represent brackish water deposits in the form of greyish sandstones and marls, which are interspersed with intermittent micaceous sandstones. The upper 500 feet (150 metres) of the Lower Devonian (DOWNTONIAN) consists predominantly of red, green and purple marls with the local development of cornstones. Occasional bands of sandstone appear to form localised steep slopes in some areas (as for example, at Weyman's Wood, G.R. 728622), but generally this sequence of rocks gives rise to no significant landforms of regional scale.

The base of the Upper Devonian (DITTONIAN) is taken as being the base of the Psammosteus Limestone, a series of interbedded, massive limestones and marls in which the limestone bands never exceed 14 feet (4.2 metres) thickness, and are more frequently of less than 6 feet (2 metres) thickness. The Psammosteus Limestone is best exposed along the western side of the Teme valley where, according to Mitchell, Pocock and Taylor (39) it forms the basis of

"an impressive escarpment, over 300 feet high . . ."
(P. 50)

Since the Psammosteus Limestone series is supposedly only 70 - 140 feet (21.3 - 42.6 metres) total thickness, this escarpment must be 'faced' by other Devonian materials - perhaps of the underlying Downtonian, and with the Psammosteus Limestone as a 'cap rock', or of the overlying Dittonian materials, of a very similar appearance and lithology, except that there are progressively more frequent bands of sandstones and cornstones.

Many of the limestone bands within the Psammosteus Limestone group are found to thin out laterally, occurring only locally as lenticular masses and passing into marls on either side, and it seems unlikely that this variable thickness alone could give rise to anything more than localised features of the landscape, and not to such an 'impressive escarpment'.

Above the Psammosteus Limestone, the Dittonian series comprises marls with progressively more frequent sandstones and cornstones. The sandstones are generally lenticular occurrences, while the cornstones, relatively rare in the Downtonian, are believed to have derived from the breaking up of earlier limestones. Also lenticular in form, they rarely exceed 6 feet (2 metres) in thickness, and like the sandstones, pass laterally into marls. The Temeside Beds, named after their occurrence throughout the floor of the Teme valley, consist of thin beds of green and purple blocky mudstones, and yellowish green micaceous flaggy sandstones.

The Psammosteus Limestone is the only formation of the Devonian which generates any significant landform, though many low ridges and hills have a capping of limestone or cornstone.

The dolerite dyke at Brockhill (G.R. 725638), just north of the village of Shelsley Beauchamp, is some 25 to 30 feet (7.6 to 9.1 metres) in width, and the intrusion has affected the Downtonian country rock for a distance of some 30 feet (9 metres) or so on either side. Both marl and bands of cornstone have been altered by this contact metamorphism. The dyke thins westwards to less than 10 feet (3 metres), and the area of altered country rock is correspondingly reduced. Definite evidence of age is lacking, but it is believed to be a Carboniferous intrusion (39); it is included at this point since it occurs in Devonian country rock. A fine-grained igneous rock, speckled black and white, it forms a prominent ridge directly across the Teme valley, and as a band of very resistant material it may have had some significance in the development of the landforms of the valley, acting as a temporary nick-point in the long profile. The terrace deposits which lie downstream of the dyke are all seen to contain a significant proportion of this dolerite.

d) <u>the Carboniferous</u>.

During most of the Carboniferous period, the area of study appears to have formed part of a land mass which extended from south-east Ireland, through Wales and across into south-east England, so that there are few occurrences of rocks of this age. Those deposits which do occur rest unconformably on middle and lower Devonian, and on Silurian rocks.

Productive coal measures occur north of the study area, while the red and mottled clays of the Old Hill (Etruria) Marl occupy most of the area between Cleobury Mortimer and Bewdley, and extend as far south as Clow's Top (G.R. 715718). South of this area, and bordering the northern edge of the study area, the Highley Beds with some workable coal seams (Main, Head and Bat's Coals) form part of the north valley side of the Teme valley above Stockton-on-Teme. The most important bed in this series is the Thick Sandstone - 95 feet (30 metres) of massive grey-brown sandstone - yet in the study area, even this bed fails to give rise to any positive landforms.

The Clent or Haffield Breccia occurs only in a few isolated localities - Berrow Hill (G.R. 744586), Woodbury

Hill (G.R. 748645), Abberley Hill (G.R. 760670) and Osebury Rock (G.R. 736555) - and consists of sub-angular fragments and blocks of volcanic rock embedded in a marly matrix, with much haematite staining, giving a dull purplish-red colour. Described by Ramsay in 1865 as 'a rudely stratified breccia' (39), it is believed to have been derived locally as a result of erosion and transport by torrential rains and rivers from former outcrops of rocks which are now beneath the Trias, but which formed high mountains during the Carboniferous, the deposit developing as a kind of massive alluvial fan at the foothills of this mountain range. The great change in landscape since this time of formation is demonstrated by the fact that at the present time, the breccia occurs as a 'cap rock' on the hill tops. The occurrences in the study area are characterised by the presence of fragments of Devonian, Silurian and Malvernian materials.

e) <u>the Trias</u>.

The Triassic period opened with the deposition of vast quantities of dune sand with markedly rounded grains, and widespread false bedding from which predominantly westerly wind flow has been inferred. This Lower Mottled Sandstone is succeeded by the deposition of the Bunter beds, and although these materials do not outcrop on the surface in the study area, many of the superficial deposits are dominated by Bunter pebbles. The dominant pebble is a brown or purplish quartzite, usually less than one inch (2.5 cms) in diameter, though many specimens exceed three inches (10 cms) in diameter.

The first bed of the Trias which occurs on the surface in the study area is the Lower Keuper Sandstone, and is found in small patches along the eastern edge of the Malvern Axis. A dull reddish colour, it contains hard bands of a cemented calcareous marl-breccia, known locally as 'catbrain', and also thin bands of red marl which become more frequent upwards. However, this series does not give rise to any significant landforms.

Wills (63) suggests that the Lower Keuper Sandstone period was followed by a phase when the region became:

> "a flat, desert plain that was periodically flooded, now here and now there, by many streams or possibly sheet floods" (P. 88)

Under these conditions, deposits of red and green marls, marlstones and thin sandstone 'skerries', and Keuper Marl were laid down. The landscape of the Keuper Marl in the study area is one of erosional features of a dissected nature, low interfluves and generally negative relief - apparently being not at all influenced by the underlying rocks.

Solid formations of subsequent geological systems are not present in the study area, suggesting either continuous erosion since the Trias, or the deposition of other rocks which have since been removed. There are, however, numerous occurrences of superficial deposits of Pleistocene and post-Pleistocene age.

2. The Drift Deposits.

During the Pleistocene, ice sheets from three source areas entered the Welsh Borderland (see Chapter Three). According to Wills (63) Older Drift deposits are "very dissected" and patchy, the sole evidence being sometimes no more than occasional large boulders. However, the Newer Drifts are divided into two recognisable groups, equivalent in Wills' view to the two main sub-stages of the Würm in North Germany. The Older Drift derives from Wales and the North Sea Basin, while the Newer Drifts derive from the Pennines, the Lake District and southern Scotland, largely via the Irish Sea route, and therefore incorporating some Welsh materials. Pocock and Whitehead (41) differ from Wills in suggesting three sources of Midland ice - Scotland and the Lake District, north Wales and central Wales. They conclude that:

> "the advance and subsequent retreat of all these ice sheets, notwithstanding minor oscillations, constitute a single major glacial episode, and the deposits left by them belong to the 'Newer Drift'. Only doubtful traces of an older drift have been found in the district" (P. 74)

Older Drift, according to Wills' interpretation, spread much further south than the Newer Drifts, so that at the time of the deposition of the latter, much of the Midlands must have been extra-glacial, and subjected to a range of periglacial conditions and processes.

There are no clear examples of Older Drift materials in the study area, while even the Newer Drifts are represented only in the materials of the river terraces, having been resorted and intermixed with materials of other origins. Indeed, it seems unlikely that drift deposits of the fourth glacial advance were ever present in the area, and that these terrace materials, though derived from those deposits originate from other areas.

The accepted limits of earlier glacial advances are such that almost the whole of the study area should have been covered by Older Drift material, but all that now remains is a few small patches of boulder clay, mapped by the Geological Survey (Sheet 182, Droitwich, Solid and Drift edition) on the hills near the Witley gap (G.R. 745636). However, these deposits are so badly weathered that positive identification is not now possible.

<u>The River Terraces.</u>

Terrace fragments are most extensive along the course of the River Severn, where they have been mapped and described in detail by Wills (62). The Woolridge and Bushley Green levels, sixth and fifth terraces respectively, lie at altitudes of over 200 feet (60.9 metres) O.D., and are very extensive around Droitwich in the valley of the River Salwarpe, although it is stated that the distinction between these two terraces "is not easy to make" (39, P. 112). The fourth or Kidderminster terrace occurs along the Severn from Holt Heath (G.R. 815630) southwards, at heights of between 220 to 150 feet (67.0 to 45.7 metres) O.D. It is most extensive, however, in the vicinity of Stourport and Kidderminster. The third or Main terrace is also extensive both above and below the city of Worcester, and lies at heights ranging between 170 and 120 feet (51.8 and 36.6 metres) O.D., and in places occurs at two distinct levels, as for example at Stourport, where two 'flats' at 120 feet (36.6 metres) and 130 feet (39.6 metres) are separated by a pronounced bluff. The Worcester terrace stands at heights of between 100 feet (30.5 metres) O.D. in the

Stourport area, and 70 feet (21.3 metres) O.D. at Worcester. The lowest terrace of the sequence is the Power Station terrace, best exposed north of Stourport, and occurring at the surface only upstream from Hallow (G.R. 835590), where it emerges from beneath the later alluvium of the flood plain. In the valley below Worcester, terraces are buried beneath this recent infill, which results from three apparent phases of aggradation in the lower Severn valley in Post-Glacial times.(2)

The materials comprising these terrace deposits are significant. The highest terraces are dominated by the Bunter quartzite pebbles, while the Kidderminster terrace, although containing abundant Bunter materials, also contains substantial proportions of igneous rocks, probably of Welsh origin. The Main terrace pebbles are of Bunter and Welsh igneous materials, but along the Severn itself northern erratics are quite common, including granites from the Lake District. The pebble content of the Worcester terrace is indistinguishable from that of the Main terrace, while the Power Station terrace is noted as "containing many igneous pebbles" (39, P. 116).

In the valley of the River Teme, high level drifts occur at two small patches (G.R. 707591 and 723626). In both of these exposures, the material is dominated by locally derived rocks, with a high proportion of the calcareous cornstone, but there are also a few igneous rocks of uncertain origin. These two patches of gravels both stand at over 360 feet (109.7 metres) O.D., well above the present river level, and even above the 'confines' of the present valley. The Geological Survey lists them as sands and gravels, and not as boulder clay or terrace material, but it seems possible that they may be surviving remnants of Older Drift.

Within the valley of the present River Teme, above Knightsford Bridge, the author has identified terraces which appear to relate to the lower levels of the Severn sequence as described by Wills. These terraces have been measured at 25 feet (7.6 metres) and 6 to 15 feet (1.8 to 4.5 metres) above present alluvium surface, and both levels have yielded northern erratics in the form of pinkish Eskdale granite. Further north, in the tributary valley of the Rea Brook, the Geological Survey has mapped terraces which have been measured at 65 to 80 feet (19.8 to 24.4 metres) above the present alluvium. Below Knightsford Bridge, the author has also identified and mapped terraces at 5 to 7 feet (1.8 metres), 20 to 35 feet (6.1 to 10.7 metres) and 55 to 70 feet (16.7 to 21.3 metres), as well as two higher levels at about 100 feet (30.5 metres) and 140 feet (42.7 metres), all above the present so-called flood plain.

According to Wills (62), six clearly identifiable stages in the development of the Severn valley may be seen:

Stage 6 ... The Forest Period - the Power Station Terrace

Stage 5 ... The Worcester Terrace Stage

Stage 4 ... The Main Terrace Stage

Stage 3 ... The Kidderminster Terrace Stage

Stage 2 ... The Bushley Green Stage

Stage 1 ... The Woolridge Stage

During the stages 1 to 3, he suggests that the

Avon - Lower Severn was the main trunk stream of the south west Midlands with the Stour as an important tributary of this stream (see also Shotton, 47). The Woolridge remnants occur in the Tewkesbury to Gloucester reach of the present Severn Valley, and appear to be contemporary with Hey's (30) Upleadon gravels. These latter gravels, deposited in the valleys of the River Leadon and the Glynch Brook, and also the Woolridge terrace deposit, stand at some 220 feet (67.1 metres) above the present alluvium. The Bushley Green terrace stands at some 130 feet (39.6 metres) above present alluvium, and is most common in the valley of the Warwickshire Avon, where Tomlinson (54) refers to it as the Avon No. 5 Terrace. In the Worcester area, gravel spreads at around 210 feet (64.0 metres) O.D., as for example at Pixham (G.R. 835485), Kempsey Common (G.R. 870480), Broadheath (G.R. 810575) and Norton Common (G.R. 883518), are thought to represent valley deposits of a stream which was a tributary of the Avon - Lower Severn trunk stream. That these deposits exhibit a steeper gradient than other Bushley Green terraces may be attributed to a steeper gradient of the tributary valley, and the greater elevation of these deposits may also be explained in this way.

The Kidderminster terrace, together with Tomlinson's Avon No. 4 terrace, stands at some 60 to90 feet (18.3 to 27.4 metres) above the present alluvium, and can be traced as far upstream as Bewdley and Kidderminster, while in the valley of the Stour this terrace extends as far upstream as Swindon (G.R. 860905). That this terrace does not extend through the Severn gorge section between Bridgnorth and Ironbridge is taken as evidence that it must pre-date the formation of this gorge by overspill from pro-glacial Lake Lapworth (60).

The Severn Main terrace and the Avon No. 3 and No. 2 terraces represent the establishment of the present drainage area and line of the Severn, in that this level is traceable, at 30 to 40 feet (9.1 to 12.2 metres) above present alluvium, through the Severn gorge section. Further, the Severn Main terraces are seen to be more widespread than the Avon equivalents, whereas the Avon No, 4 terrace was more extensive than its Severn equivalent. The implication is that the role of principal trunk stream had now passed from the Avon to the Severn. (N.B. The appearance of Irish Sea erratics in a terrace at Shelsley Beauchamp (G.R. 730635) led Wills to conclude that the Severn and the Teme were linked during Main terrace times.)

The Worcester terrace and the Avon No. 1 terrace differ in that whereas the Avon terrace is at a constant height of 10 to 15 feet (3.0 to 4.6 metres) above present alluvium, the Worcester terrace of the Severn rises upstream. At Worcester, this terrace stands at between 10 and 25 feet (3.0 and 7.6 metres) above present alluvium. The lowest terrace of the Severn, the Power Station level, has no Avon equivalent, and is buried below Worcester. Above this city, however, it rarely rises above 12 feet (3.6 metres) above present alluvium.

Thus in the Worcester area, the following terrace sequence exists:

Power Station Terrace	...	at alluvium <u>minus</u> 5 feet
Worcester Terrace	...	at alluvium plus 10 - 25 feet
Main Terraces	...	at alluvium plus 35 - 60 feet
Kidderminster Terrace	...	at alluvium plus 60 - 90 feet
Bushley Green Terrace	...	at alluvium plus 125 feet.

It is presumed that some, at least, of these terrace levels should be reflected in the terraces of the Teme valley, for which during at least a part of its geomorphological history, the Severn has served as a local base-level. Indeed in the lower Teme valley below Knightsford Bridge, the Teme terraces lie with an east to west alignment across the north to south aligned features of the Severn valley, and it is often difficult to differentiate between the terraces of the two rivers. Generally, the lower terraces clearly associate with the Teme, but the higher terraces may be the product of either the Teme or the Severn, with the latter being more likely to have been responsible for their formation.

Possible relationships between the terraces of the two river systems will be discussed in more detail in a later chapter.

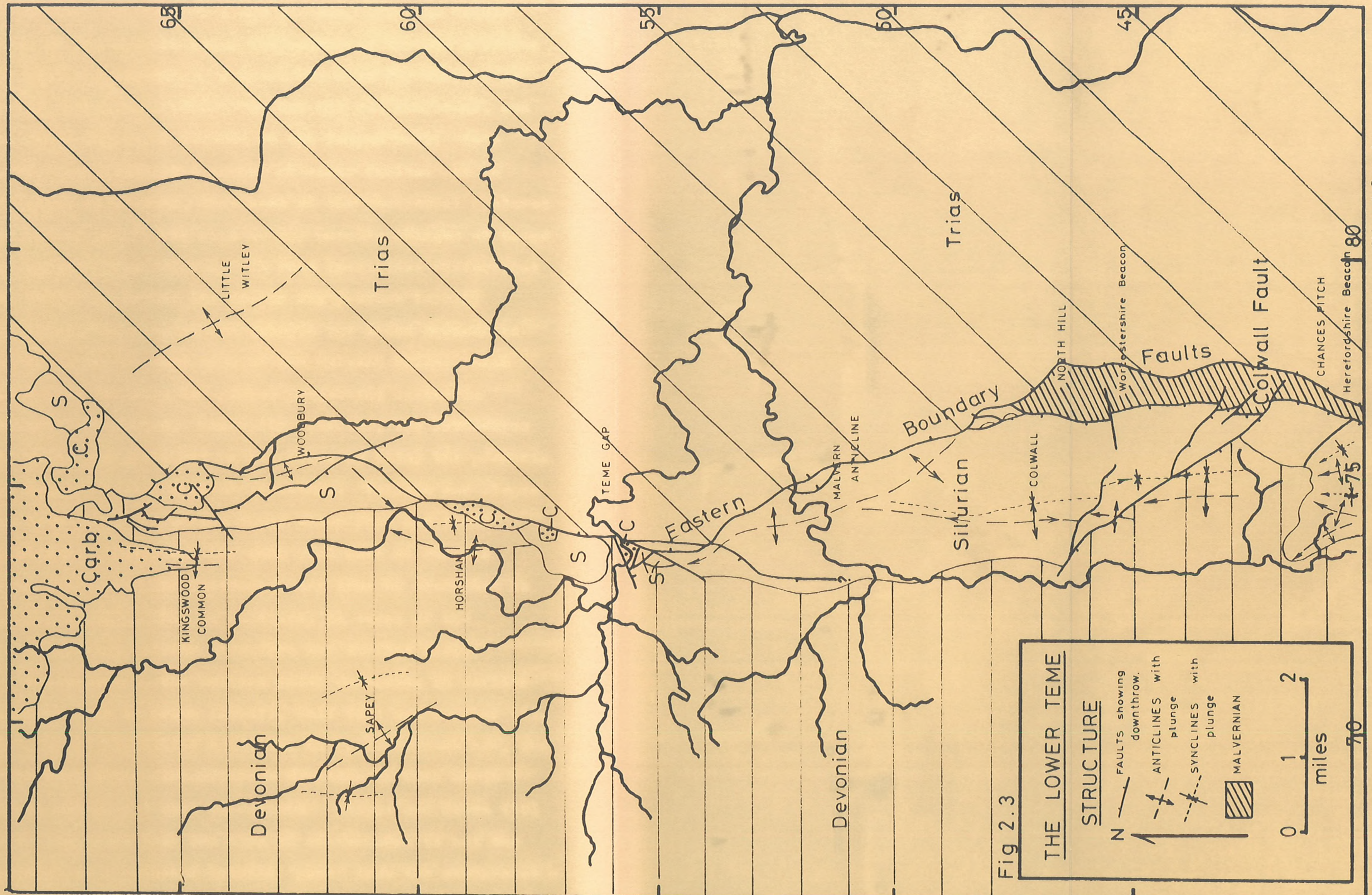
3. <u>The Structure.</u> (Fig. 2.3, P. 39).

Structurally the study area divides into three broad sub-regions:

1. The gentle folds of the Triassic Vale of Severn.

2. The intensely folded and faulted line of the Malvern Axis, which includes the Malvern Hills igneous mass.

3. The gentle folds of the Old Red Sandstone area to the west.



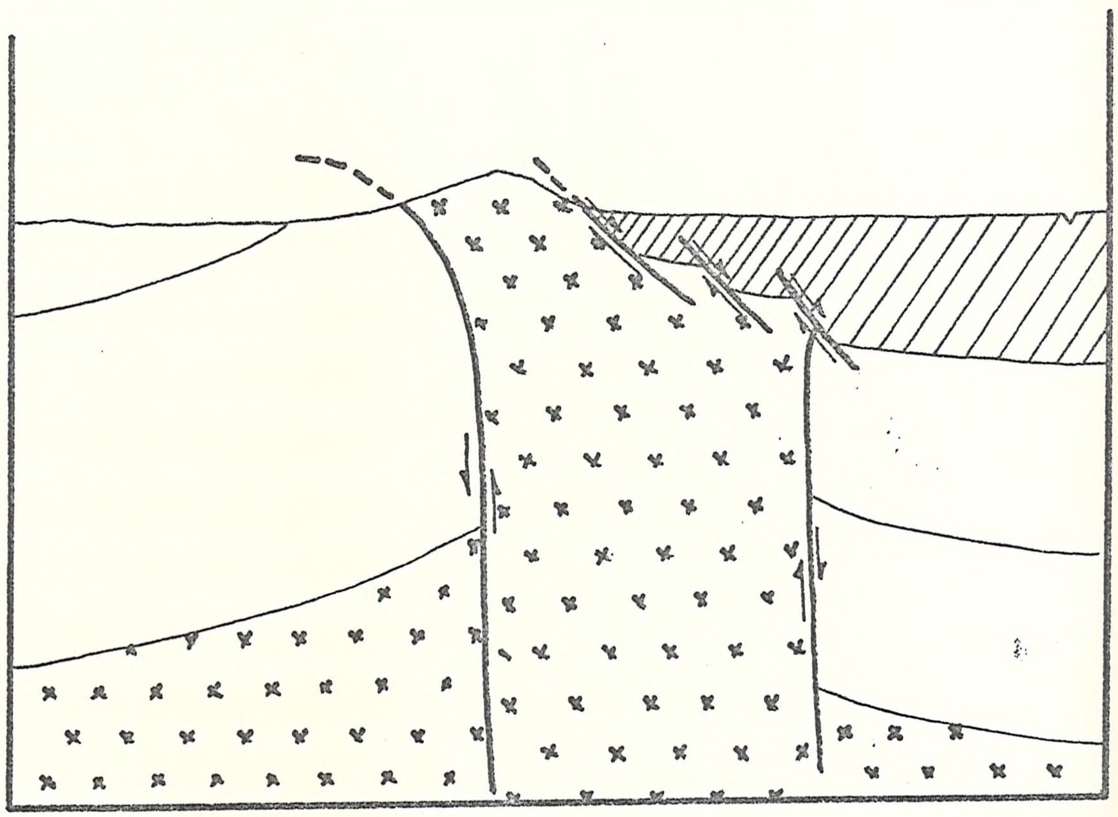
(after Phipps & Reeve)

In both sub-regions 1 and 3 above, lying on either side of the Malvern Axis, the sediments contain a number of gentle anticlines and synclines - as for example at Lower Sapey (G.R. 700600) in the Old Red Sandstone, and at Ockeridge (G.R. 775628) in the Keuper Marl. Both areas, too, exhibit a number of minor faults. It is significant however, that none of the structural features in either area gives rise to any notable changes of slope or particular landforms. In some localities differences of lithology within the system may produce locally striking features, as for example the Arden Sandstones outcrops on the east side of the Malvern Hills, which give rise to long, low ridges projecting eastwards towards the Severn. Generally, however, the landscapes of these two areas may be described as being the products of erosion rather than of structure. Valleys and slopes in both areas cut across these minor fold and fault structures, which for the most part have no surface expression, and the landscapes may thus be described as negative rather than as positive, in terms of the relationships between structure and surface shape.

Sub-region 2, the Malvern Axis, according to earlier authors such as Groom (26&27), Holl (33) and Butcher (6), is a great overfolded anticline of Carboniferous age, and with much later Carboniferous faulting in both north - south and east - west directions. Phipps and Reeve (40) have suggested that the line of disturbance is not the product of a powerful lateral 'push' from the south-east - the so-called 'Cheltenham Drive' - but is rather the result of deep-seated upthrust faulting relating to fractures of the basement rocks, and with many associated fold and fault structures. Two major lines of upthrust are proposed, which are termed the Worcestershire Beacon Upthrust and the Herefordshire Beacon Upthrust, the former lying along the eastern side of the Malverns, the latter along the west. According to Phipps and Reeve, movement along the Worcestershire Beacon Upthrust was greater than that along the western side, so that the Axis is seen as a horst structure (see Fig. 2.4, P. 42) with unequal amounts of uplift along the two fault planes. The result of this unequal movement was that the upper layers of material between the two upthrust planes were rendered unstable, and 'tumbled over' to the west by means of very localised fold and thrust movements. Thus the Cockshot Hill, Penny Hill and Rodge Hill thrust planes discussed by Mitchell, Pocock and Taylor (39) (see Fig. 2.5, P. 43) are not the products of a massive regional thrust from the south-east, but of local disturbances resulting from the inequality of movement along the two major upthrust planes.

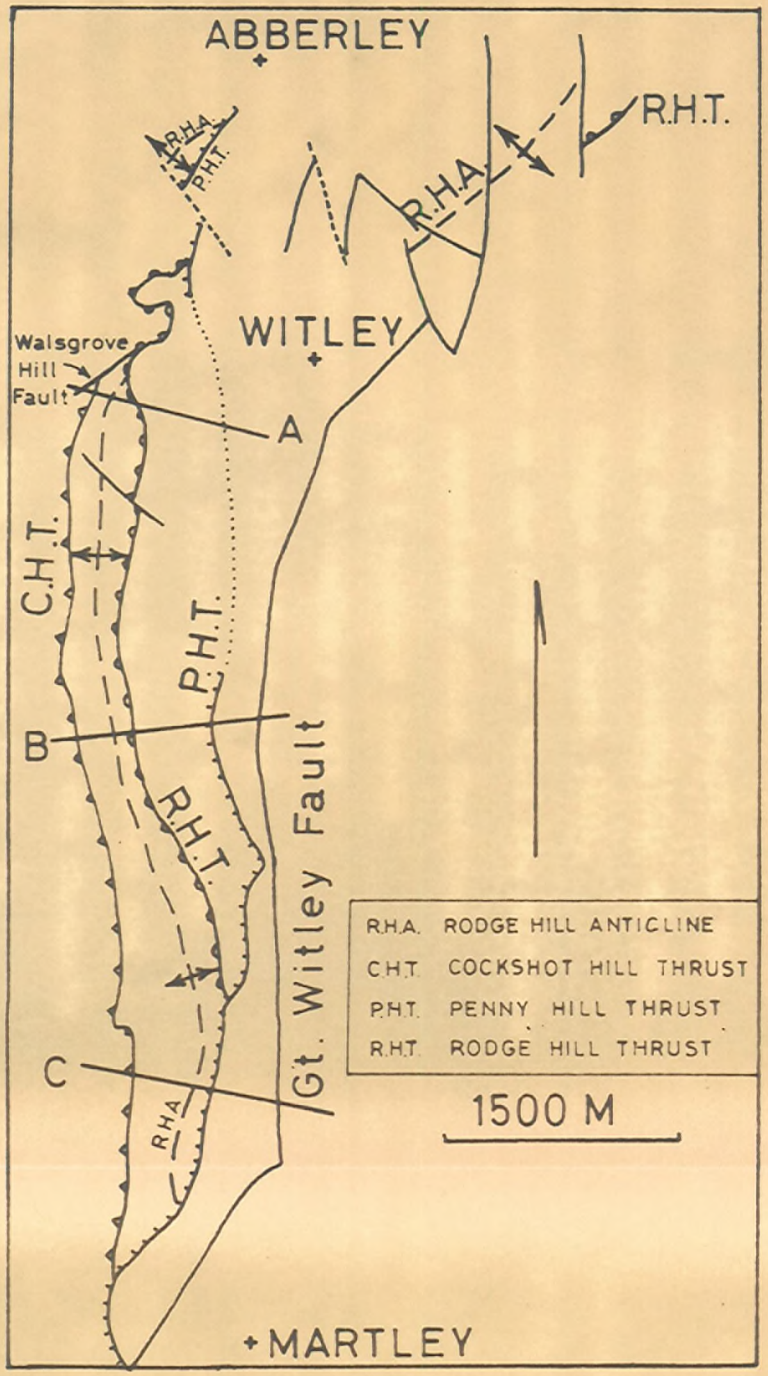
Butcher (6) argues that the surface of the pre-Cambrian is steep in the three main exposures of the Worcestershire Beacon (G.R. 768452), the Gullet Quarry (G.R. 762381) and the Whiteleaved Oak Quarry (G.R. 760360), and it is apparent that since the exposures are widely separated, the surface of these ancient rocks must be steeply inclined along the whole length of the outcrop. The conclusion is that this steep limb represents the western portion of a north - to - south aligned anticline which Groom (26) called the 'Malvern Fold'. This

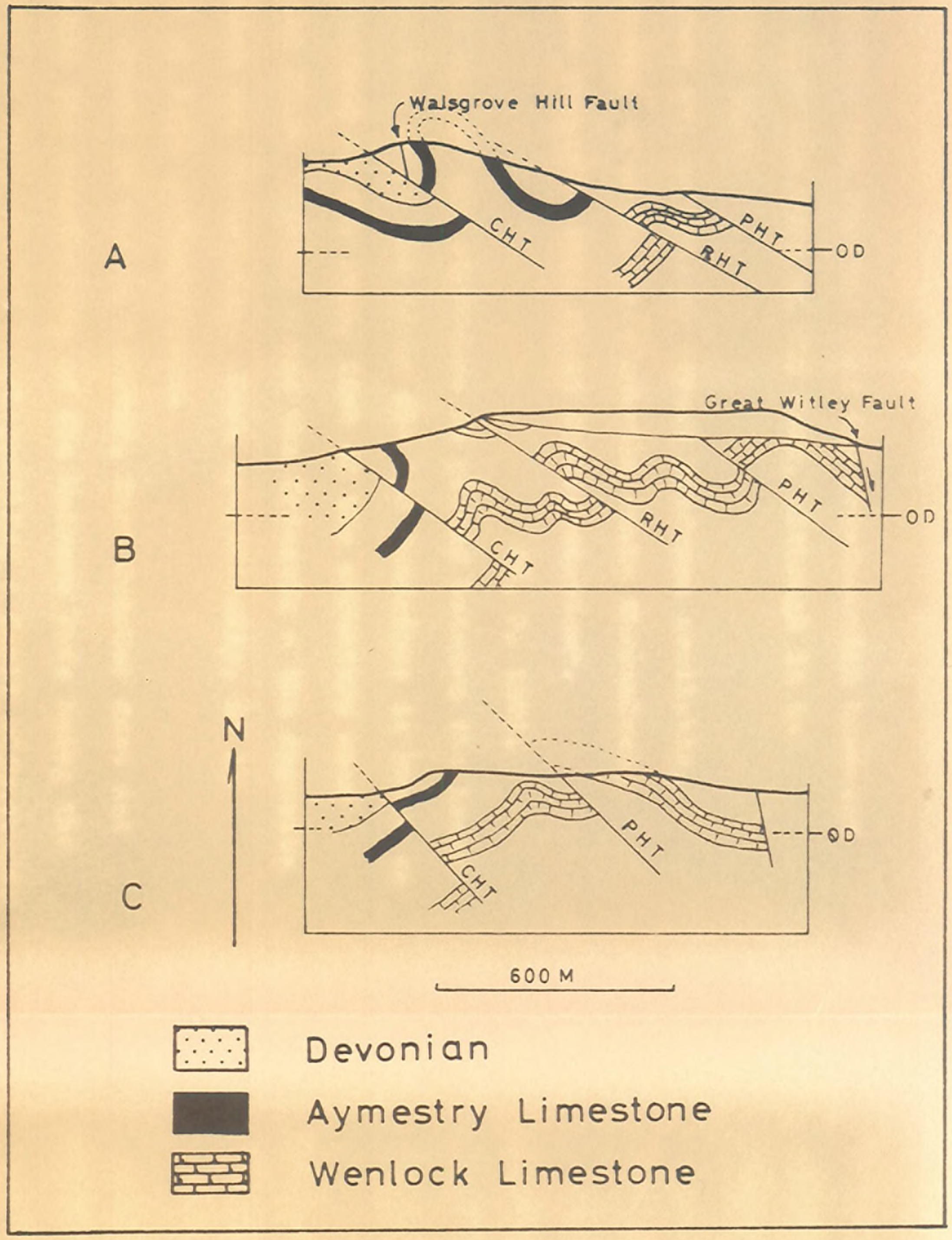
Fig 2.4 DIAGRAMMATIC SECTION TO ILLUSTRATE THE HORST STRUCTURE OF THE MALVERN HILLS



after Phipps & Reeve

Fig 2.5





THE COCKSHOT HILL, RODGE HILL AND PENNY HILL THRUSTS.

after Mitchell, Pocock & Taylor

interpretation implies that the pre-Cambrian basement rocks form the core of the fold, although it is admitted that:

> "there is, as yet, no direct evidence available, derived from the pre-Cambrian rocks themselves, that supports this field interpretation".
>
> (6, P. 110).

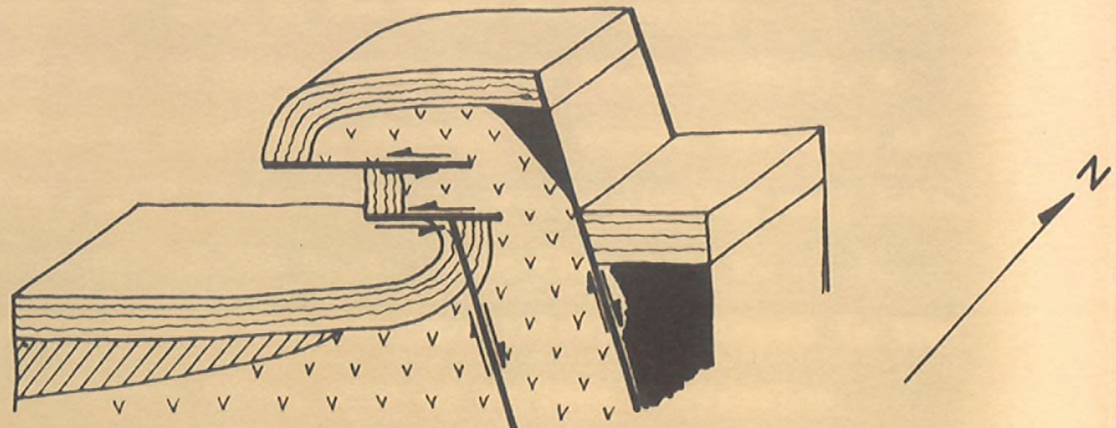
The age of the structure is placed between the lower Devonian - since the lower Old Red Sandstone is known to be involved in the steep limb of the structure near Colwall (G.R. 739422) - and the Triassic - the deposits of which are flat-lying. More specifically, it is dated as late Carboniferous.

It should be noted, however, that Butcher does not preclude the possibility of the Malvern Axis being the product of deep-seated block-jostling - fault adjustments in the basement materials - as opposed to fold movements (see Fig. 2.6, P. 45 , and 6, P. 117). It must also be noted that Hardie (28) prefers the fold origin for the structure, although allowing for the possibility of the horst origin described by Phipps and Reeve (40).

All authors are agreed on one point - that the Malvern Axis contains a number of associated minor features. Local folds are identified at Kingswood Common (G.R. 735655), southwards from Woodbury Hill (G.R. 748646), Horsham (G.R. 737578), Tedney (G.R. 735589), Ham Farm (G.R. 737598), The 'Malvern Anticline' in the parishes of Alfrick, Knightwick and Suckley, Colwall Stone (G.R. 755425) and in the Chance's Pitch area (G.R. 742402). (see Fig. 2.3, P. 39).

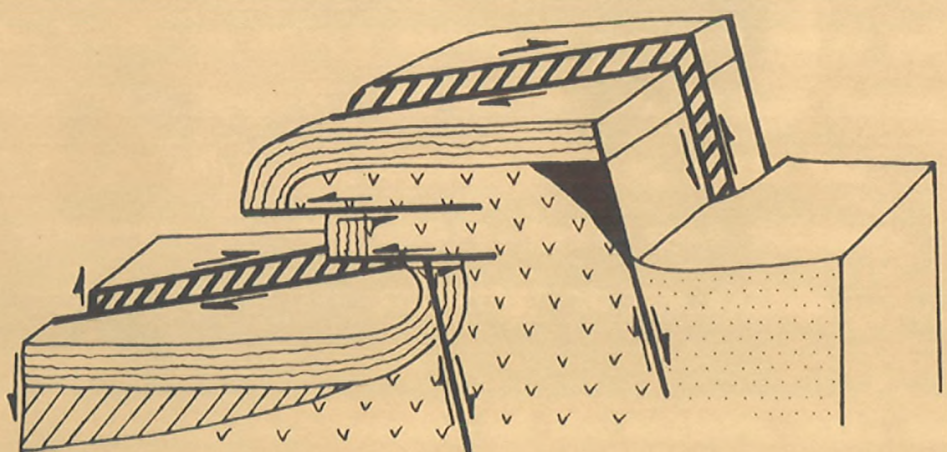
Fig 2.6 THE MALVERN FAULTED FOLD

1



PRE-CAMBRIAN AND LOWER PALAEOZOIC STRATA PUSHED UP INTO A MONOCLINAL FOLD IN LATE CARBONIFEROUS TIMES, ACCOMPANIED BY FLAT AND STEEP DIP-SLIP STRIKE FAULTING.

2



SUBSEQUENT TRANSVERSE FAULTING AND TRIASSIC DEPOSITION ON THE EAST SIDE.

TRIASSIC

SILURIAN

CAMBRIAN

PRE-CAMBRIAN VOLCANICS

PRE-CAMBRIAN MALVERNIAN

after N.E. BUTCHER, 1961

Small quarries abound in these fold areas and exposures of the limestones are therefore plentiful. The Aymestry Limestone is well seen in the Woodbury Farm quarry (G.R. 743635), and the Wenlock Limestone is to be seen there, and also at the Penny Hill quarry (G.R. 752616). At Rodge Hill quarry (G.R. 749623), a quarry entrance road cuts through to expose the axis of the Woodbury Hill anticline, the rocks dipping away both to the east and to the west. (see Fig. 2.7, P. 47). The Horsham, Tedney and Ham Farm folds, developed in the Old Red Sandstone beds, have no surface expression whatsoever, and are cut across by the valley of the River Teme in the Shelsley Reach. The only one of the fold structures to have any positive effect upon surface relief is the Malvern Anticline, where differential erosion has etched the landscape into a series of parallel vales and escarpments, with Aymestry and Wenlock limestones forming prominent ridges of a 'hog's back' nature, while the Woolhope limestone and the shales, being much thinner, generate only a 'minor irregularity' on the valley slopes (see Fig. 2.8, P. 48).

