The Dalcharn Interglacial site

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The sequence of sediments exposed in river cliff sections of the Allt Dearg at Dalcharn (Fig. 72), some 6 km south-west of the village of Cawdor [NH 845 500], includes interglacial organic deposits that are both underlain and overlain by till. The sequence is remarkable for the information it has yielded on the Quaternary history of the region and the potential it holds for providing further elaboration of this record.

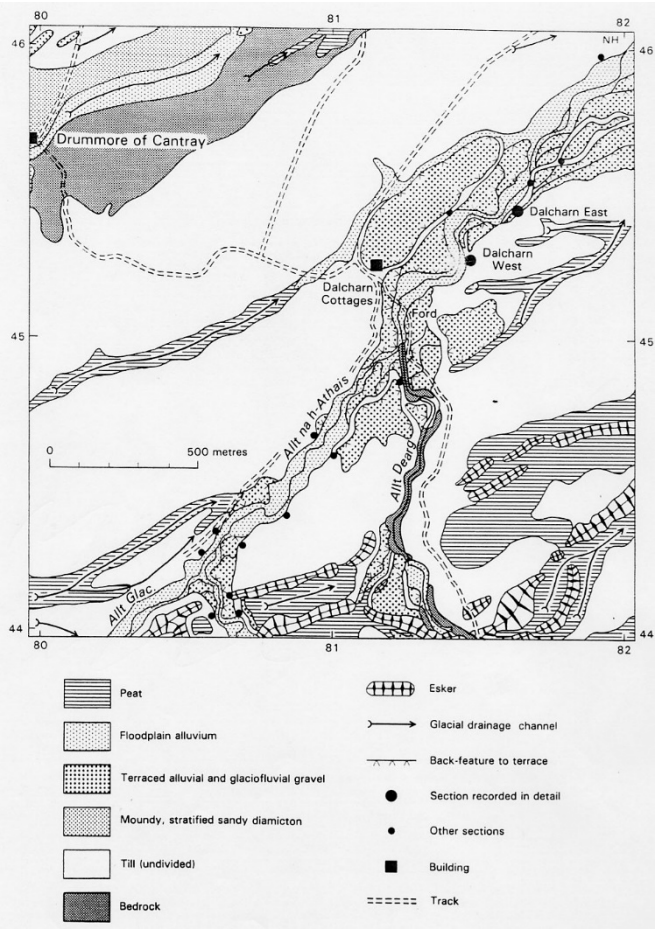

Figure 72. Superficial geological map of the area around Dalcharn (from Merritt and Auton, 1990).

Figure 73. View of the Dalcharn West site in 1988 looking north-east. The Dalcharn Palaeosol is exposed on the right bank of the Allt Dearg, below the trees.

