Lleiniog

Highlights

An historical site where the tripartite (till-sand and gravel-till) Pleistocene sequence was recorded. Its glacigenic sediments record the wastage of Devensian ice and a subsequent advance of Irish Sea ice.

Introduction

Irish Sea till and fluvioglacial sediments exposed in coastal cliffs at Lleiniog [SH 619 787] form a complex sequence important to the understanding and elaboration of Late Pleistocene events both in Anglesey and North Wales. Indeed, Greenly (1919) remarked that the deposits at Lleiniog formed "the most complex and striking drift section on the island". The sequence is of particular importance in displaying possible evidence for sequential wasting of the Late Devensian ice-sheet (Helm and Roberts 1984). According to Greenly (1919), Lleiniog was also notable for the two largest erratic blocks found on Anglesey, one measuring 24 ft x 10 ft x loft (7.3m x 3m x 3m). The site was described as early as 1831 by Trimmer, and it has since featured in studies by Edwards (1905), Greenly (1919), Embleton (1964c), Whittow and Ball (1970), Walsh *et al.* (1982) and Helm and Roberts (1984).

Description

The principal sections occur on the east coast of Anglesey, south of Lleiniog, and extend south from the mouth of Afon Lleiniog for about 500m, reaching a maximum height of about 12m. Exposures of Quaternary sediments form the low cliffs and foreshore at Trwyn y Penrhyn and can also be found on the foreshore near Gored-bach lifeboat station. The most extensively exposed sediments occur in cliff sections, and in plan on the foreshore, just to the south of the mouth of Afon Lleiniog. The succession consists of well stratified outwash (the Lleiniog Gravels of Greenly (1919)), overlain by a more homogenous, unstratified, red Irish Sea till.

Helm and Roberts (1984) divided the gravel and sand deposits at Lleiniog into two units; a lower Grey-brown Sand and Gravel Member (bed 1), and an upper Red-brown Sand and Gravel Member (bed 2). Bed 1 crops out only towards the base of the cliff, where it reaches a maximum thickness of about 2.5m, and also extensively in plan on the foreshore where the sediments are arranged in a series of ridges and troughs. These gravels are poorly sorted, sparsely cemented with calcite, and they contain a wide variety of rock types from two principal source areas. The first group includes granites from southern Scotland; Carboniferous limestones, sandstones, siltstones, shales and cherts; red millet-seed sandstones of Permian or Triassic age; pale chert and flint; and black, probably Tertiary, basalt. Such an assemblage indicates an origin from northern Britain and the Irish Sea Basin together with some local material from the immediate vicinity of Anglesey. A second group of rock types includes clasts of flow-banded devitrified rhyolite, welded tuff, extensively altered dolerite, altered microgranitoid, cleaved, plagioclase-rich greywacke and a few fragments of soft slate. The rhyolite fragments can be matched with those on Conway Mountain, and the rest of this Lower Palaeozoic assemblage is also consistent with derivation from the Conway hinterland (Helm and Roberts 1984).

The overlying sediments (bed 2) reach a maximum thickness of about 6m and rest on an irregular, undulating and channelled surface cut into bed 1. These infilled channels range from 1–60m in width and the largest extends to an estimated depth of about 2–3m below the modern beach at the base of the cliff. The fill of the channels is highly variable, from cobbly pebble gravels to very well sorted sand, and some channels, especially the smaller ones, have been modified by syn-depositional faulting. The most striking example of this faulting occurs immediately west of a large sea-stack, where the channel margins are bounded by faults which clearly post-date deposition of the infill. The clast assemblage from this bed is essentially similar to that in bed 1 beneath, and the very well sorted sands in this deposit consist mainly of iron-stained millet seed sand grains derived from Permian-Triassic (quartz) sandstones (Helm and Roberts 1984).

