Machen Quarry

[ST 223 886]

Introduction

The large, working quarry at Machen (Figure 5.87), set prominently on a steep hillside overlooking the Newport to Caerphilly A468 road, exploits dolomitized Dinantian limestones of the Pembroke Limestone Group. It is of mineralogical importance chiefly because of the species range and quantitative extent of supergene mineralization, which has formed by the alteration of Pb, Zn, Cu and Fe sulphides within Mississippi Valley-type (MVT) veins. The supergene minerals include some of the finest examples of anglesite recorded in Great Britain and also the presence of a number of rare species, including scotlandite and fraipontite.

Quarrying has taken place in the Machen–Ochrwyth area for many years, as was, formerly, lead mining, although historical records of such activities are fragmented and contradictory (see Tucker and Tucker, 1975; Foster-Smith, 1981). Lead mining was a locally important industry along the south crop of the South Wales Coalfield, exploiting veins in limestones of Dinantian age and in the overlying Mercia Mudstone Group (Triassic) rocks, with old workings scattered along a line from Machen, through Draethen and Rudry, westwards towards Llantrisant and the Bridgend district. It has been suggested (Hall, 1993) that the workings were active as far back as Medieval times, but the only well-documented lead-mining activity was in the mid-19th century, by which time mine operators were required to furnish mineral production data on an annual basis.

The mines in the area in and around Machen Quarry are not well-documented and were generally small-scale pittings. Voids occasionally broken into during quarrying may to an extent represent old workings, although some are undoubtedly karstic. However, an ENE–WSW-striking vein, which crosses the northern part of the quarry, contains sufficient galena that, had its presence been known in the 19th century, it would without doubt have been regarded as an attractive mining proposition.

The MVT Pb-Zn-Ba-dominated vein mineralization occurring in the Dinantian sequences of South Wales has received little academic attention, in comparison to the studies of deposits worked or exposed in higher horizons, such as the Mercia Mudstone Group of the Llantrisant area (see Bevins and Mason, 2000), and the marginal Lias at the Ogmore Coast GCR site. The essential features of the Dinantian-hosted veins are that: they occur along reactivated ENE–WSW-striking faults of Variscan origin; their primary mineralogy is dominated by barite, calcite, galena and sphalerite; and that texturally they are very different to the irregular iron oxide deposits and the associated and superimposed calcite-barite-dominated cavity-fill assemblages, as seen at the Ton Mawr Quarry GCR site. Machen Quarry provides an excellent opportunity to examine this important aspect of the metallogenesis of South Wales.

The MVT vein sulphides of South Wales are frequently seen to be extensively oxidized, with the development of a wide range of secondary minerals, dominated by anglesite and cerussite after galena, and smithsonite and hemimorphite after sphalerite. Machen Quarry is of particular note for a suite of specimens collected in the mid-1980s (Bevins, 1994), which included fine examples of the aforementioned supergene minerals, but also a number of very rare species. Since that time, the site has continued intermittently to produce fine examples of the commoner species, along with an increasing range of rarer species (see Plant and Jones, 1995). The paragenesis of this suite of supergene minerals is worthy of detailed research, since it formed *in situ,* as opposed to the complex post-mining assemblages found in the Central Wales Orefield, for example at the Frongoch Mine GCR site.

Description

The MVT mineralization at Machen Quarry (Figure 5.88) is best exposed on the upper benches at the northern end of the quarry. In this area, dolomitized limestones, with locally intense metasomatic cavity-fill mineralization comprising barite overgrown by rhombic and, rarely, scalenohedral, calcite is cut by a series of ENE–WSW-trending faults, some of which are heavily mineralized. Typically, the faults are linear and dip steeply to the SSE. Clay-gouge often occurs along the movement planes, and the mineralization comprises massive ribs, typically 15–30 cm wide, of barite and sulphides. A review of the mineralogy of Machen Quarry was presented by Plant and Jones (1995).

The primary mineralization is dominated by white, platy barite, with subordinate to rare calcite, in which occur bands of galena and sphalerite. Galena is the commonest sulphide, forming massive ribs often over 10 cm in thickness; crystals are rare and poorly formed. Sphalerite is rare in the unoxidized state and appears, from the limited number of specimens examined, to pre-date galena in the depositional sequence. Chalcopyrite is also very rare, again having mostly been oxidized, and, where present, forms small spots in the gangue. The galena is seen in places to be traversed by later veinlets, only 1–2 mm in thickness, of marcasite, possibly with other associated sulphides, a feature which is the subject of ongoing research.

