SOME ASPECTS OF THE GEOMORPHOLOGY OF THREE CHILTERN WIND-GAPS

by

CHERRY ANTOINETTE GOATMAN

UNIVERSITY OF LONDON

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ABSTRACT

Although there have been many publications dealing with the general geomorphology of the Central Chilterns and Vale of Aylesbury, none has yet dealt satisfactorily with the problems of the age, origin and development of the wind-gaps and their associated superficial deposits. Three gaps, the Wendover, Tring and Dagnall, have been selected for detailed study. The morphological features have been mapped on the 6 inch scale, the soils and gravels examined, and the pattern of soil series distribution related to the landforms. The various features of the gaps have then been compared, and ~~the~~ suggestions made as to the possible evolution of the gaps.

The principal hypotheses so far put forward postulate that the gaps were initiated: - 1) by pre-glacial rivers; 2) as glacial overflow channels; 3) by marine erosion in Pliocene times; 4) by pre-glacial rivers and modified by glacial melt-water. The last of these, with amplifications, seems most in accord with the field evidence accumulated in the course of the present study. Thus a hypothesis of major south-east flowing captured Mid-Tertiary consequents is submitted for the origin of the wind-gaps at Wendover and Tring. Subsequently each gap was affected by the Calabrian marine invasion and later modified both by glacial and periglacial processes.

An early cold period on the Chilterns is suggested by the head deposits in the gaps and both drift and glacial gravels in the vicinity of the Tring Gap show that a tongue of Lowestoft Ice projected into the Vale of Aylesbury. At this stage, the gaps may have been modified by the passage of melt-water. The later Gipping Advance is represented by boulder clays to the north of the Vale, and extensive coombe deposits on its floor, and was possibly the agent responsible for the blocking and reversal of the former Ouzel-Dagnall consequent. Postglacially the drift has been all but removed and the coombe material dissected.

In conclusion, it is shown that this sequence of events is generally compatible with that established in adjacent areas.

CONTENTS

FIGURES

All heights shown in these figures are in feet above Ordnance Datum.

I. INTRODUCTION

(a) GENERAL

Of the problems of Chiltern geomorphology, the dry valleys of the scarp and dip-slope and the erosion surfaces of the latter have received considerable recent attention, and satisfactory hypotheses for their development have been submitted. The problem of the age, origin, and development of the wind-gaps, their associated superficial deposits, and their general relationship to the postulated denudation chronology for South-East England, has, however, evoked less interest of late. Apart from Small's (1958) general ideas on the breaching of chalk escarpment crests, little seems to have been added to the original theories of such workers as Davis (1895), Harmer (1907), Gregory (1914), Barrow and Green (1921), and Sherlock (1912-1924).

The term "wind-gap" is used rather indefinitely in two contexts. It is often used in a wide, purely descriptive sense, without any genetical connotations, and, as such, is usually taken to mean simply a through-valley, now dry. But according to standard geomorphological text-books, "wind-gap" is a term applied to a former water-gap through which a stream no longer flows because it has been captured or beheaded. (Lake 1949.

Thornbury 1954). In the Chilterns it is used in both senses. On occasions, the implication is solely a dry gap which conceivably could have been formed in any one of a number of ways (e.g. capture, weathering at a structurally weak point on the divide, divide retreat, breaching by ice or overspill by melt-water.). Elsewhere, it signifies an origin through stream piracy. In the following pages, the term is generally used in a purely descriptive sense until the evidence for its more restricted meaning has been fully considered.

In approaching the problem of the origin and development of the Chiltern wind-gaps it was felt that a detailed geomorphological study of certain of the major gaps would perhaps yield information which would be either in accord or discord with prevailing theories, or would possibly amplify or modify them. Thus three gaps, passing by Wendover, Tring, and Dagnall, were selected for a comparative appraisal of existing material and addition of further information where available. It seemed logical to choose the central three of the five major Chiltern wind-gaps in order to avoid the complications introduced by the Oxford region to the south-west and the Hitchin area to the north-east. In addition, these gaps presented a contrast in form, in altitude and in distribution of deposits. They had figured prominently in the early literature and also have been mapped completely by the Soil Survey. In all, an area of some twelve miles by four and a half miles was considered, bounded approximately by Wendover, Tring, Edlesborough, Cheddington and Aylesbury.

The first four chapters include a general introduction to the main features of the physical environment of the area, a review of relevant literature, a consideration of the problems thus raised, and an outline of the methods of study. In the remaining chapters, a comparative assessment is made of the information obtained in relation to each gap, and it is used to build up a tentative denudation chronology for the region. In conclusion, a few remarks are made on the possibility of correlations with geomorphological studies in adjacent areas.

(b) PHYSICAL FEATURES

The Chiltern Hills consist of a chalk cuesta, trending from south-west to north-east, with a prominent escarpment rising above the Vale of Aylesbury and a dissected dip-slope falling gently towards the London Basin (Fig. 1). The crest of the escarpment varies considerably in altitude. In the south-west, near Goring, it lies at a height of 662 feet at Nuffield. It climbs

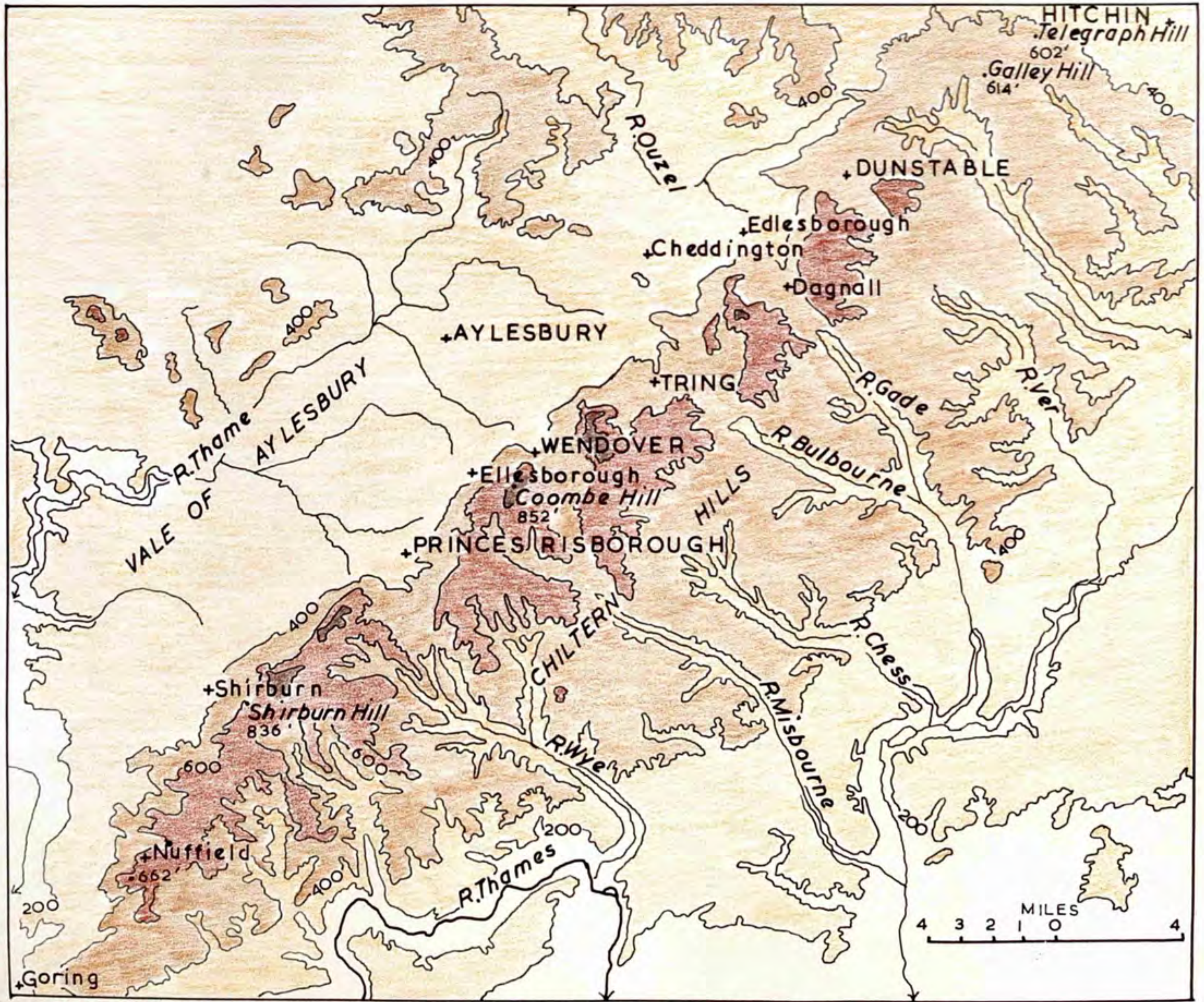


Fig. 1 CHILTERN HILLS AND VALE OF AYLESBURY - PHYSICAL FEATURES

north-eastwards to reach 836 feet at Shirburn Hill. Between Shirburn and Princes Risborough it averages about 800 feet, but between the latter and Dunstable there are several summits over 800 feet, with a maximum of 852 feet at Coombe Hill, Ellesborough. North-east of Dunstable, the escarpment loses height rapidly, with crests barely exceeding 600 feet. (Galley Hill 614 feet, Telegraph Hill 602 feet.). In contrast, the Vale of Aylesbury lies mainly below 400 feet, falling to less than 300 feet in the valleys of the south-west flowing Thame and the north flowing Ouzel.

The escarpment crest is by no means continuous along its length, but is dissected by a variety of passes. These range from shallow sags, with a vertical amplitude of less than 50 feet, high-level cols marking the heads of shallow dip-slope valleys to the more important through-valleys or wind-gaps. The five major wind-gaps between Goring and Hitchin lie at heights of 411 feet at Princes Risborough, 508 feet at Wendover, 411 feet at Tring, 436 feet at Dagnall and 500 feet at Dunstable. They trend in a north-west to south-east direction and tend to break up the Chiltern range into a number of separate blocks. Their lower reaches are occupied by the south-easterly flowing streams of the Wye, Misbourne, Bulbourne, Gade and Ver respectively.

The scarp face itself shows a variety of landforms including narrow branching coombes, finger-like spurs and amphitheatral embayments (Jukes-Browne and White 1908). At its foot is a marked bench or platform, mainly cut in the Lower Chalk, which narrows north-eastwards from a width of over a mile near the Goring Gap to a series of restricted flats between Wendover and Dunstable. The dip-slope is fretted by a system of long, sub-parallel dry valleys, often asymmetrical in cross section, which originate entirely within the dip-slope area, e.g. the Chess system. The upper parts of the cuesta preserve remnants of a summit peneplain at about 800 feet, while a bench and "back" feature can be seen on the dip-slope at approximately 600 feet.

(c) GEOLOGY

Structurally, the Chiltern cuesta is, in essence, a simple feature formed by Middle and Upper Chalk which dip gently south-eastwards at an angle of 1 - 2 degrees towards the central axis of the London Basin syncline. Significant faulting and folding are absent. The rocks beneath - the Lower Chalk, Upper Greensand and Gault, and the Jurassic - outcrop below the escarpment in the Vale of Aylesbury (Fig. 2)

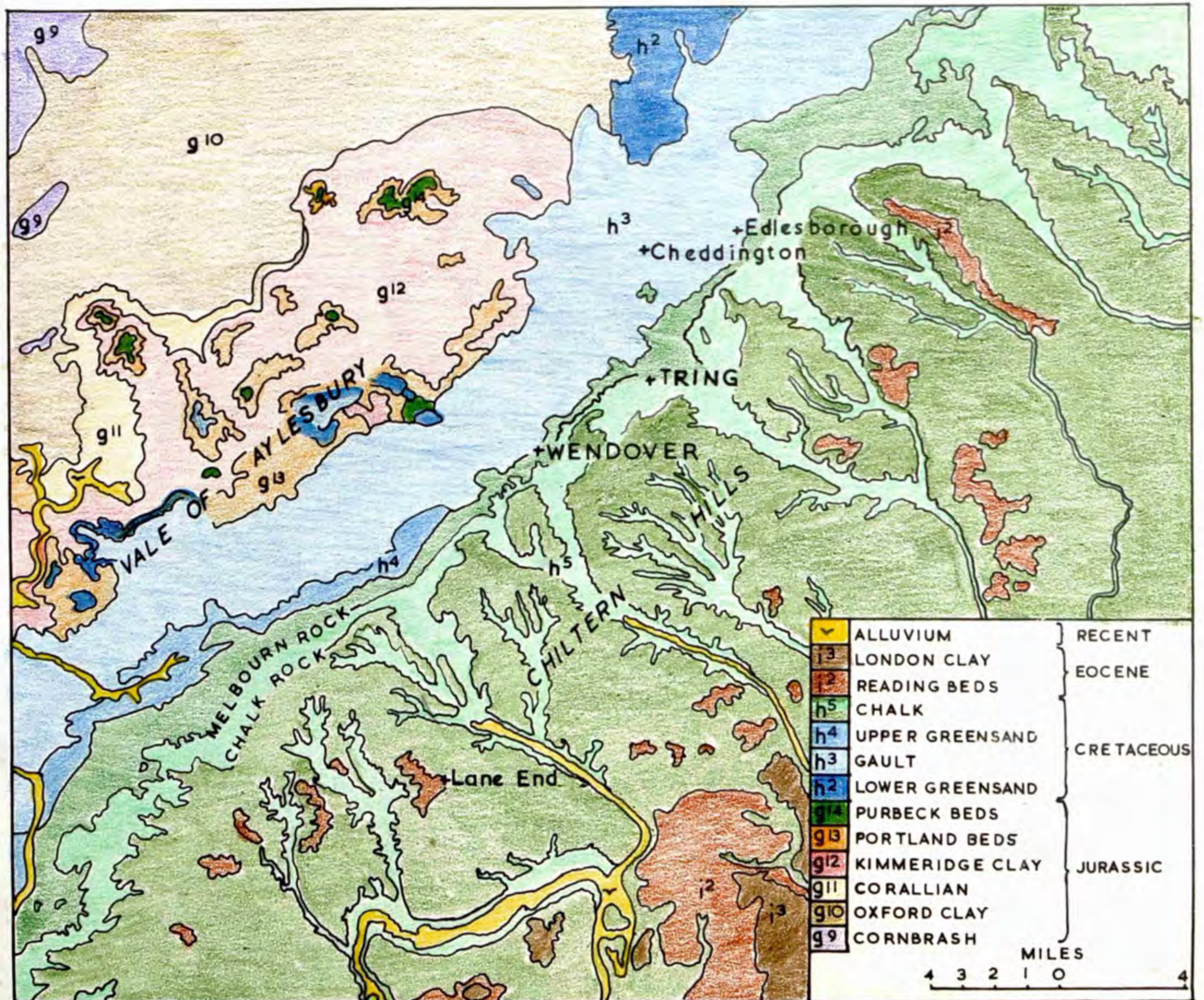


Fig.2 CHILTERN HILLS AND VALE OF AYLESBURY ~ GEOLOGY.

The following geological formations are mapped by the Geological Survey (Aylesbury Sheet, 238, 1922).

Recent and Pleistocene	Alluvium	
	Valley Gravel and Gravel opposite Chalk gaps	
	Glacial Gravel	
	Boulder Clay	
	Clay-with-Flints and associated	
	Pebbly Clay and Sand	
Eocene	London Clay	
	Reading Beds	
Cretaceous	Upper Chalk	
	Middle Chalk	
	Lower Chalk	
	Upper Greensand and Gault (Selbornian)	
	Lower Greensand (not seen at the surface)	
Jurassic	Portland Beds	round Aylesbury
	Kimmeridge Clay	

The Selbornian occupies most of the floor of the Vale of Aylesbury. In the south-west the outcrop has a width of some four miles, but broadens considerably to the north-east. For the most part it consists of stiff, dark Gault Clay passing upward into the sandy clays and malmstone of the Upper Greensand. The beds have a slight dip to the south-east and, in the vicinity of Tring, are thought to have a thickness of some 236 feet. The passage to the Lower Chalk is very gradual and the boundary is said to be recognisable only by faunal changes.

The general Chalk succession in the Chilterns is indicated in Fig. 3 . The Lower Chalk occupies a fairly continuous tract along the lower slopes of the Chilterns, apart from an outlier near Cheddington. Its outcrop varies in width from ¼ to 1¾ miles. The Totternhoe Stone horizon is, on the whole, poorly represented between Wendover and Edlesborough and is not thought, by the Geological Survey (Sherlock 1922) to make any feature at its outcrop. The Middle Chalk occupies a much larger area than the Lower Chalk, as it not only outcrops along the face of the escarpment but also in the floors of the cols and the slopes of the dry dip valleys. The Melbourn Rock, for much of its outcrop, forms or supports a shelf-like feature in the escarpment in the Middle Chalk. The escarpment is capped by a narrow fringe of Upper Chalk which outcrops again in the valleys dissecting the dip-slope. The Middle and Upper Chalk are separated by a relatively hard band - the Chalk Rock - which is often associated with a fairly marked break of

Fig. 3 THE CHALK SUCCESSION IN THE CHILTERNS

General	Zones	Thickness	Characteristics
UPPER 230 ft. (generally soft white chalk with many flints)	Micraster coranguinum	150 ft.	Soft white chalk in regular beds with layers of flints
	Micraster cortestudinarium	60 ft.	Variable series - firm white massive chalk and rough lumpy chalk. Fairly hard
	Holaster planus	20 ft.	Rough nodular lumpy chalk. Base well marked by Chalk Rock (10 ft.) hard limestone bands and beds of hard nodular chalk with a softer matrix
MIDDLE 200-220 ft. (flints rarer than Upper Chalk. Usually harder than Upper Chalk)	Terebratulina lata	140-160 ft.	Fairly soft white chalk
	Rhynchonella cuvieri	60 ft.	Tough white chalk overlying rough yellow nodular chalk. Base defined by Melbourn Rock (10 ft.)- hard, nodular chalky limestone
LOWER 180 ft. (Hard chalk passing into marly and sandy beds. No flints.)	Holaster subglobosus	80 ft.	Firm white chalk over grey gritty chalk (Plenus Marls). Local bed of rough grey chalk (3 ft.)- 'rag'. At base of zone - Totternhoe Stone (3 ft)- grey gritty stone with phosphatic nodules
	Schloenbachia varians or Chalk Marl	100 ft.	Mostly a fairly soft marl with locally two bands of 'Marl Rock' - compact grey limestone giving rise to springs

slope. In Buckinghamshire and Hertfordshire, the Chalk Rock, according to the Geological Survey, forms a more conspicuous feature than the Melbourn Rock.

The greater part of the Upper Chalk is, however, overlain by later deposits. Tertiary deposits, which were formerly more extensive, are now restricted to Eocene outliers, chiefly of Reading Beds and London Clay, on the Chiltern dip-slope, e.g. Lane End. Other more recent deposits on the dip-slope present a complex variety and have been variously interpreted (Fig. 4). Sand and shingle of early Pleistocene age (Calabrian) has been located by Wooldridge (1927) at an elevation of some 600-650 feet. Brickearth (Hull and Whitaker 1861), Pebble Gravel (Jukes-Browne and White 1908), Clay-with-Flints (as delimited by the Geological Survey) and Pebbly Clay and Sand (Sherlock 1947) have all been grouped together by Loveday (1958) under the general heading of Plateau Drift, which has a total thickness of some 30-40 feet. This drift is evidently a product of one or more of the early Pleistocene glaciations when the Chilterns possibly supported a local ice cap, according to Wooldridge (1938), and were certainly subject to the effects of periglacial climates. Loveday's terrace deposits (the Plateau Gravel of Jukes-Browne and White, 1908, and the

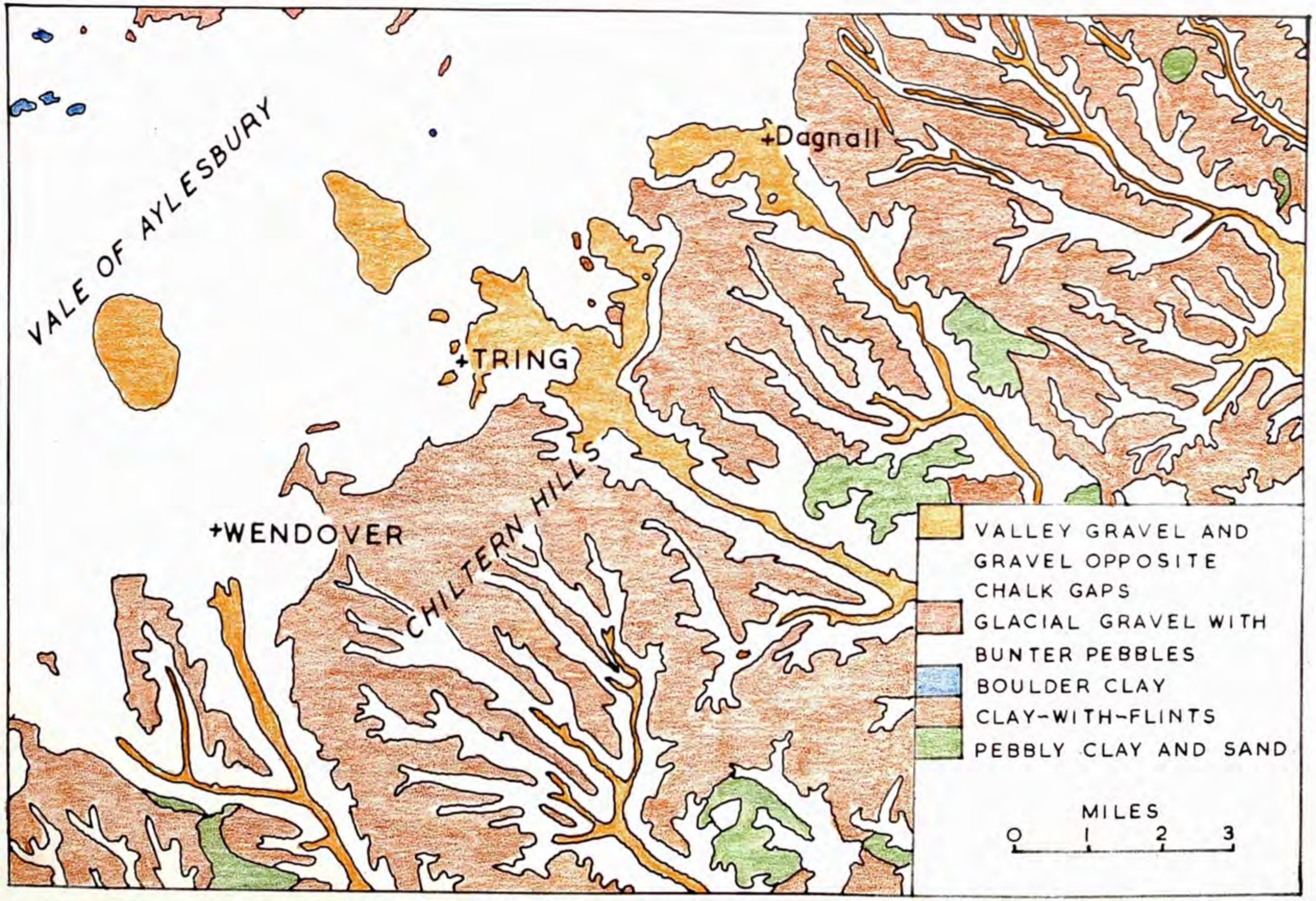


Fig. 4 CENTRAL CHILTERNS AND VALE OF AYLESBURY ~ DRIFT GEOLOGY

Glacial Gravel of the Geological Survey) generally lie below 500 feet and are younger than the Plateau Drift. They have recently been thoroughly worked over in connection with the evolution of the Thames. Patches of Glacial Gravel are also mapped by the Geological Survey on the northern margins of the Vale of Aylesbury. The Valley Gravels and Gravels opposite Chalk Gaps are thought to be head deposits resulting from solifluction during more recent Pleistocene glaciations and are intermingled with more recent hill-wash and alluvium.

(d) SOILS

The soils of the Chilterns and Vale of Aylesbury have been recently mapped, classified and described by the Soil Survey of England and Wales, and some twenty-two series (relevant to the area under consideration) have been distinguished (Fig. 5). The overall pattern of soil series distribution is basically related to geology and parent materials, but in detail it seems to show an interesting relationship to landscape form and may possibly throw some light on the physical evolution of the area.

Within the Vale of Aylesbury, there are several major soil series. North-east of Aylesbury, the Kimmeridge Clay gives rise to the Denchworth Series, a clay loam or

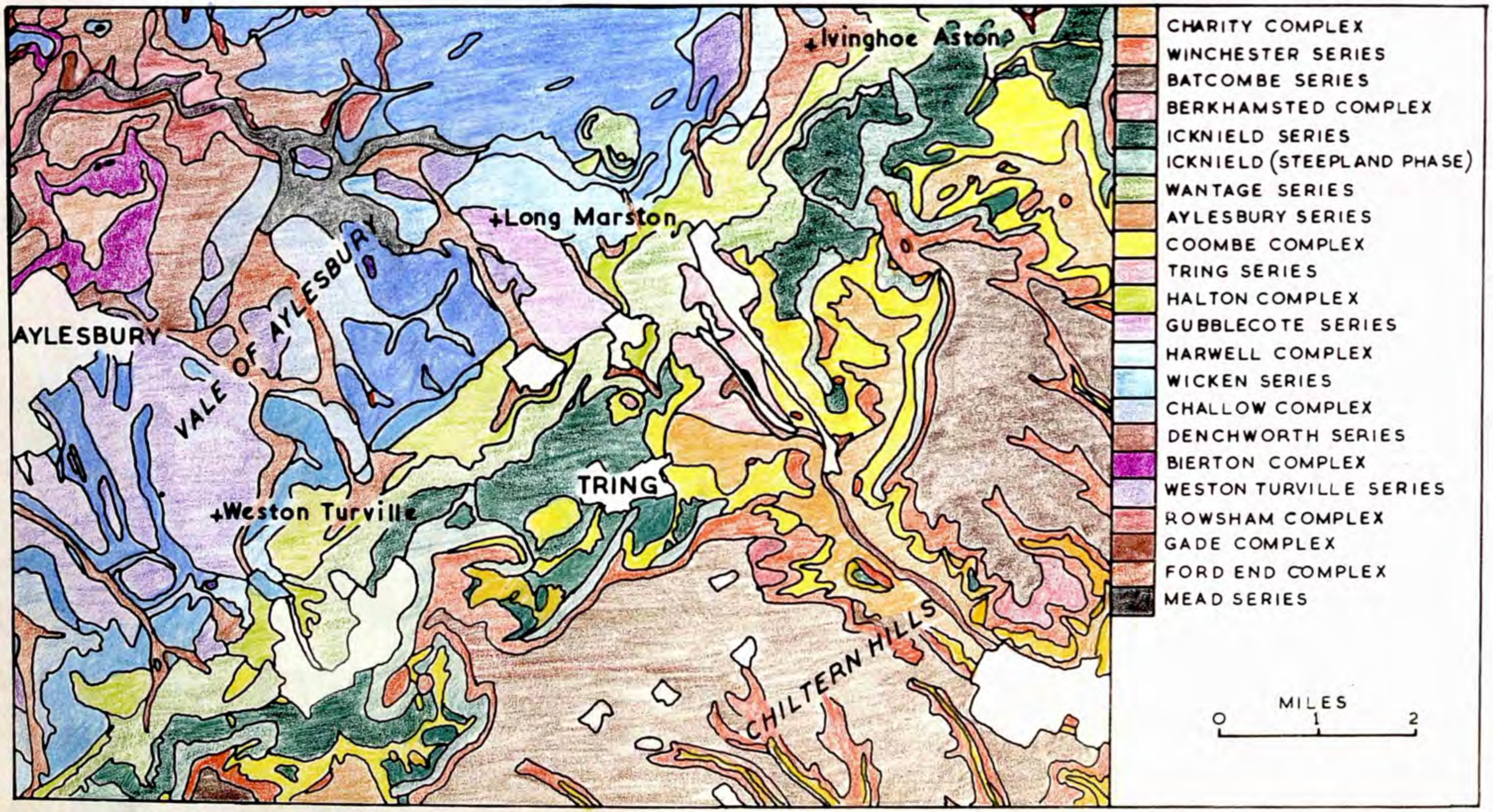


Fig.5 CENTRAL CHILTERNS AND VALE OF AYLESBURY — SOILS

clay, while the Portland Limestone bears a rendzina - the Aylesbury Series, a clay loam over a calcareous subsoil. The Bierton Complex, a fine sandy loam to silty clay loam, overlies the Portland and Upper Kimmeridge. The Wicken Series, another clay loam or clay, is predominant south and east of Aylesbury and is developed on the Gault. Both the Kimmeridge and Gault are overlain in places by superficial deposits and on the gravelly drift (the Glacial Gravels of the Geological Survey) north-east of Aylesbury the Rowsham Complex, a sandy, pebbly loam to clay loam, is found. The Challow Complex, a clay or clay loam, the Gubblecote Series, a flinty or sandy clay loam, and the Western Turville Series, a similar flinty clay loam or sandy clay loam, occupy extensive spreads north-eastwards from Weston Turville through Long Marston to Ivinghoe Aston and are formed from head deposits over Gault. The Upper Greensand gives rise to a sandy loam to silty clay loam in a narrow belt north-west of the Chalk escarpment, the Harwell Complex. The Lower Chalk, where free from superficial deposits, is covered by a rendzina - the Wantage Series, a chalky silty clay loam over a compact marl. The Halton Complex is developed on the irregular chalky, flinty head deposits on the Lower Chalk at the foot of the escarpment and is generally a flinty, clay loam or silty clay loam with a stiff, calcareous, somewhat rubbly subsoil.

Along the escarpment itself, the Icknield Series predominates. It is a very chalky friable loam, a typical rendzina. Within the gaps and on the valley slopes, the Charity and Coombe Complexes are intermingled. Both are formed on flinty head deposits but in the case of the Coombe Complex these are noticeably calcareous. The Coombe Complex also generally occurs higher up the slope. In the mouth of the Tring Gap is an isolated occurrence of the Tring Series, a flinty clay loam passing to flint and chalk rubble, which is evolved from a patch of loamy and clayey drift on the Lower Chalk.

The Chiltern summits and dip-slope are occupied by the Batcombe Series, a flinty silty loam over clay, and the Berkhamsted Complex, a pebbly loam or sandy loam over clay. Both are a product of the Plateau Drift. They are margined by the Winchester Series, a flinty or pebbly clay loam or loam over a stiff flinty clay, the true Clay - with - Flints of Hull and Whitaker (1861).

Silty loams to silty clay loams are developed on the alluvial deposits of the area. The Gade Complex, mixed alluvium over Chalk, lies in the bottom of the Gade valley, while the Ford End Complex, chalky alluvial and spring deposits over clay and marl, and the Mead Series, a clayey alluvium, margin streams and depressions in the floor of the Vale.

II A REVIEW OF LITERATURE

(a) LANDFORMS AND SUPERFICIAL DEPOSITS

Much of the geomorphological literature referring to the Chiltern wind-gaps is of a very broad and general nature, relating the formation of the gaps to the development of the drainage of the Vale of Aylesbury and the London Basin as a whole, and this work is considered here chronologically. In addition, more detailed studies on chalk landforms, e.g. dry valleys, are summarised where they are considered relevant to the physical evolution of the Central Chilterns.

Of all the Chiltern gaps, it was the Goring Gap that was the focus of a good deal of the early literature. Ramsay, for example, in 1872, postulated that the Thames was initiated on the dip-slope of a Chalk cover which extended to the north-west as far as Wales. With the retreat of the Chalk escarpment, the Thames became firmly entrenched, as seen now at Goring. Prestwich, however, in 1890, linked Goring with glaciation. He suggested a Kennet-Isis stream draining to the Wash, the connection of the Isis and Lower Thames via the Goring Gap being effected only during the Glacial period. He envisaged a "glacial current" as the mechanism responsible for the initiation of the gap which was subsequently enlarged by later glaciation. Davis's hypothesis'(1895) was essentially a modified version of Ramsay's. The drainage of South-East England was, in his view, in its second cycle of erosion. The Misbourne, Chess, Bulbourne, Gade and other Chiltern streams represented the lower parts of major consequents draining from the Midlands to the Thames; these consequents had been beheaded by the subsequent Thame and Ouse during the earlier cycle of erosion.

The work of Prestwich was attractively elaborated by Harmer in 1907. Ice was said to have blocked the Upper Thames, which formerly discharged north-east through the Fens into the Wash; the ice impounded the Upper Thames to form Lake Oxford, which discharged by overflow channels cut through the Chilterns. These are now represented by the Chiltern through-valleys.

Gregory (1914), unconvinced of the existence of Lake Oxford because of lack of evidence, inclined towards the view that the gaps were cut by pre-glacial rivers, as Davis postulated, a theory supported by the different heights of the gaps. The Triassic drift on the floor of the Goring Gap showed, according to Gregory, that it had been cut below 300 feet in preglacial times, and thus a lake could not have existed at the height of 700 feet necessary to cut the Hampden Gap. Gregory did concede the possible existence of a lake at 540 feet O.D. but this would explain only the deepening and not the origin of the gaps.

In 1919 and 1921, Barrow and Green examined the gravel deposits opposite and within the wind-gaps, particularly the Tring and Wendover Gaps, and found them to consist of fragments of chalk, angular flint chips, Tertiary pebbles, quartz pebbles, sarsen pebbles and greensand-ironstone fragments. Much of this material must have come from the Chalk escarpment, but some seemed to have originated in the Lower Greensand to the north. Barrow and Green interpreted this fact and the great coombes in the escarpment as resulting from marine action in preglacial, possibly Pliocene, times. They concluded that the Chiltern gaps themselves were caused, or at least commenced, by marine erosion in the Pliocene sea. The deep channels trenching the escarpment, e.g. near Tring, were attributed to water from melting ice-caps on the Chilterns, while the ledges cut in the hillside at 700 feet or so, e.g. near Aldbury (Grid Ref. 967 125), were regarded as unilateral channels and ice-marginal features.

Notable contributions on the geomorphology of the area were proffered by Sherlock in 1922, 1924 and again in 1947. He too examined the relationship between the valley gravels and the wind-gaps, and found that the gravels, local in composition, spread out in a fan - like manner in front of the escarpment. It was difficult to envisage these gravels being laid down under present topographical conditions and so Sherlock concluded that a mass of stagnant ice must have occupied the Vale of Aylesbury, the gravels being formed by streams pouring down the escarpment on one side and from melting ice on the other. Sherlock also refuted the ideas of a pre-glacial age for the wind-gaps. The absence of far-travelled stones in the Chiltern gaps showed, according to Sherlock, that the ice did not enter the gaps themselves. If the gaps had existed at the period of ice advance, the ice which deposited erratics at 462 feet on Southend Hill (Grid Ref. 920 165) in the Vale of Aylesbury would have reached the Tring Gap at 400 feet, the Dagnall Gap, 440 feet, and possibly the Wendover Gap at 500 feet. Thus Sherlock thought that the gaps were cut during the retreat of a Midland ice-sheet at some stage in the

Pleistocene by waters from a high-level lake, about 600 feet, held up between the receding ice-front and the Chiltern barrier, in essence the "Lake Oxford" theory of Harmer. He met Gregory's objection by showing that the actual heights of the two arms of the Hampden Gap were 625 and 617 feet respectively, so that the lake need not have been more than 630 feet O.D. He also pointed out that as the Hampden Gaps were less marked than the others between Goring and Hitchin and contained no gravel, they might conceivably have had a different mode of origin. Confirmatory evidence as to the proximity of an ice-sheet was demonstrated by the unusual series of abrupt, flat-floored valleys of constant width trenching the escarpment, e.g. Incombe Hole (Figs. 6 ,7 ,8.), which were interpreted both as marginal channels and as melt-water channels, their differing altitudes representing different stages in the retreat of the ice, though exactly what Sherlock meant is not wholly clear. In 1922, for example, Sherlock stated, (Page 50).

"Along the escarpment there are some remarkable features resembling glacially cut channels....

They seem to have been marginal channels, cut

Fig. 6. Course of Incombe Hole - upper part.

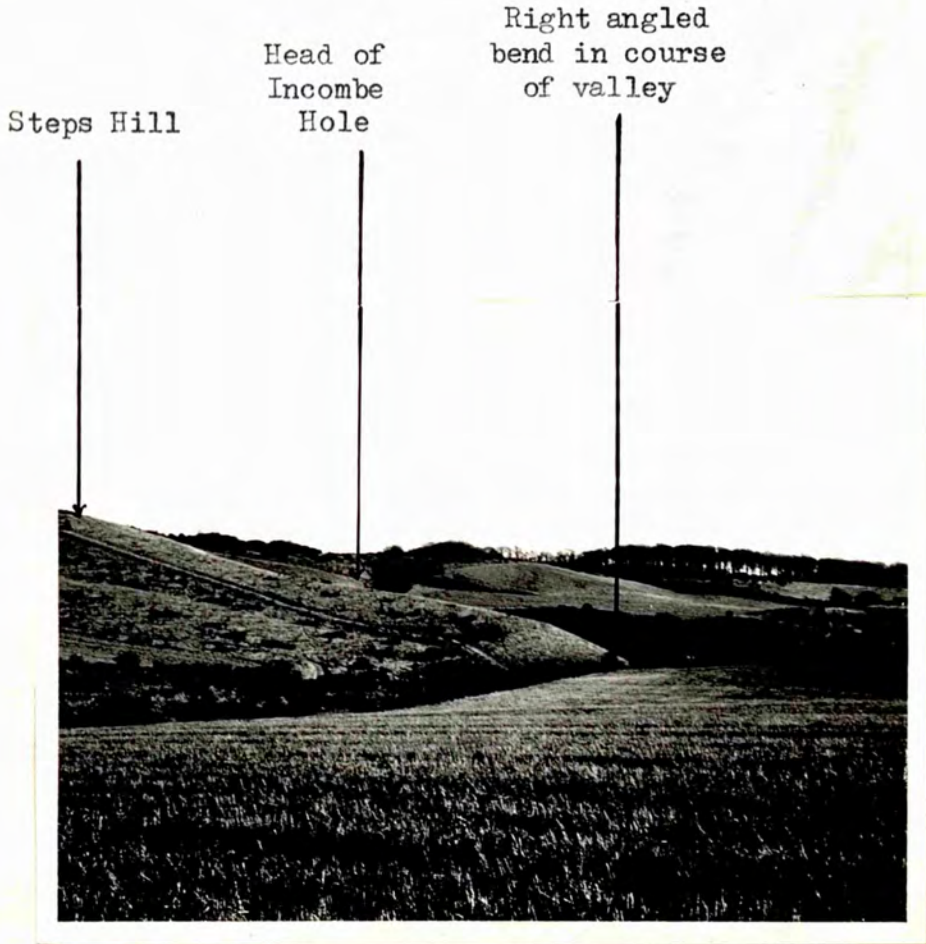


Fig. 7. Course of Incombe Hole - lower part.

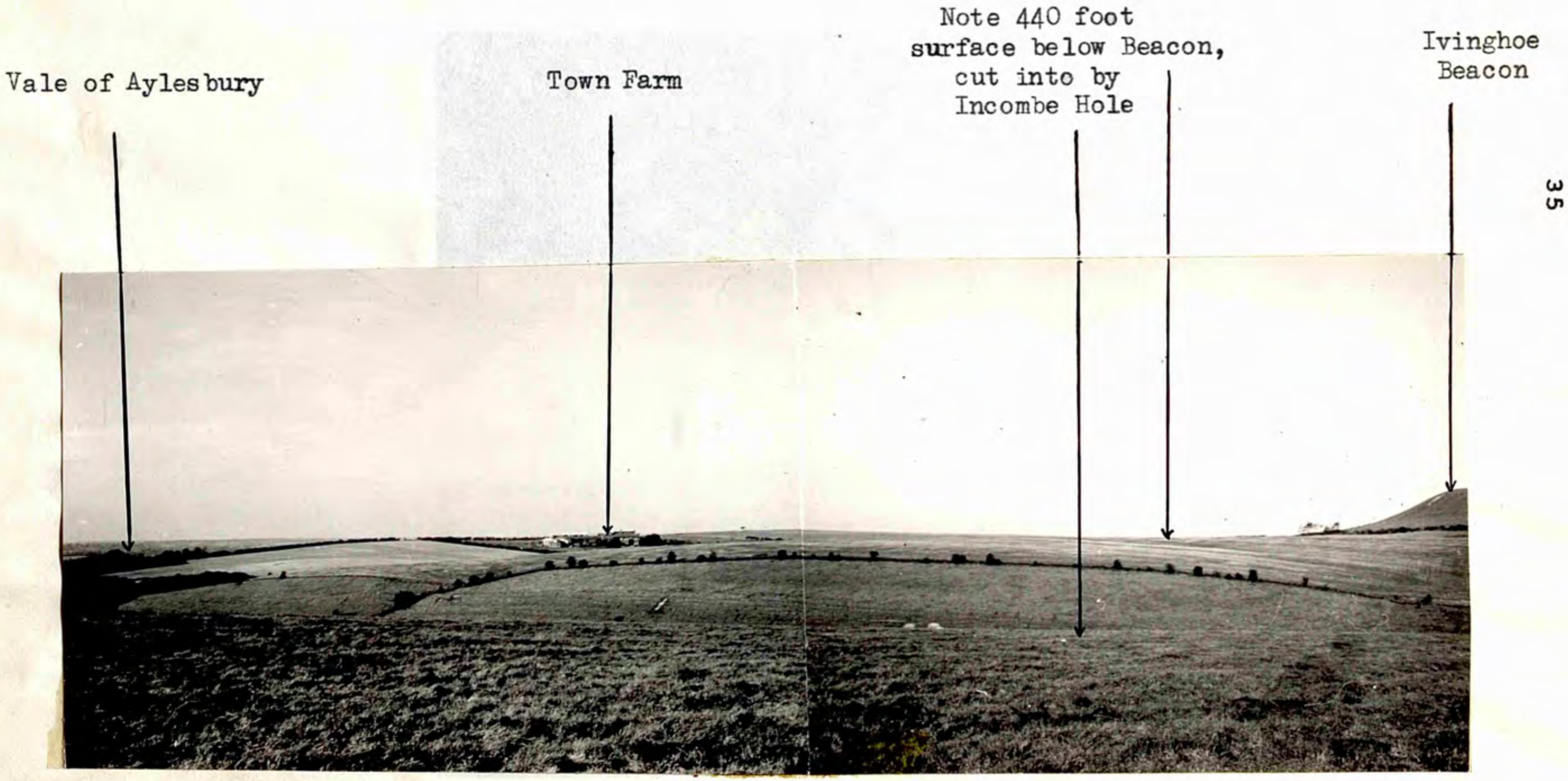
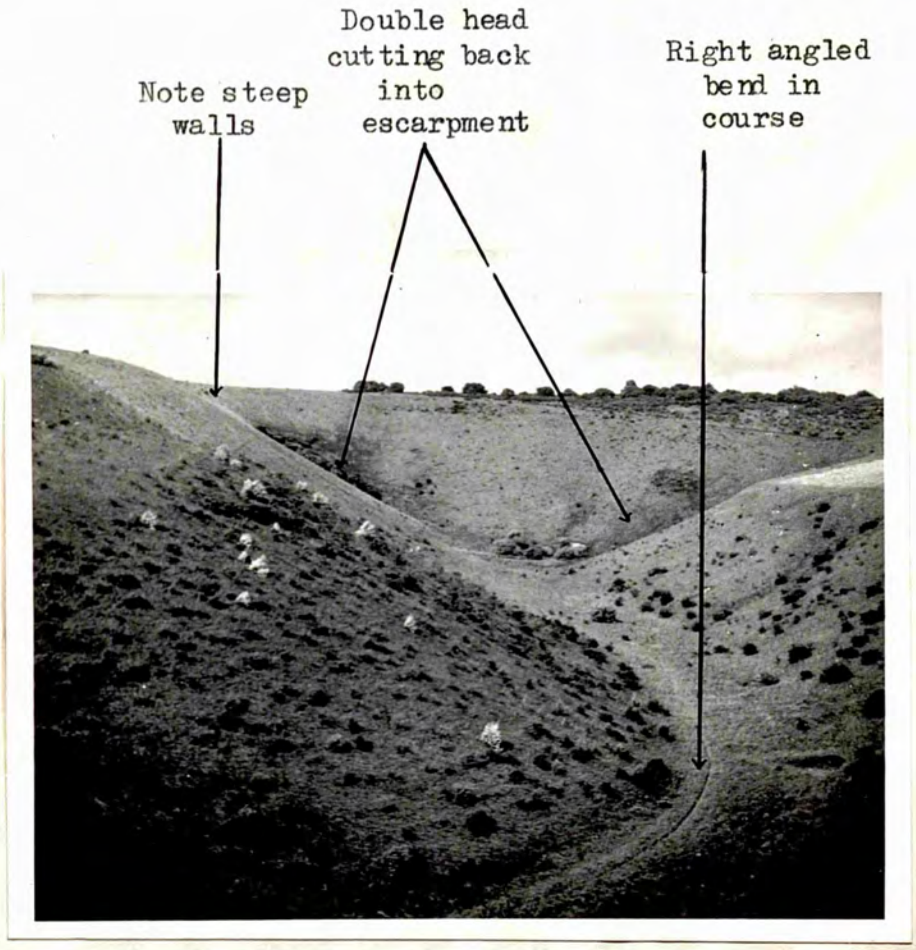


Fig. 8. Head of Incombe Hole.



partly in frozen chalk and partly in ice....

It is highly probable that the Chiltern Hills held up an ice-sheet......It is likely that, on the retreat of the ice, channels would be cut in the chalk scarp by the water produced by the melting ice and snow....."

In 1935, he referred to these features again (Page 53) as "cut out of the chalk by the melt-waters from the plateau".

Hawkins, in 1923, went even further along these lines. He suggested that the outlines of the Goring Gap had been shaped both by a tongue of ice and melt-water from a glacial lake but produced no very convincing evidence for this. He also mapped three stages in the retreat of this assumed ice mass (Fig. 9). He felt there were sufficient grounds for mapping the ice, at its farthest extent, as penetrating to the watershed of the Wendover Gap and to Berkhamstead in the Tring Gap. The second stage was thought almost to have reached the Wendover watershed and as far as Northchurch in the Tring Gap. The third and final stage was limited to areas below the 300 foot contour.

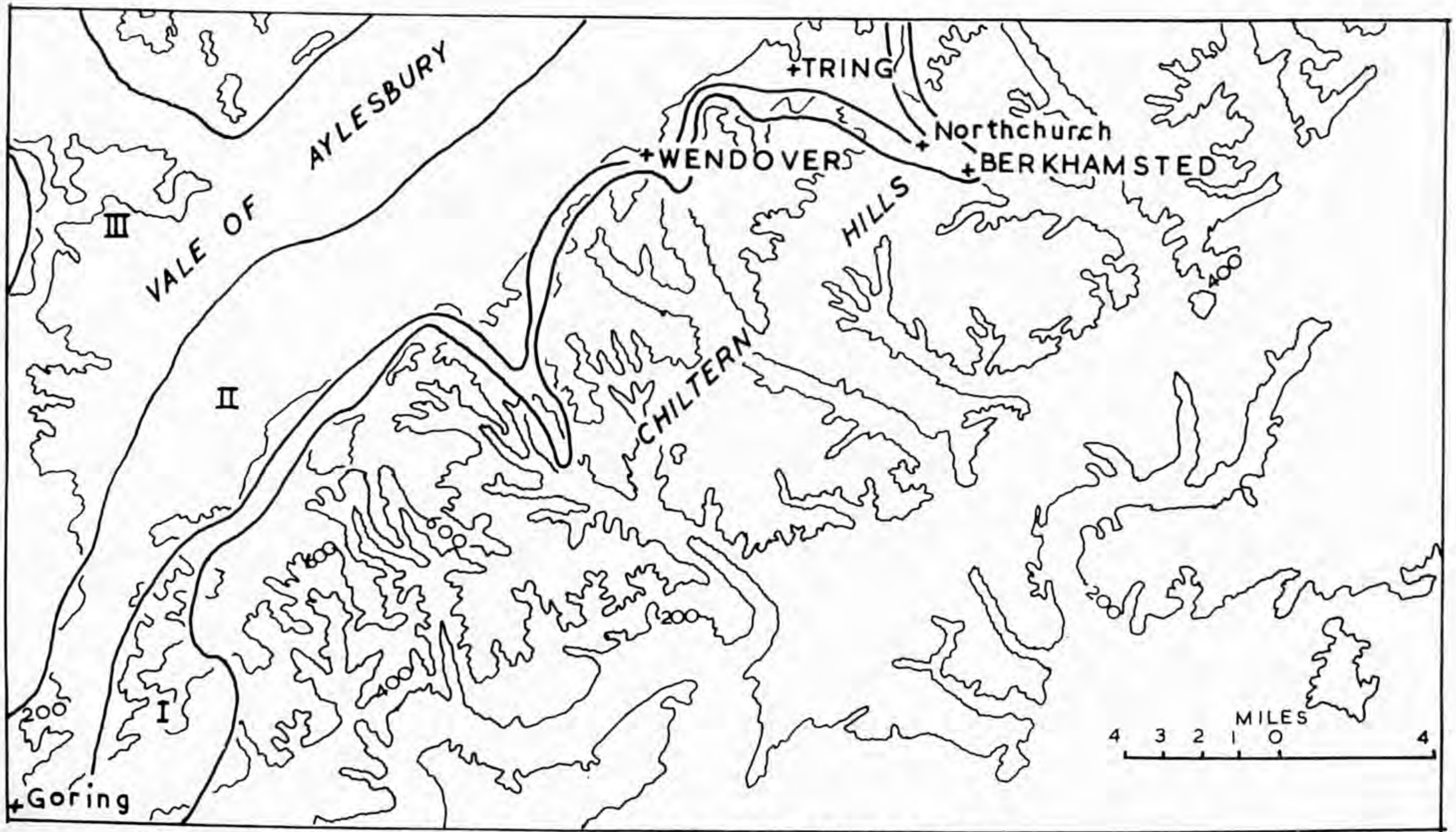


Fig. 9 CHILTERN HILLS AND VALE OF AYLESBURY
ICE RETREAT STAGES AFTER HAWKINS.

However, the absence of any satisfactory drift-deposits in the Vale of Aylesbury caused later workers to reject these theories. Earle, for example, in 1928, reverted to the idea of the gaps representing former consequent streams beheaded by subsequents working back along the soft Gault Clay. Oakley, 1936, felt that the Aylesbury gravels could equally well be explained as solifluction deposits as lake or outwash gravels and this indicated to him a pre-Pleistocene age for the gaps. Yet the Central Chiltern gaps could not have existed in precisely their present form at the onset of glaciation or Bunter material would have been introduced through them into the London Basin as it was through the Goring and Hitchin Gaps. Thus Oakley concluded that the gaps were probably intiated in pre-glacial times and were enlarged and deepened by glacial melt-water. He also felt that the absence of outwash material at the debouchment of the coombes onto the plain, and the anomalous right angled bends in the channel courses made the glacial origin of the scarp valleys suspect. The sapping back of springs in jointed chalk seemed a more likely origin.

