# THE PLEISTOCENE SUCCESSION IN THE SOUTHERN PART OF CHARNWOOD FOREST, LEICESTERSHIRE.

by

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## Summary

A succession of drift deposits for the Pleistocene period in south Charnwood Forest, based upon motorway and quarry exposures, indicates that the area was twice covered by ice. The first glaciation was by ice of north-eastern origin, whereas the second involved ice advancing, initially from the north-west and, subsequently, from the north-east. The latter ice movements are ascribed to that part of the Wolstonian stage associated with glacial lake Harrison; an earlier Wolstonian age is favoured for the first glaciation. There is evidence for local proglacial lake development at over 190 m O. D. during both glaciations and also for three phases of periglacial activity, two being dated as Wolstonian with the third, more complex period, being placed in the Devensian stage.

## Introduction

Charnwood Forest is essentially the hilly ground within a triangle formed by Leicester, Loughborough and Coalville (text-fig. 1). This part of the Midlands is famous for its Pre-Cambrian and Triassic rocks but the Pleistocene deposits were not studied in detail until the nineteen-sixties when numerous sections, rich in glacial and periglacial material, were exposed during the construction of the M1 motorway which runs almost centrally through the Forest.

Lucy (1870) had described a surface spread of quartzite pebbles and flint and suggested that it had been laid down as drift. From 1899 onwards Geological Survey maps (Sheet Nos. 141 and 155) have shown boulder clay and glacial sands and gravels covering various parts of the area. However, the significance of these observations was largely overlooked for, prior to recent work, it was generally accepted that "..... the Forest was never completely overwhelmed by an ice sheet from outside....." (Watts. 1947, p. 115).

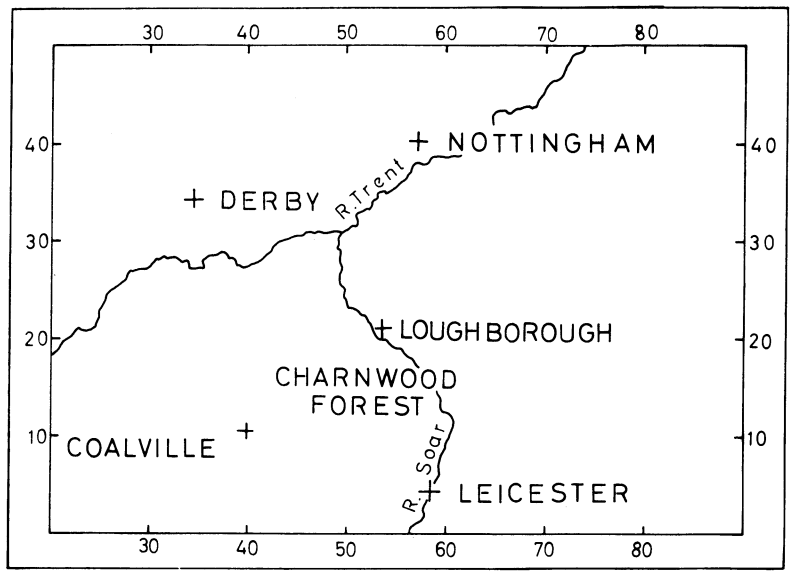
Ford (1967 and 1968) has briefly described glacial and periglacial phenomena observed in motorway cuttings and also in quarries. Motorway sections were treated in more detail by Poole (1968) who included reference to rootlet beds underlying till. Both Ford and Poole concluded that ice had covered parts of Charnwood previously believed to have escaped glaciation.

Pleistocene deposits have been examined in detail over virtually the whole of Charnwood Forest (Bridger, 1972). This paper is principally concerned with south Charnwood for it is here that the stratigraphically more important sections occur, notably temporary exposures at the following three localities:

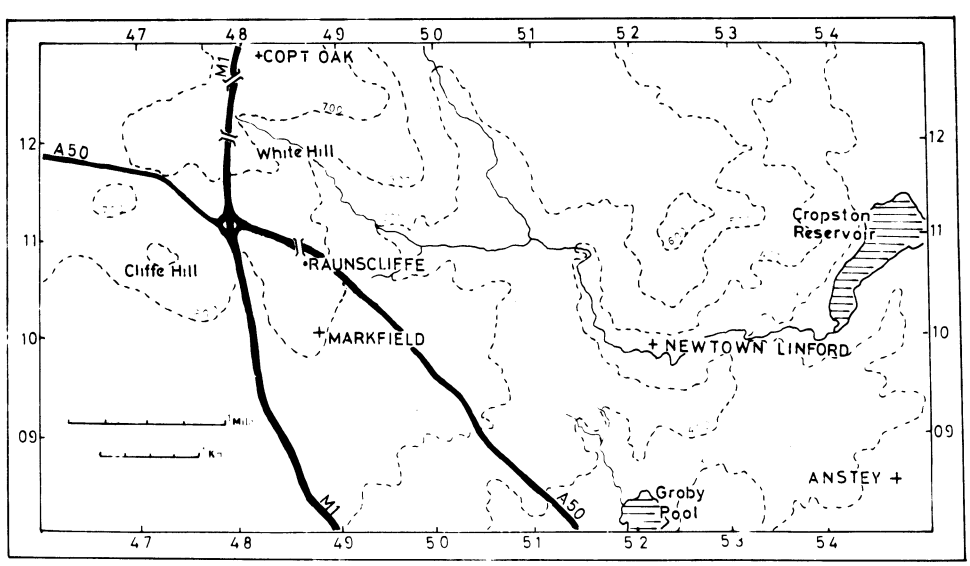
1. The cutting for the A50 Markfield By-pass (text-fig. 3) to the north of Raunscliffe (SK 487107).
2. The site of the excavations for the bridge carrying the local road across the M1 near White Hill (SK 479121) (text-fig. 4).
3. In the quarry at Cliffe Hill (SK 477104) where a cutting (text-fig. 5) in the south-eastern corner takes a new road to the lower working level.



