THE PROBLEM OF DISCORDANT DRAINAGE IN CHARNWOOD FOREST, LEICESTERSHIRE

by

J. F. D. Bridger[1]

Summary

In the light of the recent recognition that Charnwood Forest was glaciated during the Pleistocene, the origin of its discordant drainage is reconsidered. It is concluded that, whilst Watts' notion of superimposition as the process responsible for the discordant phenomenon is still valid, the present stream network has a Quaternary genesis and was not, as previously thought, inherited from a drainage pattern which had evolved on a former cover of Mesozoic rocks.

Introduction

The problem of Charnwood Forest's drainage has attracted the attention of earth scientists since the turn of the century. For many years it was accepted that the direct inheritance of a network which had developed on a former cover of Mesozoic rocks could satisfactorily explain the anomalous features. However, recent work on the Quaternary history of the area has shown that Charnwood Forest was completely glaciated during the Pleistocene and the purpose of this paper is to reconsider the evolution of the drainage in the light of this new understanding.

Geology

The basic geological structure of Charnwood Forest is a breached south-easterly plunging anticline of Precambrian age with igneous intrusions. These ancient rocks are overlain by the remnants of a one-time more extensive cover of Upper Triassic strata resting unconformably on the Precambrian structure. Quaternary deposits comprise head and glacial drift (Bridger 1972 and 1975), the widespread distribution of the latter implying that, following the final melting of the ice during the Wolstonian glaciation, a thick Pleistocene mantle almost certainly masked the preglacial landscape to give Charnwood Forest the broad topographical form of an inverted saucer.

[1]Faculty of Humanities,
Hull College of Higher Education,
Inglemire Avenue, HULL, HU6 7LJ

Mercian Geologist, 1981, Vol. 8, No. 3, pp. 217-223, 3 text-figs.

The Drainage Pattern

Although Charnwood Forest's drainage (text-fig. 1) has an ill defined watershed aligned north-east to south-west, its pattern is essentially radial at altitudes higher than 122 m. O. D. Above this datum, stream erosion has been unexceptional, producing open valleys in both Triassic and Pleistocene deposits. However, around 122 m. O. D. and occasionally well below it many streams, particularly those in the eastern and northern areas, change their direction to flow discordantly over outcrops of ancient rock where varying degrees of gorge development have been accomplished. The term discordant is applied here to streams wherever they flow over ancient rocks irrespective of the relationship of the direction of drainage flow to the structure of the strata. It should not be overlooked that, whilst the larger discordant sections are associated with stream deflection, the angle of turn may be very small, e.g. Blackbrook (SK 470170) and also that minor discordancies have developed without any perceptible change in stream direction, e.g. Lady Hay Wood (SK 515083). Furthermore, gorge formation is not restricted to localities where ancient rocks crop out and it may occur in Keuper sandstone, as at Whitwick (SK 433163) where Charnian rocks are exposed only in part of the gorge.

To a greater or lesser extent, all of the major discordancies have been modified by man, the most notable example being around the reservoir dam at Blackbrook. The one discordant section which could with any confidence be considered as displaying basically unmodified morphology is that at Grace Dieu Wood (SK 432175) near Thringston.

Previous views

Watts (1903, 1905 and 1947) argued that the crucial event in the evolution of Charnwood Forest's drainage was the burial of the area by Keuper sediments which obscured a drainage network of Triassic wadis together with elements of earlier Palaeozoic drainage history. He envisaged that the cover of Keuper and possibly other Mesozoic rocks provided a surface for the development of a new drainage system; the subsequent superimposition of this stream pattern being the process responsible for the present discordant phenomena.

The gorges were thought by Watts to have two possible modes of formation. Some were believed to be exhumed Triassic wadis cleared by streams guided onto them by factors concerning differences in the resistance between the ancient rocks and the Keuper Marl. Other gorges were seen as the work of streams turned aside from the lines of sub-Triassic valleys to pass "unconsciously" over buried ridges of ancient rock onto which they were later superimposed through Keuper deposits.

