Halkyn Mountain

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Introduction

The Halkyn Block area includes many old, and often grassed-over, mines and trials, as well as several disused and two working limestone quarries in which mineralization is intermittently exposed. In terms of industrial archaeology, the area is of great importance as an ancient mining landscape, with mining dating back to Roman and possibly older times (Williams, 1995). The detailed history of mining is, prior to the 17th century, poorly documented, although scattered references imply that the veins of the area may have yielded lead, with associated silver, virtually continuously from Roman times to the late 20th century.

By the mid-17th century, the Grosvenor family effectively controlled mining in the area, although the political upheavals associated with the Civil War brought disruption to mining operations from time to time. However, activity increased throughout the 18th century, with a series of major discoveries, including, in 1770, the opening up of the Pant-y-Pwll-d■cr vein, which, over the succeeding 30 years, yielded in excess of £1 million worth of ore (Smith, 1921). Such discoveries served to promote the area as a mining centre, with the consequent expansion of local towns and villages such as Holywell and Pentre Halkyn.

By 1850, problems were being encountered at Halkyn due to the difficulty of keeping the workings water-free, and output consequently declined. However, this trend was reversed in 1875, by which time the Halkyn deep drainage tunnel, commenced in 1818, had been driven under the area, draining several mines; the drainage system was thereafter extended by the Halkyn District Mines Drainage Company, who, having secured the drainage of a number of significant workings, went on to charge a levy on ores raised from them. At the same time, the demand for sphalerite was increasing and, as it became more abundant at depth, production increased accordingly.

A much more ambitious drainage scheme was commenced in 1897, when the Milwr (or Sealevel) Tunnel was started at Bagillt, on the Dee Estuary. While this was being driven southwards towards the mines, the onset of the First World War resulted in an increase in the demand for both lead and zinc ores, to the extent that a Government-funded pumping scheme was implemented (Smith, 1921). The Milwr Tunnel was eventually extended as far south as Loggerheads, just to the west of Mold and 16 km from the portal, although there had been plans to drive it even farther to the south, in order to drain rich ore deposits in the Llanartnon-yn-Ial district.

The many miles of drivages from this tunnel eventually drained as many as 50 separate veins (Williams, 1995), and guaranteed continued, water-free production on a large scale through to the late 1950s, and smaller-scale working thereafter, although nothing has been undertaken in recent years. During this period, limestone, as well as lead and zinc ores, was worked underground.

The total production from the Halkyn mines is impossible to estimate, as they were clearly highly productive for centuries prior to the advent of accurately compiled mineral statistics. Despite this, it is not unreasonable to suggest that the Halkyn Mountain district has yielded in excess of 1 million tons of galena since Roman times. Some idea of the productivity of these mines may be gleaned from the figures for Halkyn Mine which, between only 1883 and 1913, produced a total of 73 328 tons of galena concentrates, yielding 459 019 oz Ag, and 18 529 tons of sphalerite concentrates (Burt *et al.*, 1992).

Description

On Halkyn Mountain, Carboniferous-hosted MVT mineralization is developed along a conjugate set of east-west and north–south fault-fractures (Figure 5.72). The mineralization is developed chiefly in a sequence of thin limestones and intercalated shales of Dinantian age, passing up into banded cherts of Namurian age, the whole sequence overlying the economically important Loggerheads Limestone Formation. Features typicalof this type of open fissure-fill mineralization include joint veins, flats (particularly developed below impermeable shale caps), metasomatic replacement veins, and infilled palaeokarstic features.

Lines of shafts and bell-pits mark the course of numerous mineralized faults, while in some areas the ground is literally pockmarked with bell-pits (Figure 5.73). The latter groups of workings often appear to have no structural alignment and are reminiscent of bomb-craters, the result of diggings for the so-called 'Gravel-Ore', a form of lead ore which was locally important in the northern part of the orefield. This consisted of blocks of superficially oxidized galena, occurring in trains in the vicinity of mineral veins and broken from the vein outcrops by glacial action (Smith, 1921). The GCR site area is described below on a regional basis from south to north.