The degree of supergene oxidation of the primary sulphides, particularly sphalerite, often hampers elucidation of the primary paragenesis, but is of great intrinsic interest. Sphalerite has, in most specimens, been entirely leached away, leaving veinstone full of cavities lined with abundant hemimorphite and smithsonite. Hemimorphitc forms attractive sheaves of colourless to iron-stained crystals, which reach up to 8 mm in size and coat areas to severalsquare centimetres. Smithsonite forms distinctive globular aggregates to up to 3 mm across which are toffee-brown to white in colour, and which, under the microscope, are seen to exhibit multiple, stepped, rhomb-face terminations. Hydrozincite is a common late phase, forming earthy, white coatings which are iron-stained, and occasionally display small (*c.* 1 mm) areas of pink colouration.

The oxidation pattern of galena varies according to whether it has taken place within a pure sulphide matrix or along galena-barite interfaces. In the latter environment, the chief product is cerussite, which forms white to brownish or greyish, tabular to blocky crystals usually in the 3–5 mm range but occasionally exceeding 10 mm. Within a sulphide matrix, in contrast, the galena frequently alters to native sulphur and common, bright-yellow, powdery bindheimite, associated with anglesite and subordinate cerussite. This assemblage is of particular interest since the anglesite crystals, usually only 1–2 mm in length, are occasionally superbly developed, forming lustrous, white to grey, sharp crystals which reach up to 30 mm on particular specimens collected in the mid-1980s. These represent some of the finest examples of anglesite collected anywhere in Great Britain. Associated with some of the anglesite collected in the mid-1980s were also rare examples of mattheddleite, forming typical hexagonal prisms with pointed terminations reaching up to 0.5 mm in length, and also scotlandite, which allegedly formed adamantine, colourless, tabular crystals up to 2 mm. This latter occurrence, however, has yet to be verified.

The minor amounts of chalcopyrite oxidized along with the other sulphides have influenced the secondary assemblage in places. The most frequently observed copper-bearing supergene mineral is aurichalcite, which typically forms small, turquoise spots, but also occurs as acicular crystals forming a sky-blue, felty coating to cavities. Malachite and rosasite are much rarer associates, as is linarite, which has been recorded as small (1 mm), bladed crystals. The linarite was originally identified as schmiederite (Bevins, 1994) but has since been shown by electron microprobe analysis to be selenium-free (Plant and Jones, 1995).

Two further supergene minerals occurring at Machen Quarry are particularly worthy of note, namely cinnabar and fraipontite. Cinnabar has been confirmed qualitatively on National Museum of Wales specimen NMW 89.43G.M.7, where it forms minute, orange-red crystals in a small cavity in oxidized barite-galena veinstone (Bridges, 1990), while brick-red spots, associated particularly with cerussite and smithsonite, which are characteristic associates of supergene cinnabar (D.I. Green, pers. comm.), probably represent further examples of this rare mineral. Fraipontite, a rare zinc-bearing clay mineral, was identified recently from Machen Quarry (Goulding and Price, 1995) as forming greenish-yellow, hexagonal plates, often intergrown into book-like masses up to 0.5 mm in thickness. It is also present as cream- to white-coloured botryoids, which are easily mistaken for hydrozincite. In both cases it is most commonly developed on hemimorphite.

Interpretation

The primary paragenesis of the MVT vein-mineralization at Machen Quarry warrants further study, the main problem being the difficulty in obtaining specimens that are relatively unoxidized, particularly of sphalerite and chalcopyrite. It is difficult, therefore, to establish the crystallization sequence of the sphalerite, chalcopyrite and galena, except that sphalerite appears to have been the earliest phase to precipitate, while barite continued to precipitate after galena. The cross-cutting marcasite veinlets in the galena also require further detailed examination, but they clearly represent a post-Pb-Zn phase of epigenetic mineralization.

The primary MVT mineralization may be equated with similar Pb-Zn-Ba vein-hosted deposits occurring in Dinantian limestones, the Mercia Mudstone Group and marginal Lias rocks across South Wales. Evidence exposed at the Ogmore Coast GCR site cpnstrains this mineralization as being early Jurassic in age, and it is not unreasonable to assign all of the vein-hosted MVT Pb-Zn-Ba mineralization in South Wales to a regional metallogenic episode occurring at this time.

