Llechweddhelyg Mine

[SN 683 848]

Introduction

The small working at Llechweddhelyg (Figure 5.89), which was centred on a shaft sunk in the 1850s on a section of a major fracture-belt referred to as the 'Camdwr Lode' (Jones, 1922), encountered, by Welsh standards, an unusually substantial zone of supergene enrichment formed by the alteration of a primary Cu-Pb-dominated vein sulphide deposit. The site has produced many fine specimens of the secondary species malachite, chrysocolla, cerussite, pyromorphite and wulfenite, which are widespread in the Central Wales Orefield. In addition, a number of extremely rare micro-crystalline supergene species have been recorded, including the first Welsh occurrence of the rare Cu-Pb sulphate mineral chenite (Rust, 1994). The importance of the Llechweddhelyg site lies in the pervasive nature of the supergene alteration, in contrast with most other Central Wales Orefield sites where fresh sulphides occur in surface exposures. The suggestion has been made (Mason, 1994, 2004) that the supergene zone at Llechweddhelyg represents one of only a few preserved examples of a remnant of widespread Tertiary alteration of hypogene mineralization, most other occurrences having subsequently been eroded away by Pleistocene glaciation.

Little has been published on the history of Llechweddhelyg, except that it was active in the 1850s and produced, in 1853, 3.4 tons of lead ore (Burt *et al.,* 1986). However, it must have been active prior to this, as there are also two short trial adits, the cramped dimensions of which are diagnostic of pre-19th century drivages. During the 19th century it was at times part of the Vaughan sett, along with the neighbouring Lletty Evan–Hen Mine, which was somewhat more productive (Jones, 1987). (Figure 5.89) Map of the Llechweddhelyg Mine GCR site. After British Geological Survey 1:50 000 Sheet 163, Aberystwyth (1984).

Llechweddhelyg has long been known to mineral collectors, and is consequently well picked-over. The mineralogy was first described by Jones (1987), and subsequent discoveries have been recorded by Bevins (1994), and Rust (1990b, 1994). Although spectacular specimens are now unlikely, the site still provides worthwhile research material. The following description is based on the above accounts, along with the results of fieldwork and subsequent research undertaken in the late 1980s (J.S. Mason, unpublished data).

Description

The Llechweddhelyg deposit (Figure 5.90) is situated within the major Camdwr Fault Zone, occupying a branch of that structure. The fault downthrows mudstones of the Devil's Bridge Formation on the northern side against greenish to buff, banded mudstones of the Rhayader Mudstones Formation to the south, both units being of Lower Silurian (Llandovery) age (Cave and Haim, 1985). The primary vein mineralization at Llechweddhelyg belongs to the A1-c polymetallic assemblage within the overall Central Wales Orefield paragenesis (Mason, 1994, 1997). The mineralization occurs as breccia cements and also as solid ribs of galena intergrown with chalcopyrite. Unoxidized examples of the latter are extremely rare. Massive, fine-grained quartz, showing a grey colour due to included, finely disseminated galena and chalcopyrite, is relatively common. The galena characteristically contains inclusions of minor tetrahedrite, bournonite and ullmannite (J.S. Mason, unpublished data). At the main shaft, only this assemblage is present but at a second shaft, 100 m to the west, the debris indicates that calcite-marcasite mineralization, belonging to the A2 or late Central Wales Orefield paragenesis (Mason, 1994, 1997), was intersected.

Supergene processes have resulted in the pervasive alteration of the massive sulphides to a carbonate-dominated assemblage, occurring in a massive, vuggy matrix of iron oxides. Within the massive, fine-grained quartz, alteration has resulted in the deposition of secondary minerals along the numerous open joints that cross-cut it. Within the breccias, quartz-hosted sulphide veinlets have been partially oxidized to a wide variety of secondary minerals.

Within the iron oxides matrix, massive cerussite and fibrous malachite, accompanied in places by chrysocolla, are the chief secondary species, with pods of solid cerussite up to 5 cm having been recorded (J.S. Mason, unpublished data). Linarite occasionally replaces marginal areas of the cerussite. Malachite is abundant, and replaces chalcopyrite as massive, fibrous aggregates, which sometimes form attractive crystal sprays up to 40 mm across in part-filled cavities. Malachite is replaced in some samples by chrysocolla, and is overgrown by cerussite or,less frequently, by equant pyromorphite up to 3 mm. Coarse-grained cerussite and equant pyromorphite never occur on the same sample (Mason, 2004), although wulfenite, forming tabular crystals up to 2 mm (exceptionally up to 5 mm) is invariably associated with pyromorphite, which it overgrows. A minor, subsequent generation of micro-crystalline pyromorphite occasionally coats, and partially replaces, cerussite.

