Ceulan Mine Opencast

[SN 853 978]

Introduction

Situated in the north-eastern extremity of the Central Wales Orefield, Ceulan (Figure 5.63) is one of a group of workings developed on Pb-Zn-bearing veins belonging to the later (A2) phase of epigenetic mineralization in this complex and polyphase orefield (Mason, 1994, 1997). The opencast at Ceulan Mine (Figure 5.64) provides the finest surface exposure of an A2 Pb-Zn sulphide-bearing vein in the Central Wales Orefield, being a more complete section than is visible on Graig-Fawr at the Cwmystwyth Mine GCR site. Both important geological and textural features are clearly visible.

The opencast lies at the westernmost end of the Ceulan sett, close to the boundary with the Rhoswydol Mine. Both mines are of consider for this mineral assemblage, rarely exceeding 5 oz of silver per ton of galena concentrate. The extent of pre-19th century workings, and production therefrom, is not clear.

Description

The vein mineralization at Ceulan Mine is hosted by a fault traversing mudstones and siltstones of Llandovery age. The opencut lies just above a forest road and runs up the hillside with a ENE–WSW orientation, narrowing as it is traced eastwards. The lode is exposed about a third of the way up the opencut, in an unworked pillar, where it is nearly 1 m wide. The exposure clearly reveals brecciated mudstone cemented by quartz, galena and sphalerite with an open-space, locally crustiform texture typical of the late or A2 mineralization. The amount of sulphide, in particular galena, left unworked is unusual and provides a valuable example of the A2-a (low-Ag galena, sphalerite and quartz) assemblage (Mason, 1997), which was exploited able antiquity (Bick, 1977), perhaps not surprising as the veins outcrop on both flanks of the steep-sided ridge of Esgair Geulan, and would have been noticed by early prospectors passing through the district.

Ceulan was a relatively small mine by Central Wales Orefield standards. The production figures are fragmentary; being partly entered under Cardiganshire figures and for 1870 being split as North and South Ceulan. Hence the figures given by Jones (1922) are slightly lower than the true total given by Burt *et al.* (1986, 1990). These figures show intermittent production from 1857 to 1888, the total being 268.2 tons of galena concentrates yielding 814 oz of silver. The latter metal was only produced in certain years, the grade, typicallyat many Central Wales Orefield mines. On the well-defined footwall of the vein, which dips to the SSE at 60°, strong, W-plunging (60°) quartz slickencryst development indicates an element of dextral wrench movement. As is often the case with the Central Wales Orefield veins, the hangingwall is relatively ill-defined.

Samples of the mineralization are not abundant but may be found among the debris below the forest road. They reveal traces of early (A1) mineralization, forming very weakly quartz-veined breccia, and showing that, as is the case with many Central Wales Orefield mineralized fractures, there is a history of polyphase fracturing and mineral deposition. More abundant later (A2-a) mineralization, corresponding to that exposed in the pillar, comprises thin quartz coatings on rock clasts overgrown by galena (both with rare microscopic chalcopyrite inclusions), followed by sphalerite and crystalline quartz. This assemblage is widespread in the mines of the north-eastern part of the Central Wales Orefield, where the early or A1 phase of mineralization tends, in general, to be poorly developed. Some of the mineralized fractures in this part of the orefield also carry a late sphalerite-pyrite-marcasite assemblage which overprints the more typical Pb-Zn mineralization. Secondary mineralization at Ceulan is developed only on a superficial basis, as demonstrated by the fresh sulphide exposed only a few metres from surface in the opencut. Traces of cerussite, malachite and hemimorphite have been noted among the spoil.

Interpretation

The Pb-Zn mineralization exposed at Ceulan Mine opencut was deposited during a phase of transtensional movement which resulted in the formation of a mineralized, S-dipping normal fault with an element of dextral wrench movement. While the indication of transcurrent movement is of significance, the dip of the fault plane is less so. This is but one of a group of sub-parallel mineralized fractures which were all active during the A2 phase of mineralization, so that remarkably similar vein assemblages are developed throughout this part of the Central Wales Orefield. The fractures generally strike ENE–WSW, but may dip either to the south or north Clones, 1922), and the best interpretation of the Ceulan area is to view the various sub-parallel lodes as planes of movement within a larger zone of focused transtensional stress. Such features are not uncommon within the Central Wales Orefield, where zones containing numerous sub-parallel mineralized fractures are frequently separated by tracts of apparently unaffected ground.

The structure of the mineralized fracture, with its well-defined, slickencryst-marked footwall and poorly defined hangingwall, is characteristic of the Central Wales Orefield. The process of hydraulic brecciation, which was critical in the formation of the mineralized fracture exposed here, is more fully discussed elsewhere (see Cwmystwyth Mine GCR site report, this chapter); in the exposure at Ceulan it is possible, however, to study the features created by the process closely and *in situ.* On the hangingwall, mineral-cemented breccia grades through fractured rock into relatively undisturbed mudstone. Such features indicate that it was the hangingwall that was the focus of hydraulic brecciation. This may be explained by examining the mechanism by which hydraulic brecciation occurs (Phillips, 1972).

