CAM LOCH

H.J.B. Birks

OS Grid Reference: NC209135

Highlights

The sediments on the floor of Cam Loch contain a valuable record of environmental changes during the Lateglacial. This record has been studied in great detail using pollen, diatom and chemical methods, together with radiocarbon dating. Cam Loch is an important reference site for the Lateglacial in north-west Scotland.

Introduction

Cam Loch (NC 209135) is a large (2.6 km^2), irregularly shaped loch situated at 124 m OD just north of Elphin in west Sutherland. It has a large catchment (*c.* 87 km^2) with major inflowing and outflowing rivers. The sediments preserved on the floor of the loch are important for reconstructing the environmental history of the Lateglacial between about 13,000 and 10,000 BP. Evidence for rapid and marked climatic change during this interval is strongly represented in Scotland, both as landforms and as sedimentary, geochemical and biostratigraphical records. Cam Loch is one of the most intensively studied Lateglacial sites in Scotland and is of international importance because of the numerous interdisciplinary studies that have been made on its Lateglacial sediments by members of the Freshwater Biological Association (Pennington, 1975a, 1975b, 1975c, 1977a, 1977b; Pennington and Sackin, 1975; Haworth, 1976; Cranwell, 1977). It is the major reference site for the stratigraphy of the Lateglacial in north-west Scotland, and it provides critically important palaeoecological comparisons with sites elsewhere in the British Isles and in north-west Europe.

Description

The maximum water depth of Cam Loch is 37 m and the mean depth, 12 m. A sediment core has been obtained from a water depth of 10 m. The basal 0.65 m of sediment in this core comprise a succession of clay, silt and gyttja deposits (Figure 6.16) and were formed during the Lateglacial. These sediments have been intensively studied for their inorganic (Pennington and Sackin, 1975; Pennington, 1975a, 1977a) and organic geochemistry (Cranwell, 1977; Pennington, 1977a), their pollen stratigraphy (both as relative and absolute data) (Pennington, 1975a, 1975b, 1977a, 1977b; Pennington and Sackin, 1975) and their diatom stratigraphy (Haworth, 1976; Pennington, 1977a). As a result Cam Loch provides an extremely detailed environmental history for this time period. Seven radiocarbon dates (SRR-247 to SRR-253) have been obtained for consecutive sediment samples for the period 13,000–10,000 BP (Figure 6.16). The pollen record has been divided into seven local pollen assemblage zones (zones Ca–Ch) and three regional pollen assemblage subzones (subzones NWS A, B, C) described from the nearby sites of Loch Sionascaig and Loch Borralan. Correlation has been made with the Late Weichselian chronozones of Mangerud *et al.* (1974). The presence at Cam Loch of fossiliferous organic sediments that pre-date 13,000 BP suggests that the site and its surrounds were ice-free before that time.

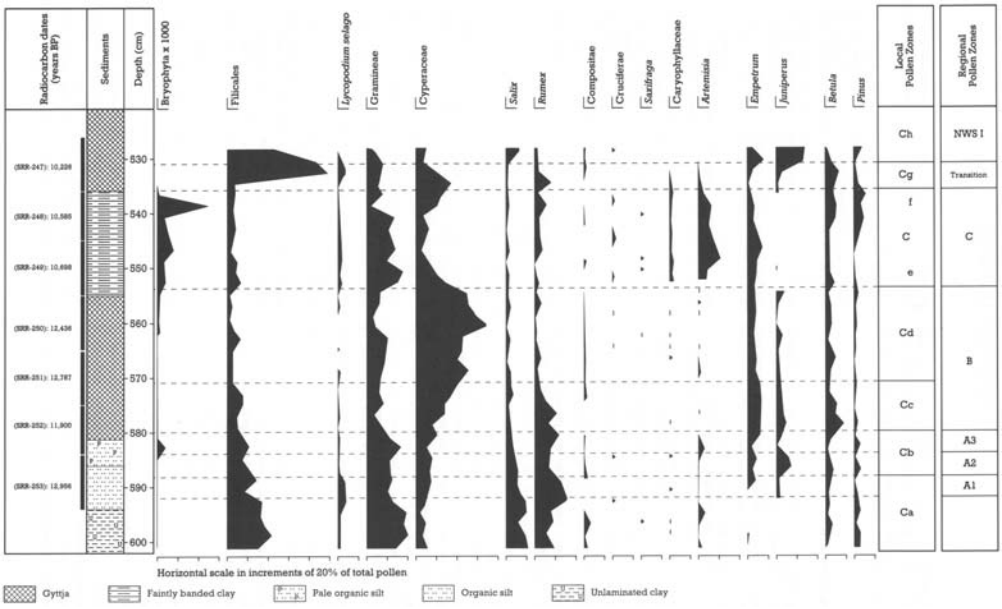

Figure 6.16: Cam Loch: relative pollen diagram, showing selected taxa as percentages of total pollen (from Pennington, 1977a).

