Carrock Mine–Brandy Gill, Cumbria

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Introduction

Tungsten mineralization at the Carrock Mine–Brandy Gill GCR site occurs mainly in three major roughly N–S-trending veins which cut a variety of rock types including the greisen within the northern portion of the Skiddaw Granite, hornfelsed Skiddaw Group rocks, and various members of the Carrock Fell Intrusive Complex. The mineralization is genetically associated with extensive greisenization of the Skiddaw Granite. The veins record a number of stages of fracturing and mineralization, each characterized by a distinctive mineral assemblage. The main tungsten-bearing veins are cut, and displaced, by a later set of lead-bearing veins.

Although the presence at this site of several conspicuous quartz veins must have attracted early prospecting, the absence of workable lead and copper minerals in the tungsten veins would have soon been recognized. Trial workings on the lead veins, which are now known to intersect the tungsten veins, began in the middle years of the 19th century although output is likely to have been small. Attempts at tungsten mining began in 1901 and continued intermittently until 1919. Investigation of the mine's potential during World War II did not lead to a resumption of production. Mining restarted in the 1970s and although a new mill was built, the mine became uneconomic and was closed down finally in 1981. The Carrock Fell veins comprise the only known economic concentration of tungsten mineralization within Britain outside of South-west England. The total output of tungsten minerals is not known but is small. The mine's history has been outlined by Postlethwaite (1913), Abraham (1917), Shaw (1970), Adams (1988), and Blundell (1992).

The Carrock Fell veins have been the subject of much research. Important descriptions of the deposits and interpretations of their formation include those by Finlayson (1910a), Hitchen (1934), Ewart (1962), Appleton and Wadge (1976), Shepherd *et al.* (1976), Fortey (1978), Beddoe-Stephens and Fortey (1981), Brown (1983), Roberts (1983), Shepherd and Waters (1984), and Ball *et al.* (1985). The great variety of minerals found within the veins has long attracted mineralogists. Comprehensive lists of the minerals and references to individual descriptions are to be found in Young (1987a), and Cooper and Stanley (1990).

Since its abandonment the site has been cleared of buildings and parts of the spoil-heaps levelled. The main entrance adit has been closed and none of the underground workings are safely accessible. Good surface exposures of parts of the veins remain, and representative examples of mineralized veinstone may be seen in the remaining spoil-heaps. The site lies within the area in which mineral collecting is controlled by a permit system administered by the Lake District National Park Authority.

Description

The geology of the site is summarized in (Figure 2.12), which incorporates the results of the most recent mapping by the British Geological Survey.

The deposits occur within a small area on the northern margin of the Grainsgill Cupola of the Skiddaw Granite. This partially unroofed intrusion has an extensive thermal metamorphic aureole in Ordovician rocks which include highly deformed slates of the Skiddaw Group, volcanic rocks of the Eycott Volcanic Group, and parts of the Carrock Fell Intrusive Complex, including gabbro and granophyre. In its northernmost outcrop in Grainsgill, the Skiddaw known mainly from underground workings. Harding and Emerson veins were the main sources of tungsten minerals. Smith Vein is said by Shaw (1970) to have contained only poor tungsten values. The main workings on these veins lie on the north side of Grainsgill Beck. The only significant workings south of Grainsgill Beck are those in the Harding Vein on the steep northern slopes of Coomb Height. According to Shaw (1970) this vein was the most prolific producer. Trials in the Emerson Vein south of Grainsgill were unsuccessful, but Shaw (1970) recorded the finding here of very fine crystals of quartz.

The veins are steeply inclined, with very sharp contacts with their wall-rocks, and vary from 0.1 m to 1.5 m in width (Shepherd *et al.,* 1976). They are typically filled with white quartz, crystals of which up to 0.3 m long have been seen in vugs. Tungsten occurs both as wolframite and scheelite. The former mineral occurs as tabular crystals up to about 10 cm across, commonly forming clusters on or near the vein walls (Figure 2.13) and (Figure 2.14). Scheelite is common, in places clearly replacing earlier wolframite; scheelite pseudomorphs after Granite exhibits intense alteration which culminates in the quartz-muscovite greisen of the Carrock Mine–Brandy Gill area.

