AN UNUSUAL OCCURRENCE OF SANDS AND GRAVELS IN DERBYSHIRE

by

Cynthia V. Burek

Summary

A block of sand and gravel, located within glacial till above the River Lathkill at Raper Pit, Derbyshire, is described in detail. The block provides evidence of pre-till transportation and deposition, probably as fluvioglacial outwash material, although other sources are considered. This occurrence is unique on the Derbyshire limestone and bears no relationship to the pocket sand deposits found elsewhere on the plateau, which are of a different lithological composition and age. Sedimentary structures are still preserved in the unconsolidated sand suggesting that transportation of the block occurred whilst it was in a frozen state. The deposit may shed light on climatic events immediately prior to the deposition of till in the northern Derbyshire area.

Introduction

A report on the preliminary investigation of a temporary exposure of sands and gravels, incorporated within glacial till, is presented in this paper. The exposure, unique on the Derbyshire limestone plateau, was first noticed in October 1974. This excavation is now partly filled in, and the deposit is no longer readily available for consultation. There are no published accounts of similar deposits in this area.

Glacial till is present to a limited extent on the limestone plateau, text-fig. 1; much less extensive than the deposits found around its margins on the outcrops of Millstone Grit and Edale Shales. This unusual exposure occurs above the River Lathkill and lies in a relatively flat interfluve area known as Haddon Fields, at an average elevation of 200 m. Traversing the area are several old lead veins of which Long Rake, near Youlgreave, has been recently quarried for fluorite. It is on the north face of East Raper Pit, a single excavation on this vein, that the unique sand and gravel deposit occurs (SK217652).

Elsewhere on the Derbyshire limestone plateau, pocket sand deposits have been described (Yorke, 1961, Boulder, 1971) resting in hollows. Blue clay overlying the sand pockets has been dated Mio-Pliocene. Thus the sand and gravel deposits described below and the sand pockets are not contemporary in age. Further they bear no similarity in appearance either structurally or lithologically.

