Moel Tryfan

Highlights

An historical site in the development of the Glacial Theory. It shows outstanding evidence for the Devensian glaciation of upland North Wales by Irish Sea ice, in the form of shelly sea-bed sediments transported to 400m above sea-level.

Introduction

Since their discovery by Trimmer in 1831, the shelly drifts of Moel Tryfan have formed a classic topic of study for glacial geologists. Indeed, as Reade (1893) stated, the site had become "a battleground of contending theories" between the "Diluvialists" and the "Glacialists". Although the theory that marine submergence accounted for the drifts was abandoned by the early twentieth century, the site has remained controversial where the origin and the dating of the sediments are concerned. The site provides unique and important evidence for Late Pleistocene events in north-west Wales, and forms a classic landmark in the development of glacial geology. The site has perhaps the longest history of research of any site in Wales, having been described and referred to by numerous workers in the last century (for example, Trimmer 1831; Buckland 1842; Ramsay 1852, 1881; Darbyshire 1863; Lyell 1873; Belt 1874; Jeffreys 1880; Mackintosh 1881, 1887; Blake 1893; Reade 1893; Greenly and Badger 1899; Hicks et al. 1899). More recently, the site was discussed by Foster (1968, 1970a), Whittow and Ball (1970) and Bowen (1977a). Amino acid ratios were provided by Davies (1988).

Description and interpretation

The shelly drift is located in the disused Alexandra slate quarry to the south-east of the Moel Tryfan summit at 426m OD. The exposures have always been endangered, particularly during the expansion of the quarry (Greenly and Badger 1899; Hicks *et al.* 1899; Greenly 1900), and the sequence of beds is far from clear. From Hicks et *al's* (1899) description of the stratigraphy, it appears that the shelly sands and gravels probably occurred as a large wedge between till deposits. They recorded about 7.6m of drift deposits lying on a slate floor at 390m OD on a small ridge between the then expanding Moel Tryfan and Alexandra slate quarries, and suggested that two main formations could be seen in the drifts — a shelly sand and gravel sequence occurring to the north-west and being replaced to the south-east by boulder clay. The sands and gravels were described as yellow, and containing pockets of gravel in which numerous marine shell fragments were present, and in which bedding was very irregular. The junction between the sands and gravels and the till was contorted into sharp folds. The till was described as a strong, unstratified deposit, dark grey in colour and full of stones, up to one metre in size. Most of the stones were subangular, many well striated, and most were of Welsh origin; the riebeckite microgranite of Mynydd Mawr being especially abundant (Hicks *et al.* 1899). The drift beds overlay slate bedrock and the lowest layers contained numerous angular slate fragments. The slate floor beneath the deposits showed terminal curvature towards the ESE. According to Hicks *et al.* (1899) and Greenly (1900) there was some suggestion that the sands and gravels were interdigitated with the till. Unfortunately, today there is little evidence for such a sequence although the till and shelly sand and gravel deposits are still visible in small exposures in separate parts of the quarry.

In contrast to many other classic Pleistocene sites in Wales, most of the references to Moel Tryfan were made during the latter part of the nineteenth century, and since that time the site has received relatively scant attention. This no doubt has been due to the destruction of key parts of the site, forecasted by earlier workers.

Trimmer (1831) was the first to record the high level drifts of Moel Tryfan with their contained fauna. Importantly, he noted that these supposed "diluvial" or flood-formed sands and gravels were extensive in this part of Caernarvonshire, a fact also supported by Ramsay (1852) who traced the 'marine' drift to the height of 701m (2,300 ft) OD in the recesses of Carnedd Dafydd and Carnedd Llewellyn, and two miles west of Snowdon near Maenbras. At this early stage, most authors favoured a marine origin for the Moel Tryfan shelly sands and gravels, and the opinions then prevalent were summed up by Sir Charles Lyell in 1873 who believed that "these shells show that Snowdon and all the highest hills which are in the neighbourhood of Moel Tryfaen were mere islands in the sea at a comparatively late period" (Davies

1969). Such was the entrenchment of the belief that Trimmer (1831), in describing striae and furrows on slate bedrock in Snowdonia, concluded that they had been caused by the 'diluvial currents'.

Despite advancement of the Glacial Theory elsewhere in Europe, Buckland (1842) rectified Trimmer's mistake and cited striations in the Llanberis Pass as clear evidence of glaciation, but still invoked a period of marine submergence to account for the shelly sands and gravels on Moel Tryfan. Darwin (1842), while refuting the concept of a flood to account for the beds on Moel Tryfan, however, also concurred with the idea that the beds were emplaced beneath the sea. Such an origin, he argued, would help to account for the presence in the sections of erratic boulders (Trimmer 1831) which he considered had been transported by floating ice. The first detailed faunal analysis of the drift beds at Moel Tryfan was carried out by Darbyshire (1863) who recognised fifty six different species of molluscs. While the majority of these was considered to be Arctic in character, there was also an infusion of more temperate, British and Atlantic species. The list was updated by Jeffreys (1880) and collectively such faunal analyses helped to reinforce the idea that the beds were of marine origin.