In the fault and fold complex of the Malvern Axis, the traverse faults may be seen as perhaps the more significant features. All of the cols across the outcrop of the Malvernian rocks are associated with such faults - Whiteleaved Oak (G.R. 760360), Hollybush (G.R. 763369), the Gullet (G.R. 762381), Wynd's Point (G.R. 763404) and the Wyche (G.R. 770437). Northwards from North Hill (G.R. 769463), along the line of the Malvern Axis and on the outcrop of the Silurian rocks, the Teme gap at

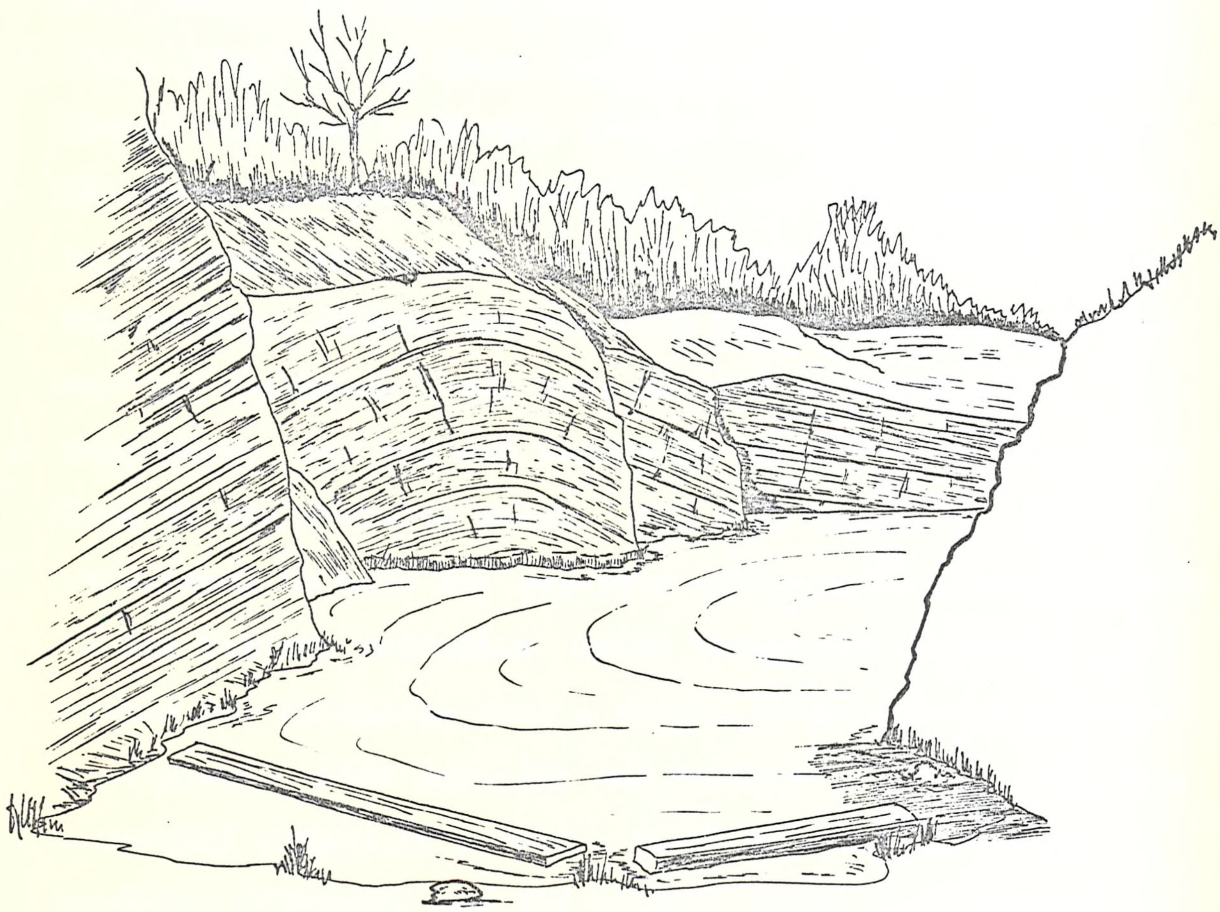
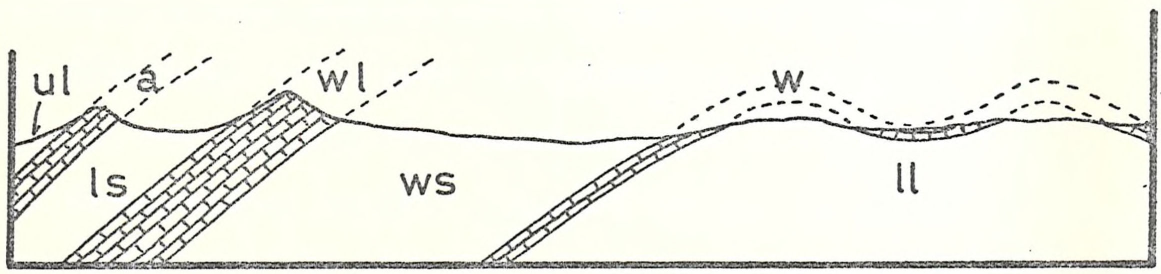


Fig 2.7 THE RODGE HILL QUARRY EXPOSURE.
(Wenlock limestone on the axis of the Woodbury Hill anticline).

Fig 2.8

THE MALVERN ANTICLINE.



ul - Upper Ludlow Shales
a - Aymestry Limestone
ls - Lower Ludlow Shales
wl - Wenlock Limestone
ws - Wenlock Shales
w - Woolhope Limestone
ll - Llandovery Sandstone

after Phipps & Reeve

Knightsford Bridge is controlled by a transverse fault, as is the high-level double gap at Abberley Hall (G.R. 748665). However, the other cols across the Silurian rocks (see P. 9) are not so related. The gap at Longley Green is at present occupied by the Leigh Brook, but the others are dry gaps at present.

Thus in the study area the landscape does not at present exhibit very strong structural controls, except for the Malvern Axis and its associated minor features, and for the localised effects of lithological differences between and within rock series. The origins of this landscape must therefore be more closely related to the processes which are, and which have been in the past, active upon it.

Chapter Three - The Glacial Chronology of the West Midlands Area.

According to R. G. West (58), the Midlands contain "a substantial record of the Middle and Upper Pleistocene . . . ice advances of the three glacial stages extending into the area, and their drainage was associated with terrace systems of the three main rivers, the Trent, the Severn and the Thames"

(P. 251)

While deposits of the Older Drift are fairly well established, nevertheless there is much dispute over the limits of the last glacial advance.

It is generally accepted that ice moved into the Midlands from three main source areas, each drift thus having its characteristic 'suite' of erratics. Welsh ice brought Uriconian rocks into the area, the Eastern drifts contain Mesozoic materials, and Northern and Irish Sea ice brought fragments of granites from the Lake District and Scotland, as well as flint from Antrim. According to the present distributions of these drifts, it seems likely that whereas the earlier glaciations were dominated by Eastern and Welsh ice, the final advance was dominated instead by ice advancing from the north-west, by the Irish Sea route. Wills (63) has mapped the limits of the various ice sheets of the Midlands (see Fig. 1.6, P. 13), and from his work it seems that the first Midlands ice advance reached as far south as Rugby, the second, at its maximum stage, as far as the Malvern Axis in the west and the Tewkesbury - Gloucester area in the south. The final advance reached only as far south as Wills' 'Wolverhampton Line'.

Tomlinson (55) agrees with West's view that there is evidence of three glacial and two interglacial stages in the Midlands, but raises the problem of nomenclature, since, as she says:

> "many names have been used to designate the glaciations of the Midlands . . . referring rather to the provenance of the material carried by the ice than to the time factor". (P. 187).

The discussion of the Midlands glaciations which here follows is taken from Tomlinson, and the tables (Figs. 3.1 and 3.2, Ps. 52 and 53) attempt to correlate the various suggested terminologies used in Europe and East Anglia with that of Tomlinson for the Midlands. Also considered in the second table (Fig. 3.2, P. 53) is the terminology used during the 1969 Conference and Field Meeting of the Quaternary Research Association in Norfolk. The suggested dates are those used by Beaver in his report to the Sand and Gravel Association (1). In the discussion which follows, the terms will be those of the Quaternary Research Association - which are in fact modified from the table 11.6, Page 230, in West (58).

The deposits of the Lower Pleistocene in the Midlands occur either as remanié deposits of gravels on hill tops, or as low level clays and tills which are found beneath later deposits. The materials are typically not local, but generally derived from sources to the north north-east or east. Since they are usually widely scattered, these deposits have obviously been so

Fig. 3.1

THE PLEISTOCENE CHRONOLOGY OF THE MIDLANDS, EAST ANGLIA AND CONTINENTAL EUROPE.

Division of the Pleistocene	Age '000 B.P.	Continent	East Anglia	Midlands
Upper	10 – 115	Wurm / Weichsel	Hunstanton	Main Irish Third Welsh
	130 – 180	Eem	Ipswichian	
Middle	190 – 230	Riss / Saale	Gippingian	Second Welsh Main Eastern Mid-Pennine
	240 – 420	Holstein	Hoxnian	
Lower	435 – 475	Mindel / Elster	Lowestoft	First Welsh Pennine Lower B.C.
	480 – 550	Bilhausen	Cromerian	

After West (58), Tomlinson (55) and Beaver (1).

Fig. 3.2

THE NOMENCLATURE OF THE QUATERNARY RESEARCH ASSOCIATION

EASTER CONFERENCE, 1969

Division of Pleistocene	Europe	Stage in Britain
Post Glacial	Flandrian	Flandrian
Upper	Weichsel	Devensian
	Eemian	Ipswichian
	Saalian	Wolstonian / Gippingian
Middle	Holsteinian	Hoxnian
	Elsterian	Anglian / Lowestoftian
	Bilhausen	Cromerian
		Beestonian
	Menapian	Pastonian
		Baventian
Lower	Waalian	Antian
	Eburonian	Thurnian
	Tiglian	Ludhamian
Pre-Glacial	Praetiglian	Calabrian

extensively eroded that they constitute only bare and fragmentary evidence of the nature and extent of the early glaciation. The few small patches of 'foreign' gravels which are found on the higher parts of the Clifton Plateau (see P. 34/5) may be remnants of these deposits, and unpublished work by G. R. Coope of the University of Birmingham suggests that some of the terrace material associated with the valley of the Kyre Brook may be derived from Older Drift formerly present on the Clifton Plateau.

Shotton (47) has shown that during the Hoxnian interglacial period, the Warwickshire Avon followed a course from a source somewhere in the area of the Bredon Gap, via the Soar valley, and thence into the River Trent. Since the Severn at that time was also a tributary of the Trent in its upper reaches (Wills 60&63), the present Vales of Worcester and Gloucester were presumably drained by a relatively small localised drainage system, possibly based upon the Worfe - Smestow - Stour - lower Severn drainage line (Triccas, 56) as the main stream.

During the Gippingian glacial period, ice came into the Midlands initially from the north, but was soon displaced by the more powerful advance of Eastern and Welsh ice sheets, which appear to have occupied the Vale of Severn as far south as the Cotswolds edge. At the same time, Eastern ice also blocked the north-east valley of the Avon, ponding up glacial Lake Harrison (47), and at a later stage completely filling the Avon valley, overspilling and coalescing with the Severn Valley Glacier. This massive spread of ice is believed to correlate with

Wills' Woolridge Terrace stage of the River Severn.

As the Eastern ice began to retreat, Lake Harrison again came into existence, as illustrated by Dury (13) who noted on the face of the Jurassic escarpment evidence of a 410 feet (124.9 metres) shoreline. Contemporaneous withdrawal of Welsh ice from the Severn Vale permitted overspill of Lake Harrison south-westwards towards the Severn, thereby reversing the direction of flow of the Avon, and initiating its early higher terrace phase. (47&54). At this stage, during the Ipswichian interglacial, the Avon, with its Severn Vale tributary system above-mentioned (P. 54) became the main drainage line of the south-west Midlands. The Gippingian retreat stage is marked in the Severn valley by the Bushley Green terrace (Avon No. 5 terrace), while the succeeding interglacial is represented by the Kidderminster terrace of the Severn and the Avon No. 4 terrace.

Ice did not reach the Avon - Severn basin during the Devensian glacial period, and only the upper parts of the present River Severn basin, above Bridgnorth were directly affected. Irish Sea ice occupied the Cheshire Plain, preventing the waters of the Upper Severn from escaping in any northerly direction, so that another pro-glacial lake sequence was initiated - Lakes Buildwas, Newport and Lapworth (60&63) - between the ice front and the high ground of the Ironbridge district, which was the pre-glacial drainage divide between the Severn and Trent basins. Lake Lapworth eventually spilled out across this water divide through a series of channels into the lower Severn valley, cutting the Ironbridge Gorge, and providing the gravel which later became the Severn Main terraces. The Main terraces occur at two distinct levels (see P. 33) in the lower Severn area; designated by Wills as M.1 and M.2, they correlate with Tomlinson's Avon terraces numbers 2 and 3. The lower M.1 Severn terrace appears to be the result of the lowering of sea level accompanying the spread of ice, while the M.2 terrace is apparently a feature of aggradation following the Lake Lapworth overspill and the rising sea-level which resulted from the diminishment of the ice sheets. It is also noticeable that the M.1 terrace extends along the lower Severn and into the valley of the Worfe, while the M.2 terrace follows the Severn valley into and beyond the Ironbridge Gorge, and is the first Severn terrace to do so. Thus this stage represents the establishment of the present drainage basin area of the River Severn, and its creation as the major river of the west Midlands - a role previously held by the Avon (see P. 55).

The major effects of glaciation upon the drainage of the west Midlands area are indicated on Fig. 3.3, P. 57), which shows the three breaches of 'pre-glacial' watersheds at Bredon, Ironbridge and Stockton-on-Teme.

Though free from ice, the southern parts of the Midlands were nevertheless subjected to 'arctic' conditions during this Devensian period, as testified by the widespread occurrence of tjaele gravels and other solifluction features of the area, and including fossil ice wedge networks reported from the Avon No. 4 terrace by Shotton (48): (see also Wills, 63, Fig. 34, P. 128).

Wills suggests that the ice front at the maximum stage

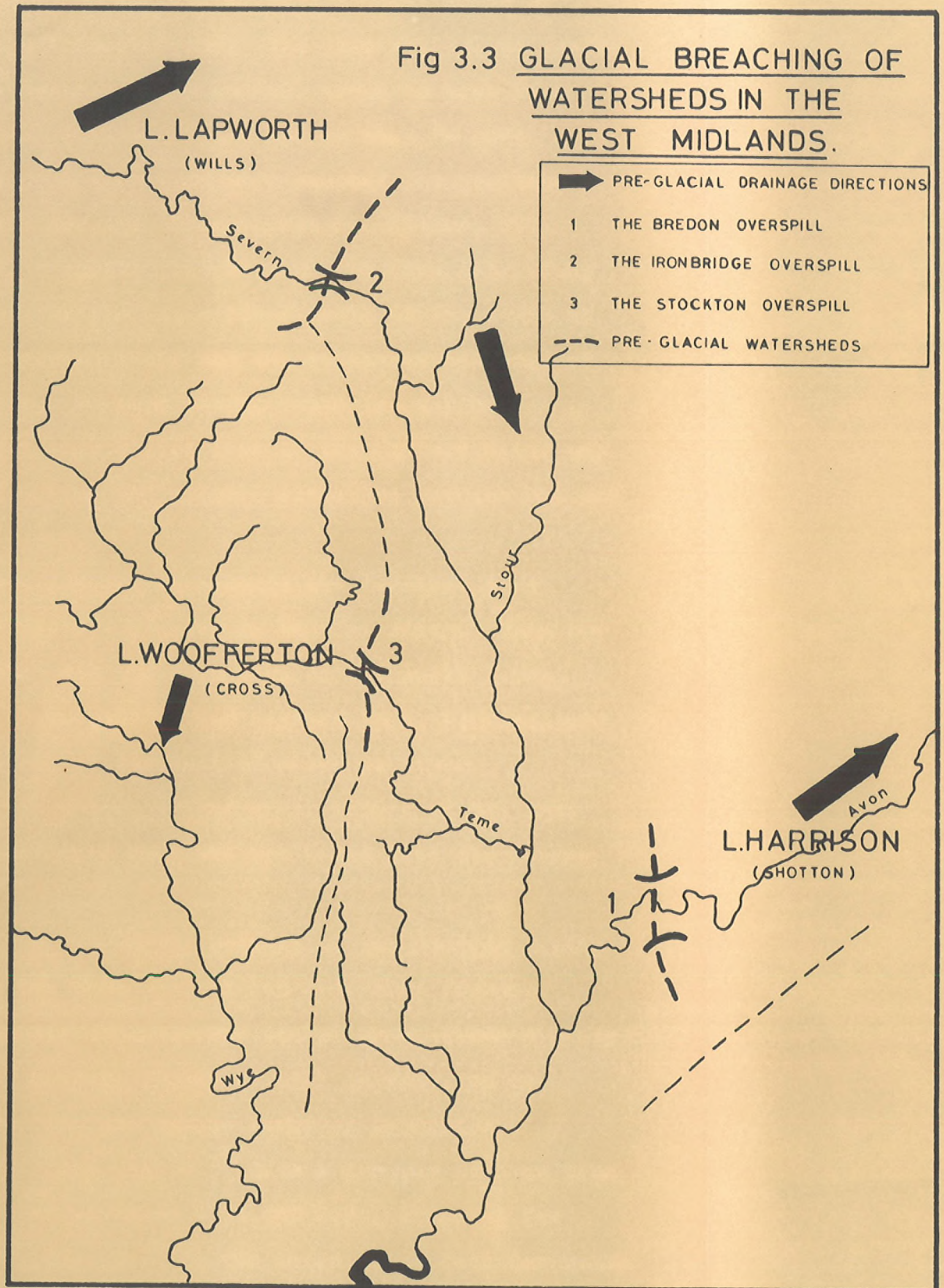


Fig 3.3 GLACIAL BREACHING OF WATERSHEDS IN THE WEST MIDLANDS.
PRE-GLACIAL DRAINAGE DIRECTIONS
1 THE BREDON OVERSPILL
2 THE IRONBRIDGE OVERSPILL
3 THE STOCKTON OVERSPILL
PRE-GLACIAL WATERSHEDS
L. LAPWORTH
(WILLS)
Severn
2
Stour
L.WOOFFERTON
(CROSS)
3
Teme
Avon
L.HARRISON
(SHOTTON)
1
Wye

of the Devensian reached a line stretching from Church Stretton (61, P. 76 and 63, P. 72), to just south of Bridgnorth and Wolverhampton. The Teme valley, at least in its lower reaches below Ludlow, seems to have been free from ice. However, Welsh ice is seen to have encroached from the west to have reached the position of the Orleton moraine (Dwerryhouse and Miller, 19), and Cross (8) suggests that it may also have lain along the north side of the hills immediately to the south of Ludlow - Bringewood Chase and the north-western edge of the Clee Hills. Further south, Welsh ice may have reached as far east as the line of the Ledbury Hills and the Bromyard Downs, the present watershed between Wye and the Severn basins.

The Orleton moraine represents the furthest east approach of this Wye glacier in that vicinity. This ice was responsible for the formation of two small lakes, Broad Heath (G.R. 336638) and Wigmore (G.R. 415692), and for the sequence of events (19) which resulted.

i) in the diversion of the upper waters of the Teme above Brampton Bryan from the Wye basin into the Severn basin, and

ii) in the accompanying cutting of the Downton Castle Gorge, where the Teme spilled out from Lake Wigmore. Cross (8), in his study of the Ludlow area, found a peaty deposit lying beneath fluvio-glacial gravels, in an excavation for the new sewage works at Comberton (G.R. 498678). The Carbon ^{14} date which was derived from this material is given as $\pm$ 14,000 B.P., allowing for contamination, thus placing the material as late-Devensian in age - presumably when the last vestiges of ice were disappearing from the area.

Recent work by Shotton (49) and others on a similar peaty deposit at Four Ashes, near Penkridge in Staffordshire, which was found to lie beneath Irish Sea till, has produced a date of ± 36,000 to ± 30,000 B.P., so that this Devensian episode in the west Midlands is dated between 36,000 and 14,000 B.P., or perhaps of the order of about 25,000 B.P. as the mid-point.

Thus it would seem that the evolution of the present landscape of the lower Teme below Ludlow must date from this time, and that the influence of large masses of ice has only been missing from the area for the last 14,000 years or so.

Since the withdrawal of Devensian ice, the rising sea-level of the Flandrian period has resulted in the infilling of estuaries such as the Severn estuary, which had been excavated to the sea-level of Devensian times. Thus the Worcester terrace and the Power Station terrace of the Severn display a steeper gradient than the infilling alluvium, and are buried features in the lower part of the valley (2). The rise of sea level has, however, been accompanied by a general diminishment of the volume of water in stream channels, and of drainage in general, so that those features of aggradation are themselves being attacked by smaller streams which are attempting to readjust their valley sizes (Dury, 14&16). Previous hypotheses postulated river capture, the glacial overspill of lakes, underflow through alluvium and flood levels as possible causes of such underfit streams. Dury, however, attributes them to:

"the high rates of rainfall and the resulting high river discharges (that) obtained at various stages during the Pleistocene". (17, P. 193)

Although the Severn has been affected by the overspill of at least two major pro-glacial lakes - Harrison and Lapworth - Dury points out that:

"Postulates of discharge from temporary ice-dammed lakes or from retreat of the ice front are readily seen to be irrelevant to the general problem of winding valleys, when it is observed that these can occur well outside the extreme limits of the Pleistocene glaciation" (17, P. 199)

It is also pointed out that it is very difficult to envisage a system of such lakes and ice-masses which would have had such an influence on the great number of valleys containing underfit streams which exist within the limits of the Pleistocene ice sheets.

Chapter Four - The Terraces of the Lower Teme Valley.

The Teme valley below Orleton Court (G.R. 702669) is seen to contain a number of terrace remnants at heights ranging between 5 feet (1.5 metres) and 140 feet (42.6 metres) above the present alluvium.

Throughout its length in the study area, the Teme valley is characterised by a clearly defined floor, varying considerably in width, but bounded for almost its entire length by well-defined bluffs of varying heights. Within this trough, the Teme meanders freely, and an ox-bow lake is in process of formation at Cotheridge (G.R. 775548), while a further incipient cut-off lake is to be found in Powick parish (G.R. 846520). A former cut-off is also noted at G.R. 828523, where the former course of the river is marked by a double line of willow trees. The Cotheridge ox-bow is of very recent age, the breaching of the 'neck' of the meander having taken place in the early 1950's, and an appreciable quantity of sediment has accumulated in the two 'neck' channels during the last four years so that at normal water level the meander is 'dry', water flowing round only at periods of exceptionally high water.

The Flood Plain Terrace.

Recent studies carried out in the lower section of the Teme valley a few hundred yards above Powick Bridge (G.R. 836525), involved the surveying of a short section of the bank and the marking of the position of the bank by means of pegs inserted at regular intervals at right angles to the line of the bank, and in a number of positions along the surveyed section. Measurements along these lines of pegs during the winter of 1968 - 69 showed a rate of erosion of the banks along both sides of the same stretch of river, of about one foot (30 cms.) per month over a period of four months. Thus the Teme at this point is apparently engaged in channel widening, as is further evidenced by the numerous examples of slumping of the banks along the entire course of the river in the study area, and beyond. Since the water level in the channel is usually some 13 to 15 feet (3.9 to 4.5 metres) below the level of the banks, it seems possible that the river is currently engaged in the cutting of a new 'flood plain' at this lower level, and that the so-called 'flood plain' of the present valley floor should be more accurately termed the <u>flood plain terrace</u>. Certainly under most conditions of the year, the river is more than adequately confined by its banks, and flooding of the so-called 'flood plain' occurs only from 'below', when the exceptionally high level of water in the main trunk stream causes a ponding back of the Teme from the confluence. The flooding of the Teme valley floor rarely reaches any higher upstream than Cotheridge, and none of the local farming populace questioned can recall the river flooding from above.

This apparent development of a new flood plain may be a form of contemporary rejuvenation, but it may equally merely be a reflection of the previously mentioned diminishment of drainage, following more pluviose conditions of the geologically recent past, with the present river attempting to create a valley which is comensurate with its present size, within the confines of a valley carved by a much larger predecessor (14, 15 and 16).

The 'flood plain terrace' is characterised by features of micro-relief which may be clearly seen. Meander scars and back channels are easily seen, and in wet conditions back-swamps begin to develop. However, the occurrence along the banks of the main channel in the lower part, mainly below Knightsford Bridge, of what appear to be levees, is more likely the result of channel dredging operations, which were carried out at least up to the 1930's, than of natural processes.

Throughout its length, the flood plain terrace is composed of silty, sandy material at the surface, with very rare small pebbles. However, at a depth of about 10 feet (3 metres), a pebble layer is encountered, exposed at low water in the banks of the channel. The pebbles are dominantly locally derived materials, including a significant number of dolerite specimens from the Brockhill Dyke. However, there are also numerous other igneous pebbles, including pink granites (Eskdale?) and micro-granites, and a large proportion of quartzites, presumably of Bunter origin. This pebble layer is seen in various places to rest upon Keuper Marl.

<u>The Higher Terraces</u>.

Other exposures of sand and gravel deposits in the Teme valley are rare, there being only a small number of unworked and badly overgrown old pits, and even fewer instances of building projects or other excavations which might have given access to deeper sections. Even the catalogue of well-boring records (Richardson, 43&44)

contains no detail relevant to the mapped terraces of the study area. Two small recent road cuttings, at Broadheath Common (G.R. 805546) and Broadwas (G.R. 754554), did, however, expose pebble layers in a similarly sandy, silty matrix.

From these few exposures and from the numerous shallow pits dug in the field, it was found that the materials contained in the higher terraces are varied, but generally consist of a predominance of locally derived pebbles of Silurian and Devonian rocks, some Malvernian materials downstream from the Knightsford Bridge area, and considerable quantities of Bunter quartzites. The most common of all the materials are those from the Bunter, together with local cornstones and limestones. It is perhaps significant that in all the higher terraces where a pebble layer was located, igneous rocks other than the black and white Brockhill dolerite occurred, yet there was no apparent concentration of any one kind in any single terrace level. Thus it seems unlikely that there is a distinctive 'suite' of pebbles for each level, although the author has no more specific evidence than that outlined above to support this suggestion.

In most of the river terraces listed, it was noted that the proportion of pebbles present in the 'section' increased with depth towards the base of the terrace, which is taken as an indication that in all phases of terrace formation, a vertical gradation of material from coarse at the base to fine at the surface was achieved.

Terraces in the field were identified on the basis of morphology, and it is appreciated that by such a subjective method many smaller 'flats' may well have been overlooked, since their limited surface extent would make it difficult to justify their inclusion without the supporting evidence of deposits over a very much greater area and number of sites.

Once identified and mapped, the terraces were measured by means of short aneroid barometer traverses (see P. 17). In all cases it was intended to obtain a number of height measurements for each remnant, in order to obtain a meaningful average height, and also to attempt to map the fragments according to transverse and longitudinal (i.e. cross- and long-profiles) slopes against the long profile of the flood plain terrace. Thus in the table which follows (Fig. 4.2, P. 85), five heights are listed for as many of the terraces as possible; columns 3 to 6 inclusive represent the average height values of a number of readings along the appropriate 'sides' of the 'flat', and column 8 is thus an overall average. The front, rear, upstream and downstream limits of the terrace, and also the centre point value (column 7) are all based upon the essentially subjective field mapping of the terraces. In some cases, however, the terraces proved too small for such a complete record of field measurements to be obtained, and for these, only an average height is listed; this height is nevertheless derived from a number of readings. It is to be noted, then, that all heights given on the table are averaged from a number of readings, in some cases as many as 50 readings on one terrace remnant.

Since the instrument used is graduated in feet, all heights are given in feet, and the metric equivalent is offered only for the average height of the terrace and for the height of the flood plain terrace at the various projection points.

For the interpretation of these terraces in relation to the flood plain terrace, the levels of the flood plain terrace were taken along a 'projection axis', or a smooth curve drawn on the map (see Fig. 4.1, P. 67) through the meanders of the present river, and following the main line of the valley. All the terraces are thus measured against the height of this projection axis. The points measured along the axis are those points which meet the lines drawn transversely across each terrace or group of terraces. In this way, the terraces are measured against the profile of the flood plain terrace, and not against the water surface, which fluctuates too greatly to be of value as a datum for such a survey. Points at which the flood plain terrace was measured are given a letter code on the map and table (Figs. 4.1 and 4.2, Ps. 67 and 85).

The Terraces of the Teme Valley

1. The Severn Vale Teme

Code Number, Name and Height in Feet (Metres) O.D.	Description
No. 1. Name: Lower Wick Height - 61 ft - 18.6 m	The site of the Worcester City sewage works and of a large dairy, this terrace has a well-marked rear bluff, though the front has been considerably altered by

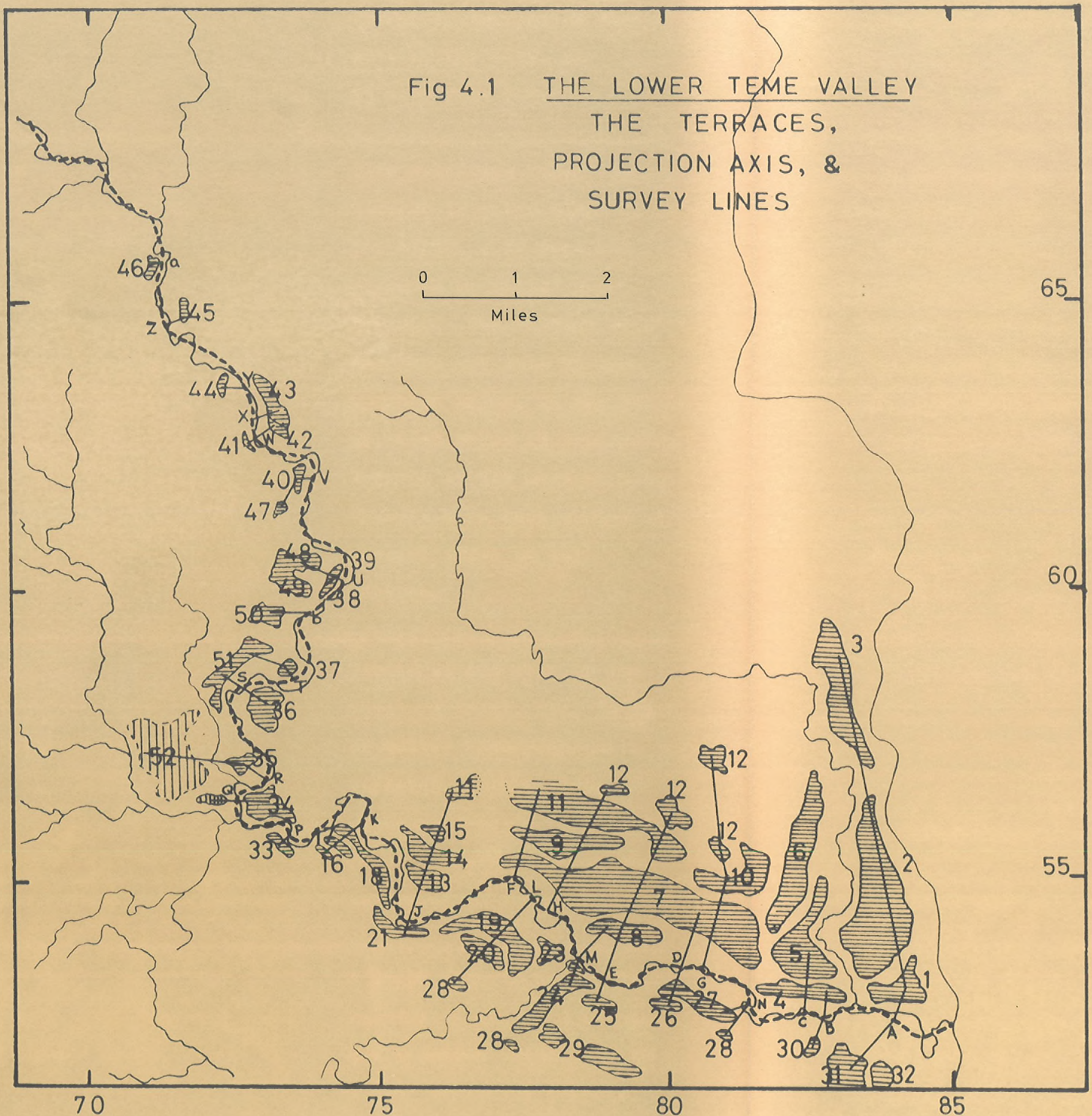


Fig 4.1 THE LOWER TEME VALLEY
THE TERRACES, PROJECTION AXIS, & SURVEY LINES
0 1 2
Miles
65
60
55
70
75
80
85

	building. It pairs with the Worcester terrace of the site of the City, at 55 - 65 feet O.D.
No. 2. Name: St. Johns. Height - 88 ft - 26.8 m	This extensive 'flat' is divided into two parts by a low bluff, a feature not uncommon on Wills' Main Terrace. The western edge has been cut into by the Laughern Brook, in the valley of which there is a matching terrace on its western side. Gravels have been worked at several sites on this terrace.
No. 3. Name: Hallow. Height - 148 ft - 45.1 m	Eroded at its rear by the Laughern Brook, this is part of Wills' Kidderminster sequence, with a steep and pronounced bluff down to the flood plain terrace of the Severn.
No. 4. Name: Wick Episcopi Height - 75 ft - 22.8 m	A small terrace which clearly relates to No. 1 across the Laughern Brook, and to Wills' Worcester terrace.

	A pit revealed significant gravel proportions.
No. 5. Name: Golf Course Height - 95 ft - 28.9 m	An extensive flat underlain by a pebble layer, and comparable in height to No.2. - Wills' Main Terrace.
No. 6. Name: Laughern Valley Height - 118 ft - 35.9 m	A number of spur-end terraces extending up the tributary valley, with significant gravel content. The height falls between that of Wills' Kidderminster and Main levels, and it seems likely to be a tributary equivalent of the latter.
No. 7. Name: Cotheridge Height - 115 ft - 35.0 m	A very extensive terrace with a very fine front bluff, it is broken into several parts by minor stream valleys. Gravels are to be seen in recent road cuttings, and a gravel layer resting on marl is found at about 4 feet depth. It appears to relate to No.6.

No. 8. Name: Cotheridge, Lower Court Height - 79 ft - 24.1 m	With clear, low bluffs at the front and rear, gravels were found in three pits. Relates to Nos. 1 and 4.
No. 9. Name: Moat Cottages Height - 134 ft - 40.8 m	Separated from No. 7 by a low bluff, gravels were seen in a row of post holes running transversely across the terrace in 1970.
No. 10. Name: Grove Covert Height - 126 ft - 38.4 m	A small terrace which appears to extend around the hill below Aymestry School. Well-marked on the A44 east of Crown East (G.R. 813547), but does not appear higher up the Laughern Valley.
No. 11. Name: Lightwood Height - 168 ft 51.2 m	A broad expanse of gently undulating land in which a general uniformity of height is apparent. Gravels have been found in small quantities in a number of shallow pits, and the level also occurs on the north side of No. 12, as well as to the south and west.

	It is presumed therefore that this level relates to the Severn rather than to the Teme, although it does not fit the height ranges of either Bushley Green or Woolridge terraces. It is nearer to the former.
No. 12. Name: Broadheath Height - 207 ft - 204 ft - 196 ft - 195 ft (Metric equiv. not given)	Four separate remnants at Upper and Lower Broadheath, Crown East and Tinker's Cross, but with no clear slopes. Gravels were seen at depths of up to 8 feet during Water Board excavations in 1968 and 1969, on three of these 'summits'. The heights suggest Wills' Bushley Green level.
No. 13. Name: Broadwas Court Height - 84 ft - 25.6 m	The site of a church and a Court, this terrace has no discernible slope. Gravels were seen during Electricity Board excavations in 1967.

No. 14. Name: Broadwas Village Height - 114 ft - 34.7 m	A small terrace with a pronounced front bluff, followed by the A44. Gravels were seen on building sites in 1967, and in a recent road cutting a layer of pebbles was revealed at a depth of about 7 feet. The material was mostly locally derived, but a few igneous pebbles were found.
No. 15. Name: Eversfield Cottages Height - 131 ft - 39.9 m	A small terrace on which gravels were reported by Davies (10) in 1951.
No. 16. Name: Lulsley - Corbets Height - 137 ft - 41.7 m	A clear bluff rises up to a small 'flat' on which there was no measurable slope.
No. 17. Name: Lulsley - Church Height - 128 ft - 39.0 m	A clearly visible terrace, the site of the church, with well-marked bluffs to front and rear. Gravels were found at a depth of less than 3 feet.

No. 18. Name: Lulsley - Court Height - 85 ft - 25.9 m	A long, low and narrow terrace with no measurable slope across, and only indistinct bluffs. Gravels were found at several sites.
No. 19. Name: Brockamin - Low Height - 113 ft - 34.4 m	An extensive 'flat' with prominent bluffs to the front and rear, gravels are present.
No. 20. Name: Brockamin - High Height - 126 ft - 38.4 m	A clear bluff separates this from No. 19, but the surface is very irregular. Gravels were found in several pits.
No. 21. Name: Folly Farm Height - 115 ft - 35.0 m	A long narrow 'flat' which pairs across the valley with No. 14.
No. 22. Name: Leigh Court Height - 74 ft - 22.5 m	The site of the church, a disused gravel pit is located on the terrace (see Davies, 10).

No. 23. Name: Leigh Height - 74 ft - 22.5 m	Although no gravels in any quantity were found, the height and position is such that this small terrace pairs with No. 22 across the Leigh Brook.
No. 24. Name: Leigh Lodge Height - 122 ft - 37.2 m	A long, narrow 'flat', which lies largely along the Leigh Brook valley. Gravels are present.
No. 25. Name: Bransford School Height - 158 ft - 48.2 m	Above Bransford School, the hill top supports gravels and the height appears to relate to that of No. 11.
No. 26. Name: Bransford Height - 111 ft - 33.8 m	This terrace has a prominent front bluff, though its rear has been extensively eroded by the small Bransford Brook. A disused railway line follows the foot of the front bluff, and there is no measurable slope across the terrace.

No. 27. Name: Bransford Court Height - 75 ft - 22.8 m	A low terrace but with clear bluffs to the front and rear. Gravels are found at about 3 feet depth, and the terrace seems to relate to Nos. 4 & 8 .
No. 28. Name: Clerkenhill Height - 207 ft - 205 ft - 201 ft (Metric equiv. not given)	South of the river Teme are three 'summits' each supporting a generous quantity of gravels, and a connection between these summits and those in Broadheath parish (No. 12) is proposed.
No. 29. Name: Smith's End Green Height - 159 ft - 48.5 m	Indistinct bluffs and an undulating surface characterise this terrace, which seems to relate to Nos. 11 and 25.
No. 30. Name: King's End, Powick Height - 130 ft - 39.6 m	This small terrace has poorly preserved bluffs at the rear, but a good front edge down to the Teme on the northern side. This is part of Wills' Kidderminster terrace of the Severn.

No. 31. Name: Powick Height - 85 ft - 25.9 m	This terrace of the Severn is very clearly defined, and gravels are found very close to the surface. Part of Wills' Main Terrace, this relates to No. 2.
No. 32. Name: Beauchamp Court Height - 57 ft - 17.4 m	Another of Wills' terrace levels, this is part of the Worcester Terrace.
2. <u>The Shelsley Reach.</u> No. 33. Name: Woodford House Height - 87 ft - 26.5 m	A low terrace, bounded on three sides by steep rises which are well-wooded. The lower edge of the terrace is almost indistinguishable from the flood plain terrace.
No. 34. Name: Talbot Inn Height - 91 ft - 27.7 m	Also very close to the flood plain terrace level, this remnant is poorly defined at front and rear, possibly because of its position inside a large meander loop. It has a good front bluff only along its northern, upstream edge.

