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LATE QUATERNARY FLOODING IN THE VALE OF PICKERING

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Introduction

Modern glacial geology in England has been attributed, by Kendall & Wroot (1924), to Henry Carvill Lewis in his text 'The Glacial Geology of Great Britain and Ireland' published in 1894. In this volume, Lewis (1894, Map II) proposed that, during an ice age, a great North Sea glacier blocked drainage exits of easterly flowing rivers along the east coast of England, such as the Humber, to impound extra-morainic lakes. It is now considered that the glacier referred to as the North Sea Lobe (NSL) of the British-Irish Ice Sheet (BIIS), reached its most southerly limit by 25.8 – 24.6 ka (Evans *et al.*, 2021). Marginal oscillations of the ice sheet forming ice-dammed lakes, including Lake Humber, are dated to 24.1 – 22.3 ka. This southerly surge of the glacier and its onshore encroachment are illustrated in Figure 1 (from Fairburn 2014). Retreat of the NSL is considered by Evans *et al.* (2021), to have occurred in stages with stands masked by six ice limits (Evans *et al.*, 2021, fig 6). The most significant retreats occurred between 19.7 and 17.3 ka (Evans *et al.*, 2021, fig 6) including a transition from glaciterrestial to glacimarine conditions (see also Clark *et al.*, 2021, p.112). Such a loss of ice from mainland Britain possibly allowed, for the first time, drainage through the Humber Gap by erosion of blocking till. The final retreat, from the North Sea into the Firth of Forth, occurred by 15.8 ka (Evans *et al.*, 2021).

Note the dates shown above have been adjusted by Beyesian statistical analysis while some of the luminescence ages, shown below, have been revised with the revised age shown in bold type (see Evans *et al.*, 2021, Table 1).

It is evident, from the above account, that there was climate cyclicity during the withdrawal of the NSL with the general retreat punctuated by stands preceded by modest advances. Such cyclicity has also been

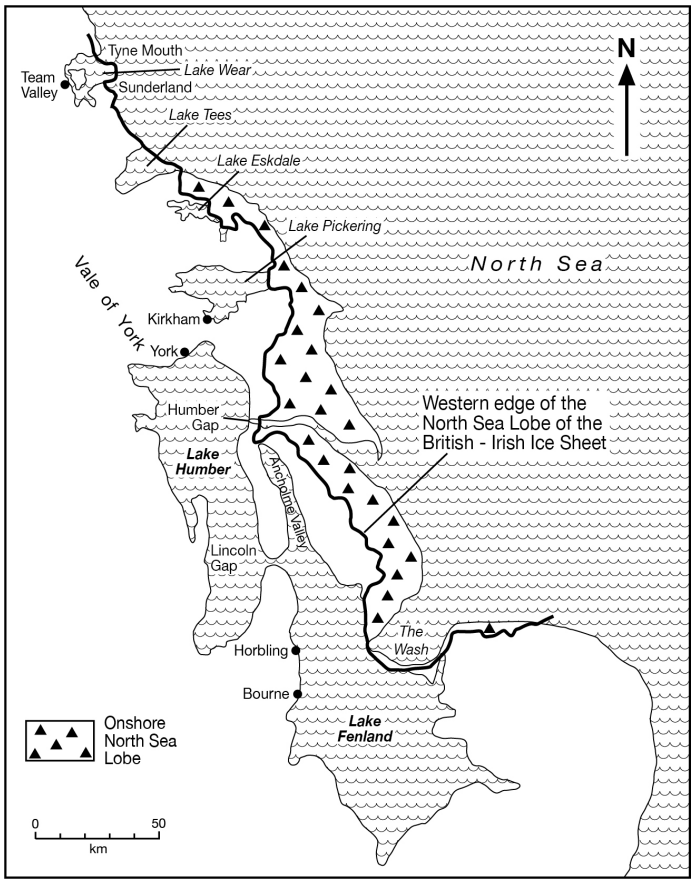


Figure 1. Plan of the east coast of England showing pro-glacial lakes impounded by the North Sea Lobe of the British and Irish Ice Sheet that extends to The Wash and north Norfolk.

noted during the draining of Lake Humber in the Vale of York (Fairburn, 2022). Here, lengthy stillstands of the lake were broken by depletions in the region of 5.0m. The nature of these depletions is not fully understood, but they were represented by metric-scale cross-bedding and coarse plastic sediments, probably deposited during catastrophic flooding episodes. (Fairburn, 2022, fig. 17).

