Gransmoor

[TA 113 597]

Potential GCR site

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Introduction

Valuable information on the floral and faunal changes of the period post-dating the recession of the last (Dimlington Stadial) ice sheet in east Yorkshire occurs in a sand and gravel pit west of the village of Gransmoor. The exposure cuts one of a series of sand and gravel ridges and intervening depressions, or kettleholes (Figure 6.23). The rich flora and fauna have allowed reconstructions of palaeoenvironmental change during the Late-glacial Interstadial and Loch Lomond/Younger Dryas Stadial in Britain, and comparisons with the high-resolution ice-core records from Greenland (Walker *et al.,* 1993; Lowe *et al.,* 1995b, 1999; Mayle *et al.,* 1999).

Description

The sand and gravel pit lies at an altitude of 8 m OD and at a distance of 6 km from the North Sea coast. The sand and gravel ridges form part of a network of N–S-aligned features that have been interpreted as kames, eskers and marine storm beaches (e.g. Lamplugh, 1925; Catt and Penny, 1966; Eyles *et al.,* 1994), although a systematic investigation of their sedimentology and regional context is still awaited. The organic remains and associated sands, silts and clays are 235 cm thick and occur in a depression between sand and gravel ridges, where they overlie sands and silts with intermittent horizons of fine-grained gravel and coal fragments (Figure 6.24). The stratigraphical sequence has been subdivided into 16 lithostratigraphical units by Walker *et al.* (1993), but is summarized here using the fourfold scheme of Lowe *et al.* (1995b). First, laminated silts and sands occur from 240–200 cm; second, organic-rich beds occur between 200 and 150 cm; third, laminated silts and sands with occasional moss layers occur from 150 to 20 cm; and fourth, Holocene peats cap the section.

Chronological control on the depositional sequence is provided by 19 radiocarbon dates on plant macrofossils from specific stratigraphical horizons (Figure 6.24). The four oldest radiocarbon age determinations have been rejected by Lowe *et al.* (1995b) owing to the probable contamination by hard-water error. The remaining dates indicate an overall increase in age with depth, and statistical analysis by Lowe *et al.* (1995b) highlights a distinct change in sedimentation rate at 130 cm or at approximately 12 300 calendar years BP (Figure 6.25).

The remains of pollen and Coleoptera provide proxy data for reconstructing climatic trends over the period of deposition. A total of 304 different taxa of Coleoptera were identified in the sediments (Walker *et al.,* 1993). The species group has been determined for 214 of the Coleoptera, and 29 species possess present-day geographical distributions outside the British Isles. The pollen data for the stratigraphical sequence are summarized in (Figure 6.26) and (Table 6.3). The biostratigraphical boundary between the Late-glacial Interstadial and the Loch Lomond/Younger Dryas Stadial is placed at the point where: (a) *Betula* falls to very low levels; (b) Cyperaceae is expanding; (c) *Rurnex* and *Thalictrum* are increasing; and (d) there is a marked reduction in *Equisetum.* In addition, the continuous occurrence of pre-Quaternary palynomorphs (pollen) also begins at this point in the stratigraphy.

Of particular interest to the archaeology of the area is a barbed point that was recovered from between lithostratigraphical units 6 and 7 at 170 cm (Sheldrick *et al.,* 1997). Worked from part of an antler, the point was found embedded in a log that was deposited contemporaneously with its enclosing sediments.

Interpretation

The radiocarbon dates (Figure 6.24) indicate that the lower organic horizons span most of the Late-glacial Interstadial. The upper minerogenic sediments date from the Loch Lomond/Younger Dryas Stadial (11 000–10 000 years BP). Therefore, the sedimentary succession records deposition of laminated sands, silts and clays in a depression lying between glaciofluvial ridges after the recession of the Dimlington Stadial ice sheet from east Yorkshire.

Palaeoclimatic and palaeoenvironmental reconstructions have been produced for the sequence based upon a combination of pollen and coleopteran evidence. Specifically, the July temperature curve (Figure 6.24) is based on the Mutual Climatic Ranges (MCR) of individual Coleoptera. This method first establishes the range of climates occupied at the present day by the species in the fossil assemblage. The area of overlap of the climatic ranges of all the species present is then taken to reflect the climate of the whole (indicator) assemblage.

The main features of the pollen record represented in (Figure 6.26) have been summarized by Walker *et al.* (1993) as follows.

1 A *prejuniperus* phase is marked by the dominance of Cyperaceae and Gramineae, with significant amounts of *Artemisia, Rumex, Thalictrum* and *Helianthemum,* and relatively abundant *Salix.* This phase therefore represents a period of open steppe or grassland vegetation, which developed on the freshly deposited glaciogenic sediments of the area.

