Dalcharn

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Highlights

The sequence of sediments exposed in the stream sections at this site includes interglacial organic deposits which are both underlain and overlain by till. Although the deposits are undated, the sequence is remarkable for the detail of information it has yielded on the Quaternary history of the Inverness area and the potential it holds for providing further elaboration of this record.

Introduction

Sediments containing compressed and disseminated biogenic matter are exposed beneath a thick sequence of tills in a river cliff of the Allt Dearg at Dalcharn [NH 815 452], some 6 km south-west of the village of Cawdor, near Nairn. The organic deposits, which lie at an altitude of *c.* 200 m OD, have been cryogenically and glaciotectonically disturbed, but contain pollen of full interglacial affinity reflecting the middle and later stages of an interglacial cycle. The overlying till sequence provides evidence of at least two separate glacial episodes, and although the age of the interglacial material cannot be firmly established at present it is probable that it pre-dates the Ipswichian.

The organic deposits occur near the bleached top of a deeply weathered gravel. The base of the gravel is not exposed at the section containing the organic material, but the gravel can be seen to overlie an older till at the base of another cliff section some 200 m to the north-east. Various aspects of these sections have been described by Bloodworth (1990), Merritt and Auton (1990), Walker (1990a), Whittington (1990) and Walker *et al.* (1992). Dalcharn provides the first evidence that the northern Grampian Highlands were covered by pine forest during at least one interglacial stage of the Middle or Late Quaternary.

Description

Exposures in the cliffs of the Allt Dearg, east of Dalcharn Cottages, display a succession of Quaternary sediments *c.* 25 m in thickness (Figure 7.2). The lithological subdivisions used in this account follow those of Merritt and Auton (1990) and Walker *et al.* (1992), and are based on a composite log of three sections: Dalcharn East [NH 8157 4537], Dalcharn West — Section A [NH 8146 4521] and Dalcharn West — Section B [NH 8143 4516], shown in (Figure 7.3). The recognized sequence is as follows:

7.	Humic soil	*c*. 0.3 m
6.	Glaciofluvial gravel	up to 2.5 m
5.	Dalcharn 'upper till formation'	8.5–10.0 m
4.	Dalcharn 'lower till formation'	8.5–9.5 m
3.	Dalcharn biogenic formation'	1.3–1.6 m
2.	Dalcharn 'gravel formation'	up to 3.0 m
1.	Dearg 'till formation'	at least 1.0 m

The Dearg 'till formation' (unit 1) is a moderate yellowish brown, very stiff, massive diamicton, with abundant clasts of Devonian sandstone and is exposed beneath the Dalcharn 'gravel formation' at the Dalcharn East Section.

The Dalcharn 'gravel formation' (unit 2) is a poorly sorted, matrix-rich gravel, bleached in its upper part, containing a high proportion of decomposed and unsound clasts. The clay mineralogy of the matrix of this deposit, in which vermiculite occurs as a product of subaerial weathering, has been described by Bloodworth (1990).

The Dalcharn tiogenic formation' (unit 3) is subdivided into an upper unit, the Dalcharn biogenic member' (0.5–0.6 m) and a lower unit, the Dalcharn 'cryoturbate member' (0.8–1.0 m). The uppermost 0.1–0.2 m of the 'biogenic member' comprises compact, laminated olive grey sandy and clayey silt with discontinuous wisps of pebbly sand and disseminated peaty matter. This overlies compact carbonaceous sandy silt and diamicton containing fibres and lumps of dark peaty material as well as discrete lenses, up to 0.05 by 0.01 m, of compressed sandy peat; an infinite radiocarbon date (>41,300 BP (GU–2340) has been obtained from compressed peat close to the base of the biogenic member'.