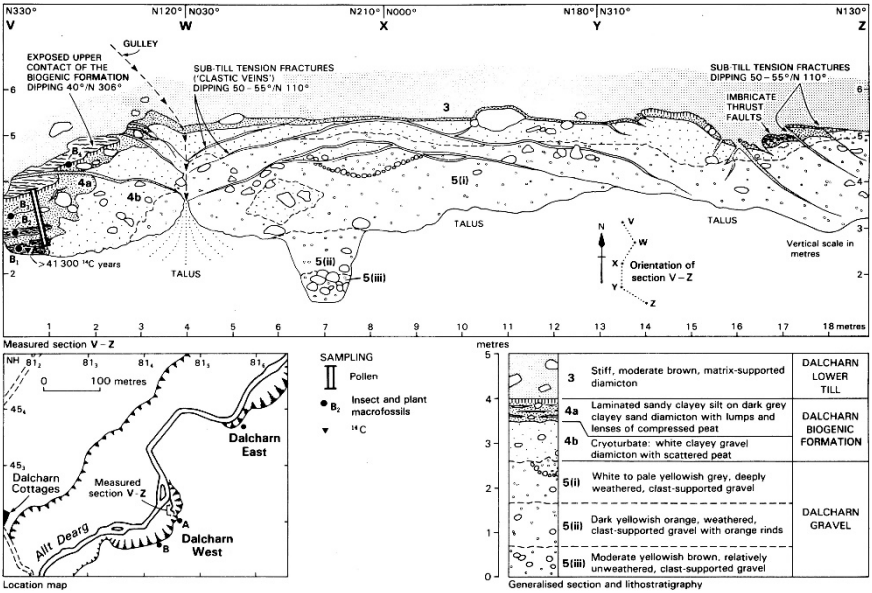

Figure 74. The Dalcharn West section logged in 1988 showing sampling point for pollen, insect and plant macrofossils (from Walker et al., 1992). Note that original lithostratigraphical names are used.

Sediments containing compressed and disseminated biogenic matter were discovered in 1987 beneath a thick sequence of tills at the 'Dalcharn West' river cliff section [NH 8143 4516] (Figs. 73 & 74), at 200 m OD (Merritt and Auton, 1990; Walker et al., 1992). The organic deposits have been cryogenically and glacitectonically disturbed, yet have yielded an essentially coherent pollen record of full interglacial affinity reflecting the middle and latter stages of an interglacial cycle. Although the age of the interglacial material has not been firmly established, it probable pre-dates the Ipswichian Interglacial. The organic deposits occur near the bleached top of a deeply weathered unit of gravel (Fig. 75). The base of the gravel is not exposed at Dalcharn West, but it can be seen to overlie an older till at the base of another section, some 200 m downstream, at 'Dalcharn East' [NH 8157 4537]. The organic deposits at Dalcharn provide 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 and the overlying till sequence provides evidence of at least two separate glacial episodes.

Figure 75. The Dalcharn Palaeosol in 1988 at the position of the sampling point shown in the previous figure.

The stratigraphy at Dalcharn is summarized in Fig. 76. The terminology follows that of McMillan et al. (2011) (original names in

brackets). The *Suidheig (Dearg) Till* [6] is a moderate yellowish brown, very stiff, massive diamict with abundant clasts of Devonian sandstone and is exposed only at Dalcharn East, where it is overlain by the *Craig an Daimh* (*Dalcharn) Gravel* [5], a poorly sorted, matrix-rich gravel, bleached in upper part, containing a high proportion of decomposed and unsound clasts. The bleached part of the deposit has a matrix of vermiculite interpreted as being the product of subaerial weathering (Bloodworth, 1990).

The *Dalcharn Palaeosol Formation* [4] at Dalcharn West includes two distinct sub-units. The upper '*Dalcharn Biogenic Member'* (0.5-0.6 m) comprises extremely compact, laminated olive grey sandy and clayey silt containing laterally discontinuous wisps of pebbly sand and disseminated peaty matter (Fig. 74). It passes down into carbonaceous sandy silt and diamict containing fibres and lumps of dark peaty material as well as discrete thin lenses of highly compressed sandy peat, from which an infinite C^{14} date of 41,300 BP has been obtained (Walker et al., 1992). The lower '*Dalcharn Cryoturbate Member'* (0.8-1.0 m) consists of massive, matrix-supported clayey gravel diamict 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 diamict are mainly of yellowish grey sandstone, many with white weathering rinds.

Five pollen assemblage zones have been recognised within the biogenic deposits (Walker et al., 1992). The pollen record indicates that closed pine forest with birch, alder and holly was succeeded by a pine and heath landscape. This was followed by a gradual disappearance of the pine forest, which was initially replaced by birch and later by heath and open grassland. No bone material, plant macrofossils or insect remains have been recovered.

The *Athais (Dalcharn Lower) Till Formation* [3] may be subdivided into three sub-units, all of which comprise reddish brown sandy diamict characterized by abundant clasts of Devonian sandstone and siltstone. The upper and lower sub-units are massive and matrix-supported; the middle sub-unit is stratified and friable.