The main objective of this article is to collate and correlate two major flooding events in the Vale of Pickering, possibly initiated by warming episodes,

that were associated with, or caused by, falling levels of the Glacial Lake Humber impounded by the North Sea ice during the Dimlington stadial. Observed reference sites include the Newton Dale outlet, an 8.0m section in the East Heslerton sand quarry and the Wykeham gravel pits. At all these sites the late Quaternary flooding was followed by a more passive lacustrine episode of sub-aerial fluvial deposition.

The Newton Dale outlet

The oldest of the flooding events here resulted from breaching the 40 and 45m O.D. terraces of the 45m lake during a fall in lake level down to perhaps 34m O.D. (Evans *et al.*, 2017; Fairburn, 2019; fig 2). This flood, which was a high-energy fluvial event, resulted in the formation of gravel beds or fanglomerates with local imbricate clast textures (Fairburn, 2019). The deposit, that may have been partly reworked into a littoral zone, contains both local and exotic lithologies with some faceted boulders.

The gravel beds were later incised and more distal parts overlain by a younger alluvial fan that extends from Newton Dale to the 30m O.D. terrace of the shrinking lake (Figure 2).

The final event at Newton Dale appears to be the fluvial emplacement of a minor, poorly defined, terrace of calcareous sand (Fig. 2). By comparison with likely equivalent aged sands at Wykeham Quarry, this mode of occurrence may not be correct.

Wykeham Gravel Pit

It is evident from the Scarborough 1:50 000 geological sheet (British Geological Survey, 1998) and Figure 3, that abundant sediments of possible glacial origin have been transported into the Vale of Pickering from Forge Valley via the River Derwent. Despite this, only one flooding event has been recognized, namely the Seamer Sand and gravel and the equivalent Hutton Buscel sand and gravel (Lincoln *et al.*, 2017, fig.47), that are probably bounded by the 30m O.D. strandline below a breach in the 40/45m O.D. shorelines (Figure 3). The critical lack of a recognizable 34 m O.D. shoreline (seen at Newton Dale and East Heslerton), plus some divergence of the sand a gravel sequences from the 30m O.D. strandline, can probably be attributed to the lack of recent mapping in the region since the mapping by Fox-Strangways in the 1880s (British Geological Survey, 1998).