The 'cryoturbate member' consists of massive, matrix-supported clayey gravel diamicton, with a matrix of light grey to white silty fine-grained sand. Small fragments of organic material are sparsely disseminated throughout the deposit. Clasts within the diamicton are mainly of yellowish grey coarse-grained sandstone, many with white weathering rinds. Five pollen assemblage zones (Figure 7.4) have been recognized within the Dalcharn 'biogenic formation' exposed at Section A — Dalcharn West (Walker, 1990a; Walker *et al.,* 1992). The pollen record appears to show that closed pine forest with birch, alder and holly (D–1) was followed by a pine and heathland episode (D–2). This was succeeded by a gradual disappearance of the pine forest, which was initially replaced by birch (D–3) and later by heath and open grassland (D–4 and D–5). No plant macrofossils or insect remains have been found in the biogenic deposits.

The Dalcharn 'lower till formation' (unit 4) is subdivided into upper (*c.* 3.0 m), middle (*c.* 3.1 m) and lower (4–5 m) 'members', which all comprise reddish brown sandy diamicton, characterized by abundant clasts of Devonian sandstone. The upper and lower 'members' are massive and matrix-supported; the middle 'member' is stratified and friable.

The Dalcharn 'upper till formation' (unit 5) is divided into upper and lower 'members', which both comprise brown, massive, matrix-supported diamicton with clasts predominantly comprising psammite, semipelite and pink and grey granite. The upper 'member' (3.0–3.5 m) is separated from the lower by a sharp subhorizontal planar discontinuity and is characterized by a strongly developed clast fabric indicating former ice movement towards N034°; a deformed mass of claybound gravel occurs close to its base. The lower 'member' (5.5–6.5 m) contains a smaller proportion of clasts of metamorphic rock types and a larger proportion of pink granitic clasts than the upper 'member'; it is characterized by a clast fabric indicating former ice movement towards N097°.

The glaciofluvial gravel (unit 6) comprises orange stained, poorly sorted, clast-supported cobble gravel showing poorly developed horizontal stratification and an imbrication indicating a north-easterly palaeocurrent.

Interpretation

The occurrence of brown till with few sandstone erratics, overlying reddish brown till with abundant sandstone clasts is a common feature of many of the sequences of Quaternary deposits which mantle the high ground flanking the coastal lowlands of the Moray Firth between Inverness and Nairn. This stratigraphic relationship, which was first recognized by Fraser (1880) in Strathnairn and subsequently by Horne and Hinxman (1914) and Horne (1923) during the primary geological surveys of the surrounding districts, is clearly seen in the cliffs of the AllIt Dearg and those of its tributaries. At Dalcharn, the recognition of discontinuities between the various tills, the change in composition of their clasts and in the orientation of their fabrics support the contention that the two till formations, which overlie the organic sediments and weathered gravel, are the products of at least two distinct glacial episodes.

Both 'members' of the Dalcharn 'upper till' formation contain flat-iron shaped cobbles and elongate clasts with striations parallel to their longer axes, and the matrices of both units are penetrated by subhorizontal fissures and sharp concavo-convex discontinuities. These features, together with the very poor sorting and overcon-solidation of the diamictons, are considered to be characteristic attributes of lodgement tills (Dreimanis, 1989). The clast fabric of the upper 'member' indicates former ice movement towards the north-east, which is parallel to the general alignment of glacially streamlined features near the Dalcharn site. The fabric of the lower 'member' indicates former ice movement towards the east.

The relative abundance of clasts of Devonian sandstone, together with a weakly developed fabric suggesting former ice movement towards the south-east, serves to distinguish the Dalcharn 'lower till formation' from the overlying diamic-tons. This south-eastward direction of ice movement corresponds to the orientation of some striae on bedrock observed at a

few sites on the high ground between Loch Moy and Loch Ness (see Merritt 1990a, fig. 1). The poorly sorted and overconsolidated nature of the upper 'member' of the 'lower till formation', the presence of striated cobbles and discontinuity surfaces suggest that it is probably a lodgement till, whereas the presence of winnowed horizons and discrete lenses of sand and gravel, particularly within the middle 'member' of the 'lower formation', suggests that these lower parts of the deposit may have been formed by basal meltout rather than by lodgement processes.