In polished section, the alteration of the sulphide ore is of particular interest as it reveals the process by which chalcopyrite is incrementally converted to chalcocite. Both bornite and covellite are intermediate products of this process: while bornite forms rare flame-like, chalcopyrite-cored inclusions in chalcocite, covellite is common and pervasively net-veins both chalcopyrite and galena Q.S. Mason, unpublished data). Small (10–20 gm), bright-yellow grains, embedded in iron oxides adjacent to the alteration products described above, have been identified optically as native gold Q.S. Mason, unpublished data), an identification supported by assays of this material which frequently show gold levels of *c.* 0.75 g/t (S.J.S. Hughes, pers. comm.).

Within the open joints traversing the massive quartz, cerussite or pyromorphite + wulfenite are the chief secondary species present; locally, spheroidal fibrous malachite (< 10 mm) accompanies the tabular cerussite crystals. These species also occur within the part-oxidized sulphide veinlets within the breccias, but are accompanied there by a much wider range of minerals which form a suite similar to that developed at the Eaglebrook Mine GCR site. Within the breccias, bleaching Of mudstone clasts, with strong development of manganese oxide dendrites, is not uncommon. The supergene assemblage is sulphate-dominated, with subordinate carbonates, and comprises, in order of abundance, linarite, caledonite, hydrocerussite, susannite, anglesite, brochantite, langite, wroewolfeite, schmiederite, steverustite, mattheddleite, elyite and chenite. Recently, redgillite has been determined from Llechweddhelyg Mine (Pluth *et al.,* 2005). All of the above mentioned species are micro-crystalline (< < 1 mm) but they tend to be well formed. The rarer species are only represented by a few samples, so that definitive associations are unclear. However, a particularly consistent association is observed between caledonite, susannite and mattheddleite. Small veinlets of intergrown native copper, chalcocite and cuprite also occur within brecciated mudstones, but are rare.

Interpretation

The supergene assemblage at Llechweddhelyg Mine is one of the best developed in the Welsh Caledonides. This is evident from the sheer quantity of coarse-grained supergene minerals and the pervasive replacement of normally stable sulphides such as galena, accompanied by the local bleaching of the mudstone wall-rocks. These features are characteristic of an environment in which prolonged and intense secondary leaching and reprecipitation processes have been acting.

The concept that the Llechweddhelyg supergene assemblage actually constitutes a well-preserved survivor of glacial erosion was first put forward by Mason (1994), and later elaborated upon by Mason (2004). There is mounting evidence (Mason, 2004) for the supergene alteration of the primary mineralization in the Central Wales Orefield to have occurred in three episodes. Firstly, intense leaching of the primary ores during the Tertiary period, under terrestrial (Cope *et al.,* 1992), protracted sub-tropical conditions, produced the coarsely crystalline supergene assemblage as seen at Llechweddhelyg Mine. Prior to the Pleistocene glaciation, such supergene zones may have existed in the near-surface parts of most if not all sulphide-bearing veins in the orefield. However, glacial erosion removed most of these zones, leaving behind only localized remnants.

Secondly, and following the Pleistocene glaciation, groundwaters began once again to attack newly exposed surfaces and, over the geologically short period of time since the end of the last glaciation, relatively modest alteration has resulted in the development of mainly micro-crystalline secondary minerals. The breccia-hosted micro-crystalline secondary assemblage at Llechweddhelyg Mine is likely to have at least partly formed in this manner.

Thirdly, the activity of mining the various deposits caused fresh sulphide surfaces to be exposed to surface conditions, so that very recent, anthropogenic secondary minerals were formed, again with a tendency to be micro-crystalline. These post-mining assemblages tend to contain metastable minerals, with often-complex parageneses (Mason and Green, 1996). At Llechweddhelyg Mine, it is uncertain whether any of the secondary minerals are of post-mining origin. However, by analogy with other sites, for example the Frongoch Mine GCR site (Green *et al.,* 1996), *it* may be surmized that elyite, hydrocerussite, langite and wroewolfeite, which all occur on part-oxidized sulphide, are likely to be of post-mining origin.

