Tyllau Mwn

[SH 844 205]

Introduction

Lower Palaeozoic ooidal ironstones, dominated by chamosite, have been worked across a wide area of North Wales where Arenig- to Caradoc-age strata crop out. The ironstones occur typically as discontinuous lenses within shallow-water siliciclastic sequences, and they vary from relatively fine-grained ooids through to coarse pisoids (Trythall, 1989). Alteration, due to low- grade metamorphism, is common and has produced siderite, magnetite, pyrite, stilpnomelane and hematite in varying amounts. At the Tyllau Mwn GCR site (Figure 5.9), both original and metamorphic features can be observed, in contrast with other sites where the ore is either totally altered, obliterating all primary textures, or only slightly affected.

Tyllau Mwn mine lies in an extremely remote location at about 600 m OD on the western flank of the Aran Mountains (Figure 5.10). Here, shallow levels and opencuts (Bick, 1990) tried a lenticular mass of ironstone, which lies at a near-vertical attitude. This working, which was initiated in the late 1700s, was originally in search of copper, and there exists a fascinating record of the works in the diary of Elizabeth Baker from October 1770, quoted by Bick (1990), in which two extracts, a week apart, gradually reveal the true nature of the deposit:

'Last friday I was at the long conceald spot that produc'd the Friars Coat — the morning was fine, but the weather soon chang'd — Hail, Rain, and the tops of the Mountains covered with snow; for two miles at least upon the edge of a precipice the mare climb'd the rock, where one false step, would have been fatal, and to compleat the expedition the rain ran off my petticoats as they were too wet to receive more. My Hopes and Belief are it will prove Copper the shaft is about four yards deep, the Level will be up to it in about a fortnight — the Shepherd told me by an interpreter they had found the stuff that made Gold that morning.'

'Now to the Friars Coat. We have sunk a Shaft five yards, the vein is about four feet wide and continues much like the sample you had from the Day; Iye drove a Level that will be up to the Shaft this week — when I hope to God it may prove a Copper Mine tho' the Magnet acts powerfully on what is raised — Clarkson Assayer was Fool or Knave to assay it for Lead — If it proves Iron and Silver, those are the Metals which constitute what is calld the Friars Coat.'

Perhaps not surprisingly, since the 'vein' was in fact a steeply dipping ironstone bed, little was heard of the site following this brief flurry of activity, until the late 19th and early 20th centuries, when intermittent extraction of ironstone took place. The remote situation must, however, have adversely affected the economics of iron mining, so that it was never of any real importance.

More recently, the site was reported on, following the discovery of well-crystallized stilpnomelane, occurring in calcite veins with fluorapatite, ilmenite and pyrrhotite (Matthews and Scoon, 1964).

Description

The ironstone worked at Tyllau Mwn strikes north-east–south-west and is nearly vertical in attitude. It forms a lenticular mass over 100 m in length and averages 2.5 m in width. It is hosted by volcaniclastic rocks of Ordovician (Arenig–Caradoc) age, which belong to the Aran Volcanic Group. A rhyolite dome intrudes the sequence to the north of the site.

The ironstone, originally composed of chamositic ooids, has been altered by metamorphic processes into a highly distinctive rock consisting of magnetite octahedra (< 0.5 mm) packed in a pale, calcite-rich chloritic matrix. Dissolution of the calcite by rainwater since the mining of the ore has left the lustrous magnetite crystals standing proud from their matrix. In hand specimen, flattened pisoids, up to *c.* 5 mm, are still visible despite the degree of recrystallization.