Mercian Geol. Vol. 5. No. 3, pp 189-203, 7 text-figs.




Text-fig. 1. Location of Charnwood Forest, Leicestershire




Text-fig. 2. Localities mentioned in the text

Although the three sections are less than 2 km apart and all extend down to bedrock they exhibit considerable differences, in lithology and stratigraphy, of the superficial deposits. Correlation has been based mainly on lithological and carbonate characteristics supplemented by a study of derived micro-fossils, in particular, ostracods. The latter have been particularly useful for, unlike most macro-fossils, the ostracods have not been crushed by ice during transportation and, in certain circumstances, meltwater has carried them beyond the range of other erratics. The most abundant material is till of which three separate types have been distinguished. One, the lowest stratigraphically, is the brown calcareous Raunscliffe Till with a predominantly Liassic suite of erratics. A second, the Newtown Linford Till, comprises a reddish non-calcareous deposit characteristically containing Coal Measure and Lower Triassic rocks. The third and upper of the three types, is the calcareous Anstey Till, a greyish chalky boulder clay with Liassic erratics in addition to its distinctive component of Cretaceous material.

The account of the succession given below includes a consideration of the genesis of the members and their local correlation. The following discussion covers chronology and relationships to successions further afield.

## The Pleistocene Succession in South Charnwood

The sequence of Pleistocene deposits in the southern part of Charnwood Forest is here divided into the following members:

NEWER DRIFT

Upper Head

OLDER DRIFT

Anstey Till

Newtown Linford Till

Markfield Clay with Middle Head

Cliffe Hill Sand and Gravel

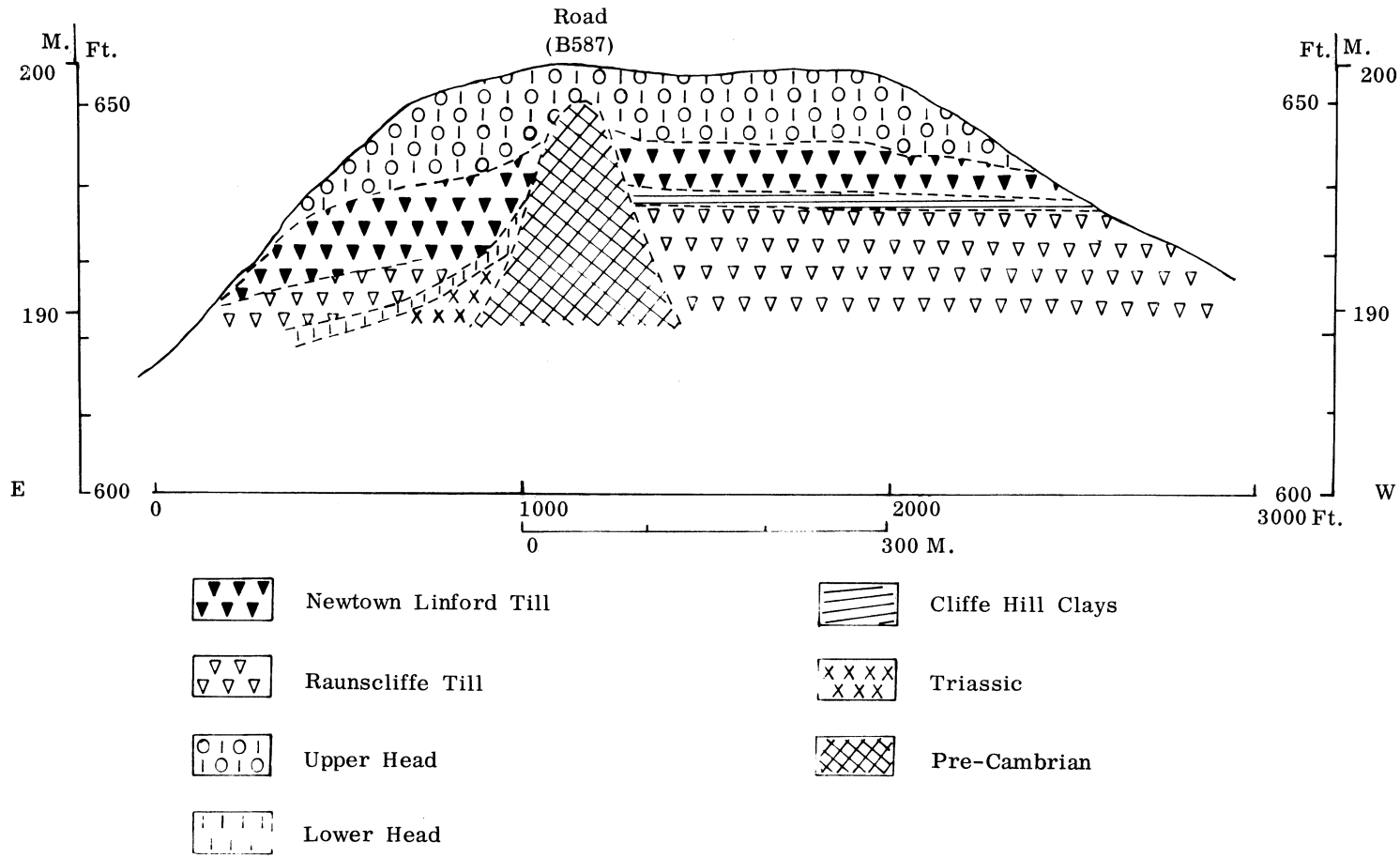
Raunscliffe Till and the White Hill Clays and Silts

