Lliwedd Mine

[SH 635 530]

Introduction

Lliwedd Mine (Figure 5.25), situated high on the shoulder of Lliwedd, one of the four summits which form the famous 'Snowdon Horseshoe', is one of a group of copper workings in the Cwm Llan district on the southern side of Snowdon, the others being Hafod-y-Llan, Braich-yr-Oen (or Y Geuallt) and Hafod-y-Porth. All these mines worked similar mineralization in a series of veins known as the 'Cwm Llan veins'. Lliwedd, however, is the most representative site because not only is mineralized material abundant in its dumps, but also because the opencut system reveals crucial evidence regarding the geometry of the mineral deposit.

Lliwedd Mine is said to have been first worked in the late 17th century (Bick, 1985), and was worked intermittently, with varying success, throughout the first half of the 19th century, before closing in the late 1860s. Much later, in the early 1900s, the site was re-appraised by the South African Gold Mining Syndicate.

In its working years, ore from Iliwedd Mine was hand cobbed (the extensive areas of finely broken veinstuff bear testimony to this) and crushed on site, using iron roll crushers and a stamp mill. The remoteness of the site, on a steep hillside between 450 m and 600 m OD, and accessible only via a steep, rough cart track, must have caused problems. As Bick (1985) commented: 'I do not think any other mine in Wales epitomizes to a greater extent the determination and spirit of the "old men"....'. As well as transporting the necessary machinery up to the site, the track saw a total of 1938 tons of copper ore make the return journey, including 303 tons in the best year, 1842.

Description

The mineralization worked at Lliwedd occurs entirely within basic tuffs and basaltic lavas belonging to the Bedded Pyroclastic Formation, within the Snowdon Volcanic Group of Caradoc age (Howells *et al.,* 1991). The vein trends ENE–WSW in the upper workings, but lower down the hillside it veers sharply to north-west-south-east, as depicted by the orientation of the spectacular, cavernous, near-vertical opencuts (Figure 5.26). The lowest opencut is one of the most impressive metal-workings in Wales, with a steep 10–15 m-high crag cut by a vertical slot over 2 m wide in places.

The ore minerals are hosted by quartz and chlorite, and comprise, in paragenetic order, abundant, often euhedral, pyrite and anhedral chalcopyrite, overprinted by a later assemblage of colloform pyrite, galena, chalcopyrite, pyrrhotite (often heavily weathered) and sphalerite. These minerals commonly display a complex, emulsoid intergrowth. Two varieties of sphalerite are present: an earlier, dark-brown, iron-rich variety displays abundant chalcopyrite-disease in polished section, while the later generation is of a lustrous, amber to yellow colour and is optically clean.

Other minerals recorded from the Cwm Llan group of mines, which, due to their similar mineralogy, may be expected to occur at Lliwedd include gold which has been detected geochemically in ore samples exceptionally reaching 1.8 g/t (T Colman, pers. comm.), and native copper, which occurs throughout this mining district as small (1–2 mm), thin bright leaves included within the wall-rock adjacent to vein margins. There also exists in this area a suite of bismuth-bearing minerals; an unidentified Pb-Bi sulphide was reported from Hafod-y-Porth Mine (Reedman *et al.,* 1985), while 2–3 mm, silvery-grey needles embedded in galena from Braich-yr-Oen Mine have been identified as cosalite (Bevins and Mason, 1998), which was shown by electron microprobe analysis to be accompanied by bismuthinite and native bismuth, both in microscopic amounts. Arsenopyrite has not been observed in the Cwm Llan veins, but does occur at Moel Hebog Mine, within the western margin of the caldera, 9 km to the south-west of Lliwedd.

A later generation of mineralization, occupying open fractures and comprising crustiform calcite with marcasite, is present in small amounts, as indeed it is throughout most of Snowdonia. At the nearby Britannia Mine, 2 km to the northwest of Lliwedd, below the summit of Snowdon, this late-stage mineralization is more widespread and also carries hematite and sphalerite (Reedman *et al.,* 1985; Bevins and Mason, 1998). Secondary mineralization at Lliwedd is limited to occasional malachite spots and the ubiquitous iron oxides, although there exists the potential underground for the existence of a post-mining assemblage similar to that described in Sneyd's Level at Britannia Mine (Bevins *et al.,* 1985).

Interpretation

The marked change in strike of the worked mineral vein at Lliwedd is indicative of a conjugate fracture pattern with ENE–WSW- and NW–SE-striking components. At most neighbouring mines only one fracturing trend (northwest-south-east at Britannia, and north-east-south-west at Hafod-y-Llan, Braich-yr-Oen and Hafod-y-Porth) is dominant, yet at Lliwedd there is clear evidence for the mineralization having been emplaced along both structural directions at the same time. The ENE–WSW trend at Lliwedd is somewhat anomalous, as most other veins within this structural set in the area trend north-east-south-west. However, this orientation falls within the field of fault orientations reported along the apical graben of the Snowdon Caldera, which is the structure genetically associated with the mineralization in the current model for emplacement (Reedman *et al.,* 1985).