Two principal sets of veins are present at Carrock Mine–Brandy Gill, namely the tungsten veins and a cross-cutting set of lead veins.

The tungsten veins strike approximately north–south on either side of Brandy Gill, the left bank tributary of Grainsgill Beck. From west to east these are known as the 'Smith', 'Harding' and 'Emerson' veins. Other minor tungsten-bearing veins are associated with these and are wolframite have been found (Young, 1987a). Well-formed crystals of pale to deep orange-yellow scheelite have long been known from here. Cooper and Stanley (1990) referred to fine specimens collected in the 19th century, including examples figured by Lévy (1837), Greg and Lettsom (1858), and Bauer (1871), and commented on the finding in the 1970s of a very large vug within Smith Vein lined with large scheelite crystals. Shaw (1970) noted that within the Harding Vein much of the tungsten was present as scheelite, whereas in the Emerson Vein wolframite was the main tungsten mineral.

In addition to tungsten ores, the veins contain a great variety of other minerals. Prominent amongst these are arsenopyrite, for which the mine is well known as a source of beautifully crystallized specimens (e.g. Cooper and Stanley, 1990), pyrite, pyrrhotite and sphalerite. This latter mineral typically occurs as the very dark-brown to black iron-rich variety known as 'marmatite'. Other metalliferous minerals recorded in smaller amounts include bismuthinite, chalcopyrite, columbite, cubanite, galena, jamesonite, josëite, molybdenite, native bismuth, powellite, stibnite, tetradymite and uraninite (Young, 1987a). Traces of gold and very rare specimens of cassiterite have also been reported (Shackleton, 1966; Shaw, 1970; Appleton and Wadge, 1976; Hartley, 1984; Young, 1987a; Cooper and Stanley, 1990). Non-metalliferous minerals include apatite, for which the mine has long been a well-known source of fine crystals (e.g. Phillips, 1823; Lévy, 1837; Greg and Lettsom, 1858; Rudler, 1905), barite, dolomite, fluorite, microcline, muscovite, rutile and tourmaline. Carrock Mine–Brandy Gill provided the first British occurrence of several minerals, including aikinite, boulangerite, carpholite, cosalite, josëite-A, and zinkenite (Kingsbury and Hartley, 1956a), and raspite (Neall and Green, 2001b).

The courses of the three principal tungsten-bearing veins are easily followed through old opencuts and collapsed stopes on either side of Brandy Gill and, in the case of the Harding Vein, on the steep slopes of Coomb Height, south of Grainsgill. Portions of quartz veinstone, with small amounts of metalliferous and other minerals, can be seen locally, particularly in the opencast workings along the Emerson Vein. Abundant spoil alongside the opencuts and adjacent to the entrances to levels driven on the veins provides good representative examples of typical veinstone. Whereas the site has long attracted the attention of mineral collectors, examples of even some of the rarer minerals may still be found. Fine sections of the veins, exposed in the underground workings, are no longer safely accesssible.

The tungsten-bearing veins are cut and displaced by at least two E–W-trending lead veins (Figure 2.12). The northernmost lead vein, which crosses Brandy Gill almost 1 km upstream from its confluence with Grainsgill, has been worked on a small scale from levels on both banks of the stream. These workings, known as 'Brandy Gill Lead mine', are well known for a variety of rare supergene minerals collected both from the vein outcrops and from the small spoil-heaps. The site has provided the first British occurrence of arseniosiderite, beaverite, duftite, hedyphane, and stolzite. A small vein exposure which has also yielded fine examples of a variety of rare supergene species including carminite and beudantite, at the head of an unnamed eastern tributary stream (Cooper and Stanley, 1990), may be on the same vein. More recently, the iron arsenate symplesite has been reported from the waste tips at Carrock Mine–Brandy Gill (Green *et* ed., 2003).

