

ALLT ODHAR

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Highlights

The stream section at Allt Odhar contains a bed of peat preserved within a sequence of glacial deposits. Analysis of pollen, plant-macrofossil and beetle remains, preserved in the peat, has allowed a detailed reconstruction of environmental conditions during an Early Devensian interstadial, the only one so far in Scotland to be unequivocally dated. The deposits also have significant potential for establishing a detailed glacial history of the area.

Introduction

The site (NJ 798368) is a river cliff located 16 km south-east of Inverness. It lies at c. 370 m OD immediately upstream of the confluence of the Allt Odhar and the Caochan nan Suidheig. A deposit of compressed peat was found towards the base of the section in 1988, during the systematic resurvey of Sheet 84 (Fortrose) by the British Geological Survey. The peat, which contains pollen, insect remains and plant macrofossils of interstadial affinity, occurs above a weathered till and there is at least one till higher in the sequence (Merritt, 1990c). The precise age of the peat is in some doubt, but there is a convergence of evidence suggesting that it accumulated during an Early Devensian interstadial. The close proximity of this site to the Dalcharn interglacial site (see above) is of major significance in Scottish Quaternary research. They are the first sites from the mainland of Scotland to provide evidence of wooded conditions during both an interstadial and an interglacial period of the Middle or Late Quaternary. The Allt Odhar deposits provide the most detailed record yet published from a Scottish site of vegetational change during a pre-Late Devensian interstadial (Walker, 1990b; Walker *et al.*, 1992).

Description

The lithostratigraphy in the vicinity of the Allt Odhar site, given below, is that established by Merritt (1990c), with minor modifications after Walker *et al.* (1992):

6.	Blanket Peat	up to 2 m
5b.	Sheet-wash Gravel	up to 1.5 m
5a	Carn Monadh Gravel	up to 10 m
4.	Moy Formation:	
4a.	Upper Till Member	up to 10 m
4b.	Lower Till Member	up to 6 m
4c.	Paraglacial Member	up to 2.2 m
3.	Odhar Peat	up to 0.6 m
2.	Odhar Gravel	up to 1.5 m
1.	Suidheig Till	at least 1.5 m

The lithostratigraphy is based on several sections because no single exposure reveals the complete sequence. At the Allt Odhar section (Figure 7.5) only units 1 to 4b are present.

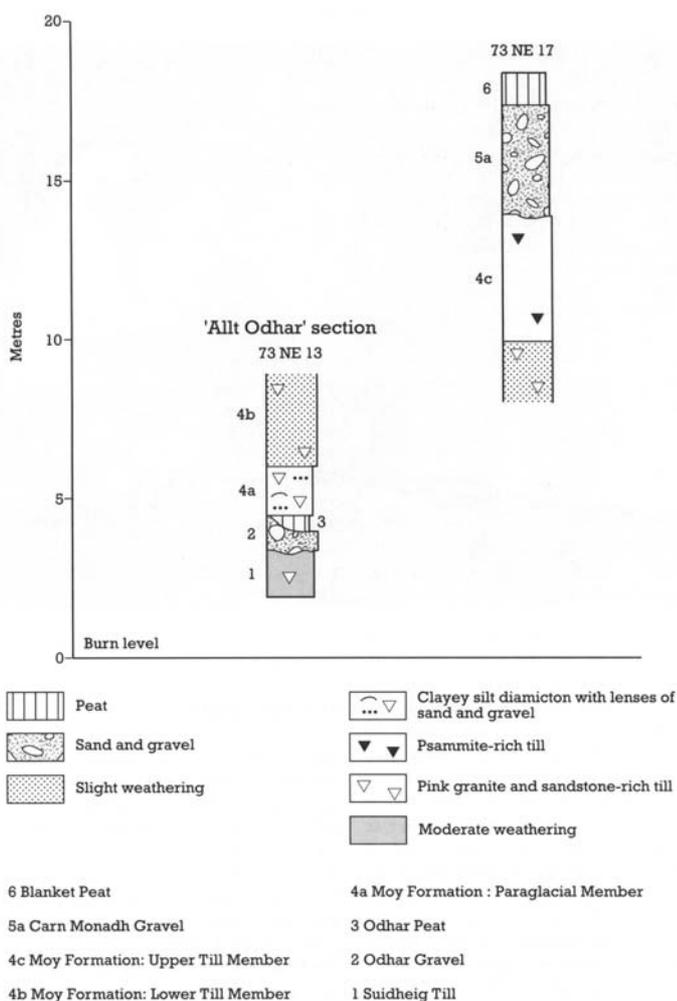


Figure 7.5: Sediment logs of the Allt Odhar and adjacent sections (from Merritt, 1990c).

