North-west coast of Lewis

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Highlights

The landforms and deposits on the coast of north-west Lewis provide important evidence for interpreting the patterns of sea-level change and glaciation in an area located towards the periphery of the main centres of glaciation. Part of the area remained ice-free throughout the Late Devensian.

Introduction

This site comprises a series of sections and landforms along a 16 km stretch of the northwest coast of Lewis, from Cunndal [NB 512 655] to Cladach Lag na Greine [NB 387 557]. These have long provided some of the most important evidence for interpreting the Pleistocene history of the Outer Hebrides (J. Geikie, 1873, 1874, 1877, 1878; Baden-Powell, 1938; McCann, 1968; von Weymarn, 1974, 1979; Peacock, 1984a, 1991; Sutherland and Walker, 1984). The interest comprises a fossil shore platform, pre-Holocene raised beach deposits, peat (?interglacial), till, complex glacigenic sediment sequences and solifluction deposits. Together these features are of the very highest importance for studying glaciation and sea-level change in an area which has a fundamental bearing on the wider understanding of ice-movement patterns, ice sources, ice extent and climatic conditions in north-west Britain during the Pleistocene.

Description

Early descriptions recognized an essentially tripartite sequence in the area of Swainbost [NB 500 635], comprising sands, gravels, clays and silts interbedded between two tills, with shells present in each of the layers (J. Geikie, 1873, 1874, 1877, 1878; Baden-Powell, 1938). However, more recent work has shown a much more complex succession of landforms and deposits represented at a number of localities along the coast (Figure 12.2). The principal features in the currently recognized sequence are as follows:

5. Till in the south and north; head and soliflucted till in the central part; multiple drift deposits at Swainbost.

4. Raised beach deposits with a cryoturbated upper horizon.

3. Head.

2. At different locations the shore platform is overlain by till and by peat; the relationship of the till to the peat is undetermined.

1. A raised shore platform and cliffline.

The oldest marine feature clearly recognizable is a low-level (7–10 m OD) raised shore platform and cliffiine (Godard, 1965; McCann, 1968; von Weymarn, 1974). It occurs discontinuously in north-west Lewis and on the Eye peninsula (Figure 12.1) but is best seen between Galson [NB 453 603] and Dell [NB 472 621] where it attains a width of 150 m (McCann, 1968; von Weymarn, 1974). As described by von Weymarn (1974), the principal features of the platform are:

1. it is cut across the bedrock structure;
2. its seaward margin is sometimes covered in modern sand and shingle;
3. there is often a step down to a lower intertidal shore platform;
4. zones of weathered rock occur on its surface;
5. its landward margin is typically drift covered;

6. it is widest in embayments and narrows towards headlands where the backing cliff is best seen (e.g. at the mouth of the Dibadale Burn at [NB 470 615] — McCann, 1968);
7. abandoned stacks occur on its surface;
8. its distribution is largely confined to the area outside that of local glaciation in Lewis; a few remnants within the latter area are severely ice-modified.

Resting on the shore platform is a complex succession of deposits. In part, following von Weymarn (1974), these can be grouped into four units:

1. Raised beach deposits associated with till. Raised beach deposits form an important stratigraphic marker and were first identified at Galson, where they appear to overlie till (Baden-Powell and Elton, 1937). Baden-Powell and Elton noted that Torridonian sandstone erratics were present in the beach deposits but absent from the till. The occurrence of the beach has since been identified intermittently along the whole coast (Figure 12.2) (McCann, 1968; von Weymarn, 1974; Peacock, 1984a). From the height of the one beach terrace of any extent at Galson, McCann (1968) inferred a maximum sea level of 32–37 ft (9.8–11.3 m) OD. At several localities the upper layers of the beach deposit are cryoturbated. In addition to Galson, the raised beach deposits overlie till at Cladach na Luinge [NB 465 611], Toa Dibadale [NB 469 615], Cunndal and Swainbost (McCann, 1968; von Weymarn, 1974; Peacock, 1984a). In contrast, in the southern part of the site, to the south of Breivig [NB 414 582], a separate till overlies the raised beach deposits.
2. Raised beach deposits associated with head and soliflucted till. Between North Galson [NB 438 595] and Breivig, soliflucted till and head overlie the raised beach deposits; in other places the beach and soliflucted deposits are interbedded, for example at South Galson [NB 431 591] and Cunndal.
3. At Toa Galson [NB 453 603] an organic deposit interbedded with sand occurs above the shore platform and is overlain in turn by head and raised beach gravels (Figure 12.3) and (Figure 12.4). The organic deposit yielded radiocarbon dates greater than 39,100 to 47,150 BP (SRR–2365) (Sutherland and Walker, 1984). The pollen spectra (Figure 12.5) indicate development of the vegetation from treeless, open grassland to grassland with acid heath.
4. Complex successions often referred to as multiple drift deposits. These occur in the Swainbost–Dell area and comprise interbedded till, sand, gravel, laminated clay and silt beds. Historically, they were described by J. Geikie (1873, 1874, 1877, 1878) and Baden-Powell (1938), who both recognized a tripartite sequence comprising sand, gravel, clay and silt interbedded between two till layers. Although more recent references acknowledge the complexity of the sequence (von Weymarn, 1974; Peacock, 1984a), there have been no detailed sedimentological studies. The deposits are glaciotectonically disturbed (J. Geikie, 1877; von Weymarn, 1974; Flinn, 1978b) and are rich in broken shell fragments. A faunal list published by Etheridge (1876) was updated by Baden-Powell (1938). According to Etheridge the faunal assemblage included species of arctic affinity (e.g. *Astarte depressa* (Brown) and *Chlamys islandica* (Müller) and northern affinity (e.g. *Nuculana pernula* (Müller), *Arctica islandica* (L.), *Saxicava norvegica* (Spengler), *Natica montacuti* (Forbes) and *Fusus gracilis* (Da Costa); Baden-Powell inferred that only the upper till of the tripartite sequence contained a diagnostic faunal assemblage (e.g. including *Astarte borealis* (Chemnitz), *Mya truncata* (L.), and *Panomya norvegica* (Spengler), indicating cold-water conditions. Radiocarbon dates on shells from the middle or lower layers of these deposits yielded ages of between 34,470 +720/–660 BP and 39,500 +1270/ –1100 BP (inner fractions) (SRR–2368 to SRR–2370) (Sutherland and Walker, 1984). Amino acid analyses of fragments of *Arctica islandica* from the same beds indicated that the shells were from at least two distinct periods. The older group (6 analyses) had alle/Ile ratios of 0.114 ± 0.007 and the younger group (9 analyses) had alle/Ile ratios of 0.079 ± 0.013 (D. G. Sutherland, unpublished data). Ratios from similar analyses on *Arctica islandica* from the last interglacial in the British Isles are 0.15–0.16 (Bowen and Sykes, 1988), indicating that the shells from northwest Lewis are Early and Middle Devensian.

Interpretation

Interpretations of the evidence in north-west Lewis fall into two main groups. The earlier accounts were focused on the drift sequences at Swainbost; later accounts have placed greater emphasis in the wider succession and its spatial variations.

In an early reference to the 'alluvial land' of north Lewis, McCulloch (1819) described superficial accumulations of 'clay and marle, together with a mixture of rolled stones of different kinds'. From their lithological composition he believed they were derived from the gneissic rocks of the mountains but was unable to suggest a mode of derivation.

Initially, from analogies with Greenland glaciers, J. Geikie (1874, p. 215) hinted that sequences such as the multiple drift deposits in north Lewis could have been laid down in a single episode at or near the front of a glacier terminating in the sea (see also J. Geikie, 1877, p. 185 footnote).

Later, however, he interpreted the middle beds of the tripartite sequence as 'interglacial' marine deposits (Geikie, 1878) and postulated a succession of glacial and non-glacial episodes and relative sea-level fluctuations to explain the development of the full sequence over a much longer time-scale (J. Geikie, 1877, 1878).

Geikie (1878) noted the restricted distribution of the shelly till and interbedded deposits. He believed that the latter had once been more extensive but had been removed by the ice which deposited the upper till; the shelly till was confined to the area where basal ice, deflected by the Hebridean land mass, impinged on its northern periphery.