Later detailed work on the Pleistocene deposits overlying the Chalk at Pitstone, near the mouth of the Tring Gap, in 1952, led Evans and Oakley to distinguish three kinds of solifluction material. The earliest deposit consisted of mainly flint-free broken chalk from the adjacent escarpment. A later solifluction of stratified deposits of chalk-powder and chalky gravel was suggestive of a flooded area, possibly the margin of a lake held up by the Vale of Aylesbury glacier. Still later, there was brought into the area a thin bed of flinty clay which was itself subjected to arctic temperatures leading to festooning and the formation of frost polygons.

A most significant contribution to the elucidation of the geomorphological history of the Chilterns in its context of the denudation chronology of South-East England as a whole was made by Wooldridge, particularly, and Linton at various intervals between 1938 and 1955. They recognised that the oldest feature in the Chiltern landscape was the summit plain, the Mio-Pliocene or Mid-Tertiary peneplain at an elevation of approximately 800 feet, which owed its preservation to the permeability of the chalk uplands. This episode in the erosional history of the area was succeeded by the incursion of the Pliocene (Calabrian) sea which all but submerged the Mid-Tertiary landscape, relicts of which invasion were now seen in a 600 foot platform with its shingle deposits on the Chiltern dip-slope. The main consequents of the area must have entered the Pliocene sea, and on the emergence of its floor must have extended themselves across it to join the pre-glacial Thames which, superimposed from Pliocene deposits, was flowing north-eastwards from Goring along the foot of the Chiltern dip-slope. Evidence of the lateral tributaries of these main consequents was found, by Wooldridge, in the Chiltern crest region. These so cut back into the interfluves as to reduce them to narrow crests flanked by coombes running south-west and north-east, e.g. near Ivinghoe and Wendover. On the seaward side of the Pliocene coast, such tributaries were seen to be absent, the dip-slope being scored by a number of independent, sub-parallel dry valleys. These were explained as representing a new series of consequents arising on the emergent sea-floor and heading near the old coast line. (Fig.10).

Much of the remaining work of Wooldridge and Linton in the area north of the Thames was concerned with

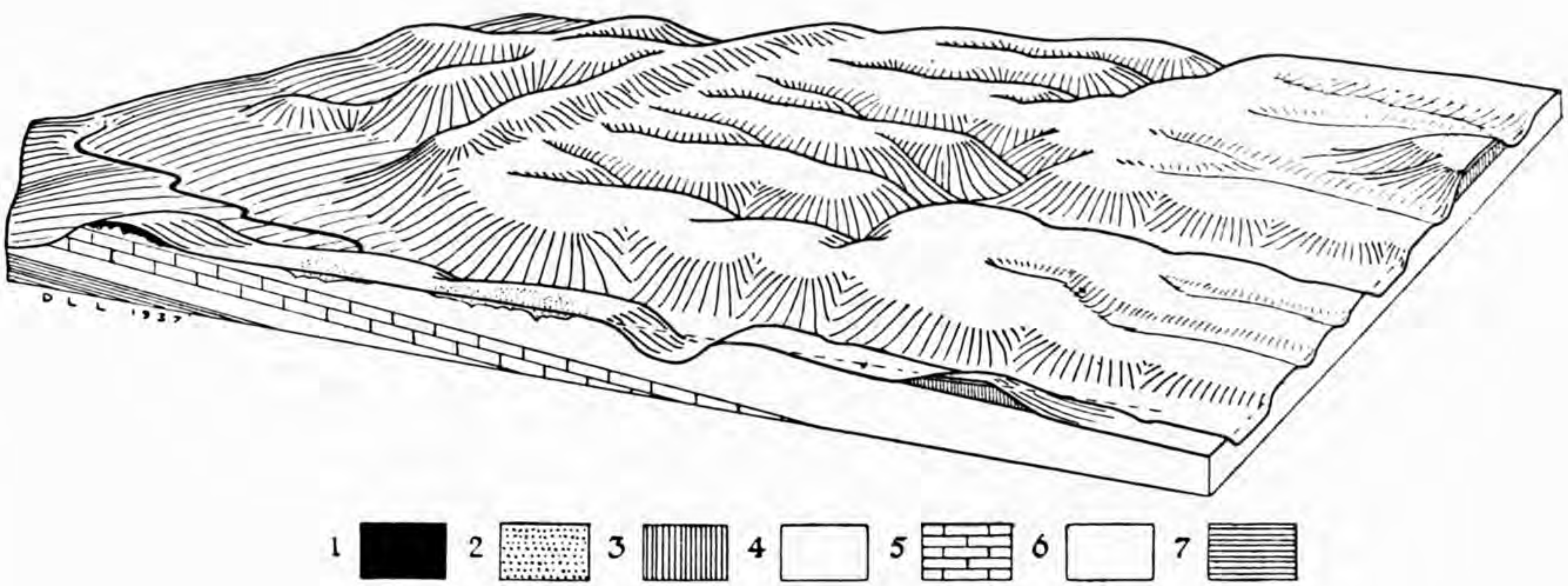


Fig. 10 The three facets of a fully developed chalk cuesta: Mio-Pliocene land surface; Pliocene marine bench; and exhumed sub-Eocene plane. 1. Residual Clay with Flints. 2. Pliocene marine deposits. 3. Eocene clay and sand. 4. Upper Chalk. 5. Middle Chalk. 6. Lower Chalk. 7. Gault clay. Approximate dimensions of block: 8 × 16 miles. (after Wooldridge and Linton)

the disentanglement of the drifts of the London Basin and the former courses of the Thames, and only indirectly with the Chilterns and the Vale of Aylesbury. From its course along the foot of the Chiltern dip-slope (traced by means of Pebble Gravel deposits at 400 feet) the Thames was diverted by Chiltern Ice (Fig. 78). Evidence for such an ice-cap was found in a drift-belt on the Chiltern dip-slope, e.g. around Amersham. The Pebble Gravel phase was succeeded by the Higher Gravel Train when the Thames overspilled through the Watford gaps, probably continuing through the Finchley Depression, and finally abandoning them in the inter-glacial Lower Gravel Train phase for the Finchley Depression. The Great Eastern Glaciation blocked both the proto-Thames successor in the Vale of St. Albans (which had by this time cut back and recaptured much of its former drainage) and the Thames itself in the Finchley Depression, in both cases reversing the drainage direction and initiatine the Lower Colne and Brent respectively. The later history of the Thames was one of successive rejuvenations, accompanied by uniclinal shifting, the Winter Hill stage (Eastern Glaciation) being followed by the Black Park, Boyn Hill, Lynch Hill, Taplow and Flood Plain stages.

This work was followed up with reference to the Chilterns in 1956 by Culling when the idea of glacial overflow was revived with respect to the wind-gaps. Culling demonstrated the multicyclic nature of the longitudinal profiles of the Chiltern streams and constructed a denudation chronology (by means of the extrapolation of fitted logarithmic curves) which was comparable up to, and including, the Winter Hill stage with that derived from morphological studies of the Thames terraces. Above this recognisable forms of the earlier stages were not represented in the profiles. This deformation above the Winter Hill in each Chiltern valley could not be coincidence, argued Culling, and the most conservative hypothesis that covered all the field evidence would be to attribute it to some climatic change. Winter Hill times and immediately prior were known to be ones of critical drainage changes in the Vale of St. Albans, and during the climatic deterioration consequent on the advance of the Eastern Ice, the stream profiles were modified. The through-valleys, Culling postulated, functioned as glacial overflow channels for the Vale of Aylesbury and their profiles were disturbed by the passage of the overflow water and outwash. In the cases of valleys whose heads did not breach the escarpment, periglacial and glacial action was less severe, though their very steepness prohibited the development of an informative profile.

Several more specialised theories have been put forward to explain the dry valley systems of both the scarp and dip-slopes and the more detailed landforms of chalk escarpments, especially in relationship to the development of chalk cuestas as a whole. Reid, for example, in 1887, and later White, (1924), felt that the dip-slope valleys of the South Downs were a result of deep freezing of the Chalk during cold conditions, which rendered it impermeable, and scouring out by violent and transitory torrents during the warmer summers, thus producing the great masses of Coombe Rock on the coastal plains. Jukes-Browne (1904), however, considered that the main valley systems of the Chalk areas were established on an impermeable cover of Eocene and Clay-with-Flints long before the Pleistocene. Chandler, in 1909, postulated that the wind-gaps represented streams beheaded by strike valleys along the Gault Clay, and that the development of the latter and allied retreat of the Chalk escarpment were accompanied by a lowering of the water-table, causing progressive desiccation of the dip-slope valleys. Chandler's theories were amplified by Fagg in 1923. The height of the Gault outcrop determined that of the

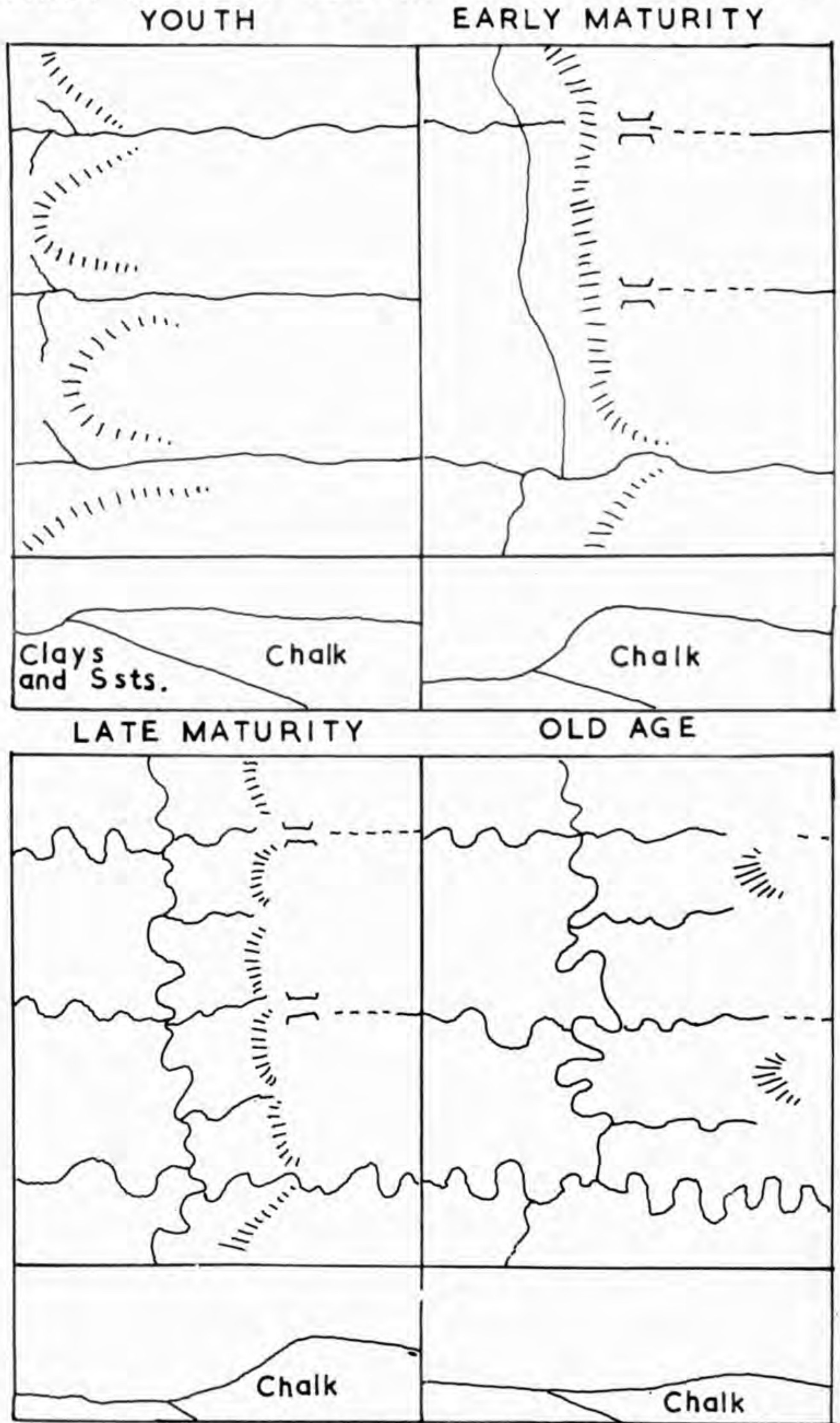
Chalk water-table and as the Gault was lowered and the scarp face driven back, so the water-table in the Chalk fell. Thus it was not necessary to involve a decrease in rainfall to explain the drying up of the Chalk valleys. He exemplified this by reference to the North Downs. In 1954, Fagg suggested that the present Chalk escarpments represented the sides of old Chalk valleys. The retreat of the escarpment had transformed dip-slope into escarpment features.

Bull likewise, in 1936 and 1940, laid particular emphasis on the Downs, attributing the dip-slope drainage to pre-glacial superimposition from an Eocene cover with modifications under cold conditions, and the scarp coombes and gullies to nivation and melt-water action in glacial times. He rejected Fagg's hypothesis on the general grounds that subaerial erosion could not cause such an exact recession of the escarpment that a narrow strip of ground would be left in each case between the head of the dry valley and the recessed escarpment. Higginbottom (1947) favoured Bull's melt-water ideas, and also submitted some general notions on the rate of escarpment retreat in relation to the down-cutting of the dip-slope. He concluded that the escarpment face must recede at least 23 times faster than the streams on the dip-slope cut down their beds. Small (1958) raised this figure to 35 times and suggested further that, as downcutting would be related to an intermittently falling base-level since the Pliocene, stillstands would be represented by dip-slope stagnation and scarp-foot terrace formation.

Sparks (1949) argued for a pre-glacial origin for the dip-slope valleys and found the melt-water hypothesis unnecessary. He related the South Downs valleys to successively emerging marine abrasion platforms and attributed their desiccation to an acceleration in the recent fall in base-level. Arkell, (1947), on the other hand, wanted a post glacial age, at least for the escarpment dry valleys, and invoked spring sapping as the mechanism responsible. Lewis, (1949), and Lewis and Sparks, (1958), elaborated this latter idea with particular reference to the Pegsdon and adjacent valleys of Hertfordshire. He abandoned the idea of the lowering of the water-table through rapid scarp-retreat because of the dry valleys on the scarp slope slope which, he felt, were youthful features cut since the scarp reached its present stage of recession. Because of their short, steep-sided, blunt-ended, flat-floored nature and rectangular pattern, Lewis postulated an origin of spring-sapping along joints when rainfall was greater and the water-table at a higher level (e.g. during the last glacial or post-glacial periods). They must have existed at least as early as late glacial times because of their infill of Coombe Rock, though were probably modified in the post-glacial phases. Pinchemel (1954) synthesised many of these arguments. He favoured a pre-glacial origin (by superimposition from an impermeable cover) with Pleistocene modifications for the dip-slope valleys, both nivation and spring action for the scarp forms, and desiccation both through lowering of the Gault and lowering of the water-table from within the Chalk by continual incision of the main valleys.

Small (1958) dealt with the evolution of chalk cuestas as a whole and submitted a very convincing hypothesis covering most of the current problems of Chalk landscapes. In essence, he suggested that the Chalk cuestas of England were in the youthful stage of the second cycle of development. In the youthful stage of the first cycle, (Fig. 11(a).), the drainage system of a chalk area would be characterised by a number of major consequents, capture by subsequent strike streams, fairly rapid scarp retreat with little penetration

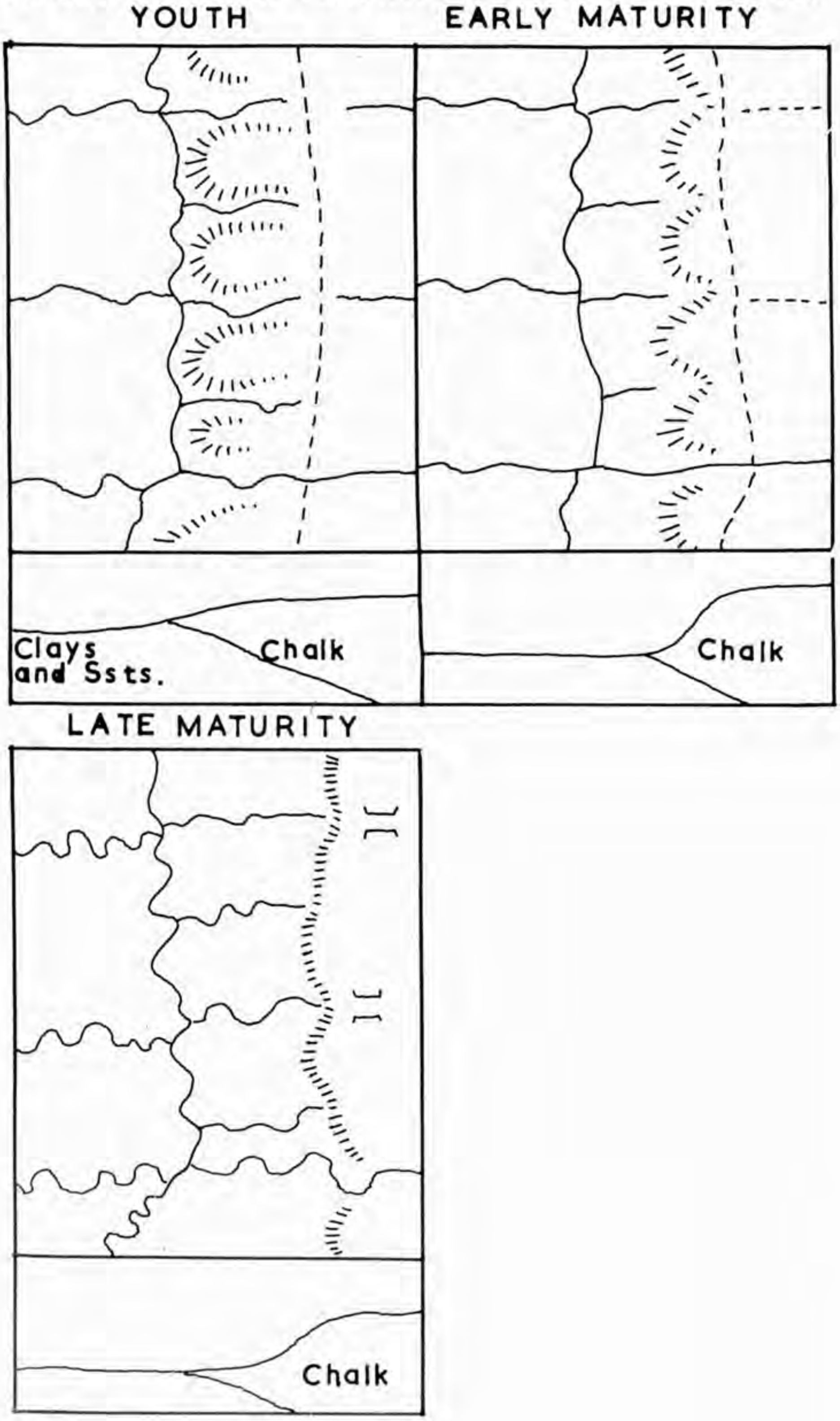
Fig.11(a) FIRST CYCLE OF ESCARPMENT DEVELOPMENT



EVOLUTION OF A CHALK CUESTA – AFTER SMALL by scarp foot springs. The mature stage would be represented by approach to base-level, the optimum development of the escarpment because of its arrested dissection, its backwearing by strike streams and springs, and the formation of piedmont slopes at the scarp foot and in the main valleys. In old age, the landscape would become part of a peneplain surface. This cycle might be interrupted by a fall in base-level and the initiation of a second cycle (Fig. 11(b).). In this case, the youthful stage would be characterised by incision of streams into the peneplain surface and rapid scarp retreat, which would constantly overtake the dip-slope strike valleys. The mature and old age stages would be essentially similar to their counterparts in the first cycle.

The most recent additions to the foregoing have been from Dury (1960) and Brown (1960). Dury, because of their regional distribution, attributed both misfit streams and dry valleys solely to climatic changes associated with precipitation and runoff regimes. Brown made a detailed examination of the head deposits at the mouths of the coombes at Brook, near Wye in Kent, and concluded that they were largely a result of sludging during late glacial times. The dry valleys

Fig.11(b) SECOND CYCLE OF ESCARPMENT DEVELOPMENT



and coombes, therefore seemed to him to be more likely due to periglacial activity than spring-sapping.

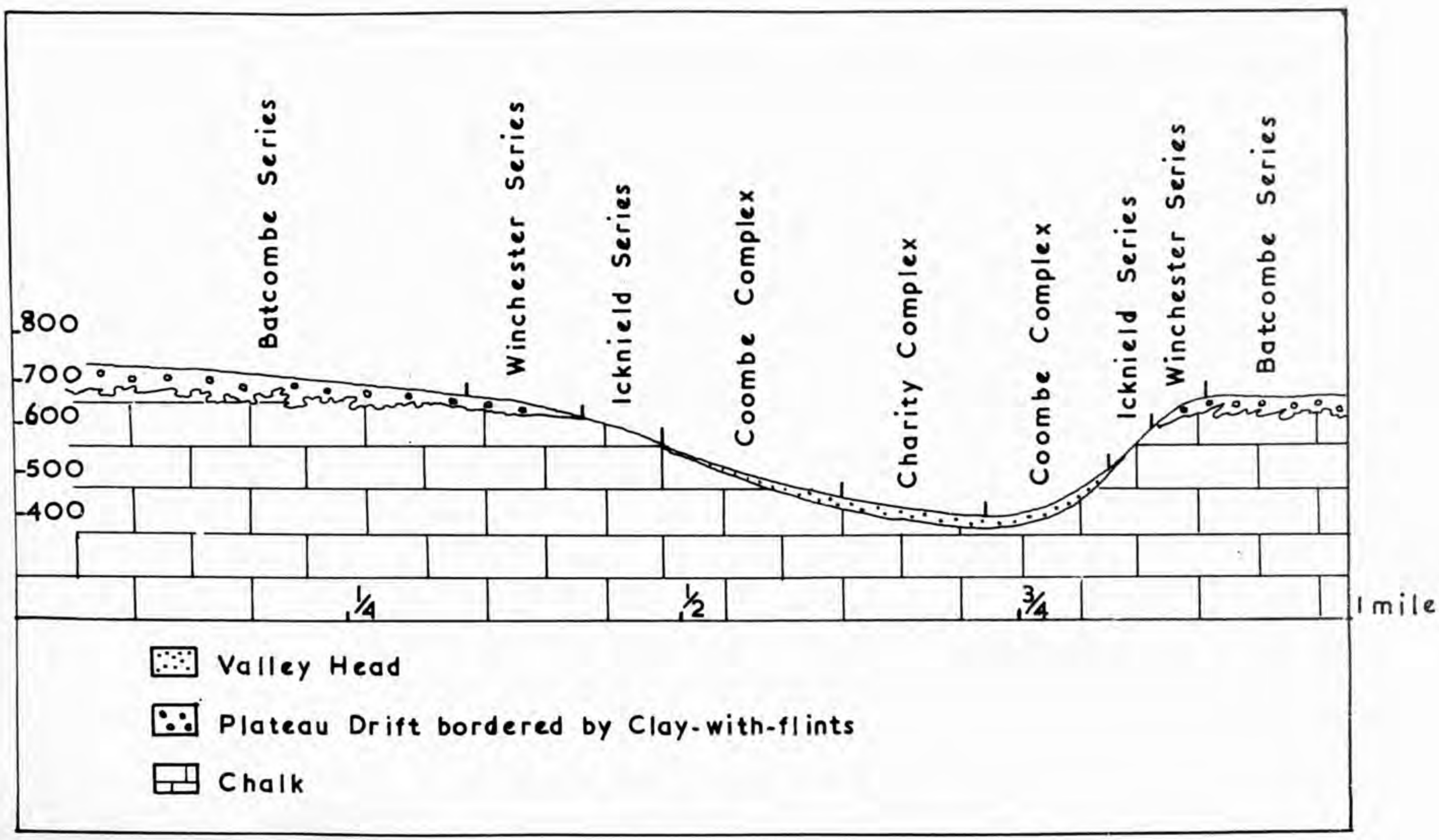
(b) SOILS.

A preliminary survey of the soils of the Chilterns and Vale of Aylesbury for the 1-inch to 1-mile Aylesbury and Hemel Hempstead sheet of the Soil Survey of England and Wales was made by the Soil Survey in 1945. During the ensuing 15 years more detailed mapping and analysis were carried out and outline descriptions and results were given at intervals in the annual reports of the Soil Survey. The Wicken and Wantage Series, for example, were recognised in 1951, and the Icknield, Winchester, Batcombe, Coombe and Charity soils in the following year. In 1953 the Berkhamsted Complex was added, in 1954 the Ford End, Harwell and Gubblecote, and in 1956 the Denchworth and Aylesbury Series. The remaining series have been distinguished since.

More detailed published material has been available since 1956 in the writings of those concerned with the mapping and classification of soils in the area. In that year Avery and Thomasson examined some of the deposits of the Chiltern plateau at various localities and concluded that the formation of Clay-with-Flints was begun in Mid-Tertiary times by solution of the Chalk beneath the pervious Eocene cover rocks and was continued during the Pleistocene as a result of solifluction and frost action. Both plateau and valley-drifts were modified by the addition of loess-like silt. They also called attention not only to the asymmetry of the Chiltern valleys but also to the differing pattern of slope deposits and soils on either side of these valleys, which they believed to be the result of differential weathering due to aspect in either periglacial or interglacial conditions. These problems of asymmetrical valleys and their associated slope deposits were enlarged upon by Ollier and Thomasson in 1957 and similar conclusions were reached. In 1959 Avery and others investigated the origin of the Charity Complex and the Batcombe and Winchester Series both in the field and laboratory and found that all three were derived in part from loess. The Charity soil was formed in decalcified head deposits which had been mixed with loess by solifluction whereas the Batcombe and Winchester profiles exhibited two distinct stages - a truncated previously weathered horizon with later superficial incorporations of loess. This weathering took place in the Tertiary or in interglacial times. Since the addition of loess, the land surfaces concerned were probably subjected to at least one alternation of periglacial and temperate conditions.

But by far the most complete account of the Chiltern soils is that of Loveday in 1958. This is largely a study in pedology and thus his work will only be summarised where relevant to the landscape development of the Central Chilterns and Vale of Aylesbury. Loveday recognised, in the higher parts of the Chilterns, a characteristic sequence of soils, (Fig. 12), with the Batcombe Series and Berkhamsted Complex occupying the plateau top positions with slopes of 0 - 3 degrees. The origin and development of the Batcombe profile was discussed in considerable detail, and although Loveday was unable to determine whether the underlying Plateau Drift was a true glacial deposit formed by a local Chiltern ice-cap (Wooldridge 1938) or only material from Eocene and Chalk re-sorted under cold conditions, he himself appeared to incline towards this latter view. The Winchester Series, on convex slopes of 2-7 degrees at the edge of the plateau was also given detailed consideration, though Loveday experienced some difficulty in deciding whether or not the underlying Clay-with-Flints was formed in situ. He concluded that the deposit beneath and adjacent to the Plateau Drift was probably formed in place, but that on sloping sites it was a form of drift, though he was unable to suggest any

Fig. 12 CHILTERN SOIL SEQUENCE – AFTER LOVEDAY (diagrammatic)



really satisfactory mechanism for its emplacement. From its relation to the Thames terrace sequence, Loveday deduced that the development of Clay-with-Flints was insignificant after the time of the formation of the Winter Hill Terrace (i.e. according to Wooldridge, 1938 and 1957, the interglacial before and after the Great Eastern Ice, though Zeuner, 1945, correlated the Winter Hill with an earlier galciation).

The Winchester Series thinned downslope to the shallow chalky Icknield Series, below which the slope normally lessened and became concave. These valley footslopes were occupied by the Coombe Complex. Loveday found that in narrow valleys, this latter calcareous soil occupied both the lower slopes and valley bottoms, but in the wider valleys there was often a lessening of slope before the valley bottom was reached. This was accompanied by a gradual change to the non-calcareous flinty Charity Complex on grades of less than 5 degrees, the Coombe Complex perhaps reappearing in the valley bottom. The slight dissection of these Coombe deposits was taken by Loveday as indicative of the rejuvenation of a previously existing stream following the deposition of the coombe material. In other words, this material was interpreted as occupying gently sloping terrace-like features which appeared to have been originally colluvial fans rather than valley-bottom alluvium.

The sequence was seen to be complicated in places by the occurrence of Winchester accompanying Charity in lower slope positions. The relation of the surfaces on which these outliers occurred was thought by Loveday to be comparable with the relation existing between the Winchester surfaces and adjacent higher terrace surfaces in the Thames Valley sequence.

Thus Loveday's work on the soils and landform evolution of the upper parts of the Chilterns, especially the summit plateau and dip-slope, provides a valuable basis for the extension of these ideas to the scarp slope, gaps and Vale of Aylesbury.

III GEOMORPHOLOGICAL PROBLEMS OF THE AREA

From the foregoing it would seem that the problem of the wind-gaps and their soils has still not yet received full and satisfactory attention. The associated questions of scarp retreat, the detailed form of the scarp face, and the scarp foot deposits would also seem to be relevant in this connection. A preliminary assessment of the most important issues will be attempted in this chapter.

(a) THE WIND-GAPS

In spite of the diversity of ideas put forward in the literature surveyed, there does seem to be general agreement that all the Chiltern wind-gaps have a common age and origin, so that in actual fact the three gaps under consideration should be fairly representative of the problems as a whole. In brief, four schools of thought pertinent to the evolution of the gaps emerge - the pre-glacial fluviatile, the glacial melt-water, the marine and the composite pre-glacial - glacial melt-water theories.

(i) THE PRE-GLACIAL FLUVIATILE THEORY

This would seem the most conservative of all the hypotheses and has certainly attracted the largest number of adherents as being best in accord with the geomorphological evidence available. In essence, it requires the development of major consequents draining from the north-west, probably on a formerly more extensive Chalk cover, the etching out of the clay vales along the strike, and capture of the original streams by these subsequents.

It does, however, raise certain queries among which are - the age of these early consequents, the date of capture, the evidence for this in the present landscape, and the subsequent development of the area. Wooldridge and Linton (1955) assign the development and capture of some of these major affluents of the Thames to the Mid-Tertiary erosion cycle, the end product of which is seen in the present summit peneplain which attained its present position during the Late Tertiary-Quaternary cycle, a cycle which is as yet incomplete. Evidence for these early consequents is found, according to Wooldridge and Linton (Page 56), in the south-west and north-east running coombes of the Chiltern crest region, former lateral tributaries. Features such as Bacombe Warren, the Hale, possibly the Aldbury Valley and The Coombe seem to support this (Figs. 58, 55, 61.).

It might also be thought that evidence for the original consequents should be sought in stream alignments in the country to the north-west of the present escarpment, and Davis (1895) suggests several such alignments. However, Wooldridge and Morgan (1937, Page 211) show that the evidence of wind-gaps should not be expected in areas in their second cycle of evolution:

"...the river captures of the first cycle will still be legible in the pattern of drainage, but there will now (in the second cycle) be no direct evidence of the former continuity of drainage lines, i.e. the wind-gaps, opposite the elbows of capture, will have disappeared in the levelling of the earlier escarpments; their former position is high above the present land surface".
Thus, according to this general principle, much of the evidence for the courses and capture of the initial consequents would have been destroyed during the Mid-Tertiary peneplanation.

From this argument it must be concluded that either the present wind-gaps are a result of incomplete Mid-Tertiary peneplanation and have been cut down a further 300 feet to their present form and altitude by some later process, or that they were among those streams which escaped Mid-Tertiary capture although this seems difficult to envisage. Wooldridge and Linton, however, cater for this latter contingency, for they indicate (Page 56) that the survivors of the Mid-Tertiary capture entered the Calabrian sea and were thus graded to a base-level now represented by the 600 foot surface. On the retreat of the sea and the emergence of its floor, the consequents extended themselves across it.

This latter hypothesis does, however, still leave the exact age of the capture unsolved. Presumably the consequents continued to grade themselves to a falling base-level and were eventually captured by the Thame or Ouse when they had cut down the gaps to practically their present depths. Davis himself cites the heights of the gaps as evidence for the successive capture of their through-streams by the Thame and Ouse i.e. the Bulbourne cut the deepest gap (411 feet) because it was the last to be beheaded. However, the Princes Risborough stream, further to the south-west and presumably one of the first to be captured by the proto-Thame, cut its gap to a similar depth i.e. 411 feet. By inference, it should be even higher than the Wendover Gap, 508 feet. If these streams had been captured in the earlier cycle of erosion, the remnants of which landscape are now preserved at altitudes of 700 - 900 feet, the present outlines and heights of the gaps must be due to later downcutting and cannot be quoted as direct evidence for progressive capture. If, on the other hand, piracy took place during the present cycle, evidence for such should be more obvious, e.g. stream alignments, unless obliterated by glacial derangement.

It would, therefore, seem possible to explain the initiation and early development of the gaps by fluviatile agencies, without involving glacial causes at all, but on the problem of the age of the capture of the through-streams, i.e. in the Mid-Tertiary or the present erosion cycle, further evidence is needed before satisfactory conclusions can be drawn. The Pleistocene geomorphology of the gaps also appears to require further investigation. The Goring Gap at least was cut down to practically its present level prior to the glaciation which left Triassic drift on its floor, and the gravels within and opposite the other Chiltern gaps, variously interpreted as solifluction, outwash or glacial lake deposits, would similarly seem to indicate that the landscape was probably much as at present by the end of the Pleistocene. This involves the further problem of why Bunter material was not introduced through these central gaps into the London Basin in glacial times as it was through the Goring and Hitchin Gaps.

(ii) THE GLACIAL MELT-WATER THEORY

This hypothesis attracted many of the earlier workers in the area and, in spite of the fact that some of the later workers felt they had conclusively disproved it, similar ideas still reappear in different guises in some of the general literature. The theory in essence requires the entrance of a tongue of ice into the Vale of Aylesbury from the north-east, the impounding of a lake between the receding ice front and the Chiltern escarpment, and the overflow of its waters through spillways breaching the Chalk cuesta. Some of the difficulties raised by this hypothesis will be discussed in this section.

Prestwich (1890) and Harmer (1907) suggested that this ice tongue impounded the Upper Thames which at this stage had its outlet through the Wash, but there is little evidence for this assumed early course of the Thames. Sherlock (1922 - 1947) only envisaged a pro-glacial lake, Harmer's Lake Oxford. None of these workers, however, specify the precise limits of such a lake. To have been responsible for all the Chiltern gaps, the lake would have been of vast dimensions. If the ice front lay somewhere between Leighton Buzzard and Dunstable, as seems probable from the drift deposits of the area, a lake is needed to occupy the whole of the Vale of Aylesbury and the Oxford Basin. Its northern, western and eastern boundaries would presumably have been the ice front, the Portland Limestone ridge and the Chalk escarpment respectively, but there seems no obvious landscape feature which would restrict the lake towards the south-west. In addition the Goring Gap was already below 300 feet at the period of the ice advance - the only time when such a lake would have been feasible.

The altitude of such a lake also raises considerable difficulties. The differing heights of the gaps were quoted by the lake supporters as evidence for their functioning as overflow channels at various levels of the lake. Presumably any channel not blocked by ice was used for overflow waters while the lake stood at its highest level and each was successively abandoned as the ice retreated and the lake level fell. The exact mechanism is not, however, made clear, nor are the original form and height of the cols defined. Gregory (1914), however, pointed out that if all the gaps were initiated by such a lake, an altitude of 700 feet for its waters would be required to cut the Hampden Gap. Sherlock modified this to 600 feet, the two arms of the Hampden Gap being at 625 feet and 617 feet respectively.

Gregory quoted a height of 540 feet O.D. as the highest possible level at which such a lake could be admitted but, even so, the altitude of the Goring Gap remains a problem. If the lake is restricted to 300 feet, the Tring, (411 feet), Wendover, (508 feet), and Dagnall, (436 feet), Gaps cannot be explained as overflow channels.

Sherlock felt that the strongest argument for the glacial initiation of the gaps is the absence from their mouths of far-travelled stones, which are present at similar altitudes on Southend Hill (Grid Ref. 920 165), opposite the Tring Gap, intimating that the gaps were not cut at the period of ice advance. It is possible, however, that they were not cut down to their present depths by the onset of glaciation.

Perhaps one of the decisive factors in this controversy is the presence or absence of evidence of a former lake on the floor of the Vale itself. Gregory felt that lake deposits on the floor of the basin were insignificant and could be adequately explained by local pools; neither did he find clear remains of lake terraces or deltas. Sherlock, on the other hand, found strong evidence for the existence of a lake in the gravel deposits of the Vale. These gravels are some 2 - 5 feet thick and form a thin skin over much of the plain (though they are not mapped by the Geological Survey where they are less than 2 feet thick). The Weston Turville spread, opposite the Wendover Gap, ranges from 313 - 281 feet O.D.; the Gubblecote spread, opposite the Tring Gap, from 337 - 285 feet. The levels fall generally north-westwards. The chief constituents are flints, mostly small and decayed, with some larger sub-rounded flints, a few Tertiary flint pebbles and rounded lumps of chalk, all derived from the Chilterns. They must have been brought into the area by streams descending the escarpment, and their thin and widespread character is thought, by Sherlock, to be indicative of deposition in a lake rather than as a talus fan.

The valley gravels themselves have also been adduced as evidence for the proximity of an ice-sheet. The Bulbourne and the Gade gravels, for example, have a most peculiar distribution, (Figs. 52, 53.), spreading out in a fan-like manner in front of the escarpment. The Bulbourne gravel splits into a left and right wing, the two lobes rising steadily up the front of the scarp. The western lobe is cut off abruptly, as is the Wendover gravel fan to the south, (Fig. 54), whereas the eastern lobe lies in a hollow in the scarp at 600 feet. The Gade Valley shows a similar development, with a left wing only, forming a terrace in the Chiltern scarp. Sherlock attributes these fans to torrential streams pouring from the escarpment on the one hand and melting ice on the other. It is certain that they could not have been formed under present topographical conditions and any theory on the development of the wind-gaps must take their distribution into account. Further more detailed examination of these gravel deposits, both beyond and within the gaps, would seem to be indicated before Sherlock's suggestions can be accepted or rejected in toto.

The glacial protagonists have also interpreted the detailed landforms of the scarp face as having a glacial origin. The broad, flat-floored, steep-sided channels trenching the escarpment were ascribed to water from melting ice-caps on the Chiltern Hills. Their abrupt ending on the plain was due to the proximity of the lake. The unilateral channels, ledges and steps in the escarpment were thought to be cut by ice marginal streams, partly in ice and partly in frozen chalk, their differing altitudes representing different stages in the retreat of the ice. It would seem, however, that such features could be equally well explained by less extreme hypotheses, e.g. spring sapping for the channels and periglacial action for the ledges. Some of the latter are probably lynchets.

In retrospect then, the problems involved in accepting the postulate of the Lake Oxford would probably seem too great. However, the possibility of a lake of smaller dimensions does not appear to be excluded, though such a lake could not be responsible for initiating the Chiltern breaches. In this connection, the exact position of the ice-margin in the Vale of Aylesbury needs clearer definition.

(iii) THE MARINE THEORY

This school of thought was chiefly represented by Barrow and Green (1921) and is now completely discounted. The hypothesis does, however, raise several important and relevant issues.

The presence of small white quartzite pebbles from the Lower Greensand in the gap deposits led Barrow and Green to suggest submergence of much of the area beneath a Pliocene sea, by which the quartzites were transported and the gaps and escarpment coombes eroded. The final moulding of the landscape - the etching of the Gault vale and capture of the smaller streams-was subsequent to the elevation of the area above sea level.

The precise role of the gaps in the geography of Pliocene times is still pertinent to theories of their evolution. Remnants of the Pliocene (Calabrian) landscape are now recognised above the 600 foot marine bench on the Chiltern dip-slope, and the downcutting of the gaps to their present floor-levels must represent a later stage in the erosion history of the district. Wooldridge (1927) interprets the steep, unbroken declivities from 600 feet to the present floors as undoubted river-cliffs, though the glacial overflow supporters differ on this point. The Calabrian coast has been mapped by Wooldridge from the morphology and patches of beach deposits, but it is possible that the sea extended north beyond this general line into the gulfs and embayments of the gaps. Wooldridge himself sought evidence for this above the present bounding slopes of the gaps and thought there was some indication of an older and wider valley in most of the gaps. He could not, however, find evidence for the extension of the sea much beyond these depressions.

It is interesting to note that in Wooldridge's work in this connection, there is some hint that although the gaps may have had a similar origin, their subsequent development may have been influenced by factors varying from gap to gap. The Calabrian coast, for example, is mapped as crossing the escarpment crest near the Princes Risborough and Hitchin Gaps (because of pre-Calabrian transverse warping).

In summary it would appear then that the outlines of the central Chiltern gaps above 600 feet were probably modified to some extent in their role as gulfs of the Calabrian sea, but it is unlikely that they were completely submerged by it. The problem of the emplacement of Barrow's white quartzite pebbles, however, still remains.

(iv) THE PRE-GLACIAL - GLACIAL MELT-WATER THEORY

Of all the hypotheses suggested, this composite theory seems the most reasonable from the material already available, but even this leaves some problems unsolved. Oakley (1936 and 1952) has been its chief exponent. The Aylesbury gravels, interpreted as solifluction deposits, indicated to him a pre-Pleistocene fluviatile origin for the gaps with enlargement and deepening by glacial melt-water. The scarp forms he attributed to spring sapping.

These suggestions still raise certain queries as to the more detailed evolution of the gaps, for example- the exact form and altitude of the gaps at the onset of glaciation, whether or not the through-streams were in fact captured before, during or after glaciation, how much of their present outline can be attributed directly to the passage of melt-water, the dimensions of any lake involved, the absence of foreign material in the gaps and so on. It is interesting to note that Evans and Oakley (1952) appear to have been the only workers to find possibly convincing evidence of lake deposits in the Vale of Aylesbury in the coombe deposits at Pitstone. They do attribute them to a pro-glacial lake in the Vale but presumably envisage a much more restricted ponding than Harmer (1907) and Sherlock (1922 - 1947). The deposits are in all some 20 feet thick and lie at an altitude of some 400 - 450 feet, indicating a lake level of, at a minimum, 450 feet. To have modified the Wendover Gap, the level would have had to be some 70 feet or so higher. This again does not provide the solution to the question of the Goring Gap, nor is there any suitable south-western barrier for a lake at or above 500 feet.

A further problem is raised by a consideration of the stage in the Pleistocene during which the gaps functioned as spillways. According to Culling (1956), the stream profiles were modified by overflow and outwash prior to the Winter Hill stage, i.e. following the advance of the Eastern Ice (Wooldridge 1938) or an earlier glaciation (Zeuner 1945). This would seem to link with the Leighton Buzzard Drift to the north-west which is thought to be of Gipping age (King 1955).

Further evidence is required however to build any sort of detailed Pleistocene chronology.

(b) SOILS AND DEPOSITS

Certain aspects of the problems of the soils and deposits of the area have already been raised in the consideration of the major question of the wind-gaps, but a brief summary of the major difficulties will be included at this point.

Loveday's (1958) characteristic Chiltern sequence on the Chiltern plateau and in the dip-slope dry valleys (Fig. 12) is fairly readily explained, but in the wind-gaps and at the foot of the escarpment this sequence is interrupted and confused and explanation of the distribution of these soils and deposits is more difficult. For example, outliers of the Winchester Series are found in anomalous positions at such low levels as 400 - 450 feet in the floor of the Tring Gap, 450 - 500 feet in the Dagnall and 500 - 550 feet in the Wendover (Fig. 45). The bulk of this material is confined to the spurs and upper slopes of valleys dissecting the Mio-Pliocene plateau and the early Pleistocene bench. From Loveday's observations on the relationship between these Winchester outliers and the accompanying Charity Complex, it can be deduced that much of the Charity Complex was formed before Winter Hill times i.e. before, according to Culling, the gaps functioned as melt-water overflow channels. The distribution of the Charity Complex itself would seem to need further examination. In the Tring Gap, it spreads north-eastwards through the Aldbury Valley and westwards round to Tring, occurring well north of the present gap watershed. In the Dagnall Gap it extends westwards into The Coombe, while in the Hampden and Wendover Gaps, it barely reaches the watersheds within the gaps (Fig. 46). This implies that the Tring and Dagnall Gaps, at least, had attained very largely their present form by the Eastern Ice epoch and that, if they functioned as overflow channels, the melt-water was responsible for little, if any, of their present outlines.

Another problematical feature is the absence of any pronounced head deposits from the immediate foot of the escarpment. Much of the 400 - 600 feet level is occupied by the Icknield Series. The distribution of the Tring Series is a further puzzle. It occurs only in the mouth of the Tring Gap on the shelf-like flat at 400 feet (Fig. 47) and investigation not only of the soil itself but also of its morphological situation and its relation to the adjacent head deposits would seem to be indicated.

The sporadic and irregular occurrence of various head deposits, represented by the Halton (Fig. 46) and

Challow Complexes and the Gubblecote and Weston Turville Series (Fig. 49), on the floor of the Vale also seems relevant to the physical evolution of the area, particularly with respect to the Pleistocene. They have an altitudinal range of some 100 feet, lying between the 250 foot and 350 foot contours, and vary in depth from 1 foot to 5 feet. The possibility of their being partly lacustrine deposits must be considered. If they are purely solifluction material, their age again raises a problem, for the landscape must have been dissected to an altitude of at least 250 feet before their emplacement. A consideration of their relationship to the Charity and Coombe Complexes is also necessary i.e. whether they are younger, contemporary or older, and whether one or several solifluction phases are represented. The extent of the Rowsham Complex (Fig. 47), developed over the Geological Survey's Boulder Clay and Glacial Gravel north of Aylesbury, at a height of 250 - 400 feet, must also be included in any attempt to unravel the Pleistocene history of the area. There is also the possibility that some of the alluvial deposits of the Vale, e.g. the Mead Series, may be of lacustrine origin.

Thus there would seem to be scope in the Chiltern wind-gaps and Vale of Aylesbury not only for a resurvey and reappraisal of work already contributed on the geomorphological problems of the area but also for more detailed research along certain lines in an endeavour to elucidate some, at least, of these problems.

IV METHODS OF APPROACH

In approaching the geomorphological problems outlined in the previous Chapter, investigations were channelled along four major lines - morphological mapping, an investigation of the gravel deposits and the mapping of the distribution of their relevant constituents, an examination of soil profiles, exposures and sections, and finally a study of the pattern of soil series distribution in relation to morphology.

(a) MORPHOLOGICAL MAPPING

The limitations of contours in portraying both concepts of relief, i.e. elevation and slope, have long been realised. This inadequacy of the contour method in displaying facets of terrain was emphasised, for example, by Miller and Summerson (1960) who expressed the need for a method of relief representation which would emphasise the "flats" and "slopes" of a landscape, (Page 195).

"A surface of a single attitude, either slope or flat, denotes an area of common origin, which has a characteristic soil, vegetation cover, and other properties that make it a recognizable unit."

Flats and slopes are, according to Wooldridge (1932), a fundamental concept of geomorphology, each differing from its neighbours in its intrinsic qualities because it has had a different origin. Geomorphology should not only be concerned with benches or platforms marking old erosion surfaces but also with scarp faces, valley sides and valley floors which are surfaces actively developing during the current cycle of erosion. The aim of geomorphology is "to study the evolution of the landscape and its essential subject matter is the surfaces of the land". (Wooldridge 1949 - 50, Page 31).

Thus a method of morphological mapping was sought for the Chiltern wind-gaps and Vale of Aylesbury which would depict each individual facet, i.e., flats and slopes, in the landscape, and that developed by Waters (1958) was found, with adaptations, to be the most suitable. A map showing the distribution and inter-relationships of such facets and landforms was considered an essential pre-requisite to any attempt to clarify the denudation chronology of the region.