The Suidheig Till (bed 1) is only recognized unequivocally at the type section, where it comprises a very stiff, light brown to moderate yellowish brown, massive, matrix-supported diamicton. Many of the clasts are decomposed and have orange weathering rinds. The nature and composition of the diamicton is similar to that of the lower till member (bed 4b) of the Moy Formation, but it is more deeply weathered.

The Odhar Gravel (bed 2) is a dense, poorly sorted, cobble gravel with a ferruginous pan towards the base. Pink granite is the dominant lithology, many clasts being unsound. The less abundant clasts of gneiss and schist are commonly decomposed. The deposit is fluvial in origin, possibly glaciofluvial.

The Odhar Peat (bed 3) (Figure 7.6) lies within a shallow depression at the top of the underlying gravel. Four distinct beds are apparent:



Figure 7.6: Section at Allt Odhar showing the Odhar Peat resting on the Odhar Gravel and overlain by the Paraglacial Member of the Moy Formation. (Photo: D. G. Sutherland.)

(i)	pebbly, peaty sand	0.2–0.3 m
(ii)	black amorphous peat with sand wisps	0.15–0.3 m
(iii)	compressed, felted, fibrous peat	0.35 m
(iv)	interlaminated sand and peat	0.2 m

The sand is generally bleached and the deposit as a whole most probably accumulated in a soligenous mire (Walker, 1990b). The results of pollen analysis on the Odhar Peat are reported by Walker (1990b) and Walker *et al.* (1992). Three pollen assemblage zones are recognized (Figure 7.7). A small number of plant macrofossil types were also recovered (*cf. Campanula* sp. (p), *Carex* sp. (p), *Cenococcum geophilum* (Fr.), *Montia fontana* ssp. *fontana* L., *Selaginella selaginoides* (L.) Link and *Viola* sp. (p.) (Walker *et al.*, 1992).

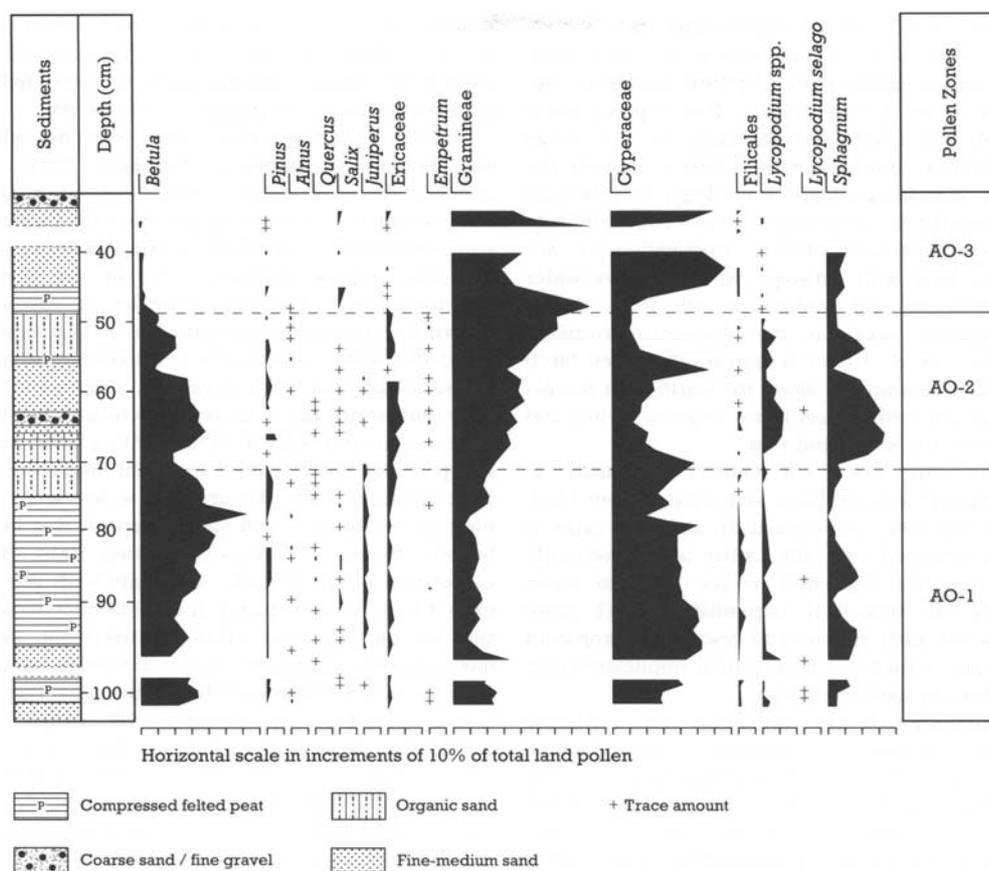


Figure 7.7: Relative pollen diagram for the Odhar Peat, showing selected taxa as percentages of total land pollen (from Walker, 1990b).