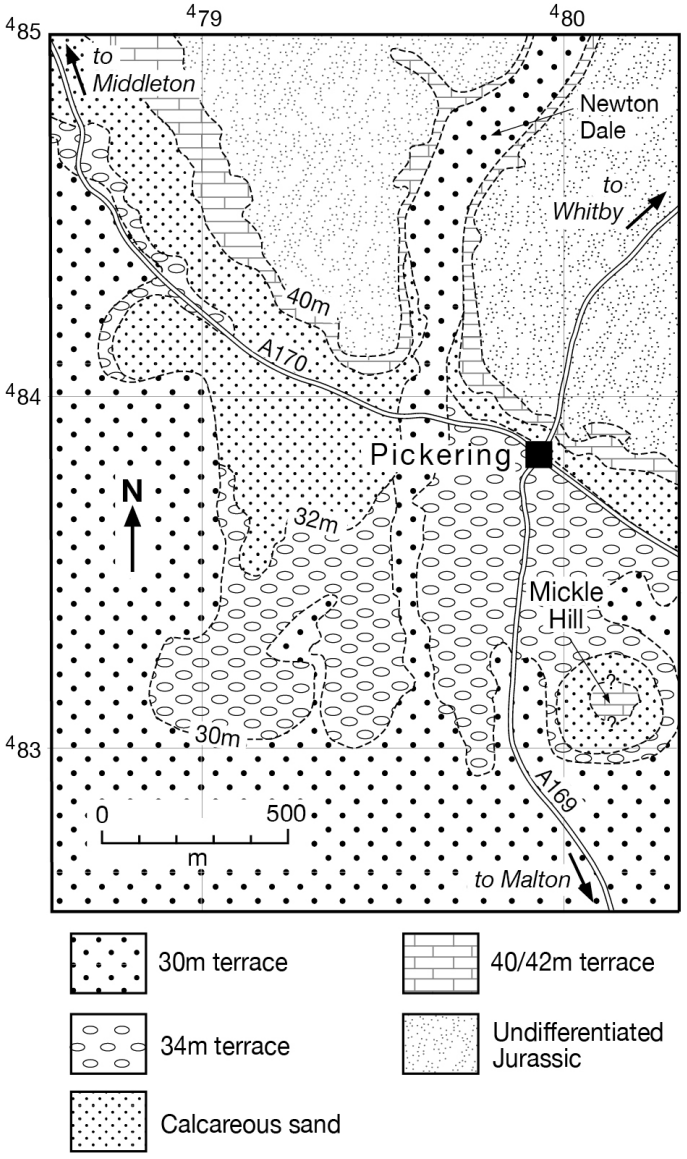
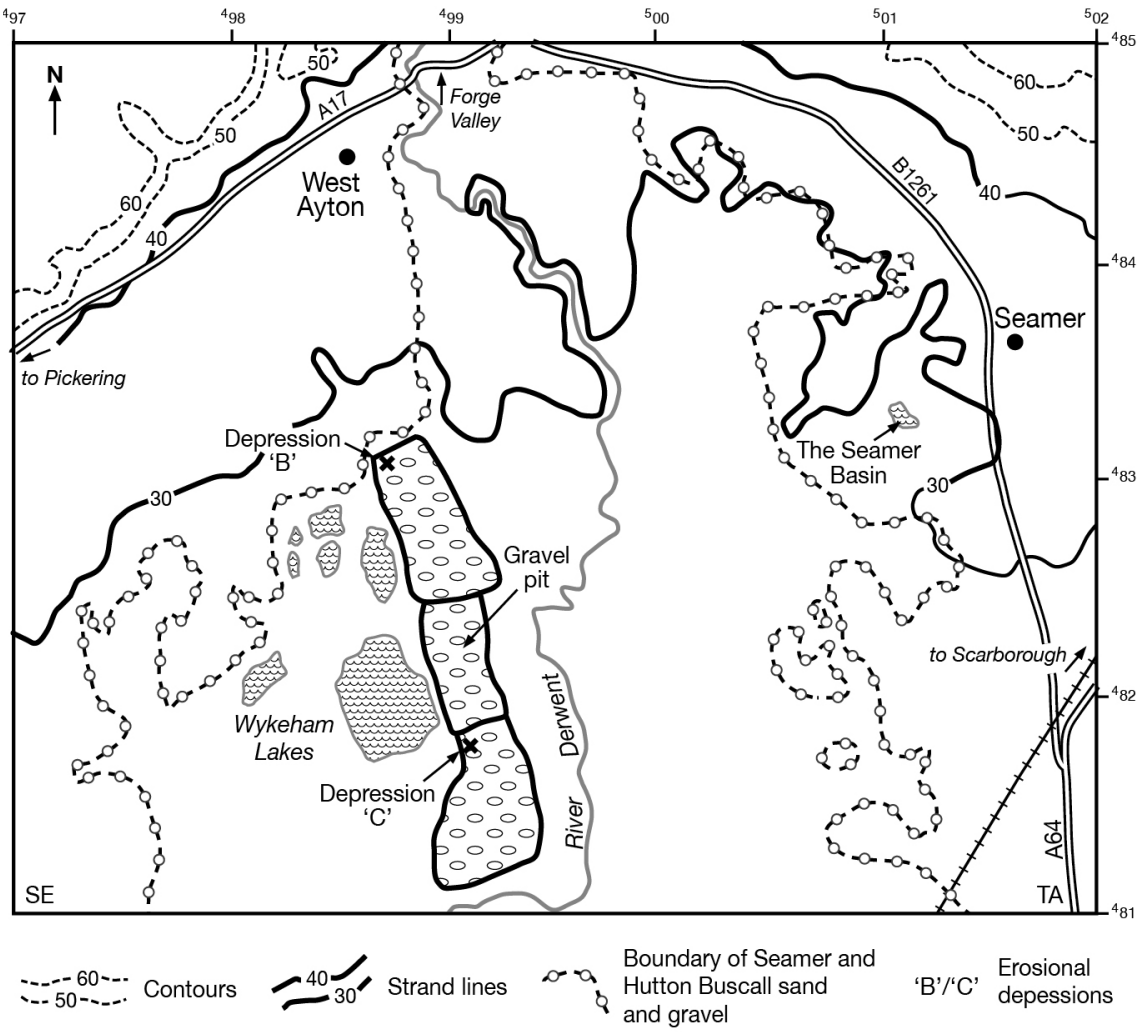


Figure 2. The Newton Dale outlet showing two flooding events forming the 34m and the 30m O.D. terraces. The emplacement of a poorly defined fluvial terrace of calcareous sand, between the 32m and 40m O.D., covers the proximal region of the 34m O.D. terrace.

In contrast to the regional mapping, a detailed account of the lithostratigraphy at the Wykeham Gravel Pit has been given by Lincoln *et al.*, 2017. These authors subdivided the quarry sequences into lithofacies units above basal lacustrine clays (Lincoln *et al.*, 2017, fig.43) that were not exposed at Newton Dale.