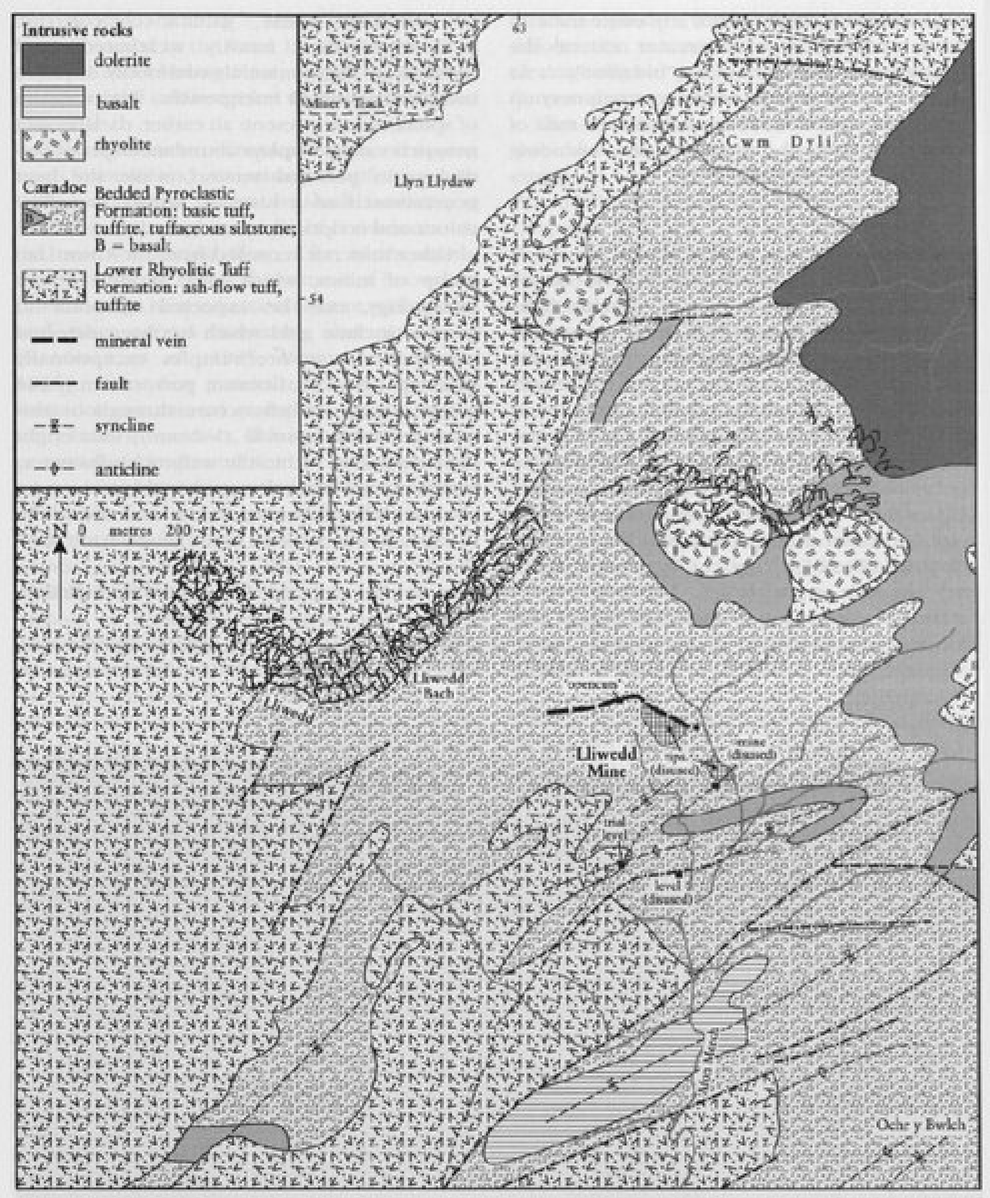
The model of Reedman *et al.* (1985) is supported by the fact that the veins are pre-tectonic in origin, as demonstrated by Fitches (1987). Both barren minor quartz veins (which are locally extremely common) and the larger, sulphide-bearing veins have suffered deformation, the nature of which varies according to vein orientation, so that veins with an initially high angle to cleavage have been folded, while those in a cleavage-parallel or sub-parallel orientation have been boudinaged. Within the massive quartz-sulphide veins, firm evidence for deformation is manifested by the existence of cleavage-aligned pressure fringes, composed of fibrous quartz, around sulphide grains.