A marine origin was also upheld by Mackintosh (1881, 1887) who noted that the sands and gravels were obliquely laminated in a manner similar to that seen on a modem beach. Similarly, Reade (1892, 1893) undertook a microscopic examination of sand grains from the Moel Tryfan beds and concluded that their extraordinary roundness and polish could only have resulted from marine agencies. Reade (1892) additionally showed that these 'marine' sands were overlain by till, probably of local derivation, whereas the sands and gravels were full of erratics from Scotland and the Lake District. However, like Darwin (1842), Reade (1893) envisaged that local glaciers had caused the submergence and consequent flooding of the land. It was during this marine submergence that the sea lapped against the Snowdonian hills depositing the shelly marine drift. Exotic, distantly derived erratics such as Shap Fell granite and Ailsa Craig microgranite in this deposit had, according to Reade, been rafted on floating ice. In contrast, Reade (1892) believed the overlying till to be a locally derived glacial deposit.

Against the tide of opinion, Thomas Belt (1874) published a perceptive paper in which he refuted the theory of marine submergence to account for the Moel Tryfan beds. He noted that "the shells are broken and worn they are just where they ought to be found on the supposition that an immense body of ice coming down from Northern Ireland, Scotland and from Cumberland and Westmorland, filled the basin of the Irish Sea, scooped out the sand with the shells that had lived and died there, and thrust them far up amongst the Welsh hills that opposed its course southward" (Belt 1874). He therefore concluded that there was no evidence for the submergence of Great Britain either during or since the 'Ice Age'.

Like Belt (1874), Blake (1893) favoured a glacial origin for the superficial deposits at Moel Tryfan. He foresaw no great difficulty in "getting the Irish Sea glacier to so great a height" and suggested that the shelly drifts of Moel Tryfan were the earliest of the glacial deposits in North Wales and that the shells themselves must have lived in pre-glacial times. However, even as late as 1910, the Moel Tryfan shelly sands were still regarded by Edward Hull, former director of the Irish Geological Survey, as evidence of marine submergence (Davies 1969).

Shortly before the turn of the century it became clear that expansion of the slate quarries on Moel Tryfan would result in the destruction of some of the key sections. A rescue operation to record and photograph the sections was therefore called for by Greenly and Badger (1899) and the results of the operation were later reported by Hicks et *al.* (1899) and by Greenly (1900). The latter two reports, which are identical, furnish what is perhaps the most detailed account of the sections, and since that time little detailed research has been undertaken.

The dating of the sediments at Moel Tryfan has proved difficult. Whittow and Ball (1970) suggested that the shelly sands represented the earliest glacial deposits in North Wales, perhaps being equivalent in age to the Criccieth Advance deposits (Simpkins 1968) in southern Ll■n and therefore of pre-Devensian age. They considered that the sands and gravels had been dredged from a pre-existing sea-floor at the onset of a glaciation, following their accumulation during a substantial interglacial period. Foster (1968, 1970a) undertook the radiocarbon dating of a bulk shell sample from the Moel Tryfan site. He obtained a date of 33,740 +2,100 -1,800 BP (1–2803) and concluded that because the shell material was derived, the glaciation responsible for its deposition must therefore post-date *c.* 34,000 BP. A Late Devensian age was therefore attributed by Foster to the beds. While a Late Devensian age would place the deposits firmly within the glacial succession established elsewhere in North Wales (for example, Saunders 1968a), such an age does little to

explain the restricted and high-level occurrence of such deposits, which in fact may be explained more easily by an earlier glacial episode (Whittow and Ball 1970). Many doubts have also been expressed concerning the reliability of radiocarbon dates from bulked shell samples (for example, Shotton 1967, 1977a; Boulton 1968). Amino acid measurements on the fauna, notably on *Macoma,* suggest that the sediment is Late Devensian in age (Davies 1988).

The site, first and foremost, is a landmark in glacial geology and geomorphology. It has the longest and most detailed history of early research at any site in Wales and was paid significant attention by both the pioneers and the opponents of the Glacial Theory. In this respect, it has been important in the development of geomorphological and geological thought in Great Britain.

Moel Tryfan also provides an important lithological record of the high-level shelly drift widely recorded from other locations in the Snowdonian foothills. It is both representative, and the best exposed of these deposits.

Further, the shelly drift demonstrates a penetration of the Irish Sea ice-sheet a considerable distance inland, and a vertical movement of the ice-sheet amounting to c. 400m in just about 10 km (Flint 1971). This southward and onshore movement of Irish sea ice, as shown by discontinuous Irish Sea sediments in Snowdonia generally and at Moel Tryfan in particular, has major repercussions for the timing and interaction of Irish Sea and Welsh ice-sheet advances. The evidence at Moel Tryfan clearly implies that the shelly drift was deposited when Welsh ice was neither sufficiently developed nor powerful enough to deflect the Irish Sea ice in this area.

The age of the Moel Tryfan deposits has been a matter of debate. It is one of very few sites in Wales where a radiocarbon date has been obtained. Recent amino acid data from the fauna have, however, supported a Late Devensian age (Davies 1988).

This locality is important for having been one of the first and also one of the most controversial Pleistocene sites described in Britain. It has been a key site in the development of scientific thought and establishment of the Glacial Theory. It provides a unique lithostratigraphical record of the high-level, shelly Irish Sea deposits, which are important for determining the sequence and pattern of Late Pleistocene glacial events in north-west Wales.

Conclusions

Moel Tryfan is an internationally famous site. Its shelly glacial deposits figured prominently in the debate which led to the acceptance of the Glacial Theory in Britain. Before 1840 or so, the view was that these deposits represented the Biblical deluge. Acceptance that they were deposited by an ice-sheet was important for changing that opinion and led directly to the acceptance of the effect of glaciers on the landscape.

References