Patterned Ground in the Lower Trent Valley near Brough, between Newark and Lincoln

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Abstract: Patterned ground is identified from aerial photographs of the terrace surface of the Balderton Sand and Gravel between Newark and Lincoln. It is interpreted to represent the surface expression of a network of ice wedge pseudomorphs, which are related to others exposed in quarry sections of the Balderton Sand and Gravel in the area. The ages of these pseudomorphs are reviewed and it is concluded that those giving rise to the patterned ground were developed and casted during the Devensian Stage, probably relating to the late Devensian Dimlington Stadial.

The area between Newark and Lincoln is notable for a sequence of sand and gravel deposits that indicate a complex history of drainage evolution during the Pleistocene (Fig. 1; Table 1). An assessment of archaeological cropmark features adjacent to the A46 Fosse Way and around the Scheduled Ancient Monument of Brough Roman 'small town' (SK 836 584), undertaken in response to Department of Transport plans to upgrade the route to dual-carriageway, involved inspection of 1:10 000 scale aerial photographs which revealed examples of patterned ground. Although periglacial features are frequently mentioned in published work on drift deposits of the Trent Valley, few examples of the surface expression of these features have been documented (e. g. Straw, 1979, fig. 3.8).

STAGE	DEPOSIT
Flandrian	Alluvium
Devensian	Floodplain Sand and Gravel
Ipswichian	Scarle Sand and Gravel Fulbeck Sand and Gravel
Wolstonian	Balderton Sand and Gravel
Wolstonian or Anglian	Eagle Moor Sand and Gravel

Table 1. Revised chronology of fluvial and fluvio-glacial sand and gravel deposits between Newark and Lincoln (after Brandon and Sumbler, 1988, 1991).

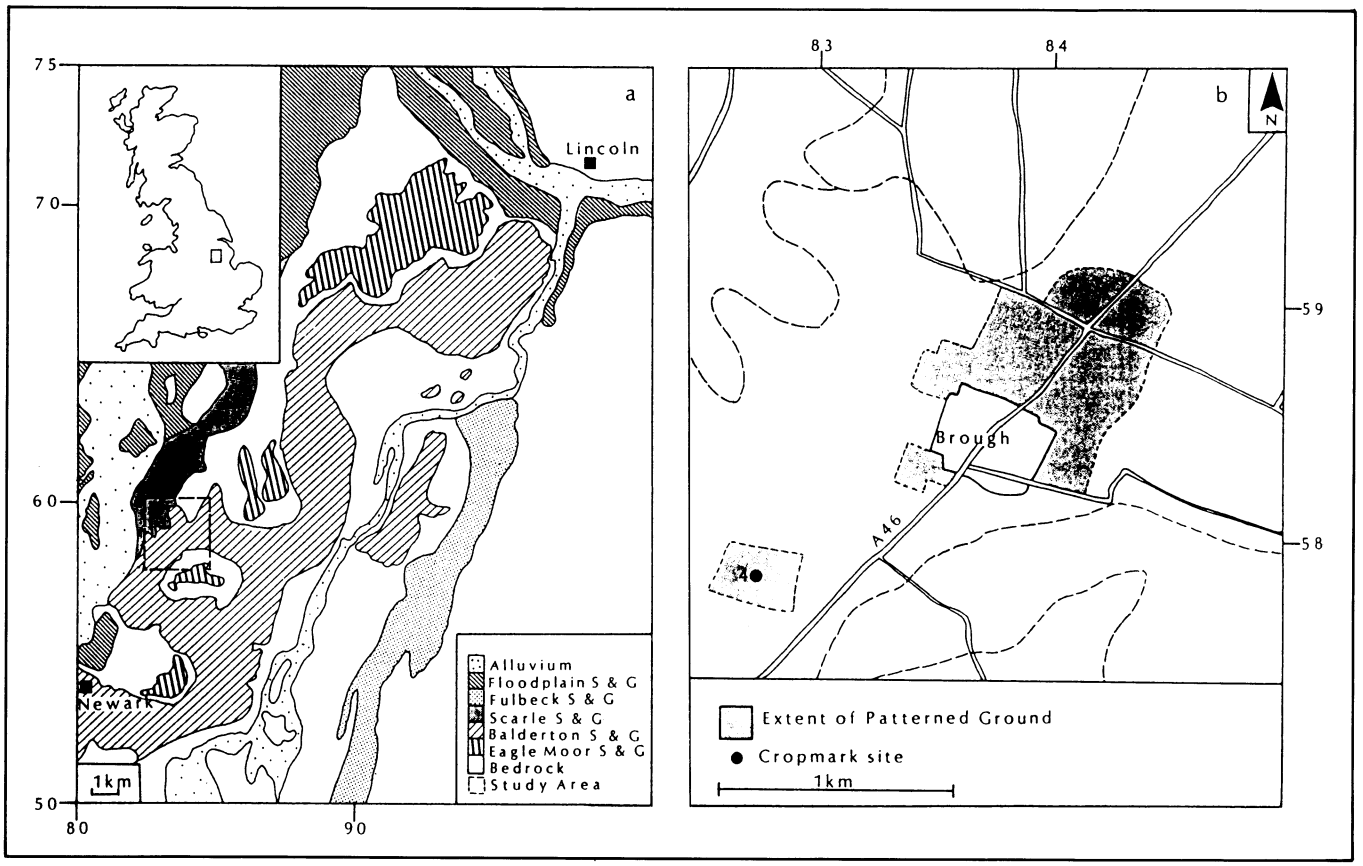

Fig. 1a. Distribution of fluvial deposits betwen Newark and Lincoln (based on BGS 1:50 000 sheets 113, 114, 126, 127, with amendments by Brandon and Sumbler, 1988, 1991). **1b.** Distribution of patterned ground and archaeological cropmark features. Site numbers are those of Knight and Kinsley (1991). Dashed lines indicate limits of superficial deposits.