At Moel-y-crio, small, partly overgrown tips around the village mark shafts on the westward extension of the Pant-y-Gof and associated California vein. The veins are unusually rich in colourless to white fluorite with deep-purple outer zones and abundant chalcopyrite inclusions, forming cubes up to 5 cm across. Historically, this site was noted by Greg and Lettsom (1858) for its excellent fluorite specimens. Immediately to the north of Moel-y-crio lies Pant Limestone Quarry. Here, in 1998, a spectacular find of azurite was made in the south-eastern part of the quarry, where an irregular zone of veining was exposed. Formed along with the associated malachite by the supergene decomposition of chalcopyrite inclusions in vuggy calcite, the azurite occurred as crystals up to 5 mm on edge, as well as pseudomorphs after chalcopyrite, and constituted some of the finest examples discovered in Great Britain in recent years. Associated primary minerals include purple fluorite, late white barite, reddish-brown sphalerite, and subhedral galena. The sphalerite commonly shows alteration to smithsonite ('calamine'), and traces of cinnabar have been identified recently (D.I. Green, pers. comm.). The primary assemblage also includes bituminous vein hydrocarbon, forming black lustrous masses in calcite up to several centimetres across. The hydrocarbon is radioactive due to the presence of disseminated, microscopic uraninite inclusions.

Farther north, across Halkyn Mountain, occurs an extensive area of common land with many spoil-heaps. In this area, workings were concentrated on several east–west veins, comprising the Long Rake, Union Vein, China Rake, Dog Pit and Wagstaff veins. The area illustrates the difficulty in separating named sites in the field, with one mine running imperceptibly into another. Galena and sphalerite occur in the tips, but the principal mineral is calcite, often occurring as clear 'Iceland spar'. Rows of small, < 2 mm, chalcopyrite inclusions occur within the calcite and are often oxidized to malachite, with minor chrysocolla. Secondary lead-zinc minerals occur in modest quantities; cerussite and smithsonite are the chief species, but pyromorphite locally occurred in workable quantities (Train, 1821). Some specimens show two generations of calcite; in addition to the 'Iceland spar' variety, a coarse-grained white generation occurs brecciated in a mottled, locally fibrous cement. These are all features typical of the mineralogy of the North-east Wales Orefield.

Just to the north-west of the common land lies the large Pant-y-Pwll-d■r Limestone Quarry. This quarry works the Loggerheads Limestone Formation and has intersected mineralization along several of its benches. The upper levels show sporadic calcite (Iceland spar') mineralization occurring as steep veins, with flats branching off beneath shale partings between limestone beds. A steeply dipping calcite vein was exposed in 1998 on the highest working bench of the quarry. This is clearly a metasomatic vein and shows irregular, pod-like replacements of the limestone. In the lower levels of the quarry, a series of fractures was recently intersected which are either mineralized with galena and calcite or alternatively with an assemblage comprising white calcite, veined by orange, crystalline sphalerite overgrown by pale-purple fluorite. Associated with some of the calcite veins are spots of black, pitch-like hydrocarbon up to 10 mm across.

Interpretation

In comparison with the other orefields of Wales (e.g. the Central Wales Orefield), the North-east Wales Orefield has a simple paragenesis. Field observations suggest that there was a single, if somewhat protracted, period of fracture initiation, fracture movement, and hydrothermal primary mineralization, followed by lengthy and highly variable supergene remobilization and re-deposition of the metals, largely as carbonates.

Studies of the mineralization at Halkyn and elsewhere in the northern part of the North-east Wales Orefield (Bevins and Mason, 1999) have indicated that the mineralization displays a well-defined paragenetic sequence, comprising an early phase of minor hematite (not observed at Halkyn), minor pyrite and/or marcasite, and fine-grained buff calcite. Quartz occurs as doubly terminated micro-crystals which have metasomatically replaced the limestones in places. The main, ore-bearing mineralization consists of abundant coarse-grained calcite intergrown with coarse-grained sphalerite followed by galena, the calcite containing rows of chalcopyrite inclusions; these minerals are in places overgrown by fluorite, again with associated chalcopyrite, a further coarse-grained calcite generation, and minor, late barite. The uraninite-bearing hydrocarbon is associated with this phase of mineralization, but its paragenetic position is ill-defined. Late-stage mineralization comprises radiating, columnar calcite, as seen at workings on the Dog Pit Vein, where it cements brecciated coarsely crystalline calcite.

