Florence Mine, Cumbria

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Introduction

The underground workings of Florence Mine, the last surviving working hematite mine in Cumbria, provided a unique opportunity to study hematite mineralization in *situ* in a large replacement orebody within Lower Carboniferous (Dinantian) limestones. At the time of editing this description (March 2007) it is understood that pumping of mine water will very soon be stopped. The underground workings are then expected to flood rapidly and become permanently inaccessible. The following section is retained here as a historical description and interpretation of this important site.

The earliest records of hematite iron ore mining in west Cumbria date from the 12th century, and mining is known to have been active here in the 17th and 18th centuries. However, it was the 19th century that was to witness the large-scale mining of these deposits. The abundance of high-grade hematite ore, together with the availability of local coal, provided the basis for the west Cumbrian iron and steel industry, which was to flourish well into the 20th century. Historical reviews of the industry include those by Daysh and Watson (1951), Hewer and McFadzean (1992), and Kelly (1994).

Sinking of the Florence Mine began in 1914 and production started in the early 1920s. In order to secure further ore reserves, the present, No. 2 Shaft (Figure 2.21) was sunk in the 1940s, a short distance north of the original, No. 1 Shaft. Later connections were made with the neighbouring Ullcoats and Beckermet mines. During this time Florence Mine made a significant contribution to the estimated output of around 250 million tons of hematite from the combined west and south Cumbrian iron ore-fields. In the late 1970s the deep workings in the enormous Florence–Ullcoats orebody were abandoned. Until early in 2007 very small-scale production of hematite was maintained from a shallow orebody accessed from the Florence No. 2 Shaft. Hematite from the most recent workings of the mine was employed in specialized steel-making as well as in the pigment industry.

Description

The west Cumbrian hematite Orefield may be considered in two parts. Limestones of the Lower Carboniferous Chief Limestone Group, which crop out in a narrow belt for about 10 km north-east of Egremont, contain numerous large orebodies, many of which reach rockhead. From Egremont south towards Calder Bridge the limestones and their contained orebodies are concealed beneath Permo-Triassic rocks. The most recent workings, including those at Florence Mine, lie within this concealed southern portion of the orefield.

Florence Mine was one of a number of mines in the Egremont area which worked the Florence–Ullcoats orebody. This extensive replacement body of hematite occurs within the lower part of the Lower Carboniferous Limestone (Dinantian) sequence within a graben between the roughly WNW–ESE-trending Ullcoats and Florence faults. The stratigraphical position of the limestone here is uncertain but appears to lie mainly within the Sixth and Seventh limestones (Smith, 1924). The limestones rest unconformably upon mudstones of the Ordovician Skiddaw Group. The limestones, and in places the hematite orebodies, are in faulted contact with Skiddaw Group rocks. Within the neighbourhood of the mine the limestones are everywhere concealed beneath Permo-Triassic rocks. These comprise a group of breccias, known locally as 'Brockram', around 70 m thick and overlain by red sandstones belonging to the St Bees Sandstone Formation, the local representative of the Triassic Sherwood Sandstone Group.

Workings in the main part of the Florence–Ullcoats orebody, and in other associated large orebodies, are now largely worked out and inaccessible in flooded deep sections of the mine. The currently accessible Florence Mine workings are within a higher portion of the orebody, known as the 'Lonely Hearts Orebody', which lies near the Ullcoats Fault between the original Florence workings and those of Ullcoats Mine to the east. Most of the important features which characterize west Cumbrian replacement hematite orebodies may be seen within the present workings. Young (2007) has compiled a detailed description of the geological and mineralogical features exposed in the accessible underground workings immediately prior to the mine's closure.

