Barmouth Hillside

[SH 615 162]

Introduction

The Barmouth Hillside (Figure 3.4) exposes an almost continuous section through the upper part of the Harlech Grits Group, from the higher part of the Rhinog Formation, through the Hafotty and Barmouth formations, into the Gamlan Formation (Figure 3.1). These exemplify a considerable part of the Cambrian succession in a part of Wales where the Cambrian System was conceived.

The rocks of the area were assigned by Sedgwick (in Sedgwick and Murchison, 1835) to the Middle Cambrian division of his newly defined Cambrian System. He subsequently named the Harlech Grits as part of a redefined Lower Cambrian (Sedgwick, 1852). The work of the Geological Survey (Jukes and Selwyn, 1848) led to the publication in 1854 of maps in which the Harlech Grits were distinguished from the overlying 'Lingula Flags'. The recognition by Lapworth and Wilson that the manganese ore mined in the area forms a stratigraphical marker enabled the Rhinog and Barmouth grits to be distinguished as separate formations (Andrew, 1910) and led to elucidation of the stratigraphy, culminating in Matley and Wilson's (1946) map and description of the Harlech Grits.

Keunen's (1953) early recognition that many of the coarse grits were deposited by turbidity currents led to descriptions of the sedimentary structures by Kopstein (1954) and facies analysis by Crimes (1970a). The manganese ore was studied petrographically by Woodland (1938, 1939) and geochemically by Mohr (1964) and Glasby (1974). Allen and Jackson (1985) described the Harlech Dome area and gave formal definition to Andrew's (1910) formational nomenclature, which had been used on their British Geological Survey map of 1982. The account of Allen and Jackson is followed here.

Description

The Barmouth Hillside site is a large area of moorland with a good deal of craggy exposure, such that the various formations and even individual beds can be traced along-strike for considerable distances (Figure 3.4). The rocks generally dip north-east or east at about 50–60°, though strikes and dips vary. The general features of these beds have been described by Matley and Wilson (1946) and Allen and Jackson (1985); they have not proved fossiliferous. The exposures are described from north to south, in ascending succession.

The upper part of the Rhinog Formation generally consists of greywacke sandstones with thin intercalations of siltstone and mudstone that give a 'scarp and slack' topography. The greywackes are medium- to coarse-grained and are generally about 50 cm (but occasionally up to 4 m) in thickness. Intercalated siltstones are usually 5–30 cm thick but can reach 3 m. Compositionally, quartz predominates and is often pink or blue (Woodland, in Matley and Wilson, 1946), but feldspar clasts and lithic fragments are also common. Most beds show elements of Bouma (1962) turbidite sequences, as described by Allen and Jackson (1985).

Amalgamated units are common. Sole marks include flute- and groove-casts and load structures (Crimes, 1970a). Mudstone rip-up clasts also occur, and burrows can sometimes be seen on the bases of sandstones or in intercalated mudstones. Beds up to 1–2 m thick of well-sorted coarse sandstone and quartz-pebble conglomerate occur throughout the sequence and include washouts with pebbly fills. The formation is 780 m thick, the upper 100 m or so being exposed here.

The Hafotty Formation overlies the Rhinog Formation conformably. It is predominantly of blue- or green-grey striped mudstones and siltstones with occasional beds of sandstone. Maley and Wilson (1946) divided the formation into three members:

Upper or Manganese Shales	100–200 m

Manganese Grit	2–60 m
Lower (or Ore Bed) Shales	15–20 m

The lower member was further subdivided by Woodland (1939) and near the middle includes the Manganese Ore Bed itself. This is a hard, fine-grained, flinty bed about 0.3 m thick, showing red-brown, yellow and occasional blue-black bands when fresh, the manganese-bearing minerals being rhodochrosite and spessartine. The petrology was described by Allen and Jackson (1985) and Woodland (1939). Although the ore itself is not easy to examine *in situ,* its outcrop can be traced across the hillside by following the old mine workings. Above the ore bed are finely laminated manganiferous mudstones, followed by banded mudstones, siltstones and fine sandstones with a distinctive ribbed appearance when weathered. Graded beds of greywacke sandstone occur, of which the Manganese Grit is the most persistent, though here it is only about 2 m thick. The mudstones forming the bulk of the formation are grey, green or purple, and they show cleavage dipping north at about 80°.