The Glacial Till

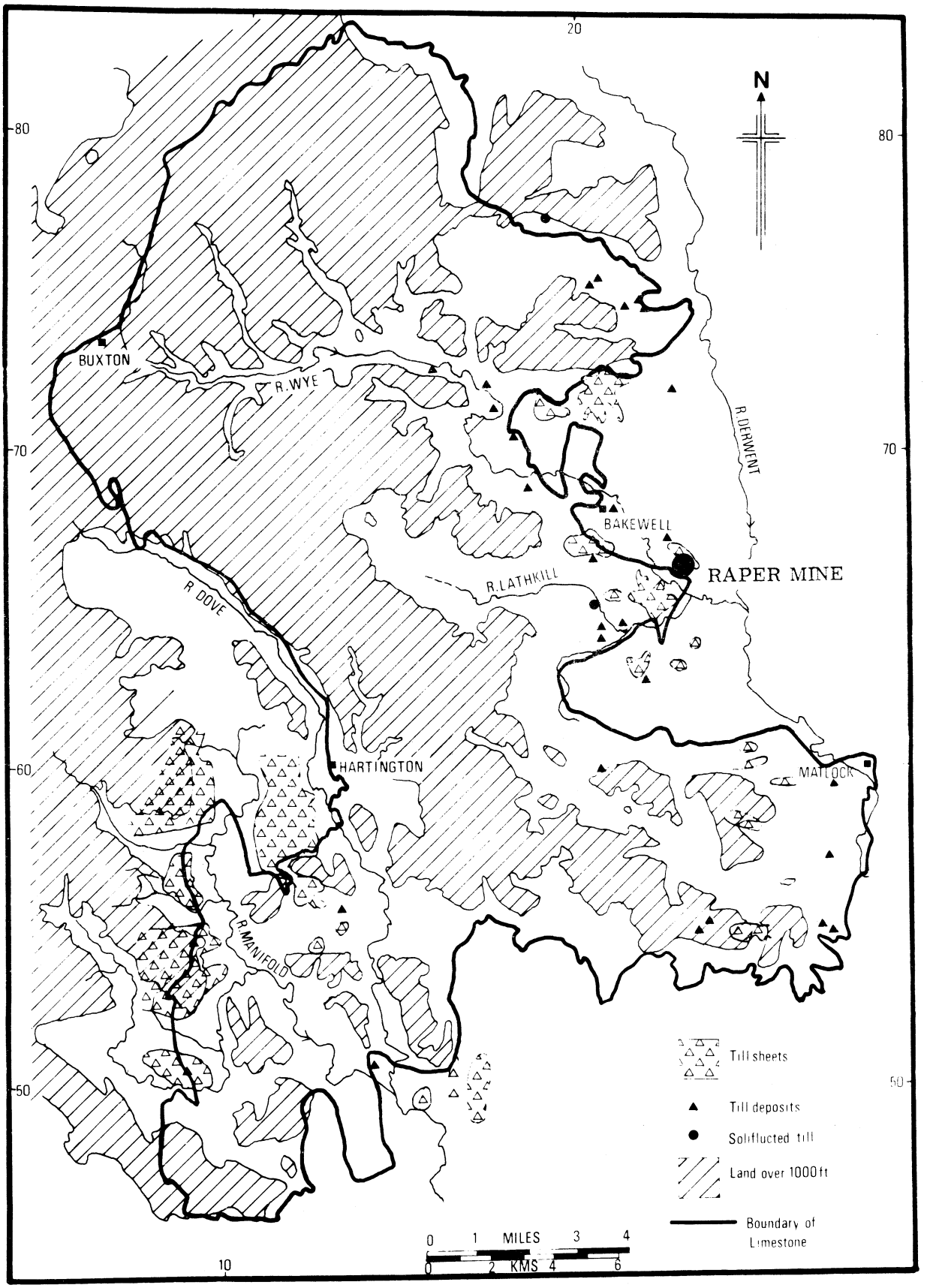
The glacial till in the vicinity of the Raper Pits, lies above both the Carboniferous Limestone and the Edale Shale, attains a maximum thickness of 15 m and feathers out east and west with a fall in altitude. Capping the till is 1 - 2 m of 'loess' which has been leached in the top 60 cm. The 'loess' appears to lie conformably over the till and the only evidence which might separate the two deposits in time, is frost-shattered boulders in the uppermost part of the till (Ford, personal communication). However, based on previously established river terrace sequences [1], clay translocated soil profiles[2], and glacial till distribution and sequences established elsewhere in the U.K. [3], it is thought that two different cold periods are represented by the till and 'loess' deposits. Therefore from evidence also

[1] Johnson, 1954; Waters and Johnson, 1958; Clayton, 1968.

[2] Cazalet, 1969.

[3] Mitchell, et. al., 1973.

Mercian Geologist, vol, 6, No. 2, 1977.
pp. 123-130, 3 text-figs., Plates 6 & 7.