The iron ore is attractive in polished section where the overprinting of relict chamosite ooids by euhedral magnetite octahedra is well displayed. As well as calcite in the ore groundmass, calcite occurring in veins is abundant on all scales up to an observed maximum thickness of 0.3 m (Matthews and Scoon, 1964). The calcite veins locally carry an interesting and unusual suite of accessory minerals, described in detail by Matthews and Scoon (1964). Stilpnomelane is the principal accessory phase, but it also occurs within the ironstone itself In the veins, stilpnomelane occurs as plates aligned normal to the vein walls, which reach a maximum size of 20 x 20 x 2 mm. It occurs only in the marginal zones of the calcite veins, however, being absent from centres of the thicker veins. Its colour in thin-section is either yellowish-brown to dark brown (ferri-stilpnomelane) or light apple-green to pale yellow (ferro-stilpnomelane), the ferric variety constituting the bulk of the vein material and the ferrous variety occurring mainly in the ore.

Fluorapatite is also present within the assemblage, occurring as occasional tabular, isolated crystals in the range 1–10 mm in size embedded in calcite. Ilmenite is rare and forms flat rhombs, again 'floating' free in the calcite, while pyrrhotite is quite common, forming both small veinlets within the ironstone and thin strings within the calcite veins, where it is often intergrown with stilpnomelane.

Interpretation

Bedded ooidal ironstones of Ordovician age are widespread across North Wales, individual horizons being laterally persistent over considerable distances. However, they are only of sufficient thickness to be worked in localized areas, typically thinning out rapidly along strike to sub-economic widths (Trythall, 1989). The ooidal to pisoidal nature of the ores and their spatial association with shallow-water siliciclastic sediments are both features indicative of accumulation in a shallow-water offshore environment in which sedimentation rates were low. The palaeogeographical position of the North Wales ironstones indicates that they formed on topographical highs within the Welsh Basin. Such features would indeed be areas of low sediment input, but their localized nature would mean that, despite iron being widely available, it would only accumulate under ideal palaeogeographical conditions: elsewhere the iron would be diluted by higher sediment input rates. Perhaps the strongest single controlling factor in iron accumulation, therefore, was fluctuations in sea level (Young, 1993).

The source of what was obviously a widespread iron influx was discussed by Young (1993). A late diagenetic origin, involving ferrification of an ooidal limestone precursor, which was at one time a popular model (e.g. Kimberley, 1974), is now generally discounted on the basis of evidence that the iron ooids actually existed within the depositional environment. Kimberley (1989) subsequently modified the diagenetic theory to allow iron ooids to be formed directly from iron-rich fluids exhaling onto the seafloor, thereby supplying the metal to the sediment–water interface. Young (1993), however, commented that the topographical highs of the Ordovician seas in which these ores accumulated were extremely unlikely locations for such fluids to be available.

Another possible ore-formation mechanism, discussed by Young (1993), involves the enrichment of iron due to terrestrial weathering at the sediment source and transport of sediments with a high iron content, such as lateritic soils, to the marine environment. This is hard to reconcile, however, with the topographical-high palaeogeographical locations of these deposits, and additionally ooids with internal compositions indicative of a lateritic origin (i.e. iron oxides and kaolinite) have yet to be recorded from any marine ironstones.

Young (1993) considered the most likely genetic model for marine ooidal ironstone formation to be the early diagenetic redistribution of iron, with the intense weathering of detrital phases and their replacement by authigenic aluminous and ferriferous clay minerals. Such sedimentary reworking would readily occur over the topographical highs of the Welsh Basin sea, where the other requirement, restricted sediment input over protracted time-periods in order to permit lengthy reworking, would be satisfied. Young (1993) suggested that the sedimentary reworking could be both biological and mechanical (e.g. in storms). The time factor is difficult to estimate, but Young *et al.* (1991) suggested a formational period in the order of 100 000 years for the Jurassic Cleveland ironstone, which, although much younger, is of a broadly similar nature to the Ordovician ironstones of North Wales.

