Cwmystwyth Mine

[SN 802 746]

Introduction

Cwmystwyth Mine (Figure 5.52) is a classic locality for the study of mining geology, mineralogy and industrial archaeology, as well as providing an excellent introduction to the mineralization of the Central Wales Orefield. Although no element of the primary or secondary paragenesis exhibited here is unique, several paragenetic stages belonging to the early A1 and late A2 phases of metallogenesis (Mason, 1994, 1997) are well represented.

The Cwmystwyth Mine site comprises two areas. Adjacent to the mountain road to Rhayader, and on the lower slopes of Graig-Fawr and Copper Hill (Bryn Copa), large amounts of study material ensure that Cwmystwyth is an ideal teaching and demonstration site (Figure 5.53). The more remote parts of the site high on Graig-Fawr and Copper Hill include, in addition to primary minerals, significant secondary mineralization (Bevins and Mason, 1997) and spectacular mining geology. Additional interest is provided by ancient opencast workings on Copper Hill, which have been excavated by mining archaeologists. Charcoal, deer antler implements and wood unearthed during these excavations have been dated by radiocarbon techniques to Early Bronze-Age times (Timberlake, 1989), making this one of the most important early mining sites in Europe (Figure 5.54).

Whether the Romans worked lead at Cwmystwyth has long been a subject of speculation, since hard evidence for any Roman activity at the site itself has yet to be found. It is likely, however, that some mining took place under the administration of the Cistercian Monks responsible for the construction of the nearby Strata Florida abbey, which was completed in 1201 (see Hughes, 1981b, for a detailed historical account). However, specific records of mining in Central Wales are generally scarce prior to the middle of the 16th century. An interesting account of the site during the reign of Henry VIII was given by Leland in his '*Itinerary in Wales 1536–39*',where he describes approaching the mine from the direction of Rhayader:

'About the middle of this Wstwith *(sic.)* valley that I ride in, being as I guess three miles in length, I saw on the right hand of the hill Cloth Moyne (= Clodd Mwyn, translating as 'Mine of Lead Ore'), where hath been a great digging for Leade, the smelting whereof hath destroid the woodes that sometimes grew plentifully thereabout' (see Hughes, 1981b).

The description shows that, by this time, the workings were already sizeable. From then onwards, the mine was rarely inactive. Leases for its working passed through the hands of many great 17th century mining figures, including Sir Hugh Myddleton and Thomas Bushell, each with strong connections to the Society of Mines Royal, but both of whom, however, were more concerned with the much more argentiferous ores at the Goginan and Darren mines, to the north-west (see Darren Mine GCR site report, this chapter). By the mid-1700s the Champion Process had been set up to extract metallic zinc from the previously worthless sphalerite which occurred abundantly at this and many other Central Wales mines. At this time Cwmystwyth Mine was under the control of Thomas Bonsall, and it has been suggested by several industrial archaeologists that mine tips containing rich zinc-ore may all pre-date the Bonsall era (see Hughes, 1981b).

Activity at Cwmystwyth continued into the 20th century, but then declined, finally ceasing just before the onset of the Second World War. According to Jones (1922), recorded production in the years 1848 to 1916 (with a few gaps) amounted to 39 912 tons of lead ore (with 33 509 oz of silver recovered) and 18 913 tons of zinc ore. This is clearly only a fraction of the total output. Estimates tend towards a production of 250 000 tons of lead ore (Hughes, 1981b), but the true figure is clearly unobtainable. Such an estimate is, however, not incompatible with the great extent of the workings.

Description

A major system, over 1.5 km in length, of mainly ENE–WSW-trending anastomozing mineralized breccia veins cuts a synclinal fold containing a sequence of mudstones and sandstones belonging to the Llyn Teifi Member of the

Cwmystwyth Grits Group of Llandovery age. This is the highest stratigraphical horizon intersected by significant vein mineralization in the Central Wales Orefield. Many individual veins are noted on old mine plans, but three principal mineralized fractures can be identified. These comprise the S-dipping Comet and Kingside lodes and the less-important, N-dipping Mitchell's Lode Cones, 1922; Davies *et al.,* 1997). In the western part of the mine, the Kingside Lode was generally referred to as 'Main Lode'. Both the Kingside and Comet lodes dip to the south at 50°–65°. In the western part of the mine, however, the dip of the 'Main Lode', flattened out between the 15-fathom and 30-fathom levels, where, 'for an area of at least 150 sq. yds. a mass of galena, lying almost horizontally with a constant thickness of 6 ft 2 in. between its roof and its floor, was worked' (Jones, 1922). This area was known as 'The Great Flat' (Jones, 1922).