Firstly, some sort of limits were necessary for the region, and in the absence of any other satisfactory criteria, altitudinal limits seemed the most logical (Fig.13). The 500 foot contour was selected as the upper limit for morphological mapping as it coincided approximately with the base of the escarpment proper

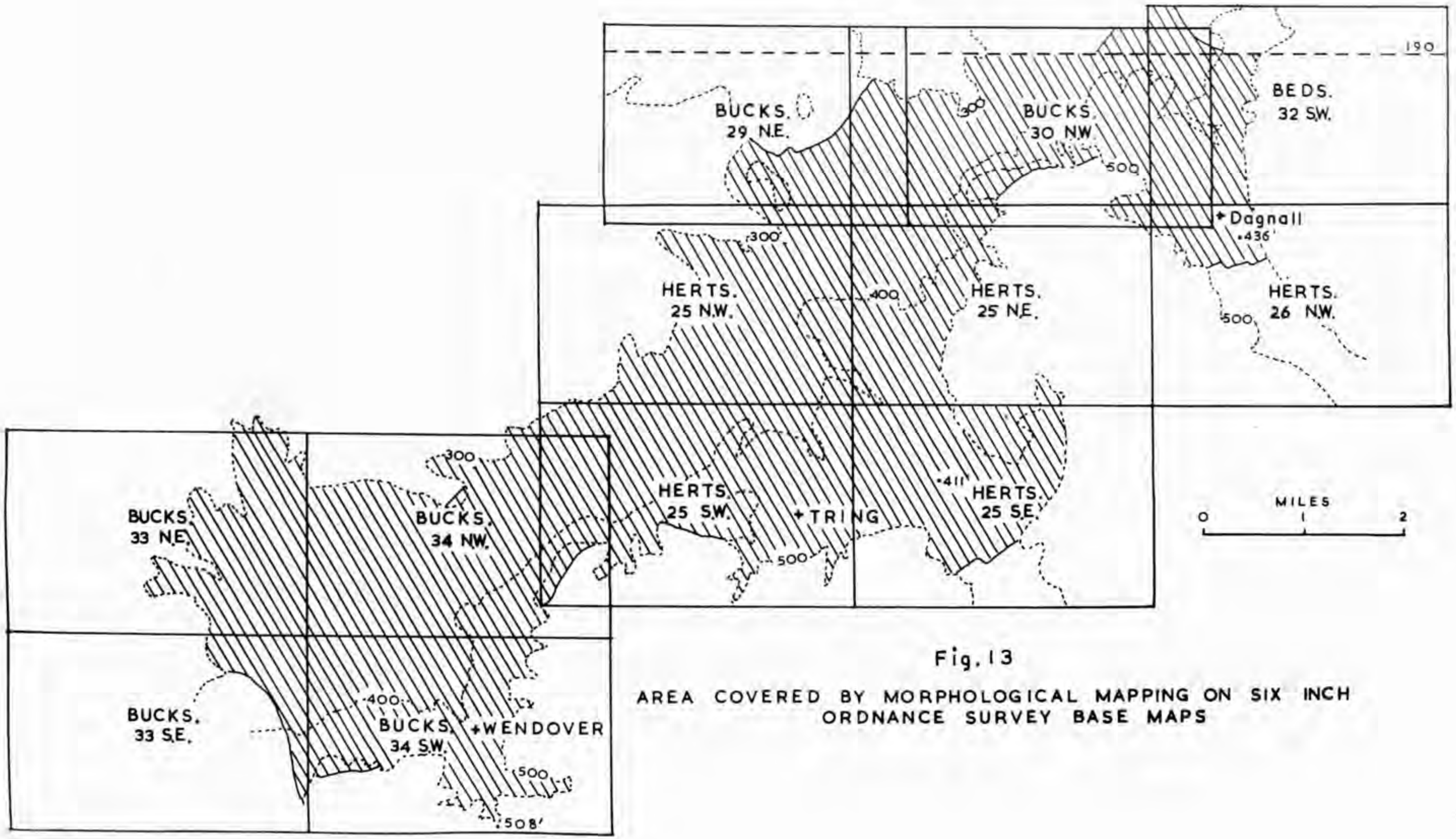
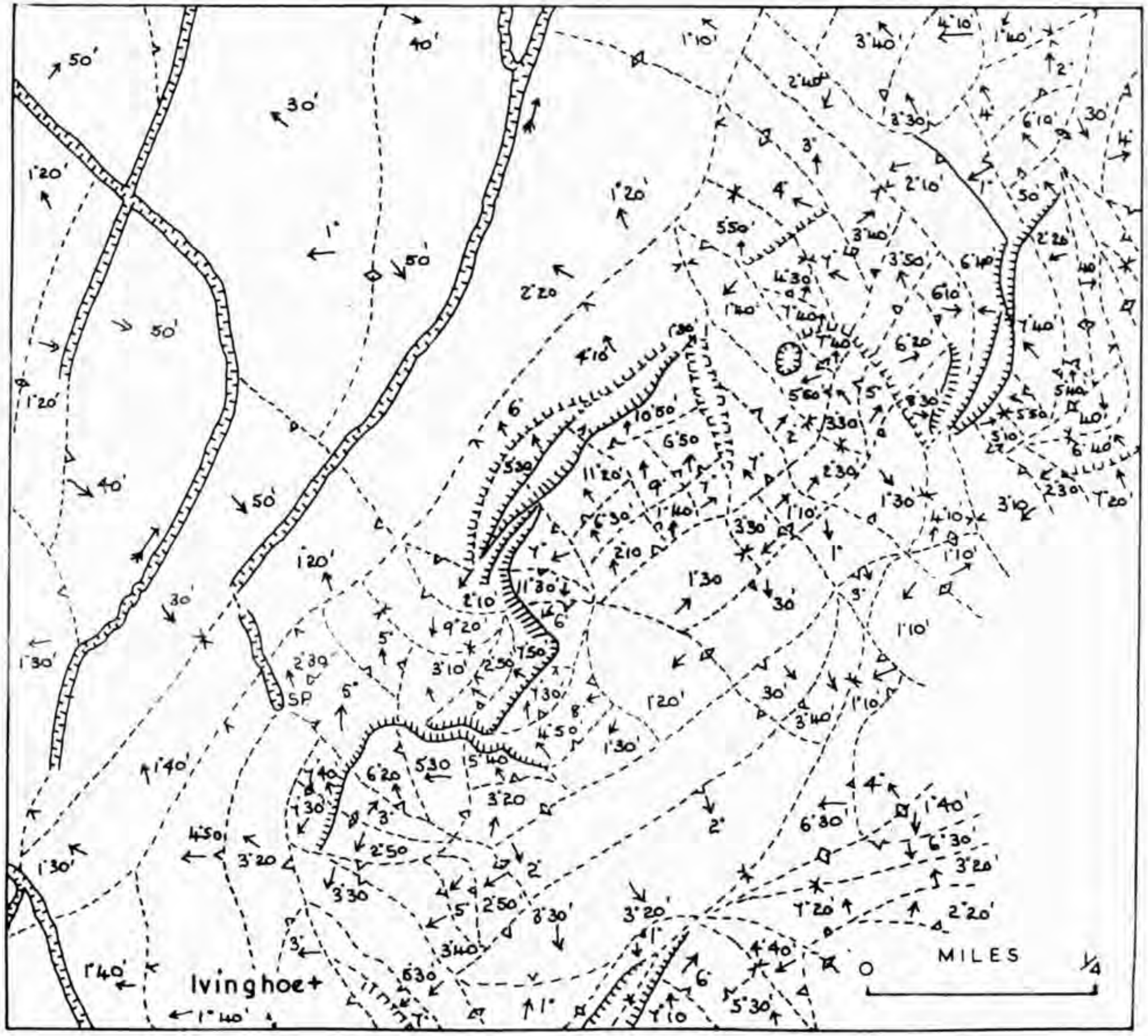


Fig. 13

AREA COVERED BY MORPHOLOGICAL MAPPING ON SIX INCH ORDNANCE SURVEY BASE MAPS and also outlined the wind-gaps reasonably well. The lower limit was chosen as the 300 foot contour. This occurred well out into the Vale and beyond it there seemed to be few features of arresting morphological significance. Within the gaps, mapping was extended to the watersheds and just beyond. The western and eastern limits, beyond the Wendover and Dagnall Gaps respectively, were somewhat arbitrarily selected along apparent major morphological discontinuities, e.g., the valley of a stream. Soil mapping had only been completed as far north as the National Grid line 190 by the Soil Survey, so morphological mapping was not continued beyond this when the 300 foot contour happened to extend north of this line.

Mapping in the field was carried out on the scale 1 : 10,560 (6 inches to 1 mile) and in all an area of some 54 square miles was covered in this way (Fig. 14). Each facet over this area was mapped by plotting its bounding morphological discontinuities. If the discontinuity was a sharp break of slope it was depicted by a continuous line. There was not necessarily, though, a great angular difference between the slopes of adjacent facets. If the break was not markedly angular but rather a smooth inflexion it was shown by a broken

Fig. 14 SAMPLE OF MORPHOLOGY MAP MADE IN THE FIELD



line located on the map midway in the zone over which the discontinuity occurred. In addition, the slope and aspect of each facet were recorded. An arrowhead symbol was used on each discontinuity, always pointing downhill and always placed on the more steeply sloping side of the line. A flat (less than 30 minutes) was thus free from symbols. The arrowheads served as indications of the nature of the break or inflexion i.e. whether concave or convex.

The actual degree of slope was measured (in its steepest part) by means of an Abney Level and was recorded directly on the base map, together with an arrow indicating the direction in which the reading had been taken. The arrows thus always indicated the steepest part of the facet and were always placed so as to point downhill. In an area with so many map reference points, position fixing was relatively straightforward, though their very abundance in places made surveying difficult e.g. hedges, buildings, roads, canals, reservoirs, railways, and quarries. Situations where the form of the ground was obviously very much disturbed by human agencies were omitted, e.g. lynchets.

Additional information was recorded where available and relevant i.e. the structural relations of the facet, its altitudinal range, and the nature of its surface, also springs, stream courses and direction of flow.

Material actually indicated on the base map had, however, to be limited for the sake of clarity. On the 6 inch scale, it was found impossible to map features smaller than 15 by 15 yards. In actual fact, when a concave break or inflexion occurred immediately below a convex one, e.g. in the case of a small ledge on a steep slope, or a very steep sided valley, a further symbol was used. All slopes were measured to within 10 minutes in the field; it is thought that 10 minutes represents the probable error of an Abney Level. Slopes with an inclination of less than 30 minutes were classed as flats.

This basic material on the 6 inch maps then had to be classified in such a way that successive degrees of slope were immediately apparent to the eye and an overall picture of the terrain was given which could be readily compared with geological and soil maps on the same scale. Then the significance of the various zones of slopes could be assessed and the morphological situation and distribution of the various soil series be examined.

Other workers have previously suggested certain groupings of slopes from their own experience. Miller and Summerson (1960), for example, differentiated eight such groupings between 0 degrees and 90 degrees, and expressed them by means of tinting. Of these, four values coincided with Wood's (1942) slope categories, i.e. waning, waxing, constant and free faces. For small scale mapping these four zones would seem adequate for they are easily portrayed and differentiated by the eye. In addition, their limits coincide fairly closely with observed natural boundaries. Miller and Summerson suggested, however, that the eight zones would be more useful on larger scale mapping.

These values proved not to be entirely suitable for application to the area under consideration, as altitudinal limits had been imposed when mapping, i.e. facets above 500 feet and below 300 feet had been omitted. Thus a further method of assessing which slope groupings were significant was sought. For this purpose a graph was constructed to show slope incidence (Fig. 15). On the horizontal axis each slope category (i.e. 30, 40 and 50 minutes, 1 degree, 1 degree 10 minutes, 1 degree 20 minutes and so on) was enumerated while the number of times each occurred over the whole area was shown on the vertical axis. The resulting graph was smoothed out by the use of the running means method, firstly in three figure groupings (Fig. 16) and secondly in ten

Fig.15 CENTRAL CHILTERN WIND-GAPS AND VALE OF AYLESBURY – SLOPE INCIDENCE GRAPH SHOWING MAJOR SLOPE GROUPINGS

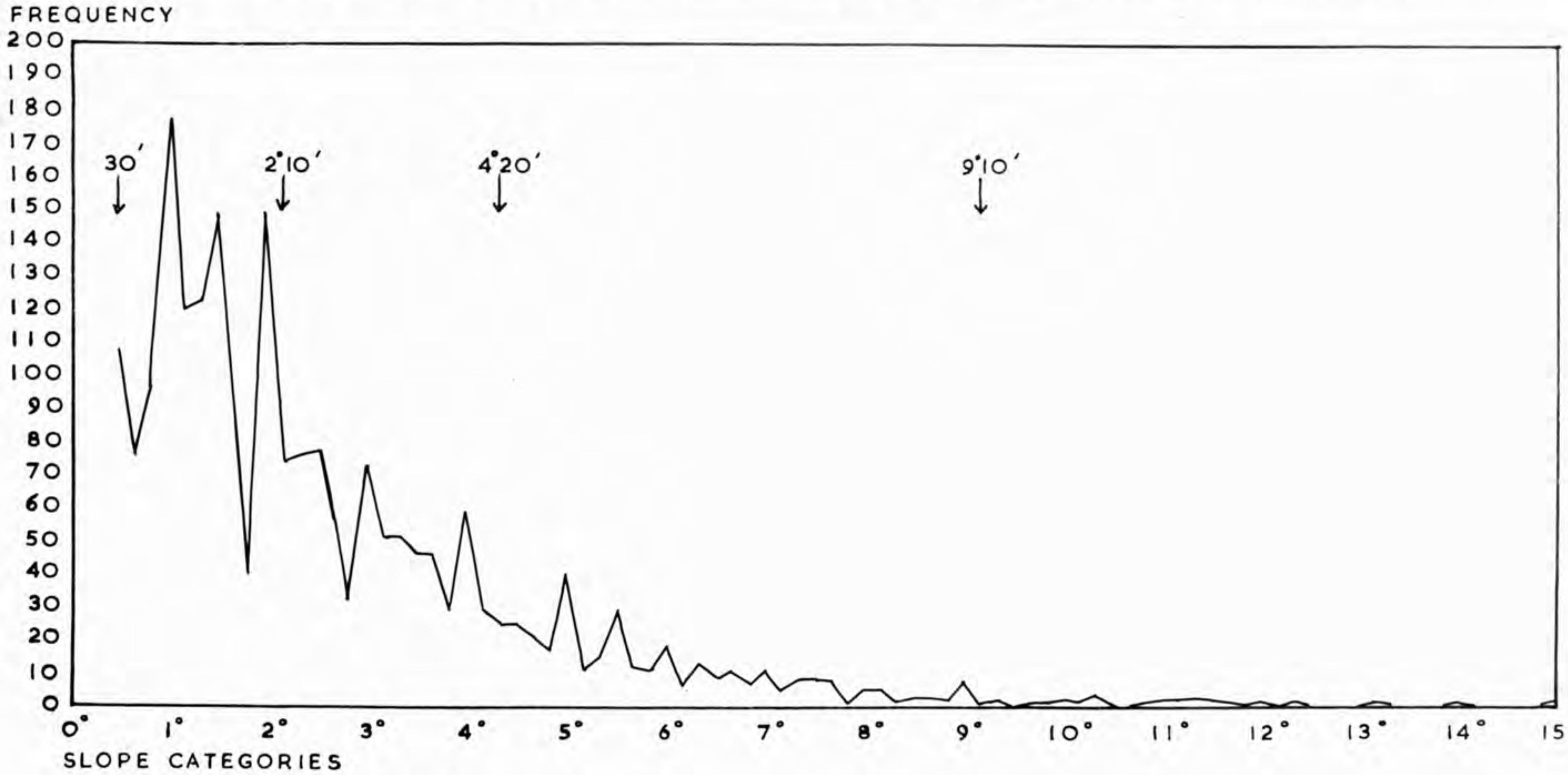


Fig. 16 CENTRAL CHILTERN WIND-GAPS AND VALE OF AYLESBURY – SLOPE INCIDENCE GRAPH USING RUNNING MEANS IN THREE FIGURE GROUPINGS

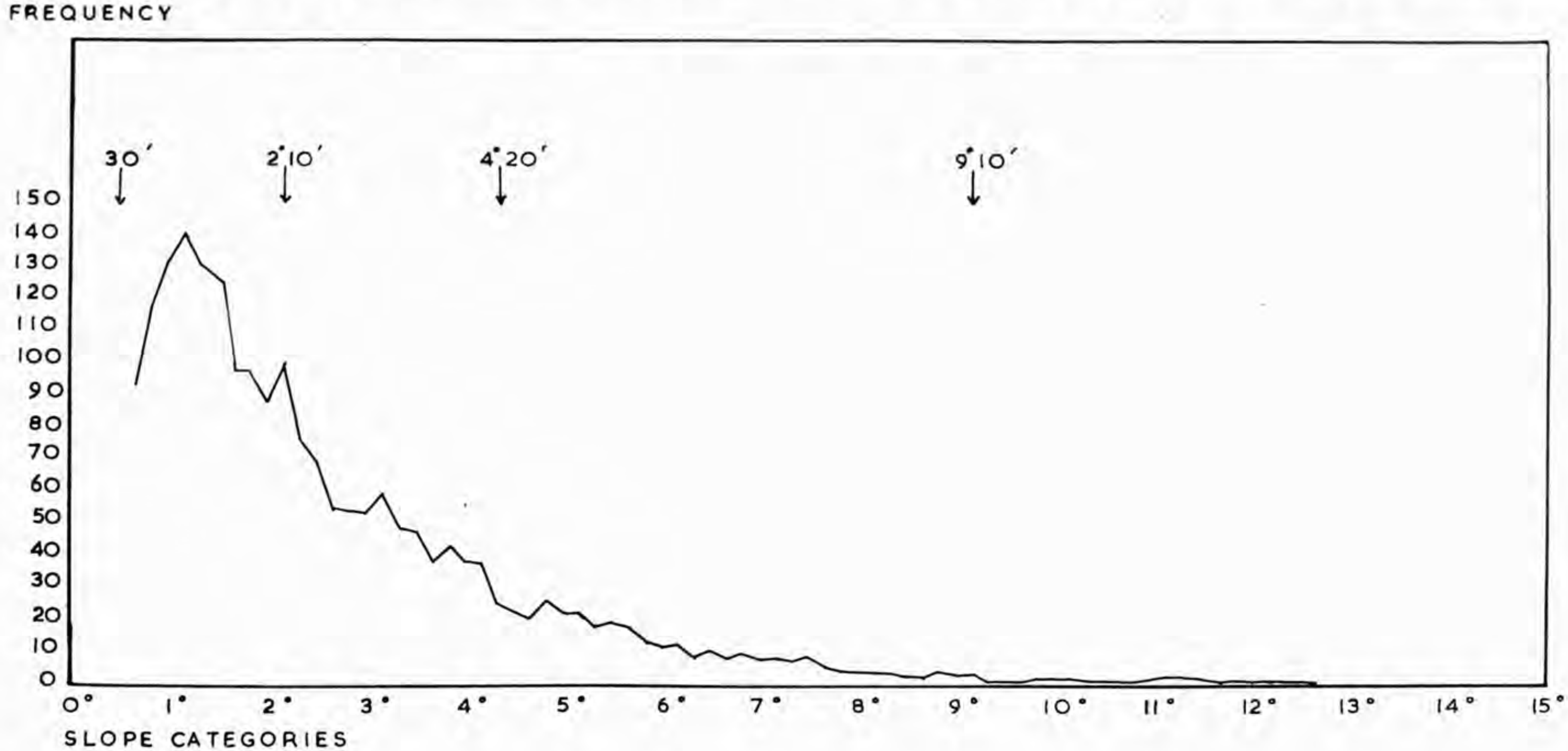


Fig.17 CENTRAL CHILTERN WIND-GAPS AND VALE OF AYLESBURY — SLOPE INCIDENCE GRAPH USING RUNNING MEANS IN TEN FIGURE GROUPINGS

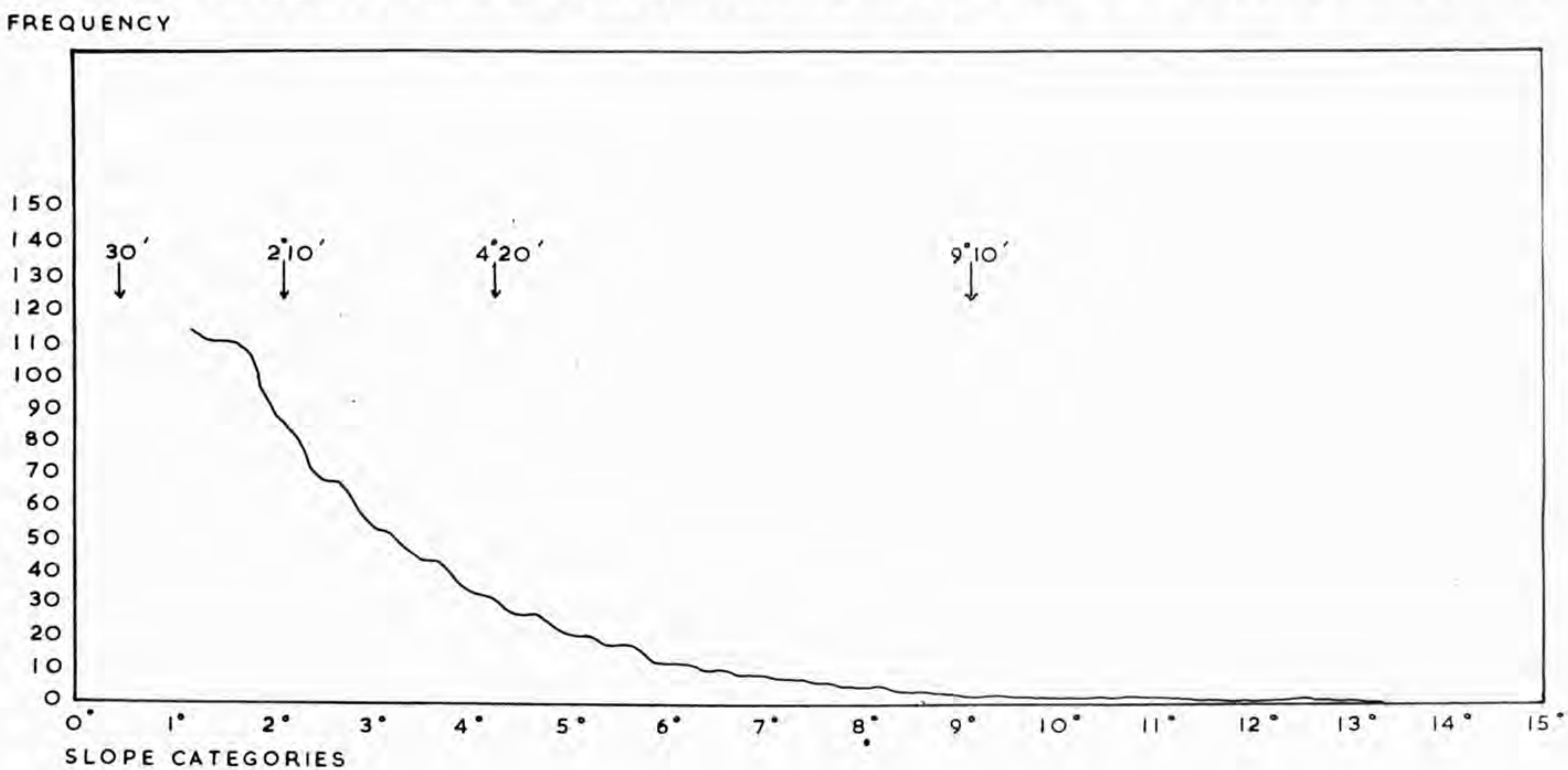


figure groupings (Fig.17). From a consideration of all three graphs, it became apparent that certain groupings were evident in each case. Ultimately four such groupings were selected (30 minutes to 2 degrees 10 minutes, 2 degrees 10 minutes to 4 degrees 20 minutes, 4 degrees 20 minutes to 9 degrees 10 minutes, and over 9 degrees 10 minutes) as it was felt that in this particular area, this was the maximum number that could be represented clearly by tinting on the finished slope map.

The completed slope map depicts every surface facet over the area, the nature of its bounding discontinuities, and the direction of its steepest slope. It also brings out certain selected grouping of slopes, the significance of which will be considered in the following chapter. With practice the form and nature of the landscape can quickly and easily be read and interpreted. Contrasting terrain patterns and variations in drainage texture stand out well, and interesting and valuable correlations can be made with the geological and soil maps.

In addition, longitudinal profiles of the gaps have been constructed from the morphological map (Figs.18,19,20). 66,68,69. A vertical scale of 1 inch to 100 feet has been used while the horizontal scale remains unchanged (i.e. 6 inches to 1 mile), giving a vertical exaggeration of 8.8.

Fig.18 LONGITUDINAL PROFILE CONSTRUCTED FROM THE MORPHOLOGICAL MAP SHOWING THE SURFACES, SOILS AND GEOLOGY OF THE TRING GAP

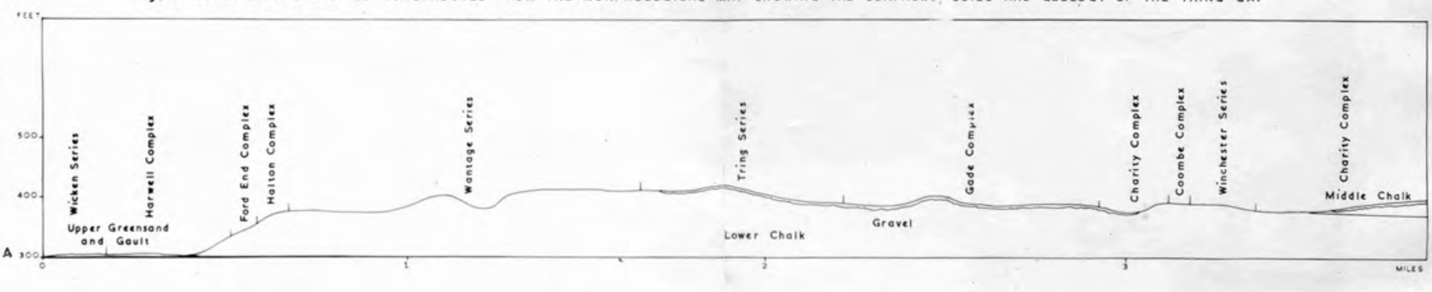


Fig.19 LONGITUDINAL PROFILE CONSTRUCTED FROM THE MORPHOLOGICAL MAP SHOWING THE SURFACES, SOILS AND GEOLOGY OF THE WENDOVER GAP

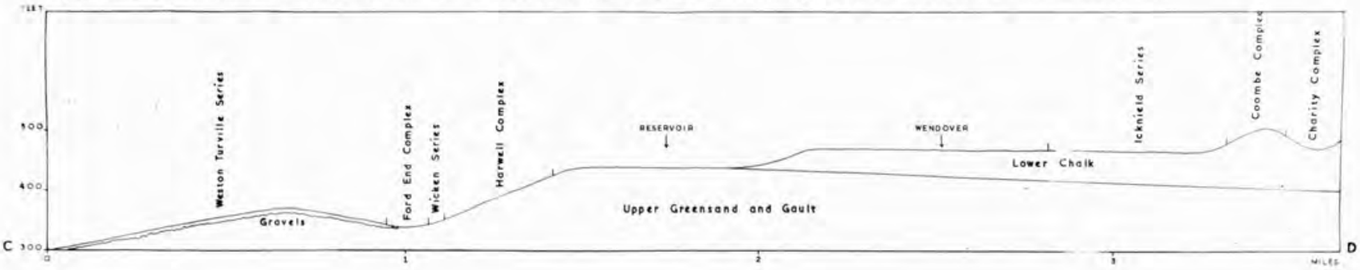
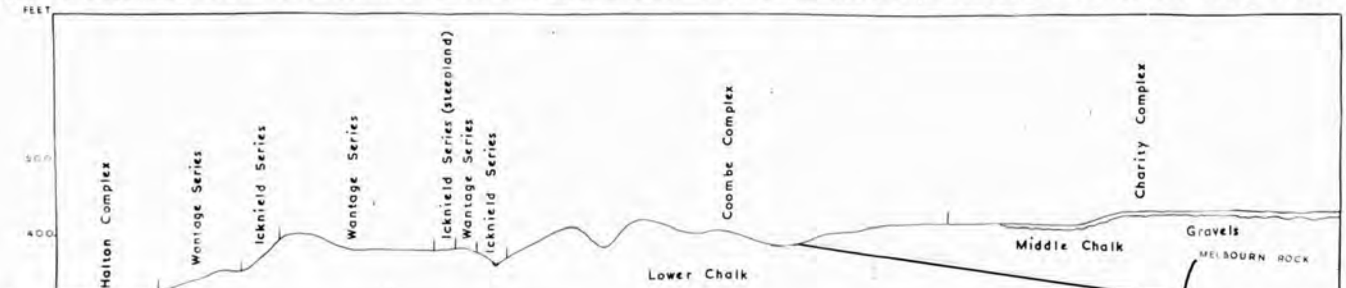


Fig.20 LONGITUDINAL PROFILE CONSTRUCTED FROM THE MORPHOLOGICAL MAP SHOWING THE SURFACES, SOILS AND GEOLOGY OF THE DAGNALL GAP



These sections are valuable in that every slope along their line is represented. They do, in other words, proffer much more information as to the form of the ground than sections constructed solely from contours, for they fill in the detailed morphology between the contours. They portray even more emphatically the significant features of the landscape suggested by the morphological map and the geological and pedological relationships of the facet can be brought out clearly by the construction of similar sections from the geology and soil maps. Further, the form, and nature of the floor of each gap are more readily compared by means of the longitudinal profiles than solely from the morphological map. The implications of these profiles and comparisons of them will again be dealt with more fully at a later stage.

(b) INVESTIGATION OF THE GRAVEL DEPOSITS AND MAPPING OF THEIR RELEVANT CONSTITUENTS

The gravel deposits within the wind-gaps and in front of the Chiltern escarpment, as mapped by the Geological Survey, clearly needed further investigation, and thus a survey was made of their location and distribution, their altitudes and thicknesses, and their constituents. Certain classic sections, e.g., in the

Wendover Gravel Pit (Grid Ref. 875 065), were examined and further information was gained from a variety of less prominent exposures, such as found in old gravel workings, railway and canal cuttings and ditch sections.

A preliminary survey of the area had revealed the presence of Bunter Quartzites in these gravel deposits at various localities, both in the wind-gaps and on the floor of the Vale of Aylesbury, and so systematic mapping of their distribution and extent was undertaken. Each field over the whole area was numbered and examined, where possible, for the occurrence of Bunter pebbles or other far-travelled stones which might be of significance in elucidating the Pleistocene history of the area. Their presence or absence was recorded and later plotted on a 2½ inch base relief map (Fig. 21).

The glacial material in the northern part of the Vale, according to the Geological Survey, was also made the subject of further investigations and borings were made in the Glacial Gravels near Wingrave (Grid Ref. 870 190) and Rowsham (Grid Ref. 853 186) and the Boulder Clay at Southend Hill, Cheddington (Grid Ref. 920 165). The findings of these investigations and their significance will be considered in the next chapter.

(c) EXAMINATION OF SOIL PROFILES, EXPOSURES AND SECTIONS

The soil mapping of the Chilterns and Vale of Aylesbury was originally carried out by the Soil Survey in the field on the scale of 1 : 10,560 (6 inches to 1 mile) and reduced to a scale of 1 : 25,000 (2½ inches to 1 mile) for plotting. The relevant 2½ inch sheets were kindly made available by the Soil Survey as a basis for further work on the area. For any detailed investigation of the morphological setting of the soil series distribution, it was necessary to be reasonably sure of the accuracy of the series boundaries (as far as they can be precisely placed). Thus some time was spent checking the major boundaries, most of which were located fairly readily and found to be sufficiently accurate for the purposes required. However, it is as well to bear in mind the limitations placed on soil mapping by the 6 inch scale and to beware of too rigid an adherence to the Soil Survey's boundaries. The Tring Series, for example, a soil with a highly significant distribution, is probably somewhat more extensive than would appear from the 2½ inch map, but has only been differentiated where it exceeds a certain critical thickness (this is not given by the Soil Survey in their publications); likewise the Coombe

Complex. The majority of such boundaries were inspected with a screw auger and, allowing for the points mentioned above, few adjustments of any significance to the work of the Soil Survey were found to be necessary.

Each of the major soil series of the region was examined in the field, in exposures and sections where available, and also by means of a spade and soil auger at regular intervals. Often both the gravels and the overlying soils could be investigated in the same cutting or ditch. Generally each series was clearly recognisable from the descriptions of the Soil Survey, and little further field information could be added. Descriptions and profiles of each of the major series were made from representative borings and will be given in the next chapter. Textures were assessed in the field by handling and classified according to the International Texture System (as outlined by Clarke, 1941).

(d) STUDY OF THE PATTERN OF SOIL SERIES DISTRIBUTION IN RELATION TO MORPHOLOGY

From the morphological studies conducted in the area under consideration, detailed information was gained on the surfaces of the landscape, "the essential subject matter of geomorphology". (Wooldridge 1949 - 50, Page 31). These surfaces have, as Wooldridge further so aptly put it, "a definite geological age, and therefore differ in exposure and duration to pedogenic processes".

The geomorphologist usually defines his surfaces in terms of relative elevation, form, shape and agency of formation. But the soils that have developed on these exposed surfaces are often discounted in any discussion of the evolution of the landscape, largely because soil development is influenced by such a number of quickly variable factors, namely parent rock, relief, climate, vegetation, drainage conditions and time. Nevertheless, by the elimination of some of these variables and by the recognition of the effects of others, the general relationship between soils and surfaces has been established. Stevens (1959), for example, in an area of homogeneous surface rock in North-East Hampshire, found a remarkable difference in soils on the Mio-Pliocene, the 600 foot and the sub-Eocene facets. Loveday, too, (1958) in the Southern Chilterns recognised the fact that certain profile characteristics were generally associated with a particular surface or slope facet. In his detailed mapping of the soils and surfaces of the area he did, in fact, find that "topographic boundaries delimited areas of soil with a considerable degree of uniformity in a number of factors", and actually in places used these topographic boundaries as the boundaries of soil series (Chapter III, Section (a)).

Wooldridge actually anticipated this as long ago as 1932 when he demonstrated that "flats" and "slopes" possess some unity of soil character either directly because of their geological constitution or indirectly because they have been exposed for a longer or shorter time to weathering.

"This latter consideration," he continued, (1932), (Page 33) "applies particularly to "flats" - a considerable difference in soil profile is to be anticipated between the residual soils of platforms of different ages. On steeper slopes transportation tends to mask the simple difference in maturity of soil."

In 1949, Wooldridge expanded these principles. Basically, and over a wide area, soil series are related to parent material, as rightly emphasised by the Soil Survey, but where thick uniform extensive geological formations are encountered, morphological considerations assume a dominant role. Thus a comparison of the morphological, geological and soil maps for the wind-gaps and Vale of Aylesbury was made in order to demonstrate, if possible, these concepts. The original geological maps on the 6 inch scale (as mapped in the field) were consulted and the 2½ inch soil maps were enlarged by hand to the 6 inch scale.

Then each soil series which had a problematical distribution was considered in its morphological setting. In short, an attempt was made to assess the relationship of a particular soil to the geomorphological history of the surface on which the soil rested, and it proved possible to draw several interesting conclusions from this particular method of approach.

These four methods of approach to the geomorphological problems of the area were found to yield a considerable amount of information. A preliminary description of this will take place in the following pages.

V. RESULTS OF THE FIELD EXAMINATION OF THE MORPHOLOGY, DEPOSITS AND SOILS OF THE GAPS

These will be discussed in the context of the previous chapter.

(a) MORPHOLOGY

The results from the morphological studies carried out can perhaps best be considered under three headings, namely - the significant factors which emerge from the slope incidence graphs, the value of the completed slope map and the salient features of the long profiles constructed from the morphological map.

(i) SLOPE INCIDENCE GRAPHS

From the original graph(Fig. 15), several interesting factors emerge. Generally, as would be expected from field observation, as the angle of slope increases, its frequency decreases. A major break in the profile seems to occur at 9 degrees 10 minutes. Repeated occurrence of slopes steeper than this is rare, the maximum value represented being only 29 degrees 10 minutes. By far the majority of slopes occur in categories below this value. These results are partly due to the fact that only areas between the 300 foot and 500 foot contours were mapped, and are partly a function of lithology (chalk country being generally characterised by gentle convex slopes). The frequency graph would thus seem to reveal a landscape of fairly gentle slopes, broken occasionally by relatively steep facets.

Another feature exhibited by this graph is the high incidence of slopes at 1 degree, 2 degrees, 3 degrees, 4 degrees, and 5 degrees, and to a lesser extent at 6 degrees, 7 degrees and 9 degrees, whereas the values on either side, for example, 50 minutes and 1 degree 10 minutes, 1 degree 50 minutes and 2 degrees 10 minutes are much lower. This phenomenon is probably due to a tendency in the field to place readings, say of 55 minutes, in the 1 degree category rather than the 50 minutes category, though this was not consciously done. In actual fact, the Abney becomes extremely difficult to read precisely when readings occur within the 10 minute divisions. However, by the smoothing out of the curve by the use of running means, these inconsistencies and irregularities were eliminated and so do not influence the ultimate slope groupings.

(ii) THE MORPHOLOGICAL MAP

The slope incidence graphs reveal that certain groupings of slopes occur persistently over the area and four such groupings (for the sake of clarity) were selected for representation on the finalised morphological map. They are shown by means of a progressive deepening of colour with steepening of slope (Figs.66-69).

It can be seen that these groups themselves represent progressively decreasing incidence, i.e., there are a large number of slopes below 2 degrees 10 minutes, a fewer number between 2 degrees 10 minutes and 4 degrees 20 minutes, and so on. It is interesting to note that Miller and Summerson's (1960) first five groupings fall within this range (i.e. 0 degrees 54 minutes - 3 degrees 35 minutes, 3 degrees 35 minutes - 8 degrees 05 minutes, 8 degrees 05 minutes - 14 degrees 24 minutes, 14 degrees 24 minutes - 23 degrees 00 minutes and over 23 degrees 00 minutes) and that there is some correlation between the early values. The present 30 minutes - 4 degrees 20 minutes divisions are recognisable in Miller and Summerson's 0 degrees 54 minutes - 3 degrees 35 minutes grouping; the 4 degrees 20 minutes - 9 degrees 10 minutes category is paralleled by their 3 degrees 35 minutes - 8 degrees 05 minutes. They also pointed out that a value of about 4 degrees bounded both waxing (flat to gentle convex upland surfaces) and waning (gently concave valley floor surfaces) slopes, and this value can certainly be seen to emphasise particular features in the landscape of the wind-gaps and Vale of Aylesbury.

From the completed morphological map an overall picture is gained of the detailed form of the landscape which both reinforces and elaborates the information given by the contours (Figs. 66-69). The orientation, scale, outline and width of the gaps stands out well because of the differentiation of their steeper sides and flatter floors. The huge re-entrant valleys are similarly emphasised, for example, the Aldbury Valley and The Coombe, (the Hale to a lesser extent). The scarp forms, too, are brought out. The deep, trenched spring-sapped features such as Coombe Bottom stand in sharp contrast to the shallower depressions such as those near Folly Farm. The map also reveals the relative flatness and lack of surface morphology of the floor of the Vale, interrupted by an area of slightly steeper slopes in the vicinity of the Thame - Ouzel watershed.

Over the whole area, the groupings of slopes and breaks are by no means continuous, but - generalising - the following pattern can possibly be recognised. Within and just beyond the mouths of the gaps, a fairly flat area is apparent with a reasonably well defined break beyond, i.e., the present floors of the gaps are well above the general level of the Vale. A similar flat, a possible continuation of this surface, is partly represented along the escarpment foot west of Tring, though it is broken by quite sizeable dry valleys. This is bounded below by a further sharp break well seen just to the north of the main Tring - Wendover road. Little

Tring and the associated reservoirs are sited on a lower surface which is terminated to the north by a further area of steeper slopes best illustrated in the country east of Marsworth. Below is the floor of the Vale proper with an ill-defined break in its even surface in the vicinity of Buckland. This sequence is discernible with greater or less ease throughout much of the area, but the detailed significance of the surfaces within each gap will be discussed in a subsequent chapter.

(iii) LONG PROFILES

These serve to emphasise the features described in the foregoing section. In a traverse from the floor of the Vale to the escarpment, four surfaces are recognisable. The lower ranges in elevation from 305 feet - 320 feet and is cut in Gault and Lower Chalk. The second transgresses again both the Gault and Lower Chalk and averages 370 feet - 382 feet. The third surface, 400 feet - 415 feet, is formed by or supported by the Lower and Middle Chalk. The upper surface, 430 feet - 440 feet, lies both in the Gault and the Middle Chalk. A fifth surface, 460 feet - 470 feet, is apparent in the Wendover Gap only.

(b) GRAVEL DEPOSITS

The results here will be considered in terms of their location and distribution, their altitudes and thicknesses, and their constituents. Results from the exposures and sections examined were felt to be sufficiently consistent over the whole area to allow generalisation of findings in this chapter rather than listing of individual exposures.

The distribution of these gravels as mapped by the Geological Survey proved to be somewhat misleading, for such deposits were found to extend over a large part of the area under consideration between the 300 foot and 500 foot contours. Over much of the area, however, they were less than 2 feet thick and were certainly more obvious at the surface where mapped by the Survey. The gravels within the gaps were considerably thicker than those in the Vale. The Wendover spreads, for example, were some 25 feet thick. The Wendover gravel was seen to be cut off on the crest of the gap watershed but the Tring and Dagnall lobes were found to thin rapidly northwards, i.e., away from the escarpment. The Vale gravel spreads showed a tendency to thicken opposite the wind-gaps, the Weston Turville and Gubblecote fans being up to 5 feet thick in contrast with the thin skin, less than 2 feet thick, of the adjacent areas.

Basically, the constituents of these gravels were found to be little different from those enumerated by Barrow and Green (1921), Sherlock (1922), and others. They consisted predominantly of flints of varying colours, exhibiting all stages of bleaching, weathering and exposure. Most were fresh and nobbly, or shattered into sharp angular fragments, and almost entirely unworn. This extremely coarse angular material had almost certainly come directly from the Upper Chalk. In addition, in certain restricted locations in the Tring Gap, some sub-angular and even some very few sub-rounded flints were noted. Tertiary flint pebbles were also well represented throughout the area, though there did seem to be a slight tendency towards a lessening of frequency in the vicinity of the Wendover Gap. The flints seemed, too, to exhibit a decrease in size and angularity towards the Gault outcrop, i.e., away from the escarpment.

Other constituents at various locations and in varying quantities included white quartz pebbles, sarsen pebbles, lydite and other fragments, which possibly were derived from the Chiltern plateau, together with local greensand - ironstone nodules (though the Upper Greensand is not actually mapped at the surface here). These were generally set in a chalky or clayey matrix. Barrow (1919) also claimed to have found a layer of white quartzite pebbles and other small, well-rounded stones beneath the Valley Gravel in the Wendover Gap, but, in spite of a fairly intensive search, this layer was not found.

Most of the earlier workers were united in noting the absence of any far-travelled stones in the Valley Gravels and Gravels opposite the Chalk Gaps. There is a reference, however, in Barrow and Green's writings (1921) to the occurrence of foreign material in a broad, flat-floored, unspecified, valley running parallel for some distance with the Chalk escarpment. In addition to flints and sarsens, Barrow located here Bunter Quartzites and tourmaline grits. From a survey of the distribution of these Bunter pebbles (tourmaline grits or other foreign material was not located in any quantity elsewhere) the accompanying map was compiled (Fig. 21). It will be seen that the Bunter material is plentiful in the Dagnall and Tring Gaps and in the vicinity of Cheddington, but is absent farther south-west (only one Bunter Quartzite was found in the Wendover Gap and one near Stoke Mandeville and it is unsafe to base any conclusions on these isolated occurrences). The pebbles extend altitudinally from 300 feet - 500 feet (but it must be remembered that the survey was not carried much beyond these limits).

This foreign material has a possible threefold origin. It may have been deposited by early consequent streams flowing from the Midlands to the Thames. It may have been deposited directly by ice, or it may have been incorporated in outwash gravels and redistributed

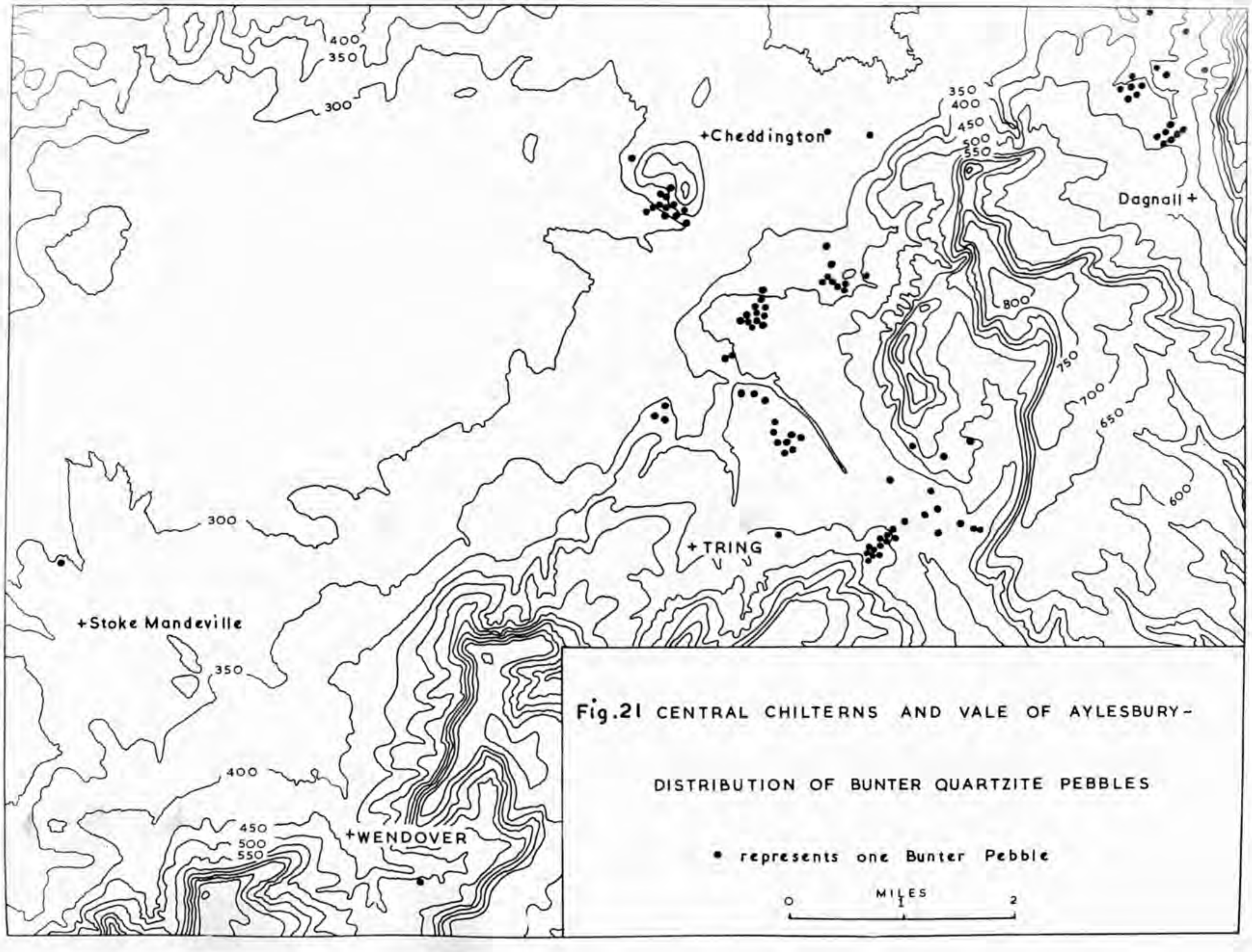


Fig.21 CENTRAL CHILTERNS AND VALE OF AYLESBURY–

DISTRIBUTION OF BUNTER QUARTZITE PEBBLES

• represents one Bunter Pebble

0 MILES 1 2

by melt-water streams. A consideration of the significance of its distribution and a discussion of its possible modes of origin will be made at a later stage.

The examination of the known Pleistocene deposits added little to the information already available. Patches of Glacial Gravel occurring north of the escarpment at 300 feet and 365 feet north of Cheddington (Grid Refs. 910 187 and 922 180), at 433 feet at Wingrave (Grid Ref. 870 190) and 300 feet north-west of Rowsham (Grid Ref. 843 188) were found to be of limited extent and abundant in Bunter Quartzites. Boulder clay, probably of Gipping age (King 1955), was located at the south-west end of Southend Hill, Cheddington (Grid Ref. 920 165), at 400 feet - 450 feet, and between Hulcott and Grendonhill, north of Aylesbury (Grid Ref. 830 170 to 842 170), at 263 feet - 298 feet.

In summary, the investigations of the gap and Vale gravel deposits would generally seem to emphasise their wide and fairly uniform distribution, and also to bring to light their change in altitude, thickness and nature away from the escarpment.

(c) SOIL PROFILES, EXPOSURES AND SECTIONS

From a personal examination of the profiles of the major soil series of the region, the following summarised descriptions have been compiled. Representative and fairly typical profiles are included to illustrate each series in the accompanying figures. Detailed mechanical and chemical analyses have been made, by Loveday (1958) and the Soil Survey (1951-56), of certain of these series. In the following descriptions those features of the series that are included are those which seem to be responsible for the series' peculiar characteristics, those which enable ready identification and those which appear to have a relevance to its morphological distribution.

(i) Batcombe Series (Fig.22(a))

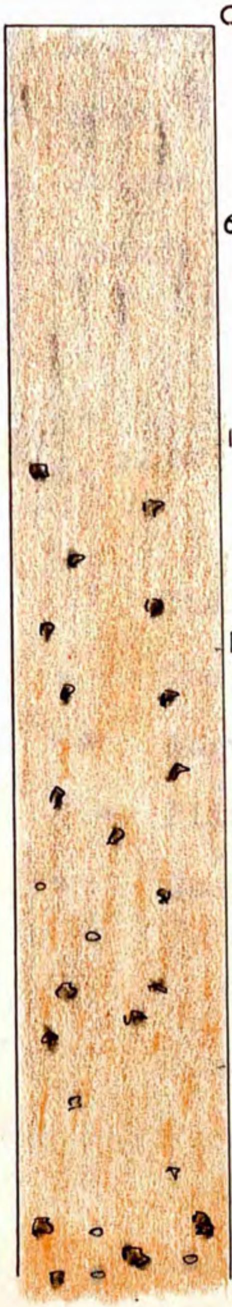
This is the principal soil of the Chiltern plateau and overlies the deep Plateau Drift at altitudes between 600 feet and 825 feet. Steep slopes are absent on the plateau surface and thus the soil is only moderately and sometimes imperfectly drained.

The surface horizon consists of a dark brown loam or silty loam over a lighter brown silty loam. The subsoil is characterised by a stiff yellow-red flinty silty clay changing to clay with red and grey mottling towards the base of the profile. The soil is generally acid throughout. Flints in varying proportions, both angular and rounded, are met throughout the profile with a maximum concentration in the sub-surface and upper subsoil horizons.

The series has been shown by field examination (in agreement with the Soil Survey) to be the weathered

Fig. 22 (a)

BORE NO.:	(i)
SOIL SERIES:	BATCOMBE SERIES
LOCATION:	Field West of Dockeywood, Ringshall 972 148
ALTITUDE:	c. 770 feet
GEOLOGY:	Clay-with-Flints over Upper Chalk
MORPHOLOGY:	Flat
SURFACE:	Grass
DRAINAGE:	Moderate.



0 Mid brown, extremely dry - falls off auger. Good loam. Flints on the surface. Texture 13.

6 Similar.

12 Similar but becoming lighter. Very dry. Flint fragments in the bore.

18 Light milk chocolate brown. Good medium loam. Flint stones in the bore. Extremely difficult to auger. Slight orange mottle.

24 Much more orange-brown with pronounced orange mottle. Tiny flint fragments. Silty loam. Still difficult to auger. Texture 14. Becoming even more orange brown. Chalk fragments, iron staining, flints. Moving towards

30 clay loam. Texture 17.

Similar in colour, moving towards a thick orange clay.

36 Bright orange clay with iron staining flints and chalk beads.

Fig. 22 (b)

INTERNATIONAL TEXTURE SYSTEM (Clarke 1941)

1. Coarse Sand	11. Fine Sandy Loam
2. Sand	12. Very Fine Sandy Loam
3. Fine Sand	13. Loam
4. Very Fine Sand	14. Silt Loam
5. Loamy Coarse Sand	15. Sandy Clay Loam
6. Loamy Sand	16. Clay Loam
7. Loamy Fine Sand	17. Silty Clay Loam
8. Loamy Very Fine Sand.	18. Sandy Clay
9. Coarse Sandy Loam	19. Clay
10. Sandy Loam	20. Silty Clay.

Fig. 22 (c)

KEY TO SYMBOLS USED IN PROFILES

Chalk fragments	Quartz crystals
Chalk beads	Sandy concretions
Angular flints	Manganese concretions
Flint pebbles	Crowstone
Quartzite pebbles	Ironstone

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remains of Upper Chalk, Reading Beds and later deposits, redistributed by local snow or ice caps during the early Pleistocene (Sherlock 1947). From its location on the Mio-Pliocene peneplain, Wooldridge and Linton (1955) feel that much of the underlying drift was formed in Tertiary times and only subject to rearrangement under periglacial conditions.

(ii) Winchester Series (Fig. 23)

This series is again characteristic of the Mio-Pliocene plateau, as well as the Calabrian bench. It is located chiefly on spurs and gentle slopes towards the plateau edge, but isolated patches occur at lower levels in the wind-gaps. Drainage is free or moderate.

The surface horizon is generally a dark grey-brown loam or silty loam with a more yellow-brown subsurface horizon. The series is characterised by a subsoil of brown to yellow-red, very sticky, plastic clay with black manganiferous staining in the lower parts. Flints are abundant in the subsoil, broken in the upper part, but more nodular at depth. The chalk surface, which is often irregular and piped, is encountered between depths of 18 inches and 6 feet. The profile is again acid throughout.

This typical yellow-red clay is thought to be the original residual Clay-with-Flints of Whitaker (1889).

Fig.23

BORE NO.: (ii)

SOIL SERIES: WINCHESTER SERIES

LOCATION: Pendley Manor Estate 946 115 Field adjacent.