The alteration of ooidal ironstone to a magnetite-dominated rock is not uncommon in North Wales. The ironstones occurring at Penyrallt Mine [SH 6285 4093] in the Ffestiniog–Porthmadog belt show the typical pattern of alteration, involving the growth of porphyroblastic magnetite euhedra, while vein stilpnomelane is locally present (Bevins and Mason, 1998). It is likely that this mineralogical alteration occurred on a widespread scale due to regional low-grade metamorphism. Alternatively, Trythall (1989) suggested that some of the secondary minerals (quartz, siderite and pyrite) occurring in the iron ore at Betws Garmon, in Snowdonia, might have been deposited from hydrothermal fluids, although these occur largely in veins, while the magnetite always occurs in the groundmass.

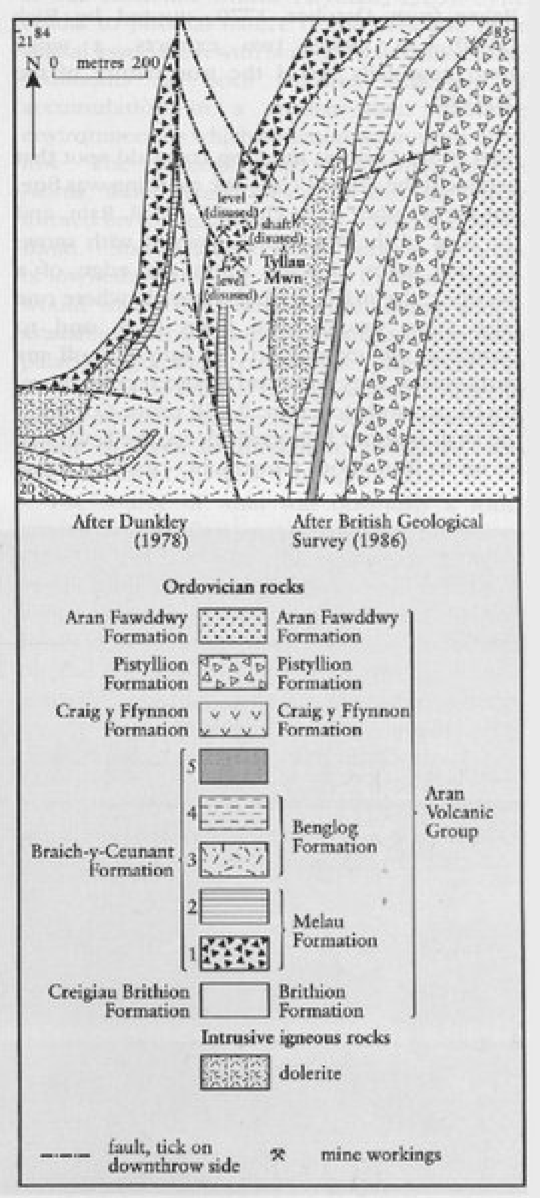
The stilpnomelane-calcite veins at Tyllau Mwn are clearly late-stage features, as they cut and contain clasts of the magnetite-dominated rock. Matthews and Scoon (1964) interpreted them as late, post-metamorphic features, although they noted that no precise data were available regarding the conditions under which they had formed. Their interpretation involved emplacement under low temperatures and hydrostatic pressures, via either an aqueous solution-vapour mix or a vapour. They proposed that stilpnomelane had formed directly from chamosite, while the vein ilmenite and apatite drew their titanium and phosphorus directly from the ore wall-rock.

It is more likely, however, that the Tyllau Mwn veins were formed during regional, burial-related metamorphism, in a similar way to the 'Alpine-type' veins of the Ffestiniog–Porthmadog belt (see Manod Quarry GCR site report). Veins with 'Alpine-type' characteristics are present elsewhere in the Aran Mountains area, although they do not contain the wide range of minerals recorded from the Ffestiniog–Porthmadog belt; they chiefly cut silicic, pyroclastic rocks of the Aran Volcanic Group and consist entirely of quartz with pink feldspar (authors' unpublished data). However, they too are interpreted as being formed by localized migration of fluids into fractures in rocks undergoing regional metamorphism, again reflecting the geochemistry of their source rock.