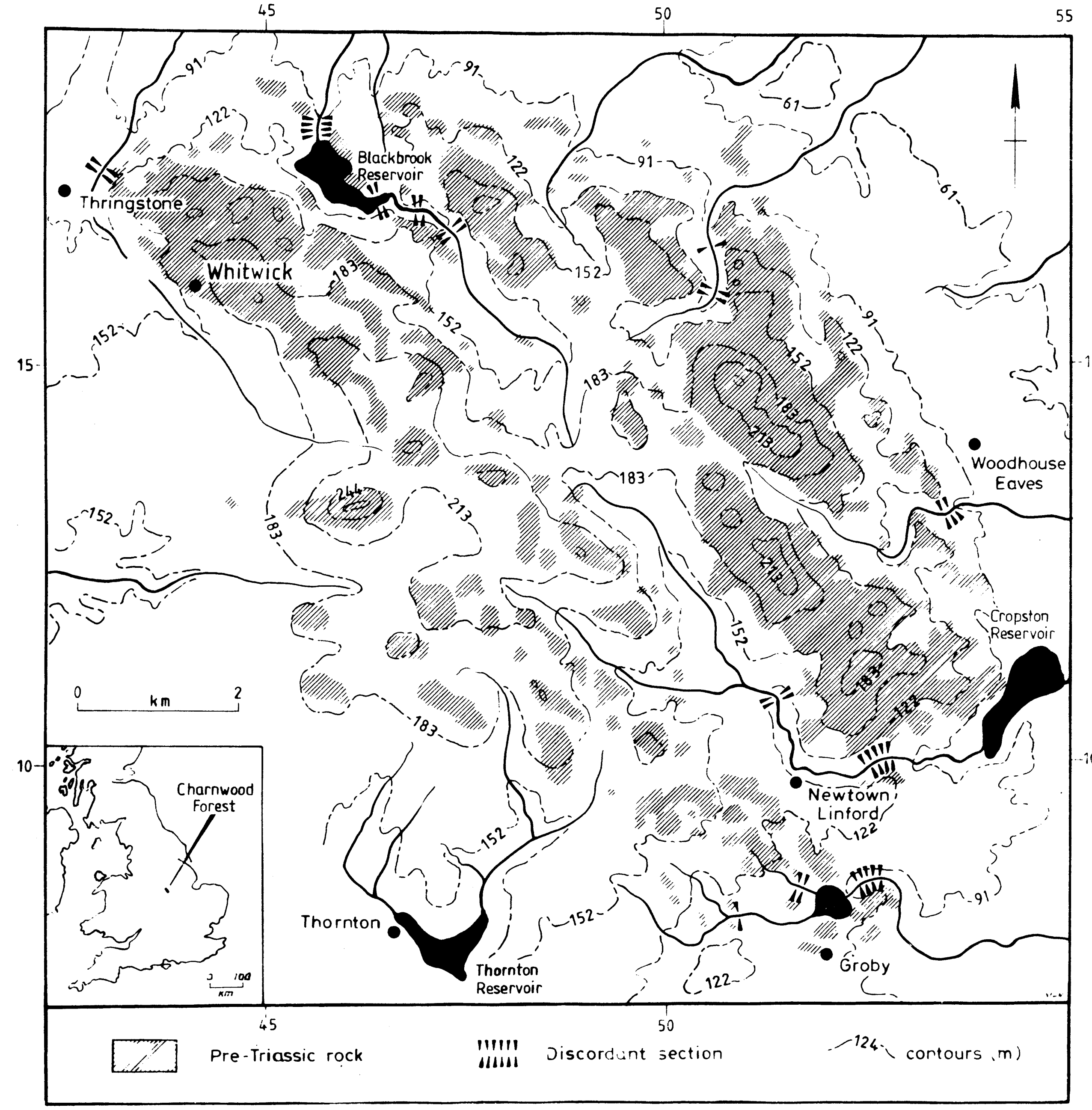
His interpretation received considerable support, particularly by Bennett (1929) who advocated superimposition through Triassic rock to account for the discordancy at Ulverscroft Mill (SK 514108).

In a reappraisal of drainage history in the Ulverscroft valley, Bridger (1968) considered his remapping of drift boundaries in the locality indicated that the formation of the Ulverscroft Mill discordancy had also involved stream superimposition through glacial deposits.

Ford (1968) stated that gorge formation was attributable to superimposition from till, but did not present detailed evidence to sustain his conclusion.

Recent field findings

Fieldwork by the author has included the topographical survey of the localities with discordant drainage as well as the mapping of them geologically. The latter activity has revealed neither Pleistocene nor Triassic rock within the gorges, but both types of deposit have been recorded in contiguous areas.



Text-fig. 1: Discordant drainage in Charnwood Forest, Leicestershire.

Three of the gorges have been levelled to Ordnance Survey bench marks, Bradgate Park (SK 526100), the Brand (SK 536131) and Grace Dieu Wood (SK 432175) and their cross-profiles together with that of Blackbrook (SK 458178), plotted from survey data kindly provided by Loughborough Corporation, are shown in text-figs. 2 and 3. The long-profile also illustrated in text-fig. 3 extends over the whole length of the discordancy at Grace Dieu Wood but it will be noted that only part of it is occupied by the gorge.