No. 35 Name: Whitbourne Height - 110 ft - 33.5 m	The site of Whitbourne Court and of a medieval Bishop's Palace, this level is poorly defined at front and rear. It lies inside a large meander loop, and has a clear front bluff on the northern, upstream edge only.
No. 36. Name: Horsham Height - 138 ft - 42.1 m	This is an extensive 'flat', and the site of two large Seventeenth Century farm-houses. It has clear bluffs to the north and west, but the southern (downstream) edge is very indistinct. Gravels are plentiful, and recent track-making has exposed a thickness of at least 6 feet of gravel beneath about 2 feet of sandy alluvium.
No. 37. Name: Tedney Height - 138 ft - 42.1 m	This terrace flanks a spur beneath Tedney House, and has a clear front bluff. There is an old, badly overgrown gravel pit on the southern edge, in which 6 feet of gravels are discernible.

No. 38. Name: Ham Mill South Height - 121 ft - 36.9 m	The site of another large timbered farmhouse, good bluffs are apparent, and gravel is plentiful.
No. 39. Name: Ham Mill North Height - 141 ft - 43.0 m	Separated from No. 38 by a southern bluff and with a marked slope down to the flood plain terrace. An overgrown gravel pit yielded igneous material, including local dolerite and pink granites from a mixture which is dominated by Devonian materials.
No. 40. Name: Homme Castle Height - 124 ft - 37.8 m	Northeast from the Homme Castle farmstead this level fronts a spur, and has clear bluffs there and on the river side. Measured at an average height of 124 feet, the average downstream slope of the terrace is about 1:600.
No. 41. Name: Newmill Bridge Height - 128 ft - 39.0 m	A small terrace at the western end of the bridge, the front bluff of which is marked by a hedgerow. It is of too limited an extent

	to obtain a meaningful longitudinal range of heights.
No. 42. Name: Shelsley Church Height - 128 ft - 39.0 m	The site of the church, this terrace has a marked front bluff, the rear rising steeply to the level above (No.43). Height measurements are almost identical with those of No. 41.
No. 43. Name: Shelsley School Height - 152 ft - 46.3 m	A very well-defined terrace and the site of the village, the noticeably flat surface gives way to very broken country behind which rises to the summits of the Malvern Axis. At the upstream end a small stream separates this level from the outcrop of the Brockhill dolerite dyke.
No. 44. Name: Shelsley Walsh Height: 152 ft - 46.3 m	The site of Shelsley Court Farm, this terrace has good bluffs at front and rear, and its northern end butts up against the dyke, and is cut across the country rock, as observed in a minor farm excavation. Gravels are

	plentiful, with an abundance of dolerite and metamorphosed marlstone, but also with other igneous pebbles.
No. 45. Name: Butler's Mill Height - 152 ft - 46.3 m	A disused gravel pit on the southern edge showed at least 4 feet thickness of sands and gravels, amongst which are to be found pinkish and other granites.
No. 46. Name: Stanford Court Height - 149 ft - 45.4 m	Stanford Court stands at the rear of this level, and various works associated with the estate have undoubtedly altered the landscape in this area. However, there is a good front bluff down to the flood plain terrace, both to the north and to the east.

The Shelsley Reach of the Teme valley is approximately the same length as the section below Knightsford Bridge - the Severn Vale Teme section - but the difference in the number of terraces identified is most noticeable (32 in the Severn Vale section, including the six terraces of the Severn at the confluence, as opposed to only 14 in the Shelsley Reach). This may be partly due to the fact that the lower reach must contain other elements of Severn terraces, especially at higher levels. Further, the enclosing valley walls are much higher, and of more resistant material, in the upper reach, so that the valley is deeper cut and narrower, and the terraces are considerably smaller in this area.

3. <u>The Tedney and Meadow Green Levels.</u>

Also occurring in the Shelsley Reach is a number of higher, apparently bevelled spurs, extending west to east into the Teme valley from the west valley side. These spurs, each of about half a mile in length, show a gentle slope eastwards towards the present river, while on the east bank, a few small hill-tops reach a comparable altitude, and may be related features. None of these spurs is wide enough, north to south, to present a measurable slope, but gravels were found in abundance on all surfaces, and also in shallow pits. Although these gravels may be derived from slope wash from the higher surface of the Clifton Plateau to the west, they are here interpreted, on the basis of morphology, as being of fluvial origin, the spurs representing the only remnants of a former valley floor which stood at about 240 feet (73 metres) O.D., or 135 to 140 feet (41.1 to 42.6 metres) above the present flood plain terrace. This level is hereafter referred to as the <u>Tedney Level</u>.

Another group of dissected surfaces, each of limited extent, is to be found in the parish of Whitbourne. A number of flat-topped hills, rather higher in the north of the area than in the south, present an average elevation of about 225 feet (68.4 metres) O.D., or again about 42 metres above the present flood plain terrace at the Whitbourne projection point. This area, the Meadow Green Level, also contains an abundance of rounded pebbles, and is proposed as being a downstream extension of the Tedney Level.

4. The Sapey Bowl.

On the south side of the Meadow Green Level, and lying on either side of the Sapey Brook in its lower reaches, a further group of terraces has been identified. In most cases, these are small, flat areas preserved on the inter-fluves between the smaller tributaries of the Sapey Brook, and in no case was there sufficient extent of flat land for the measurement of front and rear to be carried out. Thus a number of height readings were taken at various points on each flat, following a crude grid pattern, and an average value was devised. Gravels are abundant throughout the area of the Sapey Bowl, and although pits were not dug on every 'flat', a sample of pits covering over 30% of the total number, revealed a significant proportion of pebbles at depth, but no gravel layer. The table (Fig. 4.4, P. 87) shows that the 25 'flats' identified fall into three convenient groups, at average heights of 220 feet (67 metres) O.D., 175 feet (53.3 metres) O.D., and 155 feet (47.2 metres) O.D. It is also noticeable that most of these fragments are to be found on the south side of the present Sapey Brook, and extending up the spurs towards the Suckley Station col (G.R. 720540). The high group of these terraces is interpreted as constituting part of the Meadow Green Level.

All diagrams relating to the terraces of the Teme have been constructed from the data summarised in the tables, Fig. 4.2, 4.3 and 4.4,(Ps. 85, 86 and 87), and it has been assumed that the readings and measurements are accurate within the limits of the instrument used (see P. 17). It is also assumed that the surface of the terraces are within 5 feet (1.5 metres) of the heights at which they were formed (see P. 17).

TABLE OF TERRACE MEASUREMENTS.

Key to columns on Table 4.2

Column No.	Content.
1.	Terrace number, as used in descriptions on Pp. 66 - 80
2.	Distance of projection Point from Severn confluence, in miles.
3.	Measurement of upstream end of terrace - feet O.D.
4.	Measurement of downstream end of terrace - feet O.D.
5.	Measurement of rear of terrace - feet O.D.
6.	Measurement of front of terrace - feet O.D.
7.	Measurement of 'centre point' of terrace - feet O.D.
8.	Average height of terrace, derived from 3 to 7, above.
9.	Metric equivalent of 8, to the nearest tenth.
10.	Projection Point letter code.
11.	Height of flood plain terrace at Projection Points - feet O.D.
12.	Metric equivalent of 11, to the nearest tenth.
13.	Height of terrace above flood plain terrace - feet.
14.	Metric equivalent of 13, to the nearest tenth.
15.	Longitudinal dimension of terrace in metres, as measured from field mapping.
16.	Distance of front edge of terrace from projection point, in metres, as measured from field mapping.
17.	General remarks, as necessary.

TABLE 4.2. The Terraces of the Teme Valley.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0.8	-	-	64	58	61	61	18.6	A	48	14.6	13	3.9	-	-	Wills' Worcester Terrace
2	0.8	101	78	93	79	87	88	26.8	A	48	14.6	40	12.2	-	-	Wills' Main Terrace
3	0.8	154	143	-	-	149	148	45.1	A	48	14.6	100	30.4	-	-	Wills' Kidderminster Terrace
4	1.4	76	72	80	74	74	75	22.8	B	52	15.8	23	7.0	783	220	left bank
5	1.5	94	94	97	94	95	95	28.9	C	52	15.8	43	13.3	583	293	left bank
6	-	126	116	125	110	112	118	35.9	-	54	16.4	64	19.5	-	-	only present in the Laughern Valley
7	3.4	114	110	118	116	116	115	35.0	D	61	18.6	54	16.4	1766	190	left bank
8	4.4	79	78	83	76	79	79	24.1	E	61	18.6	18	5.6	583	250	left bank
9	5.6	136	131	137	133	135	134	40.8	F	64	19.5	70	21.3	483	220	left bank
10	3.2	-	-	-	-	126	126	38.4	G	60	18.3	66	20.1	392	440	left bank, Teme and Laughern valleys.
11	4.5	176	160	172	164	166	168	51.2	H	62	18.9	106	32.3	1173	587	left bank
12	Four remnants at 204,207,196,195								-	60	18.3	140	42.7	-	-	Wills' Bushley Green level?
13	6.8	-	-	-	-	84	84	25.6	J	70	21.3	14	4.3	230	147	left bank, lowest of Broadwas 'staircase'.
14	6.8	116	111	126	104	114	114	34.7	J	70	21.3	44	13.4	393	325	left bank, part of Broadwas 'staircase'.
15	6.8	-	-	136	129	130	131	39.9	J	70	21.3	61	18.6	410	410	left bank, top of Broadwas 'staircase'.
16	7.9	-	-	143	136	139	137	41.7	K	72	21.9	65	19.8	120	293	right bank, top of Lulsley 'staircase'.
17	7.9	-	-	-	-	128	128	39.0	K	72	21.9	56	17.0	350	190	right bank, part of Lulsley 'staircase'.
18	7.9	89	82	-	-	86	85	25.9	K	72	21.9	13	3.9	660	58	right bank, lowest of Lulsley 'staircase'.
19	5.5	116	112	119	106	112	113	34.4	L	63	19.2	50	15.2	660	208	right bank
20	5.5	-	-	-	-	126	126	38.4	L	63	19.2	63	19.2	566	410	right bank
21	6.8	116	113	-	-	115	115	35.0	J	70	21.3	70	21.3	533	58	right bank, Teme undercutting at the base.
22	4.5	-	-	-	-	74	74	22.5	M	62	18.9	12	3.6	100	58	right bank - this and No 23 are parts of
23	4.5	-	-	-	-	74	74	22.5	M	62	18.9	12	3.6	200	158	the same terrace.
24	4.3	130	118	128	114	121	122	37.2	M	62	18.9	60	18.3	233	147	right bank, and along Leigh Brook valley
25	3.8	-	-	-	-	158	158	48.2	E	61	18.6	97	29.6	217	100	right bank
26	3.2	114	108	-	-	111	111	33.8	D	61	18.6	50	15.2	250	217	right bank
27	3.0	78	73	78	71	76	75	22.8	N	59	18.0	16	4.9	660	116	right bank
28	Three remnants at 201,205,207							-	-	60	18.3	144	43.9	-	-	Wills' Bushley Green level?
29	4.1	171	147	170	150	158	159	48.5	G	60	18.3	99	30.1	917	517	right bank
30	1.5	-	-	-	-	130	130	39.6	B	52	15.8	78	23.8	-	-	Wills' Kidderminster Terrace
31	1.0	-	-	91	79	-	85	25.9	A	48	14.6	37	11.2	-	-	Wills' Main Terrace
32	0.6	-	-	60	54	-	57	17.4	A	48	14.6	9	2.7	-	-	Wills' Worcester Terrace
33	8.9	90	86	91	84	87	87	26.5	P	84	25.6	3	0.9	200	43	right bank, Knightsford Gap.
34	9.5	96	89	91	87	89	91	27.7	Q	85	25.9	6	1.8	200	33	left bank
35	10.1	108	97	132	102	113	110	33.5	R	88	26.8	22	6.7	100	133	right bank
36	11.2	151	126	147	125	142	138	42.1	S	91	27.3	47	14.3	200	100	left bank
37	11.4	141	136	143	131	138	138	42.1	T	101	30.8	37	11.2	100	87	right bank
38	12.4	121	120	124	119	121	121	36.9	U	110	33.5	11	3.3	88	43	right bank
39	12.4	144	136	147	148	141	141	43.0	U	110	33.5	31	9.4	100	58	right bank
40	13.8	125	122	126	124	124	124	37.8	V	114	34.7	10	3.0	200	58	right bank
41	14.6	-	-	129	126	128	128	39.0	W	115	35.0	13	3.9	100	43	right bank
42	14.6	-	-	128	125	128	128	39.0	W	115	35.0	13	3.9	83	83	left bank
43	14.8	155	146	156	150	153	152	46.3	X	118	35.9	34	10.4	350	83	left bank
44	15.1	151	144	157	146	152	152	46.3	Y	119	36.2	33	10.0	233	83	right bank
45	16.3	157	147	157	147	152	152	46.3	Z	121	36.9	31	9.4	200	43	left bank
46	17.3	148	144	156	145	152	149	45.4	a	124	37.8	25	7.6	233	43	right bank

TABLE 4.3 The High Level Remnants of the Shelsley Reach.

Terrace No.	Miles fr. con-fluence	Name	High Pt. (ft)	Mid. Pt. (ft)	Low Pt. (ft)	Average Ht.	Metric Equiv.	Proj. Pt.	Height of P.P. (O.D.)	Metric Equiv.	Ht. of Terrace above P.P. (ft)
47	13.8	The Ham	281	251	232	254	77.4	V	114	34.7	140
48	12.6	The Ashes	273	246	211	243	74.0	U	110	33.5	133
49	12.4	The Noak	268	246	226	246	75.0	U	110	33.5	136
50	11.8	Greenwoods	278	238	204	240	73.1	b	107	32.6	133
51	11.3	Tedney	246	226	208	227	69.2	S	91	27.7	136
52	10.1	Meadow Green	238	228	207	224	68.2	R	88	26.8	136

TABLE 4.4

REMNANTS OF THE SAPEY BOWL AREA

	Code Letter	Highest Value	Average Value	Feet O.D.	Metres O.D.
1. High.	A	154	142	230	70.1
	B	155	143	231	70.4
	C	151	141	229	69.8
	D	141	131	219	66.7
	E	144	135	224	68.3
	F	136	130	218	66.4
	G	139	129	217	66.1
	H	131	125	213	64.9
	J	128	126	214	65.2
	K	144	135	224	68.3
	L	146	139	227	69.2
2. Middle.	a	96	90	178	54.2
	b	92	92	180	54.8
	c	91	85	173	52.7
	d	87	82	170	51.8
	e	86	81	169	51.5
	f	94	88	176	53.6
	g	94	89	177	53.9
	h	101	91	179	54.5
	j	94	90	178	54.2
	k	96	93	184	56.0
3. Low.	1	73	66	154	46.9
	2	79	70	158	48.1
	3	73	66	154	46.9
	4	68	63	151	46.0

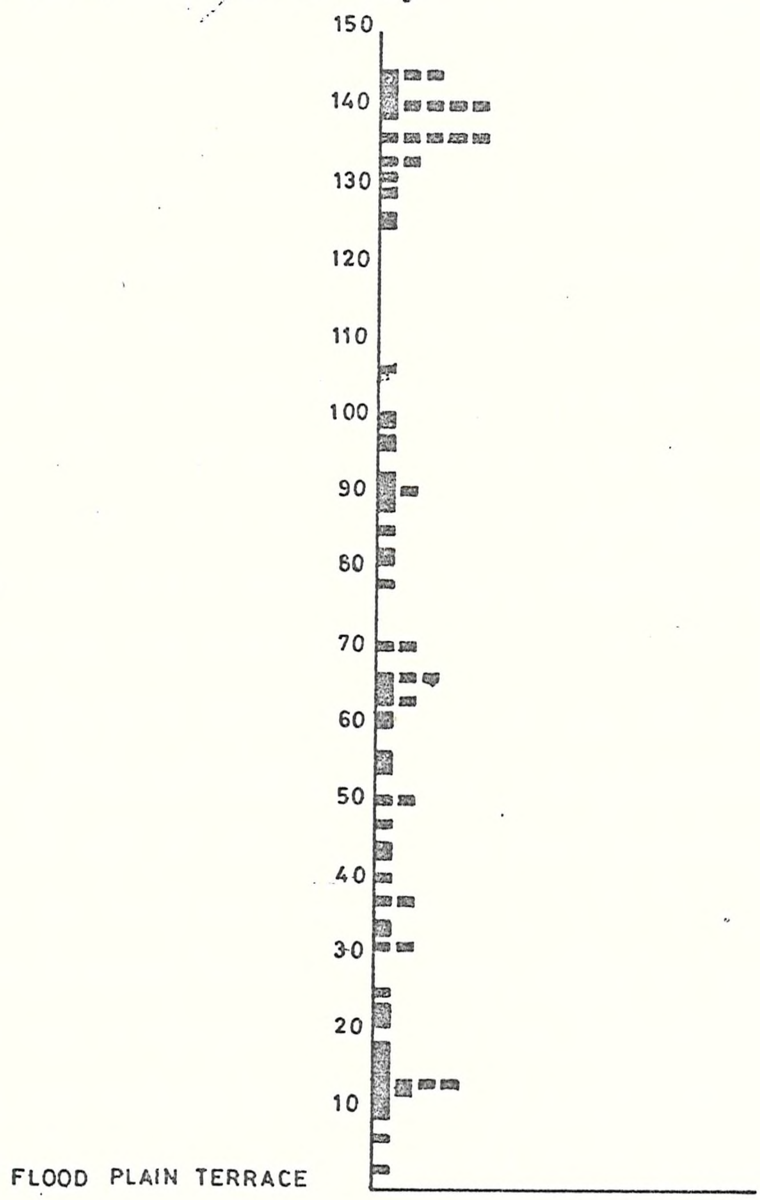
In all cases on this table, the heights listed as highest and average values are measured above the height of the nearest projection point on the Teme valley floor, Projection Point R, at 88 feet (26.8 metres).

Fig 4.5

TERRACES OF THE LOWER TEME

Average height above flood plain terrace datum

Source - field survey



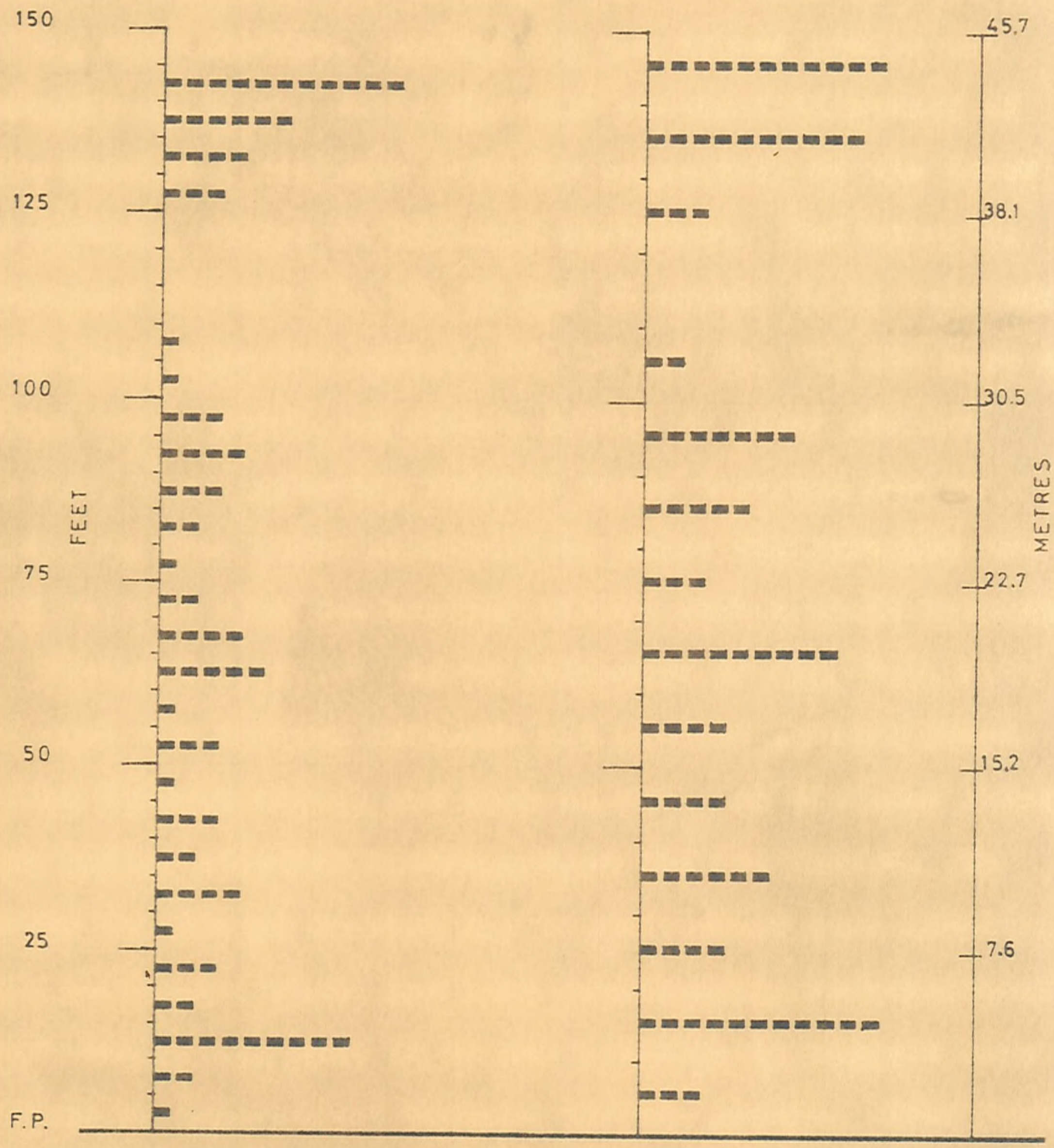
From the tables of terrace statistics, a number of graphs have been constructed, for the purpose of attempting to group the terraces into levels which may then be interpreted as former valley stages of the river Teme. Fig. 4.5, P. 88 plots each terrace simply on the basis of height above present flood plain terrace, and with no attempt to show distance upstream. On this graph, two identifiable groups emerge, a higher level group at between 125 and 145 feet (38.1 and 44.1 metres), and a second at between 80 and 110 feet (24.3 and 33.5 metres) above the flood plain terrace. The higher group includes the surveyed remnants of the Tedney and Meadow Green levels, and also the scattered high terraces of Broadheath and Bransford parishes (Nos. 12 and 28, Fig.4.2, P. 85). The high group of terraces in the Sapey Bowl area also fall into this group, while those of the middle group of the Sapey Bowl area fall into the height range of the 80 to 110 feet group.

Below 80 feet (24.3 metres), groups are less clearly defined, although there are apparent concentrations at between 60 and 70 feet (18.3 and 21.3 metres) and also at below 20 feet (6.1 metres).

In an attempt to clarify this spread of terraces between the flood plain terrace and the group above 80 feet (24.3 metres), the same figures were used on Fig. 4.6, P. 90 , but terraces were now grouped into height-ranges, so that the graph shows them in 5-feet (1.5 metres) and 10-feet (3.0 metres) groups. Again, the higher groups are clearly separated, while below 80 feet (24.3 metres), three further groups begin to emerge -

Fig 4.6
TERRACES OF THE LOWER TEME

5 Ft.& 10 Ft. Groups



5 Ft. Groups

10 Ft. Groups

at 60 to 69 feet (18.2 - 21.0 m)

at 30 to 39 feet (9.1 - 11.9 m)

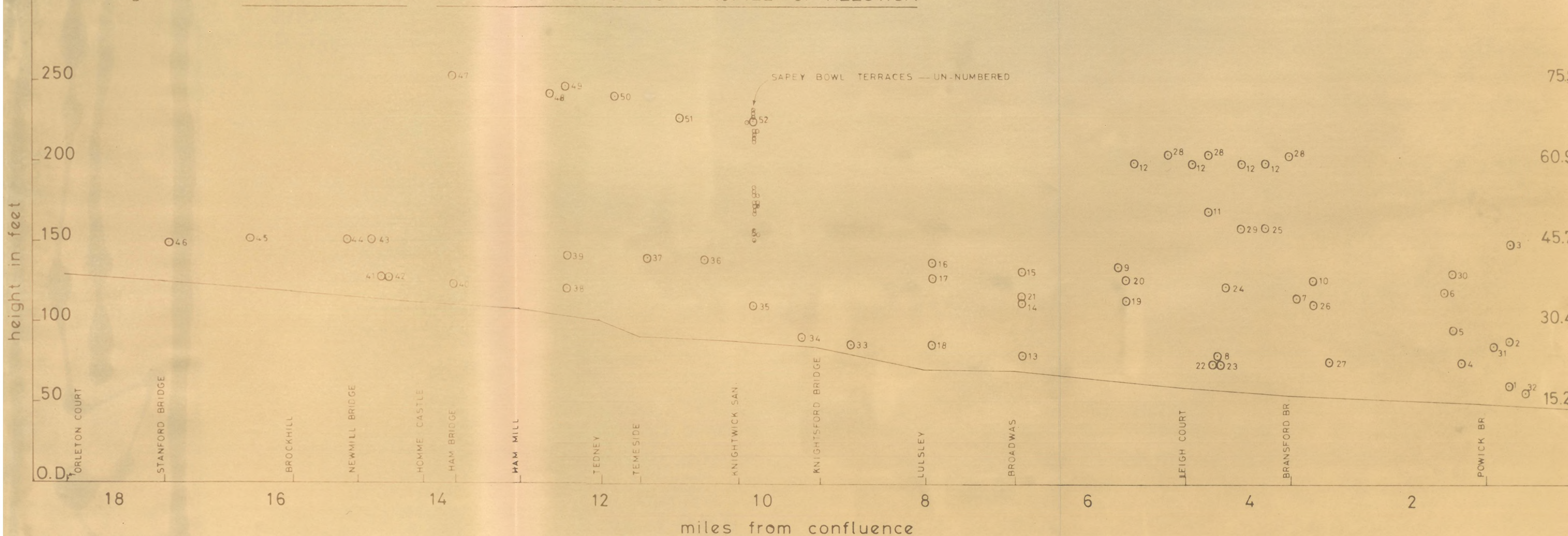
and at 10 to 19 feet (3.0 - 5.8 m).

On Fig. 4.7, P. 92 the centre point of each terrace is plotted against the profile of the flood plain terrace along the projection axis, and also in terms of position along that profile. Again, the two higher groups are clearly apparent, while the wide vertical dispersal of the remaining terraces gives no suggestion of the lower groupings, except in isolated instances. For example, terraces numbers 13, 18, 33 and 34 appear to be related; likewise, terraces numbers 36, 37 and 39. In the case of this latter group, as with a number of other similar groups, a relationship between these terraces can be inferred from field observations since the terraces are all visible from one another within such a small locality.

Figure 4.8, P. 93 is an extension of Fig. 4.6, P. 90 in that the terrace remnants are plotted against flood plain terrace datum, and also in terms of distance along the valley measured upstream from the confluence. In order to attempt to show any relationships more closely, the horizontal scale has been considerably foreshortened, with the result that it is now possible to suggest some 'lines of separation' between terrace groups. Thus from this graph, five groups of terraces are proposed:

Terrace No. 5.	145 - 125 feet	44.1 - 38.1 metres
Terrace No. 4.	110 - 75 feet	33.5 - 22.8 metres
Terrace No. 3.	70 - 50 feet	21.3 - 15.2 metres
Terrace No. 2.	45 - 30 feet	13.7 - 9.1 metres
Terrace No. 1.	25 - 5 feet	7.6 - 1.6 metres

Fig 4.7 TEME TERRACES - CENTRE POINTS AGAINST PROFILE OF ALLUVIUM



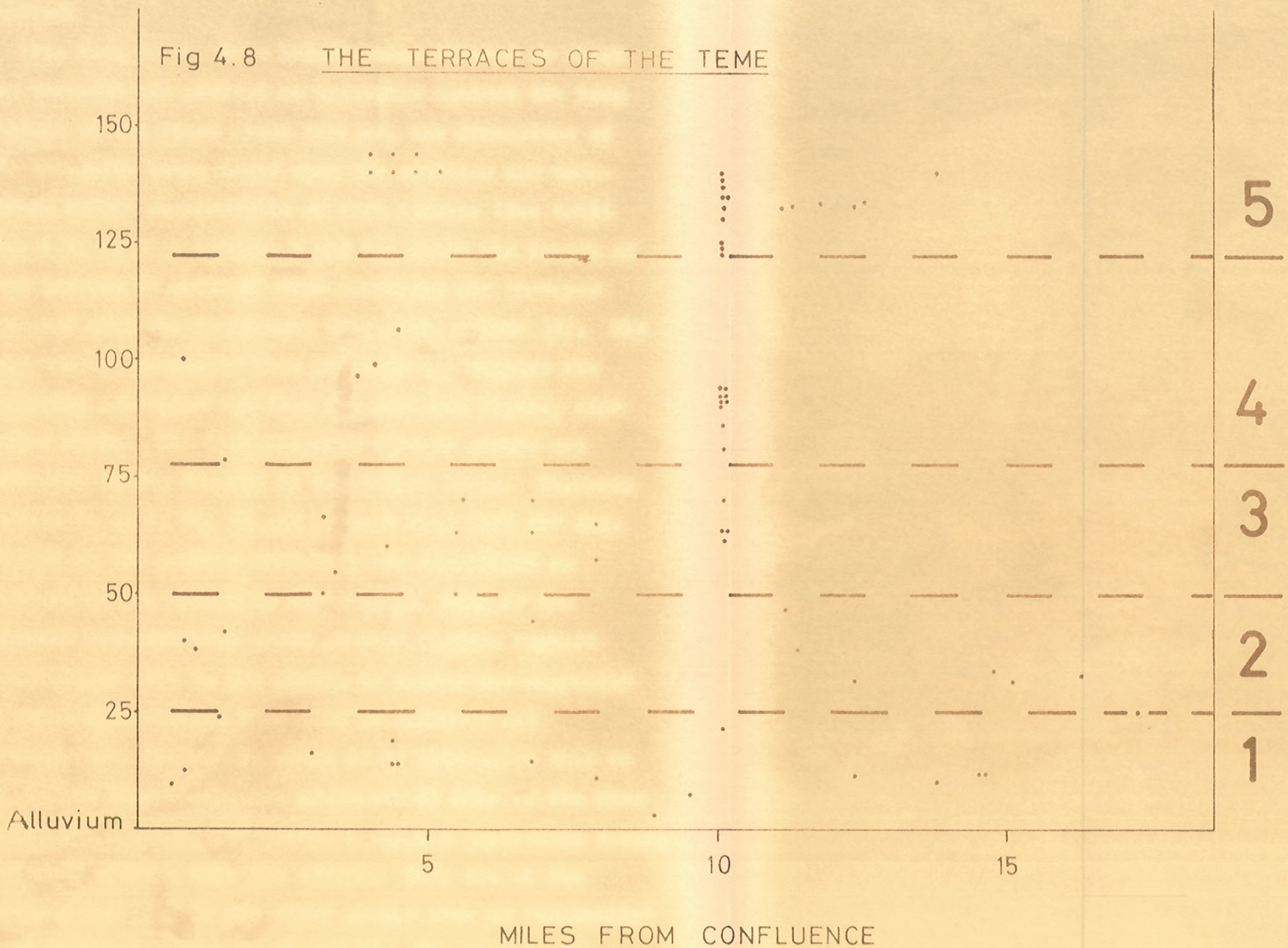


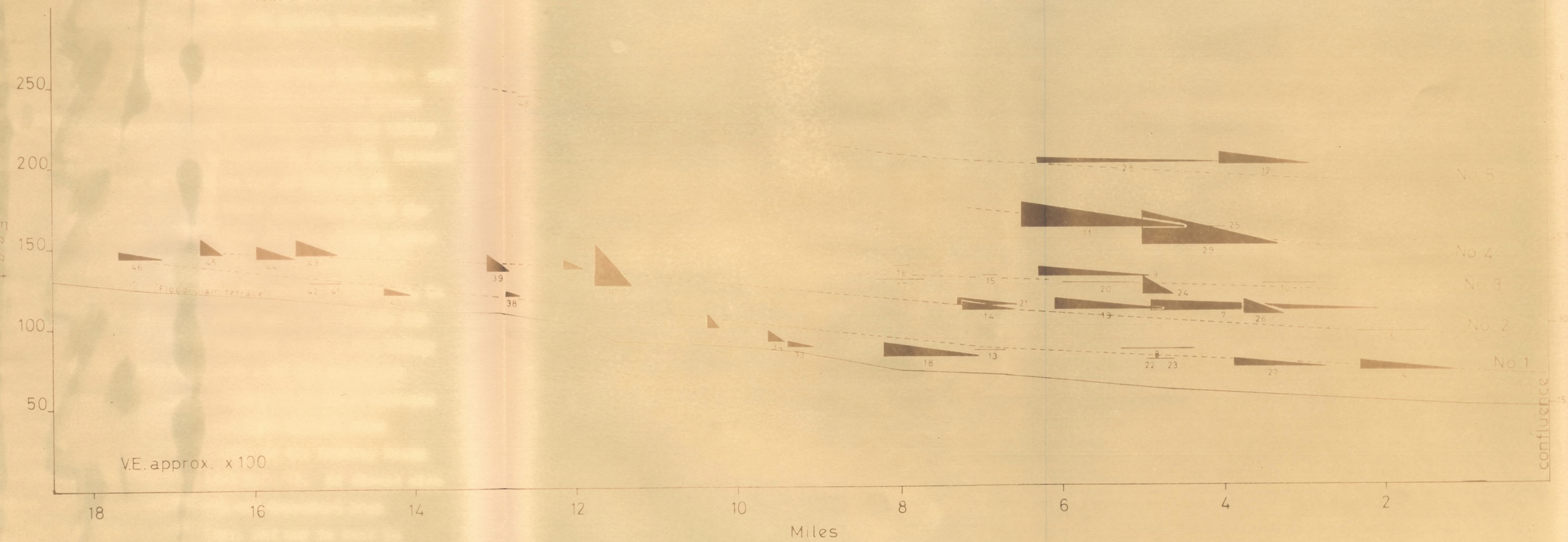
Fig 4.8
THE TERRACES OF THE TEME
150
125
100
75
50
25
Alluvium
5
10
15
MILES FROM CONFLUENCE
5
4
3
2
1

The flood plain terrace is omitted from this list since it is taken as the datum from which other groups are derived.

Fig. 4.9, P. 95 is a height-range diagram on which the terraces are plotted as triangles against the long profile of the flood plain terrace, the dimensions of the triangles being based upon the upstream and downstream height measurements of each terrace (see table Fig. 4.2, P. 85 , columns 3 and 4), while the length of each terrace is obtained from measuring the surveyed terraces from the field maps (Fig. 4.2, column 15). The diagrammatic gradients thus obtained may support the suggested relationships from the previous figure, discussed above. The five proposed terrace groups are indicated on the diagram by the broken lines. Terraces numbers 1, 2, 3, 30, 31 and 32 have been left off this diagram on the grounds that they are identified as terraces of the Severn by Wills (62). Many of the apparent relationships shown on this diagram support observations made in the field, or rather are supported by those observations (see list of terraces and descriptions, Pp. 66-80), while it is noticeable that in the Severn Vale reach, the gradients of four of the five groups are similar, the Number 4 terrace apparently having a steeper profile than the others. Only two of the surveyed terraces in the other groups show an 'unusually' steep gradient - numbers 24 and 26. The former, the Leigh Lodge terrace (P. 74) lies largely along the tributary valley of the Leigh Brook, which may explain its steeper gradient. The Bransford terrace (P. 74) has

Fig 4.9 HEIGHT-RANGE DIAGRAM OF TEME VALLEY TERRACES

Showing proposed terrace groups



been extensively eroded at its rear by the small Bransford Brook, which joins the Teme at the downstream end of the terrace, and the steeper gradient here may simply be the result of the difficulty and subjectivity of determining the terrace 'edge'.

The remnants of the Shelsley Reach, on the other hand, seem to have characteristically steep gradients, the 'unusual' terraces being those with gentle longitudinal slopes.

It is further noticeable from both Fig. 4.8, P. 93 and Fig. 4.9, P. 95 , that there are three terrace groups which can be traced over the whole length of the valley in the study area - terraces numbers 5, 2 and 1. Numbers 3 and 4 only extend upstream as far as the gap at Knightsford Bridge, and have their counterparts in the Sapey Bowl area, where the middle and low groups appear to relate to them.

The highest proposed group, the number 5 terraces, is of great interest, since it would appear to relate the two extensive levels of the Shelsley Reach - the Tedney Level and the Meadow Green Level - to the scattered high-level terraces of the Severn Vale Reach - terraces which by virtue of their height have already been tentatively related in their turn to the Bushley Green stage of the river Severn. (see P.71,75). It should also be noted that these Broadheath and Bransford high terraces are found on hill tops, and may in fact be terraces not of the Teme, but of the Severn.

The line at the base of the Number 5 Terrace is drawn through the lowest terrace of the proposed group, which

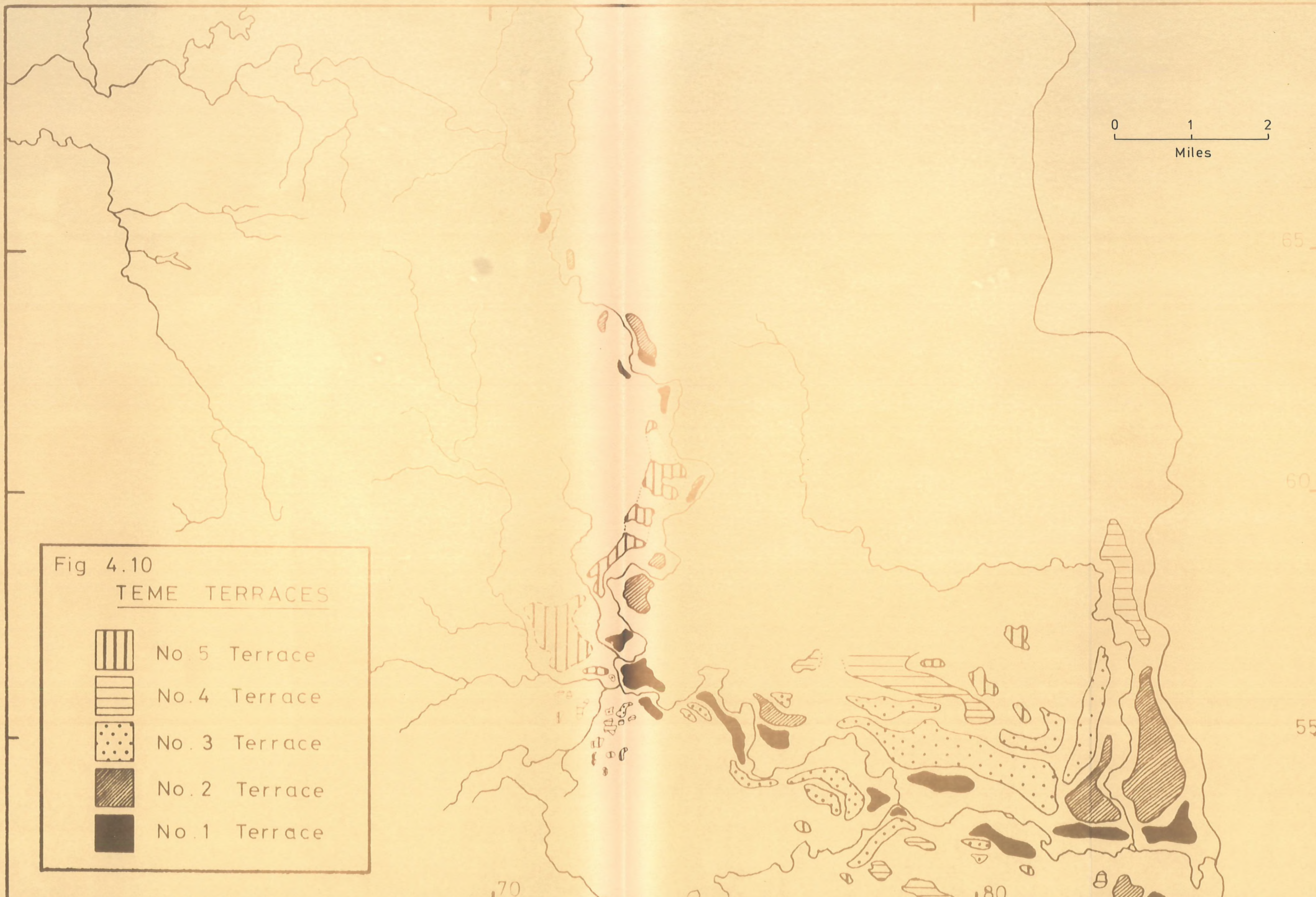

0 1 2
Miles
65
60
55
70
80
Fig 4.10
TEME TERRACES
No. 5 Terrace
No. 4 Terrace
No. 3 Terrace
No. 2 Terrace
No. 1 Terrace

Fig 4.11
TERRACES OF SAPEY BOWL

is terrace 'H' of the Sapey Bowl area, and Terrace Number 4 is also grouped according to the height of the lowest of the Sapey Bowl middle group of remnants - terrace 'e'. This Number 4 Terrace is also interesting in that there are no identified remnants in the Shelsley Reach, and few only in the Severn Vale section of the Teme valley.