At Llechweddhelyg Mine, substantial supergene mineralization clearly extends to a considerable distance below surface. However, there are other mines in the Central Wales Orefield where the reverse is the case. This is revealed at the Ceulan Mine Opencast GCR site, where fresh galena and sphalerite occur close to surface. Furthermore, an opencut at Tynyfron Mine [SN 724 785], on the side of the glacially carved Rheidol Valley, reveals fresh marcasite exposed at surface (Mason, 2004). Marcasite is particularly unstable in the near-surface environment and it is most unlikely that it would withstand millions of years of sub-tropical weathering: therefore it follows that glacial erosion must have stripped off any oxidized zone to reveal the mineral in its fresh state at surface.

The preservation of the major supergene zone at Llechweddhelyg Mine suggests that it extended to a relatively great depth, so that only part of it was eroded away. Such deep oxidation of the primary sulphide assemblage would be facilitated by the shattered nature of the broad tract of ground affected by the Camdwr Fault, permitting relatively easy and deep circulation of oxidizing groundwaters.

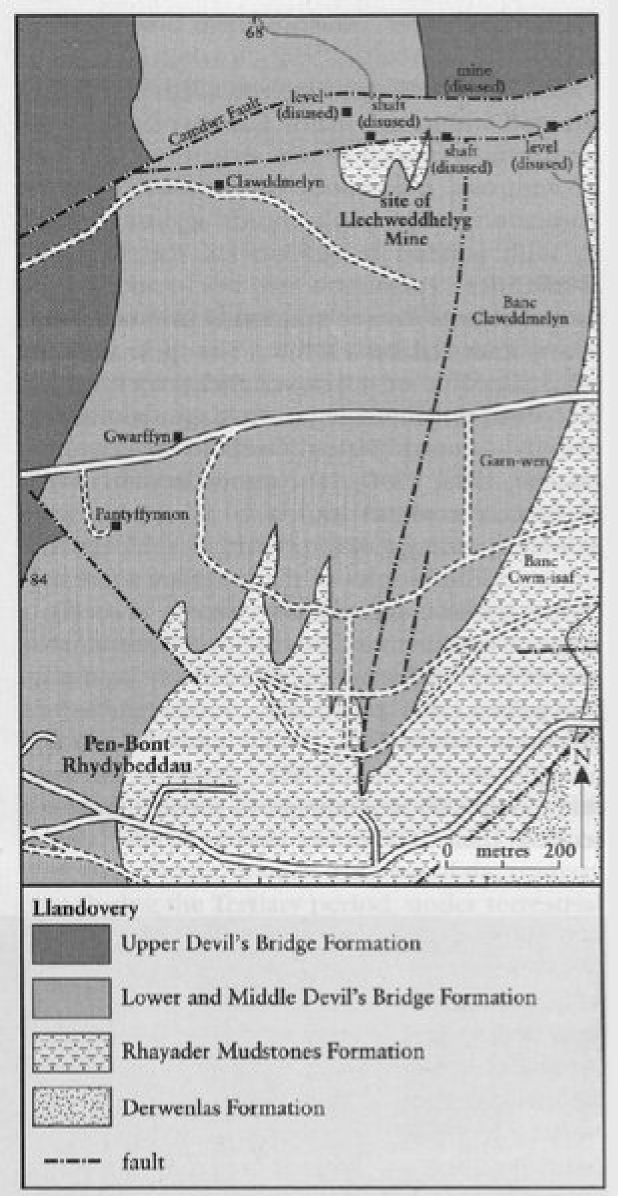
The pre-glacial theory for the origin of the supergene mineralization at Llechweddhelyg Mine is also supported by comparing the Welsh Caledonides with other mineralized areas of the British Isles. Only one area of the British Isles, namely South-west England, has been relatively unaffected by the erosional effects of glacial ice (see Campbell and Bowen, 1989). In this area, major supergene zones composed of coarse-grained secondary minerals are present within most, if not all, metalliferous veins. The quantity of coarsely crystalline supergene minerals in areas which have been intensively eroded by glaciation, such as the Caldbeck Fells, in the English Lake District (Cooper and Stanley, 1990), can be explained by particularly permeable ground conditions allowing unusually deep and extensive supergene alteration to occur, as at Llechweddhelyg Mine.

The source of the phosphate necessary for the genesis of the coarse-grained pyromorphite may be explained by the spatial link between such mineralization and bleached mudstone wall-rocks. In turbidite-dominated areas, phosphatic concretions and phosphate-rich hemipelagites are common, and the Central Wales region is no exception (Cave and Haim, 1986). Both apatite and monazite (Read *et al.,* 1987) occur in these circumstances throughout Central Wales, providing a ready source of phosphorus to aggressively leaching groundwaters. Similarly, the molybdenum required for wulfenite formation could have been provided by the wall-rocks. Only low levels of molybdenum would be necessary for wall-rock leaching to provide the small amounts of molybdenum necessary for formation of wulfenite which, although conspicuous in this assemblage, occurs in only trace amounts in quantitative terms.