Young (1987a), and Cooper and Stanley (1990) provide comprehensive lists of the minerals, including many rare supergene species, from the Carrock Fell and Brandy Gill workings.

Ryback *et al.* (2001) have demonstrated that the late A.W.G. Kingsbury falsified the localities of numerous rare mineral species. This deception affects a number of locations in the Lake District, including Carrock Fell Mine and the adjacent lead mines in Brandy Gill. The discredited claims for this site are: lindgenite (Kingsbury and Hartley, 1955), descloizite and vanadinite (Kingsbury and Hartley, 1956b), and carpholite (Kingsbury and Hartley, 1957b). Although this discovery must cast serious doubt on much of Kingsbury's labelling, the reporting of aikinite, cosalite, and other minerals from Carrock Fell Mine (Kingsbury and Hartley, 1956a) may be reliable as exactly similar material has subsequently been collected from this locality.

Interpretation

Useful synopses of the considerable volume of interpretive investigations carried out on the Carrock Fell mineralization are presented by Firman (1978a), and Rice (1993). The following brief summary incorporates the essential features and conclusions of these studies.

Intrusion of the Skiddaw Granite (minimum age 392 ± 4 Ma) was followed by greisenization within the Grainsgill Cupola, and formation of barren quartz, quartz-microcline and quartz-apatite veins (Firman, 1978a). The main tungsten-bearing veins, consisting of early quartz accompanied by a little scheelite, were then emplaced in north–south fractures. Hitchen (1934) suggested that tungsten mineralization passes laterally into manganese-rich mineralization in an outer 'halo' around the Carrock Fell deposits. This was followed shortly afterwards by the introduction of sulphides including arsenopyrite, pyrite, pyrrhotite, iron-rich sphalerite ('marmatite), chalcopyrite, bismuthinite, molybdenite, bismuth sulpho-tellurides and native bismuth (Ball *et al.,* 1985). The replacement of substantial amounts of the original wolframite by scheelite probably took place at this time, together with the local formation of columbite, perhaps exsolved from primary wolframite (Beddoe-Stephens and

Fortey, 1981). Cosalite and a number of lead antimony sulphosalts, described from Carrock Fell Mine by Kingsbury and Hartley (1956a), and the early quartz Sb-Fe-As minerals in the nearby Wet Swine Gill Vein (see Wet Swine Gill GCR site report, this chapter) (Fortey *et al.,* 1984) may also date from this period of sulphide mineralization. Hydrothermal muscovite from the intensely greisenized wall-rock of these veins gives an age of 387 Ma, suggesting a very close link between granite emplacement and mineralization. The main sequence of mineralizing events recorded within the tungsten-bearing veins is assigned a Lower Devonian age by Stanley and Vaughan (1982a). A final episode of pervasive carbonate mineralization, which filled narrow fissures within the tungsten-bearing veins with calcite, dolomite and a little arsenopyrite is undated but may represent the episode of mineralization which emplaced lead and minor copper ores in the E–W-trending veins which cut and displace the tungsten veins. These are likely to be part of the widespread suite of Lake District lead-bearing veins for which a Lower Carboniferous age has been proposed (Stanley and Vaughan, 1982a).

Mineralogical, oxygen-isotope and fluid-inclusion studies support a genetic connection between the formation of the Grainsgill Cupola greisen and the tungsten mineralization (Hitchen, 1934; Ewart, 1962; Shepherd *et al.,* 1976; Ball *et al.,* 1985). From these it appears that the mineralizing fluids responsible for the tungsten mineralization were low salinity (maximium 10 wt% NaCl equivalent), CO_2-rich aqueous fluids which were depleted in ^{18}O relative to magmatic fluids and which therefore appear to have contained a major non-magmatic component. Temperatures of 235°–335°C are indicated for this mineralization. The main sulphide mineralization appears to have been deposited at temperatures between 170°C and 235°C. The final calcite-dolomite mineralization formed at between 110°C and 130°C from high-salinity (in excess of 23 wt% NaCl equivalent) $CaCl_2$-rich aqueous fluids.