Fig. 2. Aerial view of patterned ground looking south-west along the A46 Fosse Way. Reproduced by kind permission of Cambridge University Committee for Aerial Photography, CJO 26.

Description and interpretation

Patterned ground has been found at two localities on the terrace surface of the Balderton Sand and Gravel, which crops out in a sinuous tract between Newark and Lincoln (Fig. 1a). In total, the patterning covers an area of c.0.6km^2 and takes the form of semi-regular polygonal structures, on average 8-10m in diameter (Fig. 1b; Fig. 2). At one site, the patterning is truncated by archaeological cropmark features (Site 4, in Knight and Kinsley, 1991) dating from the Iron Age to Romano-British period (700BC-450AD). The patterned ground is similar to active (e. g. Harry and Godzik, 1988, fig. 7) and relict (e. g. Svensson, 1988, fig. 15) periglacial features recorded in high latitudes. They are, therefore, interpreted as the surface expression of a network of ice wedge pseudomorphs, formed by the development of perennially frozen ground during a former cold period (Washburn, 1979).

Quarry exposures of Balderton Sand and Gravel have, to date, revealed two generations of ice wedge pseudomorph development (Brandon and Sumbler, 1991; Howard, 1992). The first comprises syndepositional ice wedge pseudomorphs. These occur approximately in the middle part of the sand and gravel sequence and are erosionally truncated by an intraformational unconformity. Typically, these features penetrate vertically downward for c.2m, are c.1.5m wide and infilled by sand and gravel. They probably form polygons 5-10m in diameter. The second generation is represented by large, epigenetic ice wedge pseudomorphs, probably forming polygons of 70-100m diameter. These developed from the base of a former active layer (i. e. the layer of ground above the permafrost which thaws in the summer and refreezes in the winter) c.0.5-1m thick and penetrated c.3-5m through the sequence of sand and gravel. The casts are 2-3m wide with infills of geliflucted clay (probably derived from the surrounding lower Jurassic rocks) and sands (Howard, 1992). Brandon and Sumbler (1991) stated that infills also include reddened Whisby Sand, interpreted as a fluvio-aeolian deposit comprising reworked material from the upper levels of the Balderton Sand and Gravel. The red colour or 'rubification' is thought to be primary (Brandon and Sumbler, 1991).

The patterned ground features described from the aerial photographs have never been recorded in the quarry sections despite regular inspections of working quarries in the Balderton Sand and Gravel over the last eight years (A. Brandon, personal communication, 1994). Their stratigraphic position is similar to the large epigenetic ice wedge pseudomorphs. It is likely that the features recorded on the aerial photographs are coeval with the large ice wedge structures, but represent locally smaller sized polygons. Alternatively, but less likely, they could have developed locally during a different cold phase and, by chance, not have been exposed to date by quarrying. It is possible that the features represent the surface expression of the syndepositional casts exhumed by erosion of the upper part of the deposit, although this seems unlikely since no evidence of erosion of the upper sequence has yet been recorded within the quarried exposures.

Age

The Balderton Sand and Gravel has recently been interpreted as a braided river deposit, aggraded during a post-Hoxnian to pre-Ipswichian cold stage ('Wolstonian'), most probably Oxygen Isotope Stage 6 (Brandon and Sumbler, 1991), although an earlier date within the 'Wolstonian' complex is possible (Howard, 1992). Hence the syndepositional ice wedge pseudomorphs must have formed during this complex stage. Analogous structures recorded at Stanton Harcourt, Oxfordshire (Seddon and Holyoak, 1985; but see Worsley, 1987, for discussion) and Marsworth, Buckinghamshire (Green *et al.*, 1984), within sediments assigned to a post-Hoxnian to pre-Ipswichian cold period, indicate the existence of intense permafrost conditions at this time (Worsley, 1987).

The upper levels of the Balderton Sand and Gravel include 'cover deposits' which, in particular the Whisby Sand, have probably been affected by pedogenesis (J. Rose, personal communication, quoted in Brandon and Sumbler, 1991). This alteration has been ascribed to the Ipswichian interglacial, primarily on the basis of red colouration (Brandon and Sumbler, 1991). The large epigenetic ice wedge pseudomorphs include infills of Whisby Sand (Brandon and Sumbler, 1991) which, together with their stratigraphic position, suggests that they were formed during a post-Ipswichian cold stage, i. e. the Devensian. Although the size of ice wedges cannot be directly related to the timescale of development (Mackay, 1988), the large scale of these features perhaps suggests a prolonged period of permafrost development, possibly indicating growth and casting during the late Devensian Dimlington Stadial, although an earlier Devensian date cannot be ruled out. No ice wedge pseudomorphs have been noted in the Floodplain Sand and Gravel north of Newark, but probable late Devensian examples have been noted in equivalent deposits at Hoveringham, east of Nottingham (A. Brandon, personal communication) and at Hemington, south-west of Long Eaton (C. Salisbury, personal communication).

Conclusion

This brief account has re-affirmed earlier accounts of Brandon and Sumbler (1991) and Howard (1992) that the periglacial features of the Newark to Lincoln area have a complex history of formation suggesting several phases of permafrost development. The patterned ground described from aerial photographs represents the surface expression of ice wedge pseudomorphs which were probably developed during the Devensian Stage, most likely the Dimlington Stadial. It is to be hoped that future topsoil stripping of the area where the patterned ground is developed (e. g. during road construction) will allow the infills of the pseudomorphs to be studied.

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