Interpretation

The basal sediments (Figure 6.16) are barren clays and silts with high sodium, potassium, calcium, and magnesium values, indicating erosion and inwash of unleached skeletal mineral soils. Immediately above these sediments there are pollen assemblages deposited prior to 13,000 BP (zone Ca) that are characterized by *Salix* (including S. *herbacea*), *Rumex acetosa* and *Oxyria digyna* pollen, and by *Lycopodium selago* spores. The vegetation was probably a mosaic of very open, pioneer vegetation with *Rumex acetosa*, *Oxyria digyna* and *Lycopodium selago,* and with extensive areas of prolonged snow-lie dominated by *Salix herbacea* (Pennington, 1980). The climate was probably oceanic with much snow and comparatively little periglacial erosion because of the extensive snow cover. At about 13,000 BP there was an increase in the carbon, nitrogen, and iodine contents of the sediments and the calcium and sodium contents fell, followed by a decrease in the potassium and magnesium values. These chemical changes suggest some stabilization of the landscape and the onset of soil leaching, humus accumulation, and chemical weathering. The pollen assemblages (lower part of zone Cb) are characterized by a rise, both in percentages and absolute values, of *Juniperus communis* and *Empetrum nigrum* pollen, suggesting that the vegetation was a dwarf-shrub heath, possibly analogous in physiognomy to the shrub tundra of coastal south-west Greenland today (Pennington, 1977a). This phase is correlated with the BØlling Chronozone. Between 12,000 and 11,800 BP there was a temporary fall in the values of *Juniperus communis* pollen and a rise in the values of *Artemisia* pollen (upper part of zone Cb). Chemical changes suggest that this was a phase of soil disturbance and erosion, and the diatom flora includes inwashed terrestrial diatoms. This short-lived phase is correlated, on the basis of the radiocarbon dates, with the Older Dryas Chronozone of Fennoscandia. The phase probably reflects a climatic recession of comparatively small magnitude. Interestingly, the geochemical data suggest that although some soil erosion occurred, no periglacial erosion of mineral soils is detectable, such as occurred prior to 13,000 BP and between 11,000 and 10,400 BP.

In the sediments deposited from 11,800 to 11,000 BP (correlated with the AllerØd Interstadial and Chronozone) pollen of *Empetrum*, Cyperaceae and *Betula* attain their highest values (zones Cc and Cd). The absolute *Betula* values do not, however, indicate that tree birches grew near the site at this time. The carbon content of the sediments attains its highest Lateglacial values during this period. The organic geochemistry indicates that much of the organic component of the AllerØd Chronozone sediments was derived from *in situ* lake biota and lake productivity, suggesting a high trophic status at this time. The reduced state of the iron and manganese in the sediments presumably resulted from oxygen depletion in the hypolimnion, a characteristic of productive eutrophic lakes today. The diatom assemblages similarly indicate that the loch was productive at this time. The soils within the catchment appear, however, to

have become leached during the interstadial, presumably because of high rainfall and the generally calcifuge nature of the dwarf-shrub and sedge-dominated vegetation. Soil erosion began during the interstadial, probably as a result of climatic deterioration. It resulted in the redeposition of organic material and some apparent anomalies in the radiocarbon dates.

Sediments deposited between 11,000 and 10,400 BP contain pollen assemblages that are characterized by high values of *Artemisia* (including *A. norvegica*), Cruciferae, Compositae, Caryophyllaceae and Gramineae pollen and of *Lycopodium selago* spores (zones Ce and Cf). The assemblages date from the first part of the Younger Dryas Stadial and Chronozone, the time during which small corrie glaciers became re-established on the mountains of north-west Scotland (Sissons, 1977a). The sediments are minerogenic and reflect the onset of intense periglacial erosion of mineral soils by frost disturbance. They resemble the lowermost sediments in their high calcium, magnesium, potassium and sodium content. Terrestrial diatom species are frequent, again indicating extensive erosion and inwashing of terrestrial material. The vegetation was probably predominantly open and species-rich, with abundant sedges and grasses, *Artemisia*, and other herbs (Pennington, 1980). The climate was probably more continental and with less snowfall than the climate pre-13,000 BP. This phase is part of the Loch Lomond Stadial and reflects a period of very marked climatic deterioration, with extensive erosion and inwashing of mineral soils.

At about 10,400 BP the sediments become more organic, the carbon content sharply rises to values higher than at any time in the Lateglacial, and elements such as sodium, potassium, calcium and magnesium decrease equally rapidly. These chemical changes indicate humus accumulation, soil stability, and high lake productivity. The pollen assemblages are dominated by Cyperaceae and *Rumex* pollen (zone Cg) and then by *Juniperus communis* and *Empetrum* pollen (zone Ch). The pollen stratigraphy clearly reflects the rapid vegetational changes that occurred at the end of the Lateglacial and the beginning of the Holocene.

The numerous geochemical and palaeontological variables that were studied in the Cam Loch sediments all indicate that a major and rapid climatic amelioration occurred at about 13,000 BP; a minor climatic recession occurred between 12,000 and 11,800 BP, and a major climatic deterioration occurred between 11,000 and 10,400 BP. These phases are correlated by Pennington (1975b, 1977a, 1977b) with the BØlling, Older Dryas, and Younger Dryas Chronozones, respectively, of Fennoscandia.