During the formation of a normal fault, such as that exposed at Ceulan, the maximum principal stress is effectively vertical and equates to the lithostatic pressure (P), defined by $P = p \times g \times d$, where 'p' is the average saturated bulk density of the rock, 'g' is the gravitational acceleration and '43' is the depth. During normal faulting, the horizontal principal stresses, caused by crustal extension, are reduced, leading to the creation of shear stresses on the fault plane. In the case of the mineralized faults of the Central Wales Orefield, fracture propagation was also assisted by hydraulic fracturing caused by ascending hydrothermal fluids. If the pressure exerted by 'such fluids exceeds the effective stress normal to the fault plane, hydraulic fracturing will take place, extending the fault plane. In the model of Phillips (1972), these pressurized hydrothermal fluids also penetrated the pore spaces of the wall-rocks, and particularly, since they were rising, those of the hangingwall. Following each phase of fracture extension, an abrupt drop in hydrothermal fluid pressure would then cause the adjacent rock, into which the hydrothermal fluid had permeated, to burst apart, forming an angular breccia.

An alternative interpretation, considered by Mason (1994), is that hydraulic brecciation occurs when strata and their contained pore-fluids, both under the lithostatic pressure of the overlying stratigraphical pile, are suddenly subjected to a drop in pressure, such as the formation of an open, fluid-filled fracture. The result of creating such a pressure differential causes a rockburst effect in the fracture walls, driven entirely by compressed pore-fluids.

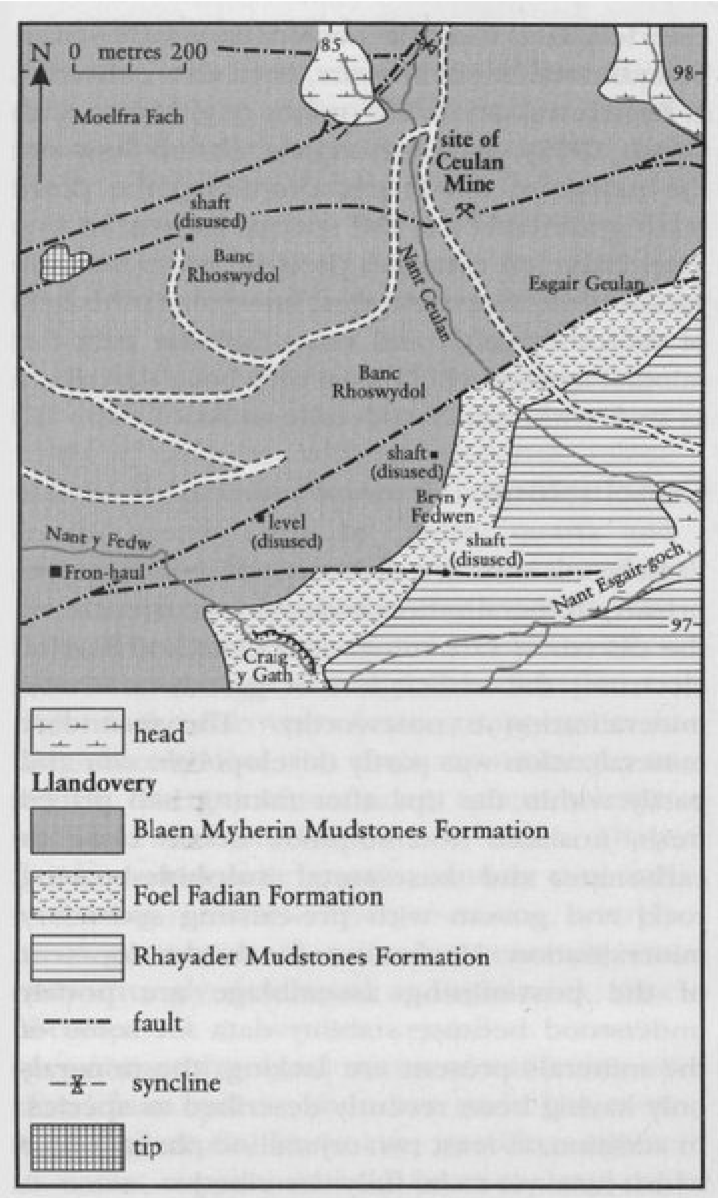
Whichever model is correct, be it hydrothermal fluids being able to permeate metamorphosed and deformed sedimentary rocks, or the original sediments still containing sufficient trapped porewater to cause explosive rupture, the brecciation effect in inclined fracture planes is much greater within the hangingwall. In the model of Phillips (1972) this was explained by the tendency for vertically ascending hydrothermal fluids to preferentially permeate the hangingwall. However, in discussion of that paper, it was commented by Knill (Phillips, 1972, pp. 355–6) that a large back-pressure in the hangingwall rocks was essential to allow for the downward collapse and consequent brecciation effects, following a rapid drop in pressure in the vein itself.