The overlying till (bed 3) reaches a maximum thickness of about 4.5m and overlies bed 1 directly in the northern part of the sections and bed 2 to the south. The till is generally poorly sorted although it contains a number of stratified lenses of silt and fine sand. The junction between the till and the gravels beneath is frequently marked by a boulder bed, interpreted by Helm and Roberts (1984) as washed, matrix-free till. Boulders up to 1.5m across occur in the till, and many larger boulders occur on the foreshore which have evidently been liberated from the till. The large limestone erratics recorded by Greenly (1919) and now perched on a low alluvial apron at the mouth of Afon Lleiniog, may also have originated from the till. Most boulders and cobbles in the till range from rounded to subangular in shape and comprise mostly Carboniferous rocks, mainly limestone, with a smaller proportion of farther-travelled rocks including the distinctive Ailsa Craig microgranite (Edwards 1905; Helm and Roberts 1984). Where the till directly overlies bed 1, but only there, the latter sometimes shows evidence of deformation to a depth of 1–2m, with recumbent and occasionally upright folds; although such disturbances are not found where the till overlies bed 2. Helm and Roberts (1984) noted that the till was sporadically overlain by a very fine sandy silt (bed 4) with vertical columnar joints and very few stones.

A sequence of Holocene marine sediments and submerged forest beds crops out towards the northern end of the cliff sections at Lleiniog, although these have not been studied in detail.

Interpretation

The coastal Pleistocene deposits in south-east Anglesey were described as early as 1831 by Trimmer who referred to broken shells occurring in the low coastal cliffs. Trimmer considered that, like the shelly sands and gravels of Moel Tryfan, these sediments were of 'diluvial' origin, and were deposited during a 'great flood'. The glacial origin of the beds at Lleiniog was, however, soon recognised (Edwards 1905). By 1919, Greenly had reconstructed a threefold sequence of Late Pleistocene events from lithostratigraphic evidence in Anglesey. At Lleiniog he recorded a sequence of blue till overlain by red sands and gravels, which in turn were succeeded by red till. He regarded the lower blue till as the product of Welsh ice which impinged on Anglesey only in the Menai Straits region.

This blue till has not been relocated at Lleiniog by subsequent workers, although similar deposits are known from other parts of eastern Anglesey (Whittow and Ball 1970). Greenly regarded the red sands and gravels as meltwater sediments deposited by currents flowing south-west between Welsh ice to the south-east and Irish Sea ice to the north-west. The upper red till was cited by Greenly as evidence of a readvance of the southwest moving Irish Sea ice-sheet. In contrast, Embleton (1964c) suggested that the sands and gravels were probably laid down beneath the decaying Irish Sea ice, but Whittow and Ball (1970) regarded the sediments as outwash belonging to their Liverpool Bay Phase of the Late Devensian ice-sheet. No part of the eastern Anglesey Pleistocene succession has been dated, although recently Whittow and Ball (1970), Bowen (1977a, 1977b) and Boulton (1977a) have regarded similar sequences in the region as Late Devensian in age. Alternatively, Thomas (1976) considered that Anglesey lay outside the maximum limit for Late Devensian Irish Sea ice, implying that the glacial sediments in Anglesey must be older.

Walsh *et al.* (1982) investigated the palynology and provenance of coal fragments contained in the Pleistocene sequence at Lleiniog. The coal occurs both as isolated fragments and more occasionally as hydraulic concentrates (Walsh et *al.* 1982) or 'seams' (Greenly 1919). The largest of the coal layers described by Walsh *et al.* (1982) measured about 4m long by 0.20m thick. Greenly (1919) recorded that the largest seam then exposed was 27 feet by 3 inches (8.2m x 0.076m). Walsh *et al.* (1982) established that coal clasts in the Lleiniog gravels contained a varied assemblage of early Westphalian spores. Directional data such as sedimentary structures, glacial striae and erratics trains in the local area showed the sediments had been derived from the north-east. Walsh *et al.* (1982) therefore considered, like Greenly (1919), that the coal clasts were probably derived from an, as yet, unidentified submarine coal outcrop located only a few kilometres to the north-east of Lleiniog. The possibility that the coal clasts had been derived from the breaking-up, locally, of far-travelled rafts of the Coal Measures was also discussed. Roundness studies of limestone clasts taken from the gravels showed that at the time of deposition the ice front probably lay across the eastern approaches of the Menai Straits, perhaps not more than 1 or 2 km from Lleiniog (Walsh *et al.* 1982).