Lower Head

### The Lower Head

At two localities solifluction or head deposits underlie the drift that is associated with the earliest recorded ice to enter the area. In the Markfield By-pass cutting (text-fig. 3) the Lower Head rests on Keuper Marl and is overlain by a calcareous till, rich in Jurassic erratics. The Lower Head is over a metre thick and is composed of a non-calcareous reddish-yellow clay with numerous angular to sub-angular blocks of rock, in size-range up to large boulder. Usually the latter have a weathered skin and are derived from the Charnian Maplewell Series which outcrops at the foot of the bridge carrying the B 587 (SK 486109) and also at the "Altar Stones" (SK 485108) a prominent crag rising to 213 m, a hundred metres to the west of Raunscliffe. A deposit of this type does not compare lithologically with any noted in the local Keuper succession (Bosworth 1912) and, although the possibility of it being the product of a restricted local glaciation cannot be entirely ruled out, it is more satisfactorily explained as a solifluction deposit.

Motorway bridge excavations near White Hill (text-fig. 4) exposed Lower Head resting on an uneven projection of Charnian Slate-agglomerate and its flanking beds of Keuper marl and breccia. Above these rocks are calcareous proglacial silts into which the head deposit passes without disturbance. The head has a maximum thickness of over 1·5 m and is in part stratified.




Text-fig. 3. Generalised section showing succession exposed above road level in the southern face of the Markfield By-pass cutting (SK 487107) recorded in 1967.

Its main constituents are brown and brownish-yellow gritty clays containing many sub-angular fragments, up to pebble-sizes, of often highly weathered Charnian-type rocks which could not be matched with the contiguous slate-agglomerate or other local Pre-Cambrian outcrops. The crucial evidence for a periglacial origin is the gradual vertical transition into proglacial silts. The presence of Charnian-type rock not identified locally may be interpreted as material derived by solifluction from nearby, formerly exposed outcrops, now buried under drift.

The Raunscliffe Till and White Hill Clays and Silts

Raunscliffe Till has only been recorded in the Markfield By-pass, where it exceeds 5 m in thickness and has a maximum altitude of close to 193 m O.D. (text-fig. 3). In the vicinity of the B 587 bridge the till rests either on Lower Head or on Charnian rock. To the west of the bridge it is overlain by Cliffe Hill Clay; however, to the east, where observation was difficult, the overlying deposit is believed to be Newtown Linford Till. Coloured reddish-brown to dark-brown, the Raunscliffe Till includes beds and lenses of silt and sand. It is, invariably, highly calcareous with calcium carbonate values of up to 17%. The erratic suite contains some Triassic and Charnian rocks but the majority are Liassic in origin. Fragments of echinoid spines and valves of the Liassic ostracod *Hungarella* sp. are not uncommon in the sand fraction. Since Jurassic beds do not outcrop to the west of the Soar valley (text-fig. 6) the predominance of Liassic erratics in the Raunscliffe Till indicates that the ice carrying them moved across Leicestershire from the north-east.

The White Hill motorway bridge site (text-fig. 4) showed over 3 m of inter-stratified clays and silts resting on Lower Head with Newtown Linford Till above. Apart from the upper half metre, the White Hill Clays and Silts are calcareous with a maximum of 17% calcium carbonate. At irregular intervals horizons with rootlet holes lie within the silts, but pollen has not been preserved. A few small quartzite pebbles and fragments of Keuper and Charnian rock are present at most levels; in the upper beds more numerous pieces of Coal Measure shale, coal, ironstone and sandstone appear. Evidence of Jurassic material is in the form of *Hungarella* valves found in most of the silts and also small fragments of echinoid spines restricted to the silts at the base of the sequence.