Terrace Number 3 is based upon the lowest of the Sapey Bowl low group, which stands at 63 feet (19.2 metres). The highest of the Sapey terraces of this group stands at 70 feet (21.3 metres). Terraces Numbers 1 and 2 are distinguished from Number 3 largely on the basis of their extent, the lower two occurring in both reaches of the Teme valley.

Figures 4.10 and 4.11, Ps. 97 and 98, show the terrace groups proposed and their disposition throughout the Teme valley in the study area, and from these maps has been constructed Fig. 4.12, P. 100, which suggests the former valley stages of the river.


70
80
0 1 2
Miles
65
60
55
Fig 4.12
PROPOSED VALLEY STAGES OF THE LOWER TEME
DERIVED FROM SURVEYED TERRACES
FIFTH TERRACE STAGE
FOURTH TERRACE STAGE
THIRD TERRACE STAGE
SECOND TERRACE STAGE
FIRST TERRACE STAGE
FLOOD PLAIN TERRACE

Chapter Five - The Morphology of the Lower Teme Basin.

As has already been stated, the course of the River Teme in the study area crosses rocks of the Devonian, Silurian and Triassic periods, its major tributaries - with the exception of the Laughern Brook - being located on Devonian rocks.

The morphology and the landscape of the area is varied, and is best described by studying the four sections into which it has been sub-divided (see P. 3 , & Fig. 1.3).

1. The Tenbury Reach.
2. The Shelsley Reach.
3. The Leigh Brook Basin.
4. The Severn Vale Teme.

The Tenbury Reach is strictly speaking beyond the scope of this dissertation, yet since its features must of necessity be related to those of the adjacent Shelsley Reach, it too must be considered. In this context, detailed reference to the work of Cross (7&8) must be made.

1. The Tenbury Reach (Fig. 5.1, P. 102)

The Teme valley above Stockton-on-Teme comprises a fairly wide, flat floor, and a steeply sloping, sometimes stepped rise on its southern side, up to the Clifton Plateau. The north valley wall is less well-defined, of generally gentler slopes, and of a much more broken nature.

The flood plain terrace varies in width from less than half a mile to more than a mile. Although it is far from being a uniform change, in general this section of the valley widens westwards - i.e. upstream - as observed by


Fig 5.1 THE TENBURY REACH MORPHOLOGY
KEY
Straight Slopes
Valley Flats
Convex Slopes
Psammosteus Lst Bench
Concave Slopes
Summits
General Direction of Other Slopes
Settlements
'Flood Plain'
Watersheds
CLEOBURY MORTIMER
SHEET
NEEN SOLLARS
LITTLE HEREFORD
TENBURY WELLS
Corn
Mill
Rea
Ledwyche
Teme
Kyre
Dumbleton
Pensax
Sapey
Death's Dingle
Hanley Dingle
Round Hill
Fall Dingle
Temple Dingle
Devils Den
Witchery Hole
CLIFTON
ABBERLEY HALL
Walsgrove Hill
Woodbury Hill
Rodge Hill
75
70
65
60
65
70
75
0
1
2
Miles

Dwerryhouse and Miller (19, Fig. 1., P. 122). The valley width from crest to crest increases from about three miles at Stanford-on-Teme (G.R. 703658) to over ten miles to the west of Tenbury Wells, while the cross section of the valley becomes progressively steeper downstream. Since there are no apparent structural or lithological reasons for these characteristics of the Teme valley, its form in this reach is interpreted by Dwerryhouse and Miller (19) as being suggestive of a formerly westwards-flowing river which has been reversed.

The southern valley wall is a pronounced and largely wooded slope, broken by a number of short, steep tributary valleys, the largest of which are known as 'dingles' - (for example, Death's Dingle, G.R. 670678, Hanley Dingle, G.R. 687664, and Fall Dingle, G.R. 696655); many of these valleys are dry for at least a part of the year. The Psammosteus limestone outcrops at about 400 feet (121.9 metres) O.D., a little above half way up the slope, and separates the Dittonian from the Downtonian marls of the Old Red Sandstone [1]. In the area north-west of Hanley William (G.R. 673659), conglomeratic cornstones and sandstones of the Ditton series give rise to localised ridges and platforms - (for example, at G.R. 683668 and G.R. 665668) - though the discontinuous nature of these more resistant bands (see P. 28) prevents such features from being other than very localised in significance.

The southern valley wall appears to have been fashioned out of the Ditton and Downton marls, in which even the

[1] It does cap Quarry Hill, at G.R. 691673.

thicker and more persistent Psammosteus limestone does not give rise to any visible change or break of slope. The only major breach of this valley wall is that of the Kyre Brook valley, which follows a south-east to north-west course across the Clifton Plateau from its source near Collington (G.R. 650601), to its confluence with the Teme at Tenbury Wells. This anomalous confluence of valleys is seen by Dwerryhouse and Miller (19) as further morphological evidence for the former westwards-flowing river. The Kyre Brook occupies a broad, shallow valley in the Ditton series (see Fig. 5.2, P. 105), within which again the more resistant bands give rise to scattered structural features, of which the most extensive and important is the Psammosteus limestone 'bench' at around 400 feet (121.9 metres) O.D., in the parishes of Kyre (G.R. 627638), and Stoke Bliss (G.R. 645629). As well as being more open and 'mature' than the valleys of the Dumbleton and Pensax Brooks (see P. 106), the cross section of the Kyre Brook valley exhibits generally concave valley side slopes.

The north valley wall is broken by numerous small valleys, most of which are much longer than those dissecting the south valley wall. There are two major tributaries to the Teme on its left bank - the Rea Brook and the Ledwyche Brook. The confluence of the Rea Brook and the Teme is similar to that of the Kyre Brook and the Teme, and the generally south-westerly direction of flow of the Rea Brook would also seem to support the suggestion of a formerly westwards-flowing river in the present Teme valley at this point. However, the Ledwyche Brook, in

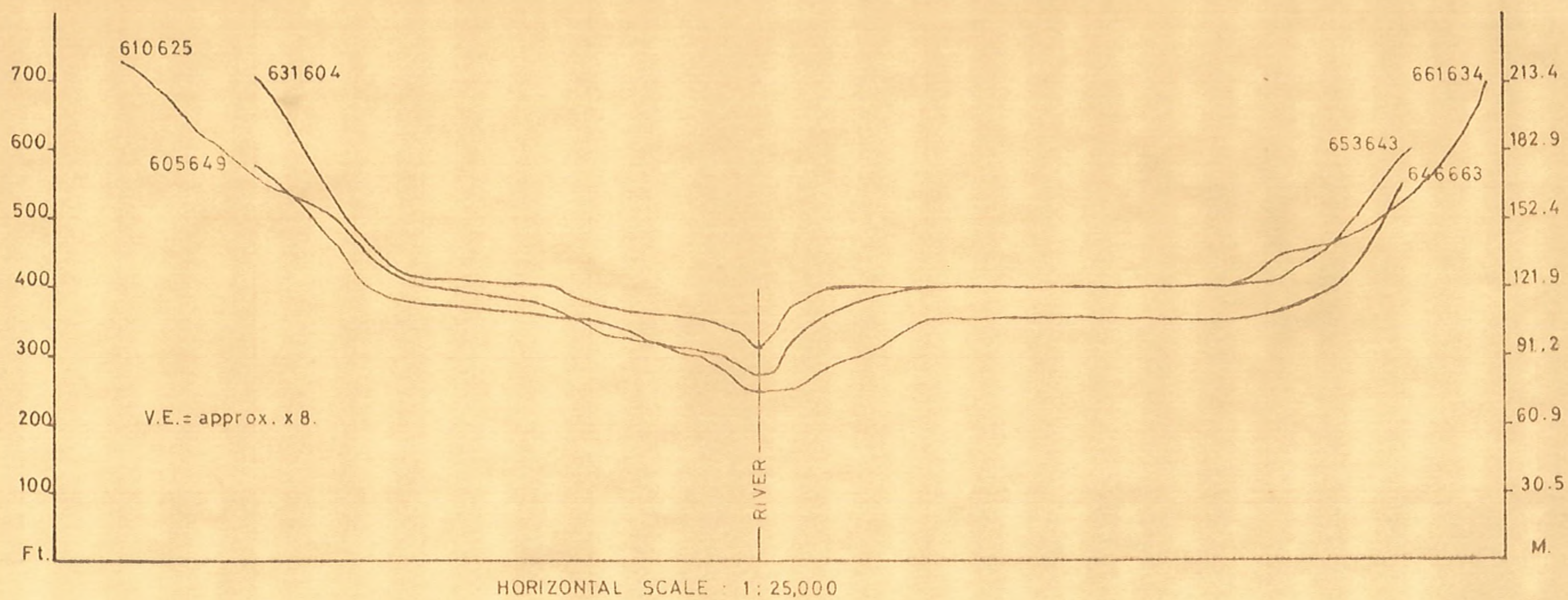


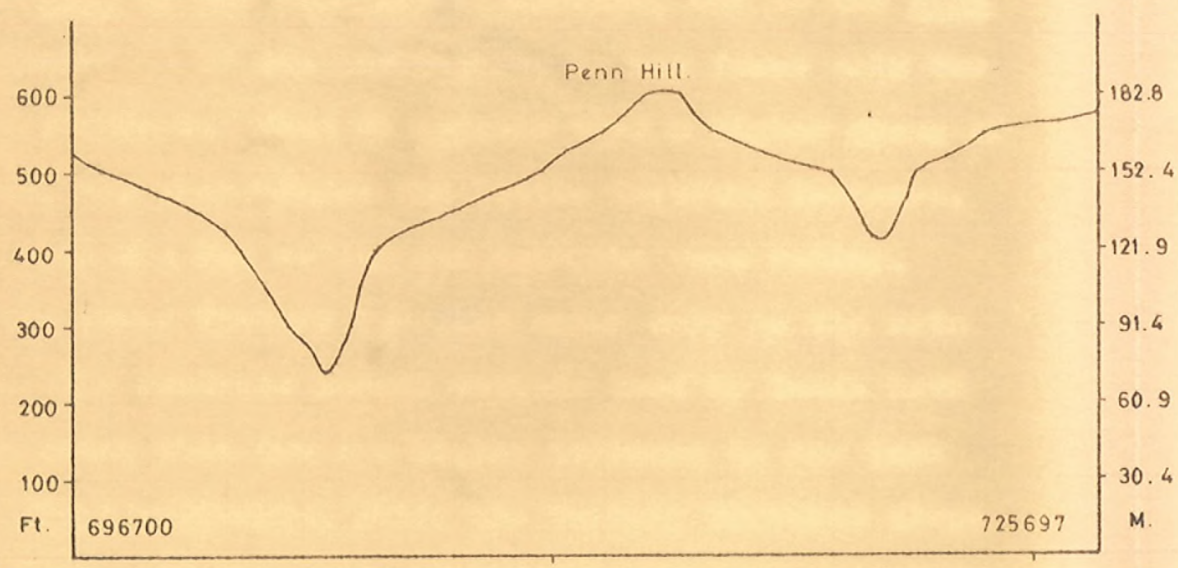
Fig 5.2 THE KYRE BROOK VALLEY - SUPERIMPOSED PROFILES

its lower reaches, flows generally south-eastwards, and its confluence with the Teme would seem to be consistent with the present eastwards-flowing Teme.

The north valley wall, though steep, is less so than its southern counterpart, and the immediate crest is lower (300 - 400 feet, 91.4 - 121.9 metres, as compared with 600 - 650 feet, 182.8 - 198.1 metres, O.D.). The slope is carved out of the Temeside Beds of the Downtonian. Beyond the immediate crest of the Teme valley, but drained by some of its tributaries, the landscape is carved out of the Highley Beds of the Carboniferous period, but the geological junction is not reflected by any further changes of landshape; nor are there any landforms within the area of the Carboniferous outcrop which appear to be related to differences in lithology.

The small streams which interrupt this north valley wall, such as the Dumbleton Brook (G.R. 702693) and the Pensax Brook (G.R. 719694) occupy deep cut, steep-sided and narrow valleys, the side slopes of which are noticeably convex - this is in contrast to the side slopes of the Kyre Brook valley. The Dumbleton Brook is cut to approximately 400 feet (121.9 metres) below the general level of the surrounding summits, which here stand at between 550 and 600 feet (167.6 and 182.9 metres) O.D. (see Fig. 5.3, P. 107) These narrow almost gorge-like valleys are strongly suggestive of incision, while a few flat-topped spurs (as at G.R. 716673, G.R. 719675 and G.R. 718678) at heights of a little over 210 feet (64.0 metres) O.D., might be regarded as remnants of a

Fig. 5.3 THE DUMBLETON AND PENSAX VALLEYS.



Horizontal Scale: 1:25,000 V.E. approx. x8

Source: O.S. 2½ inch maps

former valley floor, since they also support a thin veneer of rounded gravels.

In the Rea Brook valley, two distinct sets of terraces have been mapped by Cross (8). He proposes a higher group to which he applies the names Shakenhurst and Little Hereford Terraces, standing at heights of 140 and 90 feet respectively (42.6 and 27.4 metres) above the present Rea alluvium. He also proposes a lower group which he refers to collectively as the Tenbury Terraces, and which stand at heights of 40 - 55 feet (12.2 - 16.7 metres) and 12 - 15 feet (3.6 - 4.5 metres) above the present alluvium (see Fig. 5.4, P. 109). In the Teme valley, he has identified remnants of all of these terraces in the section <u>west</u> of the Rea-Teme confluence, but to the <u>east</u> (or downstream) of the confluence, he has found only the Tenbury Terraces. Thus it appears that a higher group of terraces, the Shakenhurst and Little Hereford Terraces, extend from the Rea valley and into the Teme valley, while the lower Tenbury Terraces occur only in the main valley. The accurate survey methods used by Cross have further shown that the two higher terraces in the Teme valley slope westwards, while the Tenbury Terraces slope to the east. In the cases of all the terraces, he states that the Rea valley terraces grade perfectly into the Teme valley terraces.

In the light of this evidence, he has concluded that the Shakenhurst and Little Hereford Terraces must be related to a major river flowing westwards, while the lower Tenbury Terraces must be related to a river which followed the same course as the present river Teme. Thus,

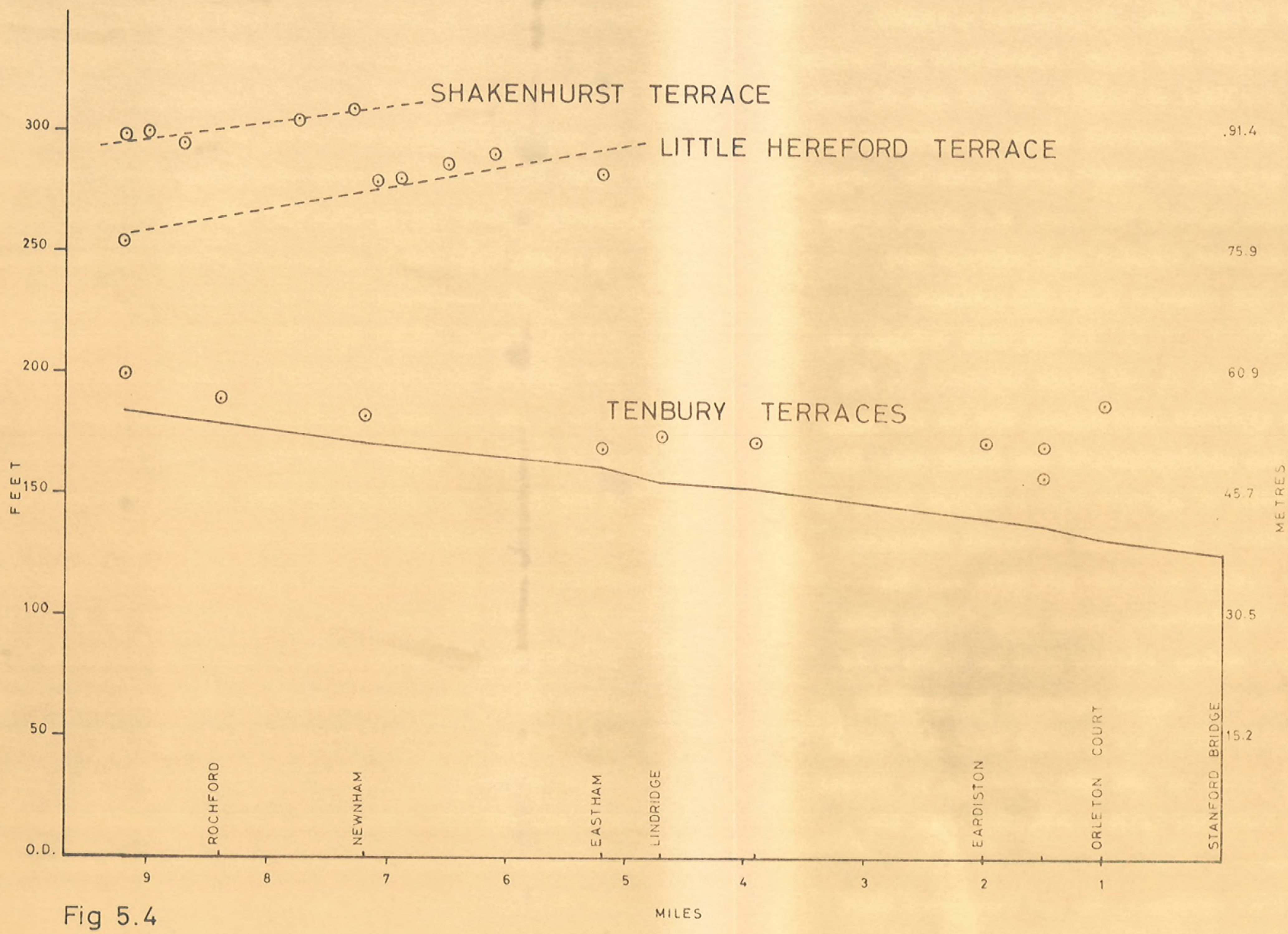


Fig 5.4

CROSS' SURVEYED TERRACES OF PART OF THE TENBURY REACH

(FROM ORIGINAL SURVEY DATA)

Cross' terrace mapping and surveying would appear to support the idea of reversal of drainage in this reach, as suggested by Dwerryhouse and Miller (19). However, these latter authors make no reference to the confluence of the Ledwyche Brook and the Teme, which appears to be related to the eastwards-flowing river. Cross suggests that the lower course of this Brook, where it flows in a south-easterly direction, is pre-reversal in age since it contains elements of the Shakenhurst and Little Hereford Terraces, while the upper course, which flows in a south-westerly direction, is also pre-reversal. He goes on to suggest that the lower part of the course of the Ledwyche Brook may have initially been followed by the Teme from Ludlow, before it changed its course to occupy the present main valley, through Ashford Bowdler.

The reversal of the Teme in the Tenbury Reach was not fully explained by Dwerryhouse and Miller (19). However, Cross suggests that the most likely explanation involves the damming of the previously westwards-flowing river by an ice sheet or a glacier. This hypothesis is further supported by the presence further west of the Orleton Moraine(in the vicinity of Woofferton, G.R. 515685), a low ridge some 50 feet (15.2 metres) or so above the surrounding lowlands, which represents the eastern limit of the advance of the Wye Glacier. The highest point of this moraine at present reaches 321 feet (97.8 metres) O.D. Cross has further identified strandlines and delta forms in the area north and east of the moraine, which are at a range of heights between 240 - 305 feet (73.1 - 92.9 metres) O.D. The broad flat gravel-strewn plain situated between these features and the moraine has yielded fine grained varves of lacustrine origin, notably from sewage works excavations at Comberton (G.R. 498678) in 1967 and 1968.

From this accumulation of evidence, Cross has concluded that:

> "the existence of such a lake is proved beyond all doubt".

Three distinct lake stages are proposed - the 'Bromfield A' stage, the 'Bromfield B' stage, and the 'Woofferton' stage (see Fig. 5.5, P. 112) - each representing a different lake level, and each associated with a series of terraces upstream from Woofferton in the valleys of the Teme, the Onny and the Corve, above Ludlow.

The reversal of the Teme is therefore presumed to have been occasioned by this lake Woofferton spilling out eastwards across a low watershed in the vicinity of Stockton-on-Teme. From the measured heights of the strandlines and delta forms, it is apparent that the lake surface reached about 305 feet (92.9 metres) O.D. maximum surface elevation, below the level of the present crest of the Orleton moraine, and therefore a pre-reversal water-divide at Stockton-on-Teme must have stood at about the same height.

Such a watershed as that proposed by Cross is nowhere suggested in the present features of the landscape. The south valley wall presents a smooth and almost continuous curving line in the Stockton-on-Teme area, while the north valley wall, though more broken, also shows no significant 'promontories' in its curve. If this watershed existed,

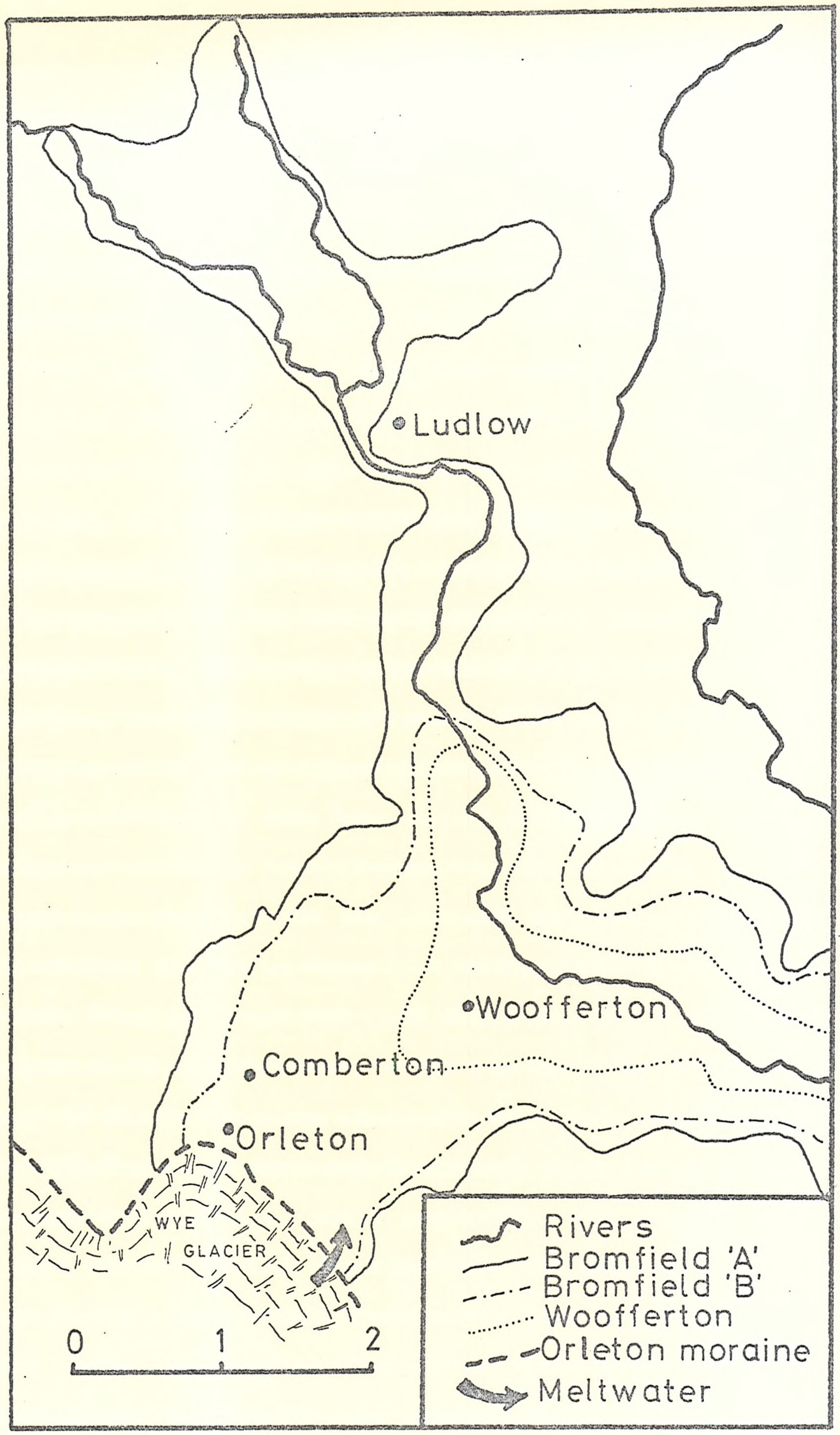


Fig 5.5 THE THREE MAIN STAGES OF LAKE WOOFFERTON (after Cross)

all trace of it appears to have been removed by subsequent events. Yet the evidence certainly suggests that a pre-reversal Teme, which was tributary to the Lugg-Wye drainage lines, was ponded up between the ice front at Orleton and its source area to the east, the resulting lake overspilling in that easterly direction, and thereby bringing about a readjustment of the Wye-Severn water divide (see Fig. 5.6, P. 114)

Since the organic remains extracted from the sewage works at Comberton have been dated at ∓ 14,000 B.P., and were seen to lie beneath fluvio-glacial gravels, this reversal of the Teme is proposed as being of Devensian age, and roughly contemporaneous with the Ironbridge overspill of the River Severn.

2. <u>The Shelsley Reach</u> (Fig. 5.7, P. 115)

Between Stockton-on-Teme and Knightsford Bridge the Teme occupies a gorge-like valley, lying between the Clifton Plateau to the west and the Silurian rocks of the Malvern Axis to the east. In this section, the level of the flood plain terrace falls from about 135 feet (41.1 metres) O.D. in the north, to about 80 feet (24.4 metres) O.D. in the area of Knightsford Bridge, while the enclosing valley walls of the gorge rise to over 600 feet (182.9 metres) O.D.

The west side of the valley consists of a steep, largely wooded slope which is an extension of the south valley wall of the Tenbury Reach, and is cut in Devonian (Downton and Ditton) rocks. The Psammosteus limestone outcrops at between 350 - 400 feet (106.7 -

DRAINAGE CHANGES IN THE LUDLOW AREA

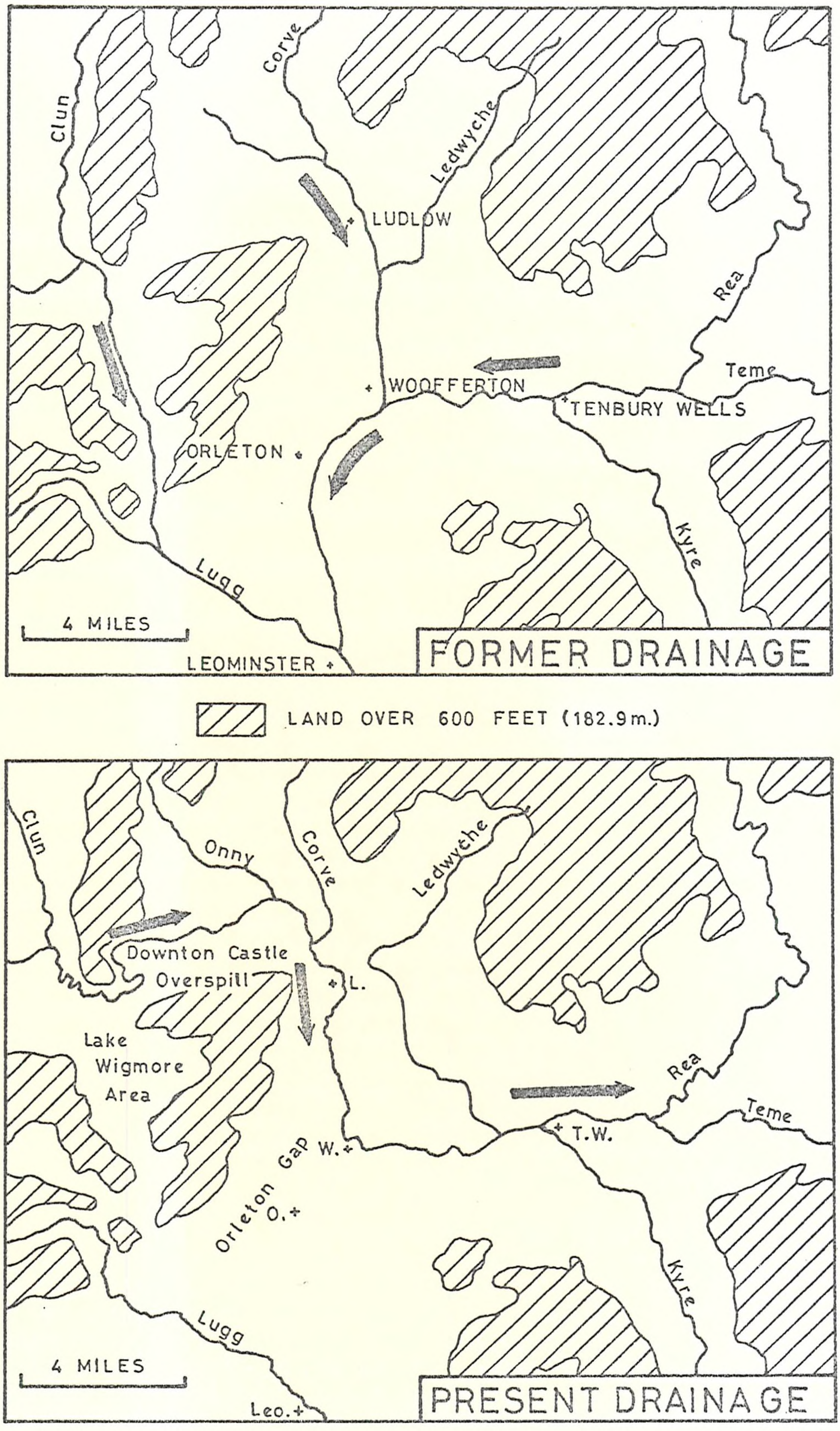


Fig 5.6

After Dwerryhouse & Miller, Cross.

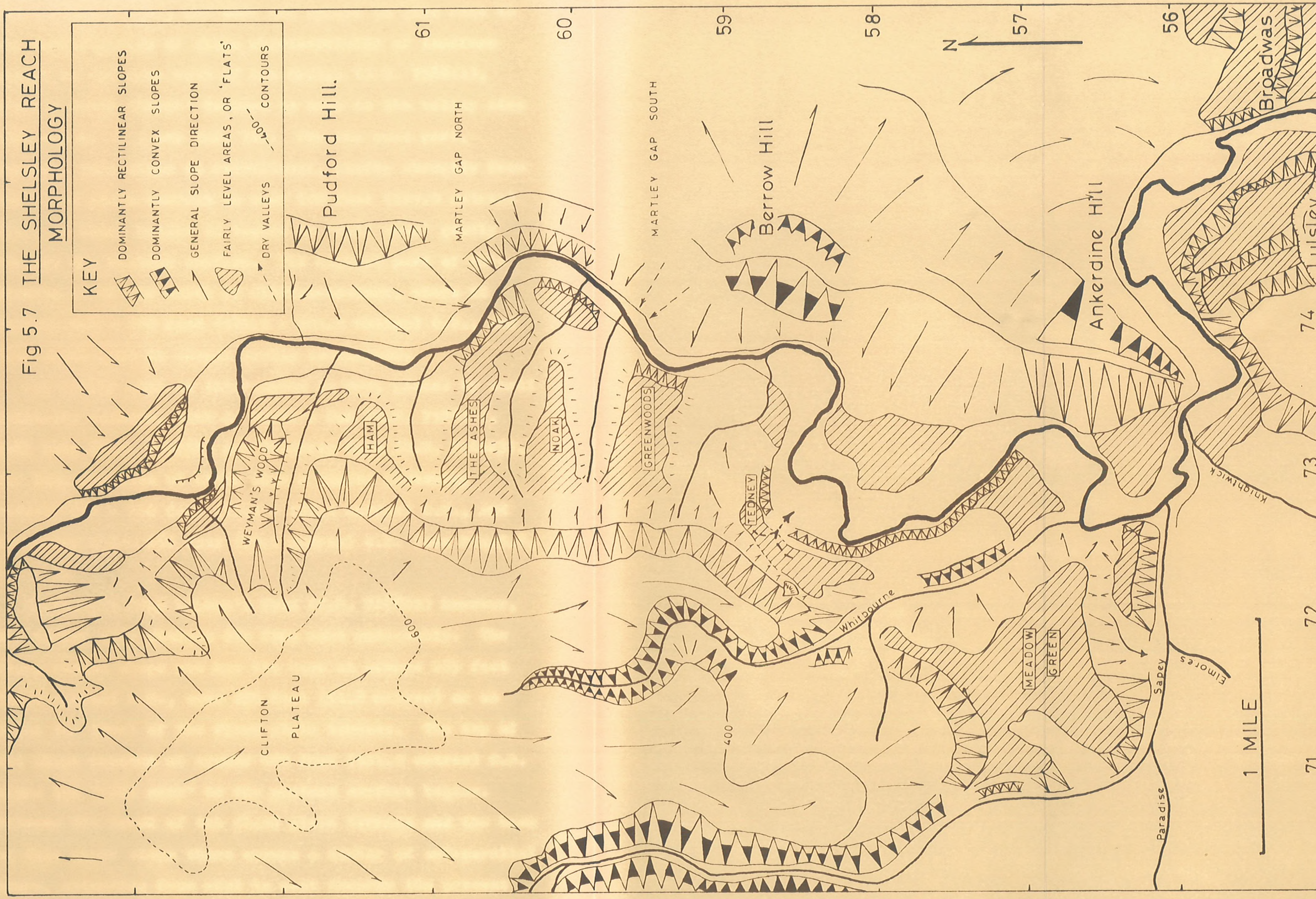


Fig 5.7 THE SHELSLEY REACH MORPHOLOGY
KEY
DOMINANTLY RECTILINEAR SLOPES
DOMINANTLY CONVEX SLOPES
GENERAL SLOPE DIRECTION
FAIRLY LEVEL AREAS, OR 'FLATS'
DRY VALLEYS
400 CONTOURS
Pudford Hill.
MARTLEY GAP NORTH
MARTLEY GAP SOUTH
Berrow Hill
Ankerdine Hill
Broadwas
Lulsley
Knightwick
N
61
60
59
58
57
56
74
73
72
71
WEYMAN'S WOOD
HAM
THE ASHES
NOAK
GREENWOODS
TEDNEY
CLIFTON PLATEAU
600
400
Whitbourne
MEADOW GREEN
Sapey
Elmores
Paradise
1 MILE

125.0 metres) O.D., and does not appear to give rise to any marked change of slope characteristic or landform except in the area west of Ham Bridge (G.R. 738611), where a minor 'bench' feature is seen in the valley side (but see P. 27 , and Ref. 39). For the most part, however, this slope is rectilinear, rising abruptly from the flood plain terrace to over 400 feet (121.9 metres) O.D., at which height it begins to 'roll over' gently towards the Plateau surface. The highest part of this plateau is to the north of Clifton-on-Teme, where it reaches 600 - 660 feet (182.9 - 201.1 metres) O.D., and from which area it slopes gently southwards.

The valley wall is interrupted in many places by small tributary valleys, such as Devil's Den (G.R. 712635), Hell Hole (G.R. 714634) and Witchery Hole (G.R. 724623), the long profiles of which show a marked convexity between 240 - 450 feet (73.1 - 137.1 metres) O.D., and concavity below 240 feet (73.1 metres) O.D. (see Fig.5.8, P. 117).