2. A *Juniperus* phase (222–208 cm), wherein the *Juniperus* pollen exceeds 15% of the total land pollen (TLP), Gramineae and Cyperaceae remain high, there are peaks in *Artemisia* and *Thalictrum,* and *Betula* accounts for 10–15% of TLP. This is characteristic of an open landscape with few trees and abundant shrub juniper. The expansion of *Juniperus* is thought to reflect significant climatic amelioration, with warmer winters and summers.

3. A *Betula* phase, marked by a decline in *Juniperus* and an increase in *Betula* to values exceeding 50% of TLP. In addition, high counts occur for *Salix* and *Filipendula,* and *Artemisia, Thalictrum* and *Helianthemum* levels drop. A distinctive feature of this phase is an oscillation in the *Betula* curve characterized by a fall and rise in the genus following its initial abrupt rise. The fall is accompanied by rises in Gramineae and Cyperaceae and the open-ground taxa *Rumex, Thalictrum, Helianthemum* and *Artemisia,* leading Walker *et al.* (1993) to suggest a reduction in the woodland cover and an increase in open grassland habitats. A similar pattern in vegetational changes_ has been documented at other sites in the region, for example, at Tadcaster (Bartley, 1962), Thorpe Bulmer and Kildale Hall (Bartley *et al.,* 1976; Jones, 1977a).

4. The Loch Lomond/Younger Dryas Stadial, reflected in the dominance of Cyperaceae, Gramineae and *Betula* and high counts of *Pinus.* In addition, *Salix* and *Juniperus* are less abundant compared to the preceding interstadial (phases 1–3). The herbaceous taxa (Caryophyllaceae, *Artemisia, Rumex, Thalictrum, Helianthemum* and *Ranunculus*) are typical of poorly developed and/or disturbed soils in arctic and alpine environments, leading Walker *et al.* (1993) to suggest an open steppe or steppe-tundra environment with discontinuous permafrost.

(Table 6.3) Stratigraphy at Gransmoor (after Walker *et al.,* 1993)

Lithological unit	**Depth (cm)**	**Description**
16	0–17/23	Fibrous peat; boundary is sharp but irregular, suggesting a possible hiatus. Blocks of reworked Late-Glacial clay occur within the Holocene peats.
15	17/23–37	Clay with sand laminae; laterally and vertically variable.
14	37–41	Angular and rounded chalk fragments.
13	41–88	Grey plastic day; clearly defined sand laminations at 49,74,82 and 89 cm.

12	90–112	Clay unit with abundant sandy laminations, varying from a few millimetres to 1 cm in thickness. Each lamination continuous and of uniform thickness.
11	112–115	Grey plastic day with small (<1 cm) pellets of chalk; latter appear flattened m the horizontal plane.
10	115–120	Silt/clay; black 'felted' peat layer at 120 cm
9	120–146	Laminated silt/clay with intercalations of 'felted' peat/plant debris.
8	146–147	Plastic grey clay.
7	147–172	Organic mud, but with clearly defined mineral/organic laminations in upper levels. Organic component variable, but maximum organic carbon values (~30%) towards the base of the unit. Bands of compressed plant debris occur in these lower levels.
6	172–187	Grey/brown silt/clay. Slightly organic (10% or less) throughout, but clearly defined clay-rich sub-unit from 174–178 cm; fibrous root material abundant.
5	187–203	Clay gyttja; organic content exceeds 20%, with maximum values (33%) near base of unit.
4	203–207	Transitional unit with intercalations of organic mud and grey silt/clay.
3	207–223	Clay marl with intermittent small (<2 cm) pellets of chalk; slightly organic (<10%) throughout.
2	223–235	Sand and clay laminae (up to 1 cm in thickness); some fine rootlet casts in the upper part.
1	Below 235	Sands and silts with intermittent horizons rich in gravel-sized particles of coal and occasional discrete lenses of slightly organic silt.

The large variety of coleopteran species allows for detailed reconstructions of changing local environmental conditions in the infilling and subsiding hollow at Gransmoor during the Late-glacial Interstadial and Loch Lomond/ Younger Dryas Stadial. Details are available in Walker *et al.* (1993) but only general trends are reviewed here. Because no pollen is available in the basal sands (below 240 cm) and the 'pre-polleniferous' sequence (225–240 cm), the Coleoptera provide invaluable palaeoenvironmental proxy data for these early Late-glacial Interstadial sediments. Specifically, the Carabidae (predatory or scavenging ground beetles) suggest a local environment dominated by sparse vegetation developing on sandy, sterile soils. This reconstruction appears to be supported by the occurrence of certain other species of Coleoptera.