The highly decomposed nature of the gravel underlying the biogenic deposits at Dalcharn indicates that it has been subjected to prolonged weathering under warm humid conditions, and suggests that the gravel and the associated organic material is of considerable antiquity. The pollen recorded from the organic horizons suggests that the weathering occurred during at least one interglacial episode prior to the Devensian.

It is also apparent that the biogenic deposits have been affected by severe post-depositional (and probably also syn-depositional) cryoturbation, as shown by the fragmentation of the peaty material and the mixing of bleached clasts from the underlying gravel into the biogenic sediments. The penetration of fissures, lined with silt and orange sand, from above the base of the overlying till, through the biogenic deposits and into the underlying gravel indicates that both the lower units have also been affected by glaciotectonic disturbance.

The origins of the biogenic deposits are uncertain and the pollen diagram may not reflect complete sequential vegetation development (Walker, 1990a; Whittington, 1990; Walker *et aL,* 1992). Nevertheless, the sequence of pollen zones appears to reflect a consistent pattern of vegetation development during an interglacial. Pollen data from sites elsewhere in Scotland indicate that pine woodland was the climax forest of the north-central Grampians during the Holocene (Pennington *et aL,* 1972; O'Sullivan, 1974a, 1976; Walker, 1975c) and, if these records can be used as an analogue for previous interglacials, then the Dalcharn sequence probably reflects a warm episode of interglacial rather than inter-stadial status.

That temperatures comparable with, or even higher than, those of today may have prevailed during the accumulation of the Dalcharn 'biogenic formation' can be inferred from the relatively high counts for *Hex* pollen. Holly is known to be intolerant of winter cold, the limiting mean temperature of the coldest month being –0.5°C while that of the warmest is 12–13°C (Iversen, 1944). The Dalcharn site lies near to the present northern limit of *Hex* in Britain (Godwin, 1975), and hence the relative abundance of *Ilex* pollen in Zone D–1 of the Dalcharn profile almost certainly reflects a climate somewhat warmer than that of today. The decline in *Ilex* at the D–1/ D–2 boundary and its subsequent disappearance from the pollen record may therefore be seen as a response to deteriorating climatic conditions. Overall, the pollen record may represent the middle and later phases of an interglacial vegetation cycle, corresponding with the mesocratic, oligocratic and initial cryocratic phases of Iversen (1958) and Andersen (1966) (see also Birks, 1986).

The pollen assemblage from Dalcharn is similar in some respects to that described from Fugla Ness on Shetland by Birks and Ransom (1969), who equated the latter with the Gortian of Ireland, and hence the Hoxnian of southern England; although a Cromerian origin for the Fugla Ness record was not excluded. However, on present evidence it is not possible to firmly attribute either the Dalcharn or the Fugla Ness record to a particular interglacial within the Middle or Late Quaternary. Similarly, correlations with other interglacial or interglacial/interstadial sites in Scotland cannot be made. The pollen records from Sel Ayre on Shetland (Birks and Peglar, 1979), Toa Galson in north-west Lewis (Sutherland and Walker, 1984) and Abhainn Ruaival on St Kilda (Sutherland *et al.,* 1984) are characterized by open grassland or heathland vegetation, and there are difficulties in establishing correlations with the palaeosols at Teindland (Edwards *et al,* 1976) and Kirkhill (Connell et al*,* 1982) in north-east Scotland (Lowe, 1984; Walker, 1984b).