Mitchell's Lode is of interest as it displaces the Comet Lode at their point of intersection, down-throwing the Comet Lode to the north. Indeed, this tract of ground has been subject to repeated fracturing; in addition to the movements which accompanied successive phases of mineral emplacement, a major, N-dipping normal fault (the Ystwyth Fault) runs along the northern side of the valley. This is a major, post-mineralization structure, the estimated downthrow of which may be as much as 1 km (Jones, 1922), which cuts off both the Kingside and Comet lodes at depth. At these intersections, large, broken masses of galena occur in day-gouge (Jones, 1922). Interestingly, the 'Great Flat' in the western part of the mine occurred where the 'Main Lode' was in proximity to its intersection with the Ystwyth Fault, which terminated the 'Flat'.

The Comet Lode is usually to the north of the Kingside, but both run together along Graig-Fawr, where vast quantities of ore were found. To the east, on Copper Hill, they again diverge, this time with the Kingside Lode to the north. A further group of mineralized fractures, termed the 'Pengeulan Lodes', outcrop on Copper Hill to the south of the main mineralized belt.

Descriptions of the mineralization of the various lodes (e.g. Jones, 1922) suggest a great degree of complexity. However, this has been clarified by paragenetic studies (Bevins and Mason, 1997) which reveal that the Comet and Pengeulan lodes on Copper Hill were initially activated during the early (A1) mineralization (Mason, 1994, 1997). This period of mineralization is represented by breccias cemented by quartz and sphalerite (A1-b assemblage) and by breccias cemented by quartz, galena (with ullmannite inclusions), chalcopyrite (hence the name, 'Copper Hill') and minor late sphalerite (A1-c/d assemblages). Abundant ferroan dolomite with quartz, belonging to the A1-e assemblage, cements clasts of both rock and earlier mineral assemblages.

The early breccias typically consist of angular rock-fragments evenly distributed throughout a mineral cement, predominantly consisting of quartz. The quartz cementing these early breccias is typically milky-white and tough; it forms radial growths around clasts and contains vugs lined with long prismatic crystals (< 15 mm) which have water-clear terminations. The aforementioned sulphides tend to occupy quartz vugs, although well-formed crystals are rare.

The remainder of the mineralization at Cwmystwyth belongs to the late (A2) phase (Mason, 1994, 1997). This is far more wide spread, being abundant on all mine tips, and provided most of the lead- and zinc-ores mined. Typically the A2 mineralization has a more open texture and comprises vuggy breccia cements and local crustiform-banded veins. Coarsely crystalline sphalerite, followed by galena with quartz, represents the A2-a assemblage and is followed by fibrous sphalerite with quartz, calcite and late pyrite (A2-c assemblage). The latest mineralization at Cwmystwyth comprises pyrite-marcasite (A2-f assemblage). Contamination of earlier Pb-Zn ores by marcasite net-veining is particularly noticeable in the western workings, where some sphalerite was so contaminated with iron sulphides as to be worthless (Jones, 1922). Old reports also indicate some vertical mineral zonation, particularly citing Mitchell's Lode, where galena in the upper workings gradually gave way to sphalerite at depth (see 'Davies *et al.,* 1997).

Post-mineralization tectonic movement along some of the mineralized fractures is indicated by the presence of foliated galena, containing bands of cataclastic sphalerite debris on some of the tips. The major, post-mineralization Ystwyth Fault is not exposed, since it runs along the valley bottom and is buried under alluvium, which extends in places to a considerable depth below the present valley floor. Indeed, 'gravel of glacial origin' was encountered in underground drivages in the vicinity of the fault zone at depths approaching 30 m from surface (Jones, 1922). The footwall of the Ystwyth Fault may at times be discerned by a line of rising springs along the side of Afon Ystwyth, some of which represent mine waters escaping to surface and are thus a potential source of pollution.

Secondary mineralization is widespread at Cwmystwyth Mine, particularly in the upper workings on Copper Hill, where the tips from surface workings on the Kingside Lode locally contain coarsely crystalline, yellow-green pyromorphite and cerussite. Good specimens are, however, rare due to centuries of weathering. Underground, crystalline hemimorphite on quartz has been collected from the Level Fawr section of the mine (Bevins, 1994), while workings on the Comet Lode in the Copper Hill area have yielded post-mining basic copper sulphates including brochantite and posnjakite, a rare member of the langite group. Minor amounts of micro-crystalline post-mining hydrozincite, malachite and linarite are widespread throughout the site.