In the most comprehensive account of the sections to date, Helm and Roberts (1984) reconstructed a detailed sequence of events and processes. They divided the sequence into four main members (as described earlier) which they

interpreted as the sequential products of a single downwasting Irish Sea ice lobe of Late Devensian age. They believed that bed 1 (Grey-brown Sands and Gravels) formed when subglacial streams from the ice-front, just offshore, debauched into a proglacial lake. Bed 2 (Red-brown Sands and Gravels), a series of channel sands and gravels, was deposited by proglacial streams, while bed 3 (Red-brown Till) was interpreted as a melt-out till, deposited following a readvance of the ice-front. The last member of the sequence (bed 4 — Red-brown Sand) is wind-blown material deposited in temporary pools on the surface of the till. The composition of the sediments indicates that they have mostly originated from northern Britain, the Irish Sea Basin and Anglesey, in particular the north and north-east of the island. A small but persistent input of clasts, however, occurred from the Welsh mainland, probably from the Conway area. Two alternative explanations were put forward to account for this mixture of erratics. Most likely, the mixture of erratics probably indicated a confluence of Irish Sea and Welsh ice immediately north-east of Penmon during the Late Devensian; or the locally derived erratics may have been reworked from pre-existing Welsh glacial sediments offshore (Helm and Roberts 1984).

The exposures at Lleiniog are the finest through Pleistocene glacial and fluvioglacial deposits in Anglesey, and they provide one of the most complete Late Pleistocene to Holocene stratigraphical records in north-west Wales. The site first featured in a number of pioneering studies which were fundamental to the firm establishment of the Glacial Theory in Great Britain and to the early sub-division of the Pleistocene record. Continued reference to the site has reinforced its importance for Pleistocene palaeoenvironmental studies.

In particular, the thick red till at the site provides some of the clearest evidence for the incursion onto Anglesey of ice from the Irish Sea Basin. In combination with stratigraphic reference sites elsewhere in Anglesey and in Ll■n, Lleiniog is important for establishing a network of sites that can be used to determine patterns of ice movements across north-west Wales during the Late Pleistocene.

The site is one of very few in north-west Wales where a variety of detailed sedimentological techniques has been applied to reconstructing palaeoenvironments. Lithostratigraphical and sedimentological data from Lleiniog suggest that till was deposited as a melt-out product following a readvance of the Irish Sea ice-sheet over a thick sequence of earlier proglacial sediments. Analysis of the latter have shown them to be the product of sequential downwasting of Irish Sea ice. The sections at Lleiniog are therefore important in providing some of the most detailed evidence from Wales for former glacial and fluvioglacial processes at or near the margins of an oscillating ice-sheet.

Although a Late Devensian age is probable for the glacigenic sequence at Lleiniog, it is not clear whether the till can be correlated with the upper till found in north Ll■n, where it has been interpreted as a readvance feature of the Late Devensian ice-sheet. It is conceivable that the Lleiniog till represents an even later readvance or minor oscillation of the Late Devensian Irish Sea ice-sheet. Lleiniog is therefore significant in demonstrating possible climatic complexity during the Late Devensian.

The interest of the site is further enhanced by Holocene marine and submerged forest beds which have considerable potential for palaeoenvironmental and sea-level studies.

Lleiniog provides one of the finest sequences through glacigenic sediments in north-west Wales. It shows a detailed sequence of events during a cycle of deglaciation and subsequent readvance of the Late Devensian Irish Sea ice-sheet. The site demonstrates the onshore movement of the Irish Sea ice-sheet onto Anglesey.

Conclusions

The succession of ice age sediments at Lleiniog is one of the finest in north-west Wales. It shows evidence for the cycle of glaciation and subsequent ice wastage during the last major glacial phase.

References