Subsequently, Jehu and Craig (1934) and Baden-Powell (1938) acknowledged Geikie's interpretation of interglacial submergence. Baden-Powell suggested that the submergence was at least 17 m and possibly as much as 60 m, the latter value corresponding with one of the planation surfaces identified by Panzer (1928). Godard (1965) largely concurred, but raised the question as to whether the altitude of the marine deposits might simply reflect older marine material reworked by glacial meltwaters. More recent interpretations, however, are agreed that the multiple drift deposits of north-west Lewis are glacigenic in origin and were formed during a single glacial episode (von Weymarn, 1974; Flinn, 1978b; Peacock, 1984a; Sutherland and Walker, 1984).

Based on what was the first systematic account of the landforms and deposits in north-west Lewis, von Weymarn (1974) inferred a possible sequence of events commencing with formation of the raised shore platform during one or more pre-Devensian interglacials. The platform was overridden by glacier ice from the east and buried by till containing Torridonian sandstone erratics. During the Ipswichian, relative sea level rose by around 7 m and the earlier till was reworked. During the Devensian glacial phases the raised beach gravels were overridden to the south of Borve by a local ice-cap on Lewis, but the coast to the north remained free of ice and subject to intense periglacial activity. The multiple drift deposits probably related to external ice in the north of Lewis during the Late Devensian.

Alternative suggestions were made by Jardine (1977) that the beach deposits could date from the Loch Lomond Stadial rather than the Ipswichian, and by Dawson (1979c) that the solifluction deposits could be of Loch Lomond Stadial age and the beach formed earlier during the Lateglacial. Flinn (1978b) inferred that the multiple drift deposits at Swainbost were deposited prior to the last glacial maximum, when the northern part of Lewis was covered by relatively inactive ice near the margin of the local ice-cap. However, subsequent work by Peacock (1981a, 1984a) and Sutherland and Walker (1984) has substantially confirmed von Weymarn's interpretations and elaborated on the details. Peacock (1981a, 1984a) identified possible limits of the Late Devensian ice in north-west Lewis. The northern limit of the local ice-cap was at Breivig. The limit of the external ice to the north was more difficult to define and he presented two alternative positions. The critical problem concerned the stratigraphic relationship of the raised beach to the multiple drift sequence at Swainbost. Peacock considered that the beach lay above the latter and therefore favoured a relatively small ice-covered area, leaving the coast between Breivig and the Butt of Lewis unglaciated. The alternative explanation that a lobe of ice crossed the coast in the Swainbost area was considered less probable because of the inferred stratigraphic relationship of the raised beach and multiple drift sequence.

Sutherland and Walker (1984) produced a different interpretation of the stratigraphy from that of von Weymarn and Peacock, concluding that the multiple drift sequences on the northwest coast lay stratigraphically above the raised beach. A Late Devensian age for the multiple drift sequence is supported by the radiocarbon dates and amino acid analyses on the shells from the glacial deposits. Therefore the coast between Eoropie and Dell Sands, where the multiple drift sequences occur, was covered by the last ice-sheet, confirming Peacock's alternative hypothesis.

The radiocarbon dates from the peat beneath the raised beach at Toa Galson confirm the antiquity of the deposit. Sutherland and Walker (1984) tentatively considered it to be of interglacial origin although there is no evidence to assign it to a particular stage. Significantly, the pollen spectra differ from those associated with the interstadial sites at Tolsta Head (see below) and St Kilda (Sutherland *et al.,* 1984), both of which produced finite radiocarbon dates.

North-west Lewis is therefore an area of the highest importance for demonstrating a series of glacial, periglacial and marine events of Devensian and possibly pre-Devensian ages. In sequence, the key elements are as follows:

6. Late Devensian features, including till limits, shelly multiple drift sequences and ice-free areas with associated periglacial deposits.

