REPORT

Periglacial features and ice wedge in Thornhaugh Quarry

In October 2000, Alan Dawn led a most interesting Society field excursion to three quarries beside the A47 road between Wansford and Duddington. These exposed the Lincolnshire Limestone Formation and the underlying Grantham Formation ("Lower Estuarine Series") of the Middle Jurassic, but as an added bonus, a variety of periglacial structures were well displayed at Thornhaugh Quarry. These structures most likely date from the Devensian (Oxygen Isotope Stage 2), when this part of England, although not covered by ice, suffered a periglacial climate for a prolonged period. However they could date from any cold period since the area was last glaciated in the Anglian stage (OIS 10).

Thornhaugh Quarry exposes the Lincolnshire Limestone, and the features of a periglacial active layer could be recognised in an abandoned face (Fig. 1). The limestone at the base of the face is not heavily weathered: it retains its massive nature, and although the surfaces have weathered brown, mainly due to insoluble residue washing down cracks, fallen blocks from the lower part of the massive unit retain blue-grey unweathered hearts. This massive limestone is overlain by weathered, thinly bedded limestone, which still retains its original bedding, and then by a bed of jumbled limestone blocks in a matrix of comminuted limestone and sand, up to about 1.5m thick. The base of this jumbled bed is channelled into the thinly bedded limestone below, in places coming to rest on the massive bed.

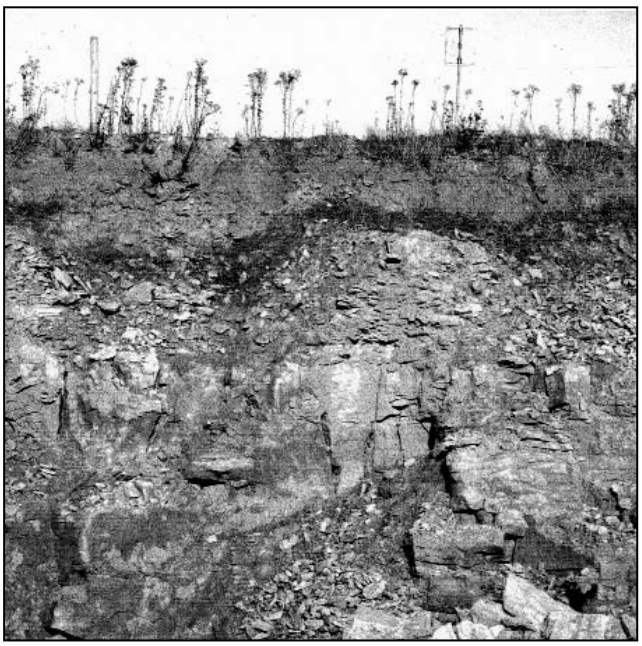

Figure 1. Cryoturbated top of the Lincolnshire Limestone in Thornhaugh Quarry.

