Brynyrafr Mine

[SN 745 879]

Introduction

Brynyrafr Mine is a key site for the study of the Central Wales Orefield mineralization. It is the largest working on the ENE–WSW-striking Hafan Lode, a major, multi-phase mineralized fracture with a strike length of some 9 km (Figure 5.55). The mine was developed relatively late in comparison with other Central Wales mines, only beginning production in 1881. It then operated continuously for 31 years (Jones, 1922), during which time almost 5000 tons of galena concentrates and over 8000 tons of sphalerite concentrates were sold (Burt *et al.,* 1986).

Brynyrafr Mine (Figure 5.56) provides one of the best sites for the textural study of both early (A1) and late (A2) generations of metalliferous vein mineralization in the Central Wales Orefield. The extensive dumps are rich in boulders which reveal a variety of brecciation, re-brecciation and cross-cutting textures, particularly when cut and polished. The demonstration of such repeated sequences of re-brecciation and cross-cutting vein relationships is an essential element in the interpretation of the mineralization of the Central Wales Orefield. Additionally, fine specimens of the rare nickel sulphide millerite occur locally.

Description

Mineralization at Brynyrafr Mine occurs in association with the fracture known as the 'Hafan Lode', one of a number of predominantly ENE–WSW-trending mineralized fractures cutting Upper Ordovician to Lower Silurian elastic rocks on the western flank of the Plynlimon Inlier (Cave and Hains, 1986). At Brynyrafr, the lode traverses mudstones and sandstones belonging to the Bryn-gas and Drosgol formations, both of Ashgill age. At the mine, the lode has an ESE–WNW trend, but it veers to the more typical ENE–WSW orientation slightly to the west of the mine. The dip is near-vertical, and displacement is only slight (Jones, 1922).

The mineralization was emplaced in two main episodes, represented by a total of five mineral assemblages (Mason, 1994, 1997). The early (A1) mineralization consists of breccias cemented by milky quartz with a range of sulphides. A feature of the breccias which is of particular interest is the presence of small, open fissures crossing intra-breccia rock-clasts. These are lined with an 'Alpine-type' mineral assemblage comprising micro-crystalline quartz, albite, rutile and apatite. Their genesis is as yet poorly understood. The main A1 assemblages represented comprise the A1-b quartz-sphalerite association, followed by the A1-c assemblage, here featuring quartz with chalcopyrite, abundant millerite and rare galena. Excellent specimens, by Central Wales standards, of acicular millerite up to 20 mm, associated with chalcopyrite, have been found in quartz cavities. The A1-e 'ferroan dolomite influx' is only weakly represented at this site (although it is abundant at Henfwlch Mine, only 1 km to the west) and comprises rare ferroan dolomite filling cavities in earlier breccias.

The later (A2) mineralization, consisting of glassy quartz-cemented breccias and crustiform fracture-linings, comprises two assemblages. Firstly, quartz with coarse-grained galena and sphalerite, some of the latter showing a fibrous, banded texture (A2-a), is common and appears to have been the main economic assemblage at the mine. Secondly, abundant quartz-pyrite-marcasite intergrowths (A2-f) occur, including finely crystallized, bladed marcasite and attractive crusts of quartz crystals up to 3 cm. As at other Central Wales Orefield mines, the A2-f assemblage appears to represent the final phase of primary mineralization.

Brynyrafr Mine is not particularly noteworthy as a locality for secondary minerals. Minor micro-crystalline hemimorphite occurs as an alteration product of sphalerite, while traces of post-mining linarite, malachite and brochantite have been found coating oxidized chalcopyrite of the A1-c assemblage.

Interpretation

Re-brecciation and cross-cutting vein textures clearly demonstrate that the primary mineralization at Brynyrafr Mine is polyphase and equates to the regional paragenetic assemblages of the Central Wales Orefield, as proposed by Mason (1994, 1997). In Central Wales, the vast majority of mineralized fractures of both A1 and A2 groups have an ENE–WSW trend. The production and subsequent re-activation of a regional set of open fractures of this orientation would require extensional stresses operating on an approximately NNW–SSE alignment, essentially normal to the Caledonian compressive trend.

The early (A1) phase of mineralization is believed to be of early Devonian age, based both on lead isotope data (Fletcher *et al.,* 1993) and on the postulated tectonic regime at that time, when post-compressional relaxation would have allowed the liberation of intraformational waters. These would have been formed earlier, during metamorphic dewatering of the underlying sedimentary pile, but would have been largely trapped under the Caledonian compressive stresses prevailing. Under the conditions of post-folding relaxation, such fluids would have become mobilized. Upward migration, accompanied by leaching of metals, would then ensue; as relaxation progressed, the metalliferous fluids would logically migrate into the low-pressure zones created by relaxation joints. Given sufficient fluid availability, the process of upward fracture propagation by hydraulic action would commence (Philips, 1972), resulting in the development of mineralized breccia-zones.