Cam Loch is of national importance because of its detailed and diverse stratigraphical record of the environmental history of the Lateglacial. It is one of the most intensively studied sites of Lateglacial age in Scotland, with detailed and integrated pollen, diatom and inorganic and organic chemical analyses, thereby providing valuable independent evidence for enviromental change during the Lateglacial. Its palaeoclimate record shows marked differences with sites elsewhere in Britain (for example, Pennington, 1977b; Walker, 1984b) and mainland Europe (for example, Watts, 1980). Such spatial differences even within north-west Scotland (Birks, 1984) indicate the complex vegetational and hence environmental patterns that may have existed during the Lateglacial, especially in extreme, marginal areas. Cam Loch provides convincing evidence from various data sources for a minor climatic recession between about 12,000 and 11,800 BP. Increasing interest is now focused on such short-lived, often rather abrupt, climatic recessions during the Lateglacial (Tipping, 1991b). Because of its wealth of palaeoecological and palaeolimnological data from the Lateglacial, Cam Loch is an important reference site for studies of Late Quaternary vegetational and climatic history.

Conclusions

The sediments at Cam Loch are important for reconstructing the environmental history of north-west Scotland from about 13,000 to 10,000 years ago, during the Lateglacial. Pollen, diatom and chemical analyses, together with radiocarbon dating, show that the climatic amelioration at the end of the last glaciation was twice interrupted by colder phases, with corresponding changes in vegetation patterns and soil stability. The first interruption was a relatively short-lived event; the second corresponds with the Loch Lomond Stadial (about 11,000 to 10,000 years ago) and brought about a change from a stable ground cover of dwarf-shrub vegetation to unstable soils with open-habitat sedges, grasses and herbs. As one of the most intensively studied Lateglacial sites in north-west Scotland, Cam Loch is a key reference

locality for this area.

Reference list

Birks, H.H. (1984) Late-Quaternary pollen and plant macrofossil stratigraphy at Lochan an Druim, north-west Scotland. In *Lake Sediments and Environmental History* (eds E.Y. Haworth and J.W.G. Lund). Leicester, Leicester University Press, 377–405.

Cranwell, P.A. (1977) Organic geochemistry of Cam Loch (Sutherland) sediments. *Chemical Geology*, **20**, 205–21.

Haworth, E.Y. (1976) Two late-glacial (Late Devensian) diatom assemblage profiles from northern Scotland. *New Phytologist*, **77**, 227–256.

Mangerud, J., Andersen, S.T., Berglund, B.G. and Donner, J.J. (1974) Quaternary stratigraphy of Norden, a proposal for terminology and classification. *Boreas*, **3**, 109–28.

Pennington, W. (1975a) Climatic changes in Britain, as interpreted from lake sediments, between 15,000 and 10,000 years ago. In *Palaeolimnology of Lake Biwa and the Japanese Pleistocene* (ed. S. Horie). Vol. 3, 536–69.

Pennington, W. (1975b) A chronostratigraphic comparison of Late-Weichselian and Late-Devensian subdivisions, illustrated by two radiocarbon-dated profiles from western Britain. *Boreas*, **4**, 157–71.

Pennington, W. (1975c) An application of principal components analysis to the zonation of two Late-Devensian profiles. II. Interpretation of the numerical analyses in terms of Late-Devensian (Late-Weichselian) environmental history. *New Phytologist*, **75**, 441–53.

Pennington, W. (1977a) Lake sediments and the Lateglacial environment in northern Scotland. In *Studies in the Scottish Lateglacial Environment* (eds J.M. Gray and J.J. Lowe). Oxford, Pergamon Press, 119–41.

Pennington, W. (1977b) The Late Devensian flora and vegetation of Britain. *Philosophical Transactions of the Royal Society*, **280B**, 247–71.

Pennington, W. (1980) Modern pollen samples from West Greenland and the interpretation of pollen data from the British late-glacial (Late Devensian). *New Phytologist*, **84**, 171–201.

Pennington, W. and Sackin, M.J. (1975) An application of principal components analysis to the zonation of two Late-Devensian profiles. I. Numerical analysis. *New Phytologist*, **75**, 419–41.

Sissons, J.B. (1977a) The Loch Lomond Readvance in the northern mainland of Scotland. In *Studies in the Scottish Lateglacial Environment* (eds J.M. Gray and J.J. Lowe). Oxford, Pergamon Press, 45–59.

Tipping, R.M. (1991b) The climatostratigraphic subdivision of the Devensian Lateglacial: evidence from a pollen site near Oban, western Scotland. *Journal of Biogeography*, **18**, 89–101.

Walker, M.J.C. (1984b) Pollen analysis and Quaternary research in Scotland. *Quaternary Science Reviews*, **4**, 369–404.

Watts, W.A. (1980) Regional variation in the response of vegetation to Lateglacial climatic events in Europe. In *Studies in the Lateglacial of North West Europe* (eds J.J. Lowe, J.M. Gray and J.E. Robinson). Oxford, Pergamon Press, 1–22.