5. Raised beach deposits (pre-Late Devensian).

4. Periglacial deposits.

3. Organic deposits, possibly interglacial (predating the raised beach deposits).

2. Till (pre-dating the raised beach deposits).

1. Raised shore platform of pre-Devensian age.

Key localities within the site are as follows:

1. Cunndal, where till is overlain by a raised beach, which is succeeded by soliflucted till. Cunndal lies outside the Late Devensian ice margin.
2. Traigh Sands [NB 511 644] to Peicir [NB 485 625], which includes a raised beach and the classic shelly multiple drift sequences now dated as Late Devensian in age.
3. Aird Dell to Toa Galson, which demonstrates the sequence of shore platform, till and raised beach outside the Late Devensian ice limit.
4. Immediately south of Toa Galson organic deposits occur between the shore platform and the raised beach.
5. Farther south, between North Galson and Breivig, the raised beach terrace is best developed and is overlain by soliflucted till and head.
6. At Breivig the Late Devensian ice limit crosses the coast and till overlies the raised beach here and to the south.
7. At Cladach Lag na Greine the raised beach rests on a shore platform and is overlain by till. Locally, where the platform rises above the beach deposit, it is striated, which provides important evidence that the beach was overridden by glacier ice and is overlain by *in situ* lodgement, rather than soliflucted till.

The assemblage of deposits and landforms represented at these localities is unique in Scotland and has significant bearing on the interpretation of the Pleistocene history and chronology of events in north-west Britain, including sea-level change, glacier reconstruction, palaeoclimatology and vegetational history. For example, as Sutherland and Walker (1984) point out, conventional models of the last Scottish ice-sheet require reassessment in the light of the evidence from north-west Lewis. The presence there of an ice-free area indicates a relatively restricted extent of the last ice-sheet in Britain at its north-west margins, which contrasts with some recent reconstructions that placed the margin on, or near, the edge of the continental shelf (Boulton *et al.,* 1977, 1085; Andersen, 1981). It also supports a growing body of evidence (see Orkney, Caithness and North-east Scotland) that the northern margins of the last ice-sheet may have been relatively limited in extent in contrast to the southern margins which reached south into South Wales, central England and the north coast of East Anglia. Sites such as the north-west coast of Lewis therefore provide critical field evidence to constrain and refine mathematical models of the last ice-sheet and the palaeoclimatic inferences derived from them.

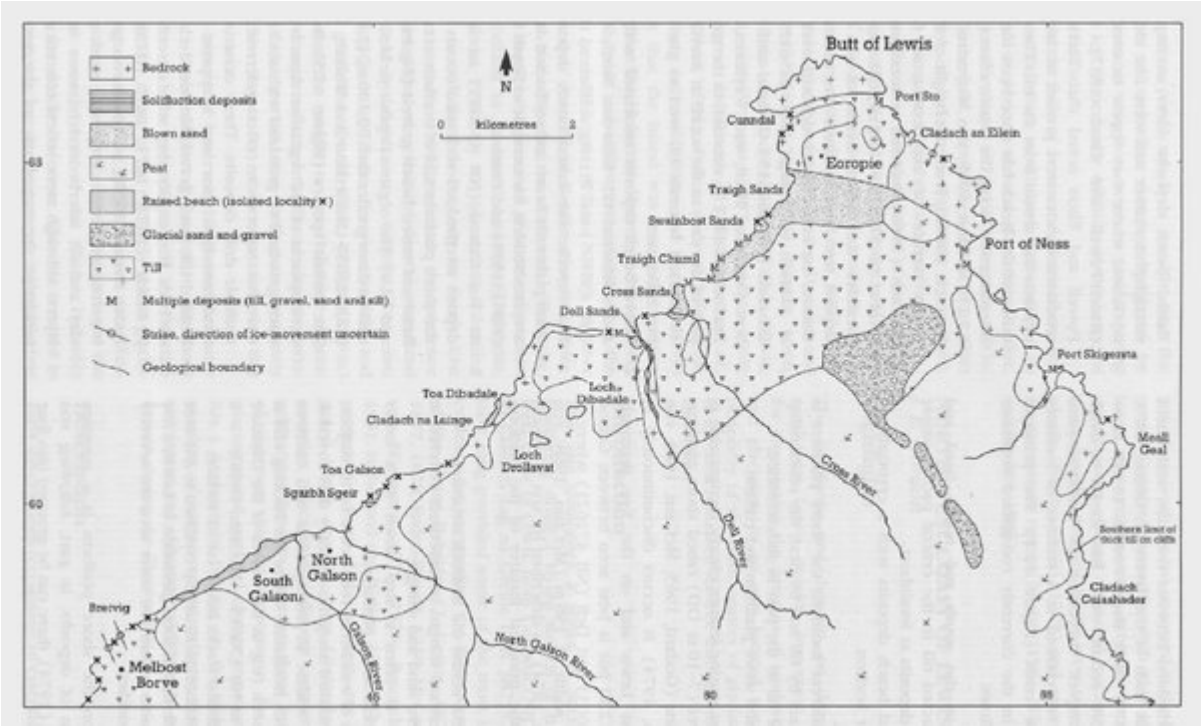
North-west Lewis is also unique in Scotland in providing unequivocal evidence for a Late Devensian ice-sheet limit on land and therefore provides exceptional opportunities for comparative studies of pre-Late Devensian and post-Late Devensian rates of weathering and soil development. Further, north-west Lewis is one of only a few sites in Scotland where interstadial or possibly interglacial organic deposits are represented. As such it is of the very highest importance