The later (A2) mineralization of the Central Wales Orefield has given a variety of lead isotope ages (Swainbank *et al.,* 1992; Fletcher *et al.,* 1993), ranging from early Carboniferous (A2-a) to Permian (A2-b + c). The A2-f marcasite-bearing assemblage clearly post-dates all assemblages for which lead isotope data have been obtainable. In regional tectonic terms, the emplacement of the A2 assemblages clearly marked the re-establishment of a similar extensional stress regime to that which led to the development of the A1 mineralization. Regional stresses of this type were again operative during the extensional phase of the Variscan orogenic cycle in late Devonian and early Carboniferous times. As with the early phase of mineralization, brecciation has played an important role in the formation of the A2 deposits, although in addition some fluids simply rose up open fractures to produce coarse-grained crustiform deposits reminiscent of the Mississippi Valley-type (MVI) mineralization of the 'Pennine-type' orefields. As with the A1 mineralization, the pattern is of the younger assemblages either cutting or re-brecciating older ones.

Mineralization similar to the Central Wales Orefield A2 assemblages is widespread in several areas of Lower Palaeozoic strata in Wales and the Welsh Borderland. The Llanengan Orefield on LISrn, the Llanrwst Orefield in eastern Snowdonia, and the West Shropshire Orefield in south-west Shropshire are all examples. Recent work on the West Shropshire Orefield, at the Snailbeach Mine GCR site (see GCR site report, Chapter 4; Pattrick and Bowell, 1991), has highlighted the role of early Carboniferous seawater as a potential fluid source. In their genetic model for the West Shropshire Orefield, Pattrick and Bowell (1991) inferred that during early Carboniferous times, when much of Wales and the Midlands comprised a landmass (the London–Brabant High), mineralization resulted from high-salinity marginal evaporitic brines percolating down into the underlying Lower Palaeozoic strata.

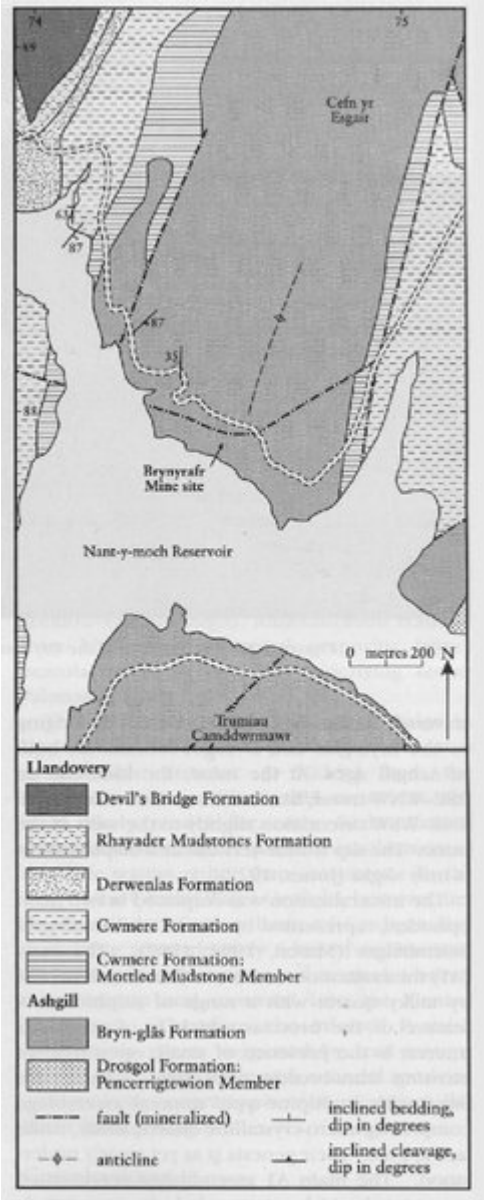
The palaeogeography of Central Wales in Upper Palaeozoic times places the area at a considerable distance (> 50 km) from the nearest seawater. Given this constraint, the most likely model for early Carboniferous mineralization would require the involvement of meteoric waters rather than seawaters. To the west of the Central Wales Orefield, however, lies the Permian to Tertiary basin of Cardigan Bay, containing approximately 6 km of sedimentary fill and a ready source of connate brines migrating up and eastward into the Central Wales area. Therefore, the inferred Permian mineralizing event, suggested by lead isotope data, is more compatible with a model involving connate brines migrating from the Cardigan Bay Basin (Mason, 1997).

Conclusions

Brynyrafr Mine provides one of the best sites for the study of textural features of mineralization in the Central Wales Orefield. The large dumps are rich in vein material from both the early (A1) and late (A2) phases of mineralization. Superb textures in breccias and cross-cutting crustiform veins are present in abundance. The site is of un-paralleled quality for demonstrating the repeated sequence of re-brecciation and crosscutting which characterizes the primary paragenesis of the Central Wales Orefield. The A1 mineralization is thought to be early Devonian in age and linked to

post-Caledonian relaxation, while the A2 mineralization is considered to have developed in early Carboniferous times and, on a smaller scale, in Permian times.

References



(Figure 5.55) Map of the Brynyrafr Mine GCR site. After British Geological Survey 1:50 000 Sheet 163, Aberystwyth (1984).

(Figure 5.56) Photograph of the Brynyrafr Mine GCR site. (Photo: T. Cotterell.)