With the exception of some parts of the basal sands and the sediments between 235 and 240 cm, aquatic Coleoptera are represented throughout the stratigraphical succession. However, the climatic deterioration that marks the beginning of the Loch Lomond Stadial is characterized by the complete absence of aquatic beetles between 160 and 170 cm. This suggests that little or no water occupied the hollow during that period of deposition, although the occurrence of abundant Helodidae indicates wet marshy conditions throughout the stadial. Moreover, the occurrence of dytiscids and hydrophilids in the organic, polleniferous part of the sequence record the existence of well-vegetated ponds throughout much of the interstadial and the succeeding stadial.

When viewed as a complete assemblage, the Coleoptera provide information on the changes in palaeotemperature that occurred during the accumulation of the sediments and organics in the Gransmoor depression. Walker *et al.* (1993) have identified 'climatically significant species' and grouped them as either cold-adapted or warmth-adapted species (Table 6.4), the former now living north of the boreal coniferous forest boundary and the latter now living south of the northern limit of oak forests. The reconstruction of the Mutual Climatic Range (MCR) for the stratigraphical succession is compared with the *Betula* and *Juniperus* pollen curves in (Figure 6.27). The MCR highlights the abrupt thermal improvement at the beginning of the Late-glacial Interstadial when temperatures peaked at 18–23°C (summer) and –4–9°C (winter). These can be compared with present-day values of 16°C and 4°C respectively for east Yorkshire.

(Table 6.4) List of climatically significant Coleoptera species from the Gransmoor stratigraphy (from Walker *et al.,* 1993).

Cold-adapted species	**Warmth-adapted species**
Nebria nivalis	*Bembidion grisvardi
*Diacheila arctica	Bembidion humerale
*Diacheila polita	Bembidion quadripustulatus
Elaphrus lapponicus	Bembidion octomaculatum
*Bembidion fellmanni	Pterostichus mater
*Bembidion mckinleyi	*Cymindis angularis
*Agonum consimile	Ochthebius pedicularis
Amara alpina	*Entomoscelis adonidis
*Pycnoglypta lurida	
*Olophrum boreale	
*Acidota guadrata	
*Boreaphilus henningianus	
*Boreaphilus nordenskioeldi	
Oreodytes alpinus	
*Colymbetes dolabratus	
Dysticus lapponicus	
Gyrinus opacus	
*Helophorus sibiricus	
*Helophorus glacialis	
*Helophorus obscurellus	
*Simplocaria metallica	
*Hippodamia arctica	

The Late-glacial Interstadial–Loch Lomond Stadial boundary is marked by a 6°C decline in mean July temperatures and a more pronounced drop in winter temperatures, falling as low as –20°C during the stadial.

Comparisons between the palynological and coleopteran data sets have led to the identification of discordant biostratigraphical signals during the early part of the Late-glacial Interstadial (Walker *et al.,* 1993). Specifically, the biological–climatic disequilibrium previously recognized for the start of the Late-glacial Interstadial (Coope *et al.,* 1971) is emphasized in the Gransmoor data. It is manifest, first, in the occurrence of the thermal maximum, as indicated by the Coleoptera and dated at 13 000 years BP (Coope and Brophy, 1972; Coope, 1977), which occurs prior to the accumulation of polleniferous sediments and, second, by a subsequent fall in July temperatures by as much as 4°C before the first shrubs had firmly established themselves in the area. Moreover, the *Juniperus* curve shows that juniper began expanding in the area only after the climatic optimum of the interstadial had passed, a similar trend to other sites, where the episode of *Juniperus* development is dated at 12 500–12 400 years BP (Walker and Harkness, 1990) or later (Cwynar and Watts, 1989). Because juniper expansion often is regarded as the earliest botanical response to climatic amelioration, it can be used to demonstrate that a several hundred year time-lag in botanical response to climate change occurred at the beginning of the Late-glacial Interstadial.