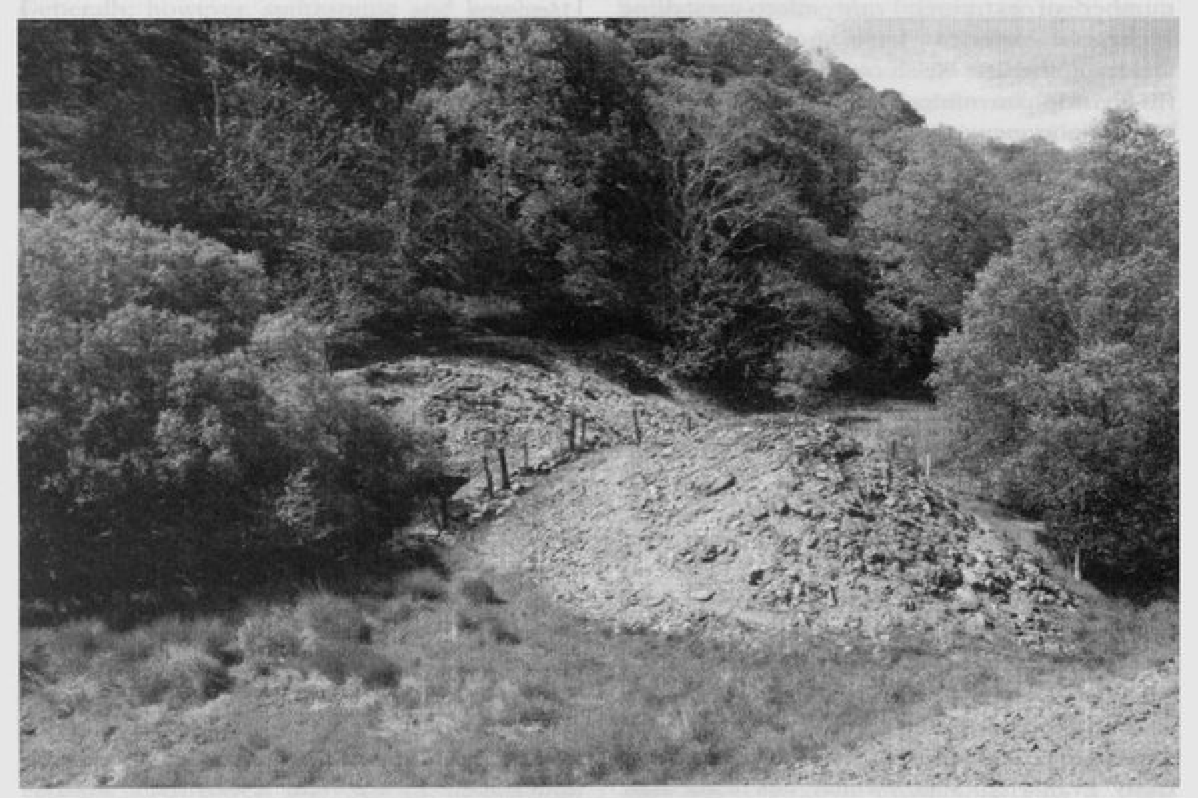
Conclusions

Supergene mineralization is particularly well-developed at Llechweddhelyg Mine. Evidence from Llechweddhelyg Mine supports the notion that more than one episode of supergene alteration has affected the metalliferous veins of the Central Wales Orefield. Deep, sub-tropical weathering in Tertiary times resulted in the formation of large quantities of oxidation products occurring as coarsely crystalline masses with well-defined parageneses in extensive zones. Glacial erosion stripped these from many veins, while exposing further fresh sulphides, which supergene processes once again began to affect, producing relatively limited amounts of secondary minerals. Finally, the creation of new, fresh sulphide exposures by mining activities again renewed the process, resulting in the post-mining suite of minerals.

References



(Figure 5.89) Map of the Llechweddhelyg Mine GCR site. After British Geological Survey 1:50 000 Sheet 163, Aberystwyth (1984).



(Figure 5.90) Photograph of the Llechweddhelyg Mine GCR site. (Photo: T. Cotterell.)