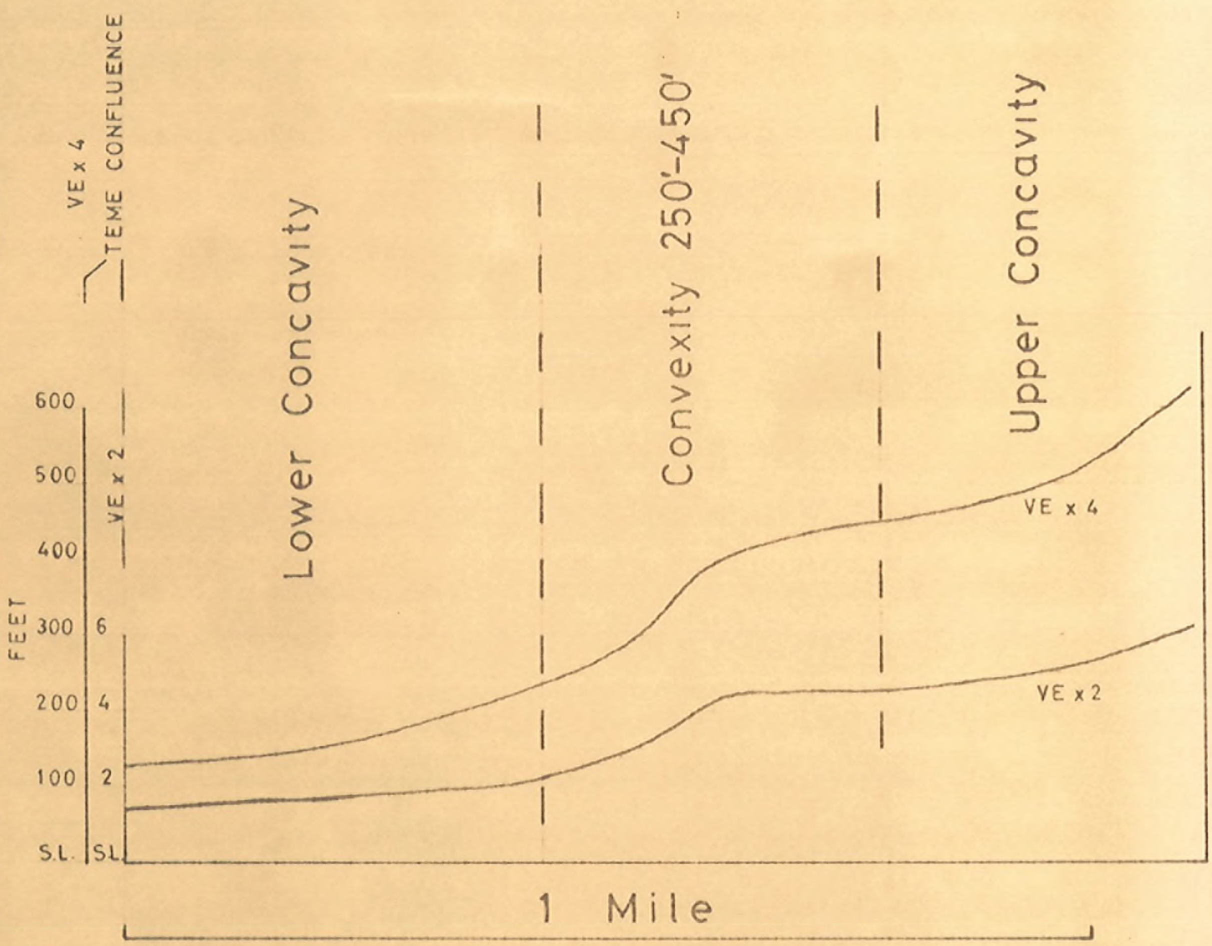
Southwards from Weyman's Wood (G.R. 728622) however, the valley wall changes its form most noticeably. The steep wooded slope now has its base at around 285 feet (86.8 metres) O.D., some 170 feet (51.8 metres) or so above the level of the flood plain terrace. The top of the slope remains at around 400 feet (121.9 metres) O.D. where the 'roll over' to the plateau surface begins. Between the level of the flood plain terrace and the base of this upper slope there occurs a number of sub-parallel spurs, extending from west to east towards the present stream. Named from the Ordnance Survey map, (scale

Fig 5.8

DEVIL'S DEN TRIBUTARY VALLEY (GR 712635)

Long profile of valley bottom

From clinometer survey



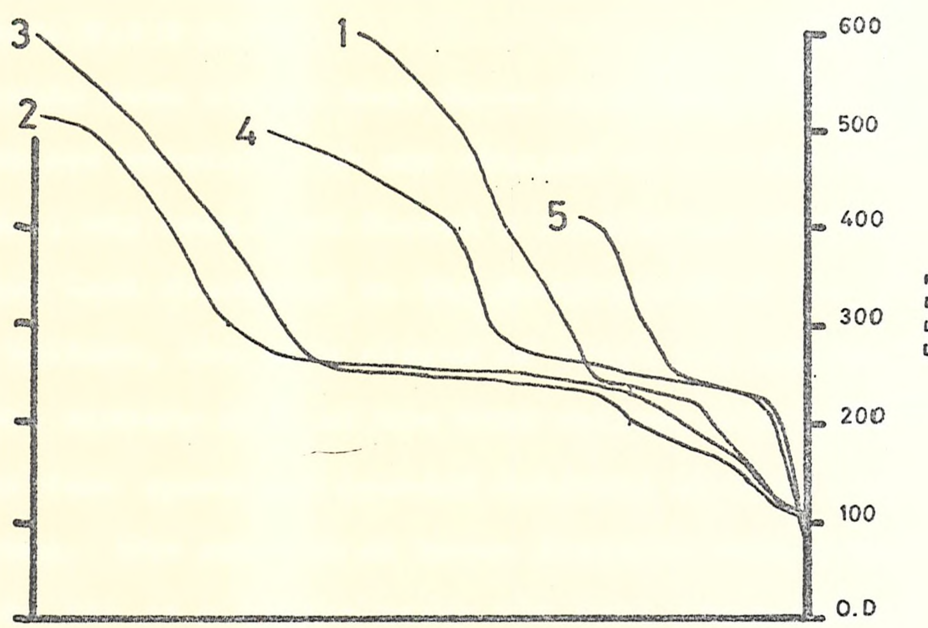
1:25,000), they are referred to as the Ham (G.R. 733614), the Noak (G.R. 734602), the Ashes (G.R. 736606), and Greenwoods (G.R. 733507). Each of these spurs comprises convex side slopes rising to a narrow surface 'flat', which is itself a very gently convex surface. Along the surface, the aneroid barometer survey has revealed that there is a fairly consistent gentle slope towards the present river, the upper, western margins of the spurs rising to about 280 feet (85.3 metres) O.D., while the spur ends, overlooking the river have been measured at about 235 feet (71.6 metres) O.D. (see Table 4.3, P. 86). Each spur presents a lower steep slope down to the flood plain terrace, of over 100 feet (30.4 metres), the most pronounced being that of the Ashes spur, at G.R. 738607 (see Figs. 5.9 & 5.10).

It would seem likely that these four spurs, the forms of which are unrelated to any changes of lithology or structure, may once have formed a continuous surface, which has been dissected by the development of the small stream valleys, the side slopes of which are convex.

On the eastern side of the Teme valley, there are three or four spurs and rounded hillocks of very small dimensions. The summits of these features were found by survey to lie at a little below 230 feet (70.1 metres) O.D. These may be remnants of the larger spurs on the west side, and therefore part of this early, high-level surface. However, whereas the large western spurs are found to support a 'smear' of rounded and sub-angular gravels, mainly of local materials but also with the occasional igneous pebble, these small eastern hillocks do not; in

Fig 5,9

SUPERIMPOSED PROFILES OF THE TEDNEY SPURS, from O.S. $2\frac{1}{2}$ inch maps.



1 THE HAM
2 THE ASHES
3 THE NOAK
4 GREENWOODS
5 TEDNEY BANK

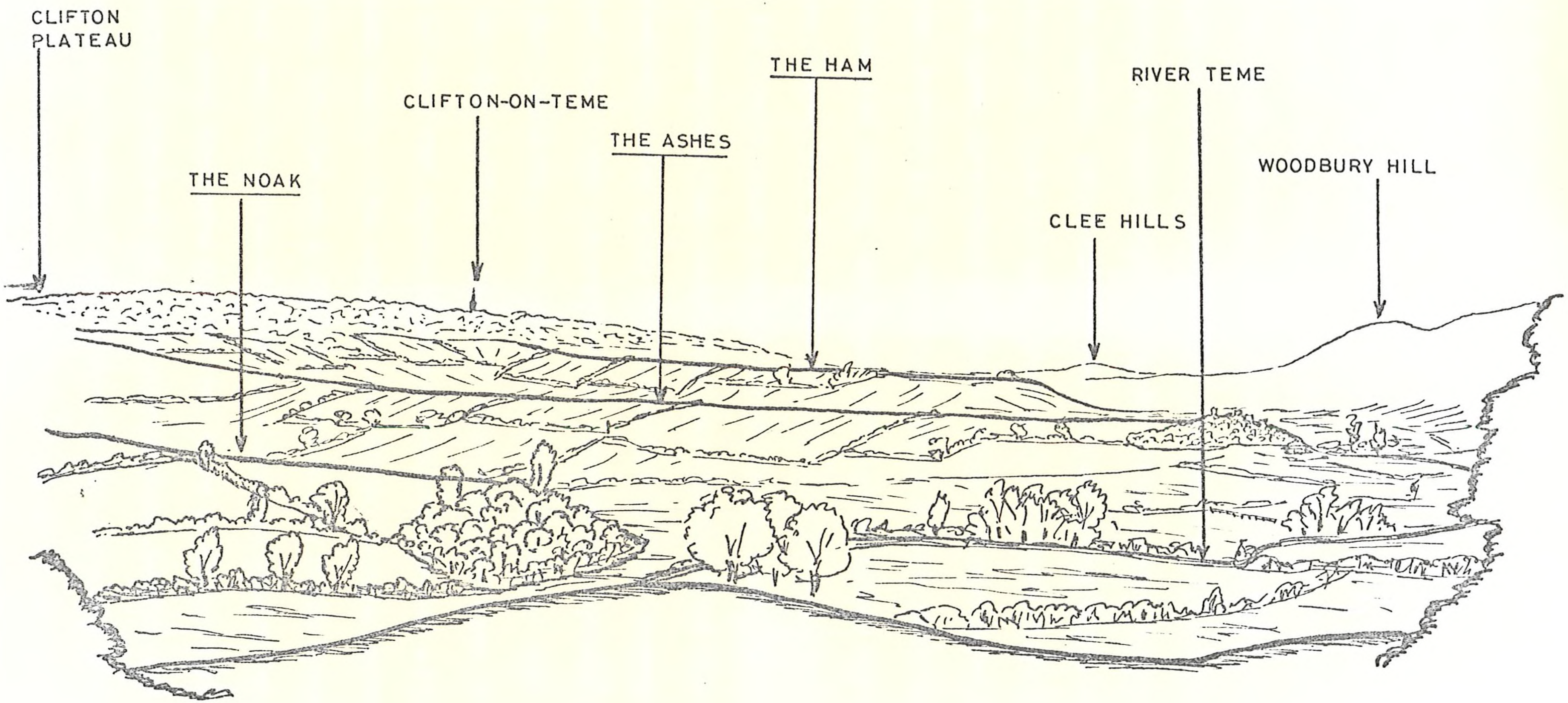


Fig 5.10 VIEW NORTH WEST FROM HORSHAM (GR 737582) SHOWING THREE SPURS OF THE TEDNEY LEVEL.

both cases, however, the material constituting the surface layers is sandy. The connection between these remnants cannot be firmly substantiated, either on the grounds of materials or of down-valley gradients, since all the summit surfaces are too limited in extent north to south for gradient to be reasonably established.

Between Tedney (G.R. 731589), Pithouse Farm (G.R. 726589) and Little Tedney (G.R. 723583), is a further high, flat surface, which may also be a part of the Tedney Level described above. Lying at the foot of an upper, steep, wooded slope - the Tedney Bank - and above another wooded slope down to the present river, this gravel-smeared and sandy surface was found by survey to lie at 260 - 220 feet (79.2 - 67.0 metres) O.D. The upper steep slope is here interpreted as a fossil river cliff, while the lower slope is being actively eroded by the present Teme at Temeside (G.R. 725583). The surface has been broken by the development of a small valley, seasonally dry, and with a spring at its lower end (G.R. 726587).

Further south again, the west valley wall of the Teme is broken by the tributary valleys of the Whitbourne Brook and the Sapey Brook. Much of the parish of Whitbourne stands at a height of a little over 220 feet (67.0 metres) O.D., and supports gravels in a sandy matrix; this area forms the Meadow Green Level.

It is suggested that the Tedney Level and the Meadow Green Level are related remnants of a former surface which sloped southwards from 255 feet (77.7 metres) O.D. in the area of the Ham spur, to 225 feet (68.5 metres) O.D. in the parish of Whitbourne. This surface may have constituted the floor of a former valley following the same direction as the present valley in this reach (see Fig. 5.11, P. 123).

The valleys of both the Whitbourne Brook and the Sapey Brook are of great interest in that, as tributaries of the Teme, any major readjustments of that river should be reflected in the form of their valleys. Moreover, the Sapey Brook is particularly interesting since it is aligned in its lower part directly opposite the Knightsford Bridge gap, where the Teme crosses the line of the Malvern Axis.

Both streams drain initially southwards off the Clifton Plateau, and both are at least partly controlled in their upper courses by the north-south alignment of gentle flexures in the Devonian marls - the Sapey on the axis of a small anticline, the Whitbourne in a syncline. However, the form of these two valleys is of great significance (Fig. 5.12, P. 124). Both occupy broad depressions into which the streams have cut inner, trench-like valleys which are strongly suggestive of incision. The upper valleys are broad with rounded outlines; the gentle slopes here were measured as between 4 and 14 degrees. These upper slopes give way to deep-cut and steep-sided inner valleys, where slopes of up to 28 degrees were recorded. Thus there is an overall convexity of valley side slope. In neither valley is there any clear indication of river terraces, nor any further indication of former valley levels. In both cases, the marked steepening of the valley side slopes begins at

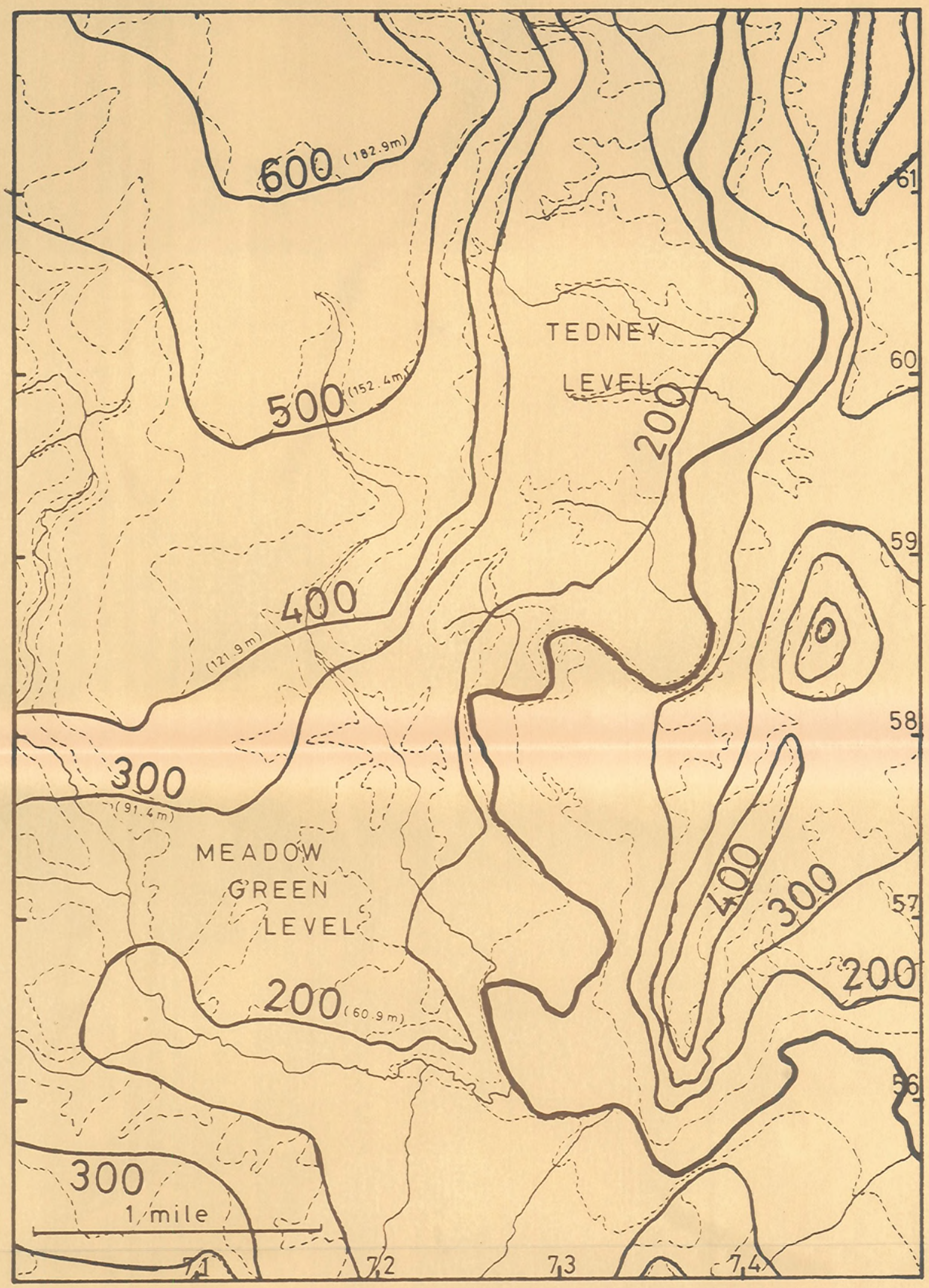


Fig 5.11 <u>THE SHELSLEY REACH</u> – <u>GENERALISED CONTOURS.</u>

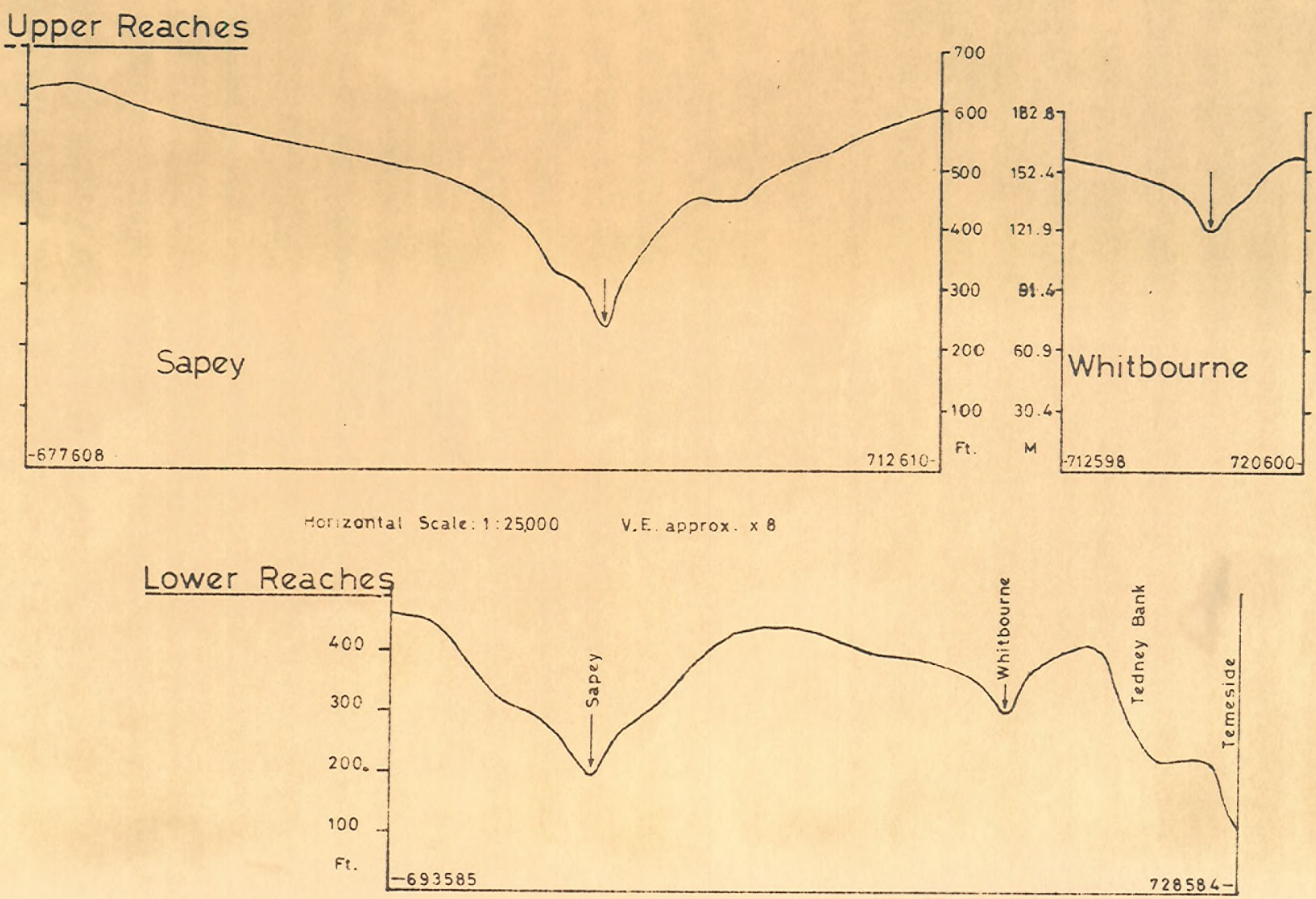


Fig 5.12 THE SAPEY AND WHITBOURNE VALLEYS

about 300 feet (91.4 metres) O.D., and the long profiles of the streams are suggestive of at least three stages of rejuvenation below that level. However, it should be remarked that these three suggested rejuvenations do not appear to have left any significant traces in the landscape beyond the nick-points on the long profiles (see Fig. 6.4, P. 178), despite the fact that the trunk stream, the Teme, clearly exhibits gravel stages in its valley development.

In the lower Sapey valley, a number of small and often isolated gravel patches have been mapped and surveyed (see Table 4.4, P. 87 and Fig. 4.11, P. 98). These appear to form altitudinal groups at 135 feet (41.1 metres), 90 feet (27.4 metres) and 60 feet (18.3 metres) above the present flood plain terrace level of the Teme at projection point 'R' (88 feet, 26.8 metres, O.D.). Into this 'Sapey Bowl' area flows a number of converging streams - Sapey, Paradise, Elmores, Knightwick and Whitbourne Brooks - each of which occupies a deep-cut valley, and each of which contains, in the 'Bowl' area, a number of these gravel patches. However, it is noted that most of these remnants are to be found on the south side of the area. The long profiles of the Sapey and Whitbourne Brooks with the three suggested nick-points, and the three altitudinal groupings, may be seen as further evidence to support the suggestion of rejuvenation in three stages.

The dissected surface of the south side of the 'Sapey Bowl' rises towards the old Worcester-to-Hereford railway line, and to a high level 'col' at the disused Suckley

Station (G.R. 721539), which has been surveyed at 296 feet (90.2 metres) O.D. To west and east of this 'col', and at a height of between 314 - 320 feet (95.7 - 97.5 metres) O.D., Davies (10) has recorded and mapped gravel spreads at Highfields Farm (G.R. 726541) and Pewcroft Farm (G.R. 718535). These he interprets as a pair of river terraces, and evidence of a former river valley flowing north-to-south across the 'col' - or in other words, a connection between the present Teme valley in the Shelsley Reach and the Leigh - Cradley Brooks vale to the west of the Malvern Axis. Gray (23&24) and Wills (62) both suggested that this may represent a former course of the river Teme prior to its diversion across the Malvern Axis at Knightsford Bridge. Dwerryhouse and Miller (19) are of a similar opinion. These authors agree that the diversion must be of late-glacial age, since the Severn Vale was occupied by ice as far south as Tewskesbury at least during the Gippingian glacial advance. However, if such a river existed at this height, then one would expect that other traces of its course would remain further north, where in fact none has been discovered. Hey (31) states that high terraces in the Shelsley Reach of the Teme <u>do</u> in fact relate to the level of the Suckley Station col, but offers no evidence in support of this statement. The author's mapping and surveying has demonstrated that the higher level terraces of the Shelsley Reach are all <u>below</u> the level of the Suckley Station col. Indeed, the highest suggested valley level (see P. 81) which is represented in this Reach is the Tedney Level, which at an average height of about 240 feet

(73.1 metres), is too low to relate to such a river, or therefore to the pair of terraces mapped by Davies (10). The author has visited both of the sites mapped by Davies, and has failed to find any significant quantity of rounded gravels on either.

The gap of the river Teme at Knightsford Bridge now stands at 84 feet (25.6 metres) O.D., and is related to a transverse fault at this point (40, and Fig. 2.3, P. 39). On the north side, Ankerdine Hill rises steeply from the flood plain terrace to over 400 feet (121.9 metres) O.D. in a horizontal distance of less than half a mile. Although flat-topped, this summit has not yielded any significant gravel deposits, and is not therefore believed to be of any great significance to the geomorphological history of the area.

Osebury Rock (G.R. 738556) on the south side of the gap, rises to over 230 feet (70.1 metres) O.D.; it represents a faulted block of the Haffield Breccia of Carboniferous age (see Pp. 40-44), and presents a very steep slope to the present valley floor. This 'rock wall' is in contrast to the Ankerdine slope both in steepness and in height. North of Knightwick Station (G.R. 734555), there is a levelling off, surveyed at 231 feet (70.4 metres) O.D., above a small valley which stands at a surveyed height of 207 feet (63.1 metres) O.D. This level is, however, much lower than the Suckley Hills to the south, which rise to summits in excess of 360 feet (109 metres) O.D. Thus the section, Fig. 5.13, (P. 128), shows that across the Knightsford Gap there are two levels, the lower forming the floor of the present valley,

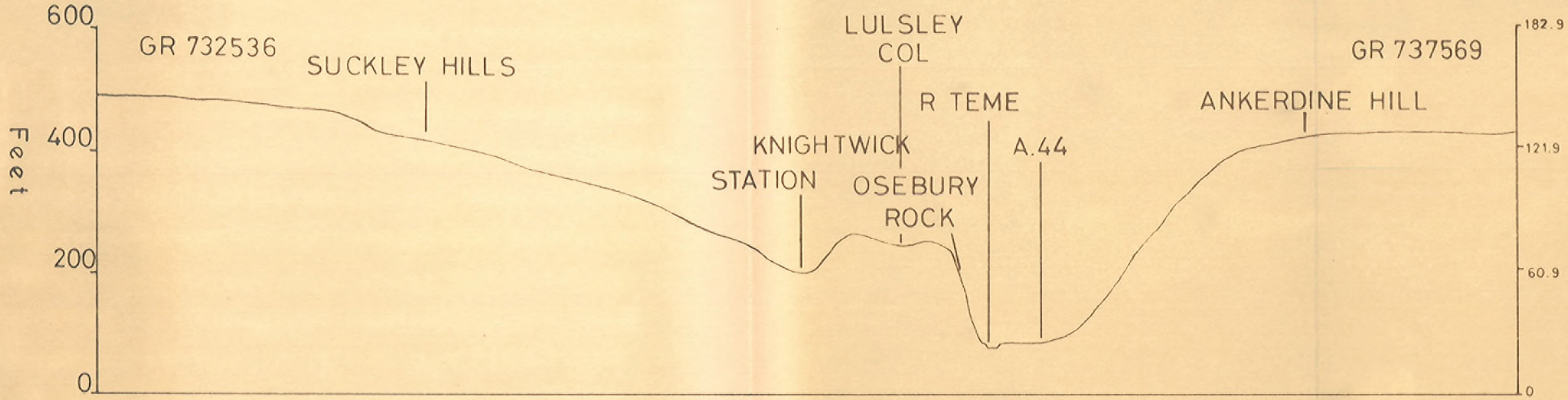


Fig 5.13 SECTION NORTH TO SOUTH ACROSS THE KNIGHTSFORD BRIDGE GAP from O.S. 1 25000 maps.

Scales: Horiz. 5 ins. to 1 mile ; V.E. = x 5 the higher Lulsley Col perhaps relating to the Tedney Level and the Meadow Green Level. The Lulsley Col has not, however, yielded any rounded materials, and the connection can only be suggested on the basis of morphology and surveyed heights. If there is such a connection - and this suggestion can only be very tenuous - then it seems possible that the 'Tedney Teme' flowed not across the Suckley Station Col, as previously suggested, but across the Malvern Axis in much the same position as the present Teme crosses the structure. The evidence of heights would suggest that this course might be the more likely.

In addition to the high-level surfaces, the Shelsley Reach contains a number of clearly defined lower terraces, as listed in Chapter Four, all of which slope southwards- i.e. downstream - and are evidently related to the present stream. Two very clear groups emerge, one at 5 - 15 feet (1.5 - 4.5 metres) above the present flood plain terrace, the other at 35 - 40 feet (10.6 - 13.7 metres) above, and both may be correlated with Cross' terraces above Stockton-on-Teme, (see P. 109), which he states "pass through the area of watershed overspill". (8)

It is significant that no terraces have been positively identified at heights above that of the Tedney Level, whereas Hey (31) has referred to high level terraces in this reach of over 300 feet (91.4 metres) O.D., which he says are associated with the Suckley Station Col level. In the author's view, there is no clear evidence to support the suggestion of a high-level Teme crossing the Suckley Station Col.

The east valley wall of the Shelsley Reach of the Teme is markedly different from the west, with its clearly marked, steep wooded slopes. The former, by way of contrast, consists of a very broken and irregular slope up to the summits of the Malvern Axis, dissected by a number of small streams and brooks, most of which occupy deeply-cut and convex-sided valleys. This main valley side is also cut largely in the Temeside Beds of the Devonian series, and the only relief feature which can be specifically related to the underlying geology is the elongated hill which is the surface expression of the Brockhill dolerite. This hill extends west-to-east across the valley (Fig. 5.14, P. 131), and on either side it 'disappears' at its ends into the country rock, at Bank Farm (G.R. 731638) and near Furnace Farm (G.R. 718637). The Geological Survey maps a number of landslips in the vicinity of Hocketts Farm (G.R. 732651) and Crundlend (G.R. 734668), as well as the patch of boulder clay at G.R. 746636.

The boulder clay patch, the landslips and the very broken nature of the country on this eastern valley side may point to glacial or periglacial activity in the area, and the possibility that ice may have overtopped the Malvern Axis in this area, via the cols at Witley, Shelsley Beauchamp and Martley (see P.9-11). Thus the broken nature of the landscape may be partly the result of ice and meltwater action, and partly the result of periglacial processes in the Gippingian and Devensian phases of the Pleistocene (see Chapter Three).

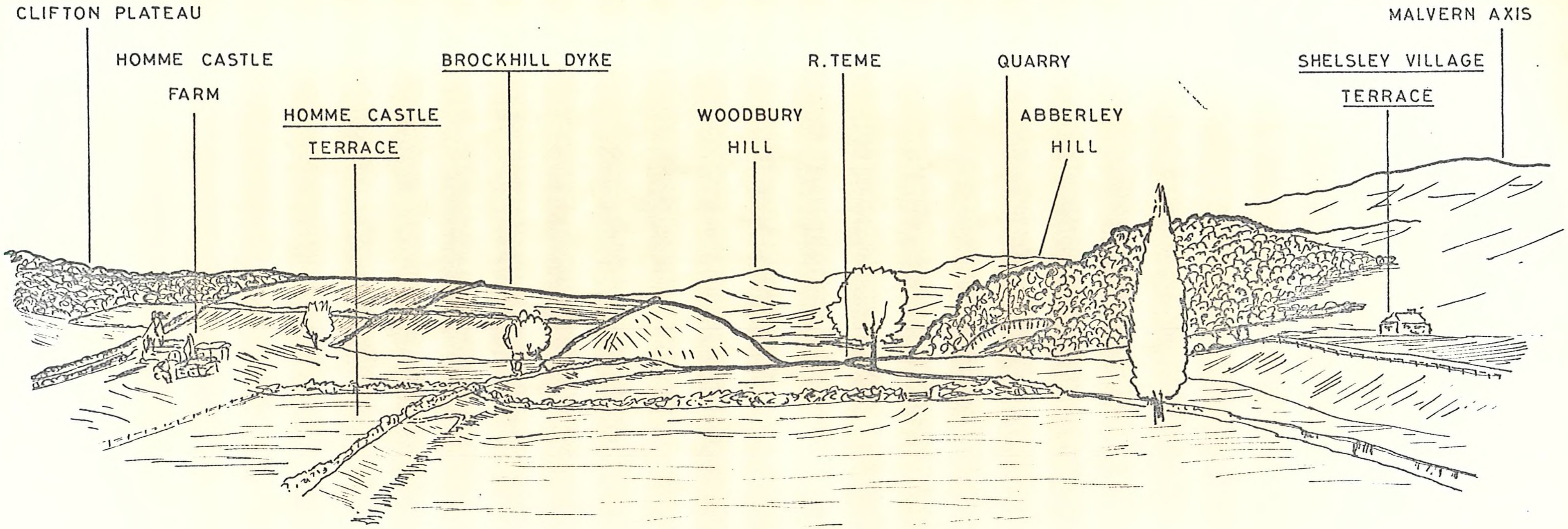


Fig 5.14 VIEW NORTH FROM NEWMILL BRIDGE (G.R. 725627) TO SHOW THE BROCKHILL DYKE.

3. <u>The Leigh Brook Basin.</u> (Fig. 5.15, P. 133)

The possible significance of a broad, mature valley west of the line of the Malvern Hills was first noted by Groom (26) in 1899. This valley appears, at first sight, to be related to the Shelsley Reach of the Teme, across the Suckley Station Col, and has led to the idea of an early Teme occupying this valley and joining the Severn via the Leadon valley, near Gloucester (see P. 7).

The eastern side of this valley consists of the dip slope of the Aymestry Limestone outcrop of the Malvern Anticline in the north, and of the Colwall and Chance's Pitch folds further south (see Fig. 2.3, P. 39). Apart from a few breaks, as at Blackhouse Farm (G.R. 728526), Longley Green (G.R. 733505), Little Halesend (G.R. 737493) and Brookhouse Farm (G.R. 745485), this dip slope is a continuous 'straight' line, presenting a fairly steep and uniformly rectilinear slope along this five-miles section. (see Fig. 5.16, P. 134). Rising to heights of over 500 feet (152.4 metres) O.D., this limestone 'hog's back' type of ridge is broken by only a few small tributary valleys which have etched out, in the lower Ludlow group of rocks, a series of small, boat-shaped strike vales between the Aymestry and Wenlock limestone outcrops (see Fig. 5.15, P. 133).

The western valley wall is much less clearly defined, and is part of the Ledbury Hills - Bromyard Downs hill area which reaches heights of over 350 feet (106.7 metres) O.D. The line of this valley side is also irregular, with numerous small east-flowing tributaries, separated by low interfluves, most of which stand at 300 - 325 feet

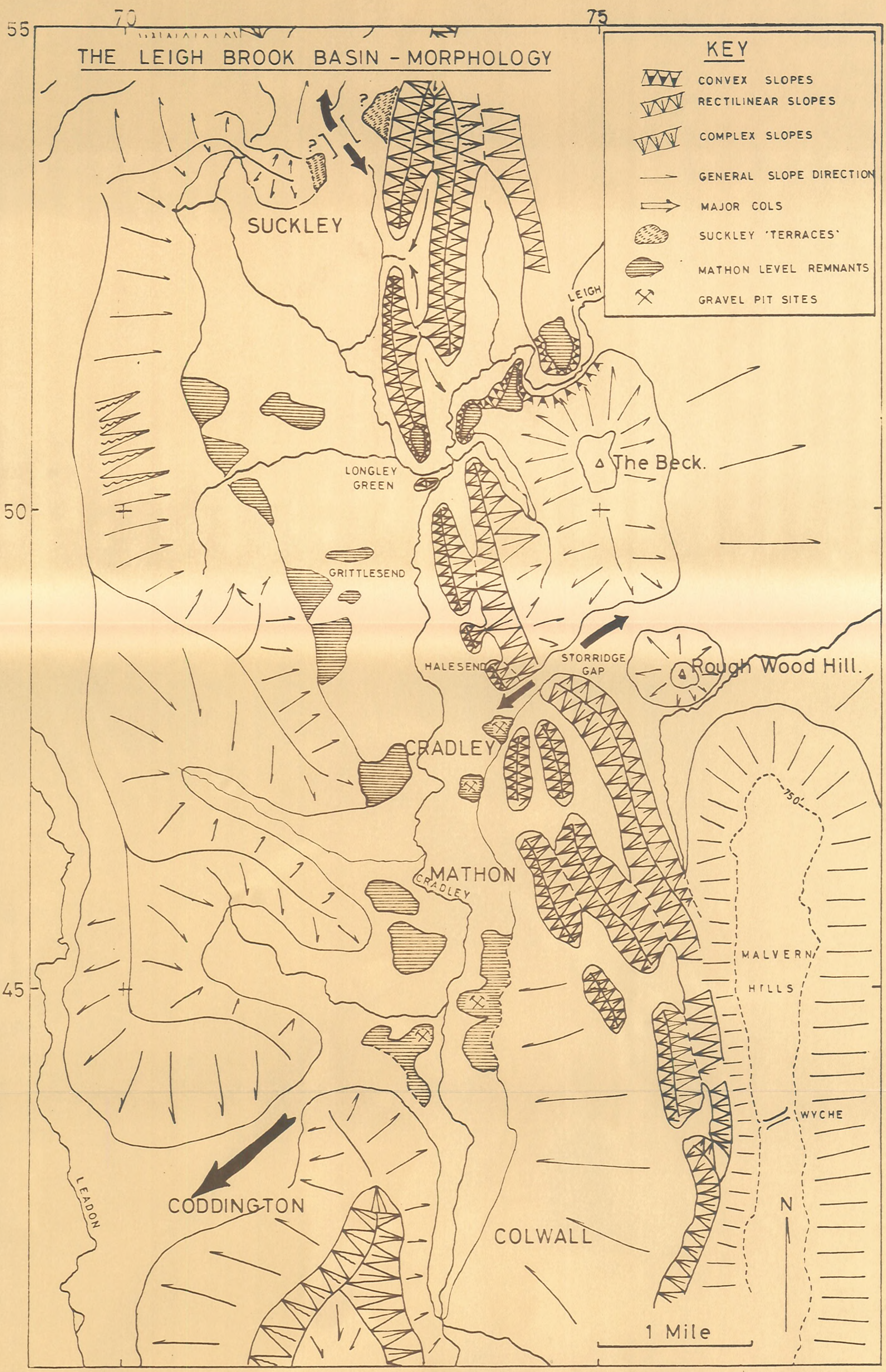

THE LEIGH BROOK BASIN - MORPHOLOGY
KEY
CONVEX SLOPES
RECTILINEAR SLOPES
COMPLEX SLOPES
GENERAL SLOPE DIRECTION
MAJOR COLS
SUCKLEY 'TERRACES'
MATHON LEVEL REMNANTS
GRAVEL PIT SITES
55
70
75
50
45
SUCKLEY
LEIGH
LONGLEY GREEN
The Beck.
GRITTLESEND
HALESEND
STORRIDGE GAP
Rough Wood Hill.
CRADLEY
MATHON
CRADLEY
750'
MALVERN HILLS
WYCHE
N
CODDINGTON
COLWALL
LEADON
1 Mile

Fig 5.15

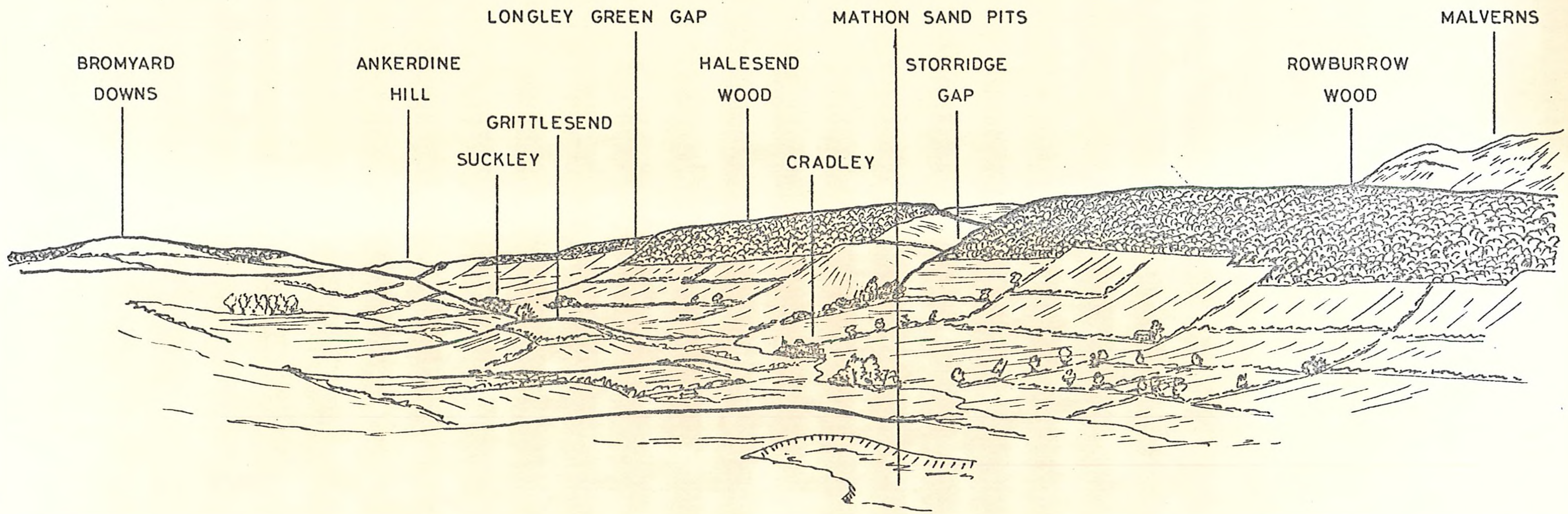


Fig 5.16 THE LIMESTONE RIDGE WEST OF THE MALVERN HILLS, VIEWED FROM MOOREND CROSS (G.R. 729453).

(91.4 - 99.0 metres) O.D. Between the two valley sides, there occurs a number of flat-topped knolls, which also reach heights of about 300 feet (91.4 metres) O.D., as at Bridge House (G.R. 722511), north of Grittlesend (G.R. 727492), Hackney Cross (G.R. 728459), and Moorend Cross (G.R. 732453). From Mathon (G.R. 735458) southwards, the valley of the Cradley Brook rises gently up towards the low watershed between it and the valley of the Glynch Brook, which watershed stands at about 370 feet (113 metres) O.D. In this area there is therefore the widespread occurrence of a level surface at around 300 - 325 feet (91.4 - 99.0 metres) O.D., which is represented by spurs and isolated knolls, and which has been dissected by the present drainage lines.

