Pennant Mine

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Introduction

Located only *c.* 5 km from the western margin of the intensively worked Halkyn Block of the North-east Wales Orefield, and closely adjacent to the Carboniferous-Lower Palaeozoic unconformity, Pennant Mine worked two near E–W-trending fissure-veins emplaced into mudstones and shales of Wenlock to Ludlow age, belonging to the Nantglyn Flags Formation. As in the North-east Wales Orefield, the chief metalliferous minerals are galena and sphalerite, with minor chalcopyrite. Here, however, barite is the principal gangue species, accompanied not only by calcite but also by significant quantities of witherite. Despite the similarity (in terms of sulphide mineralogy and textures) of the mineralization and its close proximity to the Carboniferous-hosted North-east Wales Orefield, barium minerals are rare in the latter orefield.

Pennant Mine was developed initially for lead in the 1700s (Vernon, 1993), and there are records of intermittent subsequent workings during the early 19th century (Foster-Smith, 1974). However, the main period of mining was during the latter half of the 19th century, when, in the period 1858 to 1891, 850.7 tons of galena concentrates were produced, yielding, in 1874, 35 oz of silver from 7.8 tons of ore (Burt *et al.,* 1992). Barite was produced between 1874 and 1891, and in 1913 the total recorded production was 2924 tons (Burt *et al.,* 1992), although some of these figures relate, in fact, to extraction of witherite (Carruthers *et al.,* 1915). Between 1913 and 1920, several hundred tons of witherite, with some barite and galena, were produced, partly by reworking of the extensive waste dumps (Wilson *et al.,* 1922).

Although sphalerite is a common mineral at Pennant Mine, there was no recorded zinc production, and the fact that the sphalerite proved difficult to separate from the associated barite (Dewey and Smith, 1922) may have been the reason for this. In 1919, a plant was established at the mine in an attempt to achieve this separation by heating the mixed barite/ sphalerite concentrates to *c.* 400° C on an iron plate, which caused the barite to decrepitate to a fine powder, supposedly making it easier to remove. Apparently, it was not successful (Wilson *et al.,* 1922).

Description

At Pennant Mine (Figure 5.76), shales and mudstones, of Wenlock to Ludlow age, belonging to the Nantglyn Flags Formation, are cut by a major, near E–W-trending vein (the Main Vein), a less-important sub-parallel vein (the South Vein), and a number of branch veins. The Main Vein, exceeding 3 m in width in places, has been worked over a 500 m strike length, and has been traced for a distance of approximately 1500 m (Carruthers *etal.,* 1915). Contemporary reports describe the Main Vein as having a central band rich in galena, with smaller quantities dispersed through the surrounding gangue, accompanied by 'zinc blende in aggregates of all sizes' (Dewey and Smith, 1922). The barite was described as forming a solid rib, up to 2 m in width, and was 'clearest' at the eastern end of the mine, where it was 'in proximity to the Carboniferous Limestone' (Carruthers *et al.,* 1915). Witherite was described as occurring in discrete pockets with a radial, crystalline structure.

The site (Figure 5.77) has been in a dilapidated, highly overgrown condition for many years, but recently extensive remedial works, including shaft capping and building restoration, have been undertaken in a project which will in due course see the mine open to the public as an interpretative centre. However, the amount of spoil visible at surface is now limited, although that uncovered during the restoration project has been saved and should be available for study (P. Selley, pers. comm.).

Material examined during the restoration works showed that sphalerite was the most abundant sulphide in the tips, perhaps not surprising given the difficulties experienced in separating it from barite. The coarse-grained sphalerite, of a pale yellowish-brown colour, is associated with minor chalcopyrite and occurs close to rock clasts, suggesting that it is early in the depositional sequence. Overgrowing barite, and intergrown with galena, are witherite and subordinate calcite.

Strontianite has been recorded, while a report of alstonite is thought to refer to a mis-provenanced sample (see Bevins, 1994). Secondary minerals are not common, although hydrozincite, probably post-mining in origin, occurs in trace amounts.

Interpretation

At Pennant Mine, an east-west fracture, of similar trend to those carrying Pb-Zn mineralization in the Carboniferous strata of the North-east Wales Orefield, carries a simple Pb-Zn-minor Cu ore assemblage, accompanied by calcite and barium minerals. It is possible that the mineralization worked at Pennant Mine represents a development of the North-east Wales Orefield mineralization within the subjacent Lower Palaeozoic succession. If this were proven, it would challenge the currently held view that the MVT mineralization occurring within the 'Pennine-type' orefields of Britain is confined to Carboniferous and younger carbonate-dominated, shallow-water sedimentary sequences.