The Acadian deformation of the veins implies that the mineralization must have been emplaced after the deposition of the Bedded Pyroclastic Formation but before early to mid-Devonian tectonism. Taking this into account, Reedman *et al.* (1985) invoked a modified Kuroko-type genesis, involving the hydrothermal convection of seawater through the caldera fill, driven by heat from the high-level magma chamber from which the volcanic sequence was erupted. The metals were leached by these fluids from the surrounding volcanic and sedimentary rocks, and were deposited as sulphides along the fracture system controlling caldera development, at an estimated depth of 2 km. Reedman *et al.* (1985) also suggested that in places such fluids escaped to surface, to form exhalative deposits, citing the Cae Coch massive pyrite-dominated deposit as an example (see Cae Coch Mine GCR site report, this chapter).

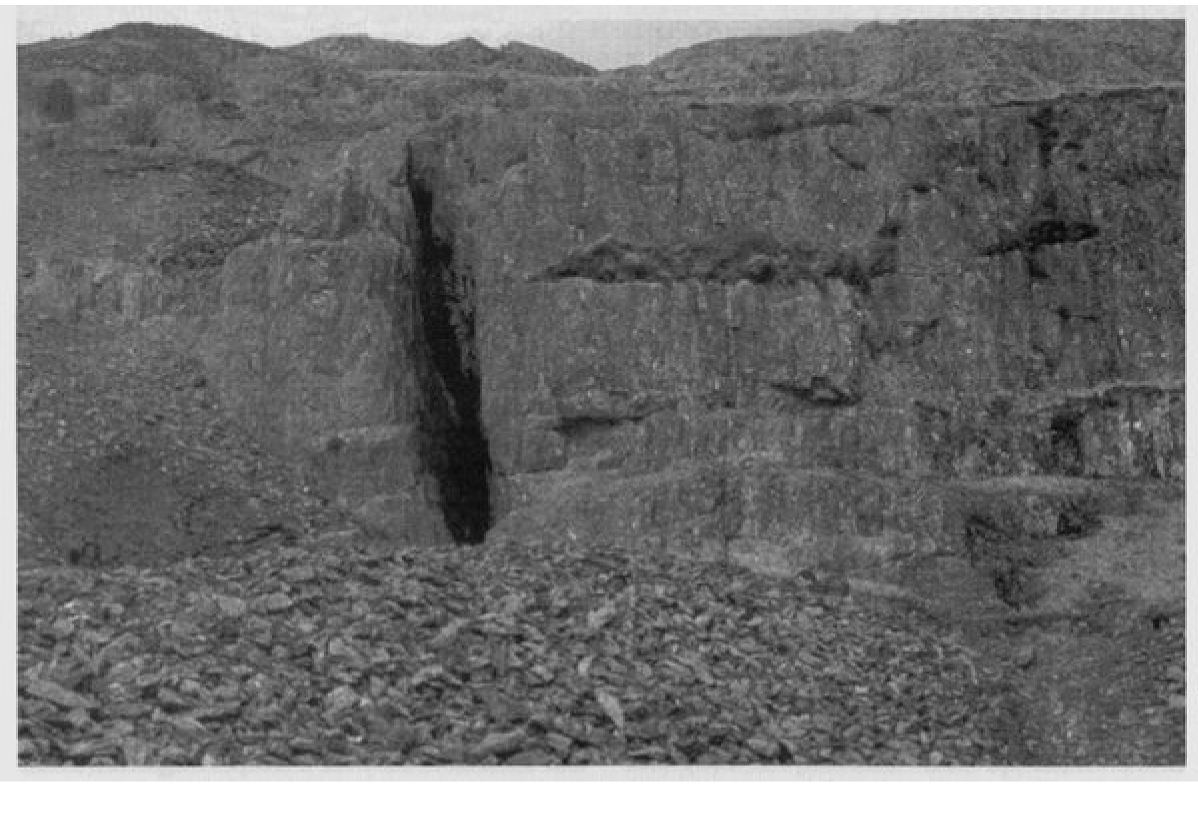
Conclusions

The Cu-Pb-Zn sulphide mineralization occurring at Lliwedd Mine is a representative example of mineralization developed within the Snowdon Caldera linked to extensive volcanic activity in Caradoc times. Quartz-sulphide veins were emplaced within the caldera along two conjugate fracture-sets trending in a ENE–WSW and northwest-south-east direction, during volcanotectonic extensional movements associated with caldera resurgence at a late stage within the volcanic cycle. Lliwedd Mine is situated along the axial zone of a NE–SW-trending apical graben which developed along the central zone of the caldera.

References



(Figure 5.25) Map of the Lliwedd Mine GCR site. After British Geological Survey 1:50 000 Sheet 119, Snowdon (1997).



(Figure 5.26) Photograph of the Lliwedd Mine GCR site. (Photo: T. Colman.)