These erosional remnants are seen to be equatable, in terms of height above sea-level, with the pair of terraces mapped by Davies (10) in the Suckley Station Col area (see P. 126) and also to the higher terraces of the Shelsley Reach of the Teme, referred to by Hey (31, and P. 126). There is, however, no field evidence to show that these remnants slope southwards, nor that their elevations are lower southwards, as might be expected if they represented a former river valley floor.

According to Hey (31&32), most of these remnants of the Mathon Level are composed of sands and gravels, while further south the same materials are to be found on the valley floor - a surface into which the Cradley Brook has cut its valley. Hey concludes from field observations, that the base of the deposit is fairly constant in the northern part of the vale, at about 290 feet (88.4 metres)

O.D. However, the two 'good sections' to which he refers (31, P. 405) have since been filled in, and no deposit is now visible at either site. These sections were located at Mill Bank Quarry (G.R. 738841) and at South End, Mathon (G.R. 739452). In the former, he described the deposit as comprising:

> "red sand with scattered sub-rounded pebbles of Silurian shales and limestone . . . the topmost four feet have been disturbed by solifluction or frost heaving, but otherwise the bedding is mainly regular and horizontal, with some small-scale current bedding".

Of the latter deposit, he says:

> "about 25 feet of red sand is exposed, again with many horizontal bedding planes, but with current bedding on a larger scale than at Mill Bank Quarry, and some signs of channelling . . . streaks of pulverised coal are common . . . there are numerous bands of red micaceous clay . . . sometimes showing signs of current bedding".

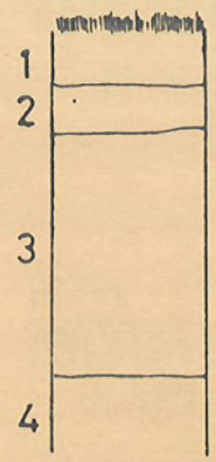
A shallow exposure at Gardiner's old pit at South End, Mathon (G.R. 732447), visible in 1968 but now in-filled, showed a mass of locally derived, rounded and sub-angular gravel, but with no sign of bedding. Only in a very few localised parts of the pit did the deposit compare favourably with Hey's description of the exposure only 200 yards distant and across the Cradley Brook, where streaks of coal and lenses of clay and sand were apparently much more widespread and extensive. However, this characterless mass of locally derived material appeared to overlay the finer, bedded materials, and may comprise the solifluction material to which Hey refers. The exposures of this finer material in this pit were too small to reveal any current bedding.

However, another pit, opened by Gardiner's firm in 1970 some 200 yards or so south from that mentioned above, at G.R. 732443, presents a very different picture. Beneath a layer of stony clay which varies in thickness from about 6 feet (1.8 metres) at the eastern end of the pit to about 2 feet (0.6 metre) at the western end, is exposed some 14 - 18 feet (4.2 - 5.5 metres) of sand, with abundant streaks of pulverised coal and very clear current bedding. A few, largely rounded, pebbles occur in indistinct layers, and there are also lenses of red clay in places (see Fig. 5.17, P. 138).

This exposure compares very favourably with Hey's descriptions, and the deposit is clearly a water-laid feature. The measurement of various angles of the topset beds in a number of locations in the pit, suggested that the stream which was responsible for their deposition came from a direction slightly east of north - i.e. from the vicinity of the Longley Green gap.

The stony clay lying above the sand layers in this pit seems to vary not only in thickness, but also in stoniness. At the top of the sand layers there is a transition zone of sandy clay in which there is an abundance of pebbles, most of which appear to be rounded. Above this zone, the clay is without structure, and there are no clearly definable stony layers - indeed, there are few stones present. Those which are to be found, however,

a) GENERAL FEATURES OF THE PIT.



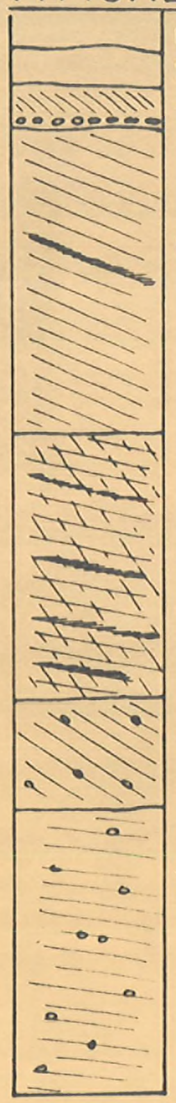
1 Upper 1 metre of sticky, unbedded, featureless clay.

2 Band of stony, clay about 0.1 metre

3 About 4 metres of pink and purplish sand, with rounded clay "pellets", scattered pebbles, streaks of pulverised coal, and marked current bedding.

4 Pit floor, with occasional views in water-filled hollows of very stony clay - thickness unknown

b) TYPICAL SECTION THROUGH SAND - LAYER 3.



16 cms stony clay

10 cms pink sand. No bedding. Pebbles rare.

10 cms pink sand. Pebble layer at base. Dip c 18°.

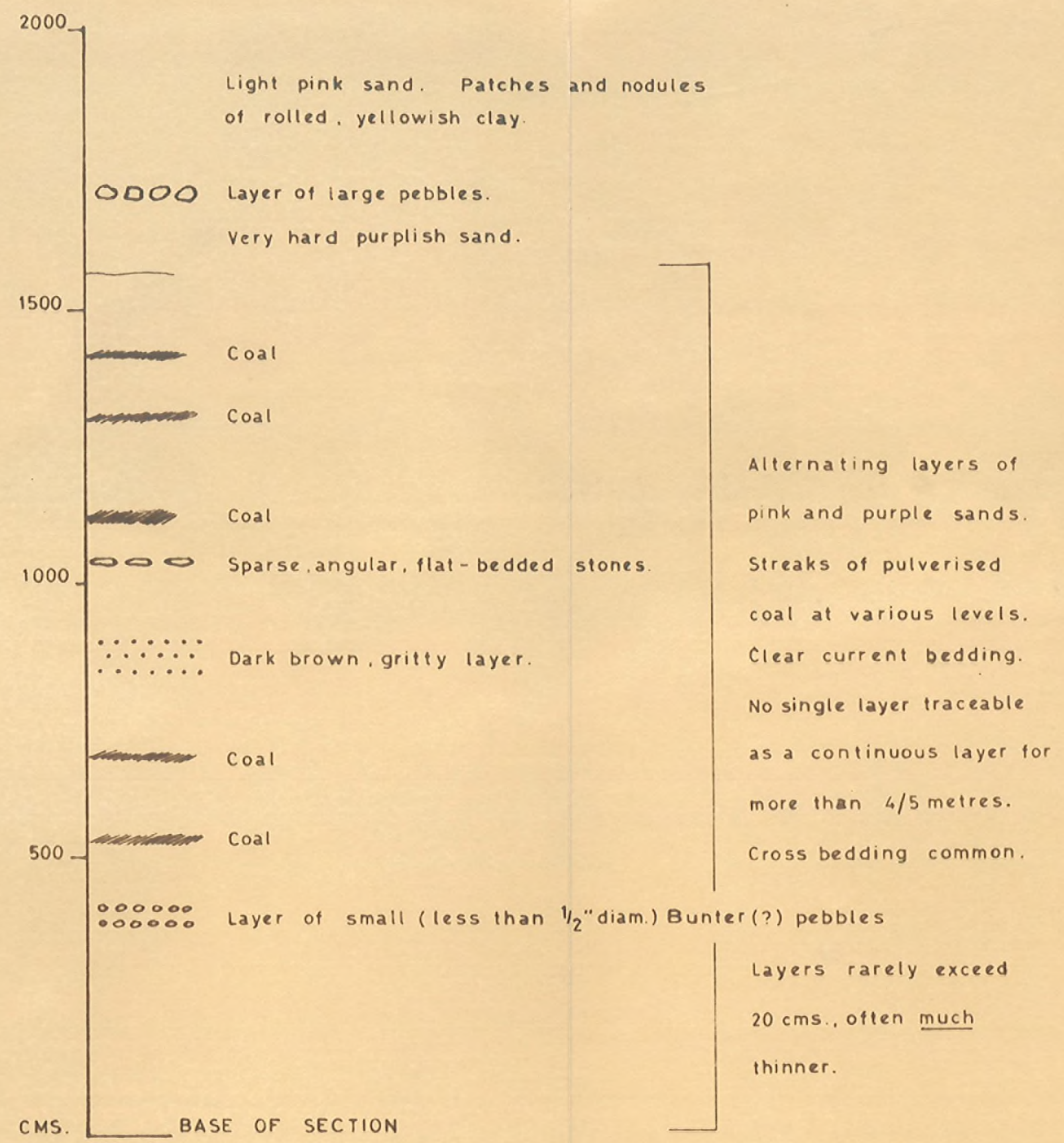
95 cms alternating pink and purple layers with coal streak at 45 cms. Dip c. 11°.

70 cms alternating sand layers. More frequent coal streaks. Purple sand bedding appears to "cross" pink sand bedding - secondary weathering feature? Dip. c.10°.

25 cms pink sand with scattered, small quartzite pebbles. Dip c. 12°

70 cms purple sand dominates, with clay pellets. Pebbles common but no distinct pebble layer. Dip c. 7°

RECORDED DIRECTIONS OF DIP SUGGEST N-NE ORIGIN.



c) DETAILED SECTION OF SAND LAYER FROM NORTH SIDE OF PIT.

Fig 5.17. GARDINER'S NEW SAND PIT, SOUTH MATHON.

(sections seen in spring 1971)

are more angular, and it is suggested that this material may be the solifluction deposit to which Hey refers, and which has incorporated rounded gravels into its base from the riverine materials beneath.

It is also noticeable that this supposed solifluction material is markedly different from that formerly exposed in Gardiner's old pit, mentioned above, in which the gravel predominated over the clay. The two sites differ in altitude by only 10 feet (3 metres) or so, but the difference in the nature of the material is most interesting.

It is also worthy of note that a map prepared for Gardiner's by an unidentified surveyor, of the area immediately to the south of the present pit, suggested the presence, in the mass of sand, of a kind of lattice-work of clay ridges, criss-crossing the area. These 'ridges' were said to be "like infilled tunnels, of about 3 feet in height". Assuming for a moment the accuracy of the survey, the author is at a loss to explain such an apparent pattern, but a possible explanation could be that the resistivity meter used may have picked up occurrences of lenses of clay, which were then interpreted falsely in this way.

Besides the Mathon deposit, Hey (31) also identifies three other distinctive materials in the area (see Fig. 5.18, P. 140). South of Mathon, the gravels give way to finely laminated silts and clays, to which he applies the term <u>White House Silts</u>, which are characterised by the 'absence of large stones, other than the occasional pebble of strictly local derivation'. These silts pass, in turn,

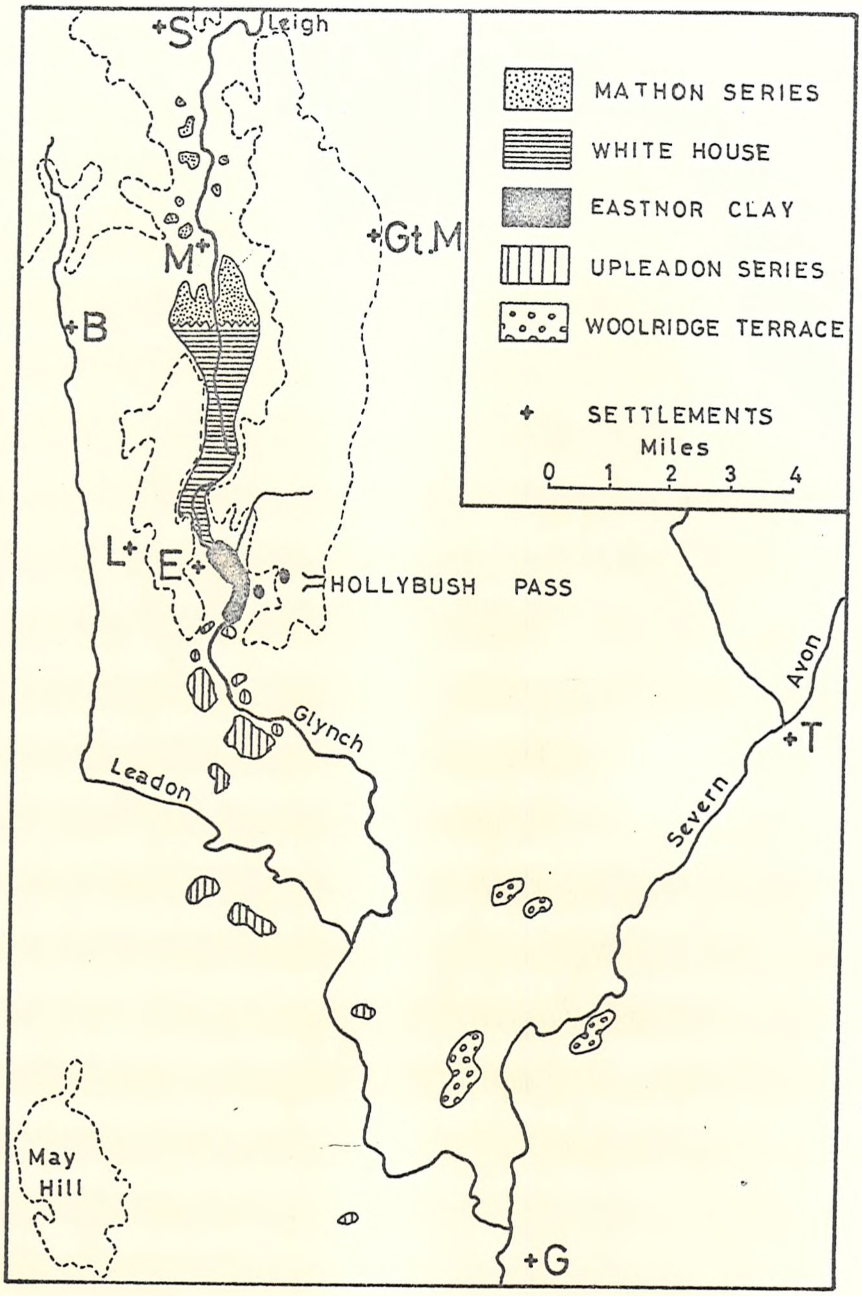


Fig 5.18 PLEISTOCENE DEPOSITS IN THE AREA ADJOINING THE MALVERN HILLS.

after R.W. Hey.

beneath a red, unbedded stony clay, which he terms the Eastnor Clay, while south of Eastnor are the northern occurrences of the Upleadon Gravels, riverine materials which were:

> "laid down at a time when there appears to have been no important stream in the main Severn valley".
>
> (30, P. 168).

Hey considers that these gravels are the relics not of a broad sheet of gravel, but:

> "of the flood plain deposits of a shallow valley, perhaps no more than a mile wide, running from north to south across the present course of the river Leadon" (30, P. 162)

The Eastnor Clay is interpreted as a boulder clay, (31) derived from a glacier lobe which came from the east, since the pebbles contained in it are predominantly Malvernian and the matrix Triassic. Such a glacier lobe is regarded as having crossed the Malvern Hills at the Hollybush Gap (G.R. 759369), which presently stands at 526 feet (160.3 metres) O.D., and as having dammed up the major southwards-flowing river (Fig. 5.19, P.142). The lake thus formed provided the conditions for the deposition of the White House Silts, while the Mathon Beds are seen as representing a large delta formation built out into the northern portion of the lake by a stream which flowed westwards across the Malvern Axis, through the Longley Green gap. Basing his interpretation upon borehole records which the author has been unable to study, Hey suggests that the White House Lake had a minimum surface elevation of 358 feet (109.1 metres) O.D.

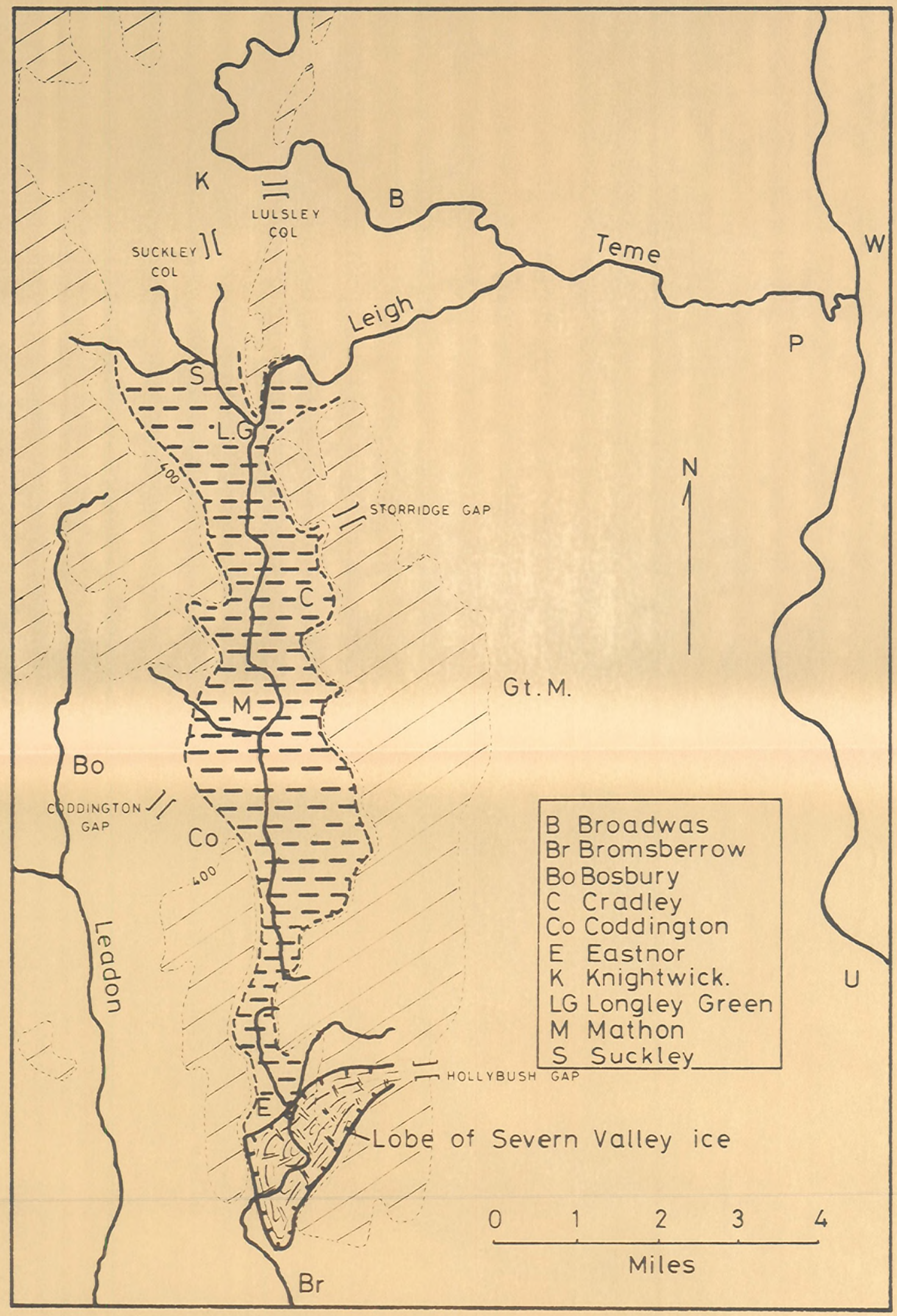


Fig 5.19 HEY'S PRO-GLACIAL LAKE MATHON

Perhaps the most significant of Hey's conclusions is the existence of a <u>buried</u> surface which he describes as falling from around 290 feet (88.4 metres) O.D. north of Mathon, to around 240 feet (73.1 metres) O.D. at Bromsberrow (G.R. 732338), and which he interprets as a sub-drift valley floor. This evidence would clearly support the idea that this area was once occupied by a major south-flowing stream. Nevertheless, as has been already stated (P. 126), no evidence to support the suggestion has been found in the Shelsley Reach of the Teme, where terrace remnants of this valley, at heights of between 300 - 400 feet (91.4 - 121.9 metres) O.D. might reasonably be expected. Although Hey states that such remnants exist, the author has failed to find them.

The present drainage of this major valley is by the Leigh and Cradley Brooks in its northern part, and by the Glynch Brook, tributary to the River Leadon, in its southern part. The northern drainage crosses the Malvern Axis at Longley Green, at right-angles to the axis of the Malvern Anticline (see P. 48/9), and in a deep-cut and meandering valley. The present river falls from 200 feet (60.9 metres) O.D. at the western end of this gap, to below 125 feet (38.1 metres) O.D. at the eastern end, near Knapp Farm (G.R. 751522), in a distance of about 2 miles. During this crossing of the Axis, the valley sides rise steeply to a series of knolls and spurs which are bevelled at a little over 300 feet (91.4 metres) O.D. On the north side of The Beck, (G.R. 749505), this slope extends from 150 feet (45.7 metres) O.D. at the river side, to over 660 feet (201.2 metres) O.D. at the summit in a smooth almost unbroken slope. Other summits in the area are over 520 feet (158.5 metres) O.D. in the Suckley Hills (as for example at G.R. 729518, and G.R. 733520), and similarly on the south side of the gap at Bearswood Common (G.R. 736497) and Halesend Wood (G.R. 740495). Throughout the length of the crossing of the Axis, the form of the land is strongly suggestive of incision.

The line of the generalised 300-feet (91.4 metres) contour (35) (see Fig. 5.20, P. 145) suggests a funnel-shaped valley, with the narrow 'neck' at Longley Green, opening out eastwards in the area of Alfrick Pound (G.R. 746521). According to Gray (23), parts of this 300-feet surface are overlain by fine red sand with quartz and quartzite pebbles (though there is now no exposure visible), and a fluvial origin is thus implied. The correlation between the 'funnel' level and the Mathon Level (P. 135) is such as to suggest that at one time a stream may have drained eastwards through the Longley Green gap at a height of about 300 feet (91.4 metres) O.D.

Within the 'funnel', the Leigh Brook now follows an intensely meandering course, consisting of four major valley swings within which are numerous smaller channel meanders, indicative of drainage diminishment (14, 16 and 17). Thus the drainage diminishment, the 'funnel' level and the incised nature of the gap would seem to suggest that the Longley Green gap has for long been the outlet for drainage of the area west of the Malvern Hills, and that a change of base-level has occurred to cause the stream to incise into an early, higher course. The age of

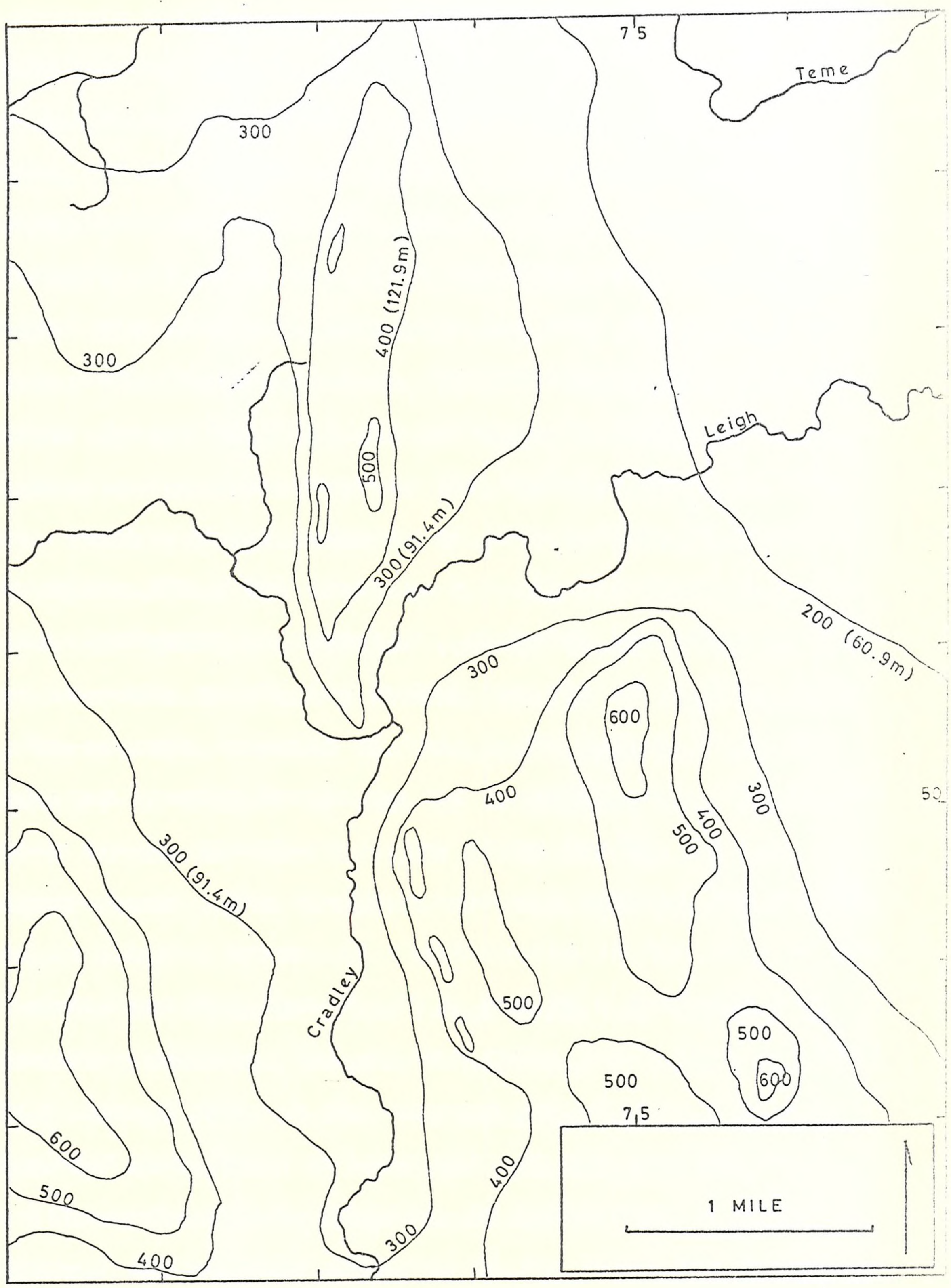


Fig 5.20 THE LEIGH GAP - GENERALISED CONTOURS

(Reduced from base maps on scale of 1:25,000) the 300-feet level is therefore of the greatest importance, but the incision of the Leigh Brook would seem to be contemporaneous with the dissection of the Mathon Level, and was effected by an eastwards-flowing stream.

Hey believes the Mathon materials to be of lacustrine origin, or to be exact a delta laid down by a meltwater stream which crossed the Malvern Axis from east to west, during the Gippingian glacial period (31, P. 412). This course of a meltwater stream is argued as being the only possible, since Bunter pebbles are to be found in abundance south of the gap, but not in the parish of Suckley, which lies to the north. Hey therefore argues that the stream could not have entered the area from the north via the Suckley Station col, since the Mathon deposit contains Bunter material. The quartzites found on the bevelled spurs in the gap (see P. 144) are quoted as further evidence.

Hey suggests that the White House Lake came into being when a glacier lobe crossed the Malvern Hills at the Hollybush gap and ponded back the southwards-flowing river. This lake then found an outlet to the south, and the final melting of the ice dam is presumed to have caused the catastrophic release of lake water into the Leadon valley, and the resultant deposition of the Upleadon Gravels. He goes on to say:

> "Subsequent events west of the Malvern Hills include the reversal of drainage through the Longley Green gap and much erosion, leading to the initiation of the present drainage system".
>
> (31, P. 416).

The detail of these 'subsequent events' is not discussed, and would appear to be a significant omission from Hey's hypothesis. Similarly, there is no detailed discussion of the origin of the Knightsford Bridge gap.

It is also worth noting that the levels of Hey's White House Lake and also of the proposed Hollybush Glacier pose some additional problems. The minimum surface elevation of this lake is put at 358 feet (109.1 metres) O.D., considerably higher than the level of the Suckley Station col and of the Tedney Level. If such a lake existed, then it must have had a very considerable northward extension, and have occupied the whole of the Shelsley Reach, and perhaps far beyond. Dwerryhouse and Miller (19) suggested that the Teme, prior to its reversal, may have had its source somewhere near the Knightsford Bridge area, so that the lake would then have extended far north and west, 'down' this valley. However, that Hey's White House Lake is not related to Cross' Lake Woofferton is evidenced by the difference between the proposed surface elevations - 358 feet (109.1 metres) and 305 feet (92.9 metres) respectively - yet the White House Lake surface is put at a higher elevation even than that of the proposed Stockton-on-Teme watershed (see P. 111) at about 305 feet (92.9 metres). Thus this lake could not have existed at Hey's proposed elevation without extending far up through the Teme valley, perhaps even beyond Ludlow, and field evidence suggests that this was not so.

There is one further area which seems to be significant in the context of Hey's White House Lake - the Coddington Gap. This feature is at its lowest in Old Country Wood (G.R. 722440) where it stands at 338 feet (103.0 metres) O.D. This altitude is not only lower than the proposed lake surface, but is also some 35 feet (10.6 metres) or so lower than the present drainage divide at Eastnor, which Hey suggests as the site of the glacial dam.

If the White House Lake existed, then there are four possible outlet routes which its overspill might have used:

a) The Longley Green Gap.

b) The Coddington Gap.

c) The Eastnor watershed.

d) The Suckley Station Col.

The Longley Green gap at this time is presumed to have been blocked by ice, and to have contained the meltwater stream responsible for the deposition of the Mathon delta formation. If the Suckley Station Col was free from ice, then the lake must have had a much greater northwards extension into the Shelsley Reach of the present Teme, but the evidence of the proposed surface elevations of the two lakes, White House and Woofferton, and also the proposed Stockton-on-Teme watershed, would seem to pose a major difficulty. (Hey does suggest, however, that 'any evidence for the northern extension (of the White House Lake) may well have been removed by the River Teme'). Of the Coddington Gap, he suggests that, since there is no evidence for any westwards extension of the lake through this area, the gap must therefore be the result of 'comparatively recent erosion of the soft Downtonian marls'.

Thus the only possible outlet for the lake would seem to have been the Eastnor watershed, where he refers to a

> "narrow valley . . . leaves the west side of the main valley at Eastnor, and rejoins it $\frac{3}{4}$-mile to the south . . . exactly where a spillway would have developed under the circumstances".
>
> (31, P. 414).

It is clear that he envisages that this spillway would have been developed around the margin of the proposed ice lobe.

Finally the question must be asked: if the Severn Valley glacier sent an offshoot across the Malvern Hills at the Hollybush Gap, at an altitude of at least 526 feet (160.3 metres) O.D. - the height of the present floor of the gap - why did it not do likewise across all the other gaps across the Malvern Axis? Hey states that there is no evidence for similar ice lobes across at the Gullet and the Whiteleaved Oak gaps, while the cols at Storridge, Lulsley, Martley and Shelsley Beauchamp are all much lower than the Hollybush gap, yet show no definite evidence of having been glaciated. Similarly the whole of the Shelsley Reach of the Teme is well below this level, yet contains no glacial landforms. Again, Hey states that of the thousands of pebbles examined from the Eastnor Clay deposit, none has shown evidence of glacial striations.

It is here suggested that because of the doubts expressed above, the White House Lake may not have existed in the form envisaged by Hey. That some, at least, of the deposits west of the Malvern Hills were laid down in water cannot be doubted (see Pp. 136-40), yet the glacial dam and ponded lake as proposed by Hey seem to be questionable. Could the Severn Valley Glacier have sent a lobe across the Hollybush gap, near the extremity of the Gippingian ice sheet, where the ice would presumably have been more or less 'dead'? Could the Severn glacier have sent such a lobe across the Hollybush gap, and not across the other lower gaps further north? Alternatively, if the glacier did send offshoots across all these cols, why is there no evidence of this at any other site? Is it possible that the Eastnor Clay deposit is not a boulder clay, as Hey suggests, but rather a solifluction deposit, containing locally derived material and in a reddish matrix not of Triassic origin, but of Malvernian and Devonian origin? (The author's reasons for questioning Hey's conclusions are summarised in Chapter Six, P. 174).

The White House Silts and the Mathon Beds were unquestionably laid down in water, either in a lake or in standing water which was occasioned by the impeded drainage characteristic of areas of permafrost conditions. The Mathon deposit may be simply a huge alluvial fan of debris derived from a meltwater stream flowing into such an area. The stream responsible, by nature of the deposit (see Fig. 5.17, P. 138), seems to have flowed westwards through the Longley Green gap, and therefore against what has already been suggested as the pre-glacial slope (P.146). Since it is unlikely that the water could have escaped eastwards through the Longley Green gap at the same time, an alternative escape route must be sought. For the post-Gippingian drainage to re-occupy the Longley Green gap in an eastwards direction, this alternative route had to be abandoned before it had been cut to a level below that of the Longley Green gap, and thus established as a permanent route. Hey believes that his White House Lake escaped southwards across the present Eastnor watershed, the 'catastrophic release' of water being then responsible for the deposition of the Upleadon Gravels further south. Yet had this been the case, why did this outbreak not establish a general southwards direction of drainage for the whole of the area occupied by the lake? Similarly, the spillway near Eastnor to which he refers does not appear to be large enough to equate with a catastrophic release of water.

Alternatively, the waters may have escaped temporarily northwards across the Suckley Station Col and into the Teme above the Knightsford Bridge gap, and thence into the Vale of Severn, by passing beneath the ice (25). If the Coddington gap was not the escape route either - and there is no field evidence for any lake extension or overflow in this direction - then the Suckley Col route would seem to be the only possible outlet. For the drainage to re-establish itself in its pre-Gippingian course eastwards across the Malvern Axis, this outlet must have been abandoned before the Mathon Beds had built up such a thickness in the Longley Green gap as to reverse the slope through the gap.

The origin of the Suckley Station Col is thus not here thought to relate to a major river flowing west of the Malvern Hills, for which it is suggested there is insufficient evidence. The positions of the Shelsley Reach of the Teme and of the Leigh - Cradley valley are such that they are both strike vales, and the apparent 'continuity' may be no more than a 'geological accident'. It is here suggested that they are the products of some form of fluvial excavation which pre-dates the glacial events - possibly stream piracy or valley abstraction. With initial drainage developed upon an eastwards-sloping surface from the Clifton Plateau - Bromyard Downs - Ledbury Hills watershed area towards the present vale of Severn, it would be reasonable to expect that adjustment to the underlying structure would result in the development of north-to-south subsequent valleys in the softer materials, or along lines of structural weakness such as geological junctions. Subsequent valleys thus developed would naturally be 'aligned', though they may never have been 'connected'.

On the eastern side of the Malvern Axis, the Leigh Brook crosses part of the Vale of Severn, to join the Teme at Leigh (G.R. 785536). In this section, the stream occupies a shallow trench of about half a mile width in the surface of the Vale, which here stands at generally between 150 - 175 feet (45.7 - 53.3 metres) O.D., though with a few rounded summits at a little over 200 feet (60.9 metres) O.D. The stream still meanders freely within the broader, more gentle valley swings, and has a narrow, though well-developed 'flood plain' which varies in width from 50 to 250 yards.

4. <u>The Severn Vale Teme</u> (Fig. 5.21, P. 154).

After crossing the line of the Malvern Axis at the Knightsford Gap, the river Teme enters the Vale of Severn - a gently undulating surface which stands generally between 250 feet (76.1 metres) O.D. at the base of the Malvern Hills, and 48 feet (14.6 metres) O.D., the level of the 'flood plain' of the Severn at Worcester. This lowest level is, however, restricted to narrow zones along the courses of the two main rivers, from which stepped slopes rise to a more general level of 150 - 180 feet (45.7 - 54.8 metres) O.D.

The landscape of this part of the Severn Vale is characterised by the terraces of the Severn which have been extensively mapped, measured and described by Wills (62), whose nomenclature is used in this study. Other workers involved in studies of the Severn area include Gray (23), Richardson (45&46), and Beckinsale and Richardson (2), while Tomlinson (54) and Shotton (47) have carried out extensive and intensive work in the closely associated valley of the Avon.

The undulating nature of the surface of the area does not appear to contain any fold or fault features, nor any landforms which may be attributed specifically to lithological variations, and it is therefore suggested that this landscape comprises features derived from the fluvial and glacial processes which have acted upon it under both the present humid temperate climate, and under past glacial and periglacial conditions. Thus gravels are to be found almost everywhere in the area, smeared in varying thicknesses across the Keuper Marl.

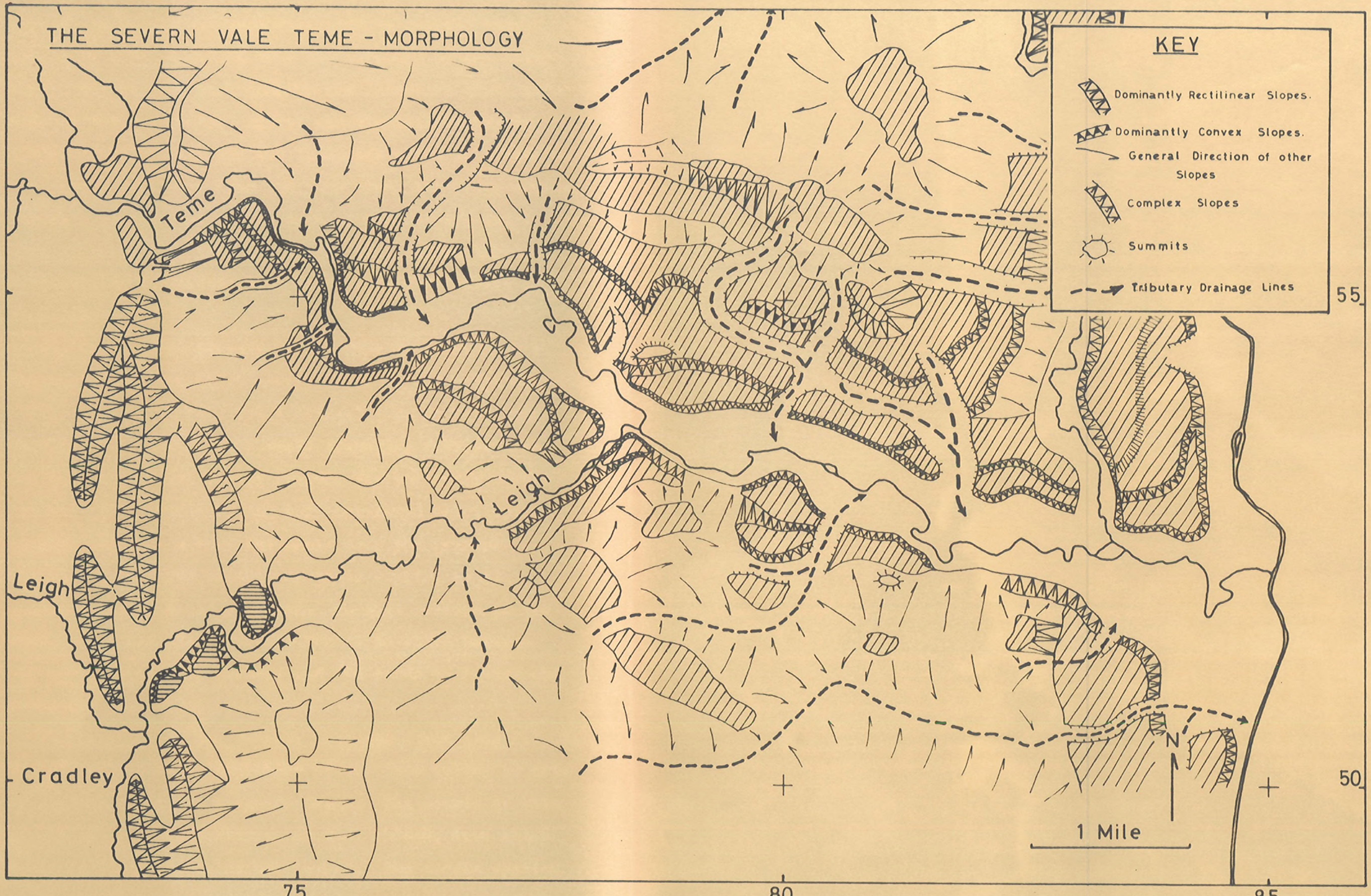

THE SEVERN VALE TEME - MORPHOLOGY
KEY
Dominantly Rectilinear Slopes.
Dominantly Convex Slopes.
General Direction of other Slopes
Complex Slopes
Summits
Tributary Drainage Lines
Teme
Leigh
Leigh
Cradley
55
50
75
80
85
N
1 Mile

Fig 5.21

The characteristics of the Severn and Teme valley terraces have already been described in Chapter Four, and it is here suggested that the terraces of the River Severn may be much more complex and extensive than Wills' account (62) suggests. Almost all the interfluves in the area are 'flat', and the landscape takes on a stepped appearance well away from the zone along the river course, and even as far west as the base of the Malvern Axis. The Teme terraces have been cut across this Severn terrace complex, and differentiation becomes very difficult in many areas.