The sequence described above is more complex and, in places, at variance with that presented by Smith (1921), although it has been observed repeatedly in many samples. The dominant part of the sequence, seen throughout the Halkyn Block, ranges from coarse-grained calcite through to fluorite. In terms of fluorite and barite distribution, no apparent zoning pattern has been discerned, contrasting with the Peak District and Alston and Askrigg blocks (see chapters 3 and 4). The fact that some veins carry fluorite+/-barite, or neither of these minerals, is interpreted as being controlled by the chronology of fracturing and fluid migration. If a fracture was either filled with minerals or tectonically sealed after deposition of the main generation of coarse-grained, lead-zinc-bearing calcite, access by the later fluorite- and final barite-depositing fluids would be prevented. If, however, the fracture remained open throughout the mineralizing episode then it would be more likely to admit further fluids and the resultant vein would then carry both fluorite and barite.

The observation by Smith (1921) that sphalerite tends to persist at depth while galena decreases in amount, is borne out by examination of the distribution of these minerals in the two working quarries. In the lower levels of both the Pant and Pant-y-Pwll-d■r quarries, sphalerite is much more abundant than galena. However, it is also worth noting that above these levels sphalerite tends to be increasingly oxidized to a skeletal boxwork of smithsonite, while much of the galena remains relatively unaltered. This implies that supergene processes may, in certain areas, result in an apparent pattern of vertical zonation. However, in the North-east Wales Orefield, the tendency for galena to become scarce at depth was well documented at a number of mines (Smith, 1921), particularly to the north of Halkyn Mountain, and also at Minera, so that some vertical zonation within the orefield appears to be present.

Although less intensively studied than the other 'Pennine-type' orefields of Great Britain, a number of theories have been advanced to explain the genesis of the North-east Wales Orefield. Initially, Earp (1958) invoked the presence of a concealed granite batholith for the existence of a vein province, then a popular model for the genesis of ore deposits. Since that time, however, the granite model has been disproved in many cases throughout Great Britain and has been replaced by the concept of laterally migrating, connate brines expelled from adjacent sedimentary basins. It is this now largely accepted model which has been applied to the MVT orefields of Great Britain; in the case of the North-east Wales Orefield, the Irish Sea and Cheshire basins to the north and east of the area, respectively, are considered to have been the principal sources of hydrothermal fluids (Ixer and Vaughan, 1993). Fluid-inclusion data obtained from fluorite samples indicate that the mineralization was derived from fluids with temperatures of $105^{0}130^{0}$ C and salinities of *c.* 24 wt% NaCl equivalent (Smith, 1973), features typical of sedimentary basin oilfield brines, and hence consistent with the above model.