Vein deposits with strong similarities in gross mineralogy and texture to those. of the Northeast Wales Orefield (i.e. simple mineral assemblages occurring as generally coarse crustiform growths) are abundant throughout the Lower Palaeozoic rocks of the Welsh Caledonides. These include the A2 or late-simple Central Wales veins (Bevins and Mason, 1997; Mason, 1997), the Llangynog Orefield (Bevins and Mason, 1997), the late-stage crustiform veins of the Dolgellau Gold-belt (Mason *et al.,* 1999), the I.lanengan veins on Ll■n, and the Llanrwst Orefield, in northern Snowdonia (Haggerty; 1995; Bevins and Mason, 1998). Similar veins occur on a small scale, cutting the Lower Palaeozoic strata of the Denbigh Moors and Clwydian Range (Bevins and Mason, 1999). The possibility exists, albeit unproven, that all of these post-Caledonian vein deposits may represent facets of a broad province of MVT vein mineralization formed during extensional phases of the Variscan cycle and linked with connate brine expulsion from adjacent sedimentary basins. Such basins developed around the Welsh Caledonide region in a piecemeal pattern over a protracted period of geological time from the Dinantian through to the early Jurassic, and were responsible for generating the fluids which so pervasively mineralized the carbonate sequences of the Carboniferous outcrops (Ixer and Vaughan, 1993).

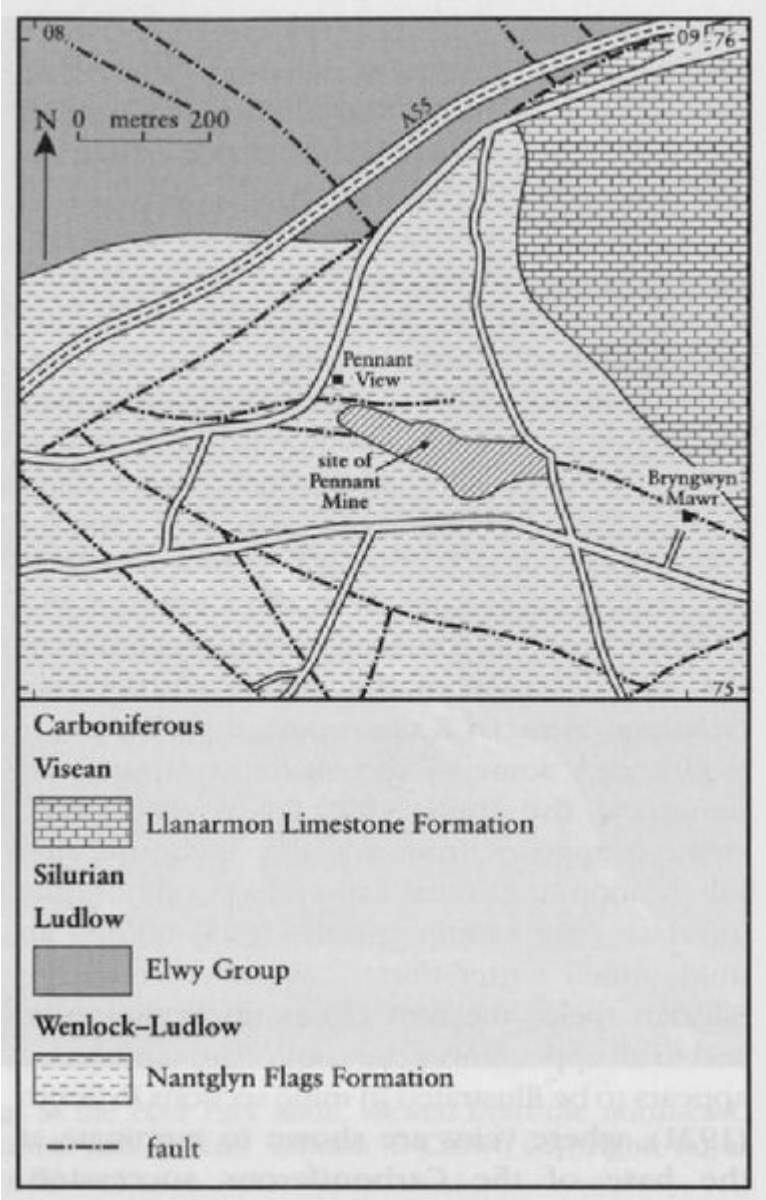
A problem in linking the mineralization at Pennant Mine to that of the Halkyn Block lies in the quantity of barium minerals occurring in the Pennant Mine mineralization. Barite is, in quantitative terms, a rare mineral within the Halkyn Block, only occurring as a late-stage phase overgrowing fluorite (which has not been reported from Pennant Mine). Witherite is virtually unknown from the Halkyn Block, the only reported occurrence being a specimen in the mineral collection of the National Museum of Wales (formerly from the R.J. King Mineral Collection), labelled as from Halkyn Mines (Bevins, 1994). Barite does occur, however, in Carboniferous rocks in other outlying areas of the North-east Wales Orefield, for example at the Bron-Eyarth Mine, to the south of Ruthin, and at Llangynhafal, to the north of Ruthin (Carruthers *et al.,* 1915). However, both of these occurrences are, compared to the Pennant Mine, relatively minor. The reason, therefore, for this localized major concentration of barium minerals remains to be established. Otherwise, the sulphide mineralization at the Pennant Mine is, in terms of textures and paragenetic sequence, remarkably similar to that of the Halkyn Block.