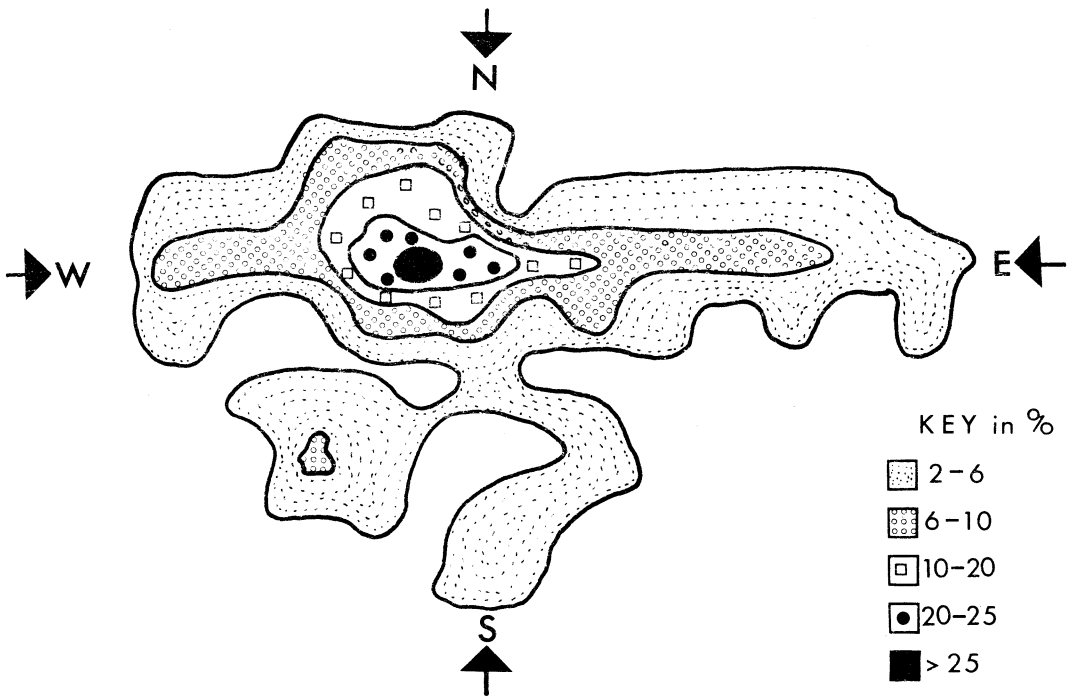


Text-fig. 1. Distribution of glacial till on the Derbyshire Limestone Plateau and the location of the Raper Pit.

based on altitude, location and weathering features, the till is generally thought to be Wolstonian in age and the 'loess', Devensian.

The boulder clay has a dark, yellowish-brown colour (Munsell Colour 10YR4/2 wet), and contains striated limestone erratics up to 1.5 m^3, shale fragments, weathered dolerite boulders and rounded Millstone Grit erratics set in a clay matrix. Only a few foreign or far-travelled erratics, eg., Shap Granite and Borrowdale Volcanic boulders have so far been found, despite systematic searching. It is concluded that this is primarily a locally derived till.

Pebble orientation of 50 erratics within the till on the north face (text-fig. 2), and the rare erratic rock types point to a north or northwest direction for the ice source, which agrees with the general idea of ice movement over the col at Dove Holes during the later part of the Pleistocene [4]. The sand and gravel block contained by the till would also be derived from a north or north-west direction.