The high quality of the palynological and coleopteran data at Gransmoor have allowed Lowe *et al.* (1999) to propose an event stratigraphy for the last glacial–interglacial transition based partly upon the site. An event stratigraphy involves the identification and correlation of short-lived geological events that have left some trace in the rock or sediment record. The palaeoecological record at Gransmoor has been compared with the palaeoclimatic data recovered from the Greenland ice cores by Lowe *et al.* (1995b) for GISP 2 (Figure 6.28) and Mayle *et al.* (1999) for GRIP Comparisons with the snow accumulation record in the GISP 2 core provide a very close match, six points of the palaeotemperature curve being highlighted by Lowe *et al.* (1995b; A–F on (Figure 6.28)). These points demarcate: (A) a thermal maximum (at 14 700 calendar years BP) occurring within 100 years of the period of maximum snow accumulation in Greenland; (A–B) a rapid decline in both temperatures at Gransmoor (4–5°C) and snow accumulation in Greenland from 14 700 to 14 000 calendar years BP; (C) a slight rise in Gransmoor temperature and snow accumulation in Greenland at 13 700–13 600 calendar years BP; (D, E) a fall and subsequent recovery, respectively, of Gransmoor temperatures towards the end of the Late-glacial Interstadial (from 13 500 to 13 000 calendar years BP), which was paralleled by a decrease and subsequent increase in snow accumulation in Greenland; (F) a rapid decline in Gransmoor temperature values (5°C) and Greenland snow accumulation at the beginning of the Loch Lomond/Younger Dryas Stadial at 12 900 calendar years BP The apparent synchroneity between climatic changes over Greenland and Britain supports suggestions, for example by Kapsner *et al.* (1995), that major warming trends in the North Atlantic region were characterized by northward storm-track displacement over Greenland.

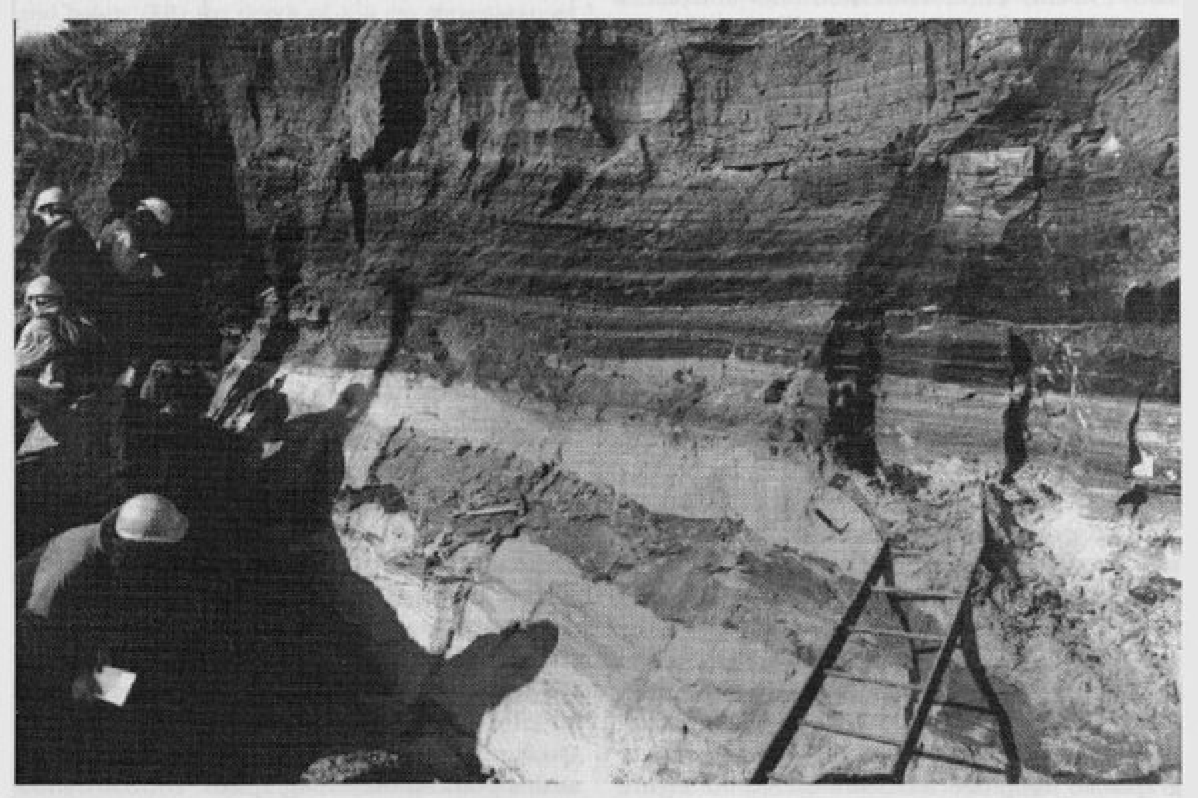
The Gransmoor palaeotemperature record has been used along with similar records from three other key sites in Britain in a comparison with the 18O signal from the GRIP ice core (e.g. Johnsen *et al.,* 1992) for the period covering the last glacial to Holocene transition (Mayle *et al.,* 1999). The British sites record some clear climatic signals that can be correlated with the GRIP 18O fluctuations. Specifically the Loch Lomond/Younger Dryas Stadial and Late-glacial Interstadial signals, referred to respectively as the 'Greenland Stadial 1' (GS-1) and 'Greenland Interstadial 1' (GI-1) by Bjorck *et al.* (1998). See the Introduction of this chapter, for discussion of GRIP event terminology.