The lower part of the deposit (beds iii and iv) has yielded the remains of 31 taxa (23 species) of fossil insect (Coleoptera) (Walker *et al.*, 1992). The species generally show a preference for humus-rich or peaty soils or damp habitats (e.g. *Patrobus assimilis* Chaud., *Pterostichus diligens* (Sturm) and *Diacheila polita* Fald.), including deciduous woodland (*Pterostichus niger* (Schall.) and thinly wooded environments with drier soils (*Calathus melanocephalus* (L.)). Five are no longer present in Britain (*Diacheila polita* Fald., *Helophorus cf. glacialis* Villa, *Olophrum boreale* (Payk.), *Euconecosum norvegicum* Munst. and *Boreaphilus henningianus* Sahlb.) but occur to-day in Fennoscandia. *Diacheila polita* Fald. is characteristic of tundra environments, but also occurs on the northern margins of the boreal forest.

Radiocarbon dating of samples from near the base of bed (iii) and from near the top of bed (ii) in both cases gave age estimates >51,100 BP (SSR-3677 and SSR-3678), indicating that the materials are older than the upper limit of radiocarbon dating (Harkness, 1990). A uranium-series disequilibrium age estimate of 124 ka + 13 ka was initially obtained on a sample of peat from bed (iii) (Heijnis, 1990). Subsequently, based on additional measurements, a revised estimate of 106 ka + 11/-10 ka was obtained (Walker *et al.*, 1992).

The Moy Formation comprises two till members and a paraglacial member. The paraglacial member (bed 4a) is an extremely compact unit of pebbly clayey silt diamicton and silty sand with lenses of sand and gravel. The upper and lower contacts of the member are gradational, and there is evidence that the deposits have been consolidated and sheared subglacially. The unit was probably originally deposited by debris-flow processes, either proglacially or in periglacial conditions prior to the arrival of glacier ice.

Throughout the area, a psammite-rich till (bed 4c) overlies a pink granite and sandstone-rich one (bed 4b). Both tills are lodgement tills as defined by Dreimanis (1989). The upper till member (bed 4c) comprises very stiff, olive grey to pale olive grey, massive, matrix-supported diamicton. The lower till member (bed 4b) is more sandy, its colour varies from moderate yellowish brown to pale olive grey and it contains clasts with orange weathering rinds. There is no unequivocal evidence that the upper and lower members formed in more than one glacial

episode, but the generally greater degree of weathering of the latter may indicate that it is the product of an earlier glaciation.

The Carn Monadh Gravel (bed 5a) appears to be restricted to the valley of the Allt Odhar. It mainly comprises thinly bedded silty sandy gravel with distinct planar subhorizontal stratification and it was probably deposited in ice-marginal fans as the higher ground became free of ice during deglaciation. The Sheet-wash Gravel (bed 5b) is a coarse, poorly sorted deposit that caps most of the river cliffs in the area. The overlying blanket peat (bed 6) contains pine stumps near the base.

Interpretation

The results of pollen analysis on the Odhar Peat (Walker, 1990b; Walker *et al.*, 1992) reveal that a landscape of birch woodland, with juniper and willow scrub interspersed with open grassland (pollen zone AD-1), was replaced first by grassland and heathland (zone AD-2) and then by an open landscape dominated by species-poor grass and sedge communities (zone AD-3). The pollen record reflects an episode of climatic amelioration, followed by a decline in temperature accompanied, perhaps, by a shift to wetter climatic conditions, and finally to a markedly more severe climatic regime. The scarcity of pine pollen, relatively low arboreal pollen counts, the absence of thermophilous taxa and the presence of herbaceous taxa with northern or montane affinities all indicate a climatic regime markedly cooler than that of a full interglacial. This conclusion is strongly supported by analysis of the fossil Coleoptera, which suggests a cool to cold climate similar to that occurring in the birch zone of the Scandinavian mountains, with mean July temperatures a little above 10°C and colder winters than at present (Walker *et al.*, 1992). The pollen and insect data taken together strongly indicate that the Odhar Peat is more likely to have formed during an interstadial than an interglacial.

The radiocarbon dates from near the base and the top of the Odhar Peat indicate that the deposit is older than Middle Devensian (Harkness, 1990). Hence, it pre-dates organic remains from a number of previously published Scottish Devensian interstadial sites, including Tolsta Head on Lewis (von Weymarn and Edwards, 1973), Sourlie near Glasgow (Jardine *et al.*, 1988) and Crossbrae Farm near Turriff in north-east Scotland (Hall, 1984b; Hall and Connell, 1991), from which finite dates in the range 22,000–29,000 BP have been obtained. The relatively high frequencies of birch pollen in the spectra from Allt Odhar also suggest that the Odhar Peat is different in age from organic horizons at Teindland (Edwards *et al.*, 1976), Burn of Benholm (Donner, 1979) and Abhainn Ruaival on St Kilda (Sutherland *et al.*, 1984), where the radiocarbon dates were either infinite or best regarded as minimal (Sutherland, 1984a), and where the pollen shows evidence only of open grassland.