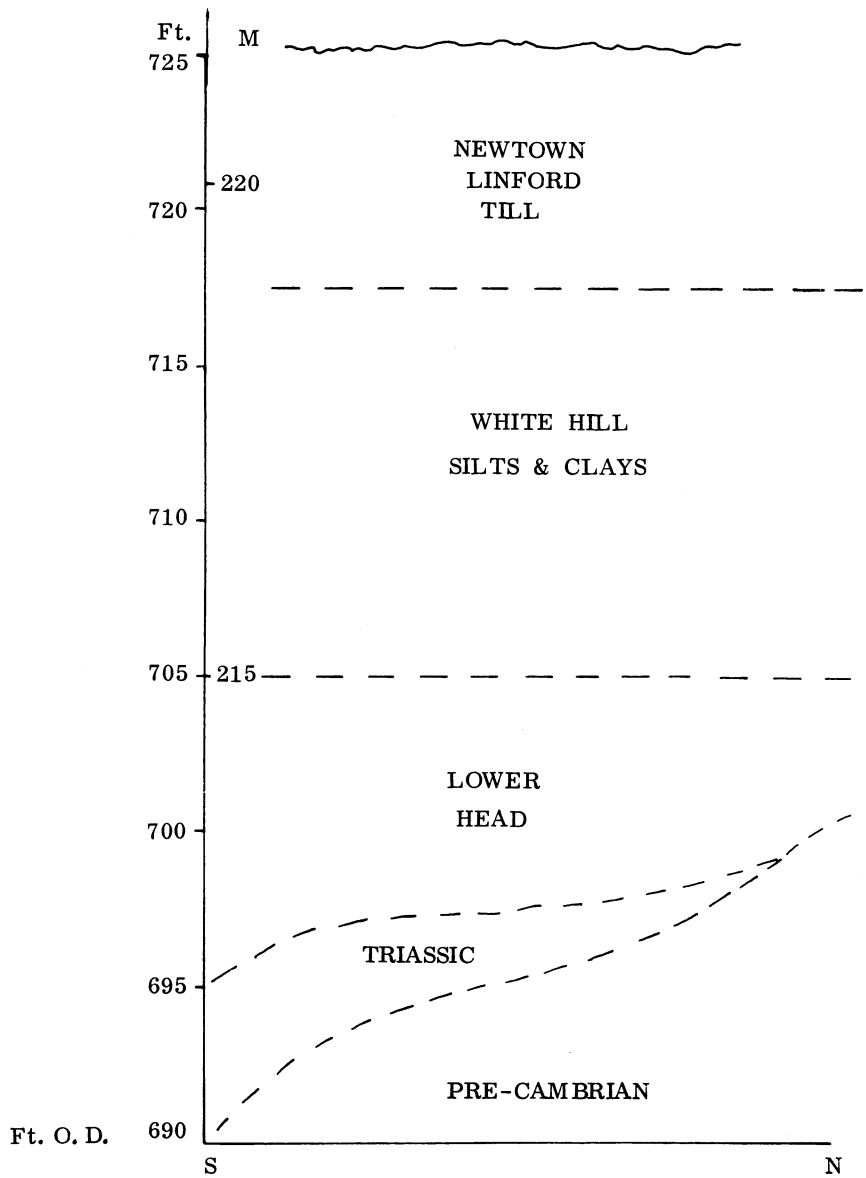
In this area, the most satisfactory explanation of sediments bearing Liassic micro-fossils at 215 m O.D., is proglacial deposition. The proximity of the Raunscliffe Till confirms the former presence of ice which may account for both the character and the formation of these deposits. Accordingly the Raunscliffe Till is correlated with the White Hill Clays and Silts (text-fig. 7), although it is accepted that the lake in which these deposits accumulated may have survived until the arrival of north-western ice early in the next glaciation.

The Cliffe Hill Sand and Gravel and the Markfield Clay

Temporary faces in the south-eastern corner of Cliffe Hill quarry (text-fig. 5) revealed an uneven, sloping surface of partially rotted micro-diorite overlain successively by beds of gravel, sand, clay, clay with head and Newtown Linford Till.

The Cliffe Hill Gravel has a brownish non-calcareous clayey sand matrix and contains up to cobble size sub-angular fragments of Coal Measure rocks and so-called Bunter pebbles with lesser amounts of Keuper and Charnian rocks and a little flint. This bed passes abruptly into an overlying layer of reddish-brown sand which has thin interstratified bands of clay in its upper part.

At approximately 192 m O.D. this sand is succeeded by a near horizontal bed of red Markfield Clay thickening southwards from 0·5 m to over 3 m. Above the point where the gradient in the bed-rock surface is steepest and for several metres to the south-west the clay is divisible into two zones, the lower being undisturbed pure clay whereas the upper contains sand from rotted igneous rock in the form of streaks, lenses and rectangular inclusions.




Text-fig. 4. Generalised succession from the foundation excavations for the motorway bridge new White Hill (SK 479121) recorded in 1964.

The upper zone also contains, up to boulder size, angular blocks of micro-diorite exhibiting, with a few exceptions, various stages of rotting. In places thin bands of silt split to envelope the clasts. This debris laden layer passes horizontally into pure clay some 10 m to the south-west. There is no disturbance at the contact with the overlying Newtown Linford Till.

Sections seen at various temporary faces during the excavation of the cutting for the Markfield By-pass displayed up to 5m of essentially stone-free clay with interstratified silt resting upon Raunscliffe Till and overlain, at about 195m O. D., partly by Newtown Linford Till and partly by Upper Head. At the base, the reddish-brown to reddish-yellow beds of clay and silt are calcareous and stoneless passing upwards into a zone with a few quartzite pebbles and fragments of Jurassic rock. Towards the top the sediments become non-calcareous and stones are again absent. Apart from disturbance at the contact with the overlying head, evidence of cryoturbation occurs within the clay at depths of one metre or more below its upper surface.