The flood plain terrace of the Teme (see Pp. 61-63) falls from 84 feet (25.6 metres) O.D. in the Knightsford Bridge area to 48 feet (14.6 metres) O.D. at the Severn confluence. Except where small tributary valleys open out onto this level valley bottom, the enclosing bluffs are remarkably straight and well-preserved rectilinear slopes. Only in a very few areas does the present channel of the Teme impinge on these bluffs, as it meanders within their confines. In this section of the Teme, the flood plain terrace varies in width between 200 yards in Lulsley parish, and 600 yards in Powick and Rushwick.

The Leigh Brook has already been mentioned (see P. 152), while the only other tributary of the Teme worthy of note in this reach is the Laughern Brook. The source of this stream is near Great Witley, at G.R. 758638, from which point it flows initially southwards. The middle section of the brook is aligned west-to-east, and it approaches to within 100 yards of the river Severn at Hallow

(G.R. 825526), where it turns south again, to parallel that river for the lower part of its course, and to the confluence with the Teme near Powick Bridge (G.R. 833526). There are no apparent structural or lithological reasons for this curious course, and it is suggested that it may be related to the glacial history of the Vale of Severn. The Severn terrace deposits have revealed that at the time of formation, the Severn was a braiding and meandering stream or series of streams, and it seems probable that the surface which was developed under these influences may well have been 'scored' with abandoned channels and scars, orientated largely north-to-south, such as that still clearly visible at the north end of Hallow village, below Greenstreet Farm (G.R. 832593). It may be that the course of the Laughern Brook is directly attributable to these sub-parallel back-channels of the early River Severn.

Chapter Six - Interpretations of the Landforms of the Lower Teme Basin.

Dwerryhouse and Miller (19) have suggested that the River Teme, which they considered in detail only in the Tenbury Reach and above, probably had its source somewhere in the vicinity of the Knightsford Bridge gap, from which area it flowed initially northwards, then westwards to join the River Lugg via the Orleton gap. They considered also that the cutting of the Knightsford Bridge Gap must of necessity be related to the events of reversal in the Tenbury Reach of the Teme. These conclusions were not, however, accompanied by any detailed discussion of the landscape of the Shelsley Reach of the Teme.

Cross (8) has demonstrated that there is ample evidence, both in the Tenbury Reach of the Teme, and in the tributary valley of the Rea Brook, to support the hypothesis of a westwards-flowing river in this section. However, there would seem to be no positive evidence for a northwards-flowing stream in the Shelsley Reach. Cross' high level Shakenhurst and Little Hereford Terraces do not appear in this section of the Teme, while the low terraces which do occur relate in height to his Tenbury Terraces, and slope southwards along the line of the present river. They are presumed, therefore, to be the products of that river.

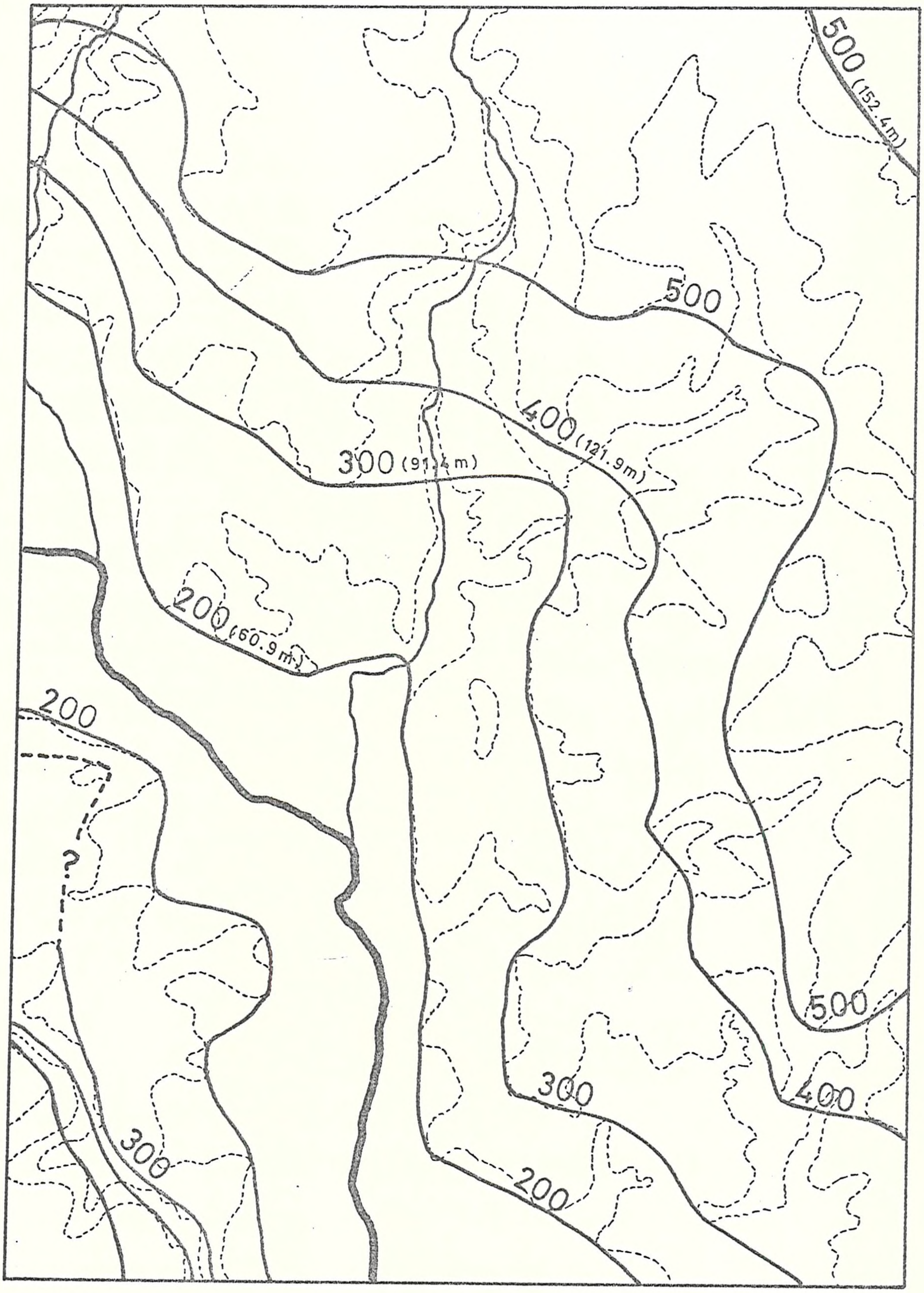
That reversal of drainage in the Tenbury Reach has occurred seems certain, and that the former drainage divide between the Severn and the Wye basins lay somewhere across the present Teme valley between the Clifton

Plateau and the Abberley Hills - Wyre Forest area, in the vicinity of Stockton-on-Teme. However, as has been stated (see P. 111), there is no field evidence for such a major former water divide in the present landscape. Indeed, the continuous nature of the valley side slopes in this area, particularly on the south side, would seem to suggest no such breaching of a watershed. However, the evidence of the Woofferton area, indicating the presence of Devensian ice damming up a pro-glacial lake, of which Cross has identified successive strandlines, would seem to be the only explanation for the present landscape of the area.

The map of the generalised contours of the area north of Stanford Bridge (Fig. 6.1, P. 159) does, however, suggest the possible existence of a promontory on the west side of the valley in that area. Nevertheless, it must be stressed that this promontory is <u>not</u> a prominent feature of the present landscape. Further, the essentially subjective nature of the cartographic exercise is such that, without the necessary field evidence, this feature may be discounted.

The former existence of this Stockton-on-Teme watershed is also supported by implication by both Gray (23) and Groom (26), who suggested that in 'pre-glacial' times - presumably pre-Gippingian in this area - a major river flowed southwards along the line of the present Shelsley Reach of the Teme, and in the broad valley west of the Malvern Hill (see Fig. 6.2, P. 160). Such a river, prior to the Devensian events of reversal in the Tenbury Reach, must have had its source somewhere in the area

Fig 6.1



GENERALISED CONTOURS OF THE STANFORD BRIDGE AREA (1:25,000)

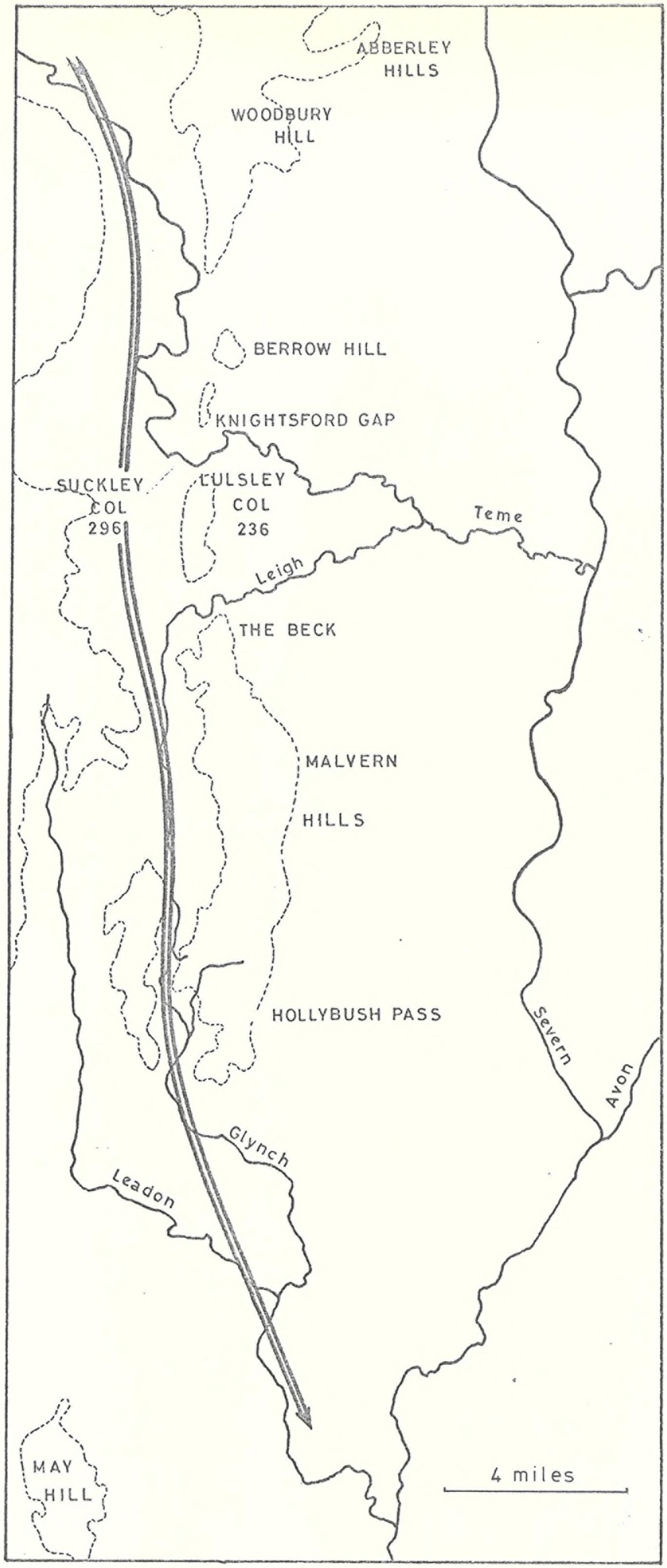


Fig 6.2 THE PROTO TEME WEST OF THE MALVERN AXIS

north and east of Stockton-on-Teme, and the Severn - Wye drainage divide is therefore implied as separating the upper waters of the Tenbury Reach from those of this Proto-Teme.

However, it must be said that the evidence for the Proto-Teme is scant. Hey (31) has argued in favour of such a river being ponded up by a glacial lobe across the Malvern Hills at Hollybush Pass, to form the pro-glacial White House Lake. He also refers to the Shelsley Reach of the Teme, where:

"there are . . . erosional terraces . . . for about 7 miles above Knightwick, rising to about 300 feet".

(31, P. 413)

However, the author has measured the highest terrace remnants in this section at heights well below this level. Hey does not give any further detail of these supposed higher terraces, and although it is possible that he suspected the Tedney Level as being the northwards extension of his Proto-Teme valley, it has been shown (P. 126) that the highest parts of this level are too low for the river which formed it to have crossed the Suckley Station Col.

Had the Proto-Teme existed in the form envisaged by Hey, then the valley floor in the Shelsley Reach must have stood at over 300 feet (91.4 metres) O.D., and have been higher northwards. This would necessarily require that the Stockton-on-Teme watershed, proposed by Cross (8) at a little over 300 feet, must likewise have been higher. However, the surface elevation of Devensian Lake Woofferton, which is presumed to have spilled out over this watershed, itself reached only a little over 300 feet (see P. 111) and a higher watershed as outlined above would therefore have precluded the possibility of such an overspill, and thus of reversal.

Hey's White House Lake is dated as being of Gippingian age (31, P. 415), while the events of the Tenbury Reach have been dated by Cross (8) as of late Devensian age. It would therefore seem possible that Gipping ice may have caused an initial lowering of a higher watershed in the Stockton-on-Teme area, perhaps by means of a lobe of ice across the Witley Col, and along the line of the Carboniferous - Devonian geological boundary in the area. This initial lowering may have made it possible for the Devensian Lake Woofferton to overspill into the Shelsley Reach at a lower altitude at that later stage. In this way, a higher level valley in the Shelsley Reach may be explained, but the absence of any field evidence for such a valley is perhaps surprising. It is perhaps conceivable that the Tedney Level, comprising as it does a series of sub-parallel interfluves, may have been lowered from a height well above 300 feet (91.4 metres) O.D., to its present height (average 240 feet, 73.1 metres, O.D.) since the Gippingian glacial phase, but this can only be conjecture, and the present field evidence would appear to support the former suggestion (P. 111).

Since it is now proposed that the Shelsley Reach of the Teme and the valley west of the Malvern Hills are not related to a Proto-Teme river, the origin of the Knightsford Bridge gap must be investigated. There would seem to be two possible reasons why a major gap should develop at this point where the Malvern Axis is crossed by a transverse fault. On the one hand, the gap may be the result of the headward erosion of a small stream in the Severn Vale area, cutting back along the fault weakness, and eventually effecting the capture of the drainage of the area to the west of the Axis - and therefore implying the existence of a Proto-Teme. On the other hand, it may be the result of the superimposition of drainage on a regional scale from some higher surface, and the gap would thus be contemporary with, or more probably pre-date, the development of the Shelsley Reach strike vale. The present field evidence would appear to support this latter suggestion, particularly in view of the nature of the Longley Green gap and the crossing of the Malvern Axis by the Leigh Brook. The course of this stream, now deeply incised, lies directly across the axis of the Malvern Anticline, which situation does not seem to be a likely product of headward erosion by a stream. It is hardly likely that the Leigh Brook was superimposed upon this structure while the Teme, a little more than one mile distant, was not. Other cols across the Malvern Axis would thus be also the result of this regional superimposition of drainage, much modified since the disappearance of the formative drainage, and further affected by the events of the Pleistocene.

The surface from which this superimposition may have taken place is difficult to specify, partly because of the degree of dissection of the landscape, and partly because of the large 'gap' in the geological succession in the area (see Chapter Three), which is such that no rocks younger than the Carboniferous occur in the study area. The suggested origin of the Haffield Breccia, as being a mountain-foot deposit derived from the erosion of former high mountains, and the preservation of this material in isolated patches along the eastern side of the Malvern Axis and on summits such as Berrow, Woodbury and Abberley Hills, may suggest that such a surface may date from that time.

Brown (3), in his work on the erosion surfaces of Wales, suggests that part of the 'Low Peneplain' is preserved in the area south and east of Tenbury Wells. This peneplain sloped eastwards and was later trimmed at around 600 feet (182.9 metres) O.D. by that same Pleistocene Sea which has been responsible for the formation of marine benches over large areas of southern England. Thus the Clifton Plateau, which reaches a height of a little over 600 feet O.D. might be seen either as a part of Brown's 'Low Peneplain', or as a part of the slightly lower Early Pleistocene Calabrian marine surface, above which there projected a few "summit islands". In either event, the subsequent lowering of sea level could have brought about the incision of drainage into the surface of low relief, from which the proposed regional superimposition took place.

A further possibility might be that superimposition occurred from the proposed Cretaceous surface, (9, 36 and 53) which is believed by many to have covered most of England and Wales at its maximum extent, but which has since been almost completely removed from everywhere except southeastern England.

Each of these four surfaces - Carboniferous, Cretaceous, Brown's 'Low Peneplain' and the Pleistocene marine surface - is thought to have sloped generally eastwards, and in each case, initial drainage would thus have flowed directly across the largely buried structure of the Malvern Axis, the higher parts of which must have projected upwards either as monadnocks, or as 'islands' in the Pleistocene Sea. Progressive erosion would then have resulted in gradual adjustment to this underlying structure, and in the gradual emergence of a drainage pattern which was orientated north-to-south, in sympathy with this structure. The survival of the two west-to-east flowing streams, in the Knightsford Bridge gap and in the Longley Green gap, would be attributed to the existence of the transverse fault in the case of the former, and to the weakened rocks of the anticlinal crest in the case of the latter. Other initial consequents which resulted from this superimposition, not having any comparable structural 'advantages', would then have been progressively eliminated by the development of strike streams in the Shelsley Reach and in the valley west of the Malverns, all that now remains of their former courses being the series of cols across the Malvern Axis. The continued existence of these cols, however, would seem to support a suggestion of recent superimposition, so that the earlier Carboniferous and Cretaceous surfaces may be discounted.

Brown goes on to say that following the erosion of the Pleistocene marine bench, the progressive lowering of sea-level resulted in the cutting of a series of lower 'platforms', at heights of about 400 feet (121.9 metres)

O.D., 300 feet (91.4 metres) O.D., and 200 feet (60.9 metres) O.D., each being accompanied by 'waves of back-cutting' which were transmitted up the rivers. In the study area, the suggestion of successive rejuvenations has already been made (see P. 125) below a height of about 300 feet (91.4 metres) O.D. (see also Fig. 5.12, P. 124).

Thus it is here suggested that a gap across the Malvern Axis in the vicinity of the present Knightsford Bridge gap was in existence before the glacial period, and that the Shelsley Reach of the Teme has therefore 'always' drained out through it.

The presence in the area west of the Malvern Hills of laminated silts and clays, as reported by Hey (31), and also of the Mathon delta deposit, testifies to the existence of water bodies in the area, but for a number of reasons, the White House Lake in precisely the form envisaged by Hey could not have existed. Had the lobe of ice from the Severn Valley Glacier crossed the Malverns at the Hollybush gap - a suggestion that has already been questioned (see P. 149) - then there was no 'major' river flowing southwards in the valley for it to pond back into a lake. Indeed, it has already been suggested that the pre-Gippingian drainage was much the same as at present. Thus the ice in the Vale of Severn would have blocked the Longley Green gap and ponded up the waters of the Leigh and Cradley Brooks system into a lake. Given the heights of the Suckley Station Col at around 300 feet (91.4 metres) O.D., and the Coddington Gap at around 340 feet (103.3 metres) O.D., together with the present height of the Eastnor watershed at about 370 feet (112.8 metres)

O.D., the only possible outlet for such a lake would have been northwards across the Suckley Station Col, as the lowest of these three possible spillways. Into this lake - Lake Mathon - would have been brought the materials comprising the Mathon Beds, a delta deposit built by a stream flowing from a wasting ice front in the Longley Green gap. For the drainage of the northern part of the broad valley to re-occupy the Longley Green gap following the withdrawal of the ice, the Suckley Station col could not have been cut to any depth, and the surface of the Mathon deposit must have been near horizontal, or even sloping to the east (see P. 170). The level of the lake must therefore have been of the order of 300 feet (91.4 metres) O.D.

The overspill of water across the Suckley Station Col must therefore have entered the Shelsley Reach of the Teme, where it might have been expected to form a second lake feature, since the exit for that drainage - the Knightsford Bridge gap - must also have been blocked by the Severn Vale ice. Yet there is no evidence of any lacustrine deposit in the Sapey Bowl area, nor anywhere else in the Shelsley Reach, so that it might be presumed that this water found an outlet beneath the ice in the gap. (25)

The inconsistency of this suggestion is that the ice which blocked the two adjacent gaps in the Malvern Axis appears to have permitted the escape of water beneath it at the one point, yet at the other was the source of a meltwater stream which deposited the Mathon Beds. It is noted that whereas the Longley Green gap, in its higher part, stands at about 300 feet (91.4 metres) O.D., the higher gap at Knightsford Bridge, referred to as the

Lulsley col, stands considerably lower, at around 230 feet (72.3 metres) O.D., and it may therefore be that the meltwater stream at Longley Green was water flowing off the surface of the ice, while the outlet at Lulsley was some 70 feet (19 metres) lower.

The sites of the clays and silts described by Hey are found to lie largely to the south of the present low watershed between the Cradley Brook and the Glynch Brook, the only occurrence noted north of this watershed being that at The Cross (G.R. 725433). Hey's description of this deposit differs quite noticeably from that of Richardson (44) some 20 years earlier, and it is also noticeable that this deposit reaches a surface height of only 310 feet (94.5 metres) O.D., while those to the south are mostly around 350 feet (106 metres) O.D., on the south side of the watershed. Thus it would seem possible that there were two lakes present in the area, and not one, as Hey suggests, and with different surface elevations. The northern Lake Mathon would have reached a maximum surface elevation which was controlled by the height of the Suckley Station col overspill, or of the order of about 300 feet (91.4 metres) O.D. The southern Lake Eastnor (see Fig. 6.3, P. 169) could have reached a greater surface elevation, of the order of about 360 feet (109.7 metres) O.D., its height being controlled by the height of the glacial 'dam' to the south, and/or the height of the Eastnor watershed in the north.

This higher southern lake would have found its outlet to the south, and may have destroyed any evidence for the 'dam' across the pre-glacial valley which was responsible

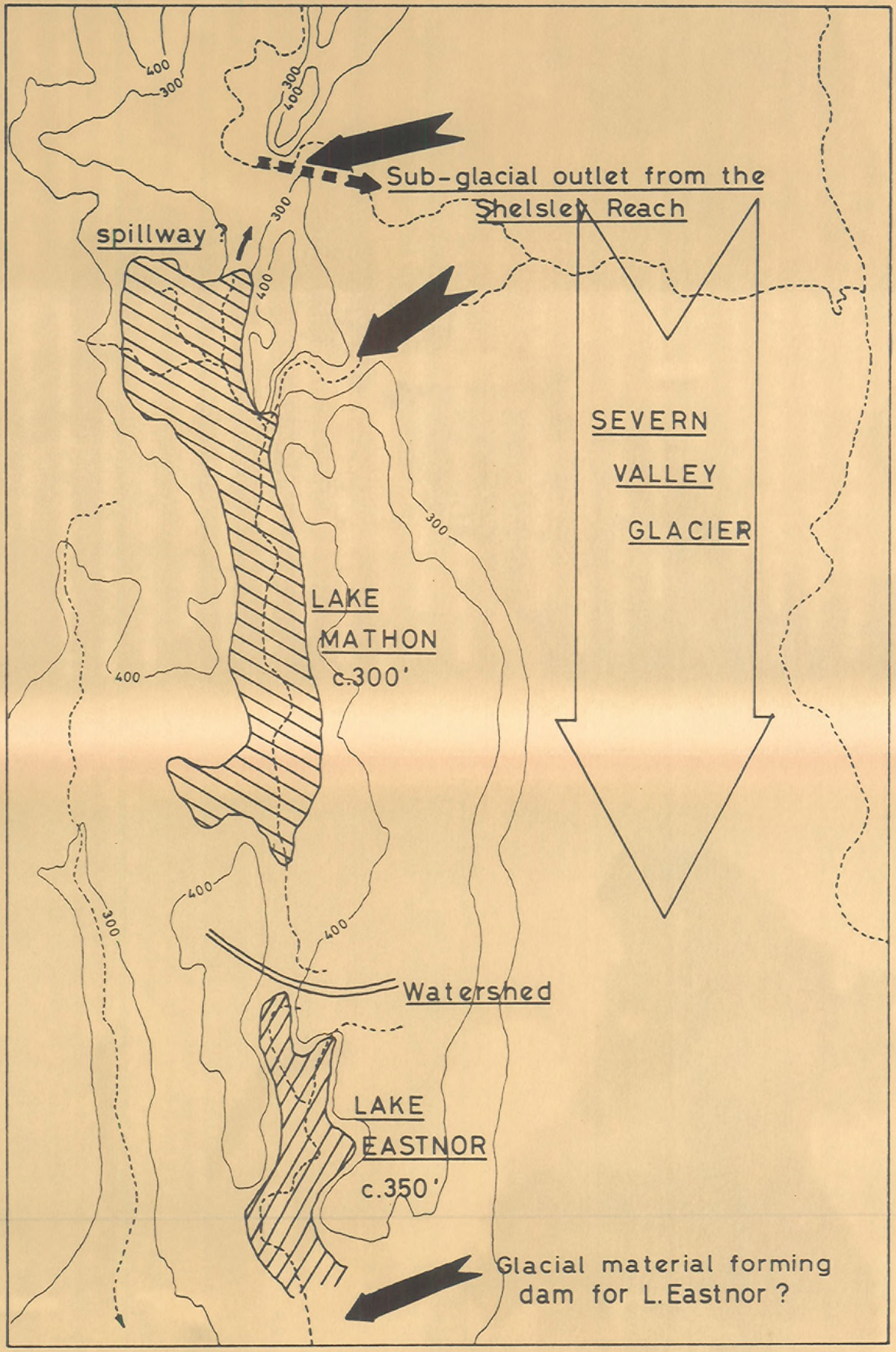


Fig 6.3 LAKE MATHON AND LAKE EASTNOR

for its formation. Its outlet stream may have been responsible for the deposition of the Upleadon Gravels - still further south. Thus the present low watershed between the Cradley Brook and the Glynch Brook is proposed as having formed a ridge between the two lakes, which reached a height of about 370 feet (112.8 metres) O.D., and it is suggested that the draining of these two lakes did no more than to re-establish the former drainage lines (see Fig. 6.3, P. 169).

The dam which may have caused the growth of Lake Eastnor, seems likely to have been formed of ice which rounded the southern end of the Malvern Hills to effect the blockage, rather than to have crossed the Hills themselves at any point.

If these two lakes existed, then a glacial dam on the site proposed by Hey is no longer required, and many of the problems posed by the supposed Hollybush glacier lobe are avoided. Conditions in the area west of the Malvern Hills may alternatively have resembled those which are found to prevail at the present time on sandur plains in front of large ice masses. In such areas, large bodies of water exist, some being virtually stagnant, others having a flow. However, the topography of the area west of the Malvern Hills - a broad but enclosed valley - does not in itself suggest the landscape of a sandur, which is usually associated with a lowland ice fringe.

The surface of the Mathon Beds, as has been already stated, must have been near-horizontal or eastwards-sloping for the drainage to re-occupy the Longley Green gap following the retreat of the ice. This would be the case only if the ice front in the Longley Green gap was 'retreating' during the period of formation of the delta. Had the ice been static, then the delta would have built up with a westwards slope. A retreating ice front, on the other hand, would have enabled the delta to develop a near-horizontal overall surface, or if the ice were retreating at a progressively faster rate, then this overall slope could even have been to the east.

The existence or otherwise of Hey's White House Lake would appear to depend largely upon his identification of the Eastnor Clay as a boulder clay, derived from the area east of the Malvern Hills. It would seem possible that this material is a later solifluction deposit in which the bulk of the material is locally derived, and with a 'few pebbles of Bunter'. It has also been noted (P. 138) that most of the pebbles appear at the base of the deposit, where it would be expected that solifluction processes would incorporate a proportion of the materials from the original surface beneath. The Eastnor Clay occurs at heights varying between 450 feet (137.1 metres) O.D., and 260 feet (79.2 metres) O.D., the highest occurrence being located on the western flanks of the Malvern Hills. The height of this deposit is significant in Hey's view, in that:

> "there was no source of red clay which could have reached this position by gravity alone . . . and I therefore concluded that it must be a glacial boulder clay, and come from the Severn Valley by way of the Hollybush Pass. No other origin could account for the

distribution of the clay, the nature of its pebbles, and indeed, the clay itself, which could well be transported Keuper Marl".

(32, P. 189).

The pebbles to which he refers are identified as being predominantly Malvernian materials and Llandovery sandstones, but also with up to 8% of Bunter pebbles. These last named materials are present in the area west of the Malverns only in the superficial deposits, which Hey suggests do not occur at heights of over 400 feet, except in this clay. However, in nearby Gullet Quarry (G.R. 762381), a conglomeration of rounded and sub-angular material, including some Bunter pebbles, in a reddish matrix, is clearly a solifluction deposit, and rests at a higher altitude than Hey's deposit. Further it is to be noted that although the two descriptions of the material are very similar, in the Eastnor area Hey refers to a boulder clay, while at Mathon he refers to a solifluction deposit.

Hey's support of the hypothesis of a major river flowing southwards across the Suckley Station Col was partly based upon his interpretation of the sub-drift valley of solid rock (see P.143) which he says slopes southwards, and is consistent with the Proto-Teme flowing in the valley. However, he states that:

"the information available is . . . insufficient for the construction of a geological map . . . "

(31, P. 407),

yet at the same time he feels that it is adequate for the ensuing discussion on the relations and origins of the deposits. The evidence available appears to have comprised only a handful of borehole records, spread very 'thinly' over the area from the north of Mathon to the south of Eastnor. On this basis, he concludes that the present valleys are underlain by a sub-drift valley in the solid rock, which "probably" falls consistently and gently to the south. It is here suggested that there is insufficient evidence to support such a conclusion. The surface of the solid formations in the whole region, up to those of the Carboniferous, slope to the south, with the summits becoming progressively lower in the same direction, but the author does not accept that the existence of a southwards-sloping valley in this area has been demonstrated.

A great many more borehole records would therefore be required to substantiate either viewpoint, but it is here suggested that the sub-drift valley is not a proven feature of the area.

If this valley does, in fact, exist, and *if* Hey's White House Lake did drain out southwards to deposit the Upleadon Gravels, then it becomes very difficult to understand why the volume of water involved did not re-create the southwards-flowing drainage of pre-glacial times. Why, in other words, did his lake floor become drained not by a single stream flowing south, but by two streams flowing in opposite directions? Hey dismisses this problem rather unsatisfactorily, with the statement that:

> "subsequent events west of the Malverns include . . . much erosion, leading to the initiation of the present drainage systems" (31, P. 416).

As was the case with the higher terraces in the Shelsley Reach of the Teme, (see P. 126), he does not expand upon this suggestion by giving any details as to how this change might have come about. It is here suggested that following the withdrawal of ice from the Vale of Severn and the re-opening of the Longley Green gap, the drainage of the area was able to re-establish itself in its pre-glacial (Gippingian) pattern, and that a change of drainage such as that proposed by Hey has not occurred.

The development of the northern Lake Mathon seems to have been occasioned by the blocking of the Longley Green gap by Severn Vale ice (although it must be stated that no author has yet discovered any suggestion of glacial drift in or near the gap). The lake developed in the pre-glacial valley which had much the same form as at present, and into this lake was brought the material comprising the Mathon Beds, deriving from a meltwater stream flowing temporarily westwards through the gap. Since the ice in the Severn Vale was stagnant and then waning, the Mathon delta did not grow to such a height as to prevent the re-establishment of eastwards drainage through the gap, so that the re-occupation of the gap following the withdrawal of the ice has resulted in the removal of both any signs of drift materials, and also of much of the original delta deposit.

Thus the author disputes Hey's conclusions on the following grounds:

1. The apparent absence of higher level terraces in the Shelsley Reach of the Teme.

2. The level of the proposed Stockton-on-Teme watershed,

as related to Hey's proposed Proto-Teme level in the area.

3. The probably superimposed origin of the gaps at Knightsford Bridge and Longley Green.

4. The interpretation of the Eastnor Clay as a boulder clay, and the conclusion that an ice lobe must have crossed the Malvern Hills at the Hollybush Pass, but not, apparently, at any other point.

5. The areal distribution of the small number of borehole records on which many of the conclusions are based.

6. The nature of the buried surface of the solid rocks in the area west of the Malvern Hills.

7. The present drainage pattern of the area, in relation to Hey's proposed pre-glacial Proto-Teme and the southwards break-out of the waters of his proposed White House Lake, which would more likely have re-established the line of the pre-glacial drainage.

The absence of any field evidence for the existence of the pre-glacial Proto-Teme has already been stressed. However, the Tedney Level and the Meadow Green Level have been proposed (Pp. 118, 121) as being remnants of a former valley floor which has been much dissected by subsequent erosion. The valley floor proposed, at heights varying between 255 feet (77.7 metres) O.D. in the north and 225 feet (68.5 metres) O.D. in the south, though too low for the stream which formed it to have crossed the Suckley Station col, nevertheless slopes southwards, and may be seen to be extended by the level of the Lulsley col across the Malvern Axis(231 feet, 70.4 metres, O.D.) and also in the higher parts of the Vale of Severn, where summits capped with gravels reach heights of around 200 feet (60.9 metres) O.D.

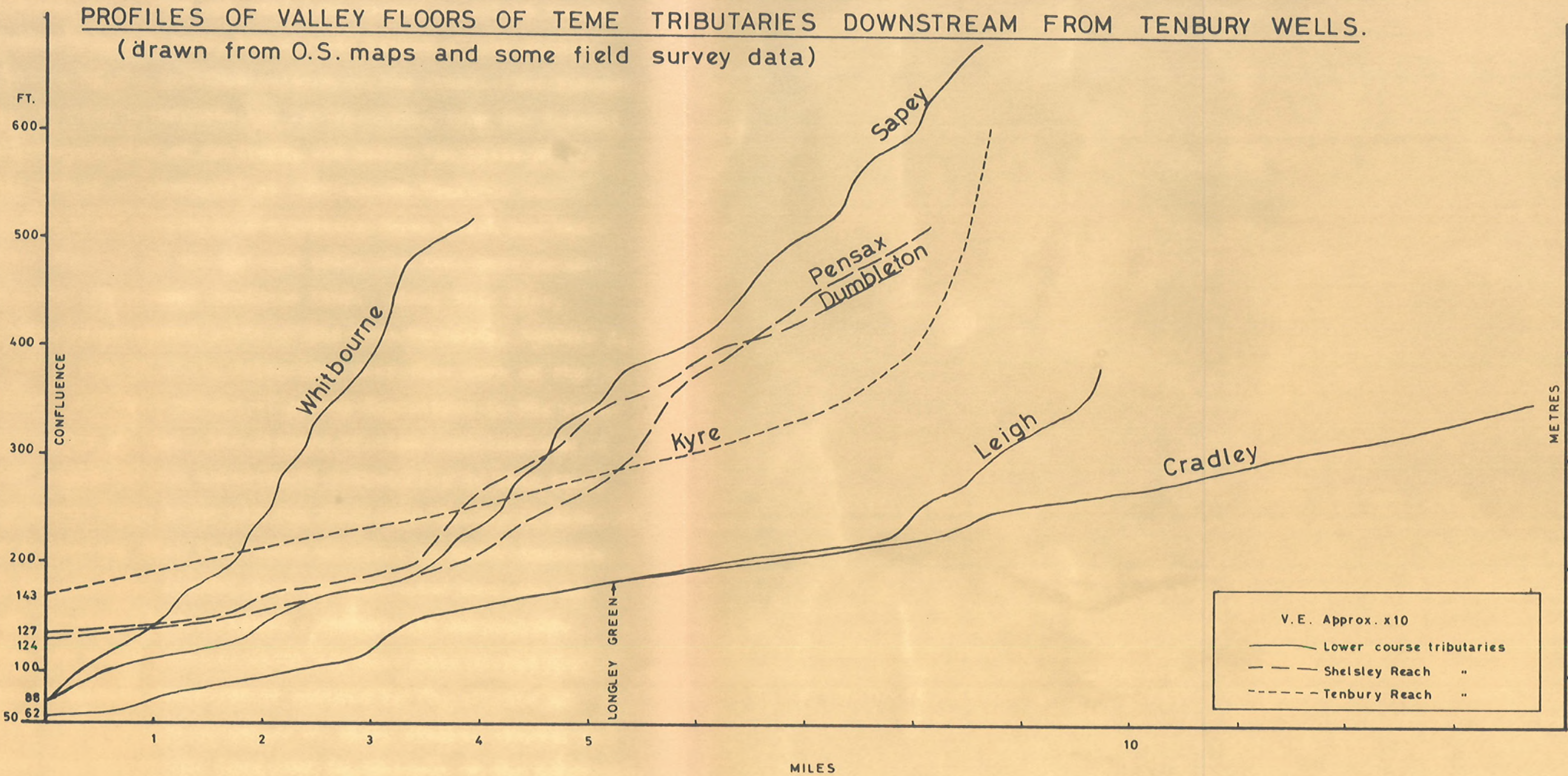
The age of this valley is difficult to determine. It must have existed by Devensian times, when Cross' Lake Woofferton is presumed to have spilled over the Stockton-on-Teme watershed, since it clearly formed the route for this overspill. If it does grade into the higher summits of the Severn Vale, which are classed as Bushley Green stage of the Severn, then it must be as old as the Bushley Green stage of the Severn, or of late Gippingian age. This would then imply that the valley was in existence at the time of the proposed Lakes Eastnor and Mathon, west of the Malvern Hills, as the author proposes, or of the White House Lake proposed by Hey. Under these circumstances the Proto-Teme could not have existed at this time.

Further, this would mean that the present pattern of drainage was already in existence at the time of the Gippingian glacial advance, and that the Gippingian and the succeeding Devensian glacial periods could not have had more than minor effects on that part of the study area.