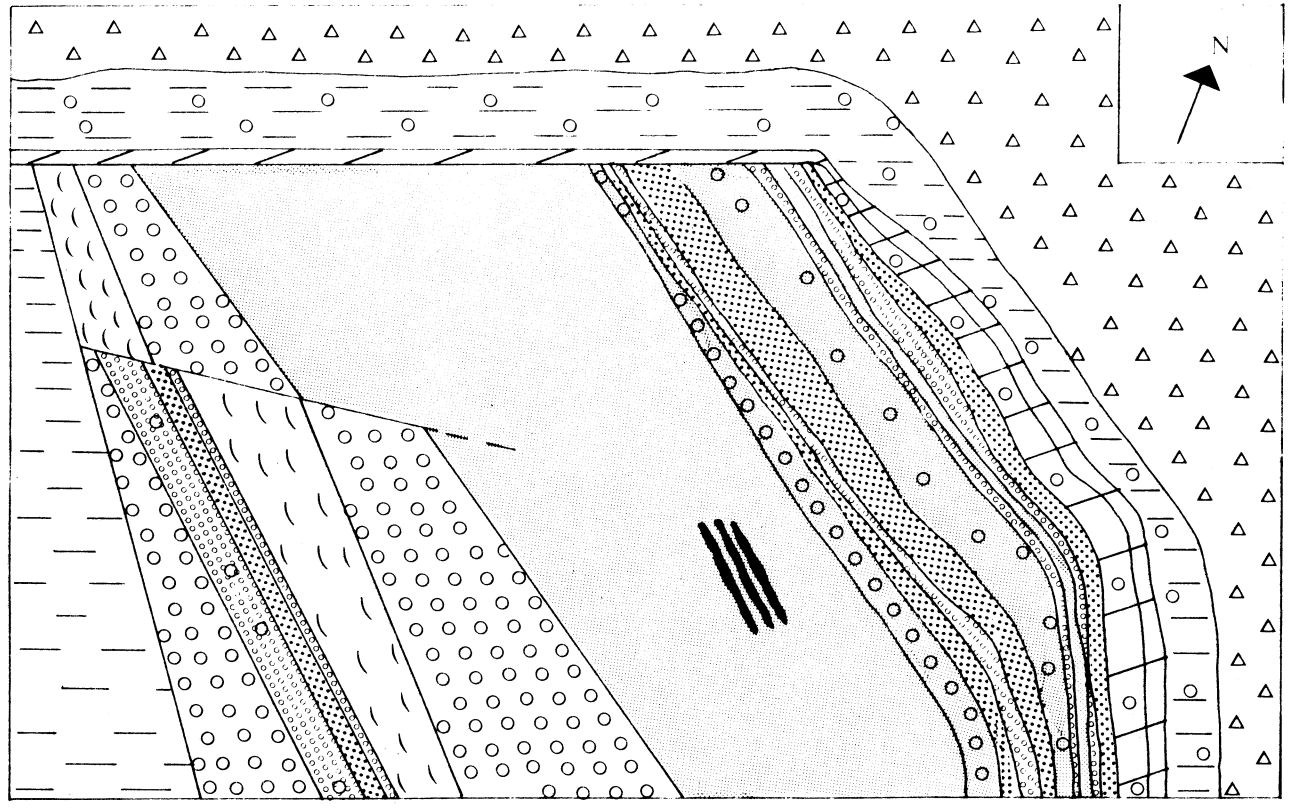


Text-fig. 2. Pebble orientation diagram (based on 50 readings)

The Sand and Gravel Block

Within the confines of the exposure the block measured 1.3×2 m. Nothing is known of its extent at right angles to the face: it does not appear to be in the south wall of the excavation, 35 m away. It is a block of alternating sand and gravel layers which appears to have been tilted through 90° (text-fig. 3; Plate 6), and now lies approximately 5 m below the turf level, incorporated within the till. Current bedding, Plate 7, fig. 2) has been detected in one of the sand beds, determining the original orientation of the material and the sequence of deposition (Table 1).

[4] Dalton, 1945, 1958; Waters and Johnson, 1958; Straw and Lewis, 1962; Burek, to be published.