The composition of the Cliffe Hill Gravel strongly suggests that it is outwash from the ice which later laid down the Newtown Linford Till. The succeeding sand and clay indicate the hydrological changes, culminating in proglacial lake formation, associated with this ice as it approached the southern part of Charnwood Forest. An explanation for the presence of the rock and sand in the Markfield Clay at Cliffe Hill quarry is given below.

The altitude of the clays at both sites is close to 195m O. D. a relationship which coupled with their close proximity, suggests that they have a common lacustrine origin. If this correlation (text-fig. 7) is accepted, chemical differences may be seen as a reflection of local variations in the depositional environment, involving the shore and bed of the lake, being easily worked calcareous till at one point and mainly igneous rock at another.

The Middle Head

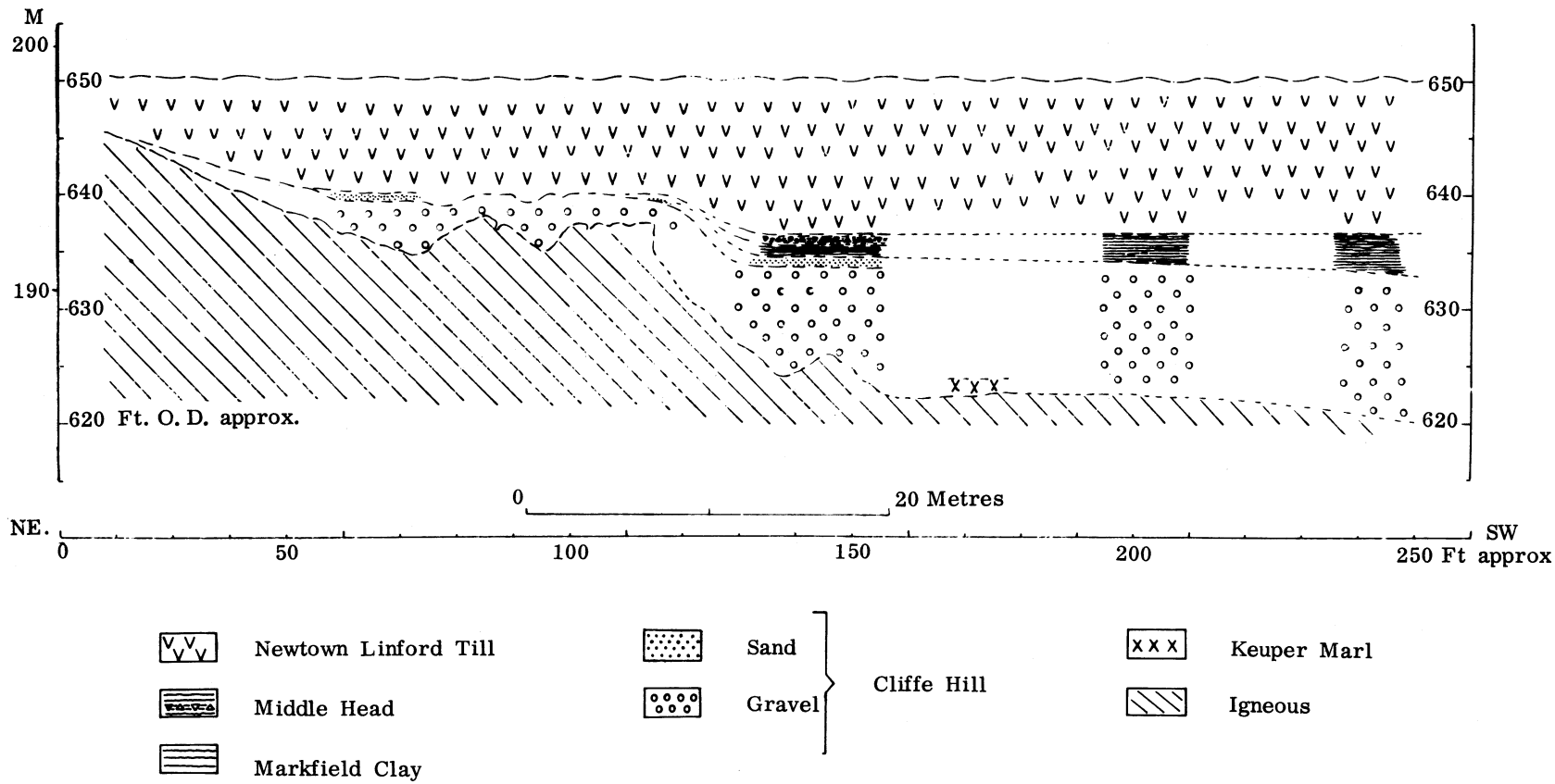
The stoney upper layer of Markfield Clay at Cliffe Hill quarry is explained as head, moved by solifluction from the shore on to the surface of adjoining lake ice which, on melting, deposited rock on the lake floor. The deposit contains a few unweathered clasts of micro-diorite with an angular outline indicating that the blocks were sound when they were incorporated into the sediment as this type of rock, where weathered, produces rounded core-stones. The sand may result from the disintegration of rock on the lake floor but equally it could involve solifluction from weathered outcrops above the shoreline.

Cryoturbated zones within the clay at the Markfield By-pass cutting indicate that the level of the lake was not constant and that periglacial processes were able to disturb the sediments.

