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# Eaglebrook (Nantycagl) Mine

[SN 736 892]

## Introduction

Perhaps the most renowned locality in Central Wales for secondary copper, lead and zinc minerals, Eaglebrook Mine, or Nantycagl Mine (Figure 5.61) has been recognized also as a key site for the study of the primary paragenesis of the Central Wales Orefield. The mineralization spans several assemblages emplaced during both the early (A1) and late (A2) metallogenic episodes, as described by Mason (1994, 1997). Prime features of the A1 mineralization are the cobalt-nickel minerals and electrum occurring in the A1-c assemblage, and the well-demonstrated post-ore ferroan dolomite influx (A1-e assemblage). Of particular interest is the presence, in the Co-Ni minerals, of the rare sulphantimonide tucekite,  $\text{Ni}_9\text{Sb}_2\text{S}_8$ , which occurs here in significant quantities. This is the first British and only the third occurrence worldwide of the mineral, and additionally its first description from a hydrothermal vein. Secondary mineralization, formed both prior to and post-mining, has resulted in a diverse assemblage, including many rare species which occur as well-developed micro-crystals. The suite includes rare species such as wroewolfeite, lautenthalite, ramsbeckite, laurionite, and cesirolite, and for specimens of these and other species the site is justifiably famous.

Eaglebrook Mine (Figure 5.62) is an extensive site and gives the impression of much greater activity having taken place than the rather sketchy historical references imply. The mine was originally known as 'Dolrhuddlan', and later also 'Nantycagl', and was being worked by the Company of Mine Adventurers prior to 1708 (Bick, 1976). However, their lease was relinquished in 1722 and the mine remained unworked from then until the mid-1850s, when the Francis brothers, under the new name Eaglebrook, promoted as the forgotten Welsh Potosi, relaunched it as a speculative venture. Such changes of name were not uncommon in the 19th century, their function being to give the impression of completely new discoveries in the drive to inflate share prices. The mine closed, however, in the mid-1870s, having reached a depth of 50 fathoms (109 m) from surface.

In post-1855 times the mine produced 598 tons of galena concentrates and 71 tons of chalcopyrite concentrates (Jones, 1922); production figures presented by Burt *et al.* (1986) give higher yields for certain years, but this is because the mine's output was at times returned in conjunction with that of other nearby sites. The true production, clearly much greater than this, remains unknown.

## Description

The mineralization at Eaglebrook Mine occupies an E–W-trending fracture with a small northerly downthrow that crosses the axis of the Carn Owen Pericline. Close to the core of the fold, sandstones and massive, poorly cleaved mudstones of the Drosgol and Bryn-glas formations, of Ashgill age, host the mineralization, but to the east the fracture passes into pyritic mudstones of the Cwmere Formation (Lower Llandovery) and the mineralization weakens. Due to favourable bedding-cleavage intersections, bedding-parallel slabs of graptolitic mudstone from the *Glyptograptus persculptus* Biozone of the Cwmere Formation occur among the tips of the eastern workings and contain well-preserved, three-dimensional pyritized graptolites and occasional orthocones.

Both early and late elements of the Central Wales Orefield paragenesis (Mason, 1994, 1997) are present on the extensive tips. Early (A1) mineralization comprises three assemblages. The A1-c polymetallic assemblage provided most of the lead and copper ores mined and comprises, in order of crystallization, quartz, pyrite, siegenite, cobalt pentlandite, millerite, chalcopyrite, electrum, tucekite, ullmannite and galena. Siegenite occurs in a similar mode to that occurring far more abundantly at the Erglodd Mine GCR site, although in this case it is locally replaced by millerite as well as the ubiquitous cobalt pentlandite. Tucekite, first described as a British mineral from this site (Mason, 1994, 1997, 1998), forms distinctive, highly anisotropic tetragonal crystals up to 0.5 mm in galena. It is difficult to observe with the naked eye, but in polished section it can be seen in conspicuous amounts, where it is occasionally associated with electrum. The electrum, which electron microprobe analysis shows to be a 60:40 Au–Ag alloy, forms rare, ragged grains (< 0.1 mm)

either in tucckite or adjacent to it in galena. Ullmannite inclusions also occur in the same generation of galena. Again, ore petrology and, in this case, repeated sectioning of anomalous material, are required in order to detect the electrum grains. The gold grade of the mineralization, while quite consistently above background, does not exceed 0.5 g/t, and is therefore of no economic interest. The A1-c assemblage at Eaglebrook Mine is best studied in comparison with that occurring at the Darren Mine and Erglodd Mine GCR sites.

The A1-e ferroan dolomite influx was a major event at Eaglebrook Mine and large blocks of the mineral are abundant on the tips, often dearly enclosing brecciated fragments of the A1-c assemblage. Ferroan dolomite is veined and locally brecciated by the A1-f assemblage, which comprises white, prismatic, crystalline quartz and minor sulphides (siegenite, cobalt-pentlandite, millerite, chalcopyrite and galena); millerite needles up to 15 mm in length are the most interesting feature of this assemblage.