Interpretation

The paragenetic sequences within the various mineral assemblages at Cwmystwyth Mine are typical of the Central Wales Orefield, with its complicated history of repeated phases of mineralizing activity extending from Devonian through into Carboniferous (and possibly even later) times (Mason, 1994, 1997). With the exception of Brynyrafr Mine, the other Central Wales Orefield GCR sites are paragenesis specific, showing the relationships of the constituent minerals of the specific assemblages.

The wide belt of mineralized tensile fractures at Cwmystwyth, accompanied by a major post-mineralization normal fault, is suggestive of the presence of a deep-seated crustal weakness underlying the area, which has focused repeated fracturing along this line. The numerous lodes described in old reports are interpreted as anastomozing mineralized tensile fractures developed within an ENE–WSW-trending zone of tensile failure which was re-activated at a later stage, when the Ystwyth Fault was formed. Furthermore, the mineralized fractures themselves may have been re-activated during development of the Ystwyth Fault. Mitchell's Lode has a similar dip to the Ystwyth Fault and has displaced the Comet Lode in a normal sense. The mineralization within Mitchell's Lode belongs to the A2-a assemblage, which is widespread within both the Kingside and Comet lodes, and is therefore likely to be cogenetic with them. It is not unreasonable, therefore, to suggest that the displacement focused along Mitchell's Lode was post-mineralization, occurring in response to the much greater movement on the Ystwyth Fault.

More speculatively, it is possible that another feature, the change in attitude of the 'Main Lode', from 50° to near-horizontal in the immediate vicinity of the Ystwyth Fault, can be explained by the effects of post-mineralization drag-folding along the hangingwall of the fault.

Mineral-cemented breccias occurring along large, generally ENE–WSW-trending tensional fractures, characteristic of the Central Wales Orefield, are particularly well-developed at Cwmystwyth. The mechanism for their development was initially described by Phillips (1972). In this now widely accepted model, fracture propagation was assisted directly by the presence of hydrothermal fluids which had migrated into the fracture plane. Fracturing propagated upwards in a series of pulses, each brittle failure occurring when the coupled forces of regional tensional stresses and the hydraulic effect of the highly pressurized hydrothermal fluid, which literally jacked the fracture walls apart, overcame the tensile strength of the rock. Following each hydraulic fracturing episode, a relatively low-pressure void, filled with hydrothermal fluid, was created, setting the scene for the next stage of the hydraulic brecciation process.

Several factors probably combined to trigger the next step of the process, amongst which the sudden drop in fluid pressure and the seeding effect generated by the introduction of millions of small rock clasts, are important. The outcome would be that the hydrothermal fluid is destabilized, so that elements previously held in solution are rapidly precipitated as quartz, carbonates and the base-metal sulphides. The minerals would nucleate on the surfaces of the angular rock-clasts, crystallizing into radial growths around the clasts and eventually locking them into a mineralized, matrix-supported breccia.

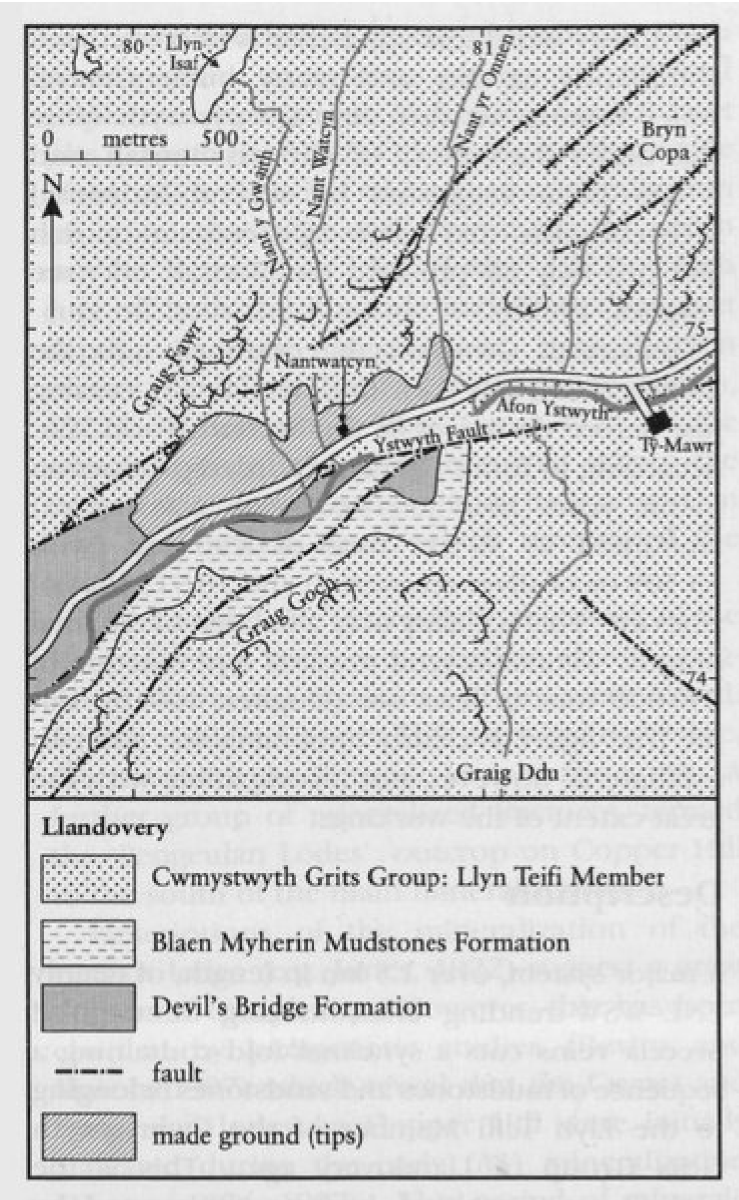
Many specimens of vein material at Cwmystwyth and other Central Wales Orefield mines reveal more than one phase of brecciation; it is not uncommon to see, for example, angular fragments of quartz-chalcopyrite mineralization cemented in a matrix of ferroan dolomite. Again, it is likely that hydraulic brecciation was the agent responsible for such textures: sudden depressuring of quartz would be likely to cause it to shatter through the hydraulic pressure of inclusion fluids. Provided a sufficient pressure differential is established rapidly enough, hydraulic brecciation is likely to occur.