for palaeoecological and palaeoenvironmental studies. Finally, the multiple drift deposits of north-west Lewis are of significant sedimentological interest for interpreting and reconstructing the depositional environments at the margin of the Late Devensian ice-sheet.

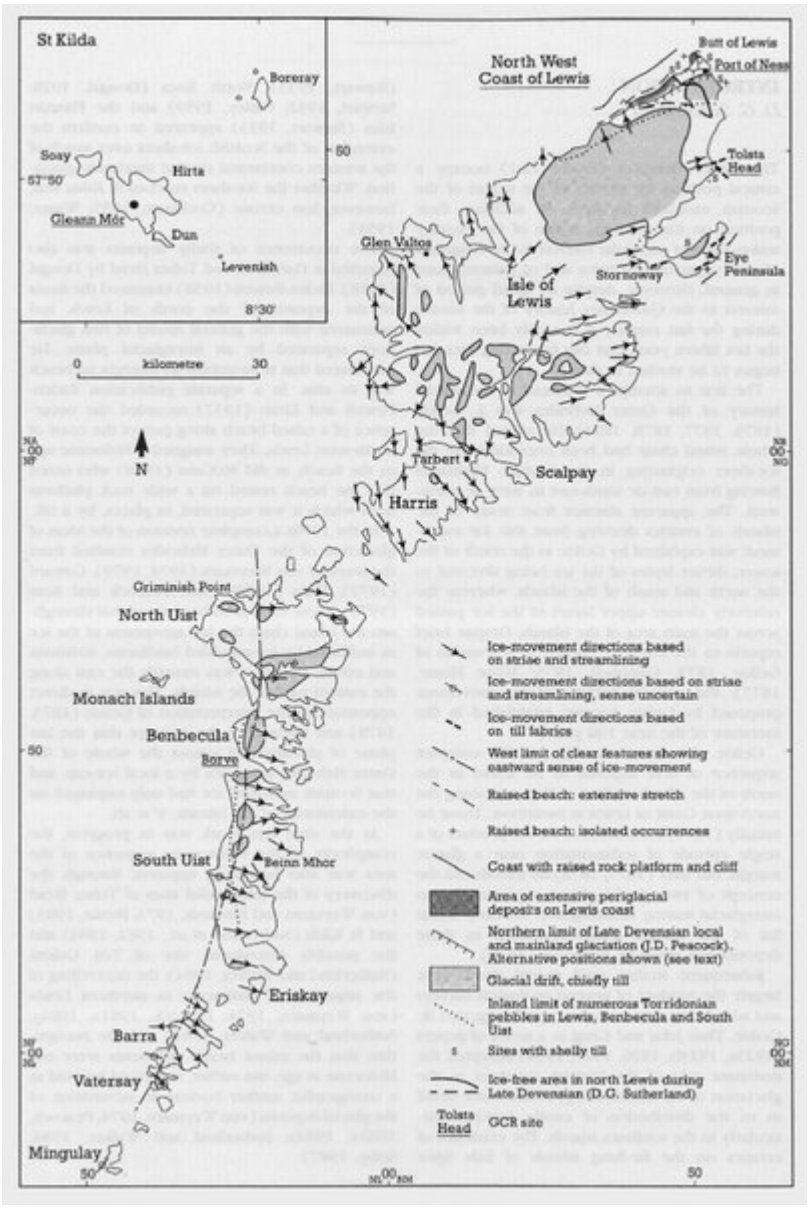
Conclusion

The unique assemblage of landforms and deposits on the north-west coast of Lewis has a long history of research and has provided critical information for interpreting the Pleistocene in Scotland. Among the key features of interest are a pre-Devensian shore platform, a pre-Late Devensian raised beach, organic deposits of