The deposits are typically wholesale replacements of limestone, commonly closely associated with, or adjacent to, faults. Original features of the limestone, including some fossils, bedding planes and locally stylolitic contacts, are commonly preserved in hematite. Thin mudstone partings within the original limestone may in places be traced through the ore. Hematite is present in a variety of forms. Compact massive hematite is most common. Within this, cavities or vugs, known by the miners as 'lough holes', are very common. Whereas the great majority of these are less than 5 cm in diameter, larger examples are sometimes encountered. They are typically lined with small tabular crystals of specular hematite, usually accompanied by bipyramidal crystals of quartz. Much of the quartz is colourless but striking specimens of deep-brown 'smoky quartz' were formerly common. More rarely quartz crystals of a distinctive deep-red colour due to included finely divided hematite, and known to miners as 'eisenkiesel' or 'tomato quartz', have been found. In many vugs a thin layer of the distinctive fibrous crystalline mammillated variety of hematite, well-known locally as 'kidney ore', separates the massive ore from the lining of specular crystals. More commonly 'kidney ore' occurs as bands and pockets within the orebody (Figure 2.22). West Cumbria haslong been celebrated as a source of specimens of this form of the mineral, spectacular examples of which are to be found in most of the world's major mineralogical collections. Florence Mine was one of the more famous sources of such specimens, and good examples were common in parts of the most recent workings. 'Kidney ore' typically breaks into roughly conical fragments parallel to the fibrous crystals. These fragments are known locally as 'pencil ore'. When of sufficiently fine grain they can be employed in making hematite jewellery. Other minerals commonly found in vugs in the Florence ore-body include fluorite as colourless or pale-blue cubes. Although good small examples of this mineral were fairly common within the recent workings they did not compare with the beautiful sky-blue cubes, sometimes up to several centimetres across, formerly recovered from the deeper workings of the Florence and Ulkoats mines. Fine examples are prominent in many important mineralogical collections. Curved rhombic crystals of creamish-white dolomite, calcite in a variety of habits, and locally a little aragonite also occur in vugs, but these minerals, together with white to pale-pink platy barite crystals are more common in veins and vugs towards the margins of the orebody close to the host limestone.

Whereas Florence Mine, along with a number of now-abandoned Cumbrian hematite mines, is well known for fine examples of several of the gangue minerals, it should be noted that they form only a very small proportion of the orebodies, the overwhelming proportion of which is composed of hematite. Rare traces of a number of sulphides, including pyrite, chalcopyrite, marcasite and galena, together with manganese oxides including manganite and hausmannite, have been found in many of these deposits, although they appear to be rare or absent from the most recent Florence Mine workings.

Interpretation

The hematite deposits of Cumbria occur as large irregular replacements of Lower Carboniferous limestones on the western and southern fringes of the Lake District. Much smaller fissure-veins of hematite, genetically related to these, occur within the Lower Palaeozoic rocks of the Lake District. The Nab Gill deposits within the Eskdale Granite are an example (see Nab Gill Mine GCR site report, this chapter).

The origin of the Cumbrian hematite deposits has long been the subject of much speculation and controversy. The most comprehensive description of the deposits is that by Smith (1924). Rose and Dunham (1977), and Shepherd and Goldring (1993) have presented a review of the deposits and their likely origin. The brief summary presented here applies to the formation of both the replacement deposits within the Lower Carboniferous limestones and the vein deposits in the Lower Palaeozoic rocks such as those at the Nab Gill Mine (see GCR site report, this chapter).

Early views centred on two different sources of iron-rich fluids. Kendall (1873–1875) suggested a deep-seated magmatic or hydro-thermal source, whereas Goodchild (1889–1890) advocated the leaching of iron by meteoric groundwaters from overlying iron-rich rocks such as the St Bees Sandstone Formation. More recently, Shepherd and Goldring (1993) suggested that brines expelled from over-pressurized sediments in the East Irish Sea Basin were driven towards the Lake District Batholith. There they leached iron from the granites before being driven upwards through fractures along the western margin of the Lake District. Rose and Dunham (1977) proposed a model whereby iron, leached by warm hypersaline fluids from the Permo-Triassic sediments of the East Irish sea Basin, were forced up-dip towards the margins of the Lake District.

Both models are consistent with the iron-rich mineralizing fluids gaining access to the limestones and Lower Palaeozoic rocks of the Lake District through fractures as well as through permeable formations within the Permo-Triassic sequence. The role of the permeable Permo-Triassic rocks is of crucial importance in this mineralizing process. In west Cumbria, where these rocks rest directly on Dinantian limestone, orebodies are commonly present; but where thick impermeable shales of Namurian, Westphalian or Upper Permian age intervene between the permeable Permo-Triassic rocks and the limestones, no orebodies are found. Young (in Jones *et al.,* 1990) has speculated that certain Coal Measures sandstones, the interstices of which contain concentrations of specular hematite, may have acted as mineralizing aquifers in suitable structural settings. Over much, if not all, of the Lake District the Permo-Triassic sequence is likely to have begun with a variable thickness of breccias or 'brockrams',which were succeeded by sandstone of the Sherwood Sandstone Group. A permeable route for mineralizing fluids is thus likely to have been present over much of the area.