Boulder beds above the basal clays, which are likely of comparable age to the gravel beds at Newton Dale, contain both sub-rounded, sub-angular and faceted forms, some of which are striated. Derivation of the boulders, which are of both local and exotic lithologies, were probably derived by flooding from older MIS 6 gravel beds that had been quarried between Yedman Dale and Forge Valley (Fairburn,

Figure 3. Landform map in the region of the Wykeham Lakes and Seamer showing 1. The outline of the Wykeham gravel pit with depressions 'B' and 'C' (from Lincoln et al. 2017, fig. 48); 2. The boundary of Seamer and Hutton Buscel sand and gravel (from British Geological Survey, 1998, Permit Number CP23/028 BGS © UKRI. All Rights Reserved; 3. the 30m O.D. strandline; 4. Glacial Lake Pickering 40m O.D. lake level.



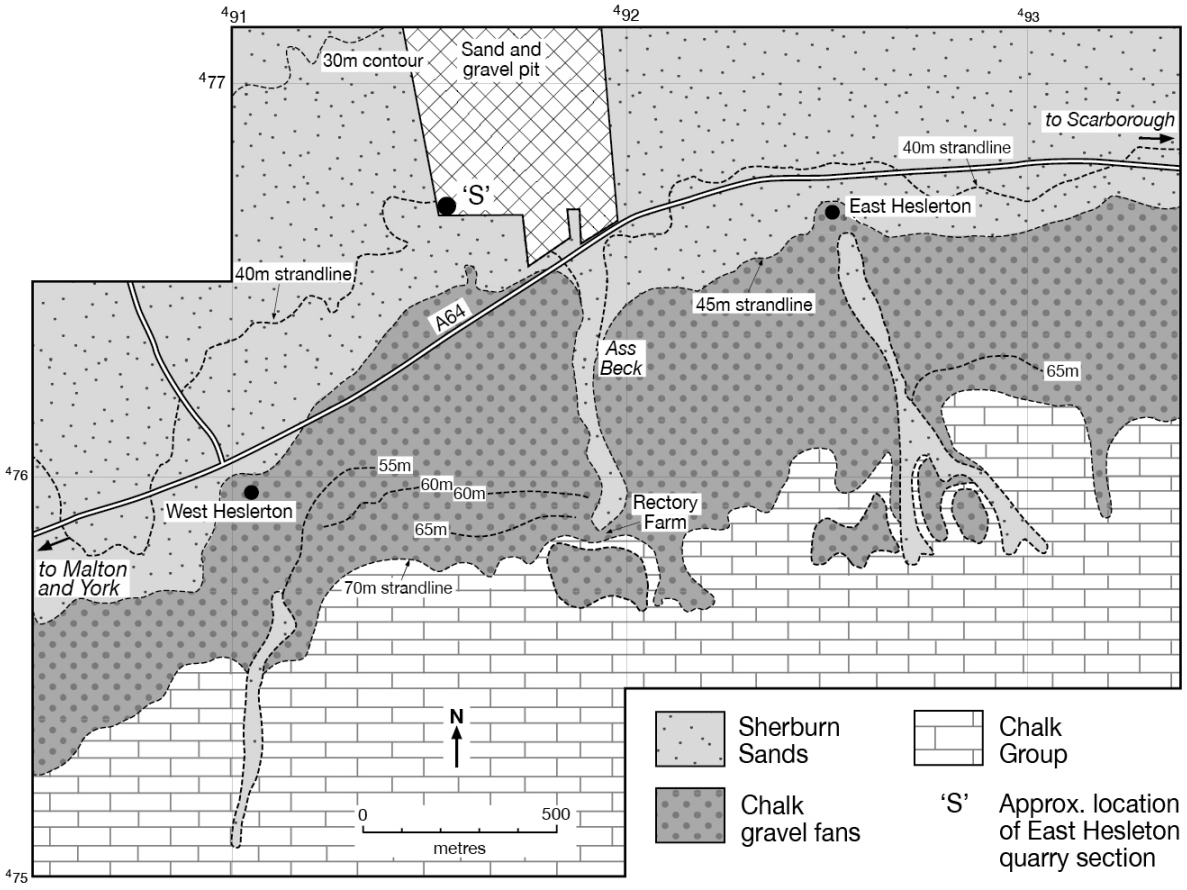


Figure 4. Geological map of the Vale of Pickering between east and West Heslerton, showing the 45m and 70m O.D. strandlines and Ass Beck draining into the East Heslerton sand pit. Note that the drainage channels south of East and West Heslerton are probably MIS 6 meltwater channels (modified from Fairburn, 2023).