The excellent chronological control on the stratigraphy at Gransmoor provides an age for the barbed point recovered from between lithostratigraphical units 6 and 7; the artefact itself was not directly dated because of its archaeological value (Sheldrick *et al.,* 1997). Three lines of evidence are used by Sheldrick *et al.* (1997) to suggest that the barbed point dates to the period 11 500–11 000 years BP or the Upper Palaeolithic: (1) it occurs in the upper part of the birch-dominated pollen zone of the late part of the Late-glacial Interstadial (11 500–11 000 years BP; Bourke, 1993; Walker *et al.,* 1993); (2) the log containing the barbed point has been radiocarbon dated to 11 475 ± 50 years BP (SRR 4920; Lowe *et al.,* 1995b), providing a maximum age for the artefact; (3) the age–depth plot on the 15 radiocarbon dates on terrestrial plant remains from the stratigraphical succession (Lowe *et al.,* 1995b) provide an age estimate of approximately 11 100 years BP for the sediment draping the log.

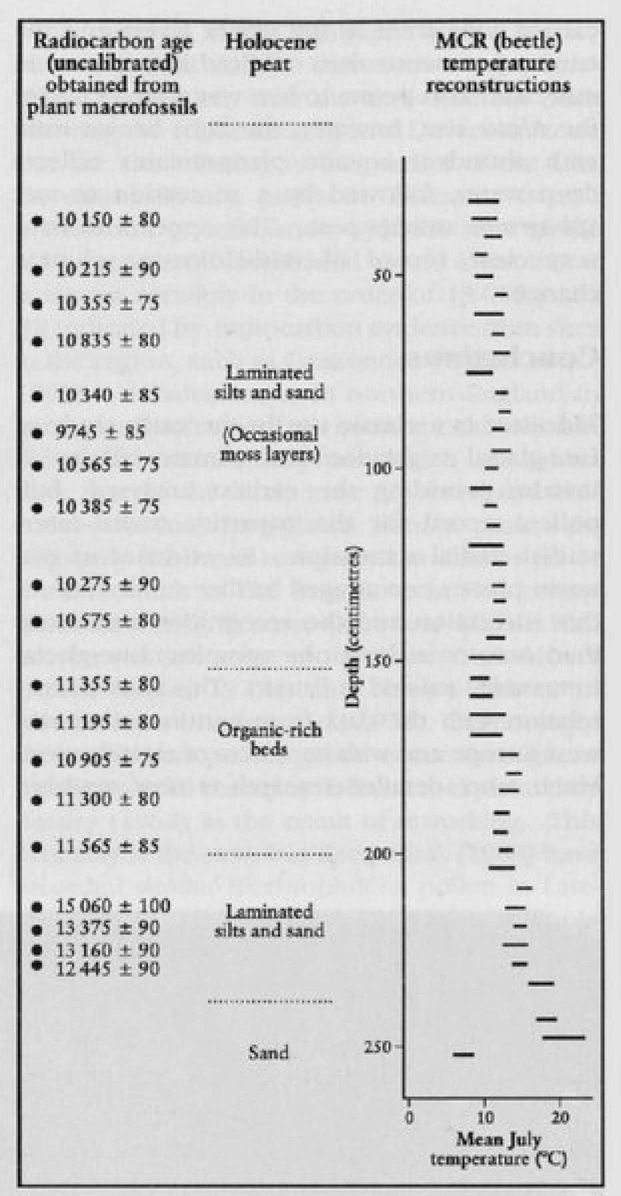
Conclusions

Palaeoecological proxy data such as that represented by the Gransmoor stratigraphical succession allow for reconstructions of localized terrestrial floral and faunal responses to regional climate changes at the close of the last glaciation and the beginning of the Late-glacial Interstadial. Gransmoor is a particularly important site in this respect in that it has yielded pollen and Coleoptera from the same stratigraphical context. This allows for a close comparison of the two proxy data sources, focusing particularly on the discordant biostratigraphical signals associated with the use of multiple proxy data sources. Together with other critical palaeoenvironmental records at sites such as Glanllynnau and Llanilid in Wales, and Borrobol and Whitrig Bog in Scotland, the Gransmoor biostratigraphy is a significant component in the recently reconstructed last glacial to Holocene event stratigraphy for the British Isles.