possible interglacial origin, solifluction deposits and a complex sequence of fossiliferous sediments deposited by the Late Devensian ice-sheet (approximately 18,000 years ago). This area therefore provides a wealth of evidence for interpreting patterns of sea-level change, palaeoenvironmental conditions and ice-sheet history. One of the key findings to emerge from recent work is that part of the area remained ice-free when the Late Devensian glaciation was at its maximum extent (about 18,000 years ago).

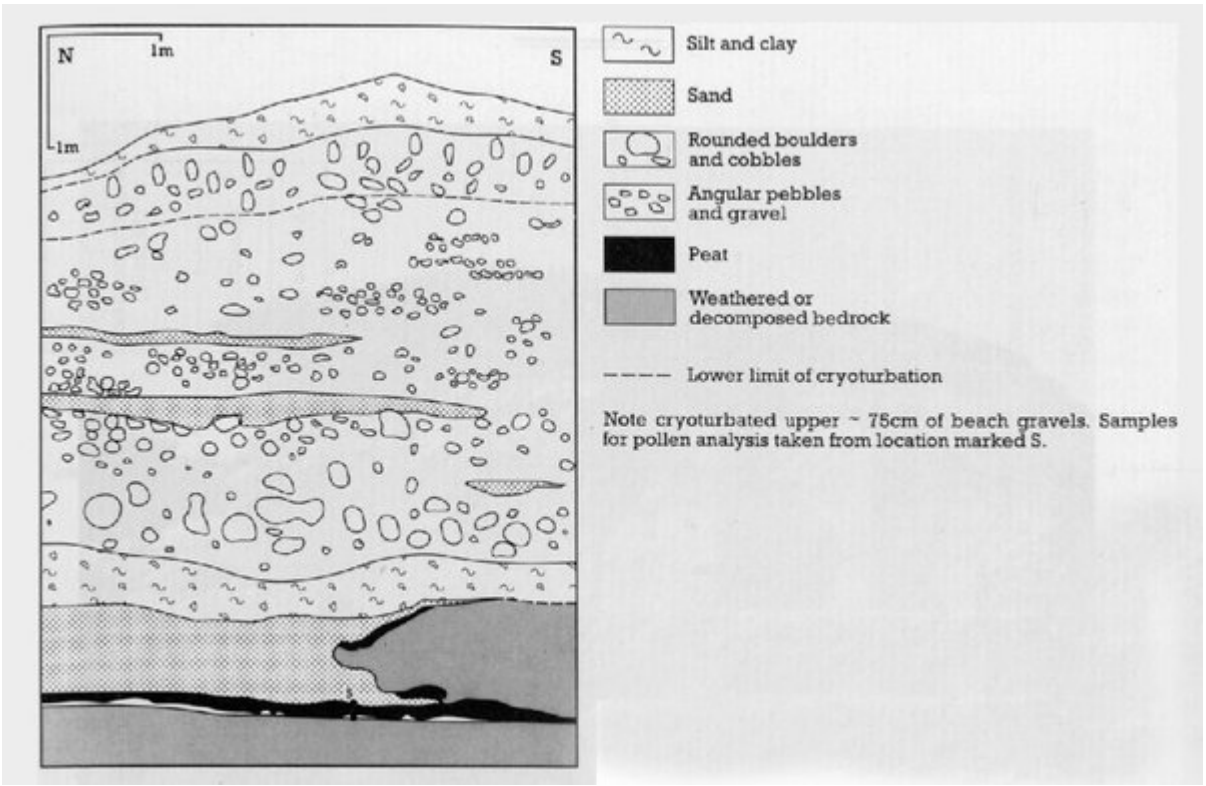
References



(Figure 12.2) Quaternary deposits of north-west Lewis (from Peacock, 1984a).