This process, from hydraulic fracturing through hydraulic brecciation to mineral deposition, is likely to have been extremely rapid, otherwise the rock clasts would sink and coalesce together. Instead, they occur evenly spaced throughout the breccia, locked fast in their mineral cement.

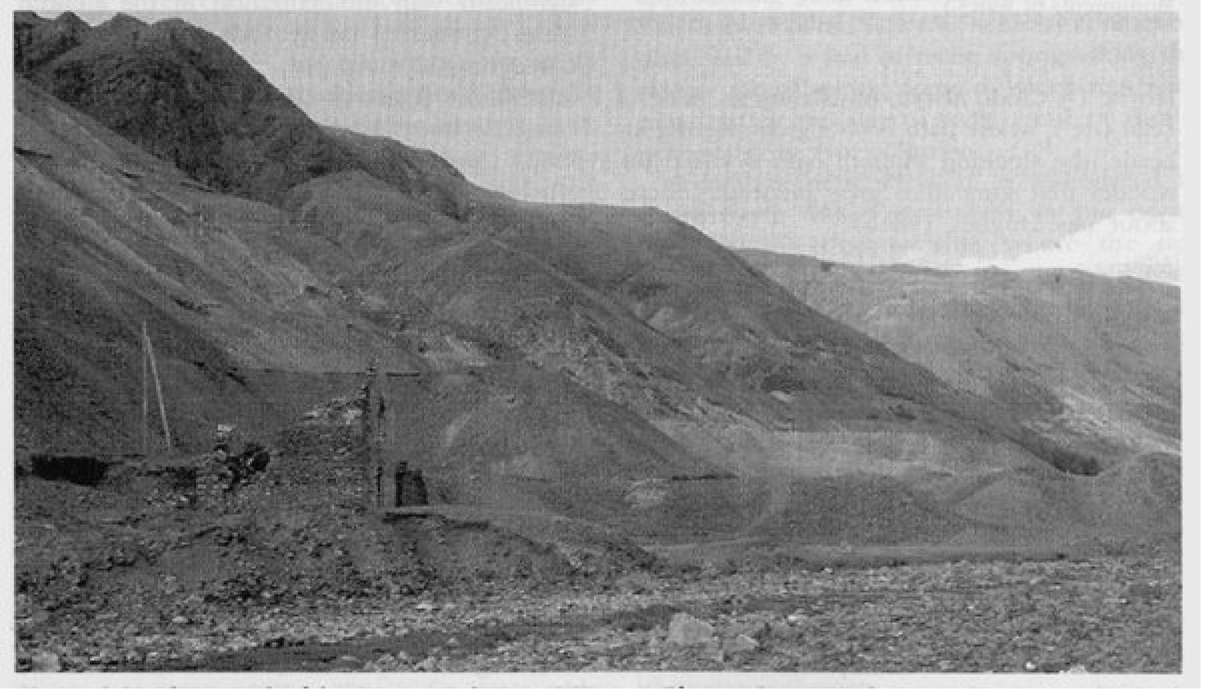
Conclusions

The mineral veins at Cwmystwyth Mine form a branching network which trends ENE–WSW and is cut off to the south by the post-mineralization Ystwyth Fault. The veins consist of breccias, cemented by quartz and other minerals. The breccias were formed by hydraulic fracturing caused by the response of pressurized mineralizing fluids to sudden and sharp pressure changes as crustal fractures extended upwards through the strata. The most important ore minerals at Cwmystwyth are galena and sphalerite. Chalcopyrite, pyrite and marcasite are less common. The