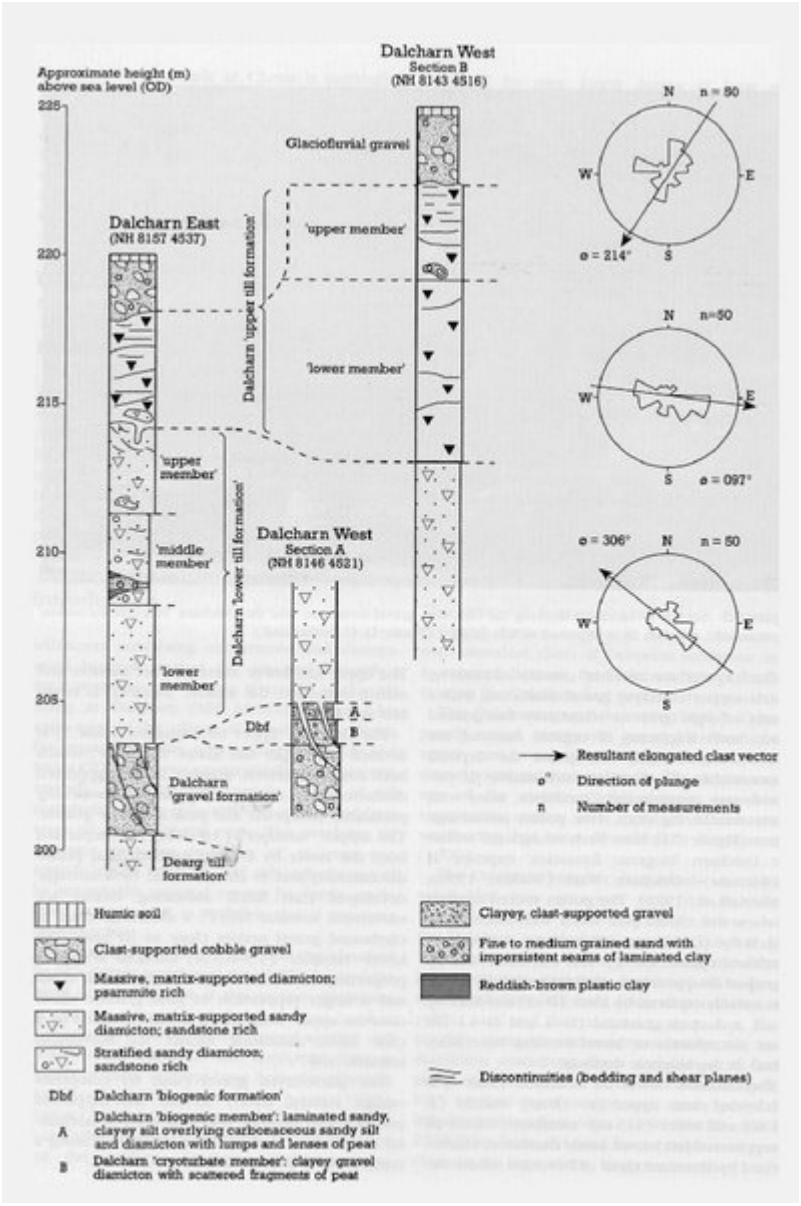
The pollen assemblage at Dalcharn represents the first record of an undoubted interglacial deposit beneath tills in the Moray Firth area, and is the first to provide unequivocal evidence of interglacial pine forest and its history. The presence of till beneath the weathered gravel at Dalcharn is also the first reported occurrence of a glacial deposit formed prior to at least one interglacial of the Middle or Late Quaternary on this part of the Scottish mainland. This recognition of pre-Late Devensian glacial and interglacial sediments has critical implications for the interpretation of multiple till sequences throughout northern Britain, which have hitherto been attributed to variations in the direction of movement within a single Late Devensian ice-sheet, but which may in fact represent successive earlier glacial episodes.