One of the most important changes in the features of the drainage of the area is, however, related to the overspill of Lake Woofferton. When the waters from this lake spilled across the watershed in the vicinity of Stockton-on-Teme in late-Devensian times, they utilised a valley which already crossed the Malvern Axis in the high level Lulsley col. The great increase in the volume of water in this stream was such that it was rejuvenated, and rapidly cut out the Shelsley Gorge - a process which would have been greatly facilitated by the fact that the crossing of the Malvern Axis lay along the line of a structural weakness, in the form of a fault. The volume of water and the speed of downcutting in the relatively unresistant Devonian marls was such that there is no evidence of stages of downcutting in the main valley at this time, in the form of valley terraces. Indeed the nature of this downcutting is essentially reflected in the form of the tributary valleys of the Teme below the area of overspill. Thus the valleys of the Dumbleton and Pensax Brooks are incised, as also are the valleys of the Sapey and Whitbourne Brooks, and of the many smaller tributaries and 'dingles'. Dwerryhouse and Miller (19) drew attention to the fact that not only does the cross-section of the Teme valley become progressively narrower and steeper downstream, but also that the tributaries of the Tenbury Reach - the Kyre, Corn and Rea Brooks - have very little fall in their lower reaches, while the rejuvenation features noted become progressively more marked downstream. Thus the Sapey and Whitbourne Brooks are more deeply incised than are the tributaries further upstream, such as the Dumbleton and Pensax Brooks. In the case of the Sapey and Whitbourne Brooks, the incision is seen to be of the order of 250 feet (75.8 metres) or more, while in the case of the Dumbleton and Pensax Brooks, it is only of the order of 150 feet (45.7 metres) or so (see Fig. 6.4, P. 178).

Dwerryhouse and Miller (19) suggested that a lake overspill might have occurred in the vicinity of the Knightsford Bridge gap, but the author agrees with Cross (8) that the Stockton-on-Teme watershed is the more likely,

Fig 6.4


PROFILES OF VALLEY FLOORS OF TEME TRIBUTARIES DOWNSTREAM FROM TENBURY WELLS.
(drawn from O.S. maps and some field survey data)
FT.
600
500
400
300
200
143
127
124
100
88
62
50
CONFLUENCE
Whitbourne
Sapey
Pensax
Dumbleton
Kyre
Leigh
Cradley
LONGLEY GREEN
1
2
3
4
5
10
MILES
METRES
182.9
152.4
121.9
91.4
60.9
30.5
V.E. Approx. x10
Lower course tributaries
Shelsley Reach "
Tenbury Reach "

despite the lack of field evidence in the area for such a 'pre-glacial' divide. Thus neither the Knightsford Bridge gap nor the Suckley Station col - the two alternative overspill routes suggested by Dwerryhouse and Miller - is seen as an overspill channel in this context (though the latter may well have formed an outlet for the author's Lake Mathon, but did not become a 'permanent' feature of the drainage pattern of the area). The former gap is here interpreted as one resulting from the initial superimposition of drainage, and later 'emphasised' by the events of overspill at Stockton-on-Teme.

The lower course of the present Sapey Brook and the Teme crossing of the Malvern Axis, are thus seen as an original consequent drainage line. Along this line, there are preserved parts of the Teme Terraces, Numbers 5, 4 and 3 (see P. 93), indicating that this part of the stream underwent stages of gravel deposition in the form of terrace phases. The absence of field evidence for such stages in the north-south tributaries to this line, the upper Sapey Brook and the Whitbourne Brook, is seen as suggesting that the volume of water in these channels at the time was insufficient for extensive terraces to have developed and survived. Further, it is probable that any small terraces which may have been formed may well have been destroyed or covered by the effects of later solifluction processes on these steeper slopes, so that they dodnot now form visible features of the landscape.

The terraces of the Teme valley downstream from Stockton-on-Teme have been discussed in Chapter Four, and five groups of terraces are proposed on the basis of height correlations alone. It must here be repeated that Terraces

Numbers 1 and 2 alone extend through the Stockton-on-Teme watershed area, and have been identified by Cross as the Tenbury Terraces in the Tenbury Reach. Terraces Numbers 3 and 4 are found both below the Knightsford Bridge gap and in the Sapey Bowl area, but not in the Shelsley Reach, suggesting that at this time, the west-to-east drainage line was more important than the north-to-south line of the Shelsley Reach of the present river, and also than the north-to-south tributaries of the upper Sapey Brook and the Whitbourne Brook. Terrace Number 5 is found in the Severn Vale, the Sapey Bowl and in the Shelsley Reach, where it is preserved as the Tedney Level and the Meadow Green Level, but it does not extend beyond the watershed area of Stockton-on-Teme.

According to Wills (63), the terraces of the Severn reflect the glacial history of the region since an 'early' glacial phase - probably Lowestoftian - during which time the Woolridge Terrace was formed in the lower reaches of the present valley (see Chapter Three). Similarly the work of Tomlinson (54) and Shotton (47) has been correlated with that of Wills, and the terraces of the Warwickshire Avon have been related to those of the Severn. It now remains to suggest possible correlations between the proposed terrace sequence of the Teme and the established sequence of the main trunk system (see Fig. 6.5, P. 181).

The Woolridge terrace of the Severn has no counterpart in the valley of the Avon, and is believed to have been formed during the early Lowestoftian glacial advance, the Bushley Green stage being initiated in the succeeding interglacial. The advance of Gippingian ice appears to

POSSIBLE RELATIONSHIPS BETWEEN THE TERRACE GROUPS OF SEVERN, AVON & TEME

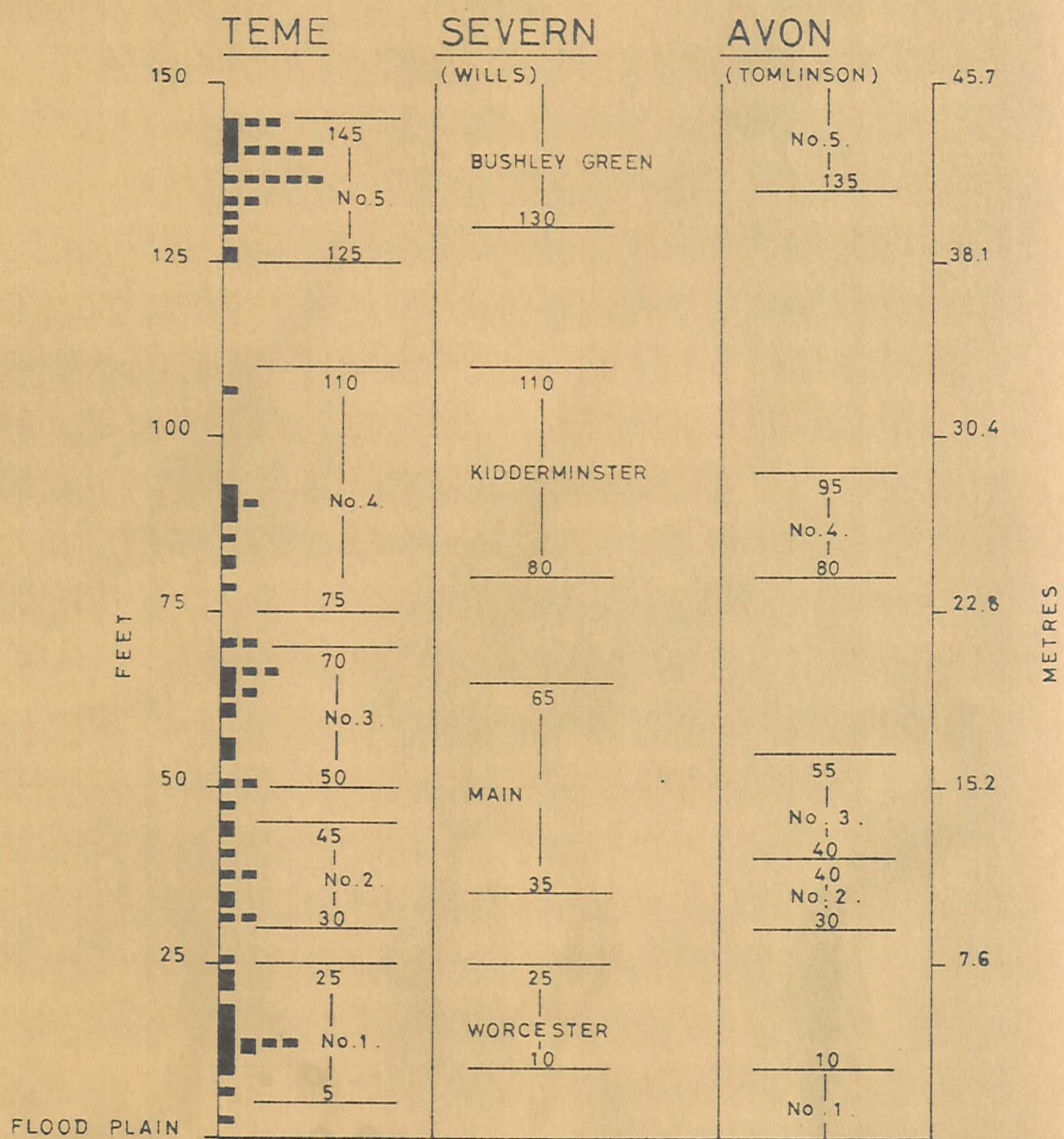


Fig 6.5

have overrun the Woolridge Terrace in part, obliterating it in many areas, while completing the formation of the Bushley Green Terrace in the lowest part of the Severn valley. This terrace was cut in relation to the Avon as the trunk stream of the West Midlands area, as was also the succeeding Kidderminster Terrace. During the Devensian glacial advance, the Severn took over the role of principal stream, following the overspill and events of Lake Lapworth and the Ironbridge area (60), so that the Main Terrace was first cut relative to the Avon No. 3 Terrace of the former trunk stream, but after overspill, to the Severn as trunk stream, into which the Avon No. 2 Terrace is graded. The Worcester Terrace is seen as dating from the withdrawal of late-Devensian ice, and the early stages of the Flandrian transgression.

During Woolridge times, there is no evidence for the existence of the River Teme as a tributary of the River Severn. The earliest evidence of the Teme is proposed as being of Bushley Green age, in the form of the Tedney and Meadow Green Levels, and the Lulsley col across the Malvern Axis. This high level valley of the Shelsley Reach appears to grade into remnants of the Bushley Green Terrace in the parishes of Broadheath and Bransford. Thus by Bushley Green times - the Hoxnian interglacial and the Gippingian advance - the Teme appears to have existed as a tributary of the river Severn, though in a form much smaller than the present river.

During the ~~Gippingian advance~~ Ipswichian interglacial stage and the ~~Ipswichian interglacial~~ early Devensian advance., terrace developments of the Avon and Severn are reflected in the course of the early Teme in the form of the Number 4 and Number 3 Terraces, both of which are extensive below the Knightsford Bridge gap, and appear also in the Sapey Bowl area, but not in the Shelsley Reach. The Devensian glacial phase, and the overspill of Lake Lapworth which greatly extended the catchment area of the River Severn, is reflected by the formation of the Main Terrace, which appears to be a very complex feature. The two distinct levels of this terrace in the Severn valley have already been referred to, and are believed to represent the major overspill, in that M.2 does not extend beyond the Ironbridge Gorge area, while the M.1 does. In the valley of the Teme, Terraces Numbers 3 and 2 equate in height to the M.2 and M.1 stages of the Severn, but the Teme Number 3 itself appears to occur at two different levels, with a higher group at 70 - 62 feet (21.3 - 18.9 metres) O.D., and lying generally 'behind' a lower group at 60 - 50 feet (18.7 - 15.2 metres) O.D. Below these two groups is the Number 2 Terrace which, at a height range of 45 - 30 feet (13.7 - 9.1 metres) O.D., grades perfectly into the Main Terrace of Wills in the St. John's area of Worcester.

It is further of significance that the Teme Number 2 Terrace passes through the Stockton-on-Teme watershed area, while the Number 3 Terrace does not. The Number 2 Terrace here referred is an extension of Cross' Tenbury Terraces of the Tenbury Reach (8). This level must therefore post-date the overspill of Lake Woofferton which Cross has dated as late Devensian, and slightly later than the Lake Lapworth overspill of the Severn valley. It is suggested therefore, that the Main Terrace complex of the

Severn reflects the advent of Devensian ice, the Lake Lapworth overspill and the Lake Woofferton overspill, as three poorly distinguishable levels in the area downstream from Worcester. Above the Severn-Teme confluence, along the valley of the Severn, there are two Main terrace levels, while in the valley of the Teme there are three, the two higher levels relating to the changes in the Severn Valley, the third level - or the Number 2 Terrace - reflecting the overspill of Lake Woofferton. Even allowing for the relatively unresistant nature of the rocks of the lower Teme area, and for the effect of the fault line across the Malvern Axis at the Knightsford Bridge gap, it is nevertheless difficult to accept the tremendous changes which have been effected in so short a period of time - Cross' date suggests that these changes have been effected only in the last 14,000 years or so.

The Teme Number 1 Terrace equates with the Worcester Terrace of the Severn, and grades perfectly into the Lower Wick Terrace at St. John's, where Wills classified this latter terrace as Worcester level. This lowest terrace of the Teme also extends through the Stockton-on-Teme watershed area, as does the flood plain terrace.

The table, Fig. 6.6, P. 185 , summarises these proposed correlations.

From the table, it can be seen that the proposed levels of the Teme terraces correspond reasonably closely with those of the Severn and the Avon when measured above the level of the flood plain at the confluence. However, it must be remembered that these measurements cannot take into account any possible earth movements which may have occurred to cause any distortion (52, P. 125, Figs. 69 & 70, Ps. 125 & 126). It is noticeable that the objectively drawn 'best fit' lines drawn through the terraces of the height-range diagram (Fig. 4.9, P. 95) coincide reasonably well with the known heights of the Wills sequence at Worcester, and that the only terraces which would appear to be liable to such distortion would be the Bushley Green Terrace, and the Teme Number 5. This terrace is equated with the Gippingian glacial phase, when ice extended as far south as Gloucester, and it is possible that this terrace may have been subject to some degree of post-Gippingian isostatic readjustment. Other later terraces would not be so affected, since later ice advances did not reach the study area.

Table Fig. 6.6.

THE TERRACES OF THE SEVERN, AVON AND TEME

Severn, at Worcester (Wills)		Avon (Tomlinson)		Teme (Adlam)	
Woolridge	-	-	-	-	-
Bushley Green	130'	No.5	135'	No.5	145' - 125'
Kidderminster	110' - 80'	No.4	95' - 80'	No.4	110' - 80'
Main	65' - 35'	No.3	55' - 40'	No.3	70' - 50'
		No.2	40' - 30'	No.2	45' - 30'
Worcester	25' - 10'	No.1	below 10'	No.1	25' - 5'

It should also be stated that observations in the field have suggested that the Wills sequence of terraces may not be as simple as suggested. While the Kidderminster, Main and Worcester terraces are commonly clearly distinguishable in the field, the higher terraces, perhaps by nature of their greater age, are not as easily defined. Further many flat-topped surfaces in the Severn Vale area around Worcester were not recorded by Wills, yet would appear to be relict terrace features which have a considerable range of surface altitudes. Thus it may be that the Bushley Green level proposed by Wills is in fact an earlier terrace complex, possibly much more complicated in its various parts than the Main Terrace complex, related as it is to both glacial advance and retreat stages of the Gippingian period. Thus in equating the Teme Number 5 Terrace with the Bushley Green level, strong reservations must be made as to the age of the terrace in this area. It is also apparent from the diagrams of Teme terraces that the 'lines of separation' between the proposed terrace groups are often arbitrary lines, in that there is no clear separation between groups, particularly at lower levels (see Figs, 4.5 & 4.6, Ps. 88 & 90). This would suggest that the terraces sequence even at these lower levels is perhaps not as clear-cut as Wills suggested, in the context of Severn terraces. This may be simply because the tributary stream was slightly 'behind' the main trunk stream in the establishment of the various levels, in the same way that the early Severn terraces are perhaps not as clear as the higher terraces of the Avon, which was then the trunk stream.

However, these reservations having been expressed, the proposed groups of the Teme terraces do appear to conform to the terrace sequence of the Severn and the Avon, and it is seen that the Teme has existed as a tributary of the Severn-Avon system since the Bushley Green times.

Chapter Seven - A Suggested Chronological Evolution of the Teme Valley.

Having described and discussed the various landforms of the study area, we must now attempt to relate all the aspects of the area to the geological time scale, and to suggest a possible sequence of events leading to the production of the present landscape.

Brown (3) has proposed a 'Low Peneplain' surface, trimmed by the early Pleistocene Sea at about 600 feet (182.9 metres) O.D., which is preserved in the study area in the form of the Clifton Plateau. It is therefore suggested that the 'initial' surface of the area comprised such a surface, sloping gently to the east, and largely 'covering' the Malvern Hills and its associated fold and fault complex, the Malvern Axis. This structural line must, by nature of the heights of the present summits, have projected upwards through this surface in places, as a line of low hills. (see Fig. 7.1, P. 189).

Upon this surface was initiated a west-to-east drainage system, flowing more or less at right angles across the main, buried structural element of the landscape. According to Brown's dating, this situation was originated during the Pliocene, and extended as the Pleistocene sea gradually withdrew from the area.

Since this initial condition, the progressive lowerings of sea level enabled the drainage to adjust itself to the emerging Malvernian structure, and to the essentially north-to-south 'grain' of the country. Thus by the time of the Gippingian glacial advance, a trellis

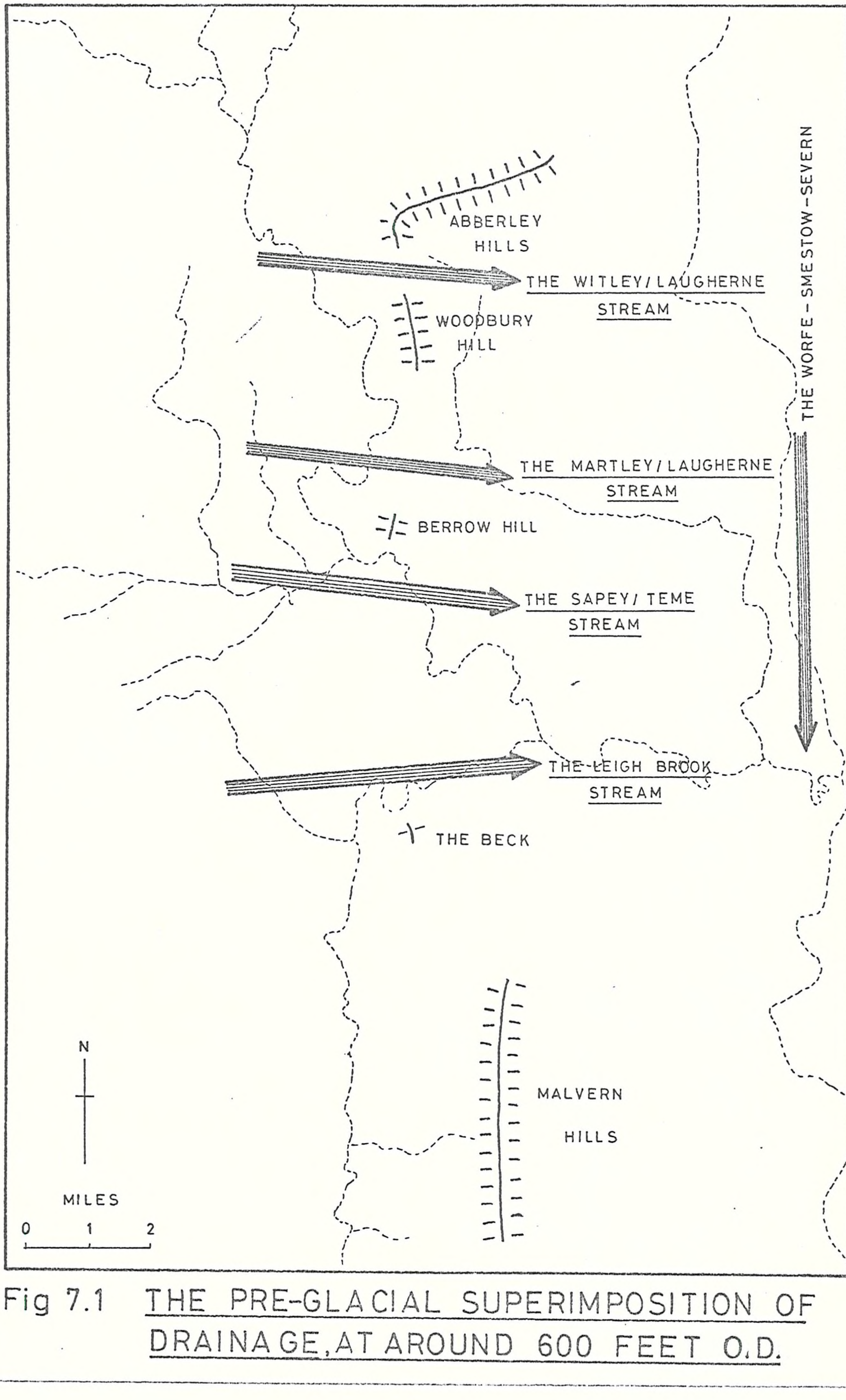


Fig 7.1 THE PRE-GLACIAL SUPERIMPOSITION OF DRAINAGE, AT AROUND 600 FEET O.D.

pattern of drainage had developed, with the Sapey-Teme and the Leigh Brook as the only surviving representatives of the original consequent drainage. (see Fig. 7.2, P. 191) These two 'master' streams had by now developed a number of subsequent tributary streams, including the Shelsley Teme, the upper part of the Sapey Brook, the Whitbourne Brook and the Cradley Brook. Of any other original consequents there is now no conclusive evidence, but merely a number of high level cols across the Malvern Axis which may represent such former stream courses.

That there are in the study area no clearly recognisable traces of a 600-feet (182.9 metres) O.D. platform or bevel may be attributed to the relatively unresistant nature of the rocks of the area, and also to the effects of later glacial and periglacial conditions, and processes.

Equally, there is no clear evidence of events of the early Pleistocene period in the study area. The materials comprising the terraces of the Kyre Brook and the isolated patches of gravels on the edge of the Clifton Plateau, may represent deposits of the Lower Pleistocene, much dissected and re-sorted, though whether these deposits may have been derived from direct glacial deposition or from fluvio-glacial outwash processes is a matter for speculation. However, it would appear that the early glacial periods had little effect upon the established drainage pattern of the study area.

During the Lowestoftian and Hoxnian periods of the Pleistocene, it seems that the main trunk stream of the West Midlands was a stream which flowed <u>east</u> of the Malverns in the present Vale of Severn area, and which

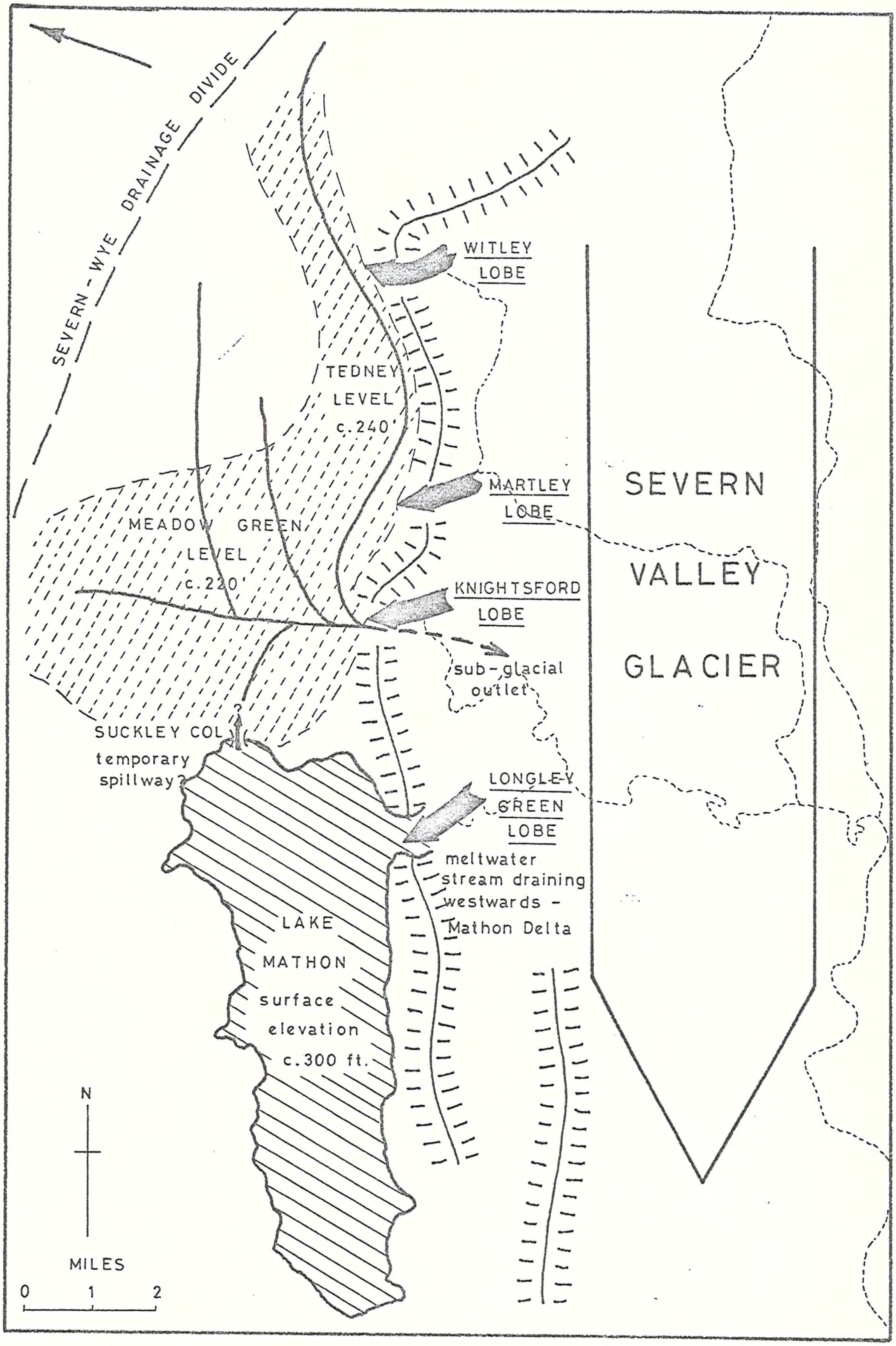


Fig 7.2 DRAINAGE FEATURES OF THE GIPPING GLACIAL PERIOD.

had the Sapey-Teme and the Leigh Brook among its right bank tributaries. This drainage was independent of both the upper Severn, which drained into the Trent at this time, and also of the Warwickshire Avon, which flowed north-eastwards away from the Bredon area, also to join the Trent system. Thus, the Lowestoftian and Hoxnian periods, though relating to the Woolridge stage of the Severn, do not appear to have altered the drainage of the area in any significant way.

The Gippingian glacial advance was apparently responsible for the formation of the Bushley Green Terrace of the Severn, but the main effect of this ice was the reversal of the Warwickshire Avon, via the Bredon gap (47, see also Fig. 3.3, P. 57), and the establishment of this river as the main trunk stream of the West Midlands, with the Severn system as a major tributary. The retreat of the ice saw the emergence of the Bushley Green Terrace complex of the Severn, and of the Avon No. 5 Terrace, but again, no significant change of drainage pattern seems to have occurred in the study area.

At its maximum extent, the ice occupied the Vale of Severn as far south as Tewkesbury and Gloucester, and must have effectively blocked any drainage routes eastwards across the Malvern Axis - as at Knightsford Bridge and Longley Green - the Lulsley col and the Longley Green 'funnel'. In the west, Welsh ice does not appear to have crossed the line of the Bromyard Downs watershed, so that between the two ice bodies there existed an apparently unglaciated area, west of the Malvern Hills. Under these conditions the Shelsley Reach of the Teme, and the Cradley Brook vale further south, were still occupied by running water. In the case of the Shelsley Teme, the outlet appears to have been retained, perhaps by nature of its height, beneath the ice 'dam' at the Lulsley col. In the case of the Leigh Brook, since the outlet at the Longley Green 'funnel' was blocked, there developed a pro-glacial lake - Lake Mathon - in which was deposited glacial outwash material in the form of the Mathon delta deposit. Further south still, another pro-glacial lake,- Lake Eastnor - was created by the temporary blocking of the course of the southwards-flowing Glynch Brook, by ice which seems to have 'rounded' the southern extremity of the Malvern Hills. (see figs. 6.3 & 7.2, Ps. 169 & 191).

The gradual waning of this virtually stagnant ice sheet resulted not in the creation of a new drainage pattern, but simply in the re-establishment of the old, at the level of the Bushley Green stage of the Severn, and with the development of the Tedney Level and the Meadow Green Level of the Shelsley Reach of the Teme, and the Mathon Level of the Leigh and Cradley Brooks. These tributary levels are thus correlated with the summit gravels in the parishes of Broadheath and Bransford, through the pre-Gippingian gaps across the Malvern Axis.

The Ipswichian interglacial saw the formation of the Kidderminster Terrace of the Severn, which equates with the Number 4 Terrace of Tomlinson, the Avon still being the main artery of the time. The Teme Number 4 Terrace is also of this age.

The onset of Devensian ice, with its accompanying lowering of sea level, caused the development of the first Main Terrace phase, the Number 3 Terrace of the Avon, and this was followed by the events of the Lake Lapworth overspill in the vicinity of Ironbridge. This great extension of the drainage area of the Severn led to its establishment as the main river of the West Midlands area, and the cutting of the second stage of the Main Terrace. The Avon Number 2 Terrace was thus cut in what had now become a tributary valley. The Lake Lapworth overspill and the cutting of the Ironbridge - Bridgnorth Gorge are both associated with a withdrawal of Devensian ice. Terraces Numbers 3 and 2 of the Teme are equated on Fig. 6.5, P.181 with the Main Terrace complex of the Severn, and the point that the Teme Number 3 Terrace itself has two distinct levels has already been made. It would appear therefore that the Teme Number 3 Terrace - which does not extend beyond the proposed Stockton-on-Teme watershed - is this valley's counterpart of the two levels of the Severn Main Terrace level. That Terrace Number 2 extends through the Stockton-on-Teme watershed area separates it from the higher level in more than height alone, although its level is still equatable with the Severn Main Terrace.

Thus a re-advance of Devensian ice, late in the period, must have caused renewed downcutting in the valleys of the Severn and Avon, but the major event of the times was probably the overspill of Lake Woofferton (8), and the great extension of the drainage area of the River Teme to something approaching its present dimensions. Thus the earlier Number 3 Terrace is found only downstream of the point of overspill, while the later Number 2 Terrace extends upstream and beyond this point, where it has been traced by Cross (8) at least as far as the Woofferton area. (see Fig. 7.3 & 7.4, Ps. 196 & 197). This immediate post-overspill period is thus the age of the Shelsley Gorge of the Teme, and also of the present gap at Knightsford Bridge, while the incision of the Leigh Brook into the 'funnel' level must be a further contemporaneous feature.

The final withdrawal of the Devensian ice from the Ludlow area has been dated by Cross as later than ∓ 14, 000 years B.P., in which time the Worcester Terrace of the Severn, and the Avon and Teme Number 1 Terraces, were cut to a lower sea level than at present. The infilling of the lower reaches of the Severn accompanied later rises in sea level, associated with the Flandrian Transgression. The Power Station Terrace of the Severn has only been positively identified in that valley, and appears to have no counterpart in either the Avon or Teme valleys - unless the buried pebble deposit sometimes to be seen in the Teme channel banks at times of exceptionally low water may be so associated.

The Devensian period did not see ice entering the study area - the Avon valley was ice-free, as was the Teme valley below the Woofferton area - but glacial margin areas such as the study area must have been subjected to periglacial conditions and processes. This is testified by the large areas of solifluction deposits identified by various authors, including Dreghorn (12), Gray (23),

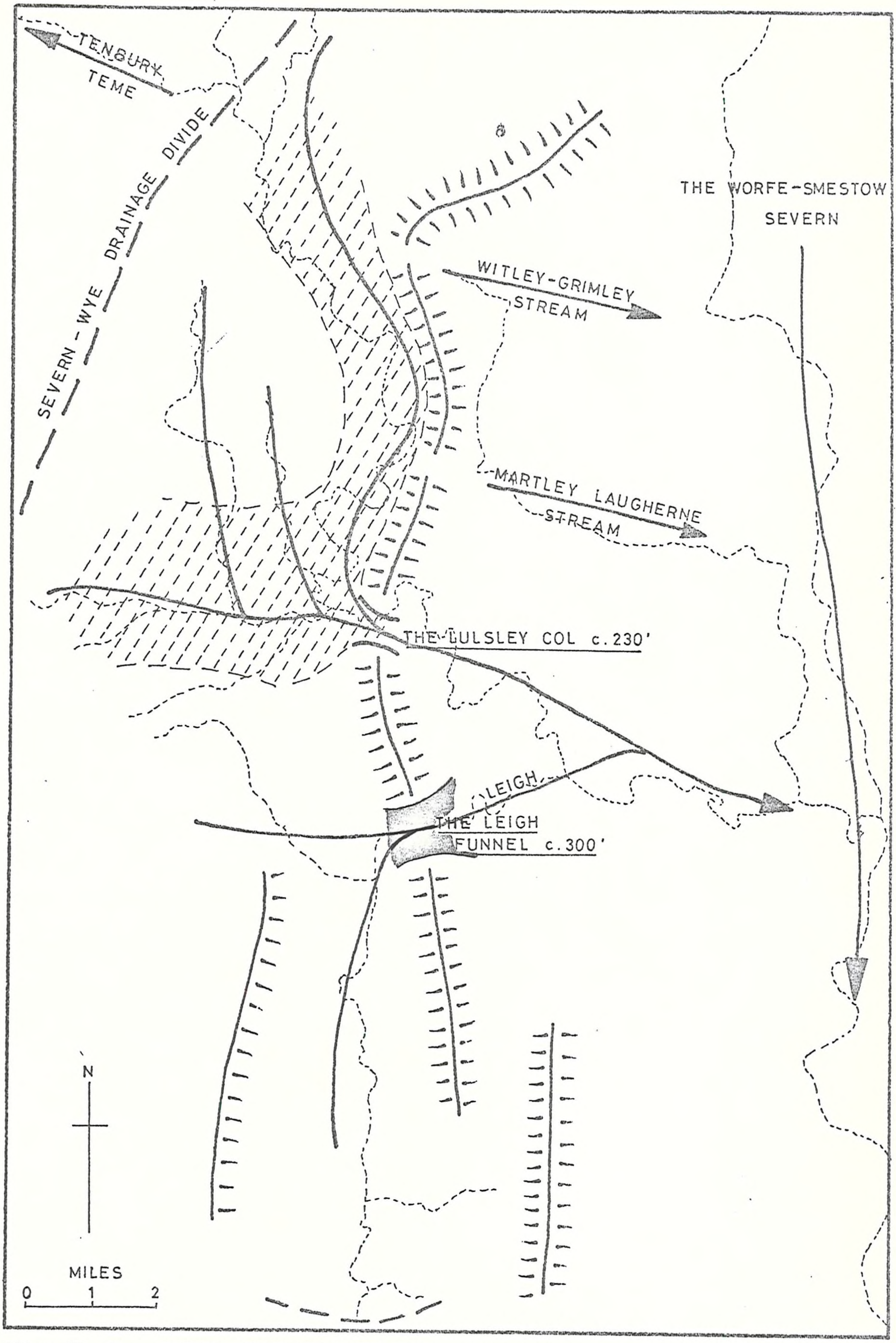


Fig 7.3 PRE-DEVENSIAN DRAINAGE LINES.

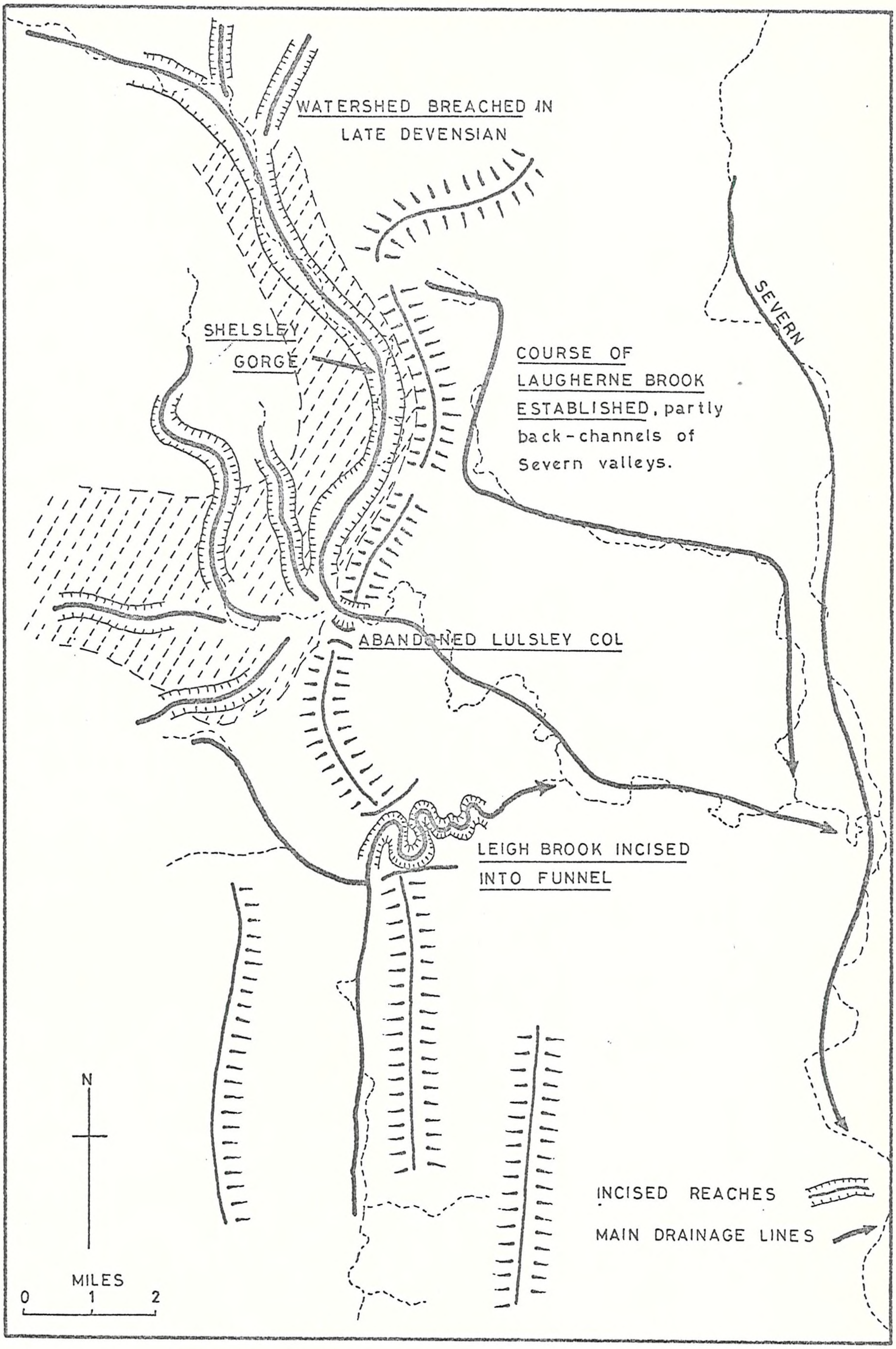


Fig 7.4 POST-DEVENSIAN DRAINAGE LINES.

Hey (31&32), Mitchell, Pocock and Taylor (39), Richardson (45&46) and Wills (63) - on either side of the Malvern structural line, and which in many areas are seen to rest upon earlier Pleistocene deposits.

Thus the present landscape of the study area is suggested as having been developed from the initial superimposition of drainage from either a Pliocene or early Pleistocene surface, which sloped generally eastwards. This present landscape still exhibits many of the features of this superimposition, but has been much modified by what appear to have been largely marginal effects of the glacial period. The only major change effected by the Pleistocene on this landscape was the incision of all streams in the study area, following the overspill of Lake Woofferton at Stockton-on-Teme, and the consequent readjustment of the Severn-Wye drainage divide.

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