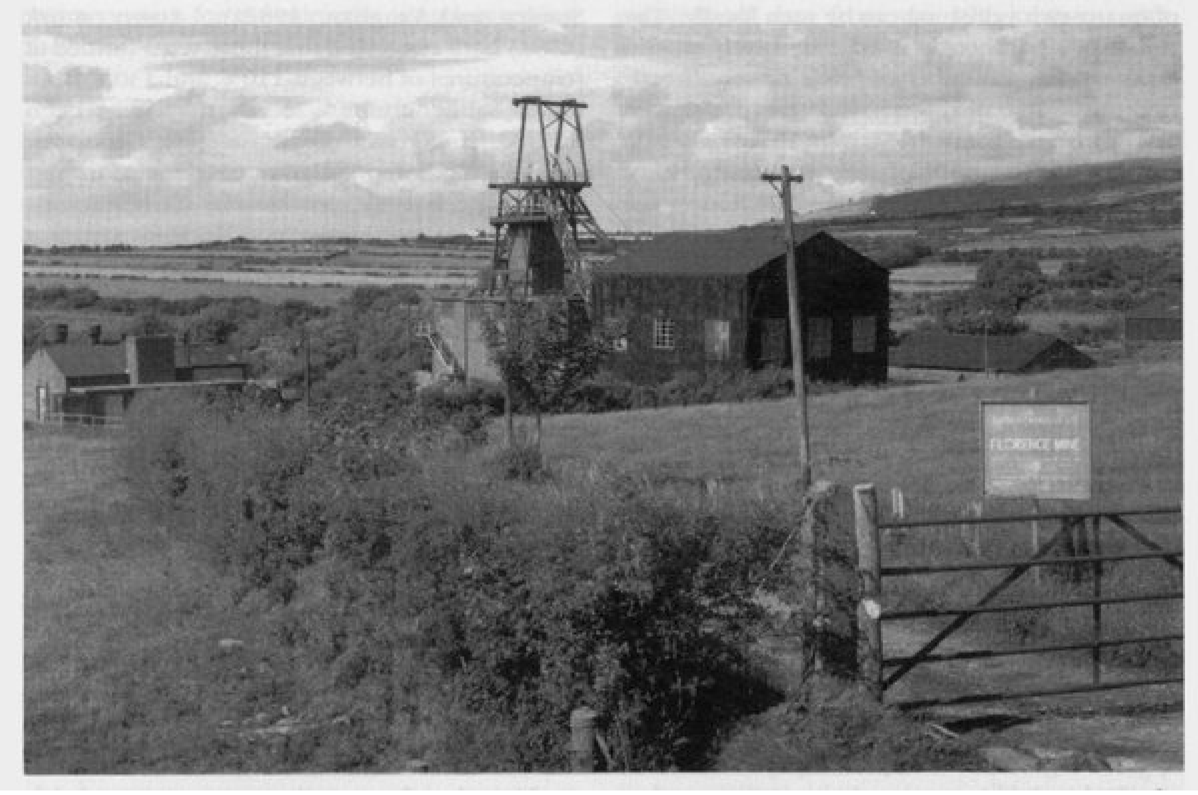
Shepherd and Goldring (1993) concluded that the hematite mineralization is the result of the mixing of sulphatic groundwaters with warm, iron-rich, relatively oxidizing sulphur-poor, hypersaline brines. They advocate a downward flow of mineralizing fluids to account for the distribution of orebodies within the limestones of west and south Cumbria. However, the occurrence of hematite veins within the Lower Palaeozoic rocks of the Lake District, and the distribution patterns for arsenic, barium and fluorine within these deposits, suggests some upward flow of mineralizing fluids. They favour a sedimentary source for the iron. Fluid-inclusion data for quartz, fluorite and calcite within the replacement deposits in the limestones indicate formation temperatures of up to 120°C.

The age of the hematite mineralization has also been disputed for many years. Shepherd (1973) favoured a middle or late Triassic age, whereas Dunham (1984) argued that the structural and stratigraphical relationships require a post-Triassic age. Using palaeomagnetic results a number of authors have proposed a Permian or early Triassic age (DuBois, 1962; Evans and El-Nikhely, 1982; Evans, 1986). In a recent palaeomagnetic study Rowe *et al.* (1998) suggested that hematite mineralization was emplaced during late Carboniferous and early Permian times, although this is difficult to reconcile with the stratigraphical and structural evidence.