Conclusion

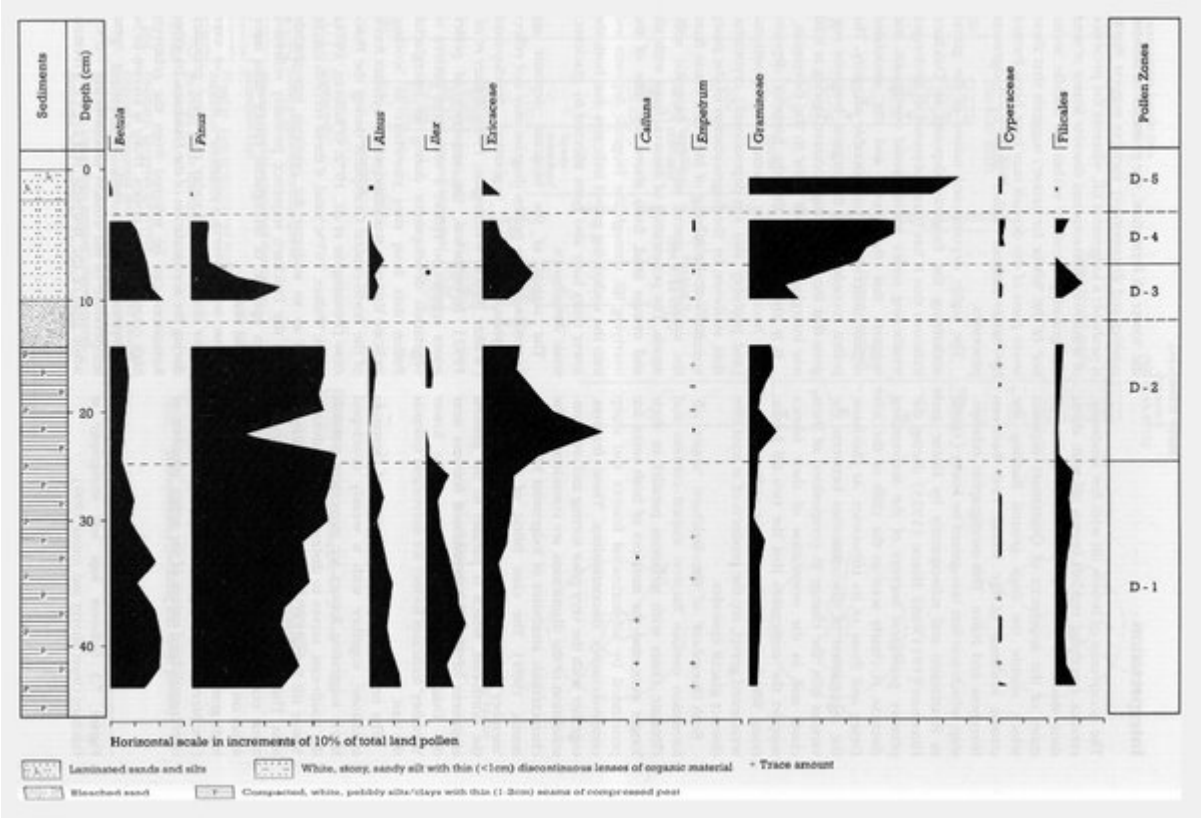
The sequence of deposits at Dalcharn is of considerable importance for the evidence it provides for the climatic and glacial history during the Quaternary. Although dating has yet to be firmly established, the length and detail of the record are exceptional, including evidence for an interglacial (temperate climate) and episodes of multiple glaciation and periglacial conditions. The interglacial deposits are significant in providing the first clear record of interglacial pine forest development in Scotland. The site has outstanding potential for elucidating further the glacial history of Scotland.

References

(Figure 7.2) Section at Dalcharn showing the Dalcharn 'gravel formation' and the Dalcharn 'biogenic formation' (bottom left), overlain by a sequence of tills (right). (Photo: D. G. Sutherland.)



(Figure 7.3) Sediment logs and stratigraphy at Dalcharn (from Merritt and Auton, 1990).



(Figure 7.4) Relative pollen diagram for the Dalcharn 'biogenic formation', showing selected taxa only as percentage of total land pollen (from Walker, 1990a).