Late (A2) mineralization is less abundant, but distinctive veinstone consisting of abundant calcite with galena and sphalerite, accompanied in places by minor quartz and chalcopyrite, has been interpreted by Mason (1994) to represent the A2-c assemblage. This material may be seen cross-cutting ferroan dolomite and other A1 material, thus demonstrating the age relationship. The latest mineralization at Eaglebrook Mine belongs to the A2-f 'iron sulphides' assemblage. As at other localities, this assemblage cross-cuts all others, often net-veining sphalerite, calcite and ferroan dolomite. Marcasite is the dominant mineral, accompanied by pyrite, quartz and minor calcite. The pyrite is noteworthy since it is strongly zoned, containing nickeliferous bands (R.A. Ixer, pers. comm.), and is often spectacular when viewed in polished section.

Prior to the discovery of rare primary minerals at Eaglebrook Mine, the site's reputation lay in the great diversity of secondary species present (Jones and Moreton, 1977; Jones, 1983). These fall into two genetic groups, namely pre- and post-mining minerals. The pre-mining, entirely natural generation of secondary minerals was clearly strongly developed at Eaglebrook Mine and comprises: massive and crystalline cerussite, rare pyromorphite and traces of wulfenite, all derived from galena; abundant malachite, with minor chrysocolla, chalcocite, covellite, cuprite and native copper, derived from chalcopyrite; and manganese oxides, goethite, smithsonite and hemimorphite. Hand-cobbed fragments of cerussite, malachite and occasionally cuprite occur around old ore-dressing areas, suggesting that both minerals were worked as ores in the past.

Post-mining mineralization has developed in the dumps, and is particularly significant in the Eastern Shaft dump. It is difficult in some cases, however, to determine whether a mineral is definitely pre- or post-mining in origin, and some species, such as linarite and anglesite, may have formed in both supergene environments. The post-mining minerals tend to occur as small (< 2 mm) groups of micro-crystals which are, however, impressive when viewed microscopically. The presence of post-mining minerals is often indicated by the coating of the outer surfaces of sulphide-rich rock fragments by linarite and brochantite. The paragenesis of the post-mining mineralization is variable according to the host in which the mineralization is developed. Thus in a ferroan dolomite or calcite matrix, basic zinc-copper sulphates and carbonates predominate, comprising common serpierite accompanied locally by devilline, aurichalcite and, rarely, ramsbeckite. Lumps of corroded chalcopyrite contain brochantite and linarite. Gossanous goethite masses containing pre-mining malachite, smithsonite, hemimorphite, cerussite, cuprite and native copper carry a diverse range of copper-lead-zinc basic sulphates. These include brochantite pseudomorphs after octahedral cuprite and well-crystallized linarite, langite and wroewolfeite. Less frequently, leadhillite and very rare lautenthalite, the latter often grown epitaxially on wroewolfeite, have been found. Corroded galena again contains linarite and leadhillite, with frequent cerussite and micro-crystals of anglesite. Rarer species found recently comprise caledonite, laurionite (Rust, 1995b) and dundasite, as well as the recently described mineral redgillite (Pluth *et al.*, 2005), and the rare supergene manganese mineral cesirolite (Cotterell, 2006b).

## Interpretation

The primary mineralization at Eaglebrook Mine has as its prime interest the occurrences of tucckite and electrum within the A1-c assemblage. The extremely rare mineral tucckite is the antimony analogue of hauchecornite ( $\text{Ni}_9\text{BiSbS}_8$ ), and was first described as a mineral species (Just and Feather, 1978) from a mineralized Archean chlorite schist at Kanowa,

western Australia, and from auriferous concentrates produced from the Vaal, Carbon Leader and Ventersdorp Contact Reefs in the Witwatersrand, South Africa. As well as its occurrence at Eaglebrook Mine, it has been found in lesser amounts at a cluster of nearby mines, namely Henfwlch, Esgairhir, Esgairfraith and Hyddgen. It has not been found elsewhere in Wales, or indeed Great Britain, however, outside of this very restricted area.

These tightly clustered occurrences of a rare mineral again emphasize a characteristic feature of the A1-c assemblage, namely that it tends to exhibit strong local mineralogical features from area to area. Gold is rather more widespread within the A1-c assemblage but seems, from the data acquired to date, to be particularly conspicuous, occurring in electrum, at Eaglebrook Mine. The occurrences at the Eaglebrook Mine and Erglodd Mine GCR sites are the first to have been authenticated in the orefield, though many claims were made to its presence in Central Wales during the 19th century. For example, in 1854, at Caegynon Mine in the Rheidol Valley, which worked A2 Pb-Zn mineralization, a 'gossan' was supposed to be under investigation which, it was claimed, contained over 2 oz of gold per ton. However, nothing came of this and, as Bick (1975) commented, it was more likely to be a sure sign that lead ore reserves were at that time running low. Later, similar claims were made, reported by Jones (1922), that the Kingside Lode on Copper Hill at the Cwmystwyth Mine GCR site contained 'three pennyweights of gold to the ton'. While gold does appear to be widespread in the Central Wales Orefield, particularly, and perhaps entirely, within the A1-c assemblage, the grades so far recorded are, however, of academic interest only.