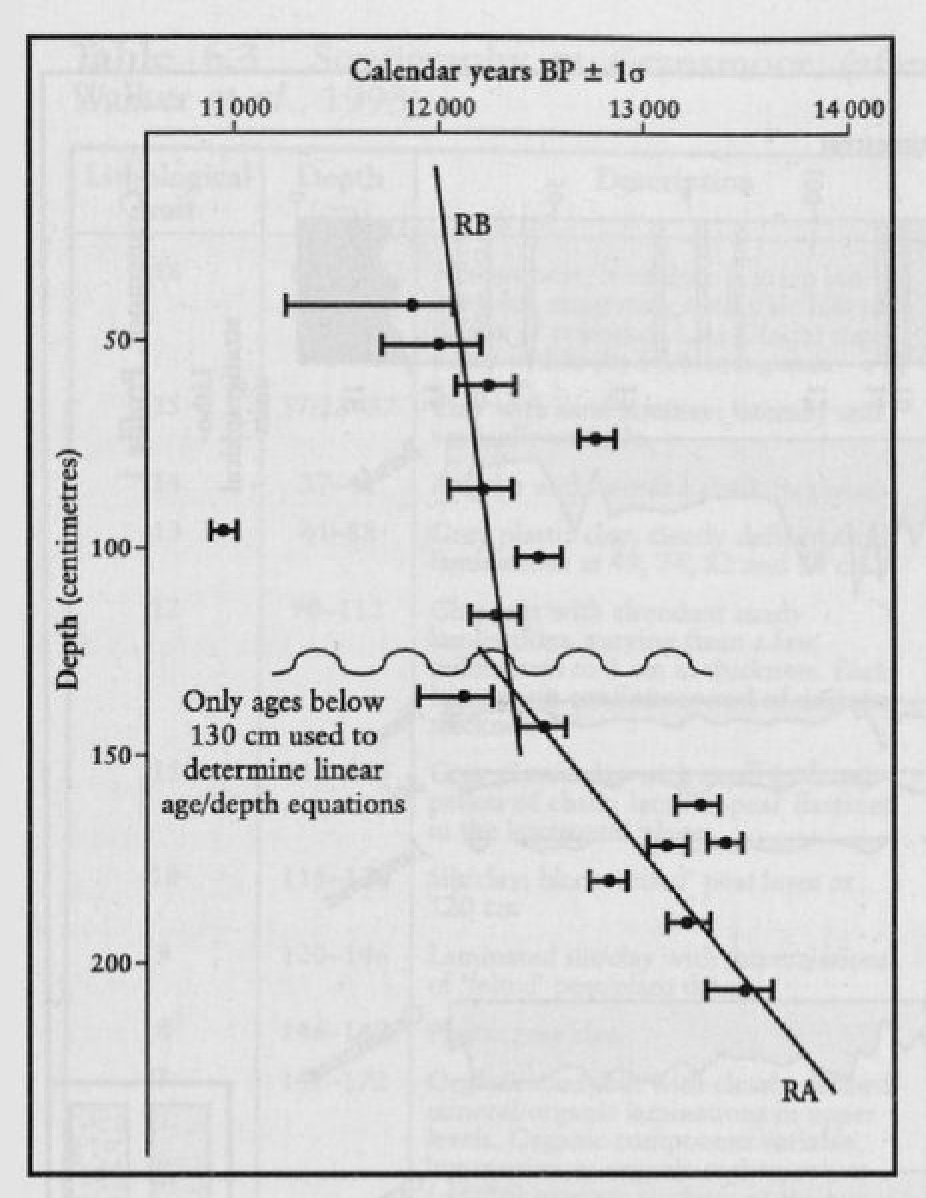
References



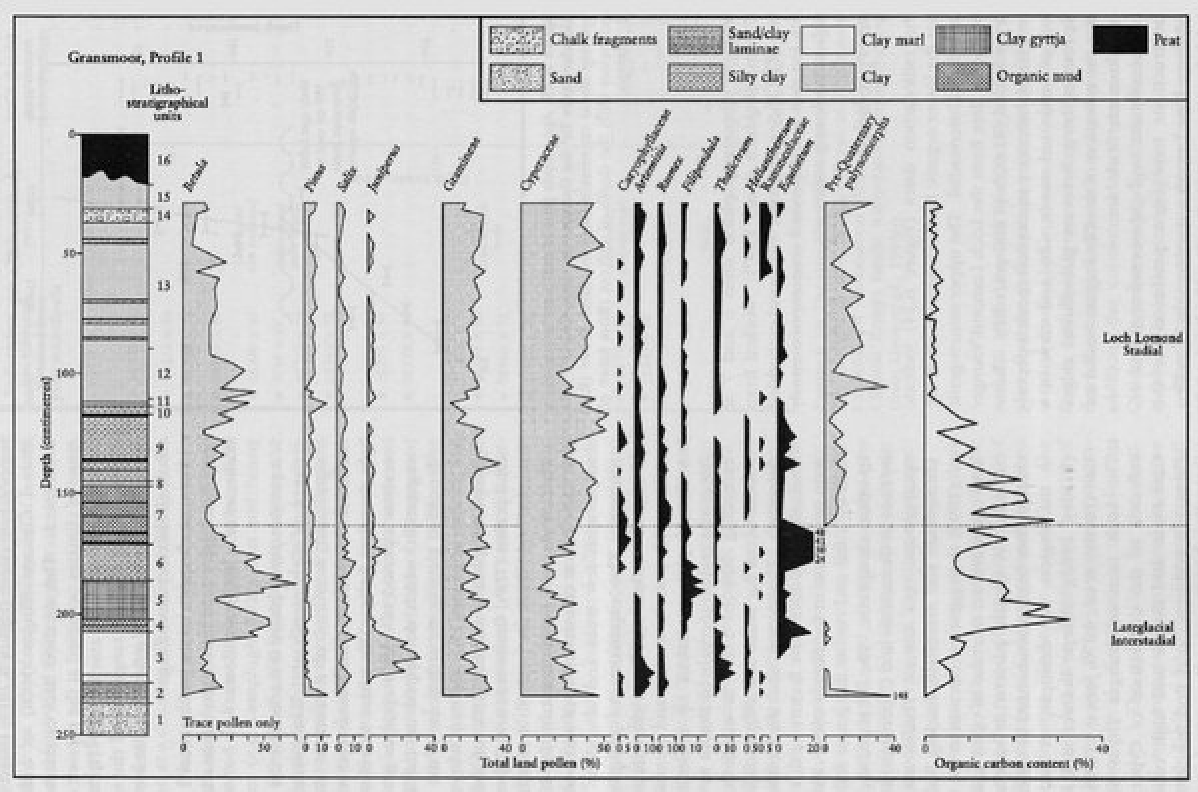
(Figure 6.23) The stratigraphical succession at Gransmoor showing the vertical grading from minerogenic to organic-rich to minerogenic sediments. (Photo: D.J.A. Evans).



(Figure 6.24) The stratigraphical succession relating to the Late-glacial and Younger Dryas at Gransmoor. Uncalibrated radiocarbon dates and MCR (Mutual Climatic Range) beetle temperature reconstructions (from Lowe et al., 1995b).



(Figure 6.25) Age–depth plot of radiocarbon dates in calendar years BP for Gransmoor, including the two separate linear regression lines for dates above (RA) and below (RB) the depth of 130 cm (from Lowe et al., 1995b).



(Figure 6.26) The percentage pollen diagram for Gransmoor. The numbers 1–16 for the lithostratigraphical units are those used by Walker et al. (1993), wherein more detailed sedimentological and stratigraphical details are available. After Walker et al. (1993).