The cross-profiles exhibit a wide range of forms with considerable differences in both scale and shape and reasonably reflect the diversity of morphologies displayed by the group of Charnwood Forest gorges as a whole.

Discussion

As a basis for understanding drainage evolution in pre-Quaternary times Watts' hypothesis is, in general, acceptable. That there was at least a measure of discordant drainage before the onset of the Wolstonian glaciation may be supported by the evidence of a small, drift-filled ravine, lying a few hundred metres to the west of the present stream discordancy, at Ulvercroft Mill. Nevertheless the absence of other records of this type suggests that such features are less common than might be anticipated.

The Pleistocene, the period totally neglected by Watts, is a vitally important stage in the history of Charnwood Forest's drainage for, apart from the actual impact of glaciation, the ice left behind a thick deposit of drift to obscure the preglacial relief. Accordingly, Watts' view, that the present drainage has an exclusively Mesozoic and Tertiary ancestry, is no longer tenable for it is clear that any satisfactory account of the drainage should take into consideration Quaternary events.

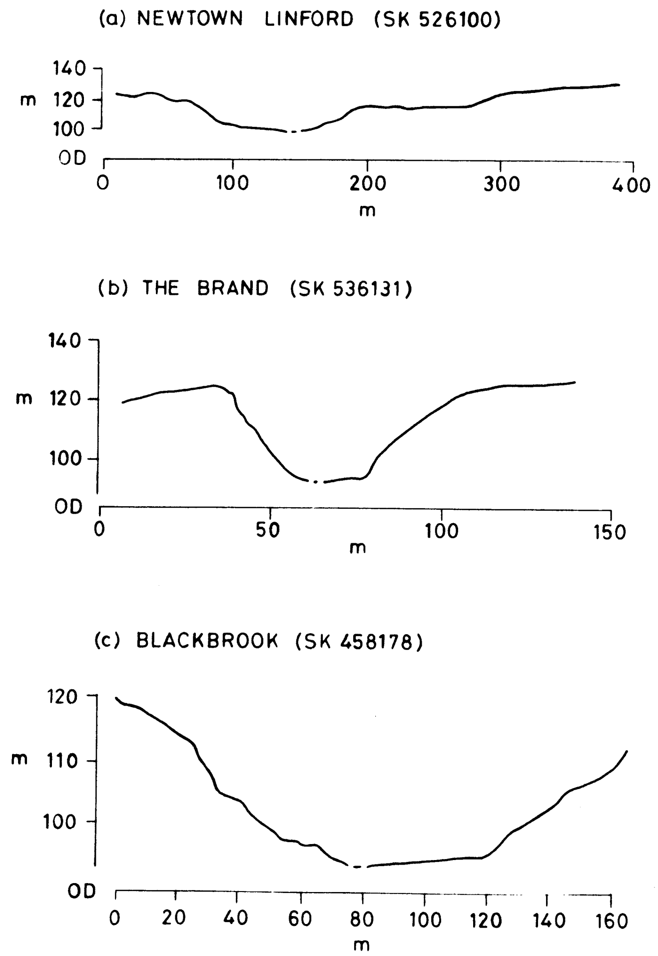
There are several instances in other glaciated regions of Britain where abnormal drainage has been attributed to the activity of meltwater. For example, gorge formation has been discussed by Price (1960) Derbyshire (1961), Sissons (1963) and Clapperton (1968), who, without exception, support a late Pleistocene glacial genesis. Clapperton believes that discordancies may be formed by the superimposition of glacial streams and that in certain circumstances melt-water routes may be influenced by crevasses.

In Charnwood Forest, which lies outside the limit of Devensian ice, but well within the Wolstonian boundary, depositional evidence for a glacial meltwater origin of the gorges has not been found. Apart from Grace Dieu, where the long profile does not show any humping, disturbance has largely removed the possibility of detecting diagnostic bedrock profiles (Peel, 1956).