2019, fig. 3). In the quarry, the gravels are everywhere overlain by a very variable sequence of fluvial sands and gravel (Lincoln *et al.*, 2017, Table 2) referred to in the quarry as 'overburden'. These deposits must have originated by flooding from Forge Valley via the River Derwent.

Later incision through the 'overburden' into the underlying gravels, produced steep-sided lacustrine basins or depressions up to 6.0m deep, that infilled with organic and carbonate-rich sediments (Lincoln *et al.*, 2017, figs 49 and 51, Table 3). Radiocarbon dating of the organic material (terrestrial plants), gave ages ranging from 15.24 ka B.P. to 10.8 ka B.P. (Lincoln *et al.*, 2017, Table 3). These organic-rich sediments must have originated by erosion of a vegetated land surface and are not related to flooding episodes in the River Derwent. In addition, the radiocarbon dating indicates these deposits are coeval with sediments deposited after 15.8 ka ± 0.9 ka in the East Heslerton section (see Evans *et al.*, 2017), that post-date fan deposition.

East Heslerton

The sand deposit in the East Heslerton quarry originated from the aggradation of a prograding alluvial fan with sediment supply originating from the Wolds via Ass Beck (Figure. 4): the beck cuts the 40 and 45m O.D. shorelines of Lake Pickering (Fig.4).

A detailed sedimentary log of an 8.0m section, in the sand pit, was described and dated by Evans *et al.*, (2017, fig. 6a). In this section a significant depositional change occurs at about 1.5m from the base of the section where lacustrine sediments give way to dominantly sub-aerial fan aggradation (i.e. above unit LF76 – see Evans *et al.*, 2017, fig. 6a). This transition, therefore, seems to record a fall in the lake level from 45m O.D., dated to 17.6 ± 1.0 ka **(18.4 ± 1.0 ka)** to *c.* 34m O.D. before 17.3 ± 1.0 ka **(18.4 ± 1.0 ka)**, Evans *et al.*, 2017, fig 6a, Table 1. A further important change recorded in the section is the cessation of fan formation at *c.* 15.8 ka due to a reduction in nival-sourced streams (Evans *et al.*, 2017).

Conclusions

Initial flooding of Glacial Lake Pickering to a level of 45m O.D., via the Derwent Valley, probably commenced after the final expansion of Lake Humber dated 17.7 ± 1.2 ka **(19.1 ± 1.1 ka)** by Bateman *et al.*, 2000. Subsequently, following deposition of lacustrine sediments at East Heslerton, dated to 17.6 ± 1.0 ka **(18.4 ± 1.0 ka)** by Evans *et al.*, 2017, two further flooding events occurred during drainage of the lake: one below the 45m terrace and the second below the 34m terrace.

The 45m flood that dropped the lake level to 34m O.D. is notably recorded by a change in sub-aerial deposition at East Heslerton (Evans *et al.*, 2017) and incision of the gravel beds at Newton Dale (Fig. 2). The event is probably represented in the Vale of York by the 33m O.D. terrace at Ferrybridge (Bateman *et al.*, 2008), by the planar washing surface at 33m O.D. on the York Moraine northwest of Siwards How (Fairburn and Bateman, 2016, fig.8), and many other locations.

The 34m flood lowered the level of Glacial Lake Pickering to a widespread 30m O.D. terrace mapped below Newton Dale, Howl Dale and Thornton-le-Dale (Fairburn, 2019, fig.5; Fig. 2). The age of the terrace must post-date the 33m O.D. terrace at Ferrybridge, i.e. 16.6 ± 1.2 ka **(19.0 ± 1.4 ka)** see Evans *et al.* (2021, Table 1) but must pre-date sand on the York Moraine, between 20 and 25m O.D. below Mill Mound, dated to 15.21 ± 0.68 ka (Fairburn and Bateman, 2016, Table 3).

It is now becoming evident that these two flooding events in the Vale of Pickering, coupled with catastrophic flooding at 15 and 20m O.D. in the vale of York (Fairburn, 2022) support the belief that drainage of Lake Humber was episodic, possibly due to cycles of upland warming.

Recommendation

There is a need to identify and map in the field the 34m and 30m O.D. shorelines of Glacial Lake Pickering between Seamer and Wykeham lakes.

Acknowledgements

Figures 2, 3 and 4 contain Ordnance Survey data © Crown Copyright and Database rights 2011. The author wishes to thank Paul Coles for his expertise in drafting the illustrations and Samantha Lyth for typing and collating the text.

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