Llyn Gwernan

Highlights

A key site where new radiocarbon dating techniques have been used to calibrate the Devensian late-glacial and Holocene rock record. Such dating allows accurate dates to be given for the onset of the last, Younger Dryas, glaciation in the Cadair Idris area, as well as for the wastage of this ice and the commencement of the Holocene.

Introduction

Llyn Gwernan contains an exceptional thickness of Devensian late-glacial deposits. Their biostratigraphy and radiocarbon dating have allowed greater resolution of Devensian late-glacial environmental change than at other sites in Wales (Lowe 1981; Lowe *et al.* 1988). A preliminary investigation of the Holocene pollen biostratigraphy was undertaken by Laing (1980).

Description

Llyn Gwernan [SH 703 159] is a small freshwater lake on the northern flank of Cadair Idris. It occupies a steep-sided valley at *c.* 170m OD. Sediments, which include about 3.5m of Devensian late-glacial, and about 10m of Holocene deposits, have accumulated on the western edge of the lake, where a gradual succession of plant communities has raised the bog to a level higher than the adjacent lake. The following generalised late-glacial and early Holocene succession occurs (Lowe 1981; Lowe *et al.* 1988):

4 Organic lake mud (0.75m)

3 Clay and silt with occasional stones (0.30m)

2 Organic lake mud (1.35m)

1 Clay and silt with some sand lenses and iron-rich (goethite) layers (>1.95m)

Organic material from comparable horizons was bulked from separate cores, and subjected to radiocarbon analyses. Eight dates were initially obtained (Lowe 1981) and are shown in relationship to lithology and a summary pollen diagram in (Figure 24). Lowe et *al.* (1988) obtained accelerator mass spectrometry measurements of radiocarbon activity for comparison with the earlier radiometric dates — see (Figure 24). The original samples for dating were bulked to minimise standard deviations from the assays (Lowe 1981).

Interpretation

From detailed pollen and radiocarbon analyses, Lowe (1981) reconstructed a sequence of Devensian late-glacial and early Holocene events. Organic sedimentation in the basin began at c. 13,200 ± 120 BP (SRR-1705). The clay and silt (bed 1) contain pollen that suggests a generally open-grassland landscape prior to c. 13,200 BP. This date is thought to provide a minimum age for Late Devensian ice wastage at the site.

The rise of *Juniperus* (bed 2) is the first clear evidence at Llyn Gwernan of thermal improvement, and is dated to 12,970 ± 130 BP (SRR-1704). A date of 12,120 ± 130 BP (SRR-1703) from higher in bed 2 is believed to mark the beginning of climatic deterioration which eventually culminated in the Younger Dryas, about a thousand years later (Lowe 1981). At Llyn Gwernan, the onset of the Younger Dryas is marked by an abrupt lithological change from organic lake muds (bed 2) to clay-rich clastic sediments (bed 3). A radiocarbon date of 11,160 ± 90 BP (SRR-1701) from organic material at the top of bed 2 provides a maximum age for clastic sediments of bed 3 (Lowe 1981). The sharp lithological change is reflected in the differing pollen content of the two beds: the tree, shrub and thermophilous pollen found in bed 2, is replaced by an

assemblage in bed 3 indicating open-habitats with herbs, notably Cyperaceae, *Rumex* and *Artemisia,* showing cooler, less favourable conditions (Lowe 1981). Radiocarbon dates of 10,040 ± 80 BP (SRR-1700) and 10,020 ± 130 BP (SRR-1702) mark the end of the Younger Dryas and the beginning of organic sedimentation (bed 4) in the Holocene. The expansion of *Corylus* during the Holocene was dated to 9,070 ± 70 BP (SRR-1698).

Lowe *et al.* (1988) examined the potential of accelerator mass spectrometry for assessing the reliability of radiocarbon dates obtained from Devensian late-glacial sediments: the thick late-glacial sequence at Llyn Gwernan was considered to provide suitable test material for such a study.

A core was taken close to that in Lowe's (1981) study. Pollen analyses were made (Lowe et *al.* 1988) in order to provide biostratigraphical correlation with the original diagram, and to provide a basis for comparing the cores and radiocarbon dates obtained from samples in them. The pollen analytical results compare well with those reported by Lowe (1981), and are shown in summary form in (Figure 24). The overall pollen biostratigraphical sequence and the successive maxima and minima of *Betula, Juniperus, Rumex, Artemisia* and *Filipendula* match almost exactly, and make comparison of the accelerator and radiometric dates straightforward (Lowe *et al.* 1988).