key

- coarse sand
- medium sand
- fine sand
- grey clay
- red clay
- gravel
- till

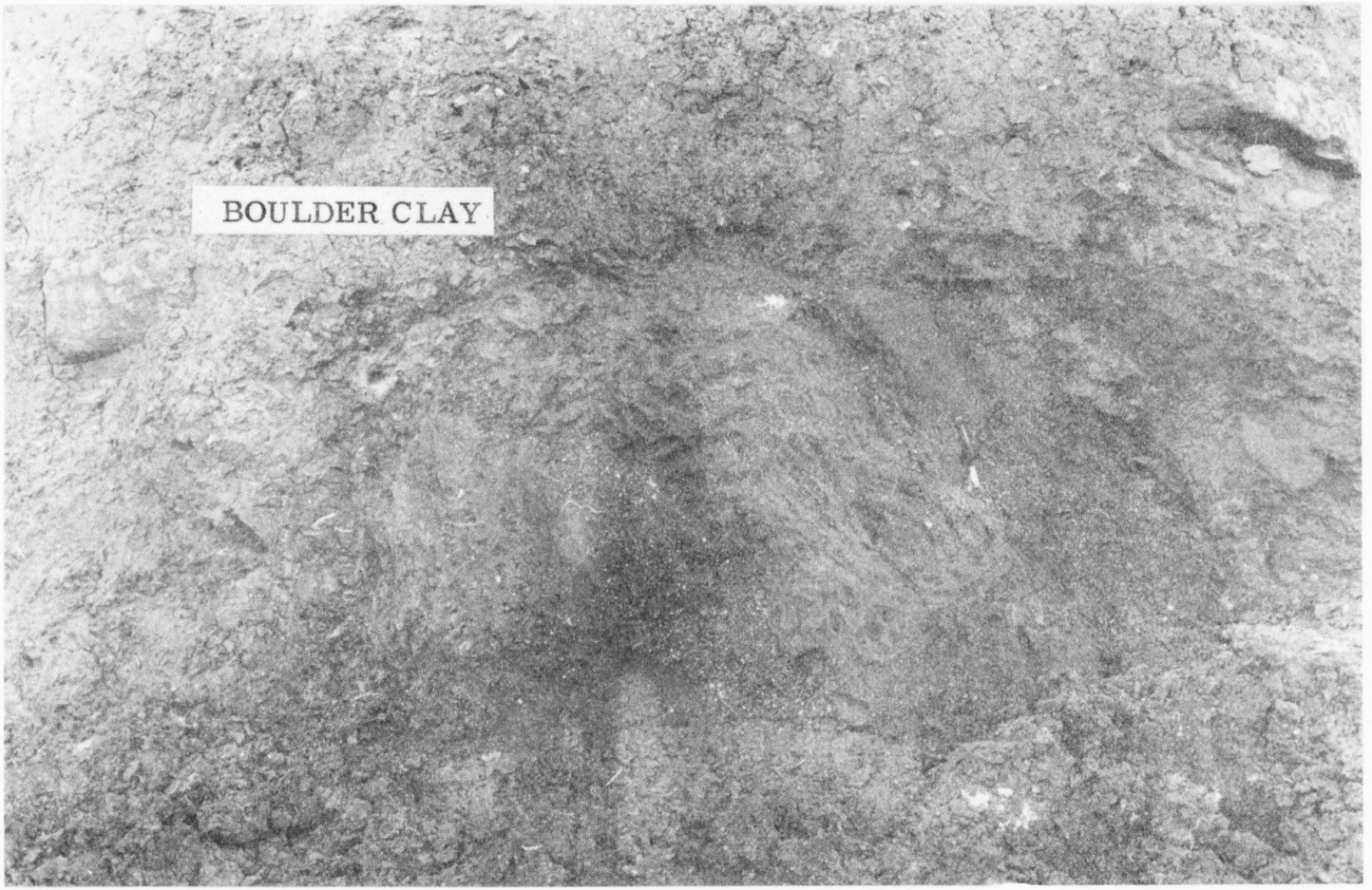
scale

0 ft 1

0 cm 30

- carbonaceous lenses
- current bedded sands
- tear fault

Text-fig. 3. Drawing of the sand and gravel block to illustrate fault, current bedding, and carbonaceous lenses. Cf. Plate 6, opposite.



Block of sand and gravel within boulder clay cf. text-fig. 3.

Table 1 Sequence within the Block

		cms
22	Till	
21	Grey clay with pebbles	12.7
20	Red clay partially surrounding the block	2.5 - 5.4
19	Red clay with pebbles	7.6
18	Medium sand	5.1
17	Coarse sand	2.5
16	Fine sand	2.5
15	Coarse sand	2.5
14	Gravel in a sandy matrix	15.2
13	Medium sand	10.1
12	Coarse sand	2.5
11	Medium sand	2.5
10	Gravel in a sandy matrix	7.6
9	Fine sand with coal lenses occurring 12.7-22 cm from the top	27.2
8	Gravels	22.9
7	Current bedded sands	20.4
6	Coarse sand	2.5
5	Medium sand	5.1
4	Coarse sand	7.6
3	Gravel	7.6
2	Stoneless clay merging with	
1	Till	

A tear fault (Plate 7, fig.1) 36 cm from the top of the block shows a lateral displacement of about 26 cm. At the west end, above and below the fault, four sand and gravel layers are missing if the sequence here is compared with that of the east end. This indicates that erosion of the block probably took place before, or during, inclusion of the erratic within the till.