The mineralization at Pennant Mine warrants more detailed comparison with that of the Halkyn Block, involving a study of sulphur isotopes (using barite, galena and sphalerite) and Pb-Pb isotope analyses of galena from both areas.

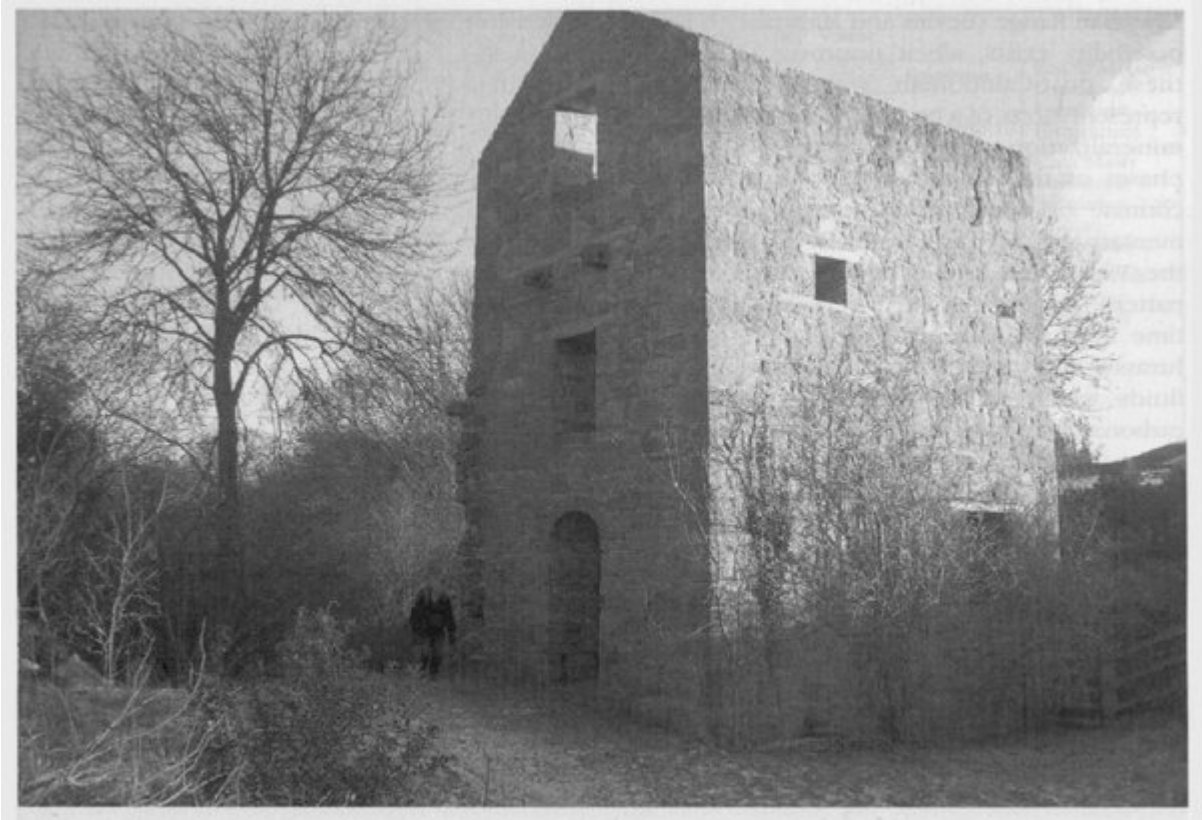
Conclusions

The mineralization worked at the Pennant Mine carries a simple Pb-Zn-minor Cu ore assemblage accompanied by calcite, barite, witherite and rare strontianite. It possibly represents an extension of the Carboniferous-hosted MVT North-east Wales Orefield, but emplaced into the subjacent Lower Palaeozoic strata. The possibility that MVT mineralization can develop in older, non-carbonate sequences as well as its more usual host is worthy of further detailed investigation, as many vein deposits in the Welsh Caledonides have mineralogical and textural similarities to the limestone-hosted MVT 'Pennine-type' deposits. The direct comparison of the Pennant Mine with the closely neighbouring Halkyn Mountain area warrants further research.

References



(Figure 5.76) Map of the Pennant Mine GCB site. Based on Institute of Geological Sciences 1:50 000 Sheet 95, Rhyl (1970), and British Geological Survey 1:50 000 sheets 107, Denbigh (1985b), and 108, Flint (1999).



(Figure 5.77) Photograph of the restored engine-house at the Pennant Mine GCR site. (Photo: T. Cotterell.)