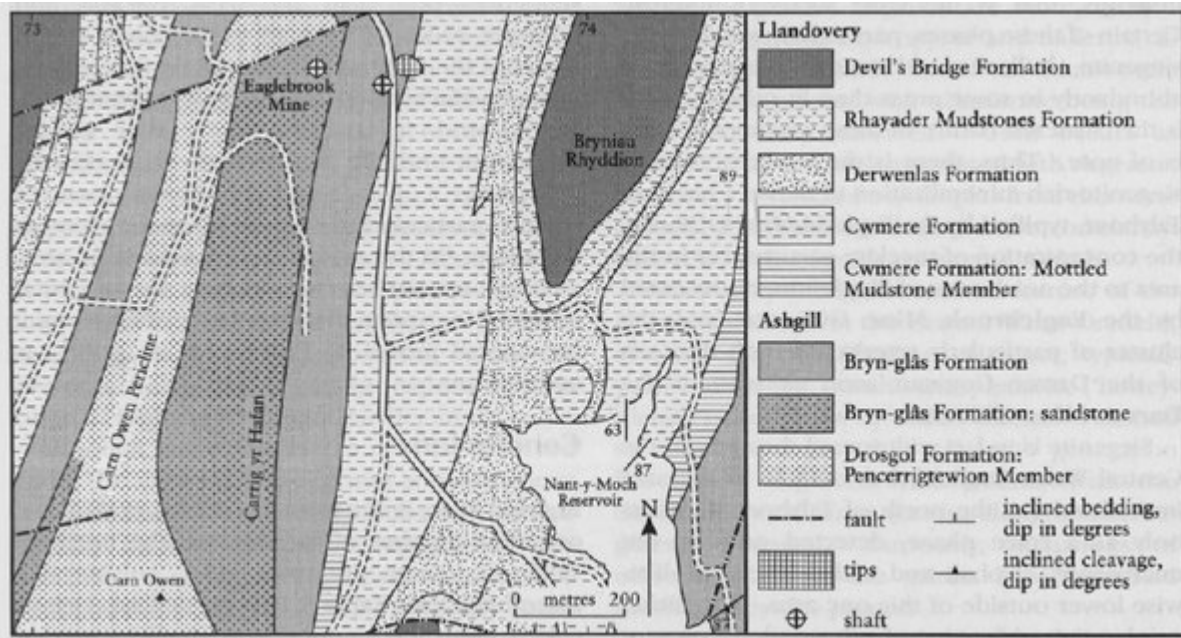
Of particular interest, however, is the strong positive correlation, reported by Mason (1998), between gold levels and occurrences of cobalt-nickel minerals in the Central Wales Orefield. Siegenite and tucelite, in particular, are important associates. The reason for this feature is currently not known: it may lie in the nature of the source terrain from which the fluids responsible for the A1-c mineralization were derived.

The diverse secondary mineralization at Eaglebrook Mine is composed of common Central Wales Orefield species that may be expected in the oxidation zones of mixed base-metal veins, and rare species which have formed in localized geochemical environments within mine tips. The post-mining phases, such as lautenthalite, ramsbeckite and wroewolfeite, may be regarded as thermodynamically unstable minerals which are generally absent from geologically mature deposits (Mason and Green, 1996). The formation of such a diverse assemblage of basic sulphate minerals may be attributed initially to mining processes which have resulted in the juxtaposition of blocks of unstable primary minerals, such as marcasite, with rocks containing carbonates and Cu-Pb-Zn sulphides in essentially a surface environment. The decomposition of marcasite, as a result of reaction with rainwater percolating through a tip, releases sulphuric acid which then reacts with other sulphides; the resultant solutions then precipitate secondary sulphates on carbonate blocks or when permeating masses of gossan containing pre-mining secondary mineralization (Mason and Green, 1995). Although the exact mechanisms involved for each localized secondary assemblage have yet to be evaluated, there appears, from data collected at Eaglebrook and other mines (e.g. Mason and Green, 1995), to be a strong correlation between the nature of the matrix containing the post-mining minerals and the species present in the assemblage. A common problem in the investigation of such assemblages, however, is the lack of thermodynamic and other stability data for mineral species which have only been described as such within the last decade or so.

## Conclusions

Eaglebrook Mine is a diverse GCR site where the primary mineralization includes occurrences of the extremely rare mineral tucelite and also of electrum; the association of gold with Co-Ni mineralization is noteworthy. The secondary mineralization was partly developed *in situ* and partly within the tips after mining had placed fresh, unstable iron sulphide debris close to carbonate and base-metal sulphide-bearing rock, and gossan with pre-existing secondary mineralization. Mechanisms for the development of the post-mining assemblage are poorly understood because stability data for some of the minerals present are lacking, the minerals only having been recently described as species. In addition, at least two crystalline phases occur which have yet to be fully described.

## [References](#)



(Figure 5.61) Map of the Eaglebrook Mine GCR site. After British Geological Survey 1:50 000 Sheet 163, Aberystwyth (1984).



(Figure 5.62) Photograph of the Eaglebrook Mine GCR site. (Photo: S. Campbell.)