The above observations imply that in three dimensions, the deposit is an irregular block, included within the till. Transportation has resulted in some erosion, rotation, and dislocation. As the block has not been completely broken up and fragmented, it is assumed that it was frozen and has not moved far from its source.

The Origin of the Sand and Gravel

Theories on the origin of the sand and gravel deposit from which the block has been derived can only be considered as tentative because of the small exposure and unique occurrence. A number of possible source areas are considered.

The most likely origin would be fluvio-glacial, possibly as an outwash sand and gravel spread. The deposit could underlie the till in the vicinity of Raper Pit or be present at a similar or higher level away from the immediate area. The relationship between the block

within the till and the underlying Edale Shales cannot readily be seen in the northern face. However, the southern face, 35 m away, exhibited bedrock lying 1 - 2 m below the northern lower limit of undisturbed till, indicating the absence of sand and gravel deposits between the till and bedrock. A similar relationship is visible in other faces of both the East and West Raper Pits; one would assume that this was the case on the north face where the contact is obliterated by quarry debris. If there were such deposits, they have long since been eroded away and were either incorporated within the till deposits further south or they were washed into the limestone joints and possibly into cave systems.

Similar sand and gravel deposits are known to occur above the Edale Shales to the north. Therefore the block could have been picked up from above the shale outcrop and transported south down the Wye valley.

A third explanation may be found in deposits associated with a pre-glacial course of the Lathkill River. The block could have been picked up from the former floodplain deposits, when it was flowing at a higher altitude. This would suggest a downcutting of 122 m to present river level, because of the present elevation of the block.

Whilst the alternation of fine, medium and coarse sands and gravels suggest fluvio-glacial deposition originally as outwash sands and gravels, the available evidence does not rule out en- or sub-glacial stream sedimentation. These deposits e.g. kames, are normally ill-sorted, current-bedded sands and gravels with ill-defined layering and are generally unlike the lithological characteristics of the block. As they are formed during the late stages of glaciation, they would normally be located, if found at all, in their original place of deposition. However, during another cold phase, the deposits could have been moved in the frozen state and retain their characteristics although rotated, eroded, and dislocated.

The Red Clay

Attention can now be focused on the red clay (20, Table 1, p. 126) which partially surrounds the block. The clay seems to be a transitional phase as it is neither part of the block, nor part of the till. Preliminary analytical work on this clay, which may eventually provide a clue to the depositional processes at work, has shown that it has a geochemical composition as indicated in Table 2. The table shows a significant difference between the composition of the red clay and both the block and till. The outwash material has high SiO_2 and Al_2O_3 values whereas the red clay has lower SiO_2 values but high Al_2O_3 and K_2O reflecting the higher clay mineral content.

Table 2 - Geochemical Data of Sand Inclusion Clay and Till Samples

in %	Block (average of 5 samples)	Clay	Till (6 samples average)
SiO_2	67.8	56.7	49.6
Al_2O_3	14.2	18.4	11.9
Total Fe Oxides	6.3	6.4	4.5
K_2O	1.7	3.3	1.5
MgO	1.1	2.6	1.3
CaO	9.2	2.1	20.5
in ppm			
MnO	731	443	1083
Cd	105	58	111
Ga	17	28	10
Li	70	119	76
Mo	34	9	35
Sr	210	102	282

The analyses were obtained using an ARL 2900B direct reading emission spectrometer located at Leicester University. (For instrumental conditions see Celenk, 1972, and Cubitt, 1975).

