Carmel Head

[SH 2907 9279]–[SH 3070 9300]

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Highlights

This is the only well-exposed and clearly identifiable, major low-angle thrust in the Welsh Caledonides. The Carmel Head Thrust, overriding an earlier steep fault and cut by later faults, can be traced eastwards for some 400 m in the cliffs and well-exposed ground to the south; it thrusts Precambrian schists southwards over Caradoc Series shales. Further east, the Ordovician Garn Breccia and overlying shales are overridden by Precambrian rocks on the Mynachdy Thrust.

Introduction

The Carmel Head region is well known for both its stratigraphical and, in particular, its structural interest. The fault relationships were first described clearly by Callaway (1884), and his conclusions were confirmed and amplified by Matley (1901) and Greenly (1919, 1920), who mapped the area on the scale of 1:2500. Greenly (1919, pp. 547–9) considered that the Precambrian Mona Complex (Monian) had been overthrust on to the Ordovician along the E–W-striking Carmel Head Thrust by about 20 km. Bates (1972, 1974) showed that the palaeogeographical arguments upon which this figure was based were incorrect. Other associated thrusts include the Mynachdy Thrust and thrusts within the Ordovician shales at this site, described by Greenly (1919), Bates (1972, 1974), Bates and Davies (1981) and Barber and Max (1979).

Description

The area shows a sequence of complexly folded and faulted units. South of Porth Ogo'r geifr there are gneisses, thought by Greenly (1919) and Barber and Max (1979) to be part of an Archaean basement, and by Shackleton (1969) to be high-grade members of the late Precambrian (Cadomian) Monian. These are faulted against cleaved Caradoc Series shales. At a small cove immediately west of Porth y Wig, the Caradoc rocks are overthrust by the Monian Amlwch Beds of the New Harbour 'Series': this is the type locality for the Carmel Head Thrust (Figure 4.21).

On Carmel Head itself, Gwna Mélange of the Mona Complex (Monian) to the east is unconformably overlain by the rather similar Ordovician Garn Formation. Towards Porth Newydd, the Garn breccias pass up gradually into graptolitic shales, with one thrust slice of Monian phyllites in the sequence. Finally, at Porth Newydd, the Church Bay Tuffs of the Monian are thrust over these shales along the Mynachdy Thrust. The Church Bay Tuffs are probably intermediate in age between the Amlwch Beds and the younger Gwna Mélange in the Monian. The principal features of the site (Figure 4.22) are described from west to east.

Porth Ogo'r geifr

The inlet is eroded in an E–W-striking fault complex with a steep, northerly dip. On the south side [SH 2914 9279] sandstones and shales of the Garn Formation are exposed, faulted against the Gader Gneisses to the south. The fault is mineralized: quartz-veined gneiss and shales are exposed in a small excavation around an old shaft opening 40 m east of the head of the inlet.

Porth Ogo'r-geifr to the Thrust Inlet [SH 2957 9303], just west of Porth y Wig

Well-exposed, cleaved Caradoc shales make up the cliffs, which gradually decrease in height to the north-east. A well-developed crenulation cleavage (first described by Greenly in 1919) is present, dipping at low angles to the south. This is spatially related to the thrusts, and was described by Bates (1974) as being linked to the thrust movements. It is

only rarely possible to determine bedding, where lithological variations are found, for instance, in the north wall of Porth y Dyfn [SH 2939 9287]. Here, there is a debris-flow breccia of extremely angular blocks of schist and phyllite (up to 0.60 m long) in a shale matrix. A low-angle north-dipping thrust within the shales is well exposed on the coastal rock platform [SH 2944 9298]. There tension gashes and slickencrysts both confirm the southerly movement of the hanging wall, and the crenulation cleavage is well developed.