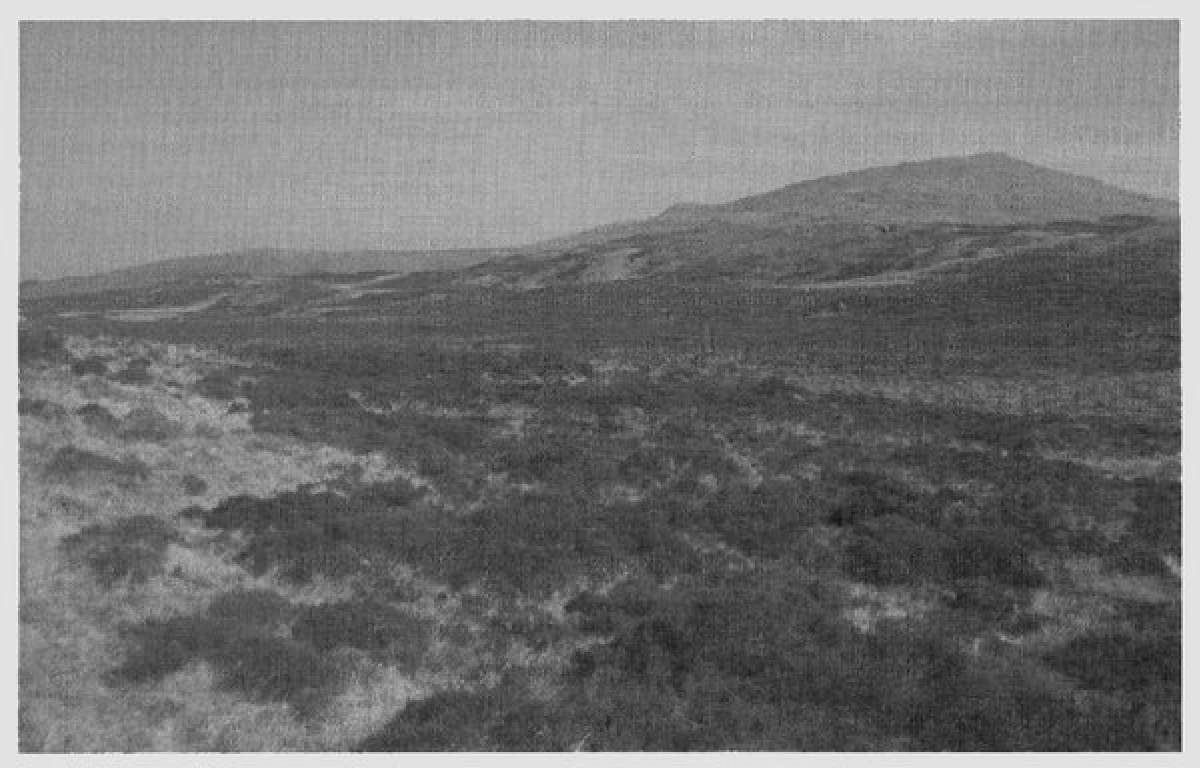
Conclusions

The Tyllau Mwn mine worked low-grade, bedded ooidal ironstones of Ordovician age. The ore deposits accumulated on topographical highs in shallow-water conditions in early to mid-Ordovician times. Originally composed of ooids and pisoids formed from iron-rich clay minerals, they were altered under regional low-grade metamorphism to chamosite-magnetite-rich rocks, the degree of mineralogical evolution being partly affected by the thermal affects of adjacent igneous intrusions. Local veining also formed during metamorphism, the vein constituents being derived from the ironstone host-rock and dominated by stilpnomelane and calcite.

References



(Figure 5.9) Map of the Tyllau Mwn GCR site. Based on Dunkley (1978), and British Geological Survey 1:50 000 Sheet 136, Bala (1986).



(Figure 5.10) Distant view of spoil heaps at the remote Tyllau Mwn GCR site. (Photo: N. Smith.)