The Newtown Linford Till

The Newtown Linford Till, in contrast to the Raunscliffe Till, is characteristically a reddish-brown non-calcareous clay with Coal Measure and Lower Triassic (Bunter) rocks as well as Charnian and Upper Triassic (Keuper) material and a little flint. It is wide spread and shows considerable variation in composition over short distances. At Newtown Linford (SK 519099) the till is very stoney and virtually structureless whilst in the Markfield By-pass cutting and also at Cliffe Hill quarry it usually has fewer stones and often shows conspicuous stratification with the local development of beds and lenses of silt and sand.

The erratic suite of this till is not inconsistent with deposition from ice which had crossed the exposed portion of the Leicestershire-Derbyshire coalfield lying to the north-west of Charnwood Forest (text-fig. 6) but the precise route taken by this ice is uncertain. The extensive cover of Newtown Linford Till at altitudes of over 200m O. D. shows conclusively that the associated ice ultimately covered the greater part, if not the whole, of Charnwood Forest.




Text-fig. 5. Generalised section showing succession exposed in the south-eastern face of the road cutting at Cliffe Hill quarry (SK 477121) recorded in 1969. The unshaded areas in the section represent parts which were obscured by downwashed spoil.

## The Anstey Till

The Anstey Till was not revealed in any of the three major sections and its stratigraphical position has been established by the evidence of smaller temporary exposures and by augering. Although this till is the upper member of the Older Drift succession it is, in general, found in topographically low positions as, for example, at Anstey Green (SK 545088) where it does not rise above 85 m O. D. In this locality drainage trenches displayed over a metre of greyish-brown calcareous till packed with small pieces of chalk in addition to flint, quartzite pebbles and discrete lumps of Lias clay. A similar chalky till, sometimes with Lias fossils and large flints occurs between Anstey and Newtown Linford at an altitude of over 100 m O. D. On the eastern outskirts of the latter village patches of chalky till are incorporated in a red-brown till with flint and quartzite pebbles. Augering into a badly slumped stream bank about 0·5 km to the north-west of the same settlement (SK 515104) revealed over a metre of greyish-blue chalky till passing downwards into Newtown Linford Till.

The Cretaceous-rich Anstey Till clearly has an eastern provenance. Its distribution is not extensive in Charnwood Forest but there is a wider spread of red-brown, non-calcareous till containing flint, to which it may be related. Although this red-brown till has not been recorded in contact with other glacial deposits it has been seen, in shallow sections, to overlie Keuper bed-rock. It is possible that the till in question is a highly weathered and decalcified Anstey Till, alternatively it may be the equivalent of the red-brown till noted near Newtown Linford to contain patches of Anstey Till. In the absence of stratigraphical evidence these relationships remain problematical.

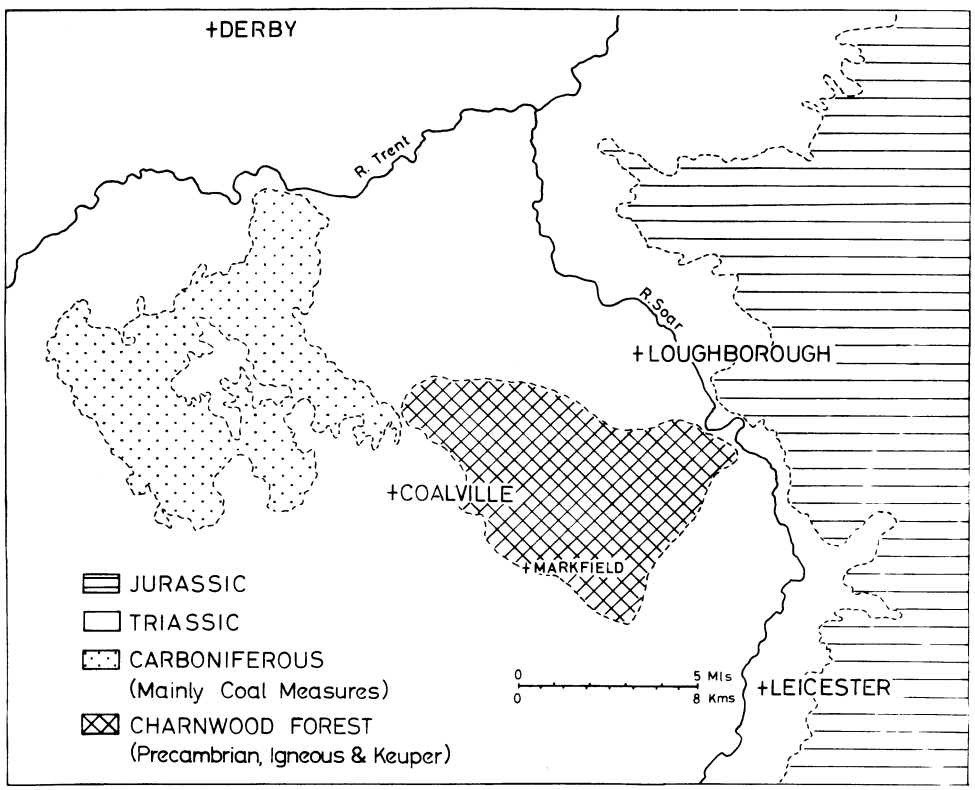
## The Upper Head

Sectioned slopes in south Charnwood Forest invariably show solifluction deposits close to the surface, sometimes over 3 m thick. They rest on till or bed-rock with inter-facial trends closely following the slopes of the present day topography. The texture of the Upper Head is extremely variable. Around tor-like outcrops of igneous and most Charnian rocks periglacial processes have produced a very coarse deposit. Where till is the parent material the soliflucted product contains smaller stones varying in type and number with the erratic content of the till; in the case of Keuper Marl the derived deposit may be stone free. It is not unusual for the Upper Head to be of composite derivation. Commonly it shows vertical zonation with a virtually stone free clay at the base passing upwards into coarser layers. Additionally the head exhibits evidence of cryoturbation in the form of frost wedge casts and stones rotated into an "on end " position.