The Thrust Inlet

The inlet is excavated along a NNW–SSE-trending high-angle fault, which displaces the Carmel Head Thrust at the head of the inlet. The thrust itself follows the north wall, where the chloritic schists of the Precambrian Amlwch Beds overlie Ordovician shales, with the fault contact dipping gently north. The thrust cuts an earlier high-angle fault towards the low water mark. It is possible that both high-angle faults are part of the thrust sequence, although Bates (1974) interpreted the earlier one as being part of a pre-thrust phase of high-angle reverse faulting.

Porth y Wig and Carmel Head

The Amlwch Beds of the New Harbour 'Series' form the hanging wall of the thrust, and the south side of Porth y Wig, but the headland (Garn Mynachdy) of Carmel Head itself is formed of Gwna Mélange; its contact with the Amlwch Beds is another fault. The mélange is predominantly siliceous, but a band of carbonate mélange is also present, with clasts of dolomite and limestone up to 2–3 m long — which may represent the remains of a dismembered carbonate horizon in the parent succession.

Porth yr Ebol—Porth Gron [SH 2990 9288]

Three rock units are present in this section, from south to north:

1. Caradoc shales beneath the thrust.
2. Gwna Mélange on the hanging wall.
3. Llandeilo (?) Garn Formation breccias, either faulted against the Gwna Mélange, or un-conformable on it.

The main thrust appears in at least five locations:

1. [SH 2990 9288] as a small faulted exposure in the cliff.
2. [SH 2996 9283] in a natural cave.
3. [SH 3000 9280] and east of it along the wave-cut platform.
4. In the east wall of Porth yr Ebol.
5. On the wave-cut platform in Porth Gron.

Again the thrust is cut by ENE–WSW and N–S-trending faults. In Porth yr Ebol the Garn Formation is faulted against the Gwna Mélange, but just east of this inlet [SH 3012 9278], it appears to be unconformable on the mélange, although as the two formations are similar in character, the boundary is difficult to trace.

Porth Padrig to Porth Newydd

In Porth Padrig, another WNW–ESE fault, dipping steeply to the north (the Padrig Slide of Greenly, 1919), separates the Gwna Mélange from the Garn Formation to the north. The Garn Formation fines upwards (Bates, 1972) into shales with thin breccia and sandstone beds. A mass of phyllites is thrust up into the shales [SH 3064 9287]. In Porth Newydd the Caradoc shales are complexly faulted on a small scale, and are overthrust on the Mynachdy Thrust by Church Bay Tuffs of the Monian.

Interpretation

The sequence described here is of both historical and current interest. It forms the type area or exposure of the Carmel Head Thrust, and there is here no doubt of the reality of this structure. Bates (1974), however, points out that Greenly's (1919, pp. 541–557) arguments for a 20 km southward translation on the thrust, were based on a palaeogeographical interpretation of the Ordovician, which is no longer tenable (Bates, 1972). Although Bates (1974) confirmed the N–S direction of transport from growth fibres and the orientation of the crenulation structure related to the movements, he had already observed (1972, p. 55) that the minimum movement required on the thrust is only in the order of metres.

At Carmel Head there are two low-angle faults which clearly emplace older (Monian) rocks over younger (Ordovician). There are also other parallel, low-angle faults that are probably thrusts, as well as high-angle reverse faults. Elsewhere on Anglesey the plane mapped as the equivalent of the Carmel Head Thrust is usually a high angle reverse fault. It is probable that remapping of this area, in conjunction with modern ideas on thrust geometry, may lead to revision of some of the faulting sequence, but should make the zone of even greater significance.