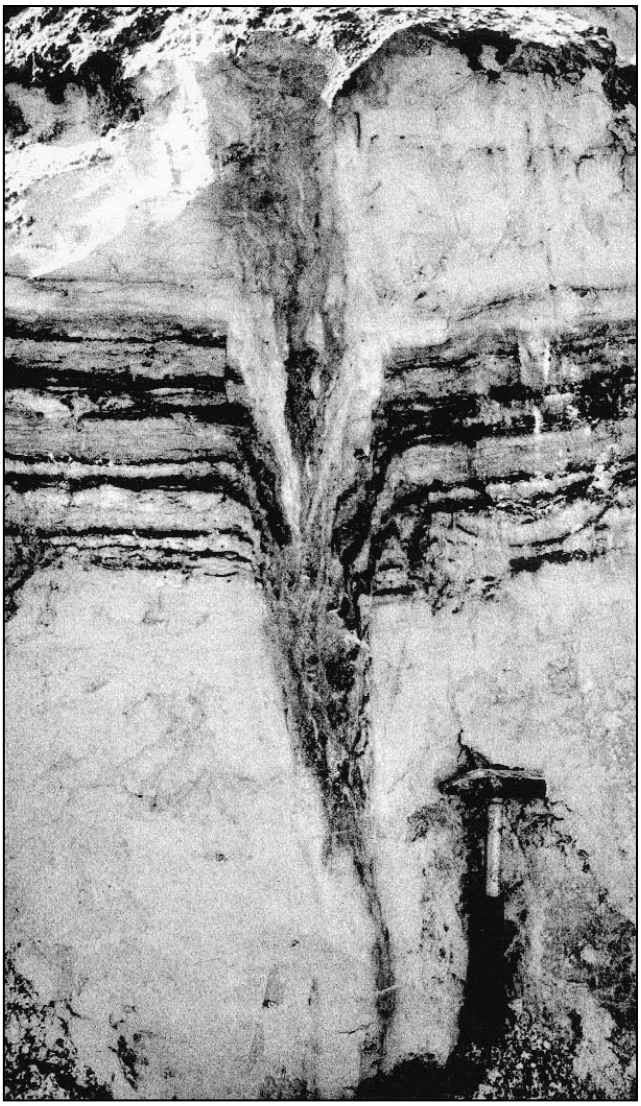

Figure 2. The ice-wedge cast in the sands of the Grantham Formation in Thornhaugh Quarry.

The jumbled bed is interpreted as the periglacial active layer. This is the layer in which groundwater freezes each winter and thaws each summer, on top of the permafrost layer which is beyond the influence of summer warming from above. These two layers are characteristic of periglacial conditions. The underlying bedded limestone remained permanently frozen, while the growth of ground ice within the upper part of the limestone split the massive rock into much thinner beds. The permafrost restricted downward drainage, and maintained a high water table in the overlying active layer during the period of summer melt. This encouraged mass movement, gelifluction, of the active layer, even on very shallow slopes. The surface layer is described as cryoturbated, because it owes its structure to the disturbance by cold processes.

Several apparent ice-wedge casts were observed within the unlithified sands of the Grantham Formation in the floor of the quarry, and the best exposed of these is shown in Figure 2. This structure

was preserved over a height of about 1.3m, but it was estimated by the leader that about 6 m of the overlying Lincolnshire Limestone would have been quarried away, so the wedge must have been at least 7 m deep originally. The width of the infilled wedge tapers downwards from about 15 cm to zero, and it is filled with vertically bedded coarse pebbly sand which was clearly not derived from the immediately adjacent Grantham Formation. The bedding in the latter is clearly delineated by black, carbonaceous horizons, which demonstrate both down-folding and small-scale normal faulting into the structure.

There has been controversy recently about the origin of apparent ice-wedges described from the British Quaternary, with Worsley (1996) arguing that many water-escape structures have been misinterpreted as ice-wedge casts, leading directly to misinterpretation of climatic history. However, Fish et al. (1998) report a feature at Trimingham, Norfolk which they interpret as a composite-wedge formed in a periglacial climate, reflecting fissuring due to thermal contraction and infilling with wind-blown sand and locally-derived surface material. The combination of both wind-blown and mass-moved material means that the fissure was both open (so that sand could be blown in) and filled with ground ice (so that material could collapse in when the ice melted). Thus a composite wedge indicates both aridity and moisture in a permafrost environment.

The structure at Thornhaugh closely resembles the one in Norfolk, with similar normal faulting and vertically bedded sand infill, although at Thornhaugh it was unclear if the infilling sand was blown in from a distance or derived from the overlying weathered Lincolnshire Limestone. There was no evidence of compressive upturning or thrusting associated with the growth of ground ice. The sequence of events started when a ground contraction crack formed by thermal contraction associated with the ground freezing at the onset of periglacial conditions. This crack then became infilled with allochthonous sand, and some snow, most likely wind-blown from the surrounding area. Finally the ice and snow thawed with climatic warming, causing normal faulting at the edges of the wedge as the host sediment settled.

Jim Rose is thanked for helpful comments during the writing of this note, which is published with the permission of the Director, British Geological Survey.

References

Fish, P.R., Carr, S.J., Rose, J., Hamblin, R.J.O. and Eissman, L., 1998. A periglacial composite-wedge cast from the Trimingham area, North Norfolk. *Bulletin of the Geological Society of Norfolk*, **44**, 11-16.

Worsley, P., 1996. On ice-wedge casts and soft sediment deformations. *Quaternary Newsletter*, **78**, 1-7.

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