Trace elements present in the primary assemblage are represented by the supergene minerals cinnabar, bindheimite and the pink-tinted hydrozincite. The source for the mercury and antimony is uncertain: antimonial galena is well known from Wales (see Frongoch Mine GCR site report, this chapter), but another possibility, given the geographical location ofMachen, is that both elements have been derived from a minor, associated tetrahedrite-group mineral. Tennantite, with substantial antimony content, is a component of MVT barite-galena-dominated vein mineralization occurring in the marginal facies of the Mercia Mudstone Group on the southern side of the Bristol Channel, at Clevedon (Ixer *et al.,* 1993; see Clevedon Shore GCR site report, Chapter 6). Both the Clevedon and Machen Quarry MVT mineralization falls within the South Wales–Mendip Orefield, and the possibility of further occurrences of tetrahedrite-group minerals within the South Wales sector of the orefield cannot be discounted. The rare, pink spots In hydrozincite (and possibly similar-looking fraipontite) have so far failed to provide distinctive X-ray diffraction patterns (S.L. Chambers, pers. comm.). It is probable that they represent contamination of zinc compounds by another transition metal cation (e.g. Co^2+ or Mn^2+). Further work is required to establish the nature of these small but conspicuous features.

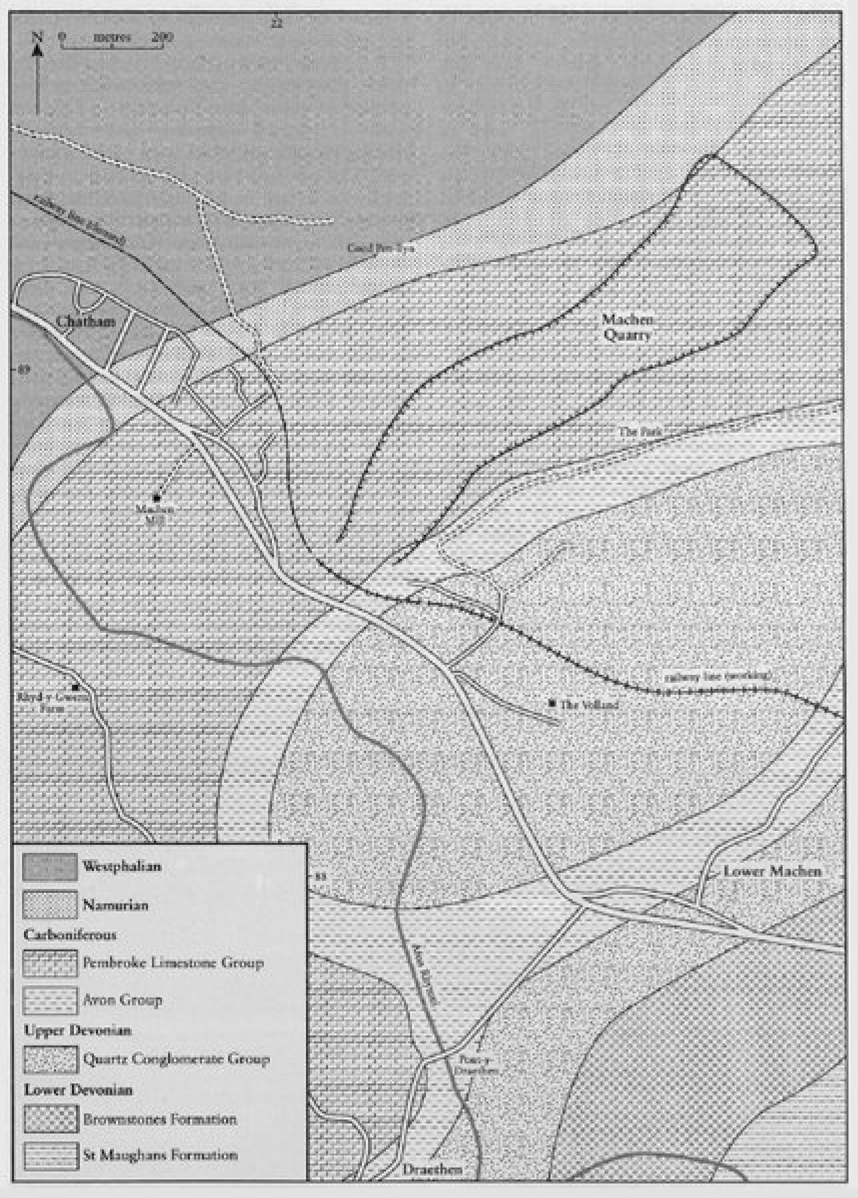
Typically, oxidation of sphalerite follows a well-defined sequence, in which initial smithsonite is overgrown by hemimorphite, which in turn is coated by hydrozincite and fraipontite. Generally, however, smithsonite and hemimorphite tend to be mutually exclusive, so that in a typical specimen, adjacent cavities may be lined with only smithsonite or only hemimorphite. Only rarely is hemimorphite observed directly overgrowing smithsonite. Hemimorphite is by far the commonest supergene zinc mineral at Machen Quarry, suggesting that, despite the veins being hosted by carbonate sediments, little free carbonate was available during the supergene process, silica being predominant.