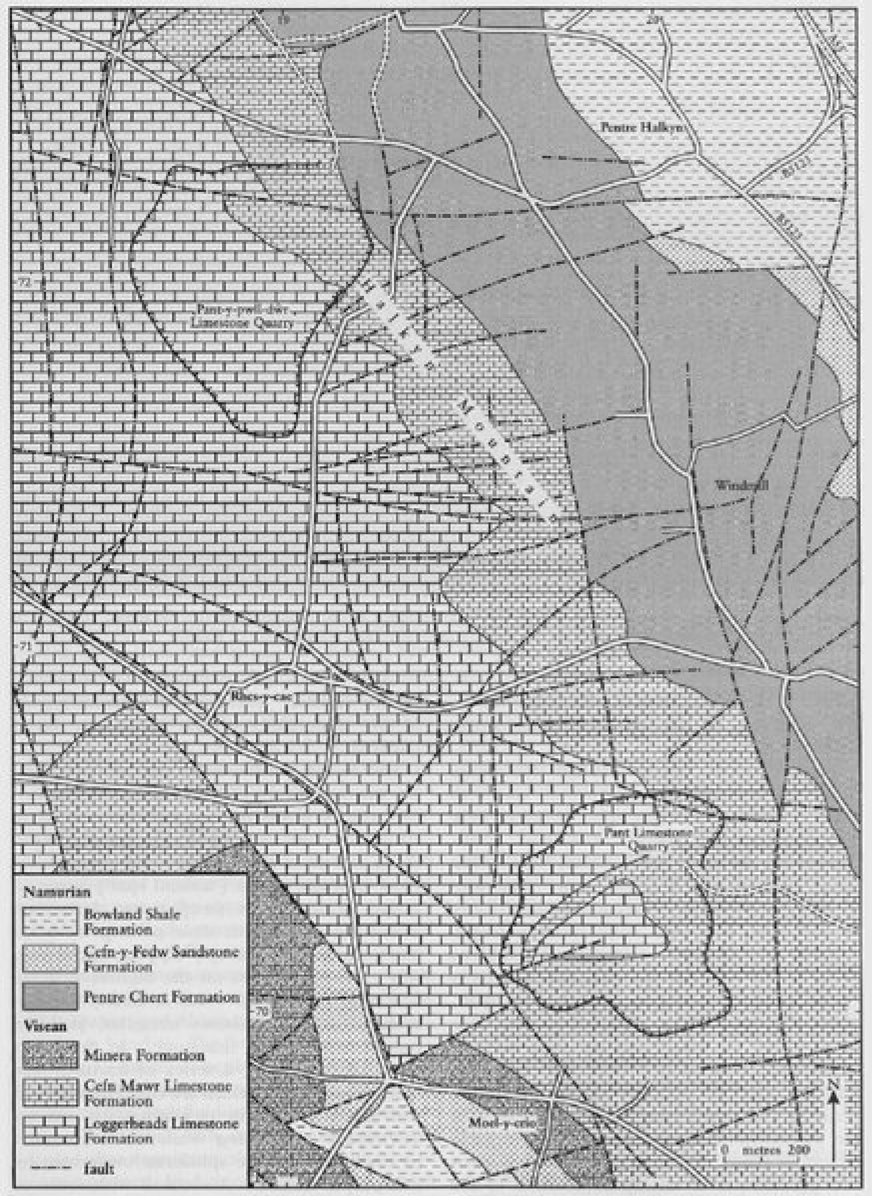
The age of the mineralization is slightly more problematic. The only available isotopic date is a Pb-Pb date (Moorbath, 1962) that indicates an early Jurassic age, but this may not be reliable (Ixer and Vaughan, 1993). However, it seems reasonable, given the field evidence that the mineralized fractures cut strata as young as Westphalian (Smith, 1921), to infer that the mineralization is post-Carboniferous in age and was probably related to the development of sedimentary basins in adjacent areas in Upper Palaeozoic to Mesozoic times. Subsidence associated with this period of basinal development would also have caused regional crustal extension across Wales, creating favourable conditions for the development of tensional fractures, ideal for access by hydrothermal fluids.

Secondary mineralization is widespread but rather limited in the number of species present. Not surprisingly, in an area dominated by carbonate sedimentary sequences, the pattern of sulphide alteration is principally linked to the generation of secondary carbonate species. Although limited in diversity, the quantity of alteration products is greater than in most other Welsh mining areas. Most notably, the alteration of sphalerite produced historically workable deposits of smithsonite ('calamine') at several localities (Smith, 1921). Secondary lead minerals, however, are of relatively limited abundance: cerussite tends to form thin, earthy external rinds on otherwise fresh galena, and only locally has significant pyromorphite been found, indicative of the relative stability of galena in comparison to sphalerite. Although occasionally occurring as aesthetically pleasing specimens, the copper carbonates azurite and malachite are only present in minor quantities, reflecting the relative paucity of the primary source copper mineral chalcopyrite. The extent of sulphide oxidation is interpreted as being related to the relatively high permeability of the Carboniferous carbonate-dominated host-rocks, allowing an enhanced amount of interaction between the primary assemblage minerals and groundwaters. Such processes continue to the present day, and extensive cementation of periglacial sands and gravels by aragonite discharged from a karstic spring has been reported at the Hendre Gravel Quarry, to the south of Halkyn Mountain (Bevins and Mason, 1999).