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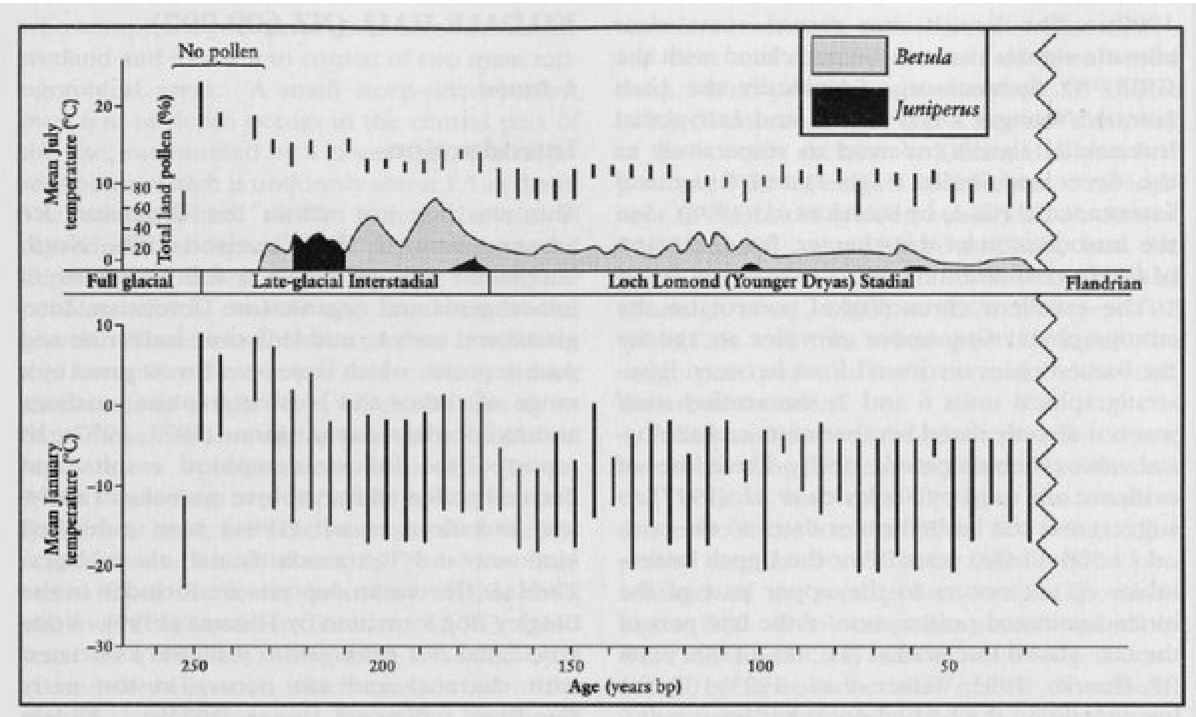
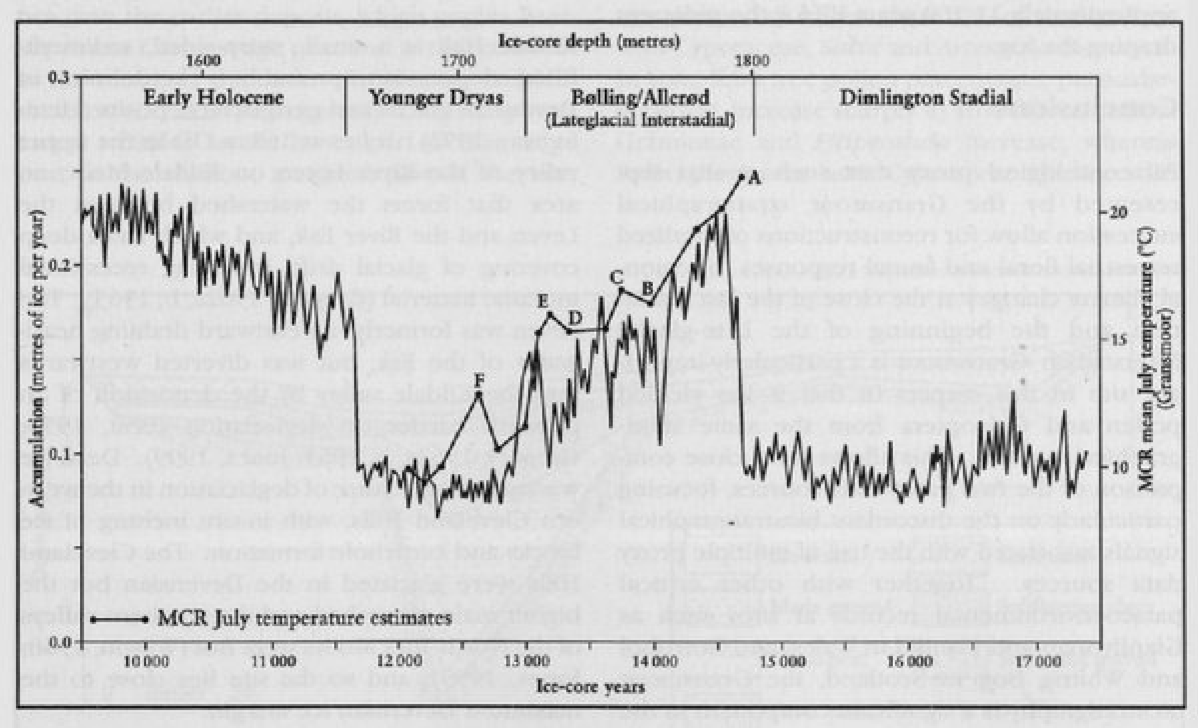


(Figure 6.27) The Mutual Climatic Range (MCR) reconstruction based upon Coleoptera from the Gransmoor stratigraphical succession. Pollen curves for Betula and Juniperus also are reproduced (from Walker et al., 1993).



(Figure 6.28) Comparisons of ice accumulation data from the GISP 2 ice core and the palaeotemperature data from Gransmoor (from Lowe et al., 1995b).