

Willow Hall Farm, Peterborough

A Goepeterborough field meeting on 20 March 2015 was held at the Willow Hall Farm RIGS [TF 242013]. The area of gravel extraction lies within a River Nene 1st Terrace (Horton, 1989; Davey, 1991), which is considered to represent the Devensian Glacial Stage (MOIS 5d–2). Maddy (1999) assigned River Nene 1st Terrace deposits to the Ecton Formation.

A face aligned close to E–W exposes the sequence (Fig. 2). At the base there is about 1 m of laterally continuous, interstratified, organic muds and silts interbedded with sand and gravel. These overlie Jurassic Oxford Clay. Above there is about 1.5 m of laterally continuous, horizontally stratified beds of closed-framework, pebbly, clast-supported gravel with occasional thin silt drapes. At the eastern end (left), lenticular beds of trough cross-bedded gravel and sand up to about 70 cm thick have incised the horizontally stratified gravels. Above the lenticular beds in the east and above the horizontally stratified beds to the west, an irregular horizon of oxidized, diamictic sediments is present, but the upper part of the section was largely obscured. In places, horizontally stratified gravel with well-marked ferruginous horizons overlies the oxidized diamictic sediments. An exposed ice-wedge cast (left of the spade) penetrates the interstratified organic muds and silts with its top beneath the oxidized diamict, but the base of the cast was obscured. Three further ice-wedge casts were observed to the west, each with its top beneath the oxidized diamictic horizon.

The southern part of the face aligned N–S could be viewed only from a distance across temporarily ponded water (Fig. 3), so dimensions were only estimated. Here again lower, horizontally stratified gravels are overlain by channel-fill, trough cross-stratified and horizontally stratified gravels. The oxidized diamictic horizon is not

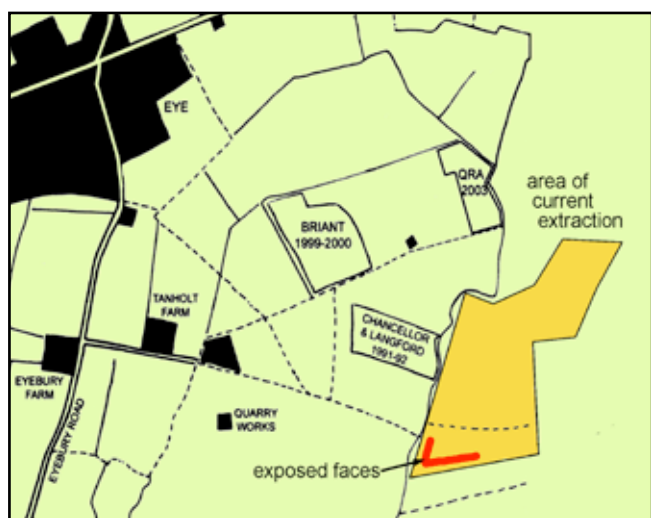


Figure 1. The location of currently exposed faces within the area of gravel extraction at Willow Hall Farm.

continuous; the material appears to infill one channel on the left and a depression on top of a wide, gravel-filled channel on the right. Above are horizontally stratified and shallow, channel-infill gravels, which to the north are overlain and cut out by larger scale channel-fill gravels in sets that aggrade laterally northward. At the top, below the soil horizon, there is an indurated (iron-cemented) structureless gravel with sand lenses, clumps of which have slipped and lodged down the face. About 40 m to the north this horizon starts to thin and by about 50 m north starts to appear as an iron-stained layer at the base of the soil horizon. Ice-wedge casts were observed at about 40, 60, 80, 90 and 100 m north, with casting at different levels: below the oxidized diamictic level (as in the E–W section), below the iron-stained layer, at the top of the sequence, and below a blackened gravel horizon. The blackened band of gravel with small sand lenses (secondary manganese and iron) occurs at about 75 m north and appears near the top of the sequence, with secondary carbonate lying between this and the iron-stained layer. Festoon structures occur at the base of the blackened gravel and in the gravels below.

A shallow, braided-stream depositional environment is indicated by the sedimentology of the gravels. Thin beds of horizontally stratified gravel probably represent accumulation by sheet floods during spring thaw events. Shallow channel cut-and-fill deposits formed by migrating dunes are also evident, either as part of the spring thaw events or as separate minor high-energy events. Locally deeper channel cut-and-fills indicate higher energy events, possibly the onset of spring thaw. Near the top of the sequence, northward migration of a major stream is indicated. It is not known whether the interstratified organic muds and silts at the base of the sequence were more widespread or were local bar-top and shallow-channel accumulations.