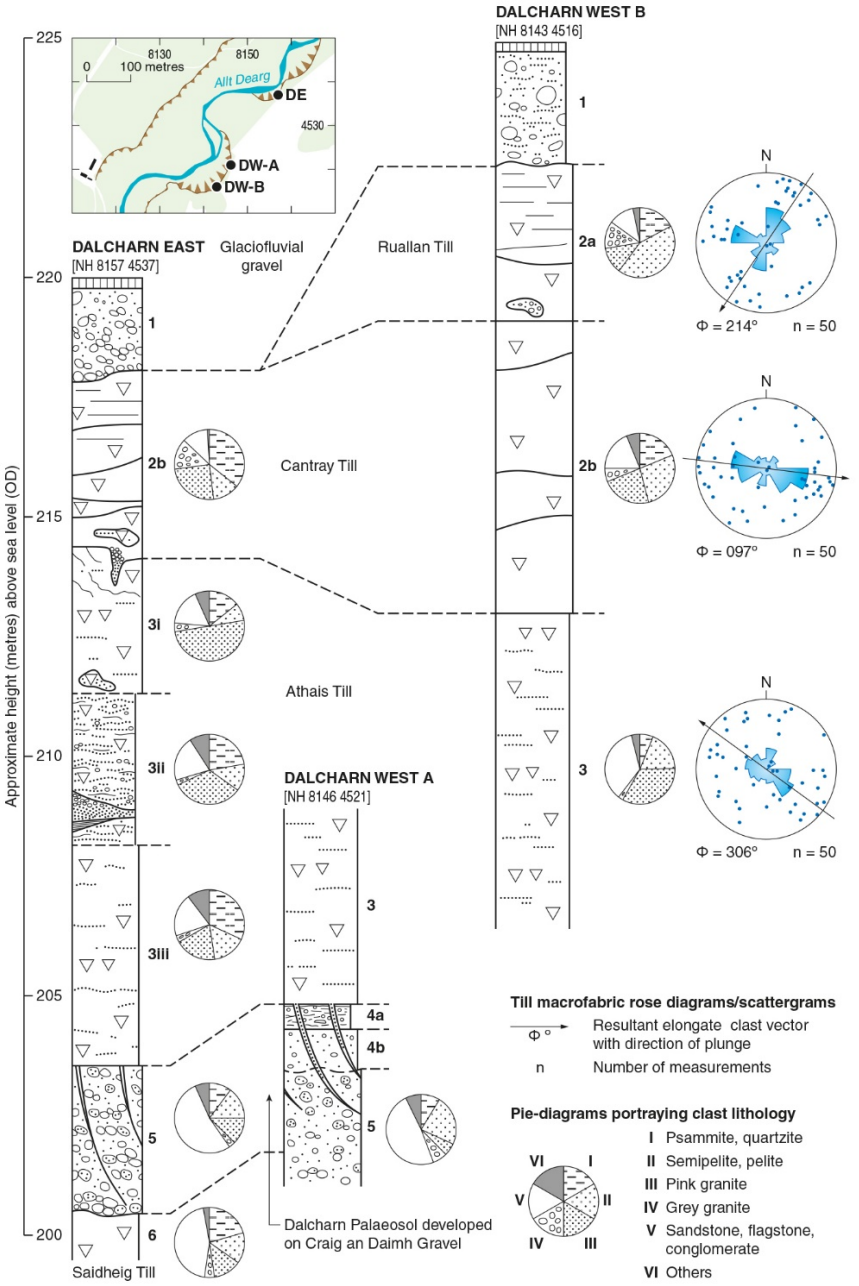

Figure 76. Logs of the sections at Dalcharn with revised lithostratigraphy.