ALTITUDE: 475 - 500 feet.

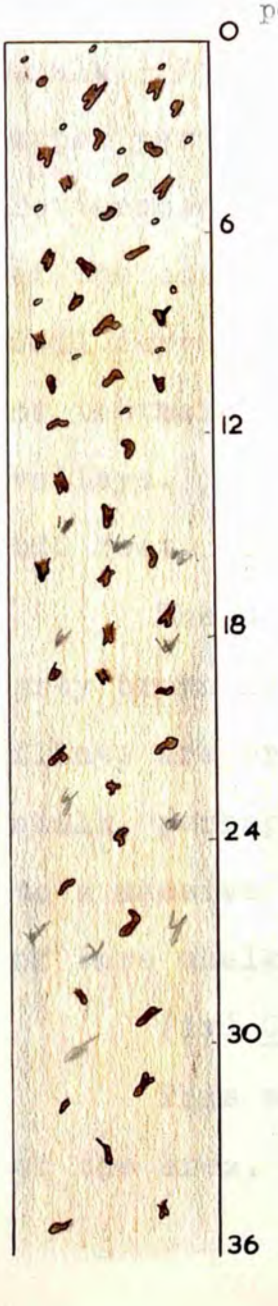
GEOLOGY: Patch of Clay-with-Flints on Middle Chalk.

MORPHOLOGY: " Slight flattening of surface.

SURFACE: Many flints, broken and rounded. All sizes, $\frac{1}{2}$"-6" diameter. Ploughed field.

DRAINAGE: Moderate.

(Stones on surface include red oxidised flints, sarsen pebbles and rounded Bunter Quartzite pebbles)



0–6: Mid-brown with broken and rounded flints. Clay loam? Texture 17. Chalk beads. Very sticky.

6–12: Ochre brown, very soft and sticky. Much small broken flint. Chalk beads. Texture 17. Moulds easily.

12–18: Light ochre, plastic, soft with flint fragments. Manganese concretions.

18–24: Stiff light ochre with angular flints.

24–30: As above. Curls off auger. Mottle with dark black manganese concretions. Fewer flints. Texture approaching clay.

30–36: Very stiff clay loam, almost a clay, light ochre colour.

Loveday (1958) concludes that it is generally in part derived from the Chalk and in part from overlying deposits either by the migration of clay from above or the synthesis of new clay from silica and sesquioxides in solution in the overlying material.

(iii) Icknield Series (Figs. 24,25.)

The Icknield Series is a rendzina, a shallow calcareous soil, derived directly from the Upper and Middle Chalk. It does, however, extend in places over the upper part of the Lower Chalk, up to and including the Totternhoe Stone. Thus it is found on the steep slopes of the escarpment and valley sides. In addition, the Soil Survey have recognised a deep phase along the foot of the main slopes and filling all the scarp channels and valleys. So it may occur at altitudes from 300 feet to 800 feet. Drainage is free or excessive.

The upper 12 inches usually consists of a dark grey brown loam, often very chalky and friable. Occasional flints are present. Below this it passes into fragmentary chalk, perhaps with a little humus, and this gives way to a massive compact white chalk. Where eroded, patches of bare chalk may occur at the surface.

(iv) Coombe Complex (Fig.26)

This soil covers the valley sides and foot slopes of the area, on either steep or gentle slopes, and the

Fig.24

BORE NO.: (iii)

SOIL SERIES: ICKNIELD SERIES

LOCATION: Field 500 yards west of Church Farm, Aldbury. 955 125.

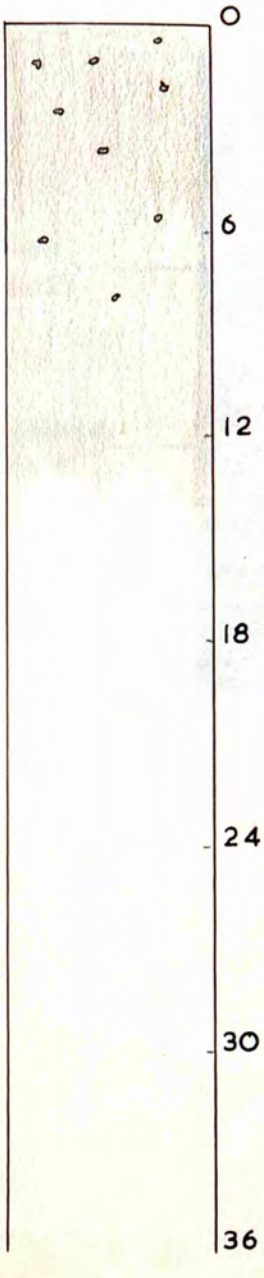
ALTITUDE: 500 feet.

GEOLOGY: Middle Chalk.

MORPHOLOGY: Slope of spur between Aldbury Valley and Gap.

SURFACE: Field of stubble.

DRAINAGE: Free.



Grey brown silty loam.
Chalk beads.
Typical rendzina appearance.

Lighter grey silty loam.

Crumbled chalky paste at 15".

Fig. 25. Exposure of Icknield Series.

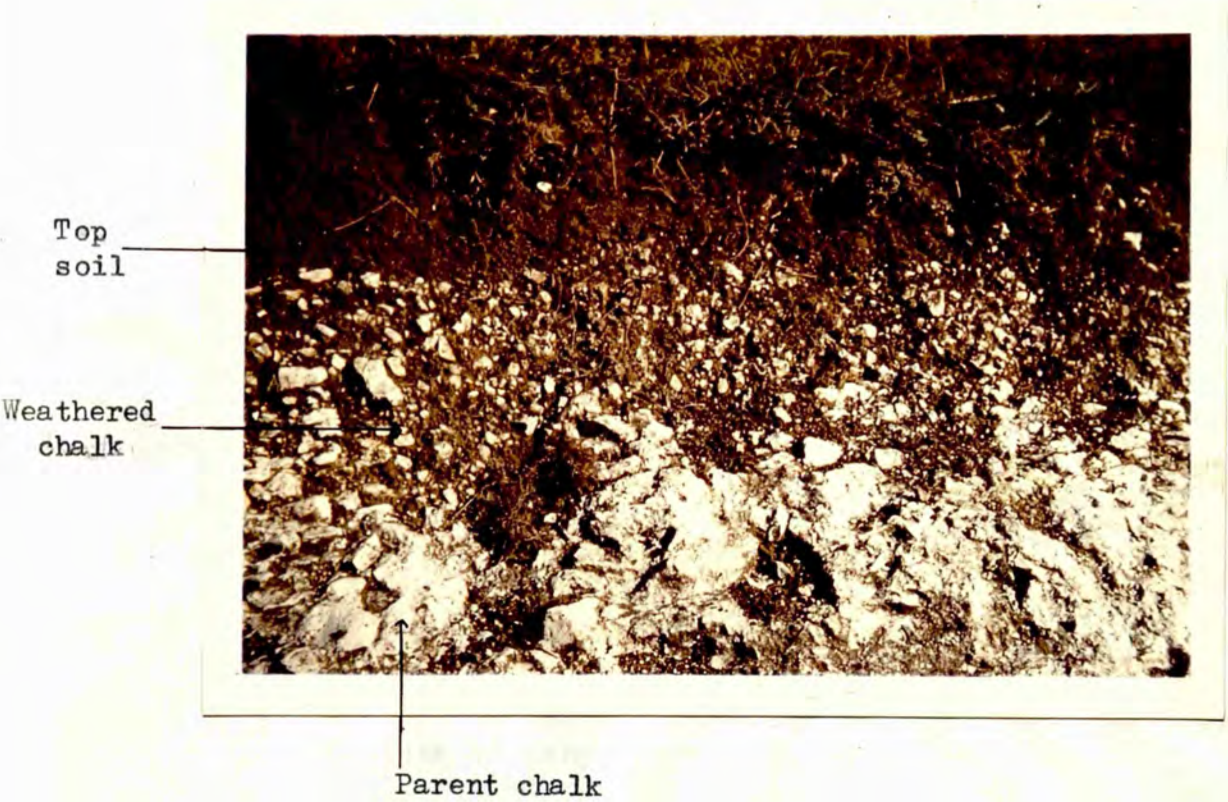
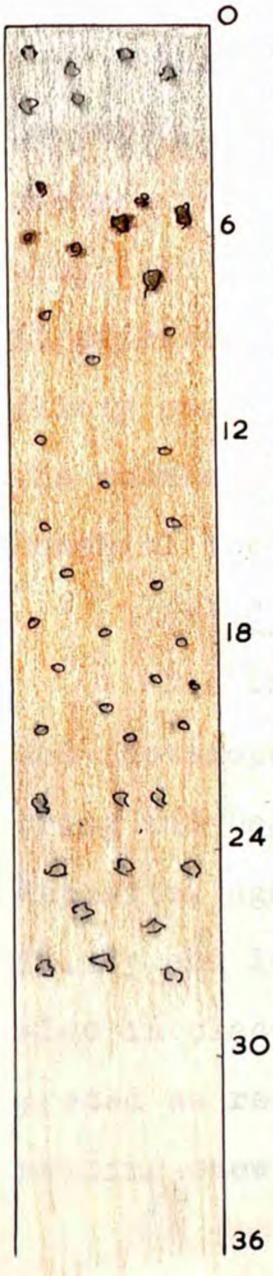


Fig.26

BORE NO.:	(iv)
SOIL SERIES:	COOMBE COMPLEX
LOCATION:	Pendley Manor Estate. 945 113. Field immediately adjacent to main Berkhamsted - Tring road.
ALTITUDE:	500 feet.
GEOLOGY:	Middle Chalk.
MORPHOLOGY:	Summit of small spur or flat.
SURFACE:	Ploughed field littered with broken flints and rounded flint pebbles.
DRAINAGE:	Moderately free.



Grey brown top soil, many chalk fragments. Silty loam?

Texture 14 or 16.

Becoming lighter - more orange brown.

Light orange-brown silty loam. Flint fragments of varying sizes.

Chalk beads.

Similar light brown colour. Silty loam.

Texture 14.

Chalk beads. Very uniform and even.

Same colour. Much more chalk.

Becoming lighter brown.

Texture 14 verging on silty clay loam (16).

At 24" chalk rubble and paste. Flint free.

Soft, white broken chalk, plastic, moulds easily.

At 26" - parent chalk.

dry valley bottoms. It is often fairly extensive in the wind-gaps. It overlies and appears to be directly developed from patches of chalky, flinty coombe or head deposits which may vary from a few inches to several feet in thickness. These deposits are largely a result of solifluction during the Pleistocene, but material from recent rainwash is also probably incorporated. They are generally well-drained.

The Coombe Complex exhibits considerable variety in depth, texture and stoniness. As a whole the upper horizon is a grey brown calcareous flinty silty loam to clay loam resting on a light brown to white chalky loam. At approximately 18 inches, this passes to a very pale flinty chalky rubble or chalk. On very steep slopes, the coombe deposits are much thinner and less conspicuous. Downhill the Coombe Complex grades into the Charity soil.

(v) Charity Complex (Fig. 27)

The Charity Complex is located on valley bottoms and footslopes, and is particularly pronounced in the Tring and Dagnall Gaps. The underlying coombe or head deposits, again presumably of Pleistocene origin, are flinty and loamy and only calcareous at depth. They also in places exhibit a rough stratification, interpreted as resulting from the action of solifluction and melting snow. Slopes are usually gentle or moderate

Fig. 118
27

BORE NO.: (v)

SOIL SERIES: CHARITY COMPLEX

LOCATION: Field abutting canal, 500 yards East of Pendley Farm. 949 119.

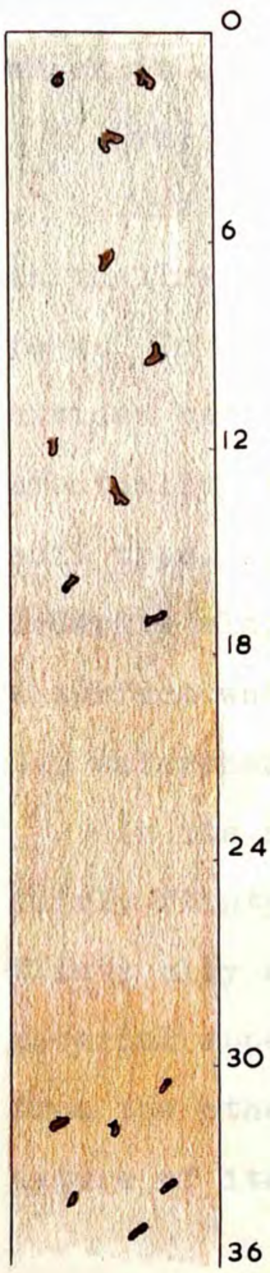
ALTITUDE: 400-425 feet.

GEOLOGY: Valley gravel overlying Lower Chalk.

MORPHOLOGY: Flat plain - floor of Gap.

SURFACE: Field of Winter wheat. Angular and rounded flints on surface.

DRAINAGE: Moderate.



Dark brown silty loam (14).
Occasional flint - large and angular.

Same. Slightly lighter.
Sharp angular flints.

Lighter brown. Texture 14.
A few angular flints.

Even milk-chocolate silty loam.
Very uniform.
Remarkably free from flints and chalk.

Same.
At 28" change to much lighter (almost ochre) brown.

Clay loam (17) with more small angular flint fragments.

Passing to pale-brown chalk rubble.

and drainage is free.

The surface horizons are characterised by brown flinty or pebbly silty loams or loams. At 9 inches to 12 inches, the subsoil assumes a more reddish brown colour and becomes a finer flinty silty clay loam to silty clay. It becomes stiffer and firmer with depth and may pass into loose flinty gravel. At any depth below about 15 inches it rests on chalky rubble and coombe deposits from which it appears to have been formed in situ.

(vi) Tring Series (Fig. 28)

This soil occurs only, with any reasonable depth, in the Tring Gap at altitudes between 400 feet and 450 feet. In the early years of work on the area it was divided between the Coombe and Charity Complexes, but eventually it was realised that it was a distinctive soil type. It occupies areas sloping, with gentle to moderate slopes, towards the Chilterns, i.e., it occupies a surface which slopes southwards to the present Tring Gap watershed. It is usually freely drained.

In its upper parts it is, characteristically, a fairly flinty clay loam. This overlies a brown stiff flinty clay with some rusty mottling; this loamy, clayey material appears to be a form of drift, differentiated from the other local drifts by its position and the nature of its stone content. The flints at the surface

Fig.28

BORE NO.: (vi)

SOIL SERIES: <u>TRING SERIES</u>

LOCATION: First field East of road from Tring Grove to Marshcroft Cottages. 935 125.

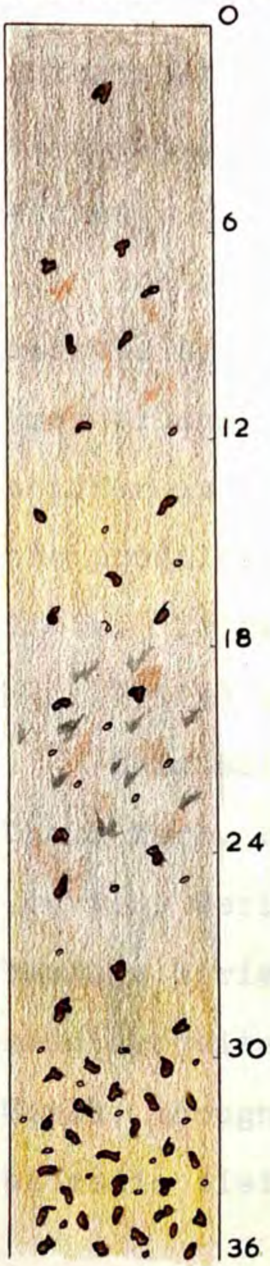
ALTITUDE: 425 feet.

GEOLOGY: Valley gravel.

MORPHOLOGY: Flat gap floor.

SURFACE: Winter wheat field. Littered with gravel, mostly flint - some round, some angular, varying in size from $\frac{1}{4}$" - 2-3". All stages of weathering. Several Bunter Quartzites (rounded). White (iron-stained) more or less rounded quartzite pebbles.

DRAINAGE: Free.



Dark brown silty loam (14). One flint fragment. Very uniform and even.

Lighter colour. Tiny angular flint fragments. Silty clay loam (16). Slight mottle. Cold soil.

More yellow brown. Chalk beads and flint fragments.

More grey brown (16). Mottled grey. Manganese concretions. Little chalk beads (minute).

At 28" grey brown passes into more yellow grey brown (16) with angular flints and possible chalk fragments. Gradually chalk beads and angular flint fragments increase. Mottled.

Yellow brown silty clay loam (16) packed with tiny white flint fragments and chalk beads.
At 33" becomes stronger yellow. Sandy clay loam (15). Packed with flint fragments - sharp and angular. Some rounded fragments.

Some chalk beads.

<u>P.T.O.</u>

36-39"	Similar yellow matrix with chalk and flint grit. Mottled. Manganese. Larger flint fragments. Towards bottom - stiffer sandy clay. Tendency for larger flint fragments to come in.

Fig.29

BORE NO.: (vii)

SOIL SERIES: <u>WANTAGE</u>

LOCATION: 50 yards North-East Church End Moat, Pitstone. 945 152.

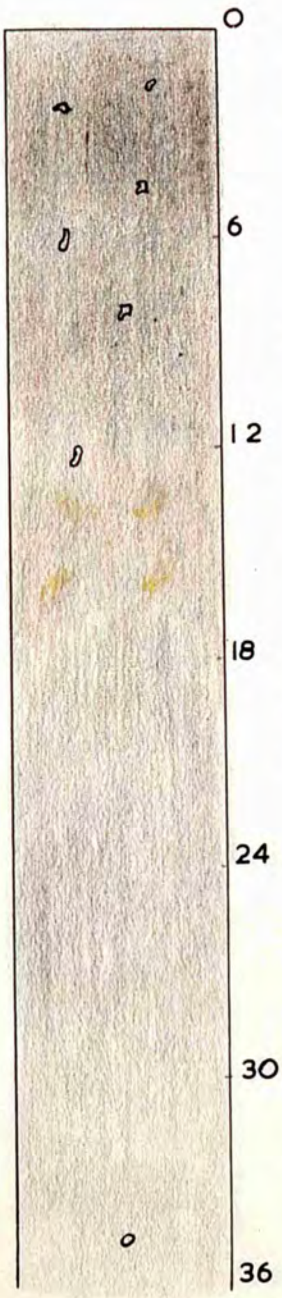
ALTITUDE: 400 feet.

GEOLOGY: Lower Chalk.

MORPHOLOGY: Gentle slope.

SURFACE: Some chalk. Little angular flint. Under grass.

DRAINAGE: Moderate.



Dark grey brown silty loam. Texture 14.
Flint free. Some small fragments.

Same, slightly lighter in colour.

Same, changing to even grey brown with
lighter brown mottle.

Pale grey silty clay loam (16).
Absence of flints or chalk beads.

Light grey paste.
Chalky silty clay loam to clay loam (16-17).

Same - changing to compact Chalk Marl.

Fig.30

BORE NO.: (viii)

SOIL SERIES: HALTON COMPLEX

LOCATION: Field North-West of Wendover Station. 860 085.

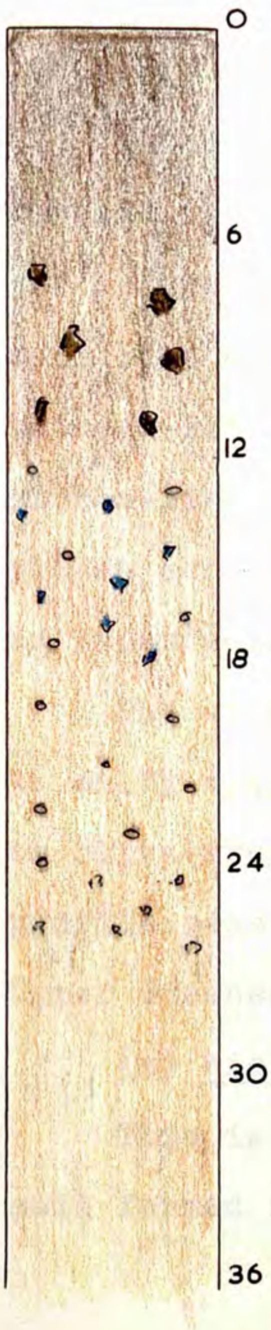
ALTITUDE: 400 feet.

GEOLOGY: Lower Chalk.

MORPHOLOGY: Flat.

SURFACE: Grass.

DRAINAGE: Moderate.



Dark brown silty loam. Texture 14.

Lighter brown. Angular flints. Orange grey mottle.
Silty clay loam. Texture 16.

Even lighter brown. Chalk beads and crow-stone.
Orange grey mottle. Silty clay loam. Texture 16.

Chalk beads. Orange sand inclusions. Texture 15.

Chalk paste. Texture 16.
Crumbly chalk paste. Moist chalk.

Silty with sandy particles (black).
Silty clay loam. Texture 16.

apparent. It is found on the gentle even grades of the Chiltern footslopes and on shelf-like flats in the landscape. Drainage may be moderate or imperfect.

In its upper parts it is a brown, mainly flinty, clay loam or silty clay loam, giving way to an olive or grey-brown stiff calcareous soil. This eventually passes into coombe deposits of rust-mottled flint and chalk rubble, and Chalk Marl.

(ix) Harwell Complex (Fig. 31)

Although the Upper Greensand is not mapped at the surface in this area, its presence can be detected from the occurrence and outline of the Harwell Complex. This soil lies along the piedmont zone of the escarpment between altitudes of 300 feet and 350 feet in a narrow, ribbon-like strip. It occupies the gentle to moderate slopes above the Gault Clay plain and is only moderately or imperfectly drained.

The upper horizons are found to be fine sandy loams to silty clay loams while the subsoils are olive-brown or olive-grey, stiffer and rust-mottled. Eventually the profile passes into the fine sandy green marls of the Upper Greensand.

(x) Wicken Series (Fig. 32)

This is a typical imperfectly or poorly drained soil formed from Gault Clay which has been superficially

Fig 31

BORE NO.: (ix)

SOIL SERIES: <u>HARWELL COMPLEX</u>

LOCATION: Halton Airodrome, off Halton - Bye Green Road. 868 107.

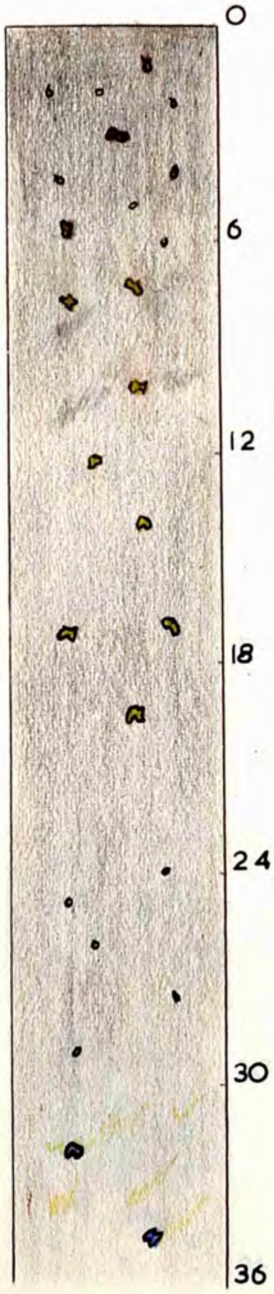
ALTITUDE: c. 369 feet.

GEOLOGY: Upper Greensand.

MORPHOLOGY: Flat.

SURFACE: Grass.

DRAINAGE: Free.



Dark grey brown colour, with chalk beads, silty loam, texture 14.

Small flint fragments.

Lighter grey brown colour, with a grey mottle.

Small sandy concretions. Clay loam, texture 17.

Dirty grey colour. Clay loam, texture 17.

Very occasional sandy concretions. Moulds easily.

Same dirty grey even colour. No mottle.

Moving towards a clay. A few sandy concretions.

Small chalk beads. Monotonous di rty grey brown colour.

Whiter grey, stiffer, closer texture. Almost clay.

Becoming almost white, with a yellow sandy mottle.

Very uniform even colour. Small crowstone. Clay texture but moulds quite easily. Dries out white.

Fig.32

BORE NO.: (x)

SOIL SERIES: WICKEN SERIES

LOCATION: Field South of Mitchell Leys Farm, Wingrave. 872 185.

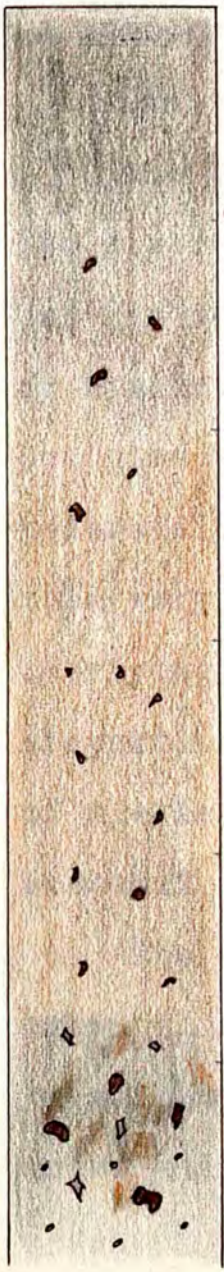
ALTITUDE: c. 355 feet.

GEOLOGY: Gault Clay.

MORPHOLOGY: Gentle slope.

SURFACE: Grass.

DRAINAGE: Moderate.



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Dark brown silty loam. Texture 14.

6

Same - lighter brown. Very even and uniform.
Slight gravel - flint.

12

Same - even mid brown.

18

Same - slightly stiffer.
Small flint fragments.

24

Stiffer. Slightly flinty. Same colour.

30

Slightly greyer brown. Small quartz crystals and large flint fragments. Orange-grey-brown mottle, marked.
Very stiff silty clay loam. Texture 16. Small chalk beads.
Becoming lighter grey brown and clay loam. Texture 17.

36

reworked. It is generally found on slight rises in the Gault plain at or just below 300 feet, and thus occupies gentle to moderate slopes.

The upper 8 inches or so of the profile consists of a dark brown-grey clay loam or clay. This rests on olive or yellow-grey very stiff mottled clay, becoming a more definite olive-grey with depth. Sandy or gravelly layers may occur very occasionally. Ultimately, light grey calcareous clay is encountered.

(xi) Gubblecote Series (Fig. 33)

The Gubblecote Series is, in effect, confined in its distribution to the Gravel outlier opposite the Tring Gap (as mapped by the Geological Survey) and thus has an altitudinal range of some 285 feet to 337 feet. It occupies very gently sloping flats and is again only moderately or imperfectly drained. It seems to be developed very largely from the chalky gravelly head deposits overlying the Gault though may perhaps contain a minute proportion of Upper Greensand material. The distribution of the head deposits overlying the Gault continues to be somewhat problematical in its irregularity.

The upper 9 inches of the series is a dark grey brown flinty clay loam or sandy clay loam, and it may be slightly calcareous. Beneath is an olive or grey brown stiff, chalky subsoil which passes into coarse,

Fig.33

BORE NO.: (xi)

SOIL SERIES: GUBBLECOTE SERIES

LOCATION: West of Startopsend Reservoir. 916 139.

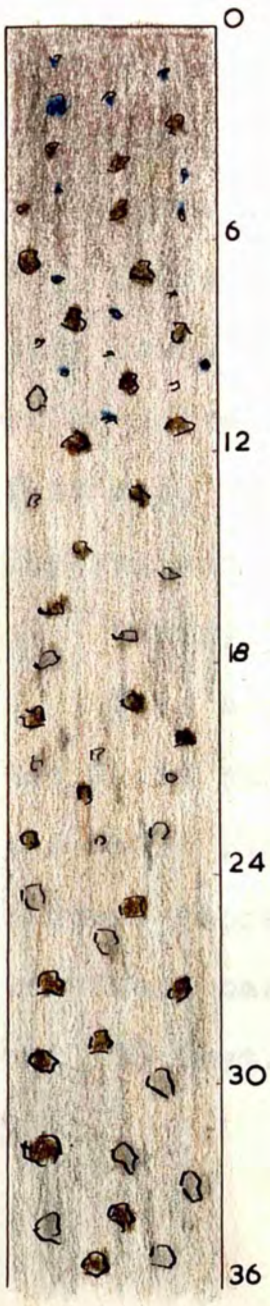
ALTITUDE: 325 feet.

GEOLOGY: Gravel over Lower Chalk.

MORPHOLOGY: Flat.

SURFACE: Grass.

DRAINAGE: Moderate to good.



Dark grey brown with crow-stone, flints. Silty loam. Texture 14.

Lighter grey brown. Large flints, crow-stone and crushed chalk. Poor silty loam.

Really dirty grey brown. Chalk fragments and flint. Moving towards a sandy clay loam. Texture 15.

Grey brown chalky flinty clay loam.

Coarse flint and chalk gravel.

Coarse gravel.

rust-mottled flint and chalk gravel.

(xii) <u>Weston Turville Series</u> (Fig. 34)

The Weston Turville soil is similarly virtually confined in its distribution to the Gravel outlier opposite the Wendover Gap with an altitudinal extent of 281 feet to 313 feet. Its localisation likewise needs explanation. It appears to have been dissected by stream or spring erosion and spreads over the intervening gentle even slopes and flats. Drainage varies from imperfect to poor. The parent material would again seem to be chalky gravelly head over Gault.

Its surface textures are characterised by flinty clay loams or sandy clay loams, while the subsoil consists of an olive to grey-brown, stiff and rust-mottled soil. This may, at intervals, contain flint and chalk gravel layers, and occasionally sandy layers.

(xiii) <u>Challow Complex</u> (Fig. 35)

This soil is derived from a more clayey head over the Gault and again has an interesting distribution on the Gault plain. It seems to prefer gentle even foot-slopes, depressions and flats and is particularly evident in stream basins and shallow valleys between 250 feet and 300 feet. Drainage is obviously, for the most part, poor.

Fig.34

BORE NO.: (xii)

SOIL SERIES: WESTON TURVILLE SERIES

LOCATION: Two fields West of Rectory Farm. Weston Turville - Aylesbury road. 852 118.

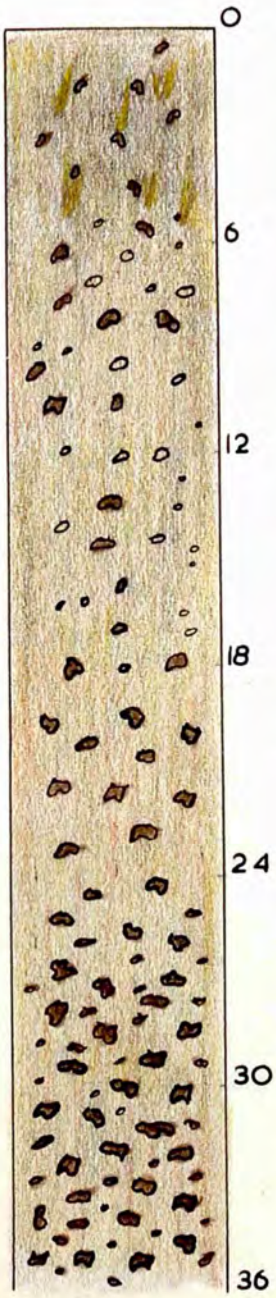
ALTITUDE: c. 300 feet.

GEOLOGY: Gravel over Gault.

MORPHOLOGY: Flat.

SURFACE: Littered with angular flints.

DRAINAGE: Moderate.



Dark yellow brown silty loam. Texture 14. Small flint fragments. Lighter yellow brown mottle.

Lighter yellow brown. Many large flint fragments. Chalk fragments and chalk beads. Texture 14. Silty loam.

Same. Crushed appearance. Gritty.

Becoming very gritty. Difficult to auger. Large flints. Becoming sandy. Change to texture 10.

Sandy loam.

Flints now so numerous that give appearance of a solid layer. Augering becomes increasingly difficult and eventually virtually impossible.

Fig.35

BORE NO.: (xiii)

SOIL SERIES: CHALLOW COMPLEX

LOCATION: Field South of Boarscroft Farm, South of Wingrave. 880 173

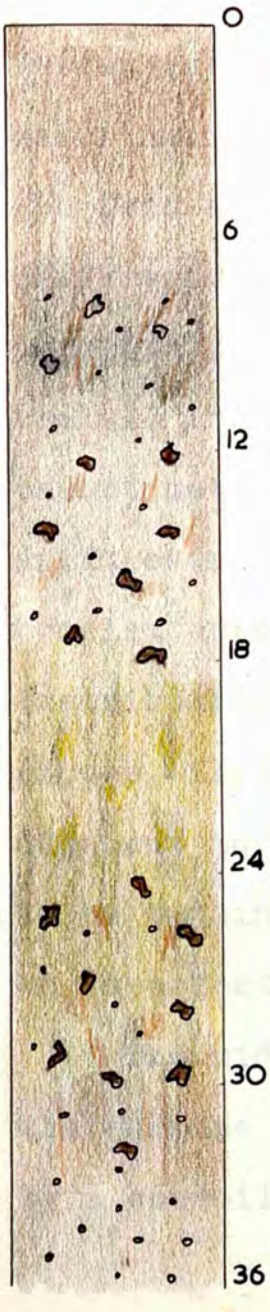
ALTITUDE: c. 270 feet.

GEOLOGY: Gault Clay.

MORPHOLOGY: Flat.

SURFACE: Grass.

DRAINAGE: Moderate.



Even mid to dark brown silty loam 14.

Dark grey brown with orange grey mottle. Some crushed chalk and chalk beads (washed down). Silty loam, 14, moving towards silty clay loam, 16.

Grey brown clay with orange grey mottle. Chalk beads and flint fragments.

Light grey yellow brown clay with similar mottle. Clay loam. Texture 17.

Dirty yellow brown clay with flint fragments, chalk beads and orange brown mottle. Sticky and tacky. Stiffer - moving towards clay.

Plastic grey brown clay. Moulds well. Chalk beads.

Getting towards pure soft grey clay with chalk beads.

The surface clay or clay loam relatively quickly gives way to a very stiff, or sometimes plastic, clay which is grey or olive in colour. It may exhibit yellow mottling. Occasionally sandy or gravelly layers may be located. Chalk is usually absent.

(xiv) Rowsham Complex (Fig. 36)

This Complex overlies both the Glacial Gravel with Bunter Pebbles and the Boulder Clay of the Geological Survey (apart from the Cheddington patch). These deposits occur north of Aylesbury at altitudes varying between 250 feet and 450 feet. There is not, however, a sufficient difference between the profiles developed on these two deposits to warrant establishing separate series. Hence the all inclusive term 'complex' is used. Basically, the parent material of this soil is a mixed loamy and gravelly drift over Gault and Kimmeridge Clays. The Rowsham Complex appears to have had a formerly more extensive distribution, but now occupies gentle to moderate foot-slopes, flat plateau remnants and terrace like features adjacent to the Upper Thame. The river seems, in fact, to be cutting down through the drift. It is generally an imperfectly or poorly drained soil.

The mid to dark grey-brown sandy or clay loams of the surface horizons, which are often pebbly, are replaced by a subsoil which is a strong yellow or grey brown in

Fig. 133
36

BORE NO.: (xiv)

SOIL SERIES: ROWSHAM COMPLEX

LOCATION: Field South of Wingrave cross roads. 860 192.

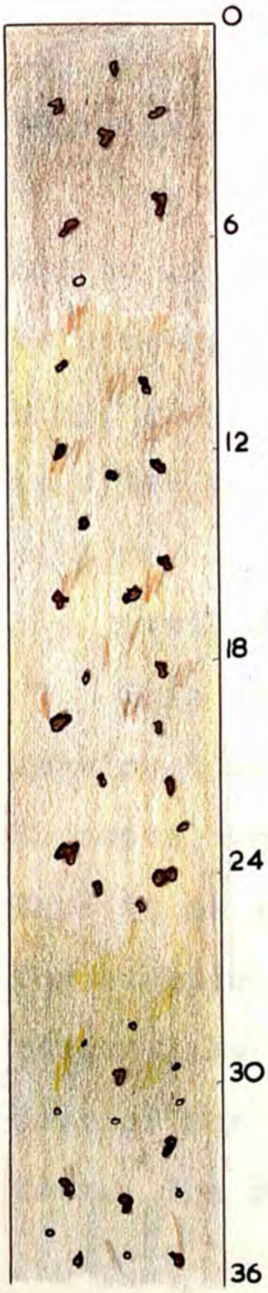
ALTITUDE: c. 300 feet.

GEOLOGY: Glacial Gravel with Bunter Pebbles over Upper Greensand and Gault.

MORPHOLOGY: Flat plateau remnant.

SURFACE: Grass.

DRAINAGE: Moderate.



0 — Silty loam, texture 14. Mid-dark brown. Flint fragments.

6 — Slightly lighter yellow brown. White quartzite. Silty loam. Orange brown mottle.

12 — Lighter yellow brown. Orange-grey mottle. Small flint fragments. Gritty. Clay loam, texture 17. Moulds easily.

18 — Light yellow dirty brown. Orange-grey-brown mottle. Small flints. Gravelly. Larger flints coming in. Moulds well. Clay loam.

24 — Much greyer. Light yellow brown mottle. Chalk beads. Tending towards a very soft plastic clay.

30 — Grey brown soft clay. Chalk beads. Grey brown mottle. Tending to a boulder clay. Becoming stiffer and packed with chalk and flint fragments.

36 — Maxshed and crushed appearance. True boulder clay.

colour. It tends to become stiffer and rust-mottled, and may contain sandy or gravelly layers before passing into a grey clay.

(xv) Mead Series (Fig. 37)

The Mead Series is developed entirely on clayey alluvium over Gault and is confined in its occurrence to the valley of the Thame. Altitudinally it extends, in the area under consideration, from the 250 foot to the 300 foot contour, and is found chiefly on alluvial flats. Drainage is poor.

The upper part of the Mead profile consists of a mid to light brown silty clay loam to clay, which may be somewhat peaty. It quickly passes to a very plastic clay, grey in colour and calcareous. Yellow mottling is often present, and layers of fine chalky gravel or silt may be encountered.

(xvi) Ford End Complex (Fig. 38)

This is another soil of alluvial origin. It is developed on chalky alluvium and gravel, and spring deposits, which overlie the Gault Clay and Chalk Marl. Thus it is located chiefly on flats alongside streams, for example, the Whistle Brook, and it extends in a finger-like fashion from the Gault plain towards the foot of the Chiltern escarpment from 250 feet to 350 feet. The Ford End Complex appears to dissect the

Fig.37

BORE NO.: (xv)

SOIL SERIES: MEAD SERIES:

LOCATION: Rowsham Bridge. 846 176.

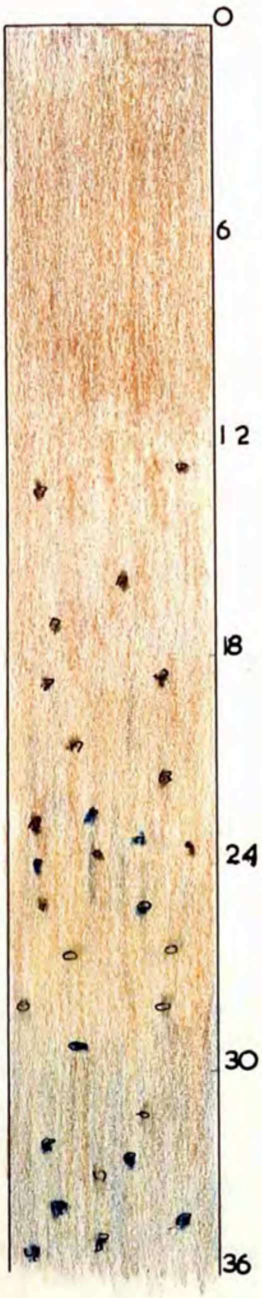
ALTITUDE: 257 feet.

GEOLOGY: Kimmeridge Clay.

MORPHOLOGY: Valley floor.

SURFACE: Flat.

DRAINAGE: Poor.



Mid-brown silty loam. Texture 14.

Light brown even silty loam.

Slightly lighter brown stiffer silty loam, very uniform. Occasional very minute flint fragments.

Orange brown, occasional flint fragments. Orange mottle.

Sandier. Sandy clay loam. Texture 15.

Becoming sandier and more orange. Sandy clay loam.

Sandy orange mottle, flint fragments. Tiny crow-stone fragments.

Orange-grey mottle, similar orange-brown colour. Tiny crow-stone and tiny chalk beads.

Orange-grey mottle, lighter orange brown colour. Sandy clay loam, chalk beads and flint fragments.

Similar, slightly greyer in colour and wetter. Moving towards silty clay loam. Texture 17.

Similar, patches of grey clay, but it is still a sandy clay loam. Crow-stone more pronounced. Very dirty, crushed appearance.

Fig.38

BORE NO.: (xvi)

SOIL SERIES: FORD END COMPLEX

LOCATION: North of Wendover Station. 863 086.

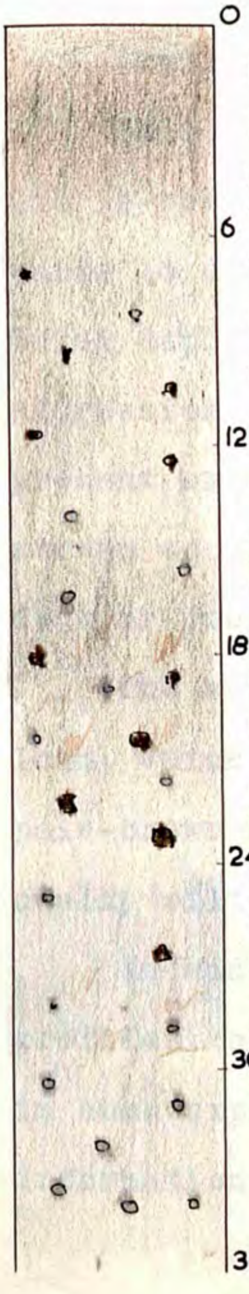
ALTITUDE: 400 feet.

GEOLOGY: Lower Chalk.

MORPHOLOGY: Stream valley.

SURFACE: Flat.

DRAINAGE: Imperfect.



Dark peaty brown, very fine and full of humus. Medium loam. Texture 13.

Mushroom-brown to orange-brown. Incompletely decomposed vegetable matter. Same peaty texture.

Same mushroom brown colour streaked with darker brown. Peaty with small flints and tiny bits of chalk. Very wet. Same texture.

At 14" changes to dark grey with orange mottle, chalk beads and undecomposed vegetable matter. Very wet. Clay loam. Texture 17.

Same dark grey-brown with chalk inclusions and flint. Still a wet clay loam. Lighter brown.

At 21" becomes much lighter grey with chalk beads, and vegetable matter. Very wet.

Similar although a slightly bluer grey. Stiffer and more compact with less vegetable matter. Grey throughout although a slight mottle due to vegetable matter. Still wet. Clay loam. Texture 19.

Similar. Pure grey with chalk beads.

various head deposits over the Gault, i.e., it appears to be a very recent soil. It is imperfectly or poorly drained.

The upper 12 inches or so are generally a very dark, almost black, calcareous loam to silty clay loam and may also be mottled or peaty. The subsoil is grey or olive in colour, very chalky and often slightly rust-mottled. Layers of flint gravel and fine chalk may be present.

(xvii) Gade Complex (Fig. 39)

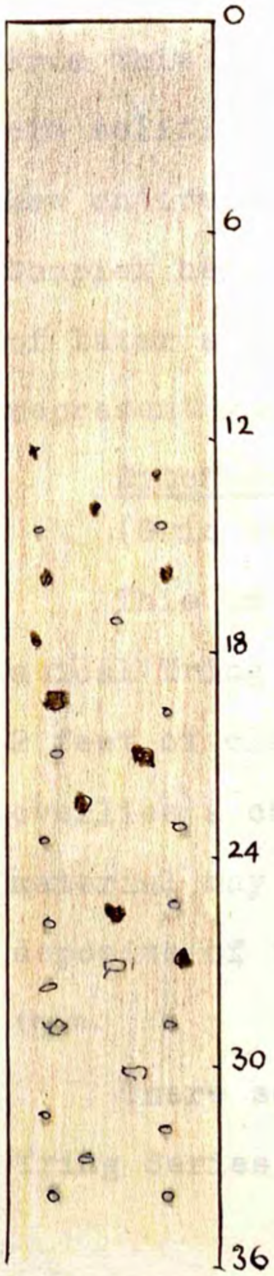
This soil is developed on mixed alluvium over chalk and is restricted to the Gade Valley. It extends northwards as a narrow ribbon right into the mouth of the Tring Gap, i.e., up to 400 feet. Its topographical expression on such alluvial flats suggests that its present extent marks part of the course of the former stream occupying the gap. Drainage is generally imperfect or poor.

The surface horizon is a grey brown silty loam or loam, which may sometimes be gravelly. Beneath is a pale-brown silty loam with rust-mottling. Layers of chalky silt and flint gravel may be obvious.

In addition to the examination of the nature of the profiles, certain problematical soils were considered in such exposures and sections as were available. The information gained from such investigations will be

Fig.39

BORE NO.:	(xvii)
SOIL SERIES:	<u>GADE COMPLEX</u>
LOCATION:	Field adjacent to canal crossing, 500 yards West of Tring Station. 949 121.
ALTITUDE:	400-425 feet.
GEOLOGY:	Valley gravel overlying Lower Chalk.
MORPHOLOGY:	Flat plain. Floor of gap.
SURFACE:	Pasture.
DRAINAGE:	Imperfect.



Grey brown silty loam.

Light brown silty loam.

Light brown with flint fragments.
Chalk beads.

Light brown silty loam.
More flints and chalk beads.

Lighter brown.
More crushed chalk and some chalk beads.

Pale brown chalky paste –
with chalk beads.

briefly summarised at this point.

Wendover Gravel Pit (Grid Ref. 875 065)

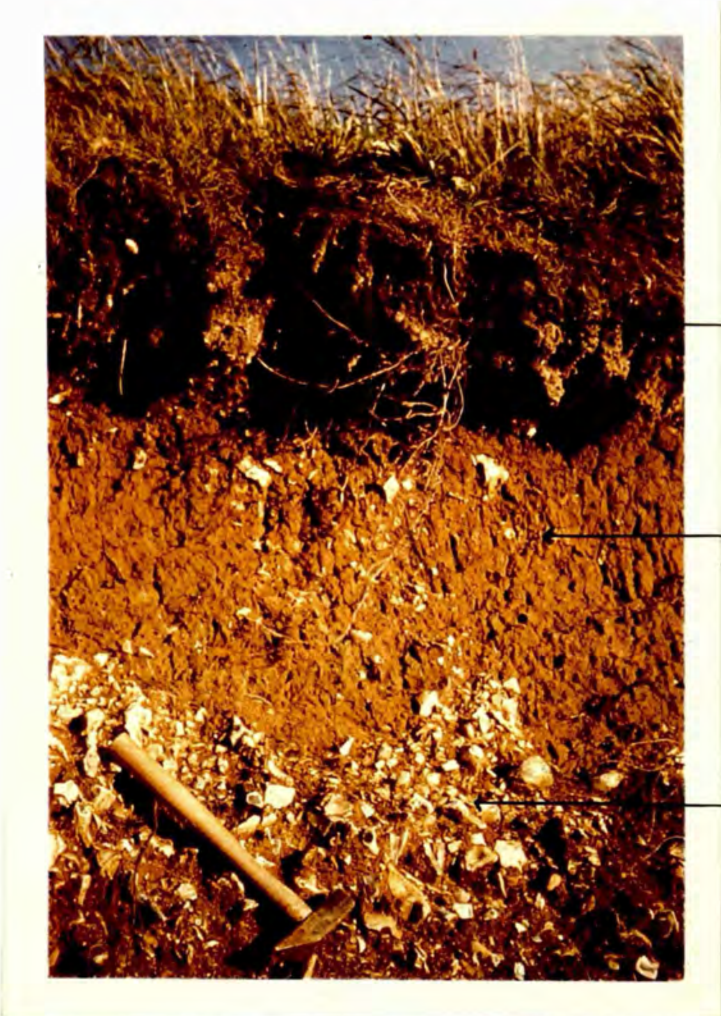
This pit enables an examination to be made of the Charity Complex in section (Fig. 40). The silty nature of the upper part of the soil is clearly seen, and bears out the theory of loess accessions in the upper horizons. It is entirely free from chalk and contains many large angular flints, which are not waterworn to any degree. From this exposure, the Complex appears to be a very old solifluction deposit from the adjacent plateau top, now entirely decalcified. The surface of the Charity Complex here exhibits frost heaving, with a thin layer of later solifluction material on top. This must represent much later periglacial conditions.

Ditch Section South of the Upper Icknield Way (Grid Ref. 133 933)

This is perhaps the best exposure of the problematical Tring Series in the whole of the Tring Gap. Here, 2 feet of clayey material, comparatively flint free, overlies a chalky solifluction deposit. This underlying material may be of the same age as the parent coombe deposits of the Charity Complex, or it may be prior to them.

There seem to be two possible explanations of the Tring Series from this section. The Tring Series may

Fig. 40. Section in Wendover Gravel Pit.



be entirely a solifluction deposit, the upper part of which has been completely decalcified. This, however, leaves its clayey nature, the paucity of flints, the presence of Bunter pebbles, and its morphological situation, unaccounted for. On the other hand, it may be a drift or till, but this raises problems of its age and emplacement. These, however, will be considered at a later stage.

Railway Cutting Section at Folly Bridge (Grid Ref. 938 140)

A fourfold sequence of deposits is visible in this exposure. The underlying undisturbed chalk is succeeded by a zone in which the chalk is frost shattered and has obviously been subjected to periglacial action. This zone is overlain by a thickness of coombe deposits, which are themselves overlain by a clayey deposit identifiable with the Tring Series. From the section there appears to be a possible age break between the frost shattered chalk and the coombe deposits. This section appears to offer a more complete record of events than the previous one.

Lower Pitstone Quarry (Grid Ref. 940 143) (Figs. 41,42.)