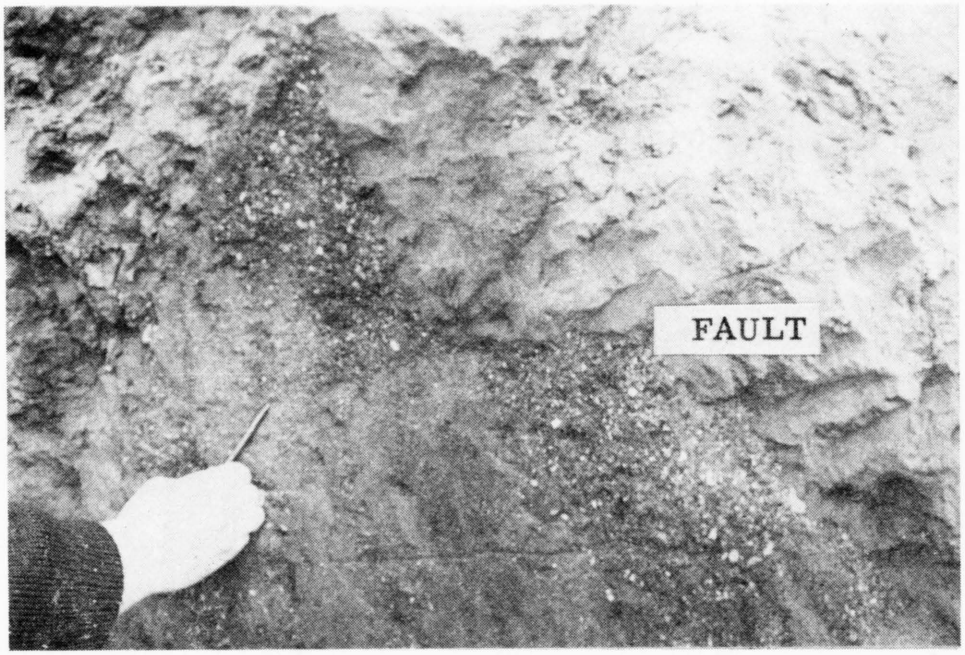


Fig. 1. Tear-fault at the edge of the block.

Fig. 2. Band of current bedding within the block.

The till is characteristically high in CaO and relatively low in SiO_2 and Al_2O_3. Trace element distribution supports the separation of the block, clay and till produced initially from the data on the major oxides. High Cd, MnO and Sr values in the till exemplify this separation and are thought to represent possible substitution of these elements for Ca^{++} in the calcite lattice. Similarly, lithium, which is concentrated in the red clay, is probably associated with high clay mineral content. The depositional nature of the red sediment remains unclear, and work continues on this aspect.

Discussion

Several inferences can now be drawn from this single occurrence. The block of sands and gravels is a remnant of former fluvial conditions as outwash, en-or sub-glacial streams or Lathkill flood-plain deposits. From consideration of the lithology and emplacement a sand and gravel outwash origin is favoured. If this assumption is accepted the history of the block allows a relative chronology to be established for Pleistocene events in North Derbyshire.

1. Fluvial or fluvio-glacial conditions, enabling deposition of the sands and gravels.
2. Periglacial conditions capable of freezing unconsolidated material.
3. Glacial Wolstonian conditions permitting the incorporation and transportation of the frozen block into the glacier. The Edale Shale cover would be removed in part during this phase.
4. Substantial downcutting by local rivers and removal of much glacial debris and underlying Edale Shales.
5. 'Loess' deposition in the Devensian.

If the block originated from high level River Lathkill floodplain deposits, ideas on the present drainage evolution of the limestone and the removal of the shale cover must be revised. When the material was incorporated within the till, the River Lathkill may have been flowing at least 122 m above its present level, and therefore, provide a relative date for the evolution of the area's drainage.

Conclusions

Despite the poor exposure of undisturbed boulder clay on the Derbyshire Limestone Plateau, which is partly responsible for the lack of knowledge concerning Pleistocene events in the area, the conclusions drawn from the study of the Raper Pit exposure are thought to be significant.