The *Beinn an Uain (Dalcharn Upper) Till Formation* [2] has been sub-divided into two members, both of which comprise brown, massive, matrix-supported diamict with clasts predominantly comprising metasandstone, metasiltstone with pink and grey granite. The upper *Ruallan Till Member* (3.0-3.5 m) is separated from the underlying *Cantray Till Member* by a sharp sub-horizontal planar discontinuity and is characterized by a strongly developed clast fabric indicating former ice movement towards NO34°; a deformed mass of clay-bound gravel occurred close to its base. The Cantray Till (5.5-6.5 m) contains a smaller proportion of metamorphic rock types and a larger proportion of pink granite; it has a clast fabric indicating former ice movement towards NO97°. Glaciofluvial gravel [1] caps the Dalcharn East section, where it underlies a terrace that has cut out the uppermost part of the till sequence exposed at Dalcharn West.

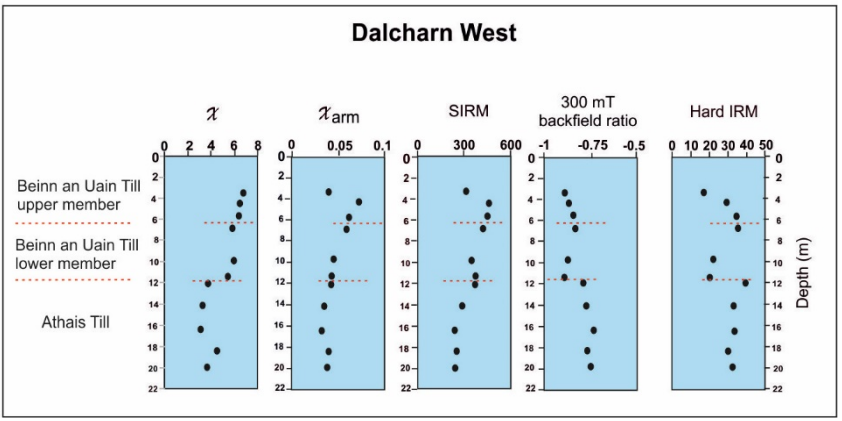

Figure 77. Mineral magnetic stratigraphy of the tills at Dalcharn West.

Analysis of mineral magnetic samples collected at 2 m intervals from the till sequence at Dalcharn West (Fig. 77) show lower concentrations of ferromagnetic minerals (e.g. magnetite) and higher concentrations of antiferromagnetic minerals (e.g. haematite) in the lower Athais Till, than are present in the upper Beinn an Uain Till (Walden and Auton, 2000). This strongly supports the change in provenance suggested by clast lithological analyses and provides further corroboration of an early advance of ice that crossed the Devonian

outcrop and laid down sandstone-rich till on Neoproterozoic metamorphic bedrock.

Regrettably, most of the palaeosol exposed at Dalcharn West was destroyed during a recent flood event, but elements of it were exposed in April 2017 [NH 8142 4528]. Interestingly, the new exposures suggest that there may be two distinct palaeosols (Fig. 78), but further work is required to rule out tectonic duplication. For example, the black organic layer within the white silt exposed at stream level (right) appears to have been pulled apart and boudinaged (Fig. 79). The Dalcharn East section has also been eroded, but a thin layer of sheared glacitectonite may now be observed at the base of the Athais Till (Fig. 80).

Figure 78. New section at Dalcharn West in 2017 apparently displaying two distinct organic horizons.

Figure 79. Close-up of the lower organic horizon exposed at Dalcharn West in 2017.

Figure 80. New section at Dalcharn East in 2017 revealing the contact between the Athais Till and the underlying Craig an Daimh Gravel containing decomposed clasts of granite.

Interpretation

The occurrence of brown till, with few sandstone erratics, overlying reddish brown till with abundant sandstone clasts is a common feature across the high ground flanking the coastal lowlands (Fletcher et al., 1996; Merritt et al., 2017). This stratigraphic relationship is clearly seen in the river cliffs of the Allt Dearg and its tributaries (Fig. 81). At Dalcharn, the discontinuities occurring between till units, together with the observed changes in clast composition and fabric, support the contention that the two tills overlying the organic sediments and weathered gravel are the products of at least two distinct glacial episodes.