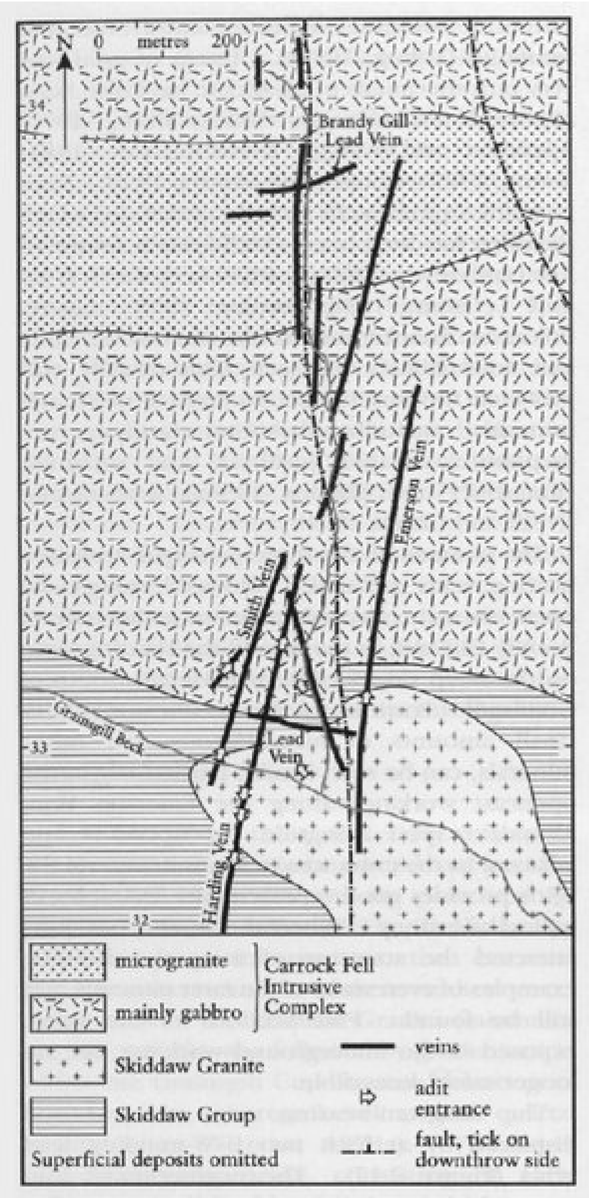
Shepherd *et al.* (1976) suggested that greisenization may have been caused by moderately saline non-magmatic fluids in the country rocks being drawn into the Grainsgill Cupola of the Skiddaw Granite during cooling. These fluids were then expelled into the north–south fractures where they mixed with additional non-magmatic fluids and deposited the main mineralization. Fluid convection is likely to have been driven by thermal energy from the cooling pluton (Shepherd and Waters, 1984).

The extensive range of supergene minerals is likely to have developed in comparatively recent geological times when erosion brought the deposits within reach of oxidizing groundwaters. Elements from both tungsten- and lead-bearing veins contributed to the formation of such rare species as wulfenite, stoizite and lindgrenite.