Permafrost features of the site

Up to three horizons of ice-wedge casting were observed, but it should be noted that the individual casts required more detailed examination for robust genetic interpretation (Worsley, 2014). The presence of ice-wedge casts indicates palaeo-permafrost. The casts appear to be epigenetic (formed post-depositionally beneath a locally stable active layer) rather than syngenetic (growing as the sediment accumulates), and were frost cracks rather than more complex forms of ice-wedge casts. The oxidized diamict and the blackened gravel horizons may represent development of an arctic soil and the position of the seasonally active layer under permafrost conditions. The two later levels of casting appear to occur after the major channel migration to the north.

Although muds and silts sampled from the base of the section are still to be examined, no visible shells have been observed to suggest they were interglacial deposits. In the area investigated by Chancellor and Langford (1992) a radiocarbon age of c.24 ka (Bateman, 1999) indicated



Figure 2. Eastern end of the E–W exposure at Willow Hall Farm; the spade is 90cm tall.

that the bulk of the gravel accumulation (up to 5 m thick) is Late Devensian, but slight contamination of the bone material submitted for dating raises uncertainty as to the reliability of this date. However, the radiocarbon date is coherent with the vertebrate biostratigraphy (Chancellor & Langford, 1992), which has an affinity with MOIS 3 mammal faunas when woolly rhinoceros, horses and humans first appeared in the Devensian (Currant & Jacobi, 2001; Langford *et al.*, 2014). In contrast, Briant *et al.* (2004a) consider that the bulk of gravel accumulation in a later extraction area was Early Devensian on the basis of optically stimulated luminescence (OSL) dating. This contrast in age of deposition over a short distance is also seen at Whittlesey (south of Willow Hall Farm), with aggradation that was Early Devensian at West Face Quarry (Langford *et al.*, 2007) but Middle–Late Devensian at Bradley Fen Quarry (Langford *et al.*, 2014).

Different horizons of ice-wedge casting are common at Tanholt Farm (Briant *et al.*, 2004a) and Podehole (Briant *et al.*, 2004b, 2005), east of Haynes Farm, and at other locations in the Cambridgeshire (West, 1993) and Lincolnshire Fens (Worsley, 2014). The better-developed levels represent periods of stability of millennia duration. Dating the different levels is not straightforward (Briant and Bateman, 2009). If organic material is present within the casts then radiocarbon dating can be used, but dates >30 ka may not be reliable. OSL dating can be used for older deposits, provided sand is available within the wedge infill. The OSL data (Briant *et al.*, 2004a, 2004b, 2005) indicates that at least the lower level of casting at Tanholt Farm and Podehole is Early Devensian in age.

Figure 3. South end of the N–S exposure at Willow Hall Farm, with the oxidized diamict arrowed; the lifebelt provides scale.



In central East Anglia four phases of patterned ground formation have been recognized: 60–55, 35–31, 22–20 and 12–11 thousand years ago (Bateman *et al.*, 2014). The earliest of three phases at Baston could relate to either of the older phases recognized in central East Anglia, with the later phases ascribed to the Last Glacial Maxim (LGM) and the Loch Lomond Stadial (Worsley, 2014). It therefore is possible that the two upper levels of casting observed at Willow Hall Farm also relate to the LGM and Loch Lomond Stadial. At a nearby site (Chancellor & Langford, 1992) an upper-level casting phase penetrated through the radiocarbon-dated gravel accumulation and, depending on the reliability of the dating, could indicate its LGM age.

In the King's Dyke, West Face and Bradley Fen quarries at Whittlesey different phases of cryogenic deformation are evident. Some of this deformation, including ice-wedge formation, is clearly MOIS 6 in age but the others are post-Ipswichian. In Bradley Fen Quarry a MOIS 3 channel truncates a wedge feature that possibly relates to the earliest phase recognized in central East Anglia. If the lower level of casting at Willow Hall Farm is coeval with the Bradley Fen event, then the organic muds and silts at the base of the sequence must be older than this and so clearly appear to be worthy of further investigation providing they are still available. Further monitoring and investigation at the site are merited.

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A Quaternary succession at Whittlesey

The recently discovered Bronze Age village at Must Farm, Whittlesey, has been dubbed 'Britain's Pompeii', but the sedimentary context of this archaeological treasure is also sufficiently unique to merit being regarded as the 'Pompeii' of the English Late Quaternary record. The complex, Late Quaternary, sedimentary succession at Whittlesey, near Peterborough, is exceptional because it preserves a relatively high-resolution, near-contiguous record back to at least Marine Oxygen Isotope Stage 8. Work on the sediments is ongoing, but the sequence has already been robustly dated using optically stimulated luminescence, amino acid racemization and radiocarbon techniques (see adjacent bibliography).

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