Both members of the Beinn an Uain Till Fm contain 'flat-iron' shaped cobbles and elongate clasts with striations parallel to their longer axes, and are penetrated by sub-horizontal fissures and sharp concavo-convex discontinuities. These features, together with the very poor sorting and over-consolidation of the diamicts, are considered characteristic attributes of a subglacial traction till (cf. Evans et al, 2006). The fabric of the lower member indicates former ice movement towards the east, whereas 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 around Dalcharn.

The relative abundance of Devonian clasts, together with a weakly developed fabric suggesting former ice movement towards the south-east, serves to distinguish the Athais Till from the overlying diamicts. The poorly sorted and over-consolidated nature of most the formation, together with the presence of striated cobbles and discontinuity surfaces, suggest that it generally formed as subglacial traction till. The presence of apparently winnowed horizons and discrete lenses of sand and gravel, particularly within the middle sub-unit at Dalcharn East, suggested to Walker et al. (1992) that these parts of the sequence may have been formed by basal meltout processes (Fig. 82). However, the sandy wisps more probably result from subglacial comminution and thus be representative of glacitectonite (cf. Benn and Evans, 2010).

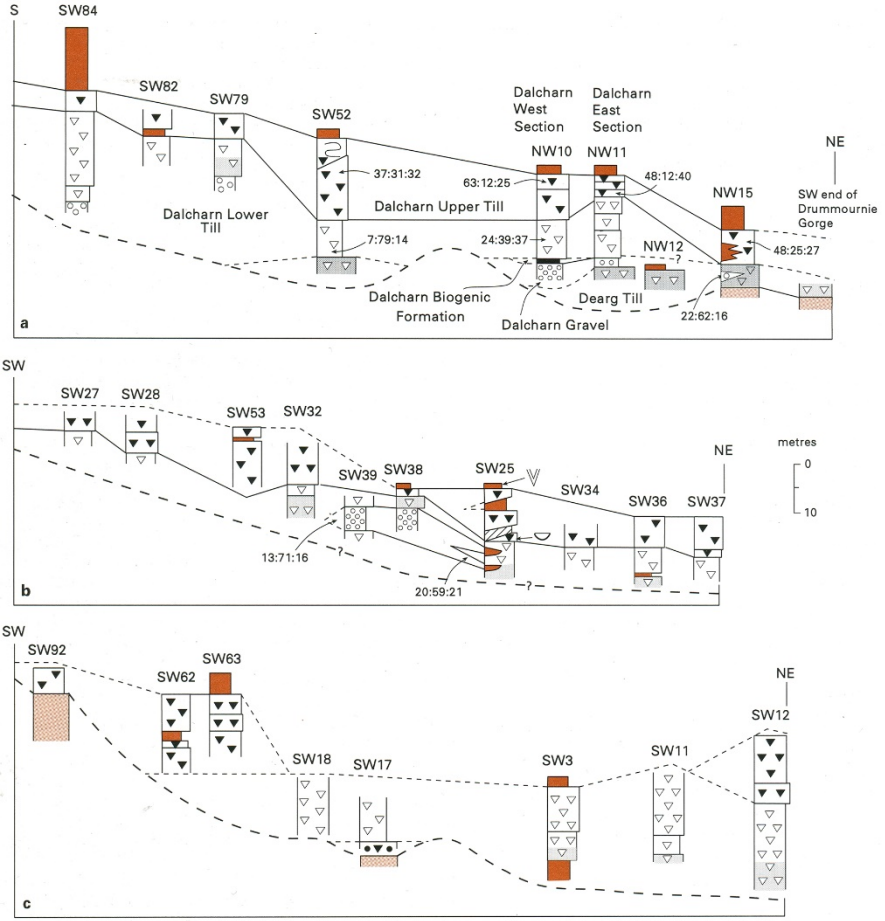

Figure 81. Stratigraphical relationships of glacigenic deposits in the valleys of a) Allt Dearg, b) Allt na h-Athais. c) Riereach Burn (from Fletcher et al., 1996). Stone-count data (e.g. 24: 39: 37) are percentages of metamorphic, Old Red Sandstone and granitic clasts respectively.