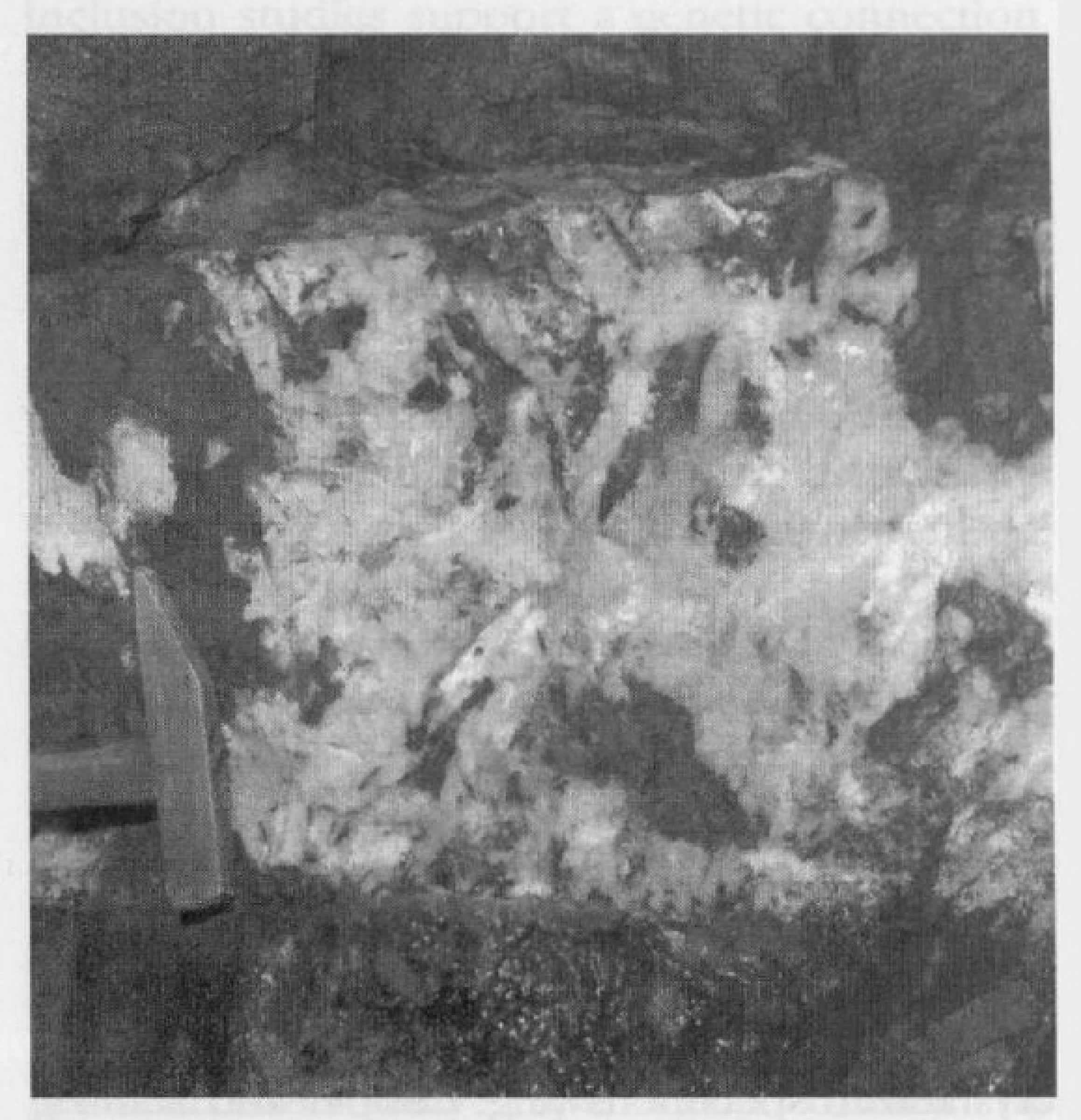
Conclusions

Carrock Mine–Brandy Gill provides opportunities to study comparatively high-temperature mineralization associated with extensive greisenization of the northern Grainsgill Cupola of the Caledonian Skiddaw Granite. Early wolframite-rich tungsten mineralization is followed by a varied assemblage of sulphides accompanied by abundant scheelite. Lead-rich mineralization occurs in later veins which cut the main tungsten-bearing veins. The Carrock Fell deposits include a great variety of primary and supergene minerals, for several of which the site is the first reported British occurrence.