The model of Phillips (1972) also needs to explain why, in many Central Wales Orefield veins, massive mineral phases such as quartz, galena and sphalerite have undergone re-brecciation, showing development of the same textures as those developed in the brecciated sedimentary rocks. Perhaps these minerals had undergone explosive brecciation as a result of being permeated, like the sedimentary rocks in the model of Phillips (1972), by rising pressurized hydrothermal fluids. Clearly, there remains considerable scope for further research into the origin of these breccias.

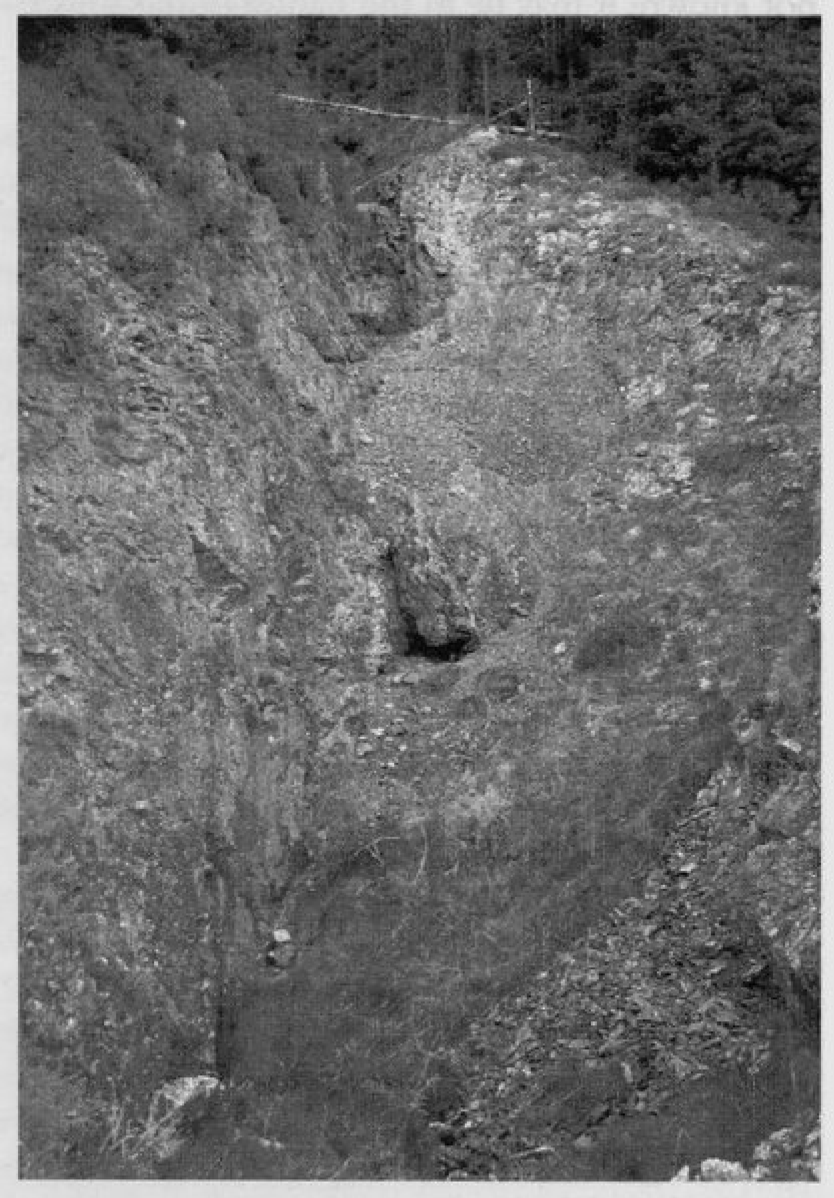
Conclusions

The lode exposure at Ceulan Mine opencut clearly displays the geological features typical of the Central Wales Orefield mineralized fractures: a normal fault, with an element of dextral wrench movement, and a well-defined slickencryst-marked footwall; a central zone of angular rock breccia cemented together by sulphides and quartz; and a poorly defined hangingwall in which brecciation grades into shattering and finally into unaffected rock.

References



(Figure 5.63) Map of the Ceulan Mine Opencast GCR site. Based on unpublished British Geological Survey 1:25 000 Sheet SN89, and Bick (1977).



(Figure 5.64) Photograph of the Ceulan Mine Opencast GCR site. (Photo: R. Mathews.)