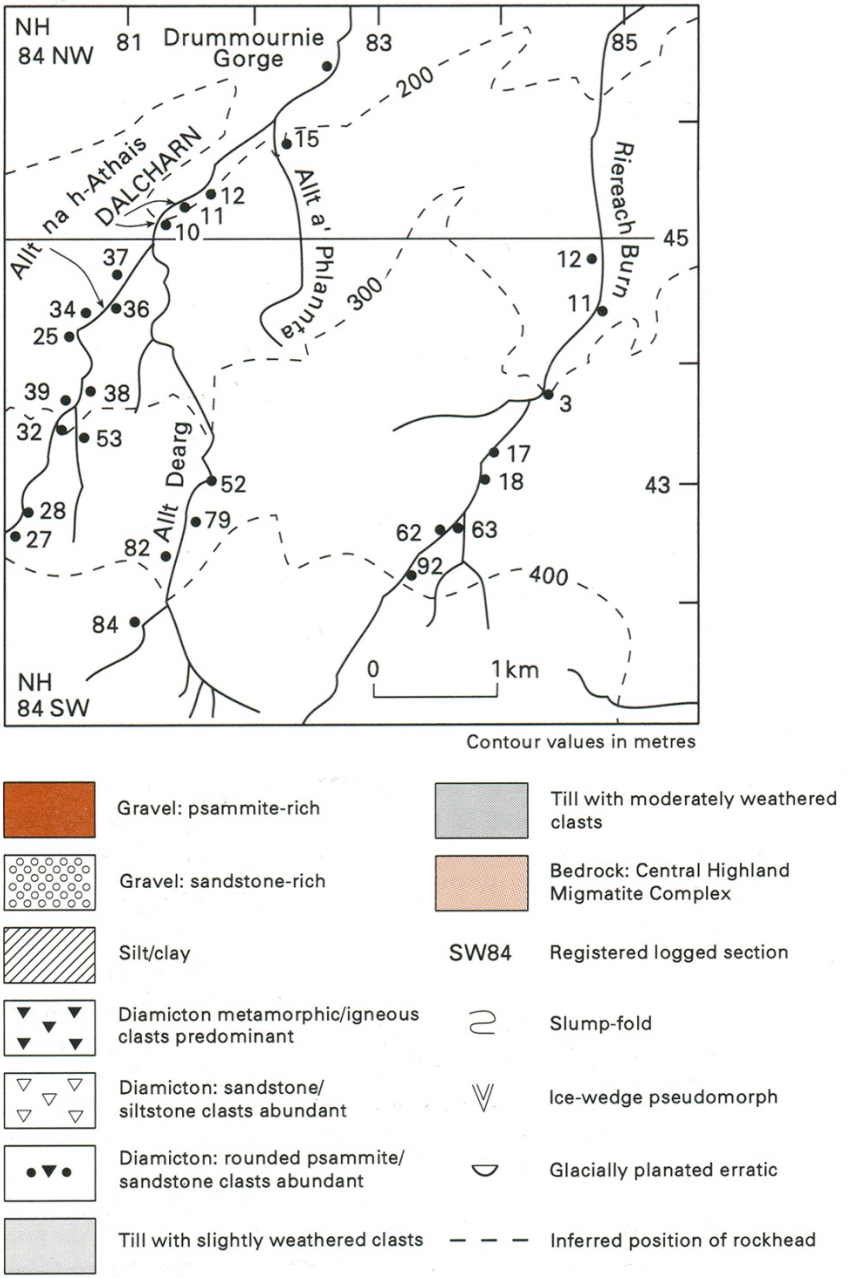

Figure 81 continued. Legend and locality map.