## Discussion

In his account of the Pleistocene deposits in the area between Coventry, Rugby and Leamington, lying some 30 km to the south-west of Charnwood Forest, Shotton (1953) gives the following Older Drift succession:

| | |
|---|---|
| Dunsmore Gravel | |
| Wolston Series | Upper Wolston Clay |
| | Wolston Sand |
| | Lower Wolston Clay |
| Baginton Sand | |
| Baginton-Lillington Gravel | |
| - Long time interval - | |
| Bubbenhall Clay | |




Text-fig. 6. Outline solid geology of northern Leicestershire and parts of adjoining counties.

On the evidence of the Wolston Series, Shotton argues that, in the Midlands, the Wolstonian (Saalian) Glaciation started with the advance of ice from the north-west and subsequently ice from the north-east became dominant. These ice movements together with the presence of Welsh ice in the Severn Estuary formed glacial Lake Harrison which at its maximum covered the greater part of the Midland plain. The glaciation culminated with north-eastern ice overrunning virtually the whole of the area at one time occupied by the lake.

Against this background the Cliffe Hill Sand and Gravel, the Markfield Clay and the Newtown Linford and Anstey Tills may be seen as the depositional representatives in south Charnwood Forest of Shotton's Older Drift succession and sequence of events. Yet, Shotton's interpretation presents difficulties when the Raunscliffe Till and White Hill Clays and Silts are considered, for there would appear to be no place for early north-eastern ice in his scheme.

It is assumed that the now isolated deposit of Liassic-rich till at Raunscliffe is a relic of what was originally an extensive and homogeneous spread of calcareous eastern drift. On this basis it becomes necessary to postulate a phase of sub-aerial erosion before the entry of north-western ice to account for the regional absence of Raunscliffe Till and also the dearth of eastern material in the overlying Newtown Linford Till.

If this denudation was accomplished during a long interval it would not be unreasonable to assign it to the interglacial predating the Wolstonian i.e. the Hoxnian, with the glaciation associated with the Raunscliffe Till being placed in the Anglian stage. This view however is given little support by research workers in other parts of the Midlands where glacial deposits of Anglian age are generally accepted as being of north-western or Welsh origin (e.g. Shotton 1953 and 1973) an exception being Poole (1968) who believed that an Anglian age should be applied to a Cretaceous bearing lower till found in the Market Harborough area, about 35 km to the south-east of Charnwood Forest.

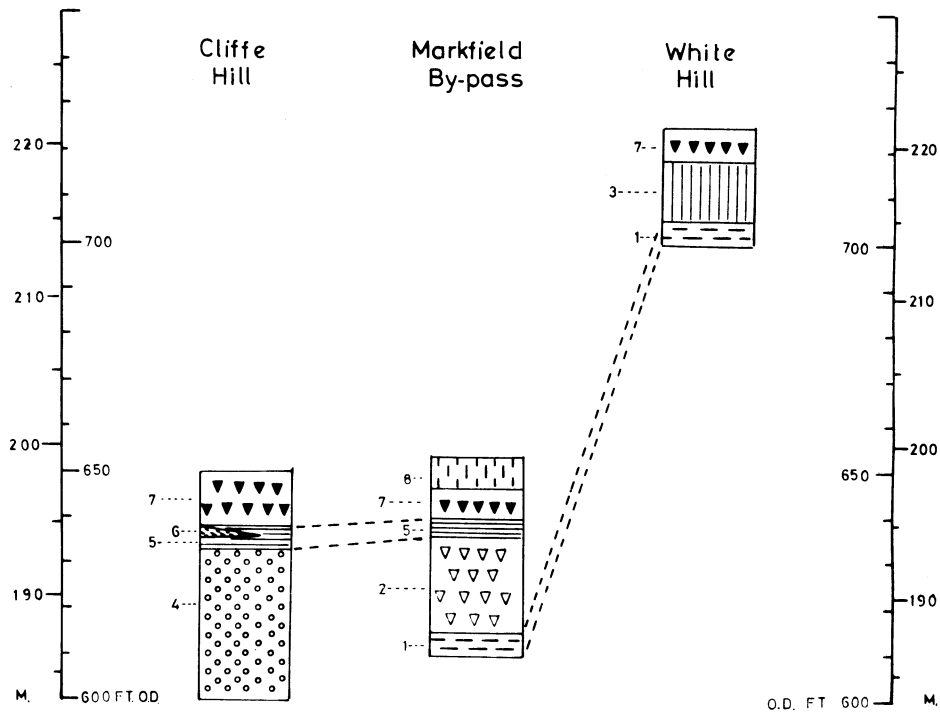
Alternatively, should the erosion have been completed during a shorter period of interstadial dimensions it might, together with the preceding glaciation, be positioned in the early part of the Wolstonian. In the Itchen valley, Bishop (1958) has recorded a till with eastern erratics underlying the Wolston Series. Bishop explains the till as the deposit from a Wolstonian ice-lobe which advanced and retreated before the entry of the north-western and eastern ice involved in forming Lake Harrison. Shotton (1968) has expressed uncertainty on the precise position within the Wolstonian for the formation of the lake. The placing of this event in an equivalent of the continental stage Saale II would solve many problems for it would allow the postulated erosion to be placed in the Saale I/II interstadial and the earlier north-eastern glaciation to correspond with Saale I.