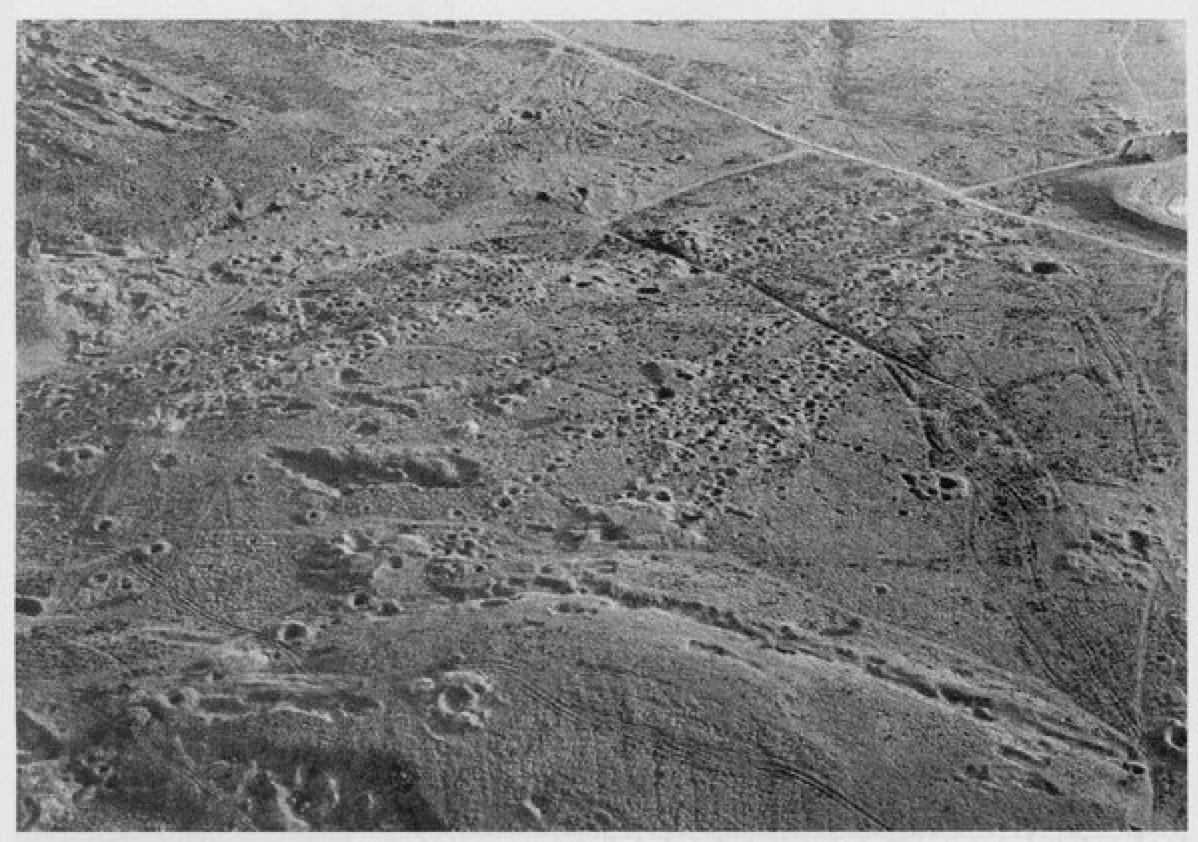
Conclusions

The Halkyn Block of the North-east Wales Orefield, typified by the Halkyn Mountain GCR site, is, compared to the other orefields of Wales, paragenetically simple. Mineralization, developed within a conjugate set of east–west and north–south extensional fractures, is dominated by calcite, with associated galena, sphalerite, chalcopyrite, fluorite and barite. The geological setting and fluid-inclusion characteristics of the mineralization are consistent with emplacement by connate brines expelled from adjacent sedimentary basins in late Palaeozoic to Mesozoic times. This genetic model is also consistent with the overall model for the development of the other major 'Pennine-type' lead-zinc orefields in Great Britain.

References



(Figure 5.72) Map of the Halkyn Mountain GCR site. After British Geological Survey 1:50 000 Sheet 108, Flint (1999).



(Figure 5.73) Oblique aerial photograph of old lead workings at the Halkyn Mountain GCR site. (Photo: 0 Crown copyright: Royal Commission on the Ancient and Historical Monuments of Wales.)