The Tring Series is here much thinner, only 6 inches to 1 foot thick, and very sporadic in occurrence. In parts of the quarry it appears directly to overlie frost

Fig. 41 DIAGRAM OF PITSTONE QUARRIES
(not to scale)

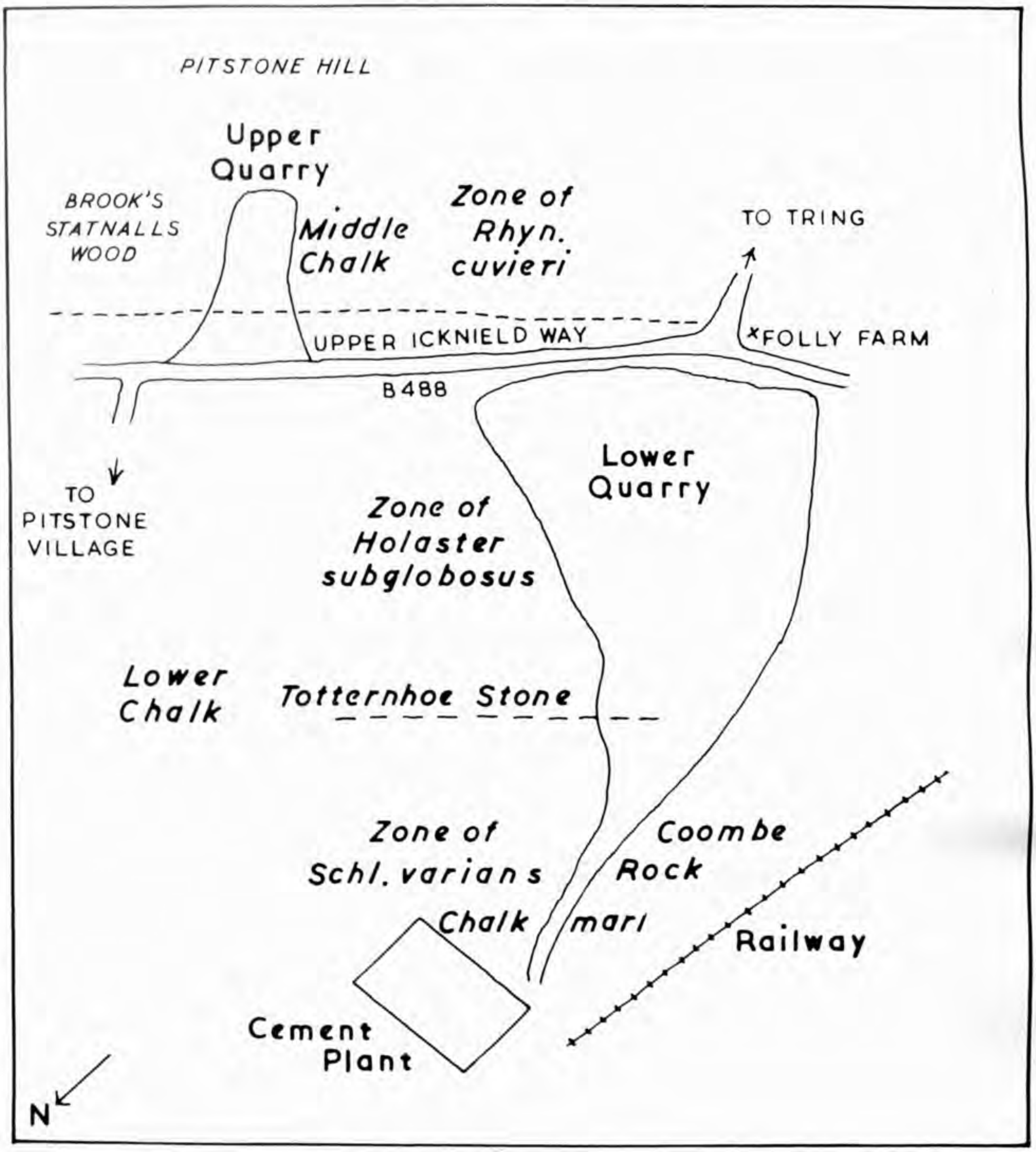


Fig. 42. Section in Lower Pitstone Quarry.

Tring Series festooned down into frost shattered chalk shattered chalk, some 2 feet thick, but elsewhere it can be seen festooned into the underlying coombe deposits. A section showing coombe deposits themselves festooned into shattered chalk has now been removed. In places in this quarry, the coombe deposits are up to 20 feet thick. This exposure would seem to bear a close relationship to the two preceding ones.

Upper Pitstone Quarry (Grid Ref. 945 145) (Fig. 43)

This section and several others in the vicinity, for example, a canal section at Bulbourne (Grid Ref. 934 137), expose some 3 feet of coombe rock (angular flints and chalk rubble) over frost shattered chalk into which the deposits have been festooned.

Gubblecote Section - Dixon's Gap Bridge
(Grid Ref. 910 145)

This exposure reveals the Gubblecote Series overlying a chalky, gravelly head deposit with angular flints. This deposit would appear younger than the Charity Complex - it is some 100 feet lower and only just above the level of the present alluvium. It could possibly be equated with the younger solifluction deposits overlying the Charity Complex and/or the Coombe Complex.

Ditch Section north of Drayton Beauchamp
(Grid Ref. 894 126)

The Halton Complex can be seen in this exposure - a

Fig. 43. Section in Upper Pitstone Quarry.

FIG. 44 ATTEMPTED CORRELATION OF SECTIONS AND EXPOSURES

Wendover Gravel Pit	Ditch Section in Tring Gap	Railway Cutting at Folly Bridge	Lower Pitstone Quarry	Upper Pitstone Quarry	Gubblecote Section at Dixon's Gap	Ditch Section nr Drayton Beauchamp	Possible Relation of other Series
875 065	133 933	938 140	940 143	945 145	910 145	894 126	
							Ford End Complex Mead Series Icknield Series Wantage Series Wicken Series
						Halton Complex	Challow Complex
Coombe Deposits?				Coombe Complex	Gubblecote Series		Weston Turville Series Rowsham Complex
	Tring Series	Tring Series	Tring Series (thin)				
Charity Complex?	Coombe Deposits	Coombe Deposits	Coombe Deposits				Winchester Series Batcombe Series
		Frost shattered Chalk	Frost shattered Chalk	Frost shattered Chalk			

chalky and flinty or gravelly head. The flints in this material appear smaller than those of the Gubblecote Series. This Complex is also more calcareous, and, both from its nature and situation, it would appear younger than the deposit exposed in the previous section.

A preliminary correlation of these sections is attempted here (Fig. 44), but a more detailed consideration of the information will be attempted when discussing the gaps as a whole.

(d) THE PATTERN OF SOIL SERIES DISTRIBUTION IN RELATION TO MORPHOLOGY

In this section, the distribution of certain problematical soils will be considered geomorphologically, the significance of this distribution will be assessed and some tentative conclusions relating to the physical evolution of the area will be offered.

The chief occurrence of the Winchester Series between 300 feet and 500 feet (the area covered by morphological mapping) is, as has been already indicated, as detached outliers in lower slope positions, associated with the Charity and Coombe Complexes (Fig. 45). These patches of Winchester lie on flat spur summits and ridges, and their neighbouring slopes, on inclinations up to 4 degrees 20 minutes. They seem to be confined generally

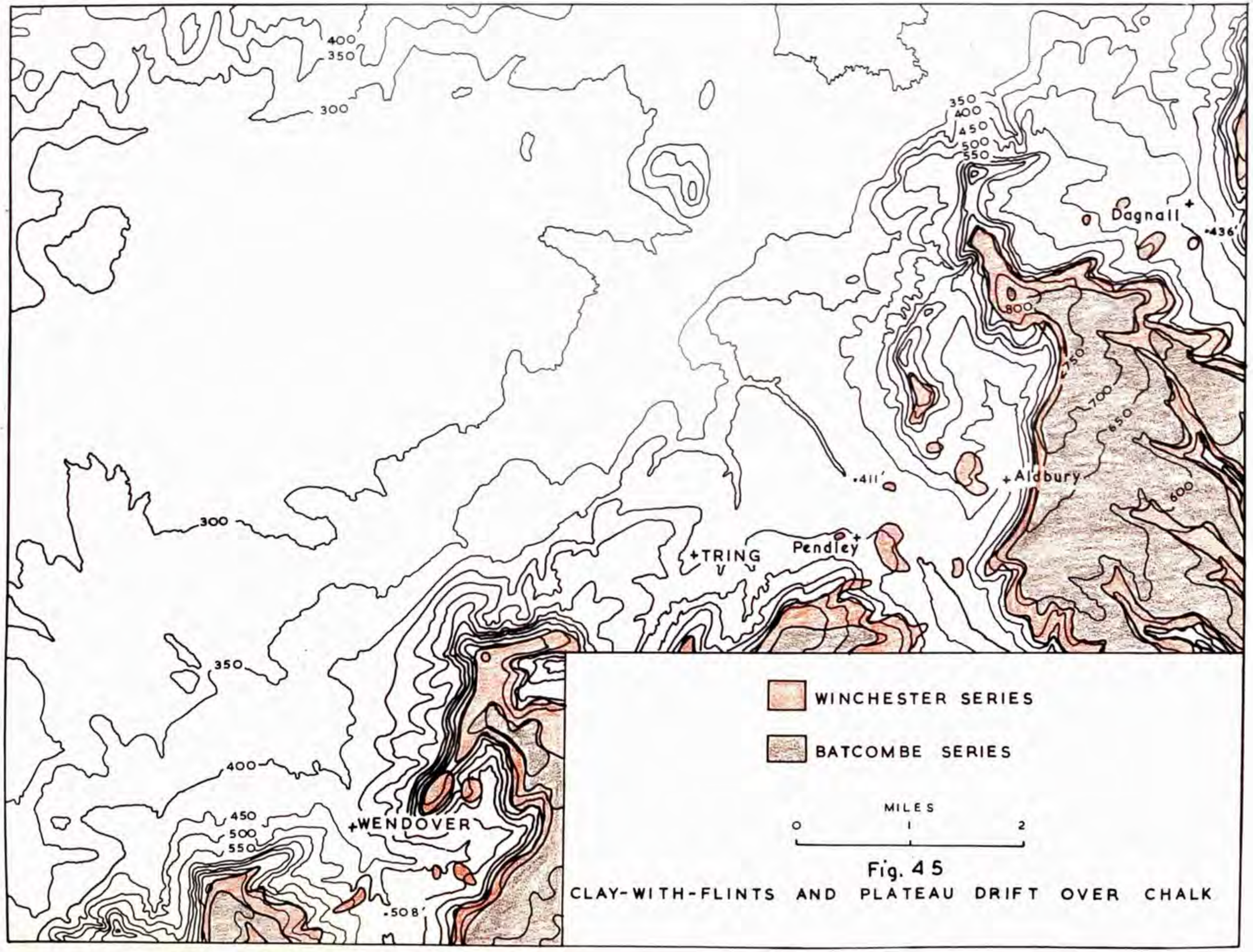


Fig. 45
CLAY-WITH-FLINTS AND PLATEAU DRIFT OVER CHALK

to surfaces between 450 feet and 500 feet. Notable examples of such outliers are found on the spur and east facing slope at Pendley, and the east facing ridge overlooking the Aldbury Valley. This 450 foot to 500 foot surface would seem to represent remnants of a formerly more extensive level on which the Winchester Series was more widely developed. The existing patches perhaps owe their preservation to their summit and ridge positions. There is, however, an inexplicable exception to this - a patch of Winchester practically on the Tring Gap watershed at just over 400 feet. If Loveday's (1958) conclusions are correct and the formation of the parent material of the Winchester Series occurred largely before Winter Hill times, the 450 foot to 500 foot surface was formed before the Chalky Boulder Clay Glaciation (after Wooldridge, 1938). It is probably, therefore, one of the oldest soils in the area and the implication is that the present gap watershed is an inherited pre-Winter Hill feature (it could, though, have been lowered somewhat since this time).

The Charity Complex is found on slopes of less than 5 degrees, from 400 feet to 500 feet (Fig. 46). It occupies the valley bottoms, the sides of the gaps and the huge re-entrant valleys, for example, Aldbury and The Coombe. Its parent material is probably older even than

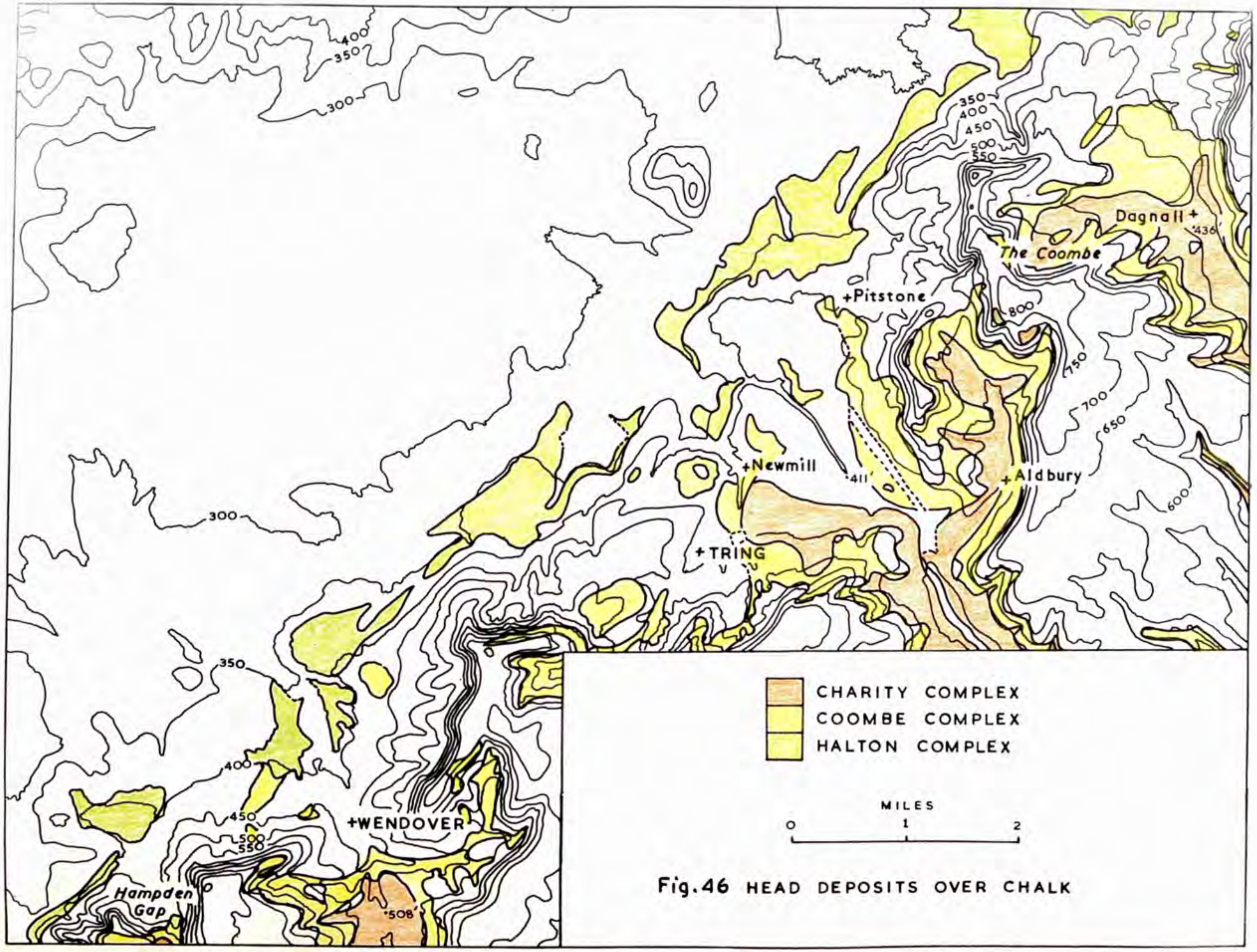


Fig.46 HEAD DEPOSITS OVER CHALK

the Winchester Series. Evidence for this includes its morphological situation, its decalcified nature and its frost heaved surface with an overlying later solifluction deposit. It would appear to have been a very early head deposit, mainly from the adjacent plateau, incompletely dissected before the next periglacial episode. This would again lead to the conclusion that the form of the gaps above 400 feet was largely determined prior to, or during, the Pleistocene Period.

The Coombe Complex has a wider and more varied distribution (Fig. 46). Not only is it prominent in upper valley slope,(for example, the Aldbury Valley), and valley bottom positions,(for example, the valley through Tring itself), but there are also considerable spreads within the gap floors,(for example, Tring and Dagnall Gaps). In detail, it transgresses ridges, depressions, and shelf-like flats, and thus may occupy slopes from 0 degrees to 9 degrees. From the scattered outliers of the Coombe Complex adjacent to the escarpment, for example, west of Newmill, it would appear that Coombe deposits were formerly more extensive at the escarpment foot. In fact, a thin layer of such deposits is known to overlie much of the area at present denoted Icknield Series (this can be seen in the Upper Quarry at Pitstone,Fig. 43) but its distribution is so irregular and thin that it has not been distinguished in mapping here. From its occurrence and calcareous nature, it would appear to be a fairly recent solifluction material which probably spread as a thin layer over a fairly extensive area. It is possible that the Coombe Complex may be of a similar age to the solifluction deposit overlying Charity. It would have been channelled to some extent by pre-existing valleys, and thus it is here that the greatest thicknesses are preserved to-day.

Morphologically, the Tring Series, located only in the Tring Gap, occupies a surface sloping very slightly in towards the gap.(Fig. 47). It has a broad distribution in the mouth of the gap but tapers out towards the gap watershed. The surface has an average elevation of some 400 feet and is little dissected. Slopes are nowhere greater than 3 degrees and generally much less. From its morphological situation it would appear to be a drift rather than a solifluction deposit. An outlier of the Tring Series at a similar elevation west of Newmill would suggest that its former extent was somewhat greater. The coombe material beneath the Tring Series must be of a fairly early date, possibly an equivalent of the early Charity Complex solifluction phase, or possibly prior to it.

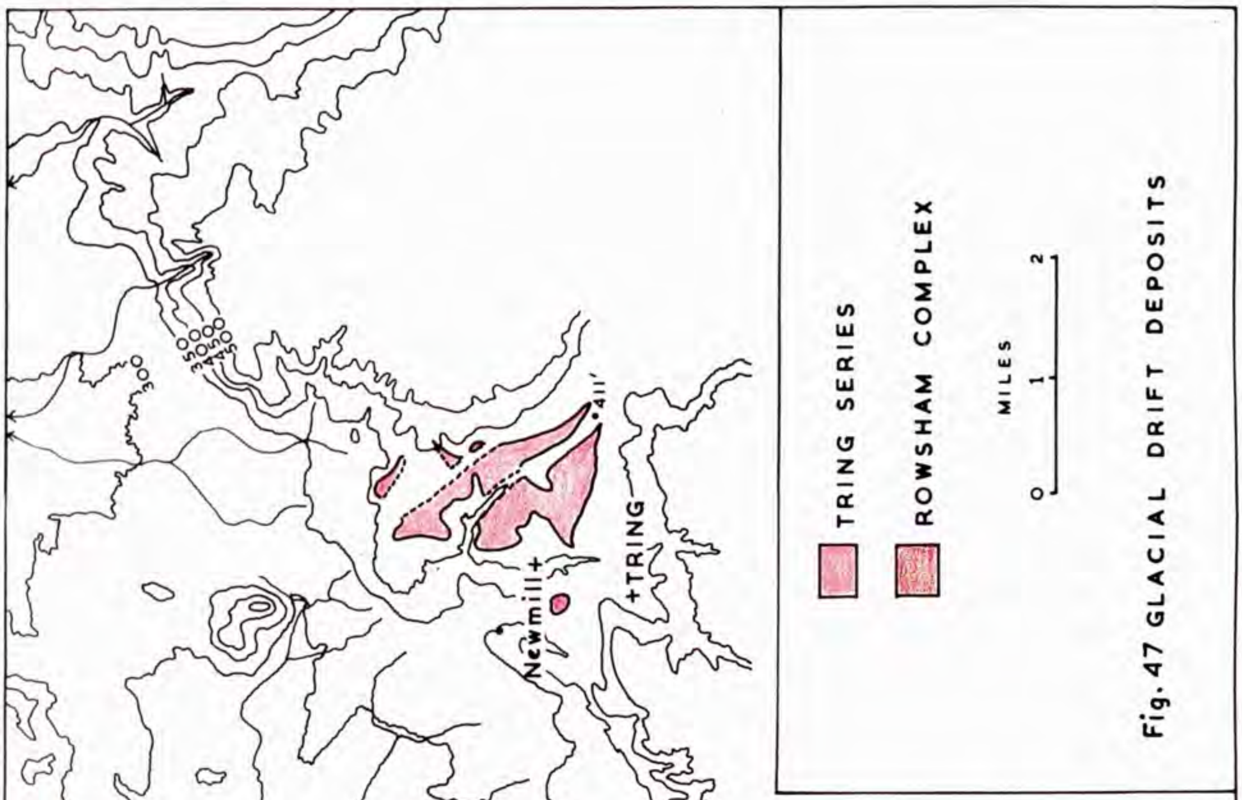


Fig. 47 GLACIAL DRIFT DEPOSITS

The Icknield Series is divided into two phases according to its morphological situation (Fig. 48). On scarp and valley slopes over about 9 degrees, a shallow phase is delimited, while on the scarp foot flats and in the gap mouths, a deeper phase is present. It is found with a variety of surface forms - from steep-sided, flat-floored, spring-sapped valleys to shallow (2 degrees to 9 degrees) undulations or depressions in the Middle Chalk platform surface. These latter depressions would appear to be features formed by melt-water in semi-thawed chalk. There is in addition a thin skin of solifluction deposits present along much of the scarp foot.

The Wantage Series occurs below, altitudinally, the Icknield and is present over the Lower Chalk at the foot of the escarpment as an almost continuous belt from Wendover to Dunstable (Fig. 48). It occurs on the shelf-like flat, which averages just over 400 feet, formed by the Chalk Marl, and on its outer slope. Thus the Series is found generally only on slopes of less than 2 degrees 20 minutes, except on the outer edge of the platform and where the shelf is cut by deep spring-sapped valleys. Slopes in this case may be increased to 5 degrees 30 minutes. Where the platform is well developed, for example, adjacent to the gaps, the Wantage Series is extensive.

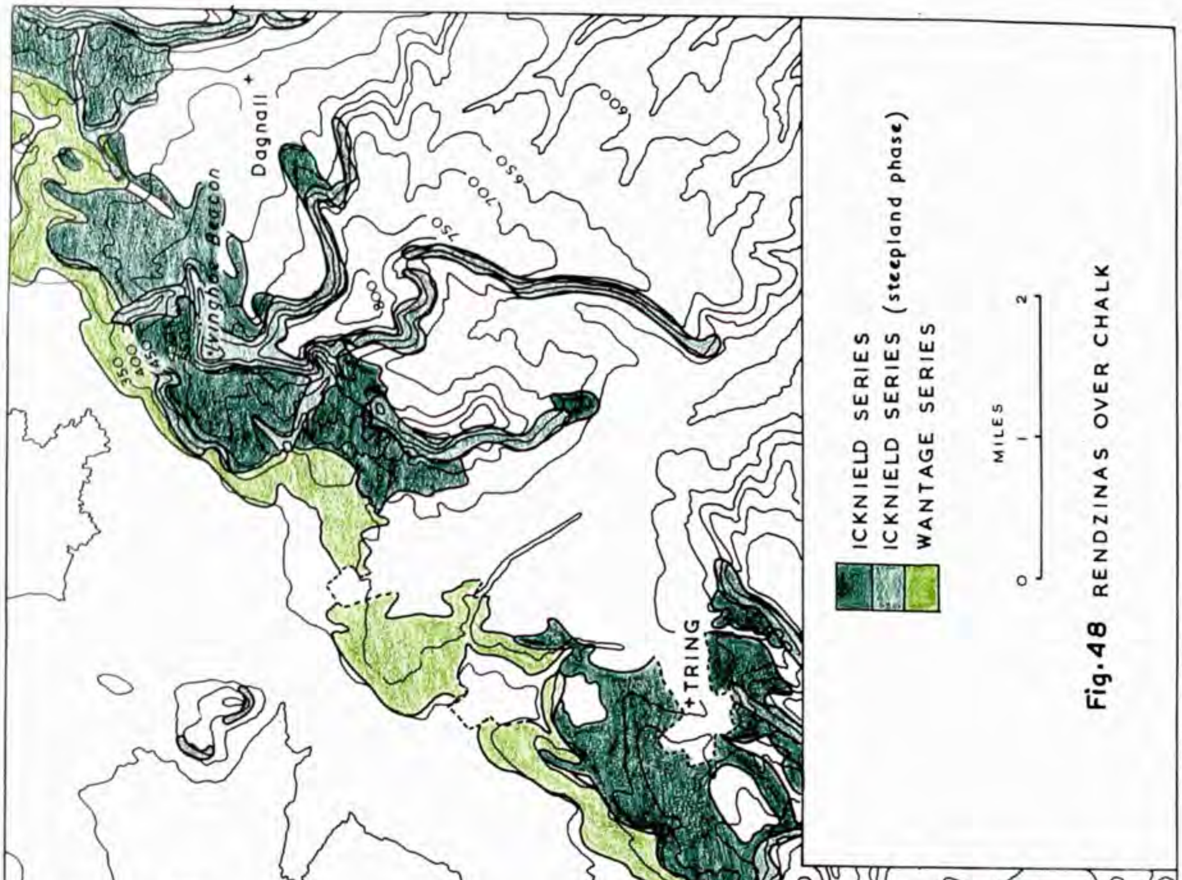


Fig. 48 RENDZINAS OVER CHALK

Where the shelf is narrow and abrupt, for example, below Ivinghoe Beacon, the Wantage Series is restricted.

The Halton Complex has a similar areal distribution as a narrow belt along the foot of the escarpment from Wendover to Dunstable, but it has a different morphological situation (Fig. 46). It lies at the foot of the outer edge of the Lower Chalk platform, overlying both Chalk Marl and Selbornian, i.e., it occurs below, in elevation, the Wantage Series. Thus it generally occupies slopes between 0 degrees and 2 degrees 10 minutes, but occasionally may be found on slopes up to 4 degrees 30 minutes where dissected by shallow streams and weak springs. It would appear to be a fairly youthful deposit which originated from the Chiltern escarpment and was sludged across the Lower Chalk shelf, and accumulated at its foot. It is also widespread across the Thame - Ouzel watershed, implying that this feature has been modified little since the late Pleistocene.

The Weston Turville and Gubblecote Series also have a particularly significant morphological distribution (Fig.49). They spread across the Gault plain of the Vale of Aylesbury at the foot of the Lower Chalk platform. The former series is particularly pronounced opposite the Wendover Gap (though a patch does occur

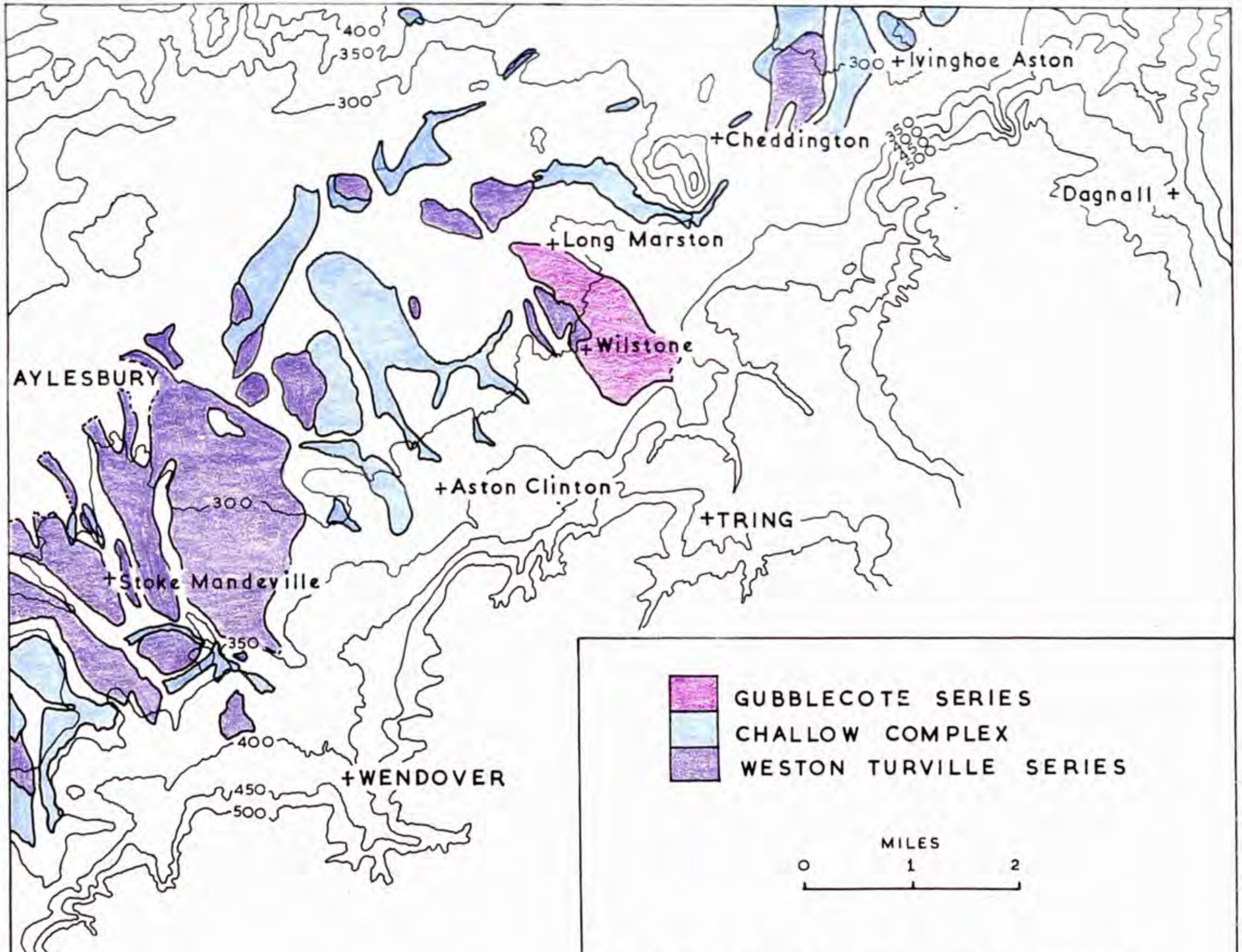


Fig.49 HEAD DEPOSITS OVER GAULT

north-east of Cheddington) while the latter is restricted to a position opposite the Tring Gap. In outline both series fan out away from the gaps and narrow towards the gap necks. Their distribution, therefore, indicates that the underlying head deposits are thicker adjacent to the gaps than elsewhere, and it would seem that much of the material must have been sludged down from the gaps and neighbouring coombes during the Pleistocene. Both series are relatively low lying, 300 feet - 350 feet, and exhibit little surface relief. Over much of their extent, the surface is flat and slopes are everywhere under 2 degrees. Both series are dissected by shallow valleys, denoted by the occurrence of the alluvial Ford End Complex, for example, north of Weston Turville and Wilstone, and thus they now virtually occupy "inter-fluvial plateaux". The actual dissection of the Weston Turville Series, for example, can be seen in process between Terrick House, Terrick (Grid Ref. 838 082), and St. Mary's Church (Grid Ref. 839 089). A small stream is cutting down through the head deposits, and isolating a patch of the Weston Turville Series north of Nash Lee (Grid Ref. 842 083). The same process has presumably been operative in cutting off the larger patch of this series to the east of St. Mary's Church.

Both the Weston Turville and Gubblecote Series are margined by occurrences of the Wicken Series in two morphological situations (Fig. 50). Firstly, it occupies valley sides, with slopes up to 3 degrees 40 minutes, on the Gault, for example, the north-west trending valley west of Stoke Mandeville. This leads to the conclusion that the parent head deposits of the Weston Turville and Gubblecote Series previously covered a wider area and have been fairly recently removed by spring and stream erosion, thus exposing the underlying Gault in the valley sides. Secondly, the Wicken Series occupies a considerable area in the Vale of Aylesbury between the Wendover and Tring Gaps, a region in which the original source for the head deposits would be much more restricted. The Gault plain in this locality was probably never covered by any great thickness of coombe material from the escarpment.

The Gault is, however, in places overlain by a purely local clayey head, the Challow Complex (Fig. 49). This material is now preserved in hollows and depressions and on footslopes, but it is quite conceivable that at an earlier stage much of the Gault outcrop was covered by a thin clayey head, since reworked.

Alternatively, the Challow Complex could be a washed down and partly decalcified form of the parent coombe

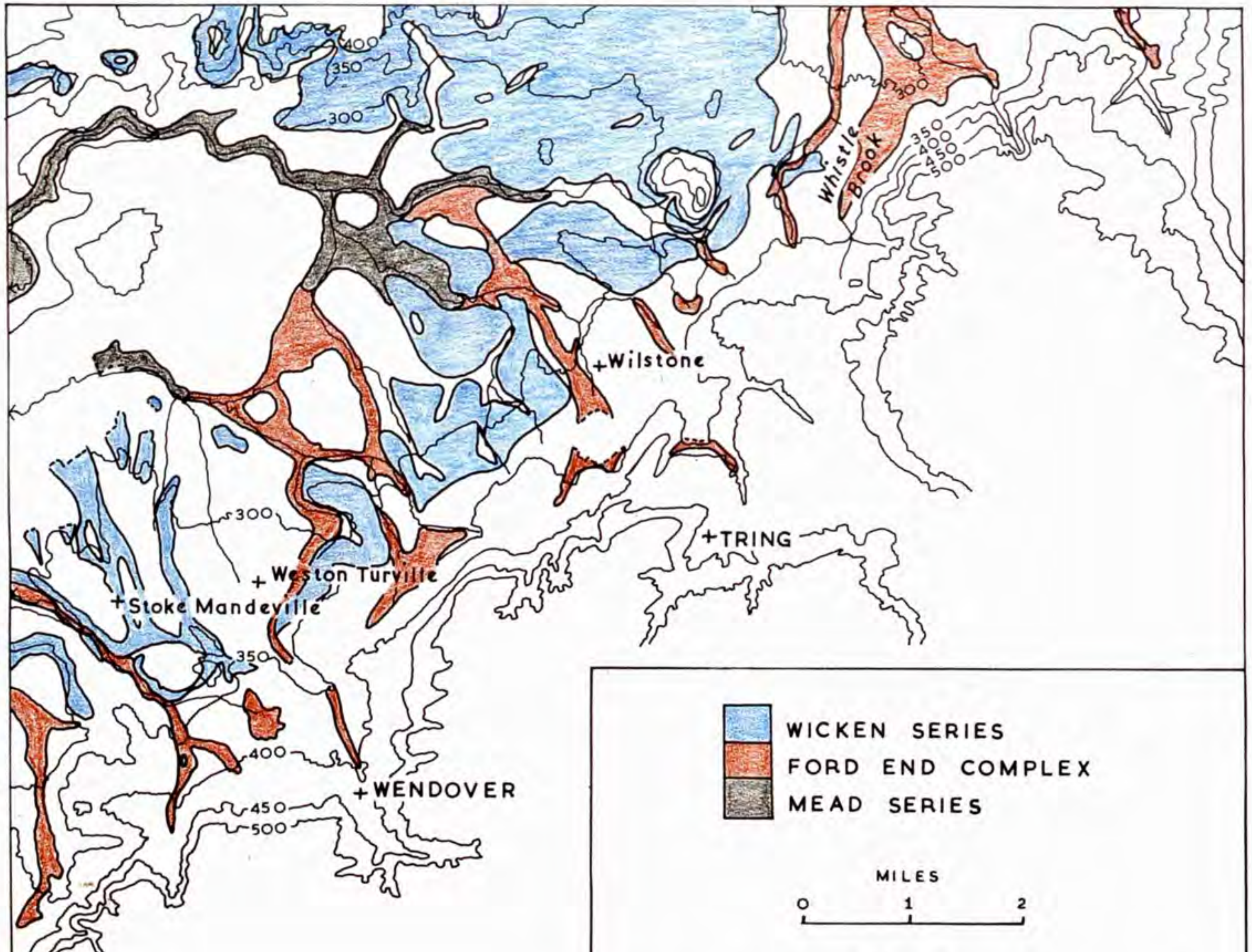


Fig. 50
ALLUVIAL DEPOSITS OVER GAULT CLAY

deposits of the Weston Turville and Gubblecote Series, mixed with Gault in the valley bottoms. The former possibility would seem to be the more likely, as the maximum extent of the Complex occurs on the Gault plain between the Wendover and Tring Gaps, and it is also much less flinty than the head deposits derived from the escarpment.

Thus from an investigation of the geomorphological problems of the Chiltern wind-gaps and Vale of Aylesbury, along the lines indicated, has emerged a whole quantity of information and attendant theories. In the succeeding chapter, an attempt is made to bring this material together in such a way that it is possible to see its relevance and assess its contribution to an elucidation of the physical development of the area.

VI A COMPARATIVE STUDY OF THE THREE MAJOR GAPS UNDER REVIEW, i.e., WENDOVER, TRING AND DAGNALL

Broadly speaking, the three Central Chiltern wind-gaps would, at first sight, seem fairly similar. All three trench the Chiltern range at its maximum development, opening out to the north-west and the Vale of Aylesbury (the Wendover Gap, in fact, has a slightly more northerly orientation than the Tring and Dagnall Gaps). All three gaps are now dry. But in detail, these broad comparisons break down and in structure and geology, morphology and drainage, and soils and deposits, there are considerable contrasts from gap to gap. Basic to these differences are the dimensions, the size or degree of development of each. The Tring Gap is by far the most impressive, the width of its floor being some 2½ miles at its maximum extent and its depth about 400 feet. The floor of the Dagnall Gap has a breadth of 1½ miles and its watershed is 350 feet below the adjacent summit plateau, while the floor of the Wendover Gap is about ¾ mile across and only 300 feet below the plateau level. Upon these facts hinge a multitude of contrasts.

(a) STRUCTURE AND GEOLOGY

Each of the three gaps is responsible for an embayment, either great or small, in the general north-east - south-west line of the escarpment. The Dagnall and Wendover Gaps, in plan, are little more than enlarged breaches in the Chiltern cuesta, while the Tring Gap forms a huge funnel-shaped re-entrant feature in the Chalk escarpment. The prominence of the Tring Gap is partly due to the nature of the escarpment in its immediate vicinity. (Fig.52) To the south-west of Tring itself it is recessed back slightly from its general line by a complex coombe feature running north-east from Coombe Hill. This is joined by a number of subsidiary, yet well developed, dry valleys, for example, in Tring Park. (Fig.51) The general trend of the escarpment is resumed again north-east of Tring in Pitstone Hill and Ivinghoe Beacon, but the opening out of the Aldbury Valley behind the escarpment into the mouth of the gap also adds to the prominence of the feature. Small (1958) suggests that both of these features, the coombe south-west of Tring and the Aldbury valley, to the west and east of the wind-gap, were formerly drained by a stream passing south-east through the gap and that desiccation of the Chalk has halted their diversion and capture by springs penetrating the scarp foot. Coombe features are also found in the Dagnall and Wendover Gaps, for example, The Coombe and

Fig. 51. Dry Valley in Tring Park.

The Hale, but these are on a lesser scale and have not been overtaken by the recession of the escarpment. (Figs.53,4) Small similarly suggests that the features east and west of the Wendover Gap (the double-headed valley of The Hale and the coombe at Bacombe Warren) arose as headwater feeders of the Misbourne and have been turned north because of the penetration of the scarp by a tributary of the Thame.

The crest of the Chiltern scarp, capped by Upper Chalk (Micraster zones), is generally aligned parallel to the strike of the beds, though it may depart slightly from this in detail. All three gaps are formed largely in Middle and Upper Chalk. The Middle Chalk is revealed in the floors of the cols and gap slopes while the Chalk Rock defines the upper slopes. On the 1 inch Geological sheet (Aylesbury Sheet, 238, 1922), this latter bed serves to outline both the gaps and associated coombe features. However, the Wendover and Tring Gaps differ geologically from the Dagnall in the fact that they are also cut down into the Lower Chalk, i.e., the gap watersheds lie just within the Lower Chalk, while the Dagnall is well in the Middle Chalk. (Figs.52-54) Thus in the floor of the Wendover breach, the base of the Middle Chalk outcrops at some 500 feet; in the Tring at about

Fig. 52 TRING GAP – GEOLOGY

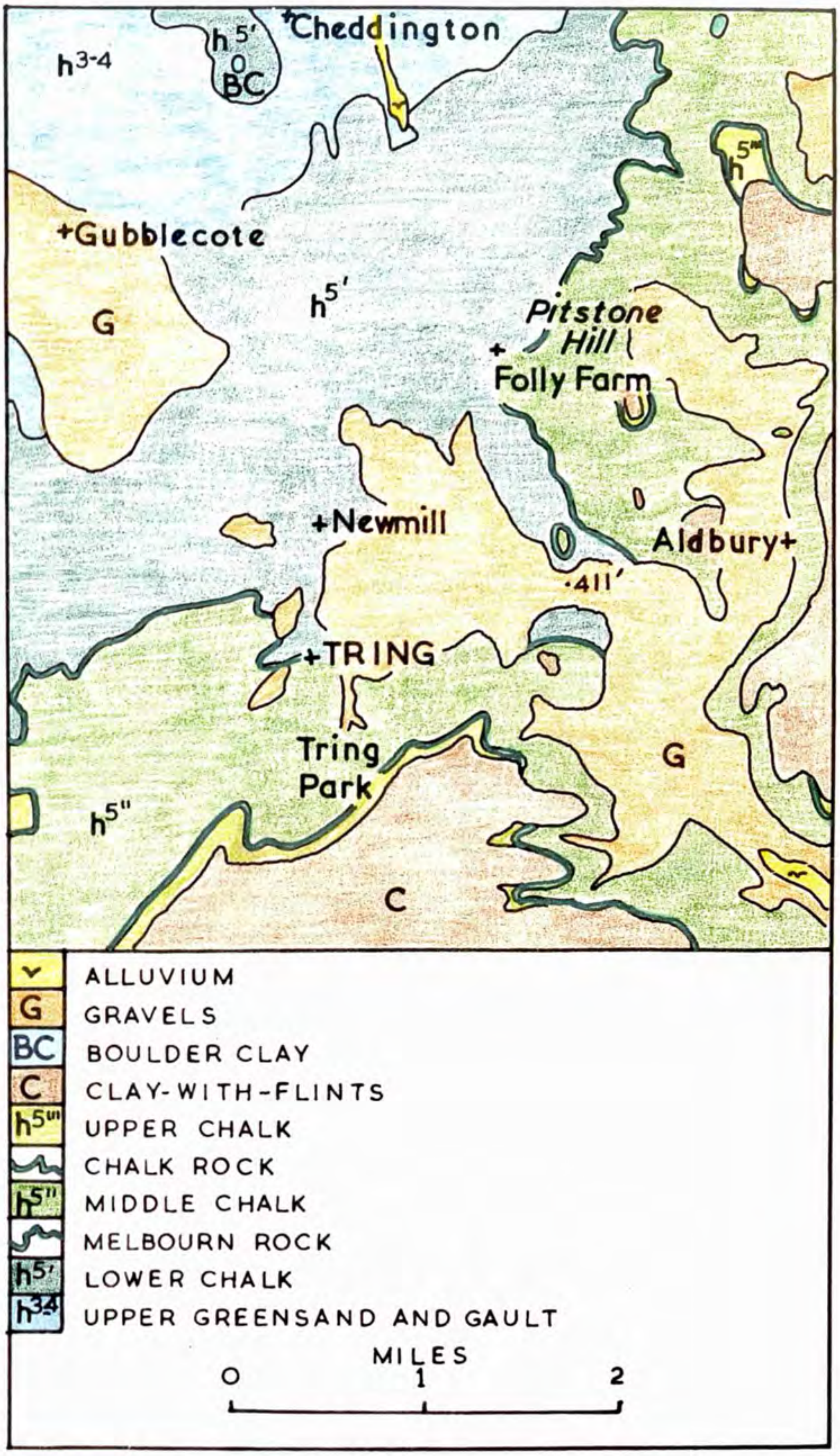


Fig.53 DAGNALL GAP-GEOLOGY

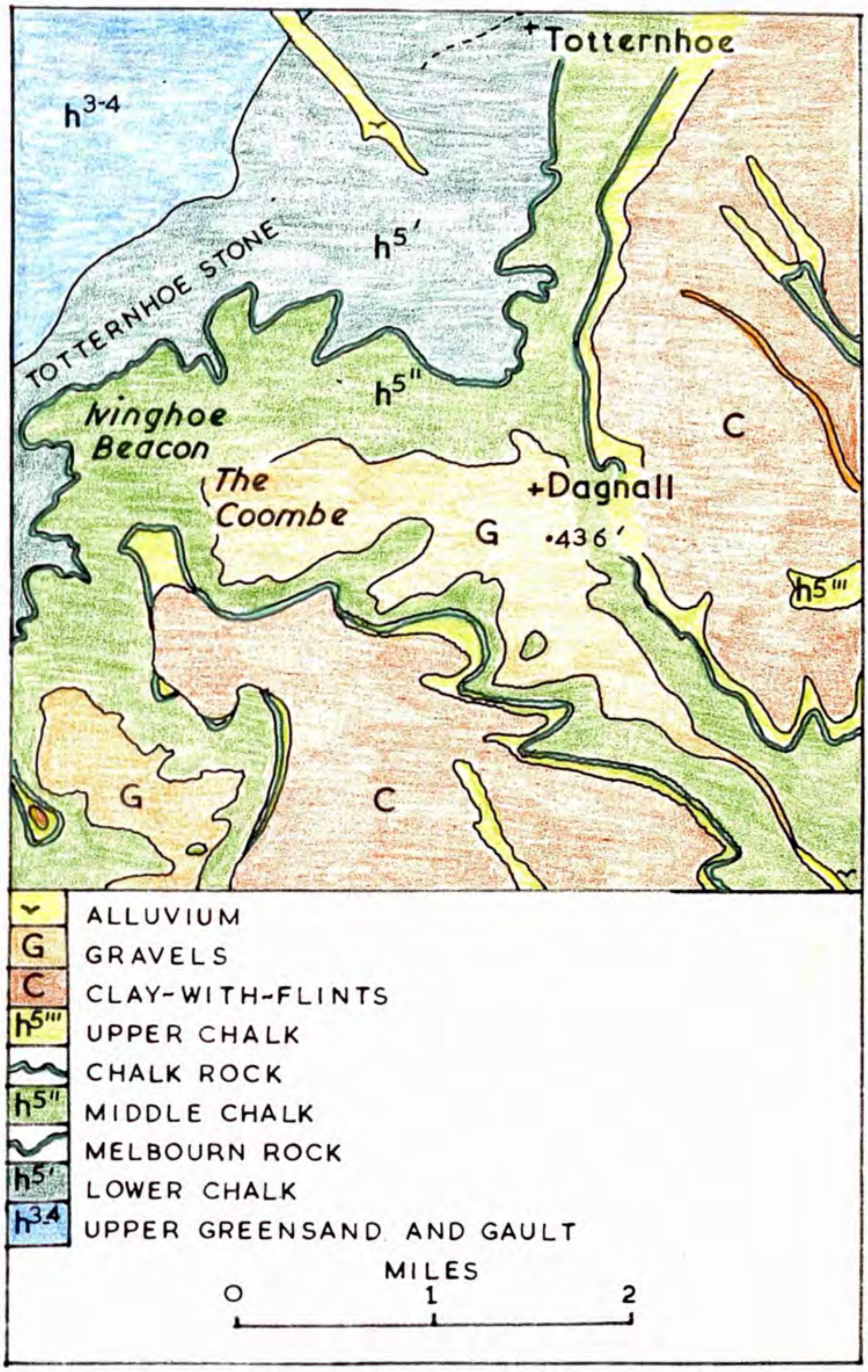
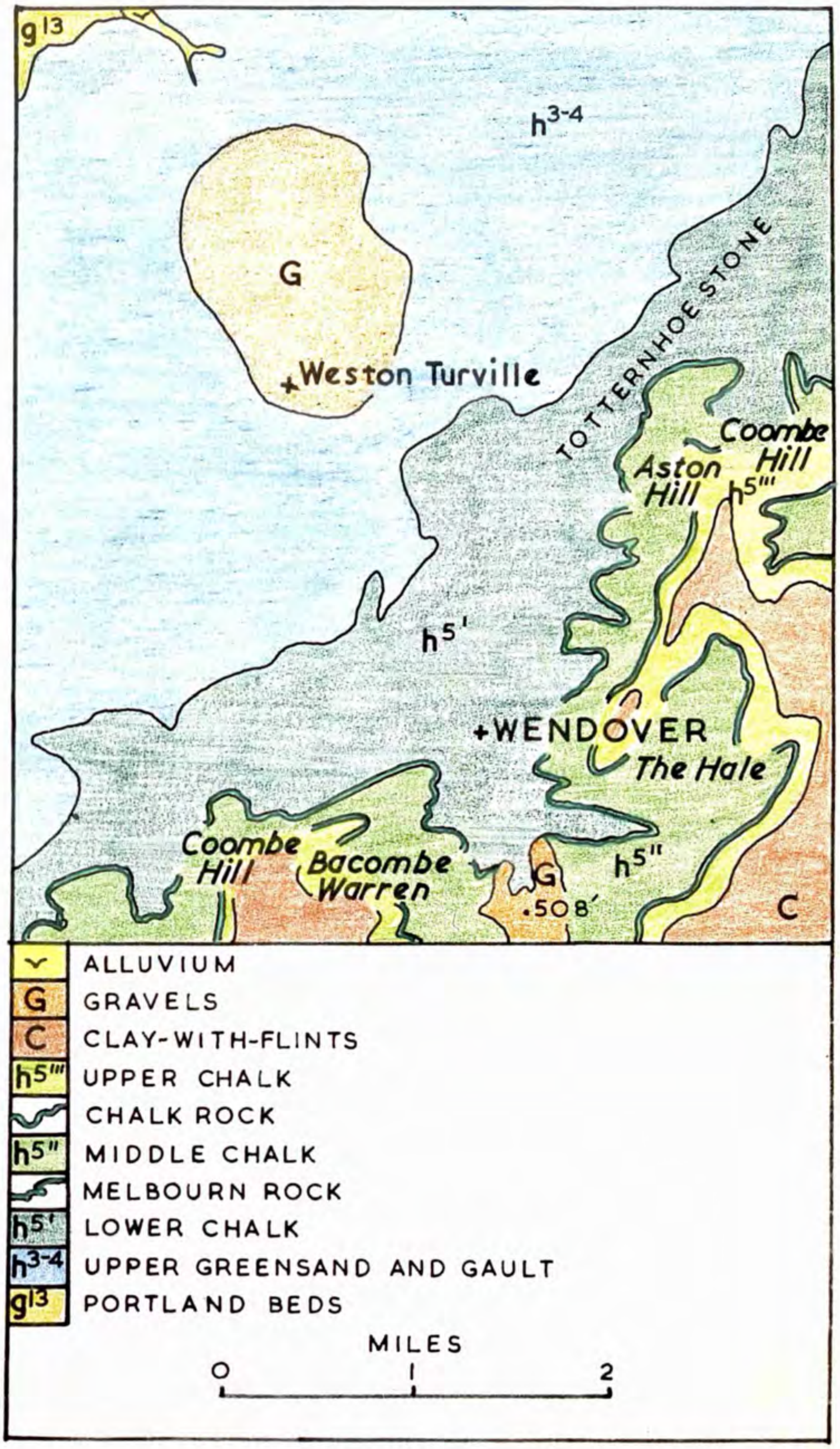


Fig. 54 WENDOVER GAP-GEOLOGY



410 feet, while in the Dagnall it outcrops only in the mouth of the gap at approximately 400 feet, i.e., there is an apparent fall of the base of the Middle Chalk north-eastwards at a rate of 100 feet in ten miles. This is a dip of only 7 minutes and is probably of little significance. In addition, allowance must be made for the position of the outcrops in relation to the strike of the Middle Chalk and in reality the outcrop of the Middle Chalk at differing heights in each gap probably represents only slight undulations in the level of its base rather than any regional dip north-eastwards.