The uranium series date of *c.* 106 ka on the Odhar Peat places it firmly in the Early Devensian (Walker *et al.*, 1992). The interstadial episode may therefore be the terrestrial equivalent of Oxygen Isotope Substage 5c of the ocean record which has been dated using the technique of 'orbital tuning' to 103.29 ± 3.41 ka (Martinson *et al.*, 1987). On the basis of the uranium series date and the pollen and insect evidence, Walker *et al.* (1992) have argued that the nearest correlative of the Odhar Peat is the interstadial deposit at Chelford in Cheshire (Simpson and West, 1958; Coope, 1959). This deposit has a thermoluminescence (TL) date in the range 90–100 ka (Rendell *et al.*, 1991), and on the basis of amino acid geochronology, the Chelford Interstadial is considered to correlate with Substage 5c (Bowen, 1989). Correlation of Allt Odhar peat with Substage 5c also allows wider comparisons with pollen records from similar interstadial sites on the European mainland (Walker *et al.*, 1992). It appears that open birch forest predominated along the north-west margin of Europe, with boreal forest of pine, spruce and birch to the south and east.

The date from Allt Odhar is broadly in agreement with uranium series dates from Chelford, but other provisional TL and OSL dates at both Chelford and Allt Odhar are significantly younger than indicated by the uranium series dating (H. McKerrell, unpublished data). More work is clearly required to resolve this apparent anomaly, which has far-reaching implications for Quaternary geochronology.

Psammite-rich till containing few sandstone erratics commonly overlies diamictons with abundant clasts of sandstone and flagstone over the high ground flanking the coastal lowlands

of the Moray Firth between Inverness and Nairn. This relationship was first recognized by Fraser (1880) in Strathnairn and it was substantiated during the primary geological survey of the Inverness area (Horne, 1923). It is clear that material derived from outcrops of Old Red Sandstone along the Moray Firth coast and around Loch Ness was transported eastwards and upwards on to the highest ground in the area (Sissons, 1967a). The final movement of ice, however, was towards the north-east, as indicated by the orientation of glacial striae, streamlined landforms and the clast composition of the youngest, psammite-rich tills (Merritt, 1990a). The precise ages and interrelationship of the psammite-rich and sandstone-rich tills are still unclear, but it is now certain at the Allt Odhar site that both are Devensian in age. The greater degree of weathering of the sandstone-rich till suggests that it could be an Early Devensian deposit, and the psammite-rich till a Late Devensian deposit. The Suidheig Till is almost certainly pre-Devensian in age. The Suidheig Till, together with the Dearg Till (?Anglian) at Dalcharn, are the only definite pre-Devensian tills known in mainland northern Scotland (cf. Worsley, 1991). The sections in the vicinity of the Allt Odhar site and those at Dalcharn offer particularly good opportunities to test new methods of dating on glacial sediments.

The Allt Odhar site is a critical reference site for Quaternary studies in Scotland. First, it contains the most detailed pollen record so far for vegetation change during a pre-Late Devensian interstadial in Scotland. Second, it includes the only organic deposits dated to the Early Devensian and therefore provides a unique record of environmental conditions at that time. Third, the pollen record is the first to demonstrate unequivocally that birch woodland, as opposed to grass and heathland, occurred in Scotland during a Devensian interstadial. Fourth, Allt Odhar has also provided the first pre-Lateglacial insect fauna from Scotland. Fifth, the uranium series date on the peat is the first from such a deposit that lies beyond the age of radiocarbon dating. Sixth, the correlation of the organic sediments with those from Chelford in England and with interstadial sites on the European mainland makes the site internationally important for establishing wider patterns of vegetation and climate during Oxygen Isotope Substage 5c. Seventh, Allt Odhar is notable for its sequence of glacial deposits. It is one of only two sites in mainland northern Scotland where pre-Devensian tills can be demonstrated. In addition, there is significant potential for further research, which may allow the establishment of Early Devensian glaciation in northern Scotland.

Conclusions

Allt Odhar is a site of great importance for Quaternary studies in Scotland. A bed of peat within a sequence of glacial deposits has yielded pollen and beetle remains that provide, so far, unique evidence for environmental conditions during the Early Devensian (around 106,000 years ago). They show a climatic determination and also that a landscape of birch woodland gave way to a more barren one with grass and sedge communities as the climate deteriorated. The site is also notable for older, pre-Devensian, glacial deposits, one of only two sites in northern Scotland where such deposits are known, and also a further till at the locality may be of Early Devensian origin.

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