Another interesting feature of the supergene mineralization at Machen Quarry is the rare occurrence of cerussite overgrown by smithsonite, suggesting that the oxidation of galena was proceeding at the same time as that of sphalerite. The latter sulphide is normally regarded as being less stable than galena, and therefore usually reacts first in the supergene environment. However, the almost total oxidation of sphalerite indicates that such relationships are relatively localized. The association of bindheimite with anglesite plus cerussite and minor native sulphur is well known from other Welsh localities (see Frongoch Mine GCR site report, this chapter), and is usually encountered in cavities within massive galena with little connection to the outside environment. Detailed paragenetic information regarding the associations of scotlandite and mattheddleite is, unfortunately, currently lacking.

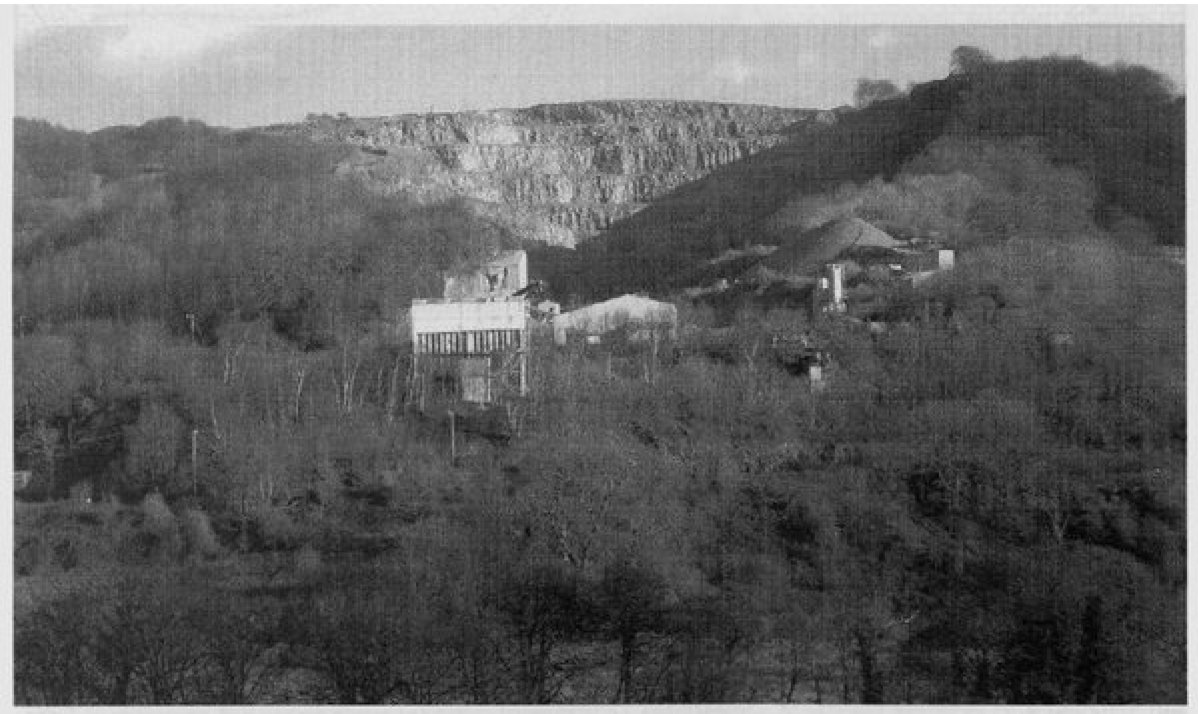
Conclusions

Fine examples of supergene mineralization which developed *in situ* are well exposed at Machen Quarry. Both the primary and supergene mineralization exposed at Machen Quarry are worthy of further research. The primary paragenetic sequence requires clarification, as does the possibility of the occurrence of minor sulphide phases carrying trace elements such as Sb and Hg, both of which form compounds within the supergene assemblage. Secondary mineralization is diverse, and it is anticipated that further field and laboratory work will increase both the number of species present, and, more importantly, the understanding of the mechanisms responsible for its genesis.

References



(Figure 5.87) Map of the Machen Quarry GCR site. After Institute of Geological Sciences 1:50 000 Sheet 249, Newport (1975).



(Figure 5.88) Photograph of the Machen Quarry GCR site. (Photo: R.E. Bevins.)