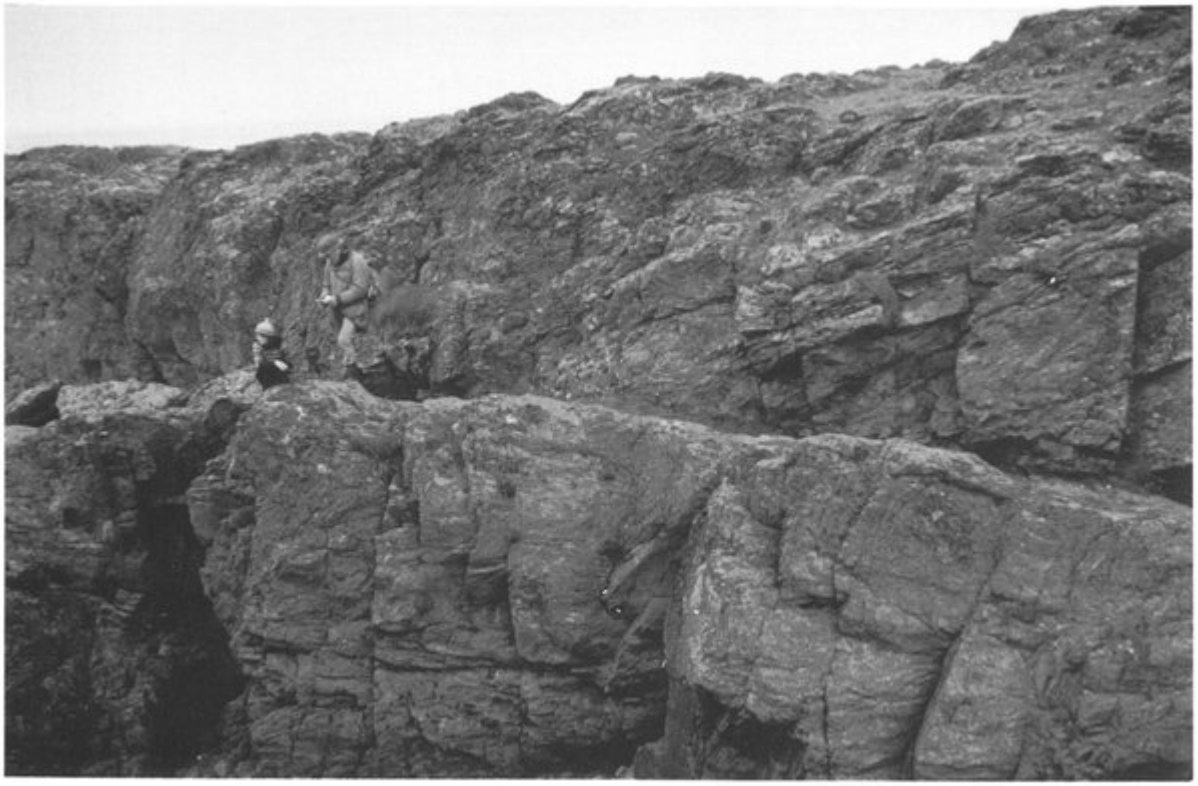
Models for the evolution of the structure of the Welsh Basin (for example, Shackleton, 1969; Coward and Siddans, 1979) appeal to thrusting, related to mid-crustal decollement, as a major response to the main-phase Caledonian shortening (late Silurian to early Devonian). The movements described here, although possibly closely following, certainly post-date the main-phase cleavage and folding. The Old Red Sandstone rocks at Lligwy Bay (see above) are also affected by southward thrusting which also appears to postdate, but to be closely associated with cleavage and folding of the same main phase. This thrusting on Anglesey appears to pre-date the Carboniferous succession.

Descriptions of similar thrusts elsewhere in the north Welsh Basin are rare. The most famous, the Tremadoc Thrust (Fearnsides, 1910), has been shown by Smith (1987, 1988) to be a pre-lithification structure. The thrusting at Trum y Ddysgl (see above) has the same south-easterly sense of movement but is directly related to the folding and cleavage.