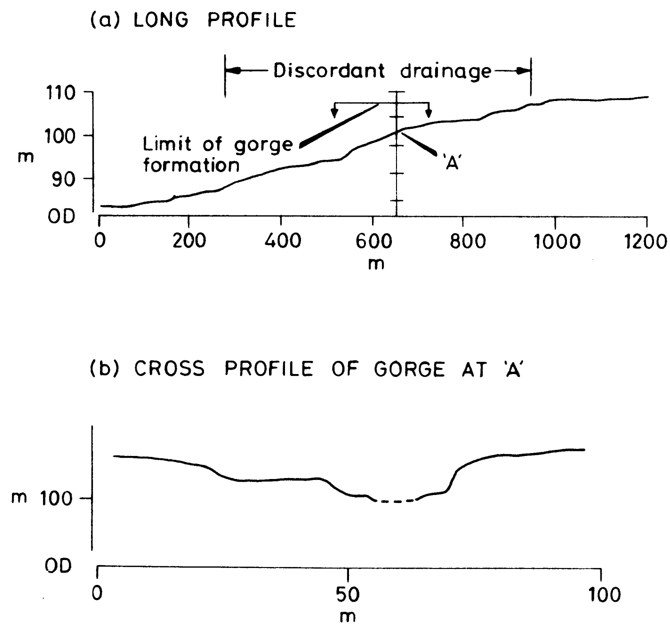
Notwithstanding the absence of unequivocal evidence, it is reasonable to assume that melt-water would play a fundamental role in the genesis of the pattern which emerged after the melting of Charnwood Forest's ice cover and the radial element in the present network is considered to be the imprint of the more important drainage routes followed at the time of deglaciation.

An explanation for the variety of turns in the courses of the streams is also presented by the setting of deglaciation for it would allow the possibility of meltwater routes being determined by a wide range of glaciological factors including the direction of crevasses. During the period of ice cover, the major-crevassed zones in Charnwood Forest would be close to its margins where gradients are steepest. Although the trends of the crevasses would not necessarily follow the isograds of the ice-bedrock interface, they would rarely be coincident with the dip. Thus glacial streams guided by crevasse systems would probably be deflected from radial routes and where these detours became particularly well established they could become permanent features of the network.

Additionally an environment of deglaciation offers conditions allowing epigenesis of drainage by down cutting through ice and it is possible that some gorges in Charnwood Forest were



Text-fig. 2: Surveyed cross-profile of gorges in Charnwood Forest



Text-fig. 3: Surveyed profiles of the Grace Dieu discordancy Thringston (SK432175) initiated in this way. However, the thick and widespread distribution of drift suggests that the mechanism of superimposition could equally have operated on glacial deposits alone. A Quaternary interpretation does not necessarily exclude the possibility of a stream cutting progressively downwards from ice and/or drift into Keuper Marl before coming in contact with older rocks and the stratigraphy of certain areas, as for example, in the Ulverscroft valley, lends support to the view that such a sequence of events may have occurred.

There remains the problem of the concentration of the discordancies in the northern and eastern parts of the area and here it is necessary to take into account the contrasting Upper Pleistocene histories proposed for the valleys of the Proto-Trent and the Proto-Soar lying respectively to the north and south of Charnwood Forest.

It has been suggested by Straw (1963) that following the withdrawal of the Wolstonian ice the Trent, in its middle reaches reoccupied the valley of the Proto-Trent. The fluvio-glacial interpretation of the Hilton Terrace by Posnansky (1960), implies that in the vicinity of Willington, Derbyshire (SK 295285), the Trent had eroded its valley to below 61 m. O.D., before the ice had finally retreated from the region. To the south of Charnwood Forest, however, it seems that a reversal of drainage direction may have followed the glaciation (Shotton 1953), the Proto-Soar's extensive valley remaining largely buried under drift. This situation would give streams flowing to the Trent from Charnwood Forest the erosional advantage of lower local base levels. Consequently, streams in the Trent's catchment would have a faster rate of downcutting and so increase their chances of forming discordant sections by superimposition.

Conclusion

It has been argued that most of the anomalies of Charnwood Forest's drainage may be explained in a Quaternary context and that it is unnecessary to postulate inheritance from preglacial periods. Watts' notion of superimposition as the process responsible for discordant drainage is still valid, but his understanding of the environments in which it operated is unsatisfactory in so far as it overlooks the area's glaciation. A revised interpretation of the history of Charnwood Forest's drainage, which takes into account Pleistocene events, is summarised in Table 1.

1. Palaeozoic

   Drainage adjusted to the Precambrian structure?

2. Mesozoic

   Triassic wadi system developed. Keuper and possibly later Mesozoic rocks bury features of earlier drainage episodes.

3. Tertiary

   New drainage pattern evolves on Mesozoic cover. Some superimposition onto pre-Triassic rock.

4. Quaternary

   i. Tertiary drainage network buried under cover of drift.

   ii. Glacial meltwater forms radial pattern with localised stream deflection by glaciological factors.

   iii. Superimposition, first through ice and later drift, forms discordancies and gorges.

   iv. Dominance of Trent drainage leads to concentration of discordancies in northern and eastern parts of Charnwood Forest.

Table 1. Drainage history of Charnwood Forest.

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