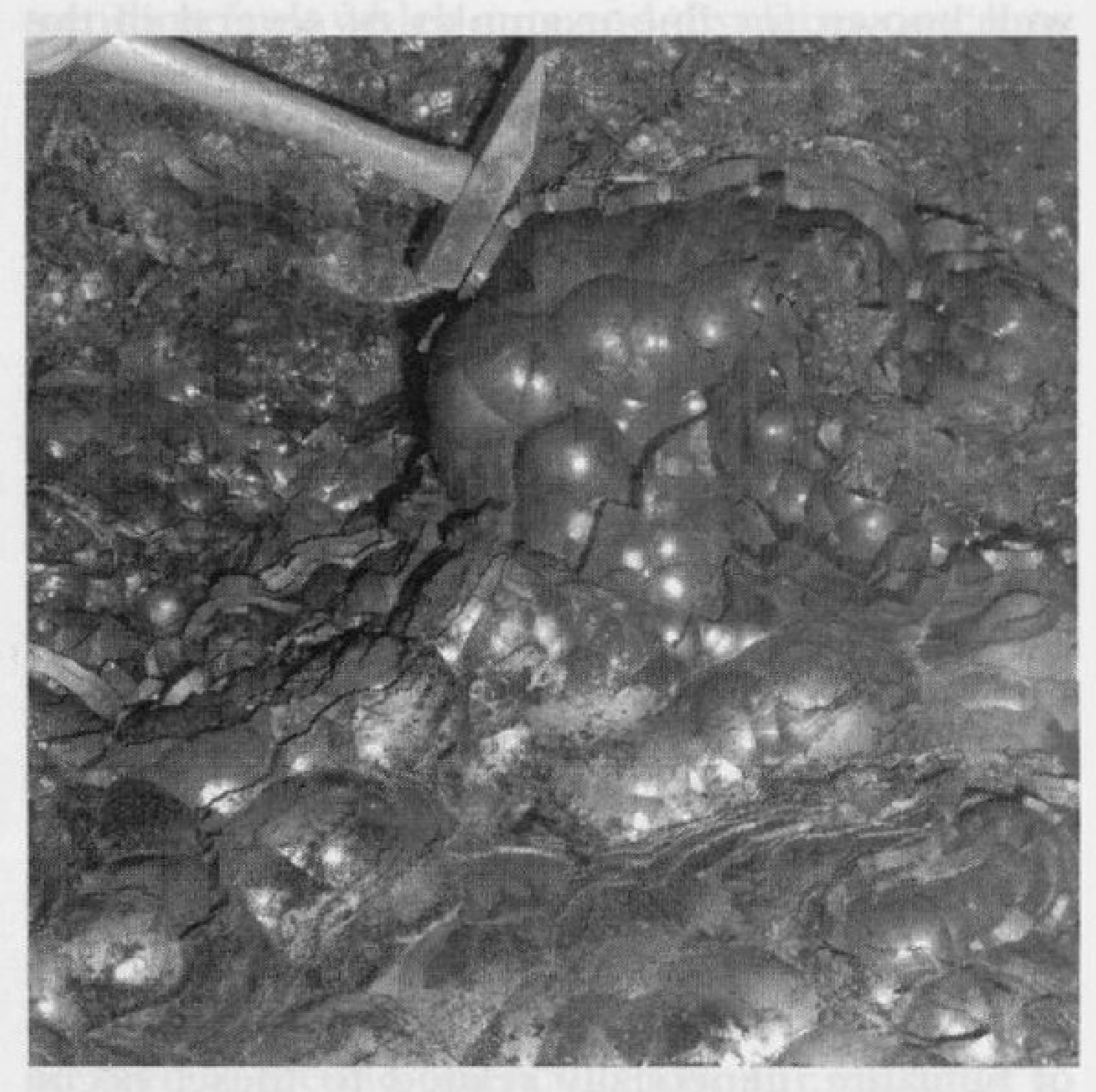
Conclusions

The underground workings of Florence Mine provided a unique opportunity to study a replacement orebody of hematite in the Lower Carboniferous limestone within its mineralogical, structural and stratigraphical context.

References



(Figure 2.21) The No. 2 Shaft headframe and buildings at Florence Mine. (Photo: T. Bain, BGS No. D3965, reproduced by permission of the British Geological Survey, © NERC. All rights reserved. IPR/116–33CY.)



(Figure 2.22) Large mass of 'kidney ore' exposed in situ in the underground workings at Florence Mine. (Photo: T. Bain, BGS No. D3974, reproduced by permission of the British Geological Survey, © NERC. All rights reserved. IPFt/116–33CY.)