Thus in the Wendover and Tring Gaps, the Melbourn Rock outcrops in the floor of the cols and forms or supports a marked surface below the steeper scarp slopes in the Middle and Upper Chalk, e.g. in the Hale in the Wendover Gap and near Folly Farm in the Tring. This feature is developed to varying degrees along much of the escarpment between Wendover and Dagnall. Because of the varying dimensions of the gaps, the Middle Chalk has a much more extensive outcrop in the Tring area, a lesser extent in the Dagnall, and a fairly restricted occurrence in the Wendover. The tributary valleys to all three gaps penetrate only to the level of the Middle Chalk; in none of them is the Lower Chalk revealed, except perhaps in the south-western extremity of the Hale.

Below each of the cols, slopes are fairly gentle, and grade into a scarp foot zone developed in the Lower Chalk. The areal extent of the Lower Chalk outcrop is again at its greatest in the mouth of and beyond the Tring Gap, and is fairly pronounced in both of the other gaps. It is narrowest where the escarpment is unbroken and reaches its maximum altitudes, e.g. Coombe Hill, Aston Hill and Ivinghoe Beacon. It is opposite the Tring Gap that the Lower Chalk outlier at Cheddington occurs. The outcrop of the Totternhoe Stone is not mapped in any of the gaps on the 6 inch Geological Survey sheets, presumably because over much of the area it is only 3 feet thick and does not make any feature at its outcrop. It is, however, mapped immediately north-east of the Dagnall Gap in the vicinity of Totternhoe itself, and its presence is indicated on the western side of the gap. There is no evidence of it in the Tring Gap, but it is again indicated north-east of the Wendover Gap, just below Aston Hill.

Thus in plan there would seem to be several geological contrasts between the gaps. The effects of these contrasts and their relationship to and influence upon the detailed landforms of the gaps will be considered in the ensuing section.

(b) MORPHOLOGY AND DRAINAGE

The difference in the dimensions and scales of the gaps have already been emphasised and stand out extremely clearly both on the contour and landform maps. The Tring Gap is wide and flat, (Figs.56,57) its floor having a general altitude of 400 feet and its watershed lying at 411 feet. (Fig.55) It is slightly restricted towards its inner margin by the knoll at Pendley, a spur of Middle Chalk held up by the Melbourn Rock. The 500 foot contour delimits the gap on the 1 inch contour map reasonably well, and the 400 foot contour marks the outer edge of the very extensive south-sloping flat in the mouth of the gap. The upper limits of the gap are set slightly behind the general trend of the escarpment and thus tend to be somewhat ill-defined, but to the east the gap is overlooked by Pitstone Hill, over 700 feet O.D., and to the west the escarpment climbs to 802 feet O.D. at Hastoe. (Grid Ref. 915.092) Aston Hill, again over 800 feet, might also be quoted as a western margin to the gap.

The Wendover Gap on the other hand is narrow and restricted. (Figs.59,60) It splays out very slightly, in plan, towards the Vale but had not attained the same degree of development as the Tring Gap. (Fig.58) Its floor rises fairly rapidly from 400 feet at the town of Wendover to

Fig. 55 TRING GAP – RELIEF AND DRAINAGE

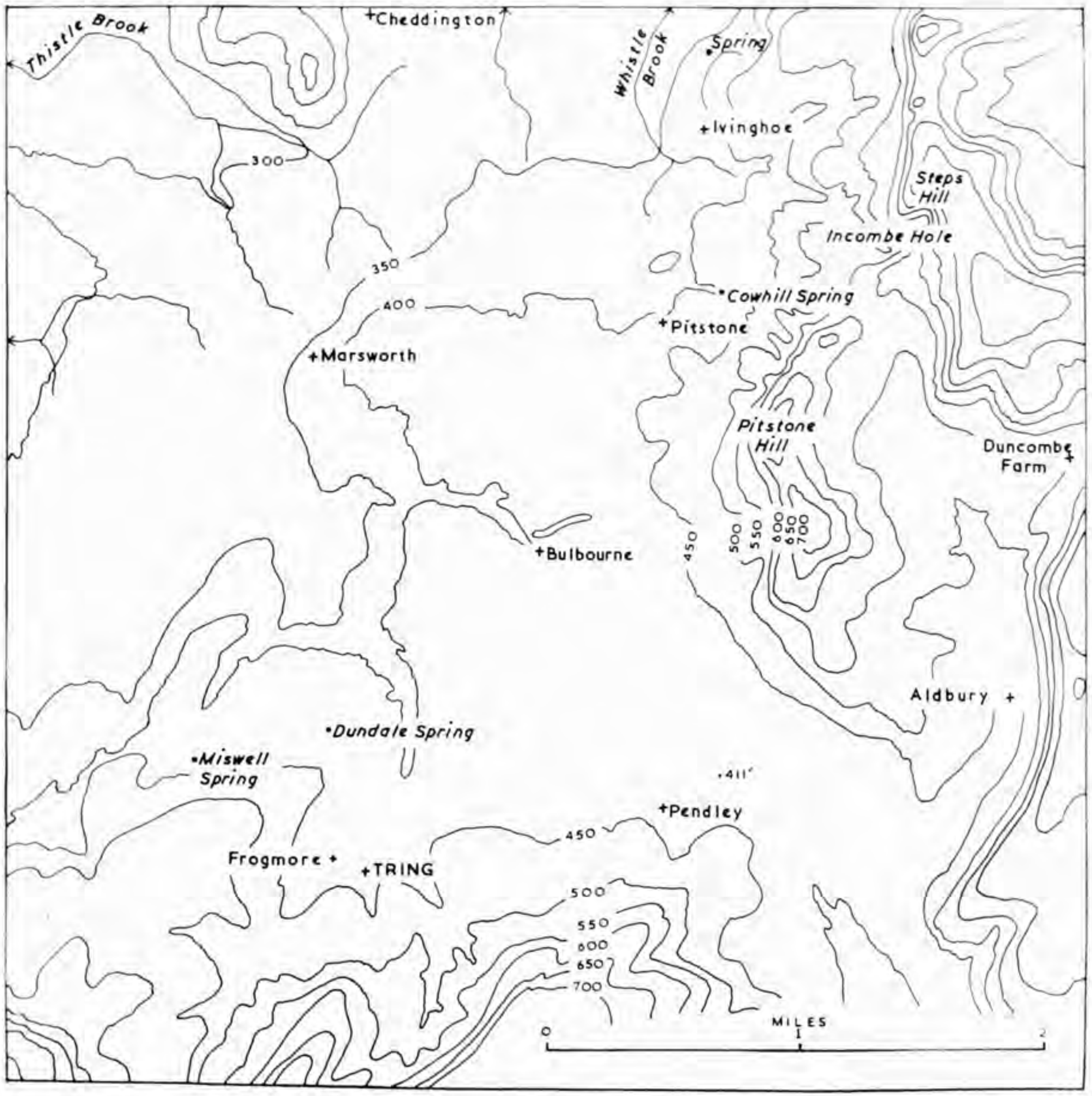


Fig. 56. Panorama of the Tring Gap from Wigginton.

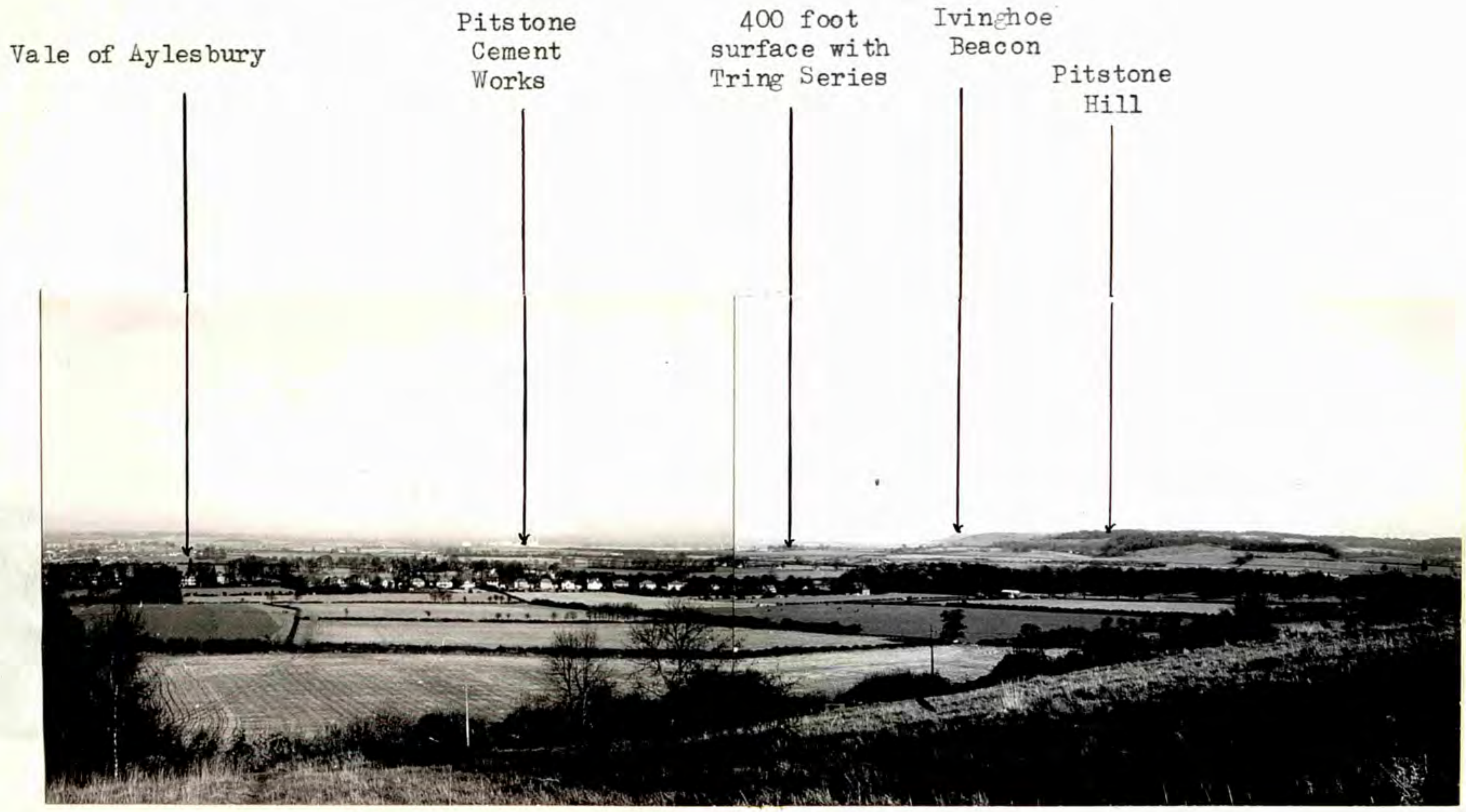


Fig. 57. Panorama of the Tring Gap from Pitstone Hill.

Fig. 58 WENDOVER GAP – RELIEF AND DRAINAGE

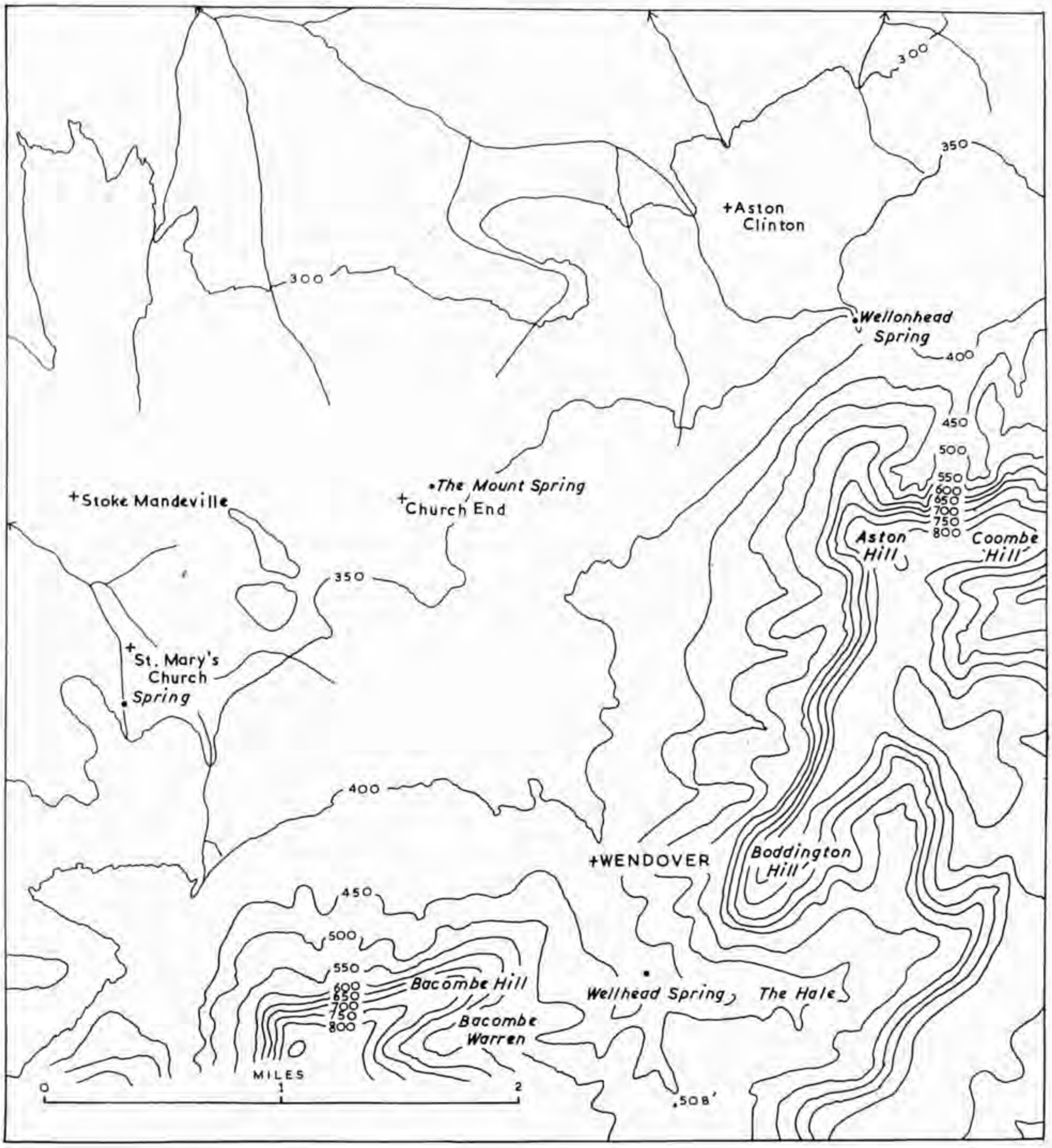


Fig. 59. Panorama of Wendover Gap from Bacombe Hill.

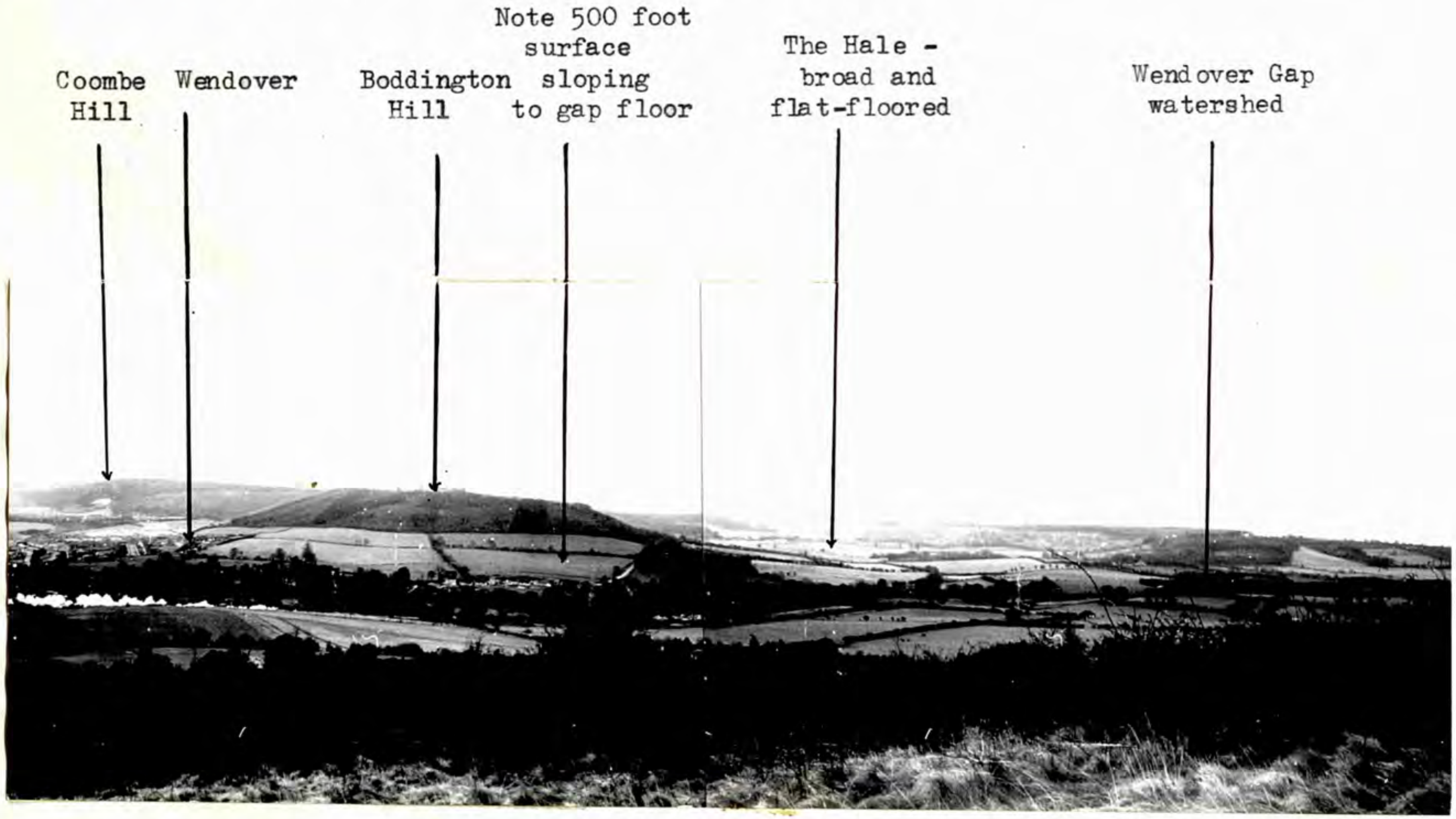
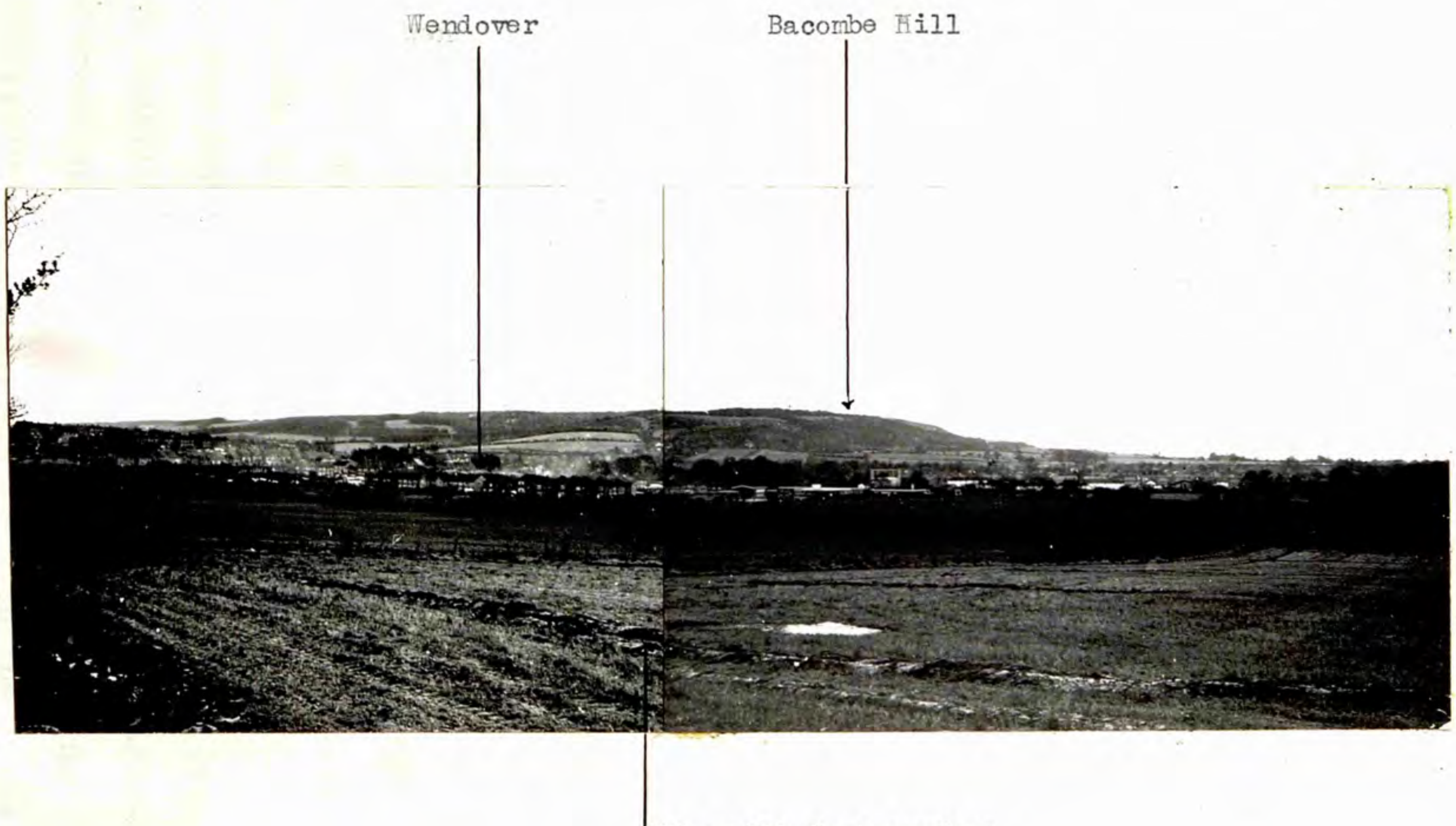


Fig. 60 Panorama of Wendover Gap from below Haddington Hill.



a maximum elevation of 508 feet on the gap watershed. The heights of the watersheds in the two gaps are, not, however, directly comparable as about 25 feet of gravel obscures the Wendover crest. The Tring gravel deposits are much thinner - probably only a few feet on the crest of the watershed as the underlying chalk is exposed at no very great depth in the nearby canal and railway cuttings. So the floor of the Wendover Gap is approximately 75 feet higher than that of the Tring Gap. The flat floor of the Wendover Gap is of very limited extent, and there is no vast south-sloping facet as in the Tring Gap. Here, the 600 foot contour defines the outline of the breach better than the 500 foot. The lower limit - the 400 foot contour - has been cut back by springs and marks the edge of only a minor 400 foot surface. The bounding hills, Bacombe Hill to the west and Boddington Hill to the east, both over 800 feet, approach the gap more nearly, overlook it more directly and define it more definitely than the heights above the Tring Gap.

The Dagnall Gap has not the width of the Tring Gap, nor yet is it as restricted as the Wendover Gap. (Figs.62,63) Generally it is broad and shallow, its floor averaging just above 400 feet, and rising to 436 feet on the watershed crest. (Fig.61) Again, a few feet of gravel obscure

Fig. 61 DAGNALL GAP – RELIEF AND DRAINAGE

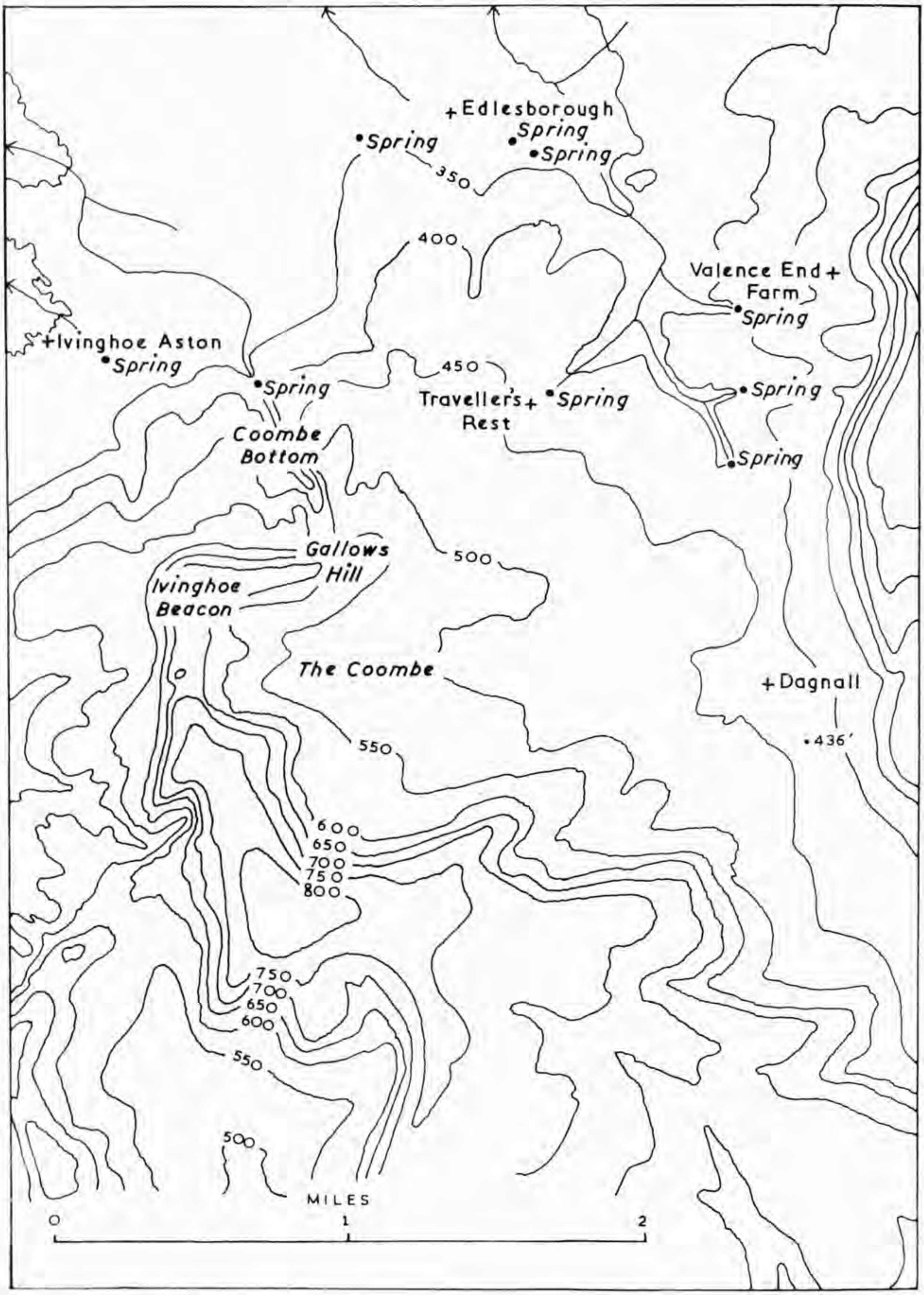


Fig. 62. Panorama of Dagnall Gap from Ivinghoe Beacon

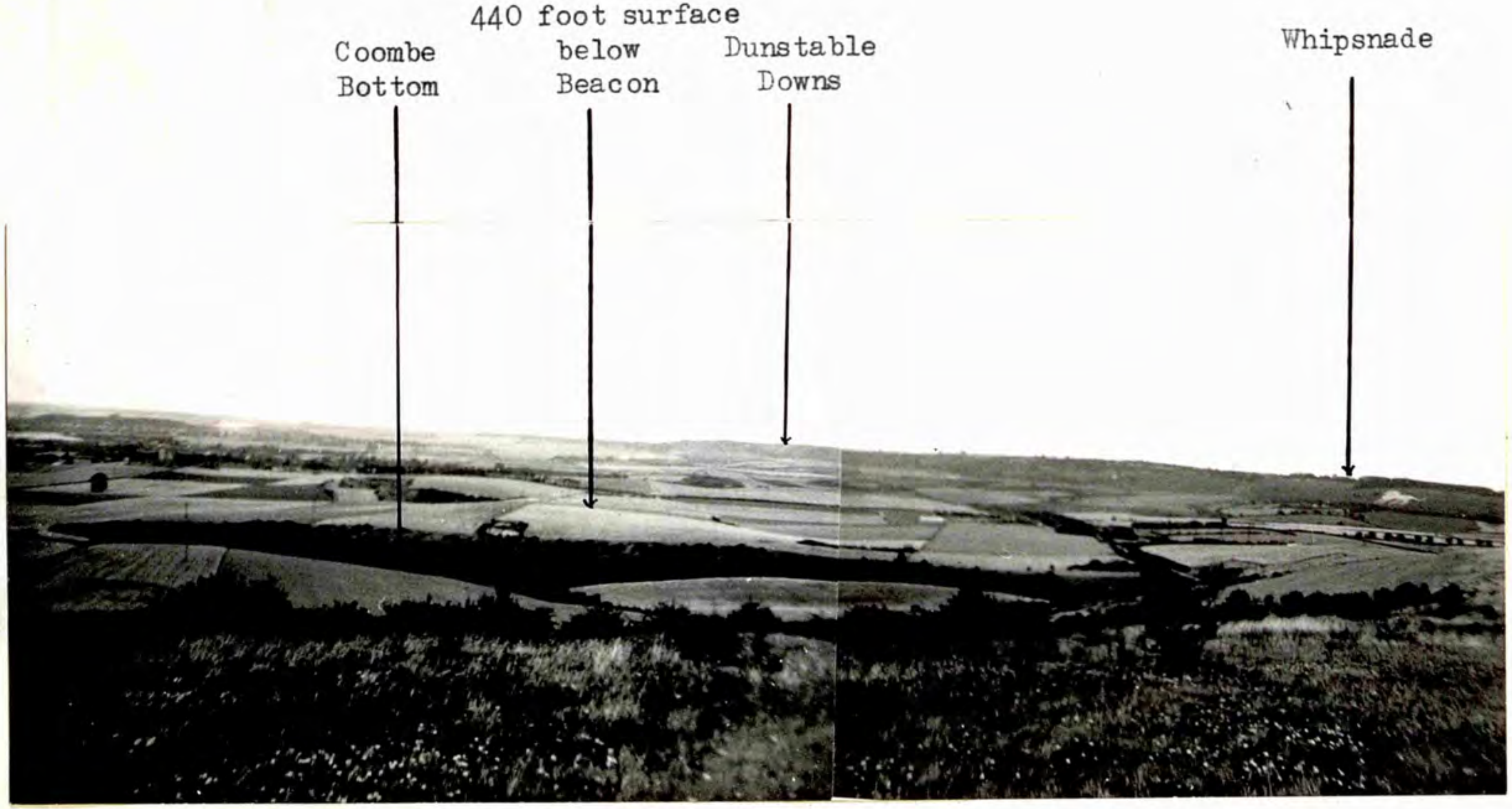
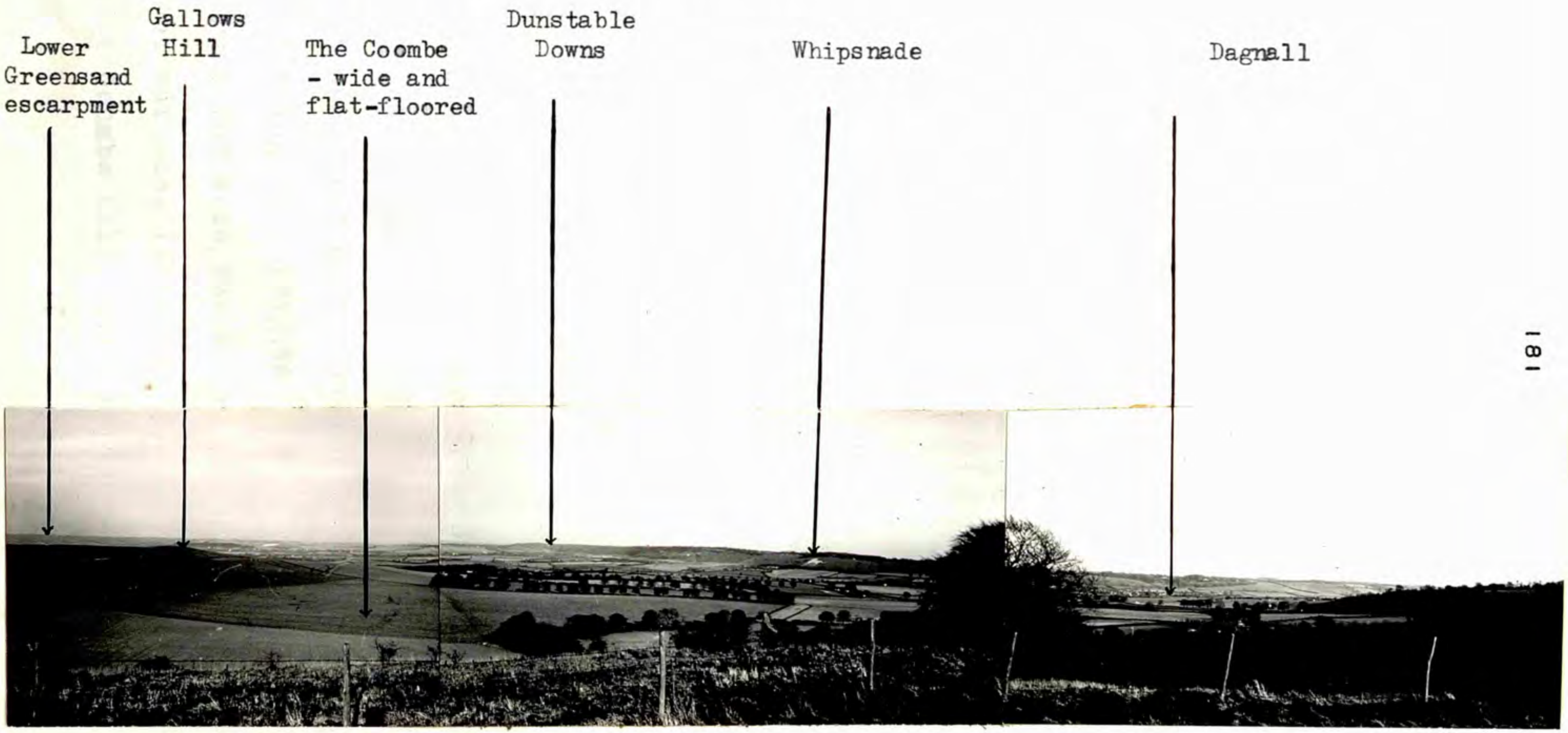


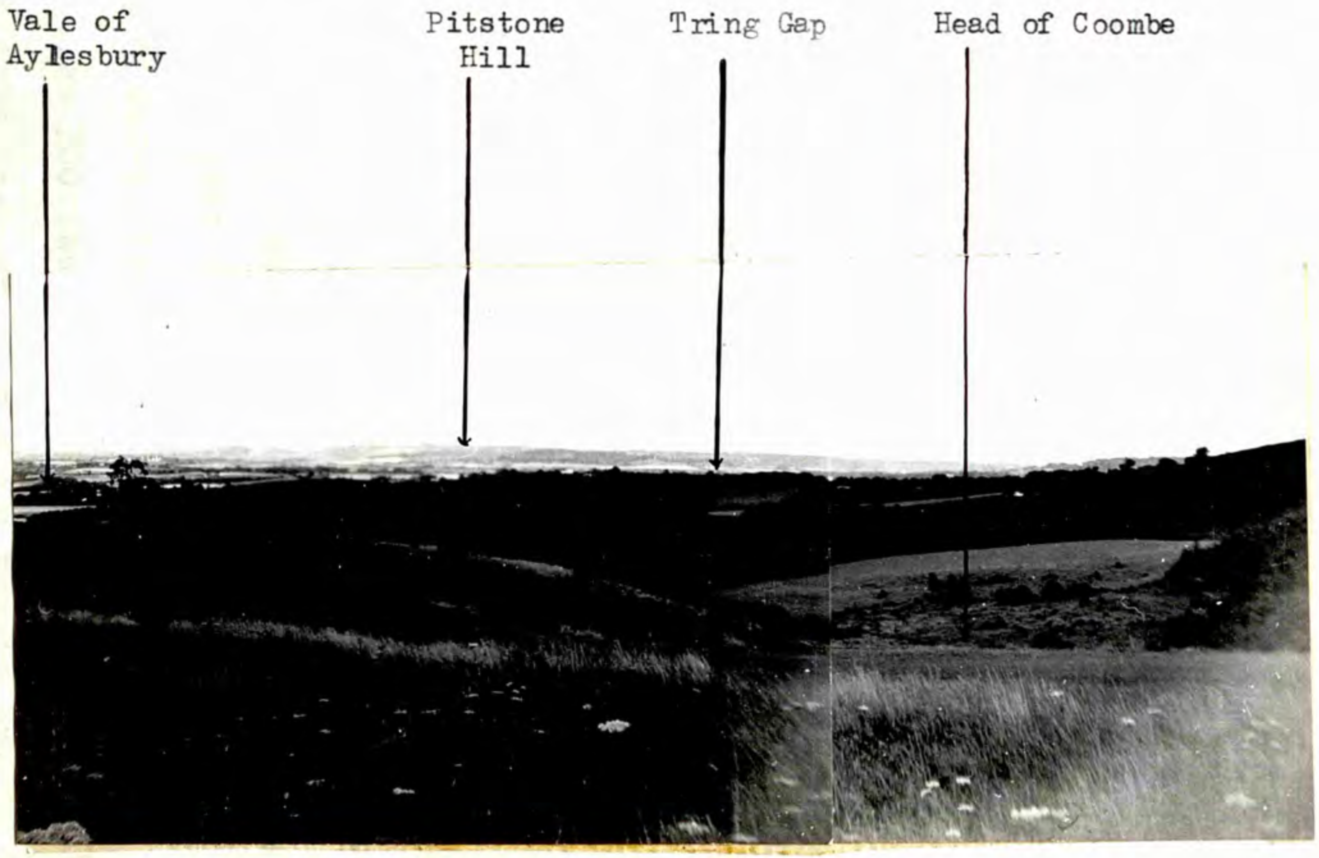
Fig. 63. Panorama of Dagnall Gap from above The Coombe.



the true height of the water parting, but it evidently lies 20 feet or so above that of the Tring Gap and about 50 feet below that of the Wendover Gap. The floor of the gap is again fairly flat, being more extensive than the Wendover flat but not reaching the development of the Tring surface, and again, there is no obvious south-sloping facet. The gap is markedly asymmetrical in cross section, the eastern side rising abruptly to the summits above Whipsnade, the western slope ascending gently to the Ivinghoe ridge. The 500 foot contour seems to delimit the gap fairly well in plan. The northern edge, the 400 foot contour, is again cut into by springs as in the case of the Wendover Gap. The bounding heights approach the breach fairly closely on the east at Whipsnade, over 700 feet, but are less prominent to the west. Gallows Hill, over 600 feet, an eastward extension of the Ivinghoe hills, projects towards the mouth of the gap on the west.

The nature of the lateral or tributary valleys entering the gaps also varies from gap to gap. The largest and best developed of the re-entrants are those leading into the Tring Gap. (Fig.55) The coombe feature west of Tring runs for some two miles before opening out onto the 400 foot surface. (Fig.64) It has a double head to the south of Coombe Hill, both of which heads cut into the

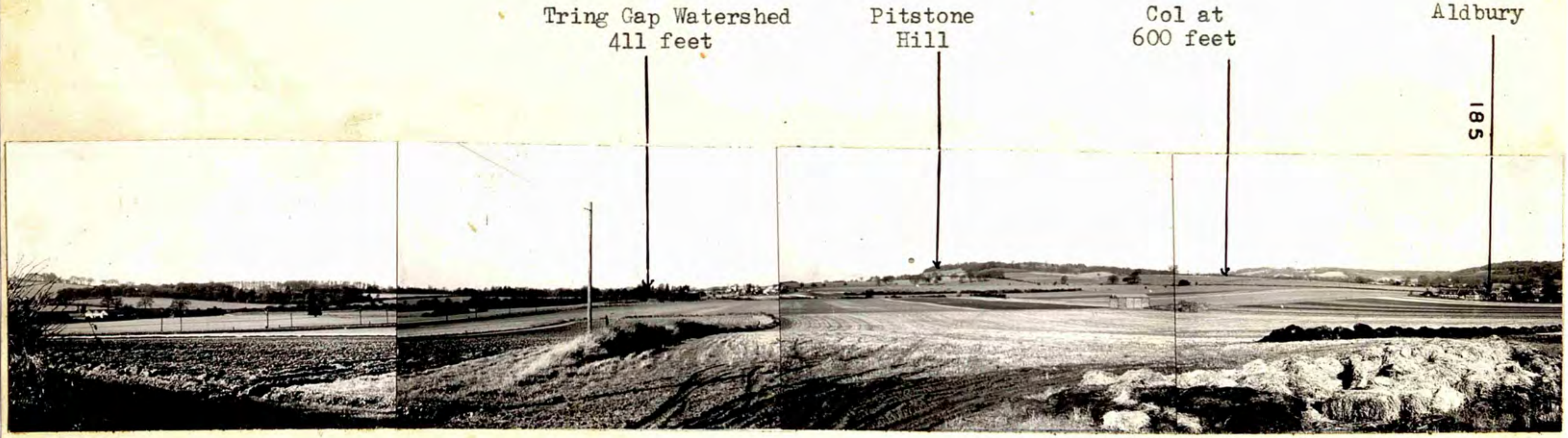
Fig. 64. Coombe Feature below Coombe Hill.



800 foot contour. The upper parts of both trend west-east but at, or just below, 600 feet, there is a change of direction to a north-easterly trend. These facts support Small's hypothesis (1958), the upper parts of the valleys representing east flowing tributaries of a former stream occupying the Tring Gap, the lower parts representing spring-sapped valleys capturing these streams by cutting back into the escarpment. This is not irreconcilable with Wooldridge and Linton's (1955) suggestion that these south-west and north-east coombes represent the lateral tributaries of the former consequent affluents of the Thames in a pre-Calabrian cycle. Their capture by scarp foot springs must represent a post-Calabrian episode.

The other major valley which enters the Tring Gap is that which passes through Aldbury (Fig. 65). The upper extension of this valley is marked by a very pronounced col or saddle in the Chiltern crest, between Steps Hill and Pitstone Hill, at just below 600 feet. The valley then trends in a south-easterly direction until it has fallen to just below 500 feet. It then trends south to south-south-west into the gap. It has a subsidiary head just above Duncombe Farm . It seems that Small is suggesting that the source of the Aldbury stream lay some distance to the north of this col. Presumably the

Fig. 65. Panorama of Aldbury Valley.



eastern side of this valley is now represented by Steps Hill, and the western side has been destroyed and the former valley cut into by Incombe Hole and other coombes. Small places these smaller, more youthful-looking valleys in a different category from the captured coombes such as Bacombe Warren, The Hale and that leading into Tring itself, and finds their origin quite satisfactorily explained by the spring sapping hypothesis. The Aldbury valley, however, remains a problem. It is only a couple of miles long, yet it is remarkably wide (up to ¾ mile) and deep (its floor, just over 400 feet, lies 300 feet below the adjacent plateau surface). It is also markedly asymmetrical - its gentle west slope contrasting strongly with its steep east side, which must have moved back very rapidly with scarp retreat. This valley perhaps itself represents the remnant of a former through-stream at a high level.

The Wendover Gap also shows two re-entrant valleys on its western and eastern sides but they are not wholly comparable with those of the Tring Gap either in size or nature. (Fig.58) Bacombe Warren is a single feature, The Hale a double coombe, both cutting back into the 800 foot contour. They trend generally east-west, although the most northerly coombe of The Hale runs north-south until it reaches an altitude of about 550 feet. Both valleys are broad and flat-floored with steep headwalls and valley slopes. Both Small's and Wooldridge's theories would again seem applicable here.

Dagnall Gap boasts only one re-entrant valley - that of The Coombe entering the gap from the west. (Fig.61) The steep eastern wall of the gap is unbreached, unlike those of the Tring and Wendover Gaps. The Coombe is more in the nature of a broad (¾ mile) shallow west-east embayment rather than a valley; it cuts back to the 700 feet ~~contour~~ and descends gently eastwards to some 450 feet. An origin as a lateral tributary to the stream formerly draining through the Dagnall Gap would not, however, seem impossible.

It is also necessary in this general account to consider the gaps in their general relationships to the relief and drainage of the Vale of Aylesbury. The floor of the Vale in the area under consideration lies just below 300 feet, and for the most part is fairly flat and featureless. It does, however, fall into two distinct drainage basins - those of the Thame and Ouzel. The watershed between these two systems, though, is not very prominent and only a low ridge, generally just over 300 feet but rising to 400 feet at Cheddington, running in a north-west to south-east direction, separates west flowing tributaries of the Thame from north and east flowing tributaries of the Ouzel. This watershed occurs just to the north of the Tring Gap, almost in fact continuing its alignment. Thus streams draining north from the Dagnall Gap fall within the Ouzel drainage basin; those draining from the Tring and Wendover Gaps join the Thame. The Ouzel, after collecting its tributary streams, follows a course, through the Lower Greensand escarpment,(Fig. 80) almost directly continuous with that of the River Gade and it is pössible that it is a modern successor of any former through consequent. No such direct stream alignment is possible for either the Tring or Wendover Gaps, for the Thame, after gathering its tributaries, follows a south-west course along the strike of the Gault.

The Thame actually rises beyond the northern margin of the Vale of Aylesbury but one of its main left bank tributaries, the Thistle Brook, is the master stream of the upper part of the Vale. The Thistle Brook has many rather indefinite branches but originates north of the Tring Gap, draining the Gault Clay tract between Marsworth and Mentmore. (Fig.55) It is reinforced by escarpment springs, rising in the Lower or Middle Chalk, which flow in a north-west direction, against the dip, across the Gault. Several fairly strong springs flow to the Thistle Brook from the vicinity of the Tring Gap. Originally four such springs, at Dundale, Frogmore, Miswell and Bulbourne, thrown out by the Melbourn Rock with its underlying marly bands and a local gritty Rag-bed, united north-west of the escarpment and flowed into the Thistle Brook, but construction of the Grand Junction Canal and its reservoirs (at the end of the eighteenth century) and the erection of the Tring Silk Mill (1824) interfered with and diverted these streams. However, there are still strong springs at Miswell and Dundale. The Thistle Brook itself follows a westerly course across the Gault to join the Thame north-west of Aylesbury.

The Wendover Gap is drained by another tributary of the Thame which joins the main stream about a mile below its junction with the Thistle Brook. (Fig.58) This tributary again has its source in springs in the Chalk (and possibly also the Upper Greensand). Examples of such springs are found at Wellonhead, Aston Clinton; The Mount, Church End; Wellhead, Wendover and south of St. Mary's Church, Stoke Mandeville.

The Ouzel, one of the main right bank tributaries of the Ouse, starts from a long set of springs, from the

Chalk, along the escarpment foot between Pitstone and Dunstable. (Fig.61) Such springs include Cowhill Spring, north-east of Pitstone Church, (one of the sources of the Whistle Brook), the spring just north of Ivinghoe Village, the spring just south of Ivinghoe Aston, Coombe Bottom Spring, the springs cutting right back into the mouth of the Dagnall Gap (at the Traveller's Rest and south of Valence-end Farm), and the springs at Edlesborough. The resultant streams are gathered up by a south-west flowing Ouzel, which eventually turns north through Grove and Linslade. Thus all three gaps are subject to erosion and attack by springs though they each bear a different relationship to the drainage and physiography of the Vale of Aylesbury.

It only remains now in this section to consider some of the more detailed morphological contrasts, and the extent to which these are or are not a function of geology. Below 500 feet, the Tring Gap is characterised by fairly extensive facets with very slight dips, generally less than 2 degrees 10 minutes, with few sharp breaks. (Fig.66) Angles of slope vary little from facet to facet, though they may increase up to 4 degrees towards the 500 foot contour. This steepening occurs just above the Melbourn Rock boundary i.e. in the Tring Gap, for the most part,

Fig.66 TRING GAP — MORPHOLOGY

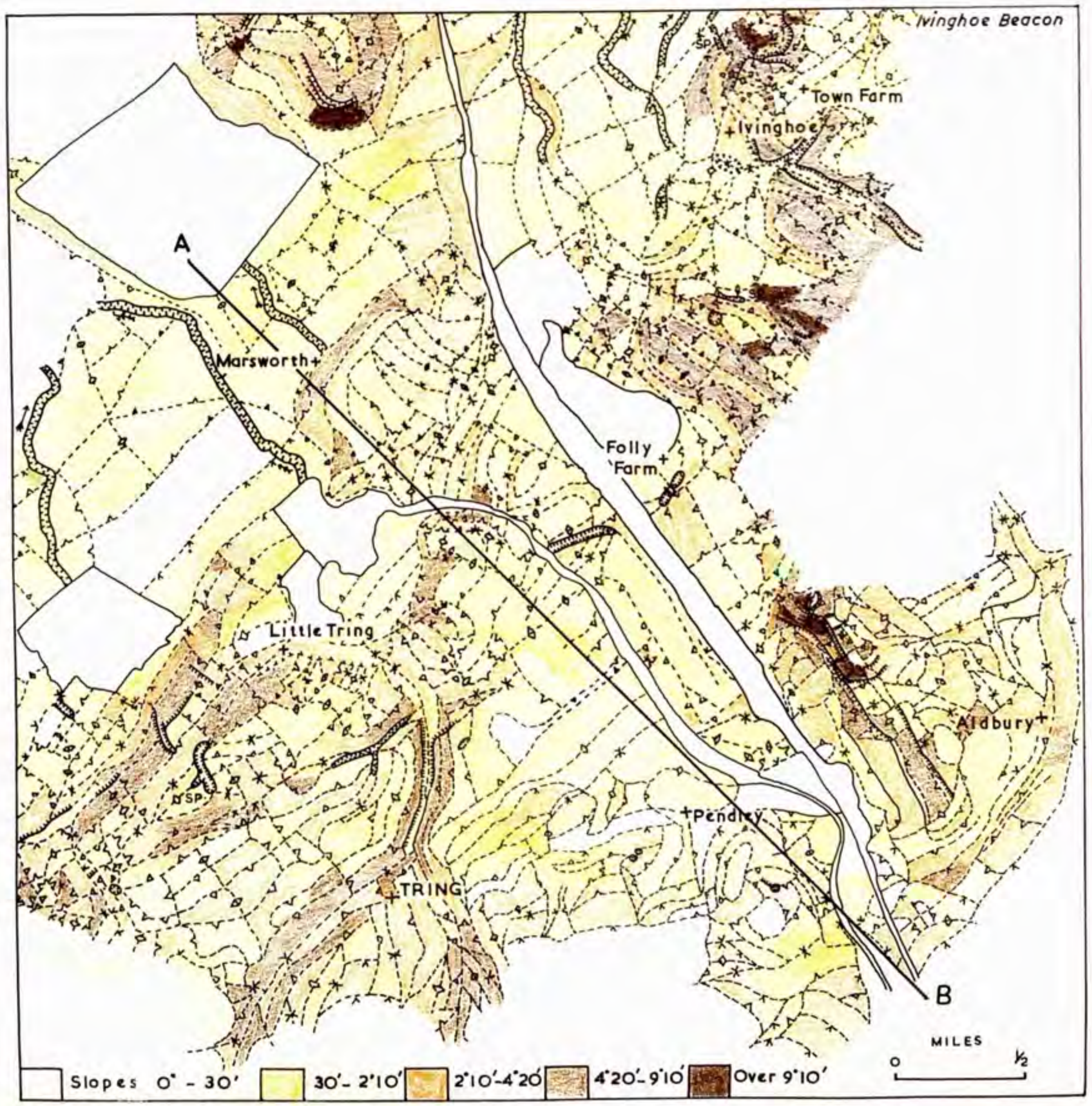
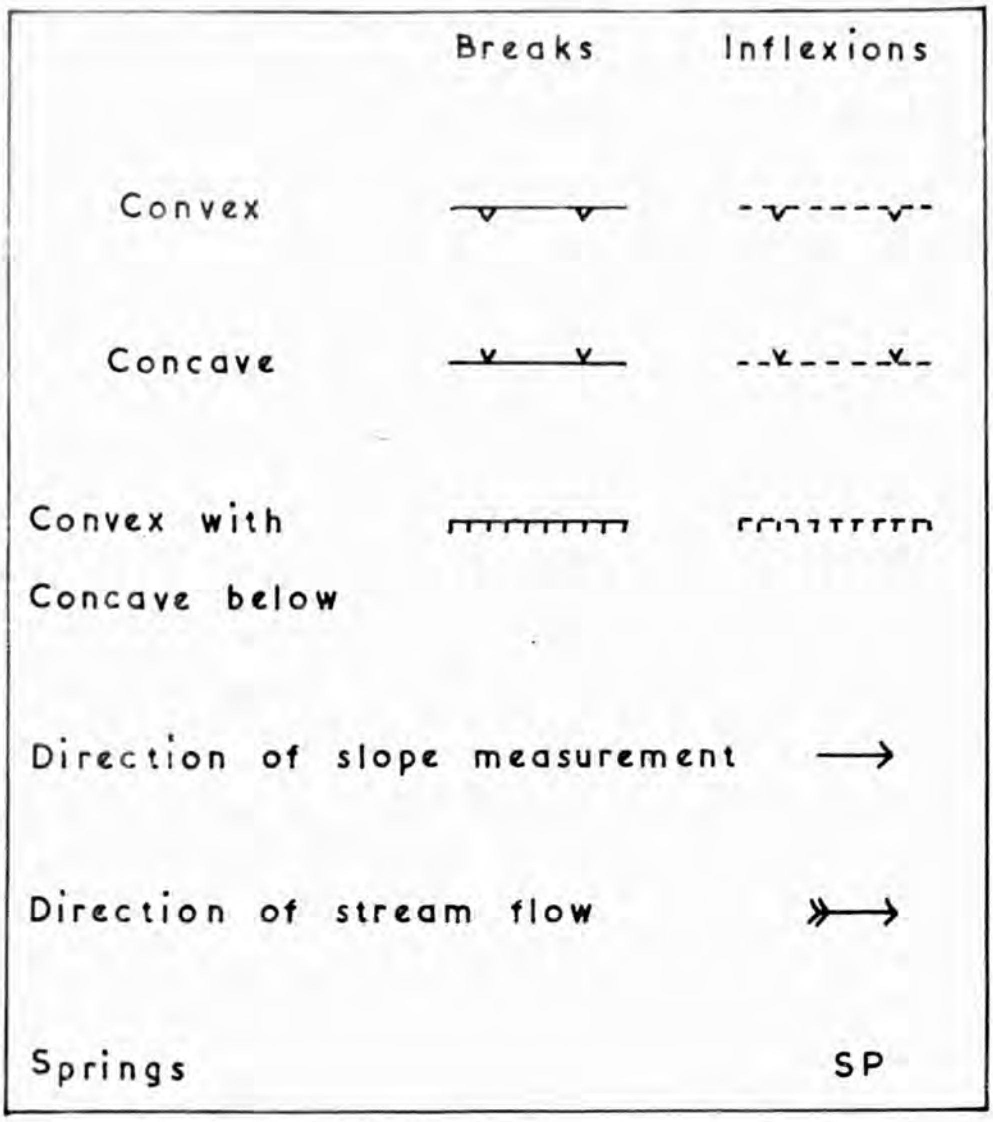


Fig.67 KEY TO MORPHOLOGY MAPS

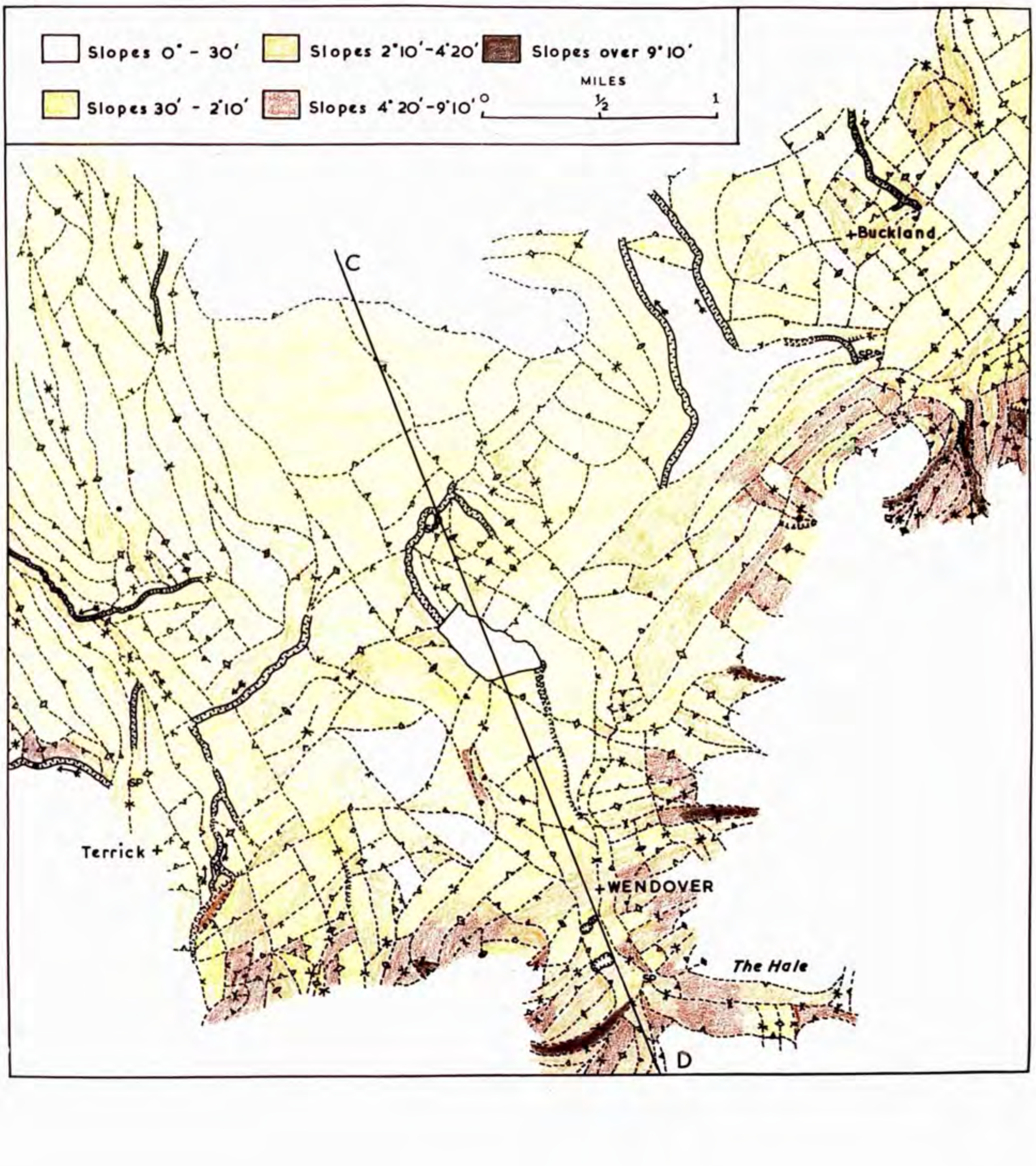


there is no definite surface associated with the Melbourn Rock outcrop, perhaps because much of the chalk is overlain by the valley gravel deposits. The undulating 400 foot surface lies almost entirely within the Geological Survey's gap gravels. However, in one or two situations, flat surfaces may be associated with the Melbourn Rock, eg. at Pendley and on the north-east margin of the gap at Folly Farm. There is also a fairly extensive flat developed on the inner margin of the gravel deposits. West of Tring itself, the Melbourn Rock is linked quite definitely with a widespread surface. On the floor of the gap breaks of slope have a definite east-west alignment, and there is little or no penetration by springs. There does not appear to be any direct geological control of the break of the slope at the mouth of the gap - it falls entirely within the Lower Chalk. The surface beyond the gap mouth and the break before the floor of the Vale is reached may be influenced by the position of the Totternhoe Stone. However, the location of this bed is uncertain (as it is not mapped here by the Geological Survey) and as it is only 3 feet thick, it is unlikely to be wholly responsible for such a well developed surface. It is interesting to note that the surface in the vicinity of Little Tring lies below the Melbourn Rock outcrop and well above any possible influence from the Totternhoe

Stone. A similar surface in the Lower Chalk occurs immediately south of Ivinghoe village. The flat ridge of the spur projecting into the Aldbury Valley likewise has no direct geological control.

By contrast, slopes in the Wendover Gap below 500 feet are much steeper. (Fig.68) Facets of any extent are associated with valley sides rather than any flat surface in the floor of the gap. Such surfaces have an average dip of some 2 to 6 degrees but in one location, a slope of 12 degrees is visible. Discontinuities are still not very sharply defined. In the Wendover Gap, the Melbourn Rock outcrops at or just below 500 feet and thus its associated surface is not mapped here, though the steepening of slopes below its outcrop is evident. There is only a very limited flatter area (slopes below 2 degrees 10 minutes) in the mouth of the gap, and there is an absence of extensive gravel deposits as in the Tring Gap. There is a slight break in the mouth of the gap, and beyond is an extensive level developed in the Lower Chalk. A very well defined break immediately west of the main Tring-Wendover road, just north of the Wendover Gap, can be linked with the suspected position of the Totternhoe Stone, but again, the scale of the surface and break makes it unlikely that lithology is the sole cause of its

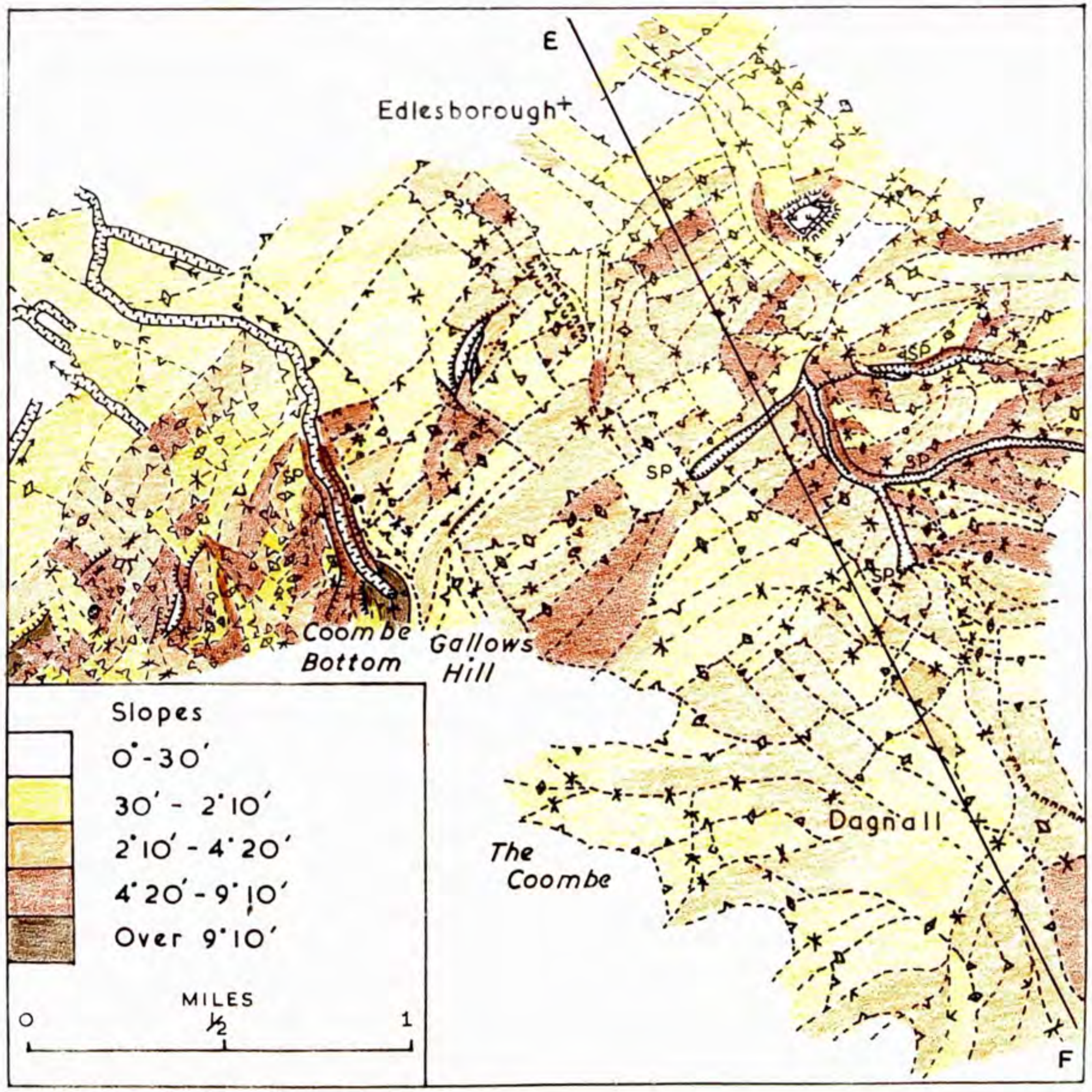
Fig. 68 WENDOVER GAP – MORPHOLOGY



preservation. Neither is the surface continued across the mouth of the gap, though there is a faint reflection of it west of the gap i.e. just north of the main Wendover-Terrick road. There is also a very slight break of slope beyond the gap associated with the Lower Chalk - Gault boundary, but, as in the case of the Tring area, it is not very pronounced. Beyond the gap facets assume a north-south trend as the terrain is dissected by long streams.

The landforms of the Dagnall Gap, however, do not seem to admit of such straightforward interpretation and correlation as those of the Tring and Wendover Gaps, nor is there any clearly emergent pattern of surfaces as in the case of the two former gaps. (Fig.69) In the neck of the gap, below 500 feet, extensive gently sloping facets are characteristic, usually less than 4 degrees 20 minutes, and often less than 2 degrees 10 minutes. There is not, though, any extensive flat area on the gap gravel deposits as in the Tring Gap. Most of the gentle slopes are associated with shallow valleys and depressions leading into the gap. Towards the mouth of the gap much steeper slopes occur, between 3 degrees and 8 degrees, and these are associated with the steep-sided, spring-

Fig. 69 DAGNALL GAP – MORPHOLOGY



sapped valleys which are cutting back into the floor of the gap. The Melbourn Rock also outcrops towards the mouth of the gap below which there is a steepening of slopes before the more level surface of the Lower Chalk is reached. But in the vicinity of the Dagnall Gap, even the Lower Chalk surface is more dissected than elsewhere, partly because of the springs at Edlesborough and partly because of the influence of the Totternhoe Stone, which is mapped immediately north-east of the gap. North and west of Edlesborough the Lower Chalk and Gault surfaces reappear. Below Ivinghoe Beacon and Gallows Hill, the influence of the Melbourn Rock is more obvious. The surface immediately east of Coombe Bottom, for example, bears a direct relationship to the Melbourn Rock. It is significant, though, that the surface on which Town Farm stands, west of Ivinghoe Beacon, is not exactly coincident with this band and does, if fact, cut across both the Middle and Lower Chalk. Further examples of this could also be quoted.

In conclusion, the general sequence of levels in each gap as revealed by the long profiles is not dissimilar, (305 - 320 feet, 370 - 382 feet, 400 - 415 feet and 430 - 440 feet), but from a more detailed consideration of the surfaces of the gaps, it becomes obvious that the pattern does vary from gap to gap and that while geological controls are not in most cases absent and therefore cannot be disregarded, they cannot be assumed without reservation to be the whole explanation of these variations. In other words, while the overall development of the gaps has been similar, their evolution in detail has differed.

(c) SOILS AND DEPOSITS

Some of the more obvious comparisons and contrasts between the gaps with respect to their superficial deposits and overlying soils have already been touched on or at least intimated. A summary of these points is, however, desirable.

The distribution of gravels, as mapped by the Geological Survey, (though it must be remembered that this may be slightly misleading Page 103,), differs markedly from gap to gap. As would be expected, the most extensive spread lies within the Tring Gap, occurring at an altitude of 400 feet on the gap watershed and rising slightly north-west into the mouth of the gap. (Fig.52) A western lobe spreads round to Tring itself and into the dry valley in Tring Park. The valley cutting back from Newmill to Tring appears to have cut into this western lobe. An eastern lobe spreads up the Aldbury Valley to a height of over 600 feet on the eastern slopes of Pitstone Hill. The lobe does not, however, pass over Pitstone Col. The Dagnall spread has a slightly higher average elevation as it occurs fairly persistently between the 400 and 600 foot contours on the western slopes of the gap. (Fig.53) The western lobe which spreads into The Coombe would seem comparable with the western lobe in the Tring Gap, apart from the fact that it occurs at a higher altitude. But the Dagnall Gap has no corresponding eastern lobe, nor does the spread project forward in front of the escarpment as in the case of Tring. These two differences can be accounted for by the fact that the Dagnall Gap has a steep, unbreached eastern wall, and no wide, flat, extensive platform in the mouth of the gap. In the Tring Gap, the gravel spreads indiscriminately over both Middle and Lower Chalk; in the Dagnall it is confined to the Middle. In the Tring Gap, the lobe narrows considerably on the gap watershed, but widens again to the south-east whereas in the Dagnall there is an uninterrupted narrowing from the mouth right through the neck of the gap. Both spreads are only a few feet thick, and thin northwards.

The Wendover gravels present a striking contrast. (Fig.54) They do not spread out in a comparable fashion at all in the mouth of the gap, and in fact are confined to a narrow strip south of the watershed, i.e. they appear cut off in the neck of the gap at an altitude of some 500 feet. They are completely absent from either of the two coombes leading into the gap, Bacombe Coombe and The Hale, from the west and east. Their absence from the mouth of the gap might be explained by the restricted nature of the breach and confined flat surface there, but it is difficult to account for their absence from the lateral valleys. The spread is again confined in its occurrence to the Middle Chalk and narrows south-eastwards down the valley of the Misbourne. It is, however, considerably thicker than the Tring or Dagnall gravels, i.e. some 25 feet thick and this may be due to its limited distribution. The remains of a Pleistocene mammoth have also been found in the Wendover gravels while it is unlikely that the Tring and Dagnall valley gravels are thick enough to harbour much in the way of faunal remains. None, at any rate, have been found.

A further feature of contrast in the occurrence of these gravels is their thickening opposite the Wendover and Tring Gaps, while no such thickening is apparent opposite the Dagnall Gap. The two outliers, at Weston Turville and Gubblecote respectively, are of comparable extent and thickness, although the Gubblecote occurrence has a slight tendency to thin in its outline away from the escarpment. In addition the Gubblecote spread overlies both Lower Chalk and Gault; the Weston Turville is confined to the Gault. Thus at Gubblecote the gravels at their lower margin are some 4 feet higher than at Weston Turville, and at their upper margin, 24 feet higher. ← So the Gubblecote outlier has a greater altitudinal range than the Weston Turville outlier, 52 feet compared with 32 feet. But the localised thickening of these Vale gravels opposite the Wendover and Tring Gaps, and their absence opposite Dagnall, remains a problem and is almost certainly tied up with the physical evolution of the gaps. (to be elucidated in Chapter VII)

In their constituents, the gravels basically differ little from gap to gap i.e. flints are the predominant constituent in each case. Most of them are noticeably angular and unworn though it may be significant that certain occurrences of sub-angular and sub-rounded flints were seen in the Tring Gap. Tertiary pebbles seemed scarcer adjacent to the Wendover Gap. In each of the gaps, though, the flints showed a tendency to decrease in size and angularity northwards. Barrow (1919) thought the Wendover Gap unique in its layer of white quartzite pebbles below the gravels but such a layer was not actually located. Of far greater significance is the distribution of Bunter pebbles. (Fig.21) These are relatively abundant in both the Dagnall and Tring Gaps and occur sporadically along the foot of the escarpment as far as Cheddington. But they are entirely absent from the Wendover Gap and its vicinity. If these Bunter Quartzites should be remnants of the original through consequents from the Midlands, their absence here is puzzling. If, however, they should happen to have been derived from drift or outwash deposits, their location suggests that ice or outwash extended little further south-west than Tring and Cheddington. In short, the Tring and Dagnall Gaps may have a different Pleistocene history from the Wendover Gap.

It must be borne in mind, however, that the picture of superficial deposits revealed by geological mapping is probably too simple, and that the real picture as revealed by soil mapping is much more complicated. (Figs. 70-73) With respect to the occurrence of the detached outliers of the Winchester Series, all three gaps are broadly similar. In the Tring and Dagnall Gaps, the Winchester Series lies on a surface between 450 and 500 feet, but in the Wendover Gap it occurs some 50 feet

Fig.70 TRING GAP ~ SOILS

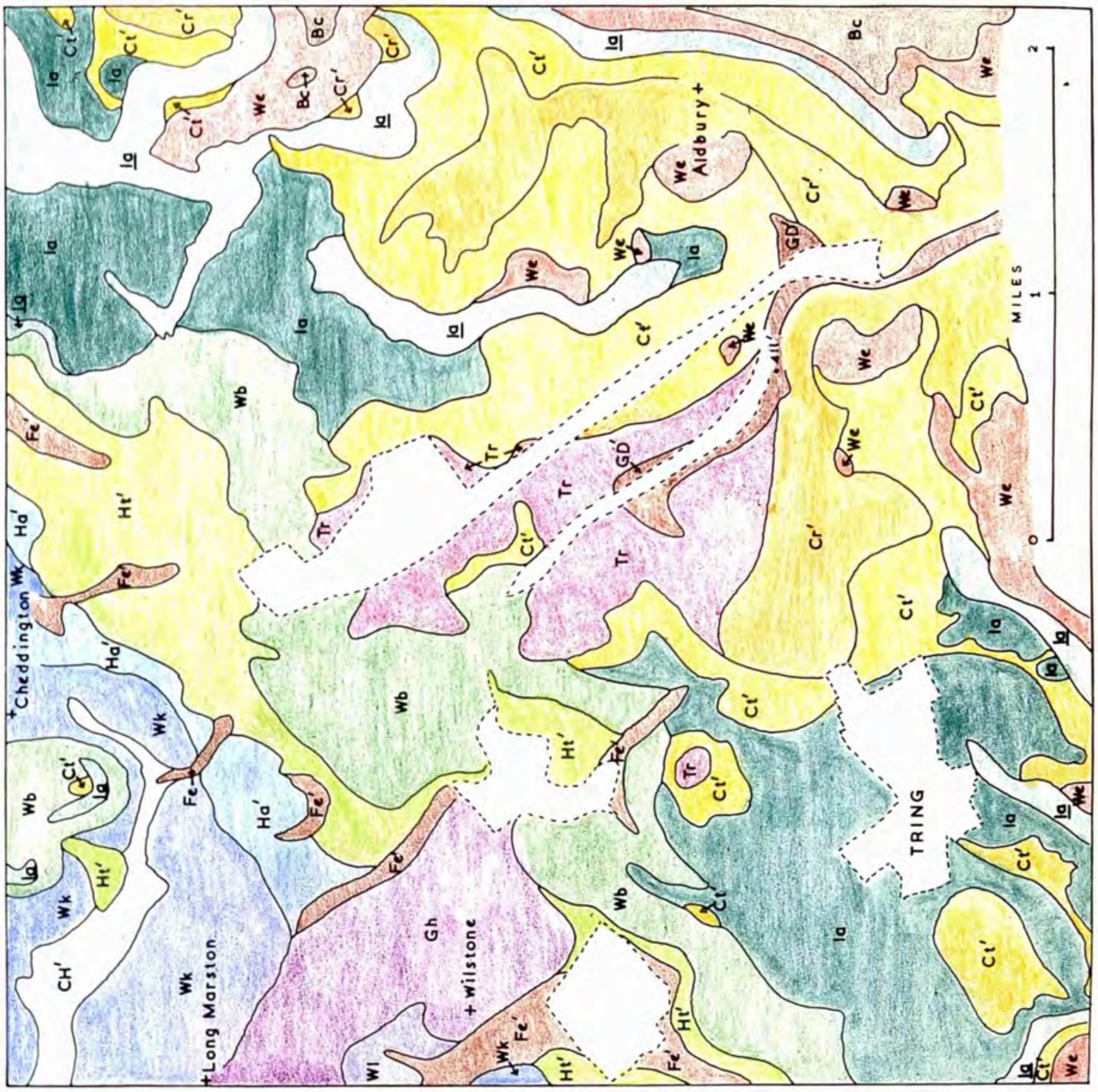


Fig. 71 EXPLANATION OF SYMBOLS

Cr'	CHARITY COMPLEX
We	WINCHESTER SERIES
Bc	BATCOMBE SERIES
Ia	ICKNIELD SERIES
Ia	ICKNIELD SERIES (steepland phase)
Wb	WANTAGE SERIES
Ct'	COOMBE COMPLEX
Tr	TRING SERIES
Ht'	HALTON COMPLEX
Gh	GUBBLECOTE SERIES
Ha'	HARWELL COMPLEX
Wk	WICKEN SERIES
CH'	CHALLOW COMPLEX
Da	DENCHWORTH SERIES
Wl	WESTON TURVILLE SERIES
GD'	GADE COMPLEX
Fe'	FORD END COMPLEX
MD'	MEAD SERIES

Fig.72 DAGNALL GAP – SOILS

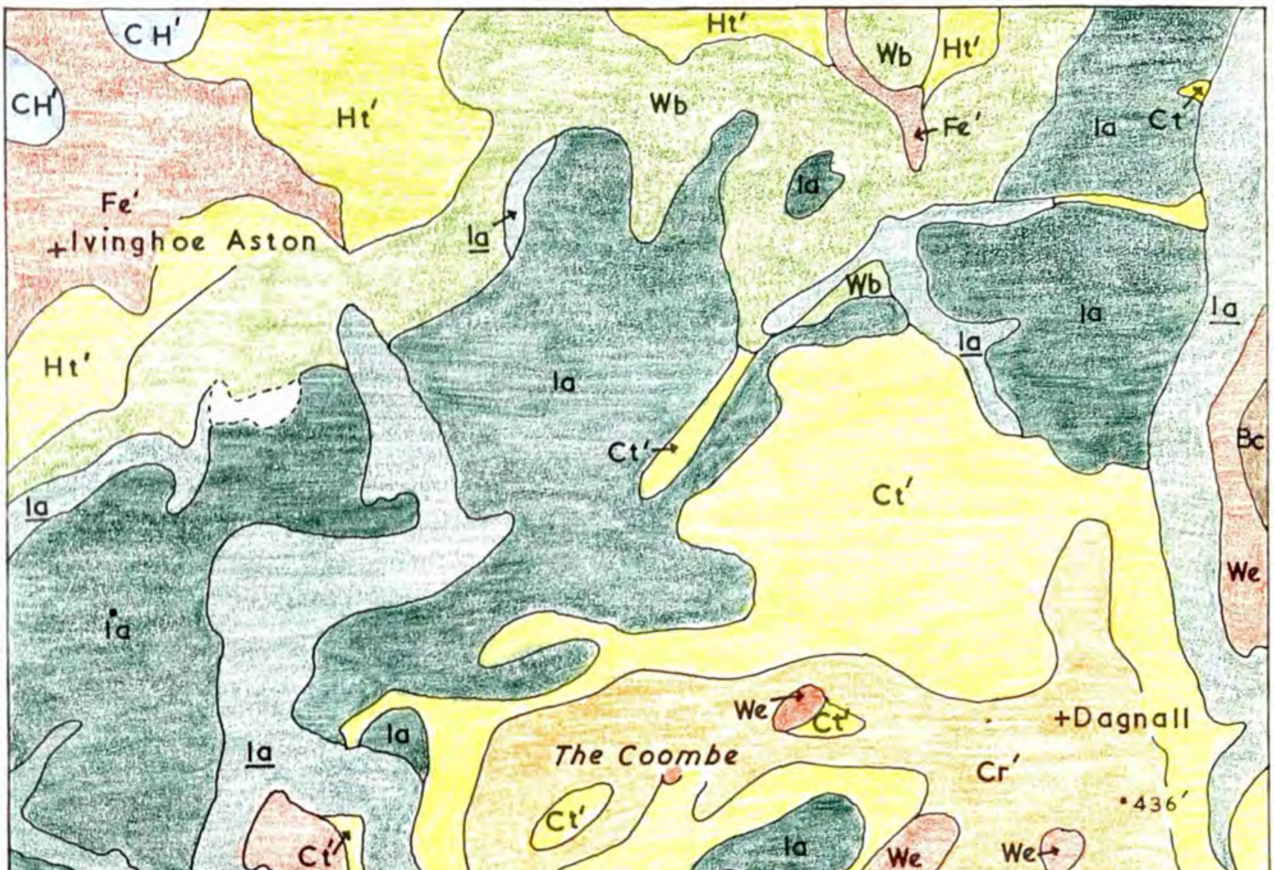
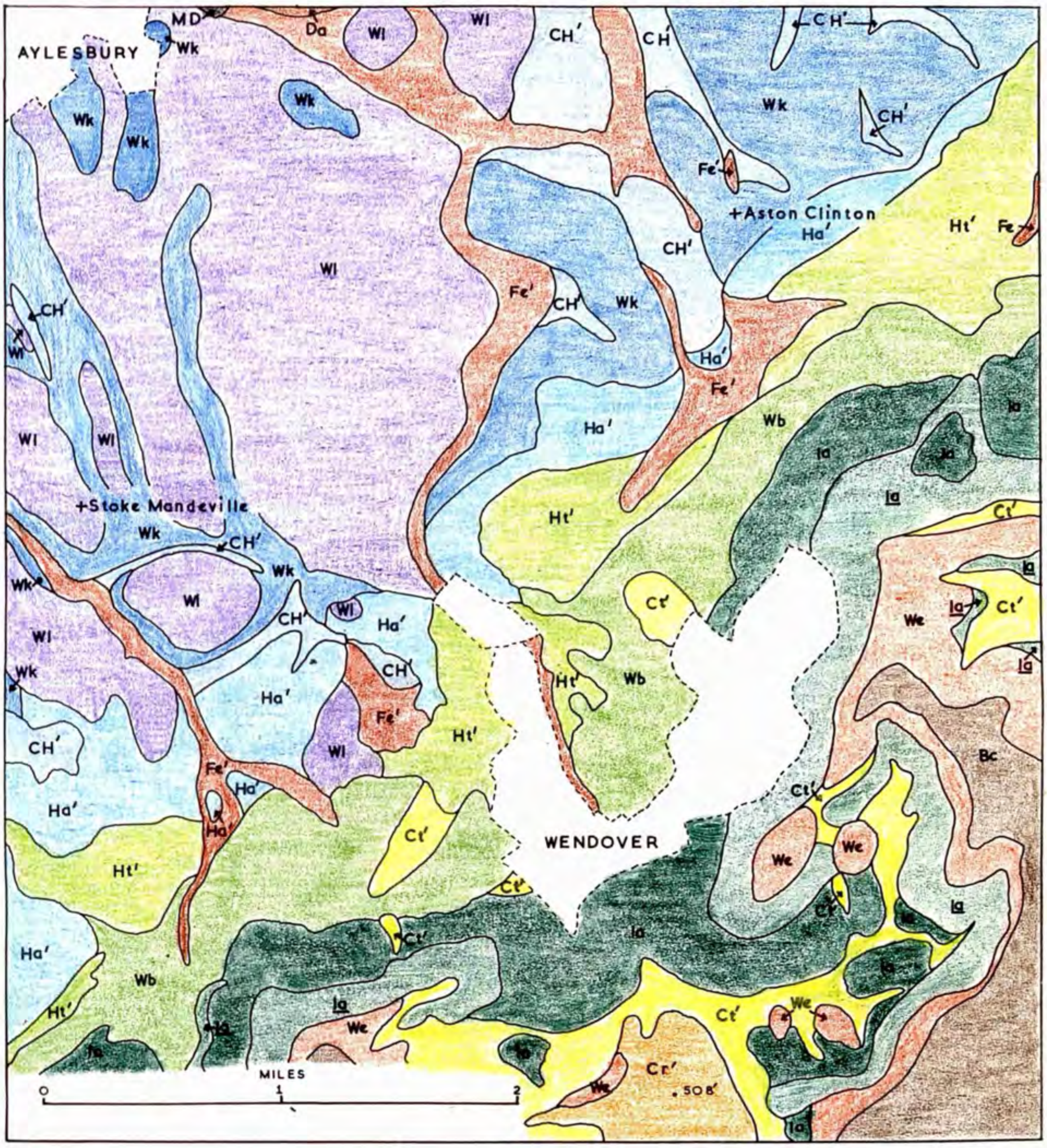


Fig.73 WENDOVER GAP – SOILS



higher i.e. at altitudes of 500 and 550 feet. The Charity Complex can in part be equated with the valley-bottom gravel deposits, and therefore the contrasts in the distribution of the Charity Complex between the gaps have also been emphasised. In the Tring Gap, the Complex occupies the lower slopes of the Bulbourne valley and spreads in two tongues to the west and east of the gap, that is, round to Tring and up the Aldbury valley. In the Dagnall, it is found throughout the Gade valley and as a lobe projecting into the floor of The Coombe to the west of the gap. Unlike the Tring Gap, it here does not extend north of the present watershed although it has a similar altitudinal range, (400 - 600 feet), and morphological situation. In the Wendover Gap, it is confined to the lower slopes and floor of the Misbourne Valley and extends little north of the gap watershed. Nor is it present in the adjacent coombes.

The Coombe Complex has a more comparable extent in each gap. In each case it margins the Charity Complex and thus occurs on the gap slopes and re-entrant valley sides. In the Wendover re-entrants it is restricted to north facing slopes. In each gap, it does not extend much beyond the mouth in any great thickness and has probably been partly eroded by springs. The Tring Series has already received comment, but its confinement to the Tring Gap must again be emphasised here in association with the well developed 400 foot surface found only in the Tring Gap. If this is accepted as a drift or ice deposit, it must again be inferred that Pleistocene events differed slightly from gap to gap. In conjunction with the Bunter pebble distribution, this occurrence of drift would lead to the suggestion that the thin edge of an ice sheet occupying the northern part of the Vale of Aylesbury reached the Tring Gap, but not the Wendover. The absence of drift in the Dagnall Gap might be due to its narrower and more restricted form.

The Icknield Series is particularly prominent along the scarp, but it extends across the mouths of both the Dagnall and Wendover Gaps, presumably because bare chalk surfaces were exposed here. The mouth of the Tring Gap, by contrast, is occupied by the problematical Tring Series. In each gap it is confined to surfaces above 400 feet. The Wantage Series is present beyond the mouths of each of the three gaps at altitudes just above 400 feet, and is particularly extensive adjacent to the Tring and Wendover Gaps. The Halton Complex has a similar distribution in relation to each of the gaps.

The Weston Turville and Gubblecote Series are approximately coincident with the gravel outliers, opposite the Wendover and Tring Gaps respectively, already considered. The Weston Turville Series, however, is not as restricted in its occurrence as the corresponding gravel spread as it extends westwards as far as Stoke Mandeville and northwards as far as Aylesbury. Patches are also found north of Wilstone, north-west of Long Marston and east of Cheddington. But from the soil map, the distribution of head deposits is seen to be much more prominent opposite the Wendover than the Tring Gap. Few valid conclusions can be made about the relationship of such head deposits to the Dagnall Gap as soil mapping has not proceeded to such a distance into the Vale as in the case of the previous two gaps. It would certainly appear, though, that a much more limited supply of coombe material was available from the Tring and Dagnall Gaps, or that the head deposits adjacent to these gaps have since been removed. The clayey head of the Challow Complex attains its maximum development between the gaps, e.g. north-west of Aston Clinton and west of Ivinghoe Aston, rather than in the neighbourhood of the gaps themselves.

Thus the distribution of the superficial deposits and soils both within and adjacent to the gaps is yet a further point of contrast between them, in addition to the contrasts of structure, geology, morphology and drainage. It remains now to consider to what extent the gaps have experienced a similar geomorphological development and to what extent their evolution has differed; and from this to work out, as far as possible, a chronology for the region. This can then, in conclusion, be considered in the light of suggested chronologies for adjacent areas.

VII. THEORETICAL DEVELOPMENT OF THE GAPS AND A TENTATIVE CHRONOLOGY

In the preceding pages, the existing material relevant to the origin and development of the Wendover, Tring and Dagnall Gaps has been appraised and some further information has been added. In the light of this evidence, it is proposed to consider whether the prevailing theories are proved, disproved or amended, and some suggestions pertinent to the possible physical evolution of the gaps will then be offered.

In Chapter I, it was indicated that the term 'wind-gap' would be used in a descriptive as opposed to a genetical sense until sufficient consideration had been given to modes of origin. From the foregoing it would seem that certain possibilities can immediately be eliminated. For example - lack of evidence of structural weaknesses in the chalk makes it unlikely that these major Chiltern wind-gaps originated through weathering and mass movement at structurally weak points on the divide such as fault notches. Watershed breaching by ice as envisaged by Linton (1949) in the Scottish Highlands is also inapplicable here as there is no evidence of an ice-sheet of the necessary thickness, or moving with sufficient power, in the Vale of Aylesbury.

The more specialised theory of Barrow and Green (1921) relating the origin of the gaps to marine erosion in a Pliocene sea is likewise discounted, now that the limits of the Calabrian marine invasion have been mapped by Wooldridge (1927), though it is obvious that the role of the gaps in Pliocene geography is a relevant issue in a consideration of their development.

Formation of the Chalk gaps as a result of divide retreat merits more serious attention. Formerly, the Chalk outcrop was more extensive, probably reaching far beyond its present limits in southern England. During Tertiary and Pleistocene times its margins were slowly driven east and southwards under the influence of subaerial processes and, at a fairly late stage, periglacial processes. The Chalk watershed followed the direction of scarp retreat, progressively beheading the dip-slope valleys at the heads of which cols would be left indenting the escarpment crestline. This hypothesis is dealt with by Small (1958) in his discussion of the problem of the breaching of the Chalk escarpment crests of South-East England as a whole.

While undoubtedly such a sequence of events has taken place, it is unsatisfactory as a complete solution for all Chalk breaches as it disregards such problems as the rarity of cols in some regions and the heading of so many dip-slope valleys immediately behind the escarpment. Small's contention that the Chalklands of South-East England are for the most part in at least a second cycle of development answers these objections and, in the context of his postulated evolution of chalk cuestas (pages 48-51), the place of divide retreat in the formation of the Chiltern wind-gaps is more acceptable. This will shortly be worked out in detail.

The theory attributing the gaps in their entirety to overspill from a pro-glacial lake held up in the Vale of Aylesbury has gained little material support. The drift evidence indicates that, at some stage during the Pleistocene, an ice-sheet must have occupied the north and east of the Vale and that, as it wasted away, a considerable amount of meltwater must have been liberated. But the 'lake theory' is untenable on areal and altitudinal bases. There is no satisfactory south-western limit to the ponding and a lake occupying the Vale of Aylesbury and Oxford Basin seems too extravagant a hypothesis.

Drift on the floor of the Goring Gap (Hawkins, 1923) and Bunter pebbles in the Tring and Dagnall Gaps indicate that the gaps were cut much to their present altitudes before the main glaciation in the region, the only period in which a pro-glacial lake would be possible. In addition, there is no depositional evidence in the Vale for a lake of the required dimensions, and an examination of the soils and gravels of the Vale revealed that periglacial rather than lacustrine conditions had been predominant during the Pleistocene (pages 121-147). This does not exclude the possibility that glacial overflow played some part in modifying the form of the gaps, as suggested by Culling (1956) from the evidence of the long profiles of the Chiltern streams.

It would therefore seem a logical conclusion that the gaps must have had a pre-glacial fluviatile origin, their present outlines being a result of capture at some stage in the drainage evolution. Their subsequent development appears to have been complex, and several possibilities must be considered. The early history of the area is bound up with the Mid-Tertiary erosion cycle, the end product of which is seen in the present Mio-Pliocene summit peneplain. The youthful stage of the cycle was probably characterised by major consequents with lateral tributaries, as indicated by Wooldridge and Linton (1955), draining from the Midlands to the south-east on a formerly more extensive Chalk cover. Gradually, the Chalk escarpment was driven south-eastwards, and by the stage of early maturity subsequents had etched out the clay vale at the escarpment foot, the more powerful consequents and subsequents beheading the weaker. Thus, even at this early stage, the cuesta was cut by the water-gaps of the dominant consequents, e.g. Goring, and the wind-gaps of the captured streams. It would seem highly probable that the streams occupying the Wendover and Tring Gaps were captured at this point, all evidence for the former continuity of these drainage lines being eradicated by subsequent peneplanation and glaciation of the area. There is, however, a possibility that these captures were not effected until the second cycle of erosion, but there is no evidence for such recent capture in the form of present stream alignments because of glacial derangement. A postulate of capture in the current cycle also encounters the difficulty raised by the heights of the gaps. If the Wendover stream was captured by the proto-Thame subsequent to the Princes Risborough, it should have cut a deeper gap, whereas, in actual fact its floor is approximately 65 feet higher than the

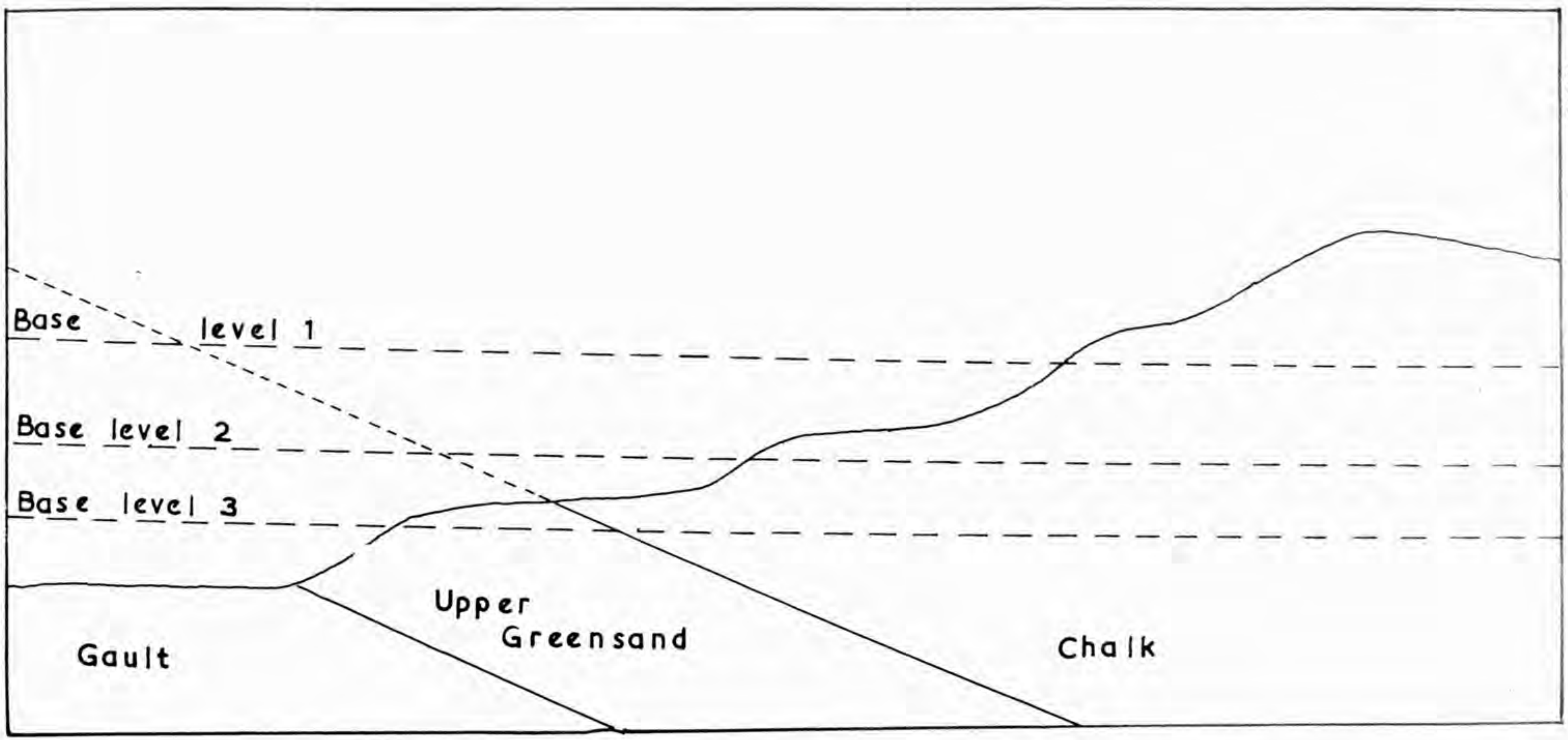
Princes Risborough col. The Dagnall stream was possibly the only one excluded from capture in the Mid-Tertiary cycle as it now exhibits marked alignment with the Ouzel. Disruption of the consequent stream here would seem a much more recent episode.

During the mature stage of the Mid-Tertiary cycle, the subsequent waters of the Gault vale were almost certainly collected together into a master stream tributary to the major consequent through Goring, i.e. the precursor of the Thame. However, it is not impossible that the Gault drainage was led away to the Wash to the north-east by an early Thames as envisaged by Prestwich (1890) and Harmer (1907). By late maturity, the streams of the area were slowly approaching the base-level of erosion and the escarpment, in a state of arrested dissection, had reached its maximum development, rising several hundred feet above the Gault Vale. Small (1958) demonstrates that backwearing would then become the chief process operative in moulding the scarp face and, under the influence of such parallel slope retreat, a piedmont slope of gradually increasing breadth would form on the chalk outcrop at the foot of the escarpment. As the piedmont slope developed, obsequents, fed by scarp foot springs, would flow from the escarpment, across the chalk 'flat', to join the subsequents of the Vale. The final stage of the Mid-Tertiary cycle of erosion was marked by a peneplain surface which all but obliterated the wind-gaps, scarp face and piedmont slopes of late maturity. Thus the gaps, whether dry or still containing uncaptured streams, were at this period quite insignificant features in the Chiltern landscape.

The physical history of South-East England in the later Tertiary and early Quaternary has been characterised by a succession of progressively falling base-levels and the Mid-Tertiary erosion cycle was followed by a number of short-lived epicycles related to temporary still-stands of this base-level. The Calabrian sea invaded an area graded to a 600 foot to 650 foot base-level, for example. The wind-gaps were probably attacked both by the revived obsequents flowing to the Gault Vale, and the beheaded portions of the old south-east flowing consequents. These beheaded consequents, together with any streams which had escaped capture, entered the Calabrian sea and upon its retreat extended themselves across its emergent floor. Other consequents, now represented by the dry valleys of the Chiltern dip-slope, were initiated on this new surface, heading at the old coast-line (Wooldridge and Linton, 1955). The wind-gaps at this stage were presumably only cut to a depth of 150 to 200 feet and are thought to have acted only as gulfs or embayments of the sea. There is no evidence of any extension of the Calabrian sea north of the present escarpment.

Evidence of subsequent epicycles is indicated by the incomplete piedmont slopes at the foot of the present Chiltern scarp face. Small (1958) points out that each epicycle which had progressed as far as the mature stage would be represented by a bench on the scarp slope, above and below which would be a steeper chalk bluff. (Fig. 74) This he illustrates by reference to the 400 foot, 320 foot, 200 foot and other flats on the South Downs escarpment (Bull, 1936). These levels are often attributed to lithological influences but though this may sometimes be a factor in their preservation, it can be demonstrated that in detail such levels may be quite independent of the known hard bands in the Chalk. Two such benches are obvious along the Chiltern scarp between Wendover and Whipsnade, at just over 500 feet and between 400 and 415 feet. Both have been traced in detail in Chapter VI and in places have been seen to be supported by the Melbourn Rock and possibly by the Totternhoe Stone; in places they were shown to be independent of these formations. Other levels have also been distinguished - 430 feet to 440 feet, 370 to 382 feet, and 305 to 320 feet - but as these are ~~less~~

Fig.74 VARIOUS STAGES IN THE EVOLUTION OF ESCARPMENT FORMS WHICH WOULD DEVELOP IN THREE SUCCESSIVE EPICYCLES, EACH OF SHORTER DURATION THAN THE PRECEEDING ONE – AFTER SMALL.



less well developed and of more limited distribution they may well be related to local rather than regional base-levels.

It is conceivable that the capture of the streams occupying these Chiltern through-valleys by the Thame took place immediately prior to their grading to the 400 foot base-level, i.e. after they had cut the gaps to their present forms. This involves the corollary that the differing heights of the present gaps are not sufficiently large to be of any great significance in this respect. Evidence of the former courses of these consequents would not be preserved in the present landscape because of the influence of glaciation and later downcutting (apart from the Dagnall-Ouzel alignment).

The present cycle of erosion - the Late Tertiary-Quaternary cycle - is as yet incomplete. (Small suggests that over much of the Chalk cuestas of England it has not progressed much beyond the youthful stage.) The old surfaces have been dissected, and the escarpment, in profile, has become a prominent feature in the landscape again. Obsequents inherited from the first cycle indent the scarp foot piedmont slopes, e.g. the Whistle Brook. The present location of the gap watersheds is therefore due to activity both by the beheaded gap streams and these revived obsequents. This cycle has, however, been interrupted by the Pleistocene and a complex glacial legacy has been imparted to the area in terms of its deposits, soils and detailed landforms. Glaciation has, in fact, been a major episode in the development of the gaps.

The earliest record of cold conditions in the vicinity of the Wendover, Tring and Dagnall Gaps is the frost shattered chalk seen in situ in the exposures at Folly Bridge (page 141) and in the Lower and Upper Pitstone Quarries (pages 141-5). This itself was subjected to further cold conditions, during which time the early coombe deposits of the area were festooned into the underlying chalk (seen in the section in the Lower Pitstone Quarry (Fig. 42)) on the 400 foot surface. It is possible that the parent material of the Charity Complex was likewise a product of this early cold period, but, in contrast with the Pitstone coombe deposits which were derived directly from the scarp face and were purely local in origin, the Charity Complex represents a solifluction material derived from the adjacent plateau top. This is suggested by its decalcified nature, its obvious age, and the nature of its restricted distribution within the gaps. The exact age of the Charity Complex is, however, open to question and much depends upon its interpretation in relation to the Tring Series i.e. whether it is older, equivalent to or younger than this Series.

If the Charity Complex is older than the Tring Series, and from the evidence of its location over 400 feet and its decalcification it may well be so, it could conceivably be contemporaneous with the Older or Chiltern Drift of Wooldridge and Linton (1955), (assigned to the Gunz Glaciation by Wooldridge and Henderson 1955). If it is equivalent in age to the Tring Series, three possibilities are open. On the basis of the evidence previously discussed, the Tring Series is thought to resemble a drift rather than a pure solifluction deposit, though the problem of its age is by no means resolved. Brown* regards it as of pre-Chalky Boulder Clay origin, i.e. he equates it with the Chiltern Drift at 400 feet, principally on an altitudinal and lithological basis. Avery and Thomasson*, on the other hand, because of its Bunter content, believe the Tring 'till' to be of more recent origin, and assign it to the main period of advance of the Great Chalky Boulder Clay ice. This is equivalent to the Lowestoft Advance (Elster Glaciation) of West and Donner (1956) in East Anglia and the Midlands. This ice-sheet is thought to have moved out north-eastwards and south-eastwards from the Southern Pennines, spreading in the latter case over East Anglia

* in conversation

and at least as far south as Hertford where it diverted the pre-glacial Thames as envisaged by Wooldridge and Linton (1955). Others have expressed their opinion that the Tring Series is of even more recent age and correlate it with the Leighton Buzzard Drift to the north at 400 feet and the boulder clay mapped within the Vale of Aylesbury by the Geological and Soil Surveys, i.e. the Rowsham Complex and drift on Southend Hill, Cheddington, again at an altitude of just over 400 feet and containing Bunter Quartzite pebbles. This would place the Tring Series in West and Donner's Gipping Advance (Saale Glaciation) which deposited chalky boulder clay both in the East Midlands and East Anglia. From a centre north of the Wash, this ice sheet is known to have moved westwards as far as Moreton-in-the-Marsh, southwards as least to St.Albans (the St. Albans lobe of Wooldridge, 1953), and eastwards at least to Ipswich. It is possible that a lobe very similar to that which advanced down the Vale of St. Albans projected into the Vale of Aylesbury.

Hence, if the Charity Complex is contemporaneous with the Tring Series, it could be of Older or Chiltern Drift age, Chalky Boulder Clay Lowestoft Advance or Chalky Boulder Clay Gipping Advance. Finally, if the

Tring Series is assigned to the era of the Chiltern Drift or the Lowestoft Advance (as advocated by Brown*, and Avery and Thomasson* respectively), the Charity Complex might well belong to the Gipping Advance. This is suggested by Brown as a result of his interpretation of the relation of the Charity and Tring soils and because of the known proximity of the ice sheet of the Saale Glaciation. Avery et alia,(1959), similarly attribute the Charity Complex to the combined agencies of solifluction and melting snow during a cold phase of the Saale Glaciation.

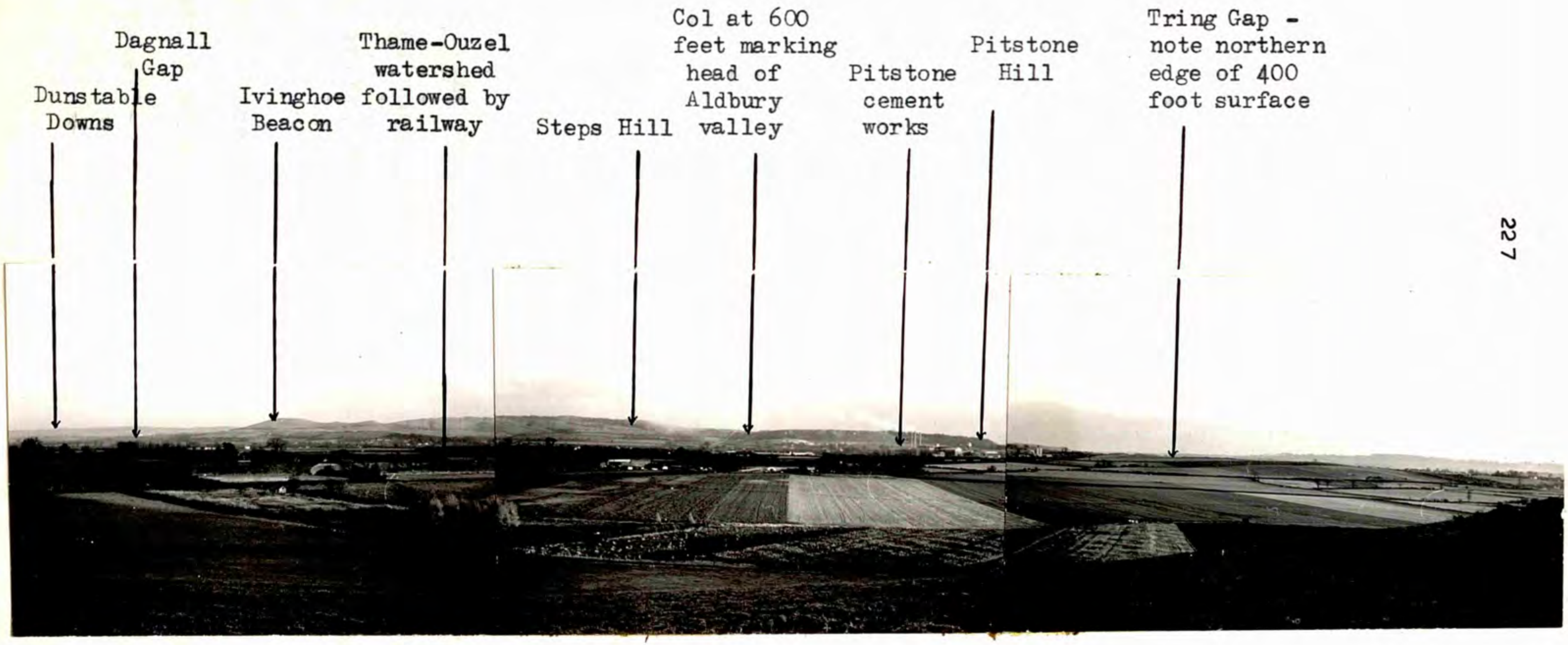
The conflict cannot conclusively and finally be resolved from the evidence available. From its altitude, distribution and leached nature, the Charity Complex would appear older than the Tring Series, i.e. belonging to the Chiltern Drift period. From the fact that the Tring Series must have had a formerly more extensive distribution and that a considerable period of time would be necessary to erode and remove the drift, it would seem logical to assign the Tring Series to the Lowestoft rather than the Gipping Advance. However, it would seem just as plausible to attribute the Charity Complex to the Elster cold period and the Tring Series to the Saale Glaciation. Perhaps a

* in conversation

decisive factor in favour of the former interpretation is Loveday's (1958) intimation, from the relation of the Winchester outliers to the Charity Complex, that much of the Charity soil was formed prior to the Winchester, i.e. before Winter Hill times (Lowestoft Advance), the development of the Winchester soil being insignificant after Winter Hill times.

Whatever conclusions are drawn from the foregoing arguments it is apparent that the gaps were affected by the proximity of at least one, and probably two, ice-margins during the Pleistocene by which time their outlines were much as at present. The floor of the Vale at this stage probably averaged some 400 feet. Ice is definitely known, from the boulder clay evidence, to have occupied the ground to the north of the present Vale (Rowsham Complex) and to have extended into the Vale at least as far as Southend Hill, Cheddington, i.e. approximately as far as the present Thame-Ouzel watershed which, at this period, was probably 50 to 100 feet higher (Fig.75). It is now suggested that, either during this or an earlier glaciation, a thin tongue of ice extended into the mouth of the Tring Gap, and reached approximately as far as the gap watershed, accomplishing no significant erosion but being

Fig. 75. Panorama of the Tring Gap from Southend Hill, Cheddington.



responsible for the deposition of the Tring Series. It is further suggested that the deposition of this drift was responsible for reversing the normal northerly slope of the gap floor to a southerly slope. The chief evidence for this is the presence and unique location of the Tring Series within the Tring Gap, together with a consideration of the known distribution of Bunter pebbles.

Because of the absence of Bunter material from the Wendover Gap, it seems unlikely that these pebbles are relics of the former early through consequents draining from the Midlands to the London Basin. It seems improbable that such evidence should have survived only in the Tring and Dagnall Gaps, even if it survived at all. Each of the remaining two possibilities would seem equally plausible. The Quartzites may have been deposited directly by the ice, being incorporated in the former extent of the Tring Series, or they may be regarded as having been redistributed by melt-water streams from outwash gravels. Taken with the evidence of the Tring drift, the former interpretation is preferable. Most of the pebbles are found between 350 and 550 feet, with a predominance at the 400 foot level, again suggesting an earlier rather than a later glacial origin when base-level would have been lower (Fig. 21).

An ice tongue of a thickness of 150 feet over a 400 foot surface would account for the presence of the isolated Quartzites above 500 feet. According to these conclusions, the ice margin would not have reached the Wendover Gap and would probably not have extended much beyond the town of Tring itself. If the Bunter material had been redistributed from outwash there does not seem to be any logical reason why it should not have been carried further to the south-west, as there is no major topographical obstruction.

As the ice tongue waned and the ice margin stagnated, quantities of meltwater would be released in the Vale of Aylesbury. Small pro-glacial lakes may have formed in depressions and undulations in the surface of the Vale floor. For example, the stratified chalky deposits noted by Evans and Oakley (1952) in the Lower Pitstone Quarry are indicative of a flooded area and probable lacustrine conditions. It may well have been at this stage that the gaps functioned as meltwater channels for pro-glacial pools on the 400 foot surface as suggested by Culling (1956), though others have suggested that extensive solifluction activity in the Chiltern valleys was responsible for the deformation of their profiles above the Winter Hill stage. If the disruption of the profiles should be due to the passage of meltwater, again an early (Winter Hill or Lowestoft) age rather than a later (Gipping) would be inferred for the ice occupying the Vale of Aylesbury.

It has been suggested that if the idea of an early Thames occupying the line of the Vale of Aylesbury is tenable, then during the Pleistocene it was blocked by ice and reversed. The right bank tributaries of the proto-Thames occupying the present wind-gaps would likewise suffer reversal. Lack of evidence is the chief objection to this hypothesis. Ice, however, was probably the agent responsible for blocking the former Ouzel-Dagnall stream, upon the retreat of which the Ouzel turned northwards and the Gade south-eastwards. The ice does not seem to have penetrated the Dagnall Gap to any great extent - no evidence of drift remains in its mouth though there is a fairly marked scatter of Bunter Quartzites.

If it is accepted that the Tring Series is attributable to the Lowestoft Advance, it is apparent that part of the detailed moulding of the present landscape, at least, must be assigned to the Elster/Saale interglacial and the ensuing Gipping Advance, as well as to the post-glacial epoch. The floor of the Vale must have been cut down almost 100 feet prior to the Gipping Advance, as the most recent head deposits are found below 300 feet in places, e.g. the Gubblecote and Weston Turville Series. During the Saale Glaciation, the Chilterns were in close proximity to an ice mass and must have suffered fairly intensive periglacial weathering. During this time great masses of chalk and flints sludged down, particularly from the wind-gaps and neighbouring coombes, on to the Gault Clay surface. The escarpment face was also denuded, and a thin skin of coombe deposits collected at the foot of exposed slopes. Some of this material is now incorporated in the Coombe and Halton Complexes. The surface of the Charity Complex underwent frost-heaving and the addition of a further solifluction deposit either at this or an earlier time. The Gault surface, too, was not immune from periglacial processes and, where free from head deposits from the escarpment, was covered with a thin purely local clayey head, the Challow Complex. During this third glaciation, the undulations and depressions in the Middle Chalk platform surface were probably formed, by melt-water in semi-thawed chalk, and spring-sapped valleys in the escarpment, e.g. Incombe Hole, were modified by the passage of melt-water. The spring-sapped features cutting into the 400 foot level, e.g. Coombe Bottom (Figs. 76, 77), a result of the intensive

Fig. 76. Head of Coombe Bottom.

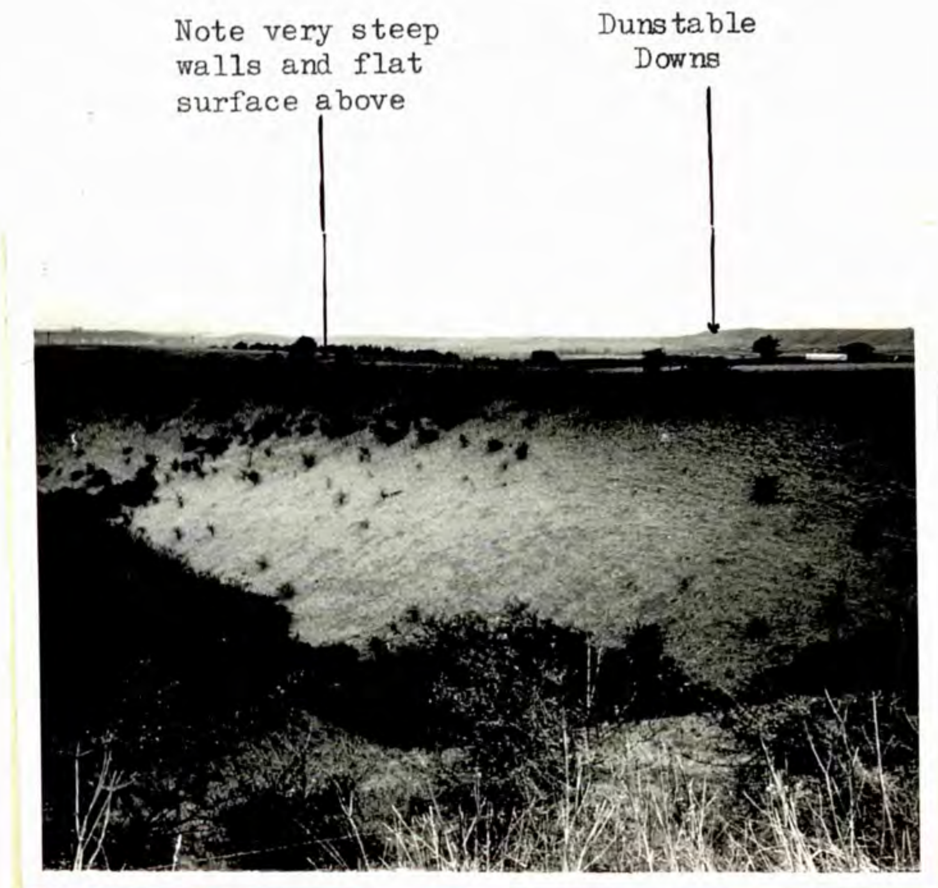
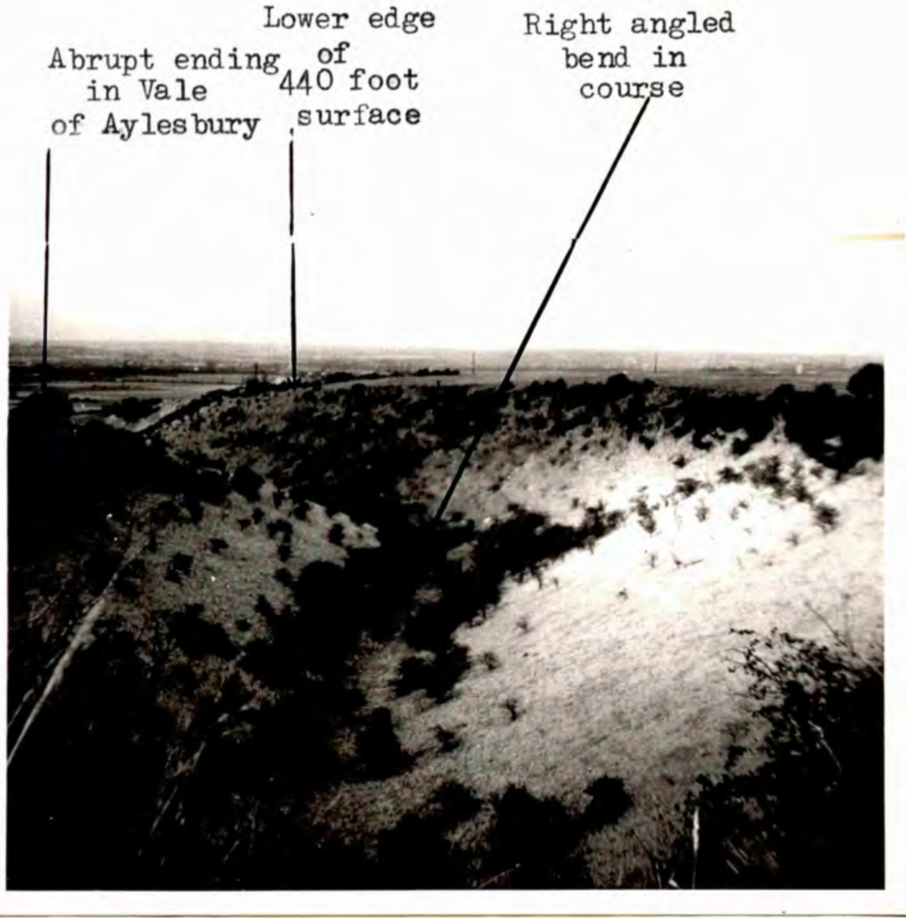


Fig. 77. Coombe Bottom from its Head.



spring and stream activity of the Elster/Saale interglacial, were likewise retouched by meltwater from the escarpment.

Post-glacial activity has been chiefly concerned with the dissection of the spreads of coombe deposits, principally by spring erosion. The Weston Turville and Gubblecote Series, for example, are cut through by shallow valleys marked by the recent alluvial and spring deposits of the Ford End Complex. Where the Gault has been laid bare of head deposits, the Wicken Series has developed. On the northern margin of the Vale, the Thame and its tributaries are in the process of dissecting the boulder clay and glacial gravels of the Rowsham Complex. The gaps themselves appear to have suffered little post-glacial modification, apart from a progressive desiccation and south-eastward migration of their beheaded streams.

In essence, a detailed examination of the landforms and deposits of the Central Chiltern wind-gaps and Vale of Aylesbury would seem to bear out Small's (1958) general hypothesis for the evolution of chalk cuestas. Most of the facts established can be explained in terms of the Mid-Tertiary and Late Tertiary-Quaternary erosion cycles. Such a scheme, however, must be modified in this region because of glacial intervention. A complete

Pleistocene chronology has been seen to be impossible, but tentative suggestions as to the sequence of events during the Quaternary have been offered. It has been demonstrated that one theory cannot be applied haphazardly to every gap regardless of its individual geomorphology. The Wendover, Tring and Dagnall Gaps do have a similar origin but in detail their development has differed. A hypothesis of capture would seem the most logical conclusion with the Pleistocene modifications to a greater or lesser degree.

VIII RELATIONSHIP TO GEOMORPHOLOGICAL STUDIES IN ADJACENT AREAS AND A POSSIBLE CORRELATION

Although the chronology proposed for the development of the Central Chiltern wind-gaps and Vale of Aylesbury in the previous chapter is of a very tentative nature, it would seem valuable, in conclusion, to consider it in the light of suggested chronologies for neighbouring areas, particularly the London Basin, and also the Oxford Region and Ouzel Basin.

(a) THE LONDON BASIN

The most complete work on the geomorphology of this region is that of Wooldridge and Linton (1955). They, in fact, as already outlined, perceived that the oldest feature in the landscape was the Mio-Pliocene or Mid-Tertiary summit peneplain, now only recognisable in the bevelled hill tops of the Chilterns and North Downs at about 800 feet. Drainage of this plain was guided by the topographic expressions of the Mid-Tertiary earth movements; the rivers themselves produced the plain, and, as it was uplifted, dissected it

"bringing into being the graceful lines of the present landscape with its broad lowland vales separated by scarp-bounded uplands through which the rivers, older than the hills they traverse, wind in narrow defiles." (Wooldridge and Linton, 1955. page 149).

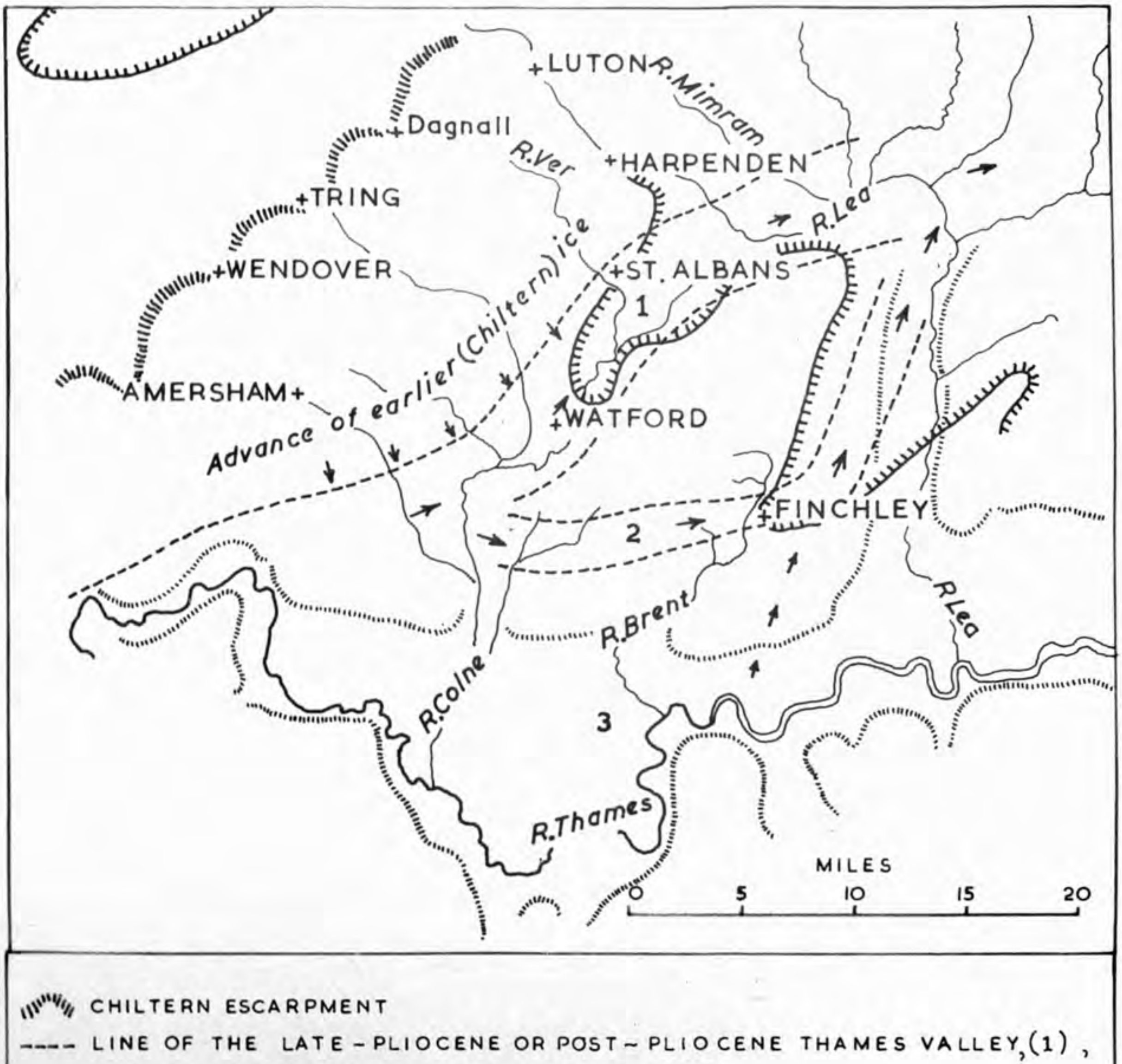
Even at this early period in the evolution of the area, the London Basin syncline was probably occupied by a proto-Thames stream. Linton (1951) suggested a major longitudinal consequent Thames draining from South Wales to the North Sea Basin paralleled to the north by a west-east proto-Trent and to the south by a similar longitudinal Frome-Solent stream. The left bank tributaries of Linton's proto-Thames are now represented by the superimposed Taff, Usk, Monnow and Wye streams, the right bank tributaries of the present middle Severn (Teme and Leadon), and the Cotswold and Chiltern wind-gaps (Fig. 79). The north flowing streams of the North Downs would have joined the proto-Thames on its right bank. Thus the main consequents of the Chilterns fit into the regional pattern of northerly affluents draining from the Midlands to the Thames across a Chalk cover.

The Mio-Pliocene peneplanation was followed in the London Basin by the incursion of the Calabrian sea, evidence for which is seen in the broad bench, cut largely in the Chalk, on the slopes of the Chilterns and North Downs, together with its marine deposits. Its extent was indicated by the position of the low bluff backing the Calabrian shelf - the former coastline. This is not traceable beyond the wind-gaps and there would seem no objection to their functioning simply as shallow inlets in ~~the~~ Calabrian times.

Following this episode, the physiographic development of the London Basin has consisted in the uplift and dissection, stage by stage, of the Calabrian sea-floor. Wooldridge and Linton (1955) demonstrated that the stages of this uplift were recorded in the minor platforms and terraces, former valley floors, of the Basin and related them to the sequence of glacial deposits. From the evidence of the Pebble Gravel belt at 400 feet, the ancestor of the Thames, superimposed from the Calabrian sea-floor, is known to have pursued a course, following the retreat of the Calabrian sea, along the foot of the Chiltern dip-slope. At a later stage it is thought to have introduced Triassic debris to the Basin via the Goring Gap. The 400 foot level in the Vale of Aylesbury may be correlated with the well developed surface at this altitude in the London Basin. In both areas, evidence indicates that it is a pre-glacial base-level.

In the London Basin, three glacial episodes have been traced by Wooldridge and Linton, (Fig.78), the earliest of which blocked the Thames in its course along the line of the Vale of St. Albans, diverting it through the Watford Gaps during the 375 foot Higher Gravel Train phase. This diversion is attributed to an ice-mass moving south-eastwards from the Chiltern Plateau principally on

Fig. 78 SUCCESSIVE COURSES OF THE THAMES DURING AND AFTER THE ICE AGE (after S.W. Wooldridge)



CHILTERN ESCARPMENT

LINE OF THE LATE-PLIOCENE OR POST-PLIOCENE THAMES VALLEY, (1), AND ITS DIVERSION IN EARLY GLACIAL TIMES

BOUNDARIES OF THE LATER PLEISTOCENE VALLEY, (3), I.E. THE TERRACED VALLEY OF THE PRESENT THAMES

ICE-FRONT OF THE "CHALKY BOULDER CLAY" ICE the basis of the Chiltern or Older Drift, regarded by Wooldridge (1938) as a true boulder clay. This Drift lies at an altitude of 270 to 500 feet on the Chiltern dip-slope. It may have been deposited by local ice formed on the Chiltern plateau, or may mark the margin of an ice mass of more distant origin overrunning the Chiltern scarp from the north-west, possibly correlatable with the continental Gunz glaciation (Wooldridge and Henderson 1955). Early evidence of cold conditions in the wind-gaps and Vale of Aylesbury - the coombe deposits and Charity Complex - possibly belong to this first glacial epoch. The evidence for assigning the Tring Series to such an early glaciation has already been considered in the previous chapter.

Following the postulated advance of the Chiltern ice into the London Basin, the proto-Thames abandoned the Watford Gaps in the inter-glacial Lower Gravel Train times (marked by a 300 foot to 315 foot base-level) and turned eastwards via the Finchley Depression, regaining its former line near Ware. A relict eastward flowing stream continued to occupy the line of the Vale of St. Albans, cutting back and re-capturing much of the Chiltern dip-slope drainage. There is no direct evidence of events in the Vale of Aylesbury during this interglacial but it seems probable that much of the Winchester Series was

was formed during this warmer period.

The second glacial episode in the London Basin is represented by an ice-sheet, the Lowestoft Advance of the Great Chalky Boulder Clay Ice, which projected as two lobes into the Vale of St. Albans and the Finchley Depression impounding and reversing the existing drainage and thus initiating the Lower Colne and Lower Lea respectively. This is represented by the Winter Hill Terrace at 250 feet and the Black Park at 200 feet. Dissection of the landscape in the Vale of Aylesbury had not proceeded quite so far as in the London Basin, as it is suggested that a tongue of the same ice sheet advanced into the Vale as far as the Tring Gap into a landscape not much below 400 feet, depositing the Tring drift and scattered Bunter Quartzite pebbles. It is at this stage that the gaps may have carried meltwater from the Vale of Aylesbury into the London Basin.

Consequent upon the Lowestoft Glaciation, the Thames was diverted to its present valley, undergoing successive rejuvenations as it gradually migrated southwards. The Elster/Saale (Lowestoft/Gipping) interglacial is represented in the London Basin by the Boyn Hill Terrace at 175 feet (Slough). In the Vale of Aylesbury, this interglacial was marked by intensive erosive activity, the Gault being lowered almost 100 feet, much of the Lowestoft drift being dissected by springs and removed.

Evidence for the latest glacial advance in the London Basin is found in the Upper Chalky Boulder Clay Drift of the Vale of St. Albans and Finchley. Wooldridge (1953) has examined the relations between this drift and the Mimram, Lea, Harpenden and Ver valleys and has worked out a complicated series of detailed temporary glacial diversions associated with small pro-glacial lakes. Clayton (1960) equates this third glaciation with the Gipping Advance of East Anglia. In the Vale of Aylesbury, this advance was responsible for the Woburn Plateau drift and the Rowsham and Cheddington boulder clays (though this latter may belong to the Lowestoft Advance). At the same time, in the unglaciated areas of the Vale, coombe material was sludged from the wind-gaps and escarpment coombes, forming the Weston Turville and Gubblecote Series, and from the bare scarp faces, giving rise to the Coombe and Halton Complexes; on the clayey head of the Gault, the Challow Complex developed.

In the London Basin, post-glacial dissection of the landscape is summarised by the Lynch Hill Terrace at 130 feet, the Taplow Terrace at 100 feet and the Flood Plain Terrace between 65 and 70 feet (Slough). To the north-west of the Chilterns post-glacial activity has been confined to the spring and stream erosion of the coombe and drift deposits.

Thus there would not appear to be any major contradictions between the established sequence of events in the London Basin and the suggested sequence for the Chiltern wind-gaps and Vale of Aylesbury. The correlation is, however, far from complete for the detailed chapter of events in the London Basin is not legible in its entirety further to the north-west.

(b) THE OXFORD REGION

The two most comprehensive studies of the Oxford Region, relevant to its physical evolution, are those of Sandford (1929) and Arkell (1947) both of which studies bear an interesting relationship to events in the Chilterns and Vale of Aylesbury, particularly during the Pleistocene.

Sandford succeeded in establishing a three-fold glacial sequence in the Oxford district. The first, which formed the Plateau Drift, was equated with the maximum glaciation of the South Midlands, of early Pleistocene or Plio-Pleistocene age. This drift contained erratics from Scandinavia, Scotland, East Anglia, the Midlands (Bunter pebbles) and possibly the South-West, and was found at altitudes over 600 feet. It was thought, by Sandford, to have entered the district through the Cotswold escarpment by the gaps, now occupied by the northerly tributaries of the Upper Thames, in the form of a 'fluvio-glacial inundation'. From its archaeological content and morphological situation Sandford tentatively placed it in the Mindel Glacial episode. He regarded it as a little younger than the East Anglian Cromer Forest Bed, and older than the 140 foot and 100 foot terraces of the Upper Thames Basin which he assigned to the Mindel/Riss Interglacial. Some of the material was redeposited in terraces up to 350 feet above the present rivers.

During the later two glacial episodes (Riss and Wurm?), the Oxford district was an ice-free area between the glaciers of the Eastern counties and of Wales. Thus it is only on the eastern margin of the Oxford district that boulder clay of later date is found. Sandford noted that the western borders of this drift were not accurately defined, but suggested that Tingewick, Buckingham and Winslow were probably within reach of it or its gravels (Fig. 79). He pointed out that this was illustrated by the change in the topography of the superficial deposits between Oxford and Cambridge e.g. near Buckingham and Biddenham (1929, page 377).

"Eastwards, the greatly dissected and thin patches of Plateau Drift are left behind and one passes to a more 'subdued' region in which thick deposits of sand, gravel and boulder clay are important... In the Upper Thames Basin, the rivers have cut their beds 100 feet and more below the foot of the Plateau Drift. In the adjacent basin of the Ouse, the rivers are still engaged in cutting through the superficial deposits and, nearer Cambridge, the river valleys are still choked with gravel and boulder clay to great depths."

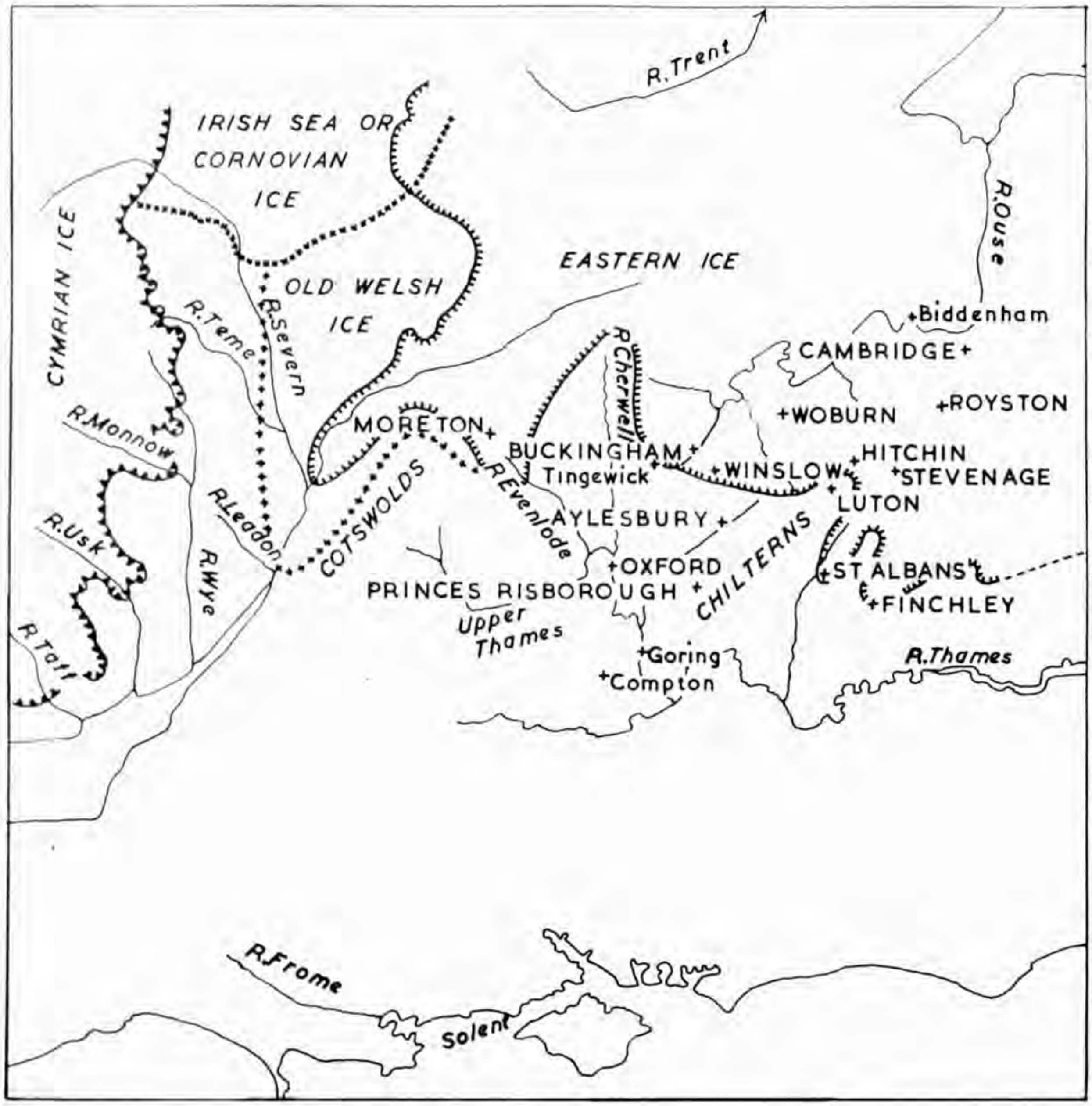
Sandford concludes that the remains of the very early Plateau Drift glaciation have been destroyed in East Anglia by the later glacials, or incorporated in the younger boulder clays.

It is possible that Sandford's high-level Plateau Drift is equivalent to Wooldridge's Older or Chiltern Drift and the Charity Complex of the wind-gaps, though this does not signify agreement with his glacial chronology. The two later glaciations he refers to may well be the East Anglian Lowestoft and Gipping advances which are thought to have penetrated almost as far as the northern margins of the Oxford Basin.

Arkell revises Sandford's terminology of 'Plateau Drift' to 'Northern Drift', a deposit which he traces from the highest ground on the hills round Oxford, through the Goring Gap into the London Basin. Because of its erratic content, Arkell believes the drift to have entered the Oxford Basin by way of the Moreton Gap and Evenlode and considers this to be indicative of an ancient line of consequent drainage which passed from the Midlands, through Moreton and Goring, into the London Basin, a line still occupied by the Evenlode and Thames. The higher occurrences of the Northern Drift he regards as a true boulder clay deposited by an ice-lobe invading the pre-glacial Evenlode-Thames valley. With Sandford, he attributes the lower patches to re-sorting by subsequent river action. A pre-glacial consequent Evenlode-Thames would presumably be paralleled by similar streams north-eastwards as suggested for the Central Chiltern area.

Arkell intimates a correlation of this early glacial with the first Great Welsh Advance of the Midlands, and envisages a great mass of ice (or meltwater) piling up behind the Cotswold escarpment, crossing it at Moreton and creeping south to Oxford (Fig.79). If the Evenlode lobe, he continues, reached the Chiltern escarpment, it would be funnelled through Goring. This is essentially a revision of Hawkins' (1923) earlier hypothesis of an ice sheet occupying the whole of the Vale of Aylesbury and Oxford plain, extending into the Goring Gap and discharging meltwater through the Compton and Princes Risborough Gaps. Arkell notes, however, that if these gaps ever contained Northern Drift outwash, they have

Fig. 79 THE ICE-SHEETS OF SOUTH-CENTRAL ENGLAND (after Arkell)



been subsequently scoured out and now only contain drifts of local origin. Neither is there evidence of this Northern Drift in any of the wind-gaps to the north (unless the Tring Series is identified with it) and, apart from the Charity Complex and early coombe deposits, there would seem to be no record of these complex events in the Oxford Basin in the Chiltern wind-gaps and Vale of Aylesbury.

Arkell believes the retreat stages of the Oxfordshire Northern Drift ice to be correlatable, by means of their position and lithology, with the great gravel trains with Triassic pebbles, (Pebble Gravels, Higher Gravel Train and Lower Gravel Train) of the London Basin. This implies that the Northern Drift must be of similar age to the Chiltern Drift (i.e. Gunz), as there is no other body of drift in the London Basin older than these gravel trains.

Evidence for the second great glaciation affecting the Oxford Region is found by Arkell in the chalky boulder clays, sands and gravels lying within the Moreton Gap. He equates this Moreton Drift with the Eastern Drift of the London Basin, but also gives it the appellation of Mindel. Included in this Eastern Drift is the drift of the Upper Ouse Basin, Vale of Aylesbury and

North London. This great south-westward extension of the Pleistocene ice-sheet from its centre in East Anglia is regarded as the greatest of several (three?), but the later lesser ones never again encroached into the Oxford Basin. These succeeding events are represented in the Oxford district only by fluviatile deposits and terraces.

The Moreton Drift of Arkell probably finds its equivalent further north-west in the Tring Series of the Tring Gap and the Lowestoft Till of East Anglia. Arkell has some interesting remarks to make on the function of the Chilterns during the glacial advance from East Anglia, though he does not specify whether he is referring to the first (Lowestoft) advance or a later one (Gipping?). (1947, page 206).

"The Chiltern Hills, striking north-east, acted as a bastion or cutwater standing in the path of the farthest advances of the ice-front. The lesser chalk hills of Cambridgeshire and Hertfordshire were over-ridden as far as Hitchin, even up to the summits of 500 feet O.D. near Royston. At Luton, however, where the Chilterns proper begin, the high ground cleaved the ice flow into two streams. One stream was forced south-east through the Stevenage Gap into the London Basin; the other joined a great lobe of ice which filled the Ouse Basin and advanced as far as Aylesbury and Buckingham...

The south-west advance of this ice-sheet (i.e. in the Ouse Basin) towards Oxford was apparently dammed by the Lower Greensand Hills about Woburn, but a lobe at one time extended into the Vale of Aylesbury, where patches of boulder clay occur at heights of 300 to over 400 feet O.D. Thence the ice-front ran south-west past Winslow and Tingewick, then turned nearly north round the head-waters of the Cherwell into the Vale of Warwickshire and Worcestershire."

A consideration of the sequence of events in the Central Chiltern wind-gaps and Vale of Aylesbury has indicated that Arkell's picture, in actual fact, is probably not far removed from reality. Arkell's studies in the Oxford Basin give little or no help in the precise dating of happenings in the region to the north-east though his general conclusions are of some relevance. The detailed physical evolution of the Oxford district has perhaps not been worked out so fully as that of the London Basin, and therefore correlations are even more unsatisfactory than those with the London region. Nevertheless interesting and profitable, to a greater or lesser degree, speculations can be made.

(c) THE OUZEL BASIN

This region has been the focus of a recent geomorphological study by Gardiner (1960), particularly with respect to its Pleistocene history. The southernmost part of the Ouzel drainage basin - the Gault vale north of Ivinghoe - margins the area covered by the present study, and thus Gardiner's conclusions concerning this tract of country are of considerable interest.

From the extensive spreads of boulder clay and glacial drift Gardiner demonstrates that the Ouzel Basin lay near the southernmost limit of at least one, and possibly two, glaciations. Two boulder clays are recognised not far to the north (Hollingworth and Taylor, 1946): the lower, composed predominantly of Jurassic and Bunter material, is correlated with the Lowestoft Till of East Anglia (Elster) and the upper, containing a large proportion of chalk and flints, with the Gipping Till (Saale) (Baden-Powell, 1948). The boulder clay of the Ouzel Basin is assigned to the Gipping Advance (King, 1955) because of its highly calcareous nature, and it is thought to be the product of an ice-sheet moving up the Ouse valley from the Wash.

To Gardiner, the quantity of Midland material, including Jurassic limestones, Bunter sandstone and quartzite, and granite, found in the Chalky Boulder Clay of the Ouzel Basin, is suggestive of the existence of an earlier boulder clay in the area, though only at Tingrith is there any possible sign of a lower boulder clay. Thus although the occurrence of Midlands erratics in the glacial drift strongly suggests that Lowestoft Ice advanced into the Ouzel Basin, there is no direct evidence of such advance.

Therefore it would not seem impossible that the Tring Series with its Bunter content farther south-east is a relic of this earlier Lowestoft Boulder Clay which, because of its unusual morphological situation, has been preserved. It may also be significant that Bunter material was noted in the Rowsham Complex (Gipping) to the north of the Vale of Aylesbury in the same way as Gardiner noted it further east.

On the extent of the Gipping Chalky Boulder Clay ice, Gardiner comments that the ice sheet reached at least as far as Winslow and Buckingham, and possibly further. She establishes that ice covered the whole of the Vale of Bedford, most of the Lower Greensand outcrop, and part of the Vale of Aylesbury, attaining heights of 400-500 feet near its outer limits (Fig.80). This agrees tolerably well with the tentative upper limit of the ice (from the Bunter Quartzite evidence) at 550 feet in the Tring Gap. The drift and gravel-capped ridges of the Ouzel Basin are interpreted by Gardiner as possible moraines or drumlins.

The reconstruction of the sub-drift surface of the Ouzel Basin by Gardiner reveals a gently undulating landscape with the Ouse and lower Ouzel valleys in approximately their present positions. The drift cover adapted itself

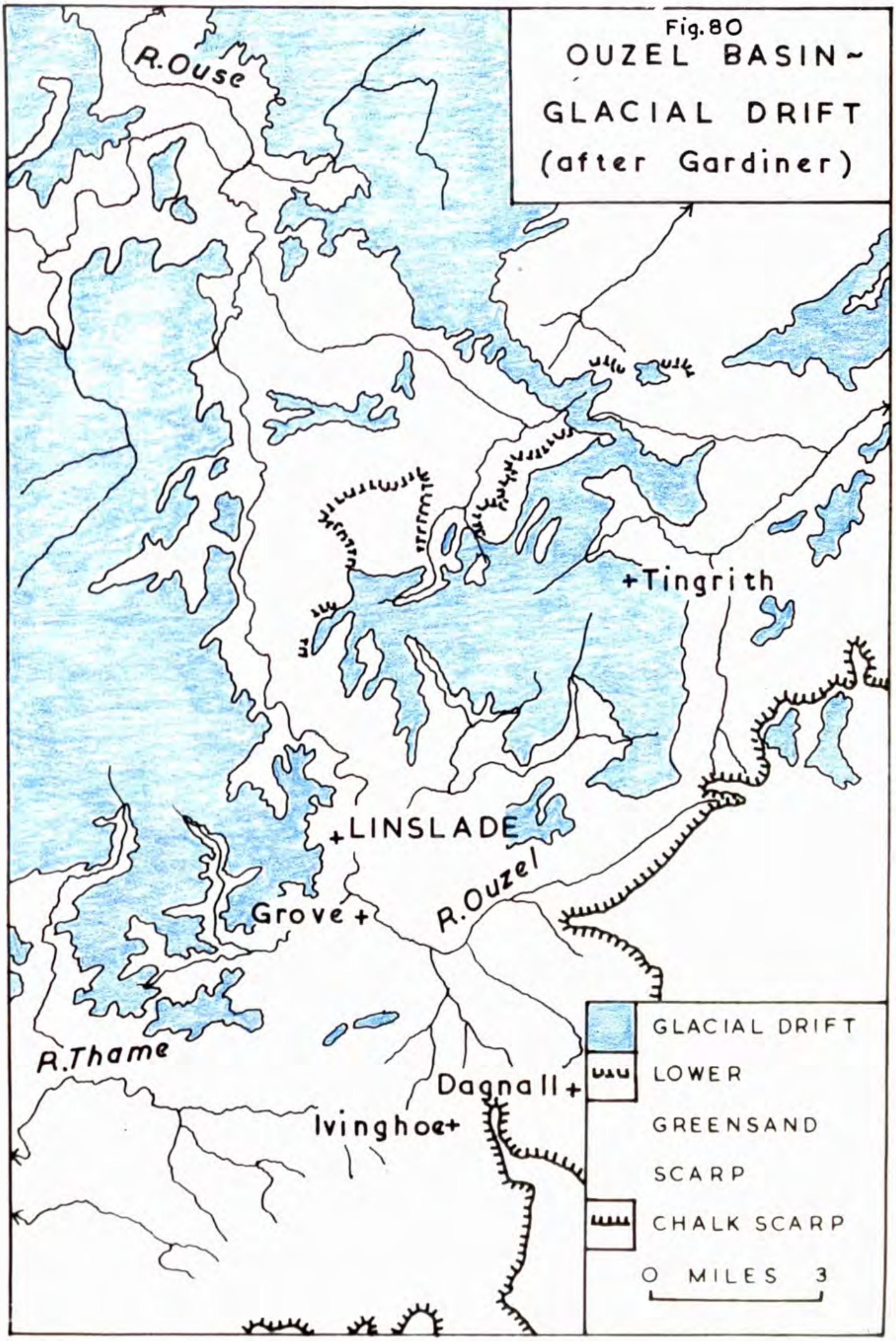


Fig. 80
OUZEL BASIN ~
GLACIAL DRIFT
(after Gardiner)
R. Ouse
+Tingrith
+LINSLADE
R. Ouzel
Grove +
R. Thame
Dagnall +
Ivinghoe+
GLACIAL DRIFT
LOWER
GREENSAND
SCARP
CHALK SCARP
0 MILES 3

to the existing landscape, the larger valleys being marked by depressions in the drift surface. The Ouzel has now cut down below the drift base and a sequence of terraces at 60 feet, 40 feet, 20 to 25 feet and 10 feet above the alluvium have been preserved. The highest has a cover of boulder clay and must therefore pre-date the deposition of drift; the lower ones are gravel covered and of post-glacial origin.

These factors would seem to offer confirmatory evidence to the suggestion that a stream occupied the line of the Ouzel-Dagnall Gap prior to and up to the Gipping Glaciation. Gardiner finds no conclusive evidence as to its direction of flow before glaciation but admits the possibility of a south-flowing consequent stream, disrupted by the advance of ice into the area. Postglacially, the Ouzel has cut an impressive gorge through the Lower Greensand. It may have functioned as an overflow channel when ice occupied the Oxford Clay Vale to the north, but Gardiner rejects this hypothesis on similar grounds to those used against the theory of a pro-glacial lake of any dimensions in the Vale of Aylesbury.

The earliest of Gardiner's terraces at 60 to 70 feet above present river level find interesting parallels in the region to the south. Gardiner notes that these high-level flats are cut into the Lower Greensand dip-slope at altitudes of approximately 320 feet, and pre-date the

Chalky Boulder Clay drift. In the Vale of Aylesbury, similar surfaces were noted in the present work with an altitudinal range of 305 to 320 feet (page 102). These also, because of their covering of coombe deposits, were thought to pre-date the Gipping Advance into the area. Thus it would seem highly probable that they were controlled by a common base-level at about 320 feet immediately prior to the Gipping Glaciation. There would not therefore seem to be a great deal of discrepancy between Gardiner's suggested Pleistocene evolution of the Ouzel Basin and the tentative chronology worked out for the Dagnall, Tring and Wendover wind-gaps and Vale of Aylesbury.

(d) CONCLUSIONS

An attempt has been made in these eight chapters to consider some of the aspects of the geomorphology of three Chiltern wind-gaps, particularly the problems of their age, origin and development. Attention has also been focussed upon their associated superficial deposits. As a result of these considerations, a possible sequence of events in the evolution of both the gaps and their deposits has been tentatively suggested and this sequence has been related to the established denudation chronology for South-East England. Lack of evidence on many points has made an exhaustive treatment and an impeccable solution impossible, but perhaps some contribution has been made towards the geomorphologist's task -

"To understand a region in its entirety requires that we first trace the origin, so that we can explain the form and pattern, of its hills, valleys and coasts." (Wooldridge and Linton, 1955, page 3).

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ABBREVIATIONS

Ad. Sc.:	The Advancement of Science
Geog.:	Geography
G. J.:	The Geographical Journal
G. M.:	The Geological Magazine
G. R.:	The Geographical Review
G. S. M.:	Geological Survey Memoir
H. M. S. O.:	Her Majesty's Stationery Office
I. B. G.:	The Institute of British Geographers: Transactions and Papers
Jour. Soil Sc.:	Journal of Soil Science
Mag. Cam. Univ. Geog. Soc.:	The Magazine of Cambridge University Geographical Society (Compass)
P. G. A.:	Proceedings of the Geologists' Association
Proc. Croydon Nat. Hist. Sc. Soc.:	Proceedings of the Croydon Natural History and Science Society
Proc. Prehist. Soc.:	Proceedings of the Prehistorical Society
Q. J. G. S.:	Quarterly Journal of the Geological Society
S. G. M.:	The Scottish Geographical Magazine