1. The sedimentary structures in the unconsolidated sediment of the block are undisturbed and indicate, therefore, that the block was transported in a frozen state.
2. During transport, the block must have been rotated, as the current bedding lies in a nearly vertical position.
3. Faulting occurred during transport and whilst the block was in a frozen state, because during movement, the block remained entire and did not disintegrate.
4. There is no evidence of sands and gravels at the till/limestone boundary in these excavations.
5. The deposit is thought to represent former outwash sands and gravels, rather than en- or sub-glacial stream deposits, or high level Lathkill floodplain deposits.
6. The block is of earlier origin than the till in which it is incorporated. Despite a lack of macrofossils and palynological dating evidence, a tentative Wolstonian date is assigned to the till and period of transport based on evidence reviewed by Burek (to be published), Shotton (1976, personal communication) and presented here.
7. An earlier date (Wolstonian) is allocated to the source outwash sands and gravels and a later date (Devensian) for subsequent downcutting of the local rivers and 'loess' deposition.

Acknowledgements

The author would like to thank Laporte Industries Ltd., for access to Raper Pit; J. Moseley, N. Worley, R. Burek and B. Basset for field assistance; Drs. T.D. Ford and B.M. Hand for useful discussion; and Drs. E.H. Muller and J. M. Cubitt for critically reading the manuscript. Miss V. Rutherford of Leicester University ran the emission spectrometer and is duly thanked.

References

BOULTER, M.C. 1971. A survey of the Neogene flora from two Derbyshire pocket-deposits, *Mercian Geol.*, vol.4, pp.45-61.

BUREK, C.V., The Peak District in the Ice Age, (to be published).

CAZALET, P.C.D., 1969. Correlation of Cheshire Plain and Derbyshire Dome glacial deposits, *Mercian Geol.*, vol.3, pp.71-84.

CELENK, O. 1972. *Application of computer-oriented statistical and mathematical techniques to the interpretation of geochemical prospecting data with reference to the PIREJMAN area, South East Turkey.*, Ph.D., thesis, University of Leicester.

CLAYTON, K.M., 1968. Structure and surface in the middle part of the Derwent basin, *East Midlands Geogr.*, vol.4, pp.321-328.

CUBITT, J.M. 1975. *A computer analysis of geochemical and mineralogical data together with the petrology of the Upper Pennsylvanian and Lower Permian Shales of Kansas, U.S.A.*, Ph.D. thesis, University of Leicester.

DALTON, A.C.. 1945. Notes on some glacial features in N.E. Derbyshire *Proc. Geol. Ass.*, vol.56, pp.26-31.

DALTON, A.C. 1958. The distribution of dolerite boulders in the area around Bakewell, Derbyshire, *Proc. Geol. Ass.*, vol.68, pp.278-285.

JOHNSON, R.H. 1954. *An investigation of the landforms and morphological evolution of part of the limestone area of Derbyshire*, M.A. thesis, University of Sheffield.

MITCHELL, G.F., PENNY, L.F., SHOTTON, F.W., and WEST, R.G. A correlation of Quaterary deposits in the British Isles, *Geol. Soc. Lond., Special Report No.4.*, 99 pp.

SHOTTON, F.W. 1976. Amplification of the Wolstonian Stage of the British Pleistocene. *Geol. Mag.*, vol.113, pp.241-250.

STRAW, A and LEWIS, G.M. 1962. Glacial drift in the area around Bakewell, Derbyshire, *East Midlands Geogr.*, vol.3, pp.72-80.

WATERS, R.S., and JOHNSON, R.H. 1958. The terraces of the Derbyshire Derwent, *East Midlands Geogr.*, vol.2, pp.3-15.

YORKE, C. 1961. The pocket deposits of Derbyshire, private publication, Birkenhead, 86 pp.

Cynthia V. Burek,
Department of Geology,
Syracuse University,
Syracuse,
New York, 13210.
U.S.A.