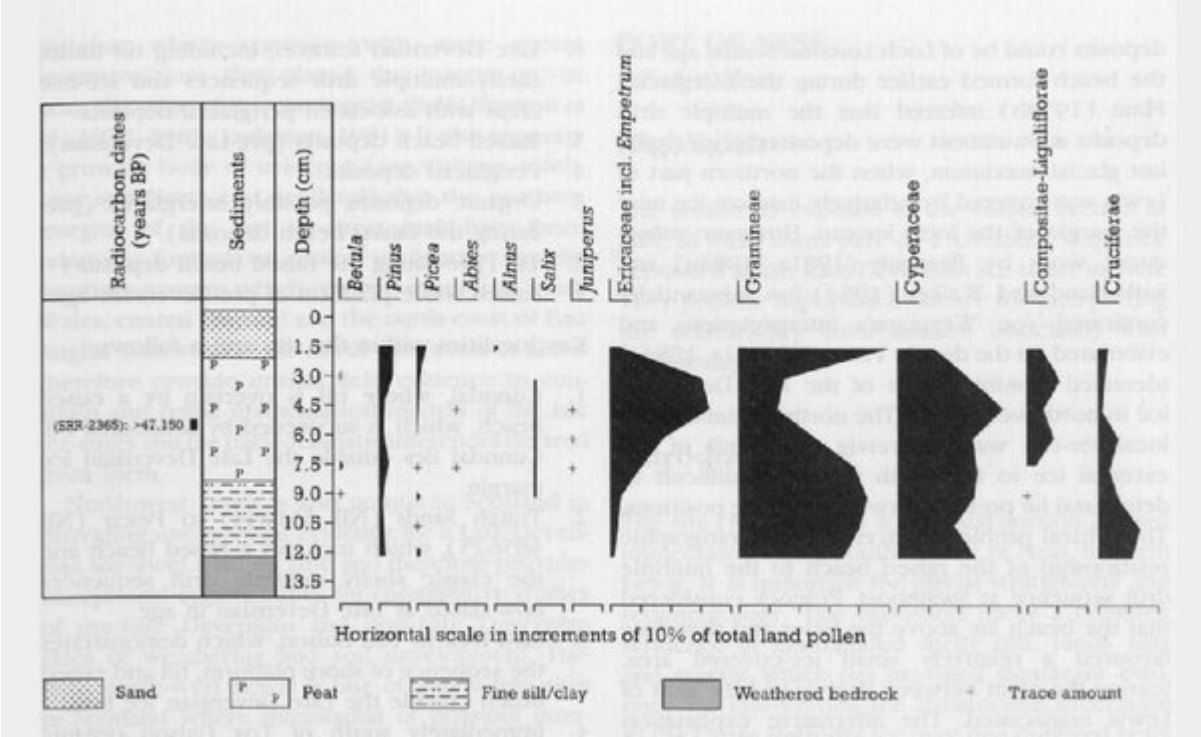


(Figure 12.1) Location map and principal Quaternary features of the Outer Hebrides (from Peacock, 1984a).



(Figure 12.3) Toa Gilson: sequence of sediments (from Sutherland and Walker, 1984).

(Figure 12.4) Section at Toa Galson, north-west Lewis, showing the interglacial peat resting on bedrock and overlain by sand, head and the Galson Beach deposits. The upper part of the beach deposits has been affected by cryoturbation. (Photo: D. G. Sutherland.)



(Figure 12.5) Relative pollen diagram for the peat deposit at Toa Galson showing selected taxa as percentages of total land pollen (from Sutherland and Walker, 1984). The location of the sample is shown in Figure 12.3.