mineralization was emplaced through repeated phases of tensile fracturing which began in Devonian times and continued through into Carboniferous and, possibly, later times. Major upper crustal tensile failure subsequently occurred along the same structural trend, resulting in the formation of the universalized Ystwyth Fault, with a down-throw to the north of up to 1 km.

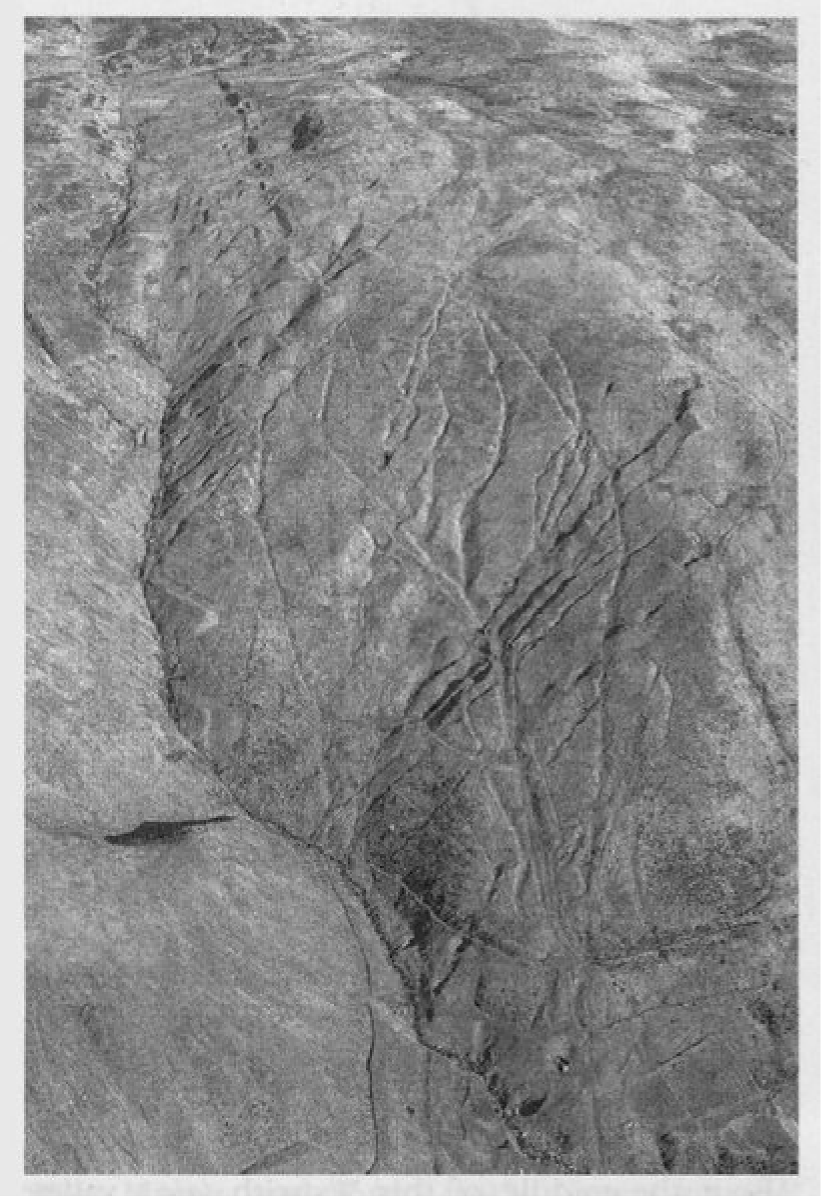
[References](#)



(Figure 5.52) Map of the Cwmystwyth Mine GCR site. Based on British Geological Survey 1:50 000 sheets 179, Rhayader (1993a), and 178, Llanilar (1994).



(Figure 5.53) Photograph of the Cwmystwyth Mine GCR site. (Photo: J.S. Mason, © National Museum of Wales.)



(Figure 5.54) Oblique aerial photograph of the Cwmystwyth Mine GCR site, showing complex sets of hushes and leats. (Photo: © Crown copyright: Royal Commission on the Ancient and Historical Monuments of Wales.)