The stratotype base for the Barmouth Formation (Allen and Jackson, 1985) is on the hillside path above Barmouth [SH 6160 1580]. It rests abruptly but conformably on the Hafotty Formation and is marked by the abrupt appearance of coarse, pebbly greywacke sandstones, the lowermost showing a complete Bouma sequence (*a* to *e* divisions). However, the quartz pebbles are usually white in colour, the pink and blue varieties of the Rhinog Formation being absent. The characteristics of this formation, described by Allen and Jackson (1985), are very similar to those of the Rhinog Formation, although the beds are generally coarser,, with fewer and thinner mudstone intercalations.

The Barmouth Formation is abruptly succeeded by the Gamlan Formation, which consists of green-grey and blue-grey silty mudstones, with thin beds of fine- to medium-grained sandstone. The boundary forms a topographical slack that can be traced along strike, and the transition is exposed north of the footpath across the top of the hill [SH 6178 1584] (Allen and Jackson, 1985). The strata are well and thinly bedded, and prominently striped. Siltstone and fine sandstone beds, from a few millimetres to 10 cm thick, occur; they often show parallel, convolute or cross-lamination (Bouma *bcd* or *cd* sequences). Sediment-filled *Planolites* burrows are common parallel to bedding. Some 50 m of the lower part of this unit are exposed here.

Interpretation

The sandstones of the Rhinog Formation are interpreted as proximal turbidites (Kuenen, 1953) deposited under conditions of a high-flow regime, transported by south-flowing currents (Crimes, 1970a; Allen and Jackson, 1985). The better-sorted cross-bedded sandstones represent reworking; washouts at their bases show an east—west orientation perpendicular to that given by the sole marks in the turbidites, and the cross-bedding implies westerly transport. Thus, although turbidity current flow was from the north, an easterly source was also operating. The abrupt appearance of the Rhinog turbidites over mudstones of the underlying Llanbedr Formation indicates the advance of a prograding turbidite fan, the Rhinog Grits representing the mid- to inner fan. The overlying banded mudstones, siltstones and sandstones of, the Hafotty Formation exhibit sedimentary structures and grain-size variations that indicate they were deposited by distal turbidites.

Woodland (1939) considered that the manganese ore was deposited by precipitation as a colloidal gel, in very quiet water conditions, probably in an enclosed basin. Both he and Mohr (1956) favoured a gneissic landmass as the source of the manganese. Glasby (1974) favoured a diagenetic origin for the ore bed, ruling out the need for a manganese-rich source, and suggested that the ore formed in a shallow marine basin where reducing conditions had developed. However, the coarse greywacke sandstones of the Manganese Grit resemble those of the Rhinog Grits above and are difficult to reconcile with a shallow basin (Allen and Jackson, 1985); and Binstock (1977) considered the manganese-bearing beds to be part of a deep-water sequence, the manganese enrichment being related to an interval of pelagic deposition.

The Barmouth Formation represents a renewed influx of proximal turbidites. Sole marks and washouts indicate a general NW–SE alignment (Crimes, 1970a), while directional sole marks indicate currents flowing to the north-west. These sediments were presumably derived from a source to the south-east of the Harlech Dome. The overlying Gamlan Formation siltstones and mudstones were deposited from turbidity currents also flowing towards the north or north-west,

but represent more distal, lower energy deposits.

The Barmouth Hillside site thus displays a stratigraphical succession through the principal formations of the Harlech Grits Group, with examples of the contacts between the formations and including the basal stratotypes of the Barmouth and Gamlan formations. It also illustrates the filling of the basin by two cycles of turbidite deposition, though whether the quiescent period in between represented a period of shallowing is debated.