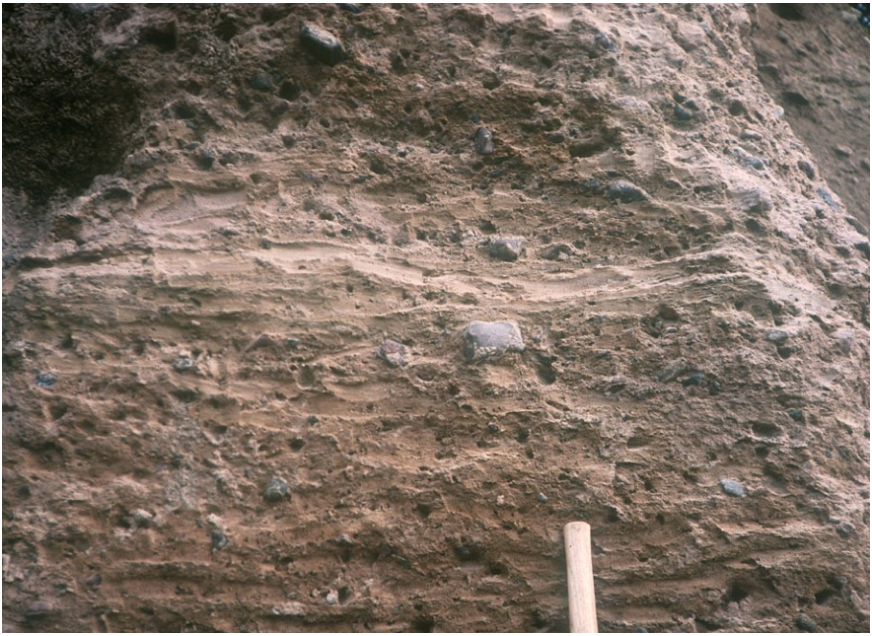

Figure 82. The middle sub-unit of the Athais Till at Dalcharn East in 1990.

The origins of the biogenic materials are uncertain, but they probably represent the remains of a destroyed palaeosol, in which case the pollen diagram may not reflect complete sequential vegetation development. 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 (Bennett, 1984), and, if these records can be used as an analogue for previous interglacials, then the Dalcharn sequence reflects a warm episode of interglacial status. Furthermore, as the Dalcharn lies near to the present northern limit of holly in Britain the relative abundance of *Ilex* pollen in the profile almost certainly reflects a climate somewhat warmer than that of today (Walker et al., 1992). The pollen assemblage at Dalcharn provides unequivocal evidence of interglacial pine forest on the Scottish mainland and the presence of till beneath the weathered gravel at Dalcharn provides proof of a glacial deposit formed prior to at least one interglacial of the Middle or Late Quaternary. This recognition of pre-Late Devensian glacial and interglacial sediment has important implications for the interpretation of

multiple till sequences throughout northern Britain, which have hitherto been attributed to the last glaciation.

The highly decomposed and consolidated 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. However, TL samples collected from a unit of white, clayey, cryoturbated gravel with disseminated peaty material taken from beneath the uppermost organic part of the Dalcharn Palaeosol have yielded maximal luminescence ages of 68 and 50 ka (Duller et al., 1995). The ages are consistent with an infinite radiocarbon date of > 41.3 ka obtained from a bulk sample of the organic unit above, but suggests that the thermophilous arboreal pollen in the palaeosol must be either allochthonous (Whittington, 1990) or reworked. Indeed, the new evidence described above suggests that two organic horizons may be present at the site (Fig. 78). The main palaeosol is unlikely to be part of a glacial raft for it is part of a coherent weathering profile within the Craig an Daimh Gravel that can be traced laterally for at least 400 m. The severity and depth of the weathering profile (over 3 m) begs comparison with the Troutbeck Palaeosol in Cumbria, England (Boardman, 1985), which is also of complex origin, but likely to be the result of a considerable period of temperate conditions including the Ipswichian and earlier interglacials.

The biogenic deposits have been affected by severe post-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 underlying gravel indicates that both the lower units have also been affected by glaciotectonic disturbance (Figs. 74 & 75).