An advantage of accelerator measurements is that residual radiocarbon can be determined from minute amounts of sample carbon, enabling various components of sedimentary organic matter, such as lipids, amino acids and humic acids to be assessed individually (Lowe *et al.* 1988). In theory, this aids the identification of contaminants such as older and younger compounds which may have been incorporated into the sediments through, for example, recycling of sediments, infiltration or sampling contamination.

Lowe *et al.* presented accelerator mass spectrometry data for four horizons which coincided with clearly defined lithostratigraphic boundaries. Three samples correspond directly with material dated by Lowe (1981), and an additional determination (OxA260) was presented from material at the base of bed 2:

Accelerator dates (humic acid fraction) (Lowe *et al*.1988)

OxA240	10,400	± 130
OxA246	11,750	± 120
OxA253	13,720	± 180
OxA260	14,200	± 240

Radiometric (decay) dates (Lowe 1981)

SRR-1700	10,040	± 80
SRR-1702	10,020	± 130
SRR-1701	11,160	± 90
SRR-1705	13,200	± 120

Note — all ages in years BP.

It should be noted that the age estimates (OxA 240, 246, 253, 260) are those derived from the humic acid component of the samples; these may provide the most reliable age estimates, since they are not subject to mineral carbon error (Lowe *et al.* 1988). In every case, the accelerator dates are older than the equivalent radiometric (decay) dates provided by Lowe (1981).

Although the studies by Laing (1980), Lowe (1981) and Lowe *et al.* (1988) provide an important record of Devensian late-glacial and Holocene environmental changes in Mid Wales, the pollen results so far presented are just enough to provide a biostratigraphic framework for interpreting the radiocarbon dates and for allowing correlations. More detailed presentations of the pollen results, together with palaeomagnetic data, will be published later (Lowe *et al.* 1988).

The relative advantages of the accelerator and standard radiocarbon dating techniques are discussed in detail by Lowe *et al.,* and although it is clear that the accelerator technique has certain clear advantages, such as pinpointing sources of

error, it is not intended to replace the earlier method and dates. One of the main conclusions drawn in the study of Lowe *et al.* (1988), was that a degree of mineral carbon error appears to have affected all four of the stratigraphic horizons investigated. If the humic acid activity is compared with the earlier results, a systematic error of about 600 years is evident. The cause of this error is unclear: the fact that the two sets of dates (SRR and OxA) were obtained from different cores hampers direct comparisons. It is nonetheless clear that variations within the site in radiocarbon activity occur within contemporaneous sedimentary horizons (Lowe *et al.* 1988). Lowe *et al.* concluded that sediments will therefore vary in suitability for the application of accelerator radiocarbon techniques, and that, until the method has been more widely applied and evaluated, they recommend that radiometric measurements of bulk samples are still simultaneously undertaken for the same horizons.

A minimum age for Late Devensian ice-sheet wastage in the Cadair Idris region, and for the commencement of early late-glacial sedimentation is now indicated by a date of 14,200 ± 240 BP (OxA 260) from Llyn Gwernan. This date corresponds closely with dates from Glanllynnau and Clogwynygarreg of 14,468 ± 300 BP (Birm 212) and 13,670 ± 280 BP (Birm 884), respectively. Despite the inherent uncertainties associated with radiocarbon dates and their comparison, these dates probably confirm that the wastage of the Late Devensian ice-sheet was not uniform everywhere in Wales.