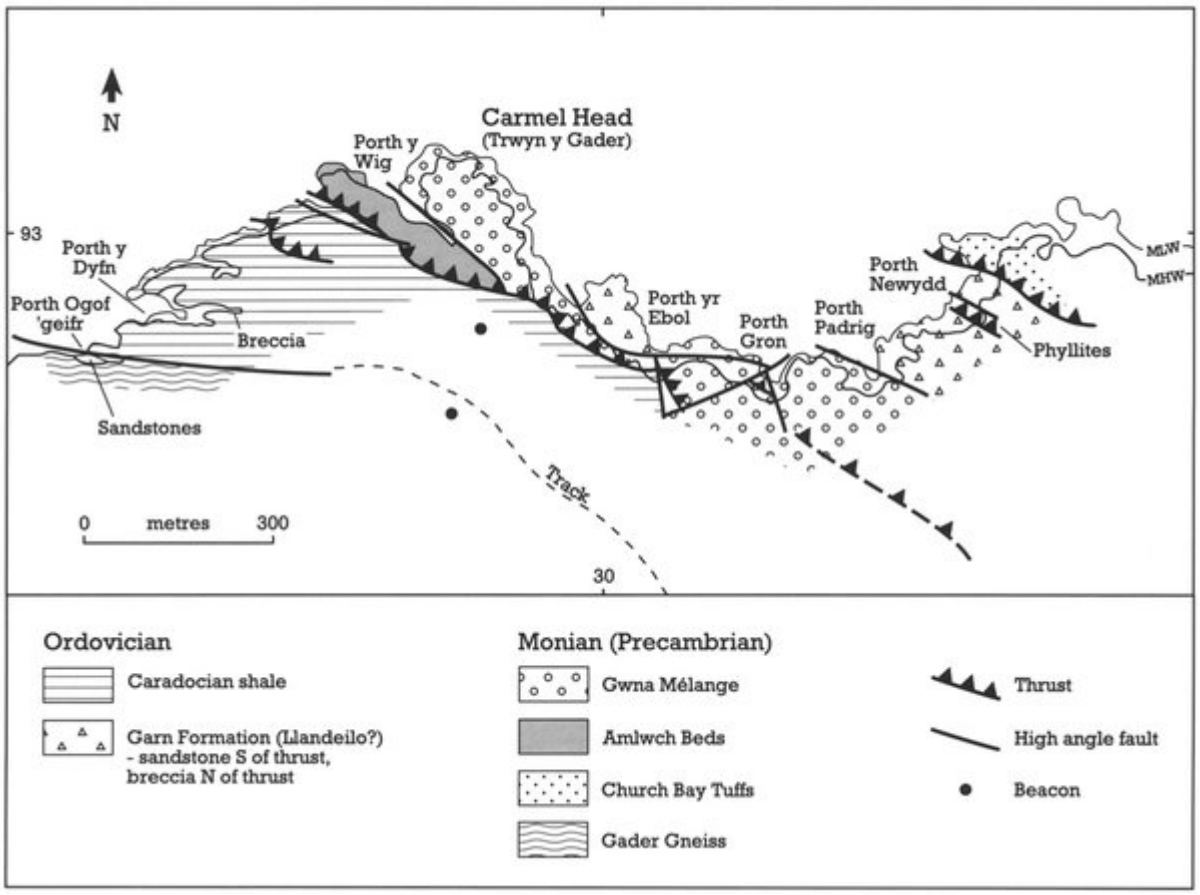
Conclusions

Carmel Head provides one of the clearest, and the only convincing, examples of late thrusting in the Caledonides of Wales. Thrusts (faults lying at a low angle to the horizontal) were a major product of crustal shortening caused by compression in the Caledonian event. The amount of movement on this particular major dislocation has been the subject of dispute, but it thrusts already cleaved and folded Precambrian basement rocks south over Early Palaeozoic rocks. The thrust movements post-date the folding and cleavage which were formed by the main tectonic events of the Caledonian Orogeny, and this has significance in establishing a chronology for this period of mountain building. The clarity of the exposures hereabouts makes the region of paramount importance.

References



(Figure 4.21) Carmel Head, Anglesey. Figure standing on the low-angle fault plane which has thrust Precambrian schists over Ordovician shales. (Photo: J. Treagus.)



(Figure 4.22) Geology of the Carmel Head site.