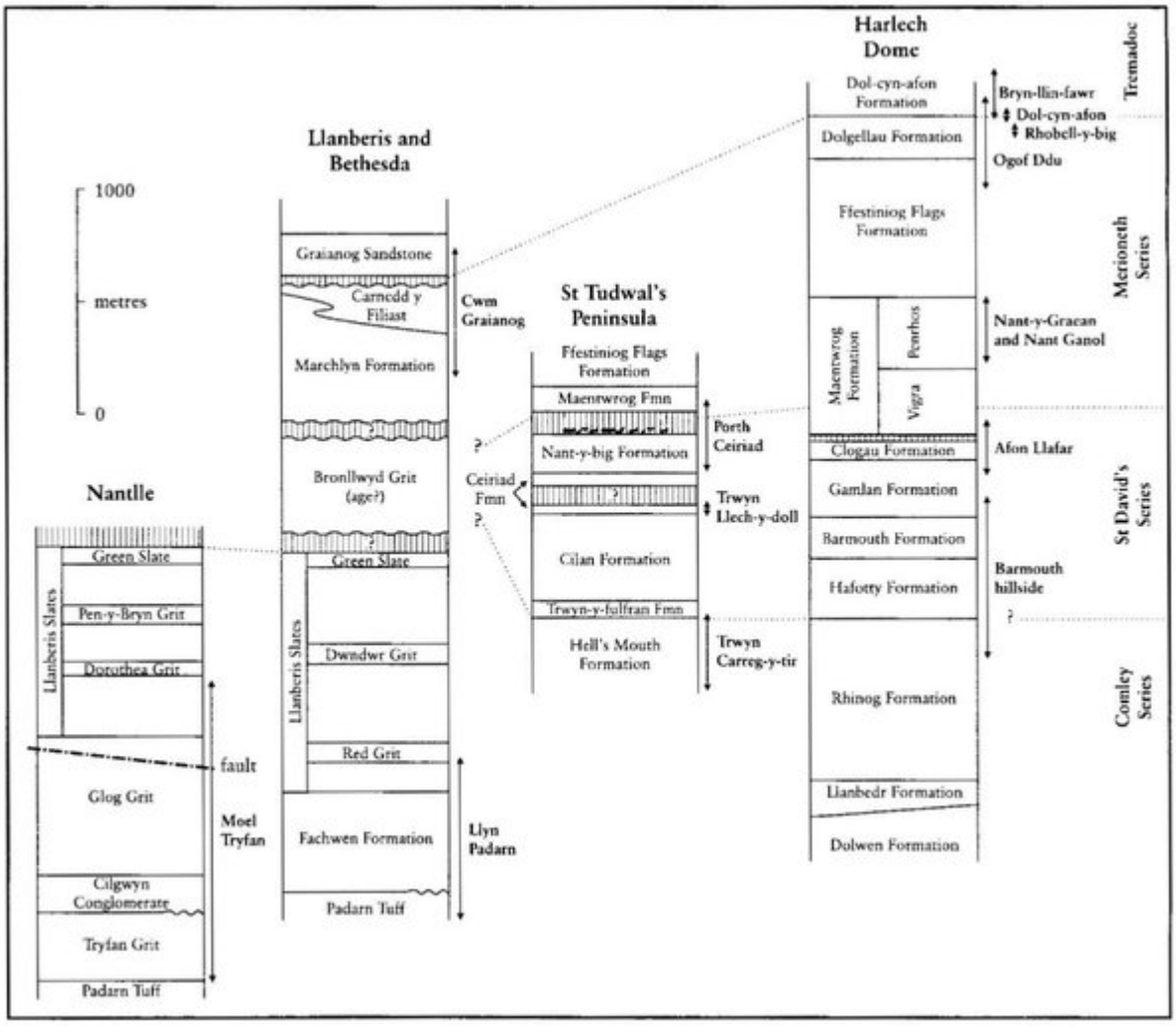
The general similarity of the sequence exposed on Barmouth Hillside with that in St Tudwal's Peninsula, and in particular the presence of manganiferous beds (Nicholas, 1915), allows correlation of the Harlech Grits Group in the two areas. This is important stratigraphically because of the presence of fossils in the St Tudwal's succession (see the Trwyn Carreg-y-tir site report). Correlation by manganese has been extended to Newfoundland (Mohr and Allen, 1965), where a manganese-rich horizon occurs at the base of the Chamberlain's Brook Formation, which is assumed to be early Middle Cambrian in age.

Conclusions

The site on Barmouth Hillside displays a thick Lower to Middle Cambrian sequence typical of the Harlech Grits Group. These are coarse sandstones and mudstones, deposited in a deep marine basin by strong flows of sediment-laden water, that typify a major part of the Cambrian of the historical type area. Particularly important is a manganese-rich horizon that can be used as a marker band and which allows correlation, in the absence of fossils, with similar, locally fossiliferous, rocks in St Tudwal's Peninsula.

References

(Figure 3.4) Barmouth, viewed from the west. To the left, greywackes of the Rhinog Formation (Lower Cambrian) form wooded outcrops above the town. The smoother terrain beyond is occupied by the Hafotty Formation (St David's Series), the manganiferous basal beds lying approximately along the line of the track that extends from the church (centre right, arrowed) obliquely up the hill to the left. The rougher highest ground consists of Barmouth Formation greywackes, with the Gamlan, Clogau and Maentwrog formations beyond. The far side of the Mawddach Estuary is made up of upper Cambrian and lower Ordovician rocks. (Photo: Cambridge University Collection of Air Photographs, BST 038: copyright reserved.)



(Figure 3.1) Correlation of the principal Cambrian sequences in North Wales, modified from Rushton (1974, fig. 2). The arrows in this and succeeding figures indicate the stratigraphical ranges of individual GCR sites.