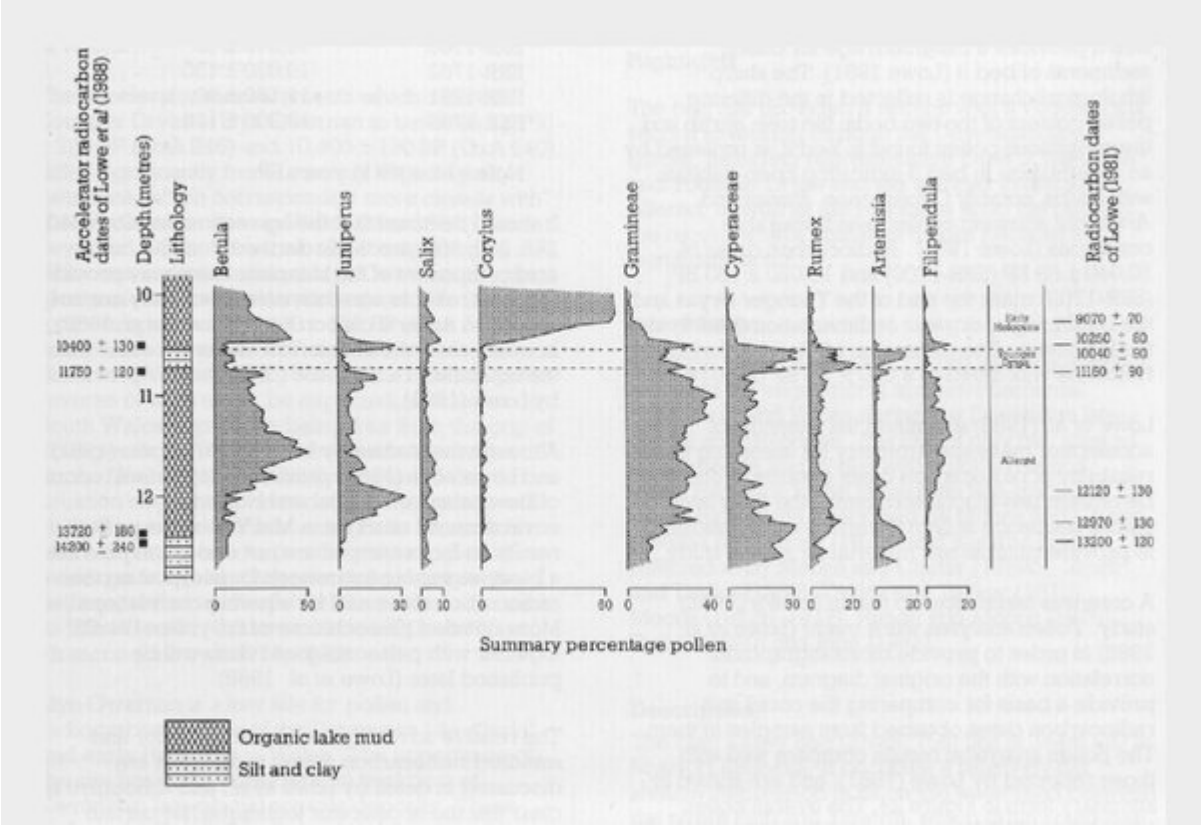
The accelerator measurements which date the Younger Dryas at Llyn Gwernan to between 11,750 ± 120 BP (OxA 246) and 10,400 ± 130 BP (OxA 240), differ significantly from Lowe's (1981) original estimates, which corresponded more closely with dates from other sites in Wales (Ince 1981; Seymour 1985). Paradoxically, the opening of Holocene sedimentation at Llyn Gwernan, the start of organic sedimentation and a major rise in *Juniperus* pollen, at 10,400 ± 130 BP (OxA 240) is now even earlier than at Traeth Mawr in the Brecon Beacons (Walker 1980, 1982a). This situation is the reverse of what might be expected; with areas of South Wales apparently being free from the grip of Younger Dryas ice later than sites farther to the north. Walker (1980, 1982a) speculated that this situation might have been caused by a southward shift of the ocean surface water Polar Front. It is also interesting to note that the palynological evidence from Llyn Gwernan does not show the Bølling oscillation interpreted from other sites such as Cors Geuallt (Crabtree 1969, 1970) and Nant Ffrancon (Burrows 1974, 1975).

Llyn Gwernan is a key site for pollen and radiocarbon studies of the Devensian late-glacial and early Holocene in Wales. The importance of the site lies in the considerable thickness of Devensian late-glacial organic deposits. These preserve a detailed pollen record that, together with radiocarbon dates, have allowed a far greater resolution of the Devensian late-glacial than elsewhere in Wales. The site is particularly important for the detailed radiocarbon timescale of Devensian late-glacial events: standard radiometric dates having recently been supplemented by accelerator derived dates. Llyn Gwernan is the first site in Wales where the newer method has been applied and is therefore important for methodological comparisons which have considerable implications for Devensian late-glacial and Holocene studies.

Conclusions

Llyn Gwernan contains an exceptional thickness of organic deposits which accumulated over the last 15,000 years or so. These contain fossil pollen grains and have been radiocarbon dated to give the most detailed timescale of climatic change over this period anywhere in Wales. This evidence has been recently supplemented by AMS (accelerator mass spectrometry) radiocarbon dates, the same technique as used to date the Turin Shroud.

References



(Figure 24) Llyn Gwernan: a summary of pollen, lithological and radiocarbon evidence (from Lowe et al. 1988)