It should be noted that Poole (1968), whose foremost argument is for a Hoxnian interglacial interval between the lower and upper tills of Market Harborough, does not rule out the possibility of these tills being related to separate minor glacial phases within a single stage but, in his case, an Anglian age is preferred.

In the southern part of Charnwood Forest deposits which may be unequivocally dated as Hoxnian have yet to be observed and therefore an interstadial episode of Wolstonian age is favoured for the period between the deposition of the Raunscliffe and the Newtown Linford tills. Although the acceptance of such an interpretation would require a revision of existing British schemes it would not be at variance with evidence from the continental mainland where a two-fold division of the Saale stage is well established (Woldstedt, 1955).

It follows that an early Wolstonian age is applicable to the Lower Head for there is nothing to suggest that it was formed in other than a periglacial phase related to the advance of the ice which laid down the Raunscliffe Till.

Later members of the succession are more easily related to Shotton's scheme for the Wolstonian, although some exhibit features reflecting exceptional local environments of deposition. For example, whilst the composition of the Cliffe Hill gravel confirms the dominance of north-western




8 Upper Head

7 Newtown Linford Till

6 Middle Head

5 Markfield Clay

4 Cliffe Hill Sand & Gravel

3 White Hill Clays & Silts

2 Raunscliffe Till

1 Lower Head

Text-fig. 7. Height relationships and correlation of the successions at Cliffe Hill, Markfield By-Pass and White Hill.

ice at the beginning of the glaciation associated with Lake Harrison, the altitude of the Markfield Clay indicates Charnwood Forest proglacial lake levels 60 m or more above those recorded elsewhere in the Midlands (Bishop, 1958). Notwithstanding this discrepancy, the absence of evidence showing any influence of north-eastern ice in the formation of the Charnwood lake justifies the correlation of the Markfield Clay with Shotton's Lower Wolston Clay, but there was, of course, no physical continuity between Lake Harrison and the proglacial ponding around Charnwood Forest.

The age of the Middle Head is therefore established for it lies within the Markfield Clay. It is hardly surprising that this head has no recorded counterpart in the Midlands as the shoreline conditions leading to its formation were probably unique to south Charnwood Forest.

Although the Newtown Linford Till shows a variable composition it characteristically contains some Coal Measure erratics. This trait may be taken as an indication of south-easterly ice movement over the topographically unobstructed ground lying between the exposed portion of the Leicestershire-Derbyshire coalfield and south Charnwood Forest. There was, however, an additional route open to ice from the coalfield via the low terrain north of Charnwood Forest and the valley of the Proto-Soar (Rice, 1968). Support for the utilisation of the latter course by north-western ice is found in the Thrussington Till mapped by Rice in the northern part of the Soar Valley and it therefore seems probable that both routes were used by lobes of ice which had initially advanced over the Coal Measure outcrop. Although their respective contributions to the Newtown Linford Till are not understood this interpretation goes some way towards explaining its variability.

The youngest member of the Older Drift in south Charnwood Forest, the chalky Anstey Till, supports evidence from other parts of the Midlands for the dominance of north-eastern ice in the closing phases of the glaciation.

The relationship of the Upper Head to valley slopes developed on Wolstonian drift demonstrates that the head is younger than the main period of valley formation. The greater part of the erosion was probably effected during the Ipswichian interglacial and the origin of the Upper Head has accordingly been attributed to the periglacial environments of the following Devensian cold stage.

Cryoturbation disturbances of the head indicate more than one periglacial phase but it has not been possible to work out the sequence. Some indication of the number of phases involved and their position within the stage may be gained from Shotton's observations around Brandon where four Devensian cryoturbation periods have been provisionally dated, with three being placed in the early Devensian and one in the Upton Warren interstadial.

## Conclusion

In the light of the above discussion the pattern of Pleistocene events for south Charnwood Forest may be summarised as follows:

A. Wolstonian

i. Early period of periglacial environment (Lower Head).

ii. Entry of north-eastern ice (Raunscliffe Till).

iii. Formation of proglacial lake (White Hill Clays and Silt).

iv. Erosion of glacial deposits laid down in stages ii. and iii.

v. Advance of north-western ice (Cliffe Hill Sand and Gravel).

vi. Formation of proglacial lake (Markfield Clay).

vii. Periglacial environment with head becoming incorporated into proglacial lake sediments (Middle Head).

viii. Entry of north-western ice (Newtown Linford Till).

ix. North-eastern ice becomes dominant (Anstey Till).

B. Ipswichian

i. Erosion

C. Devensian

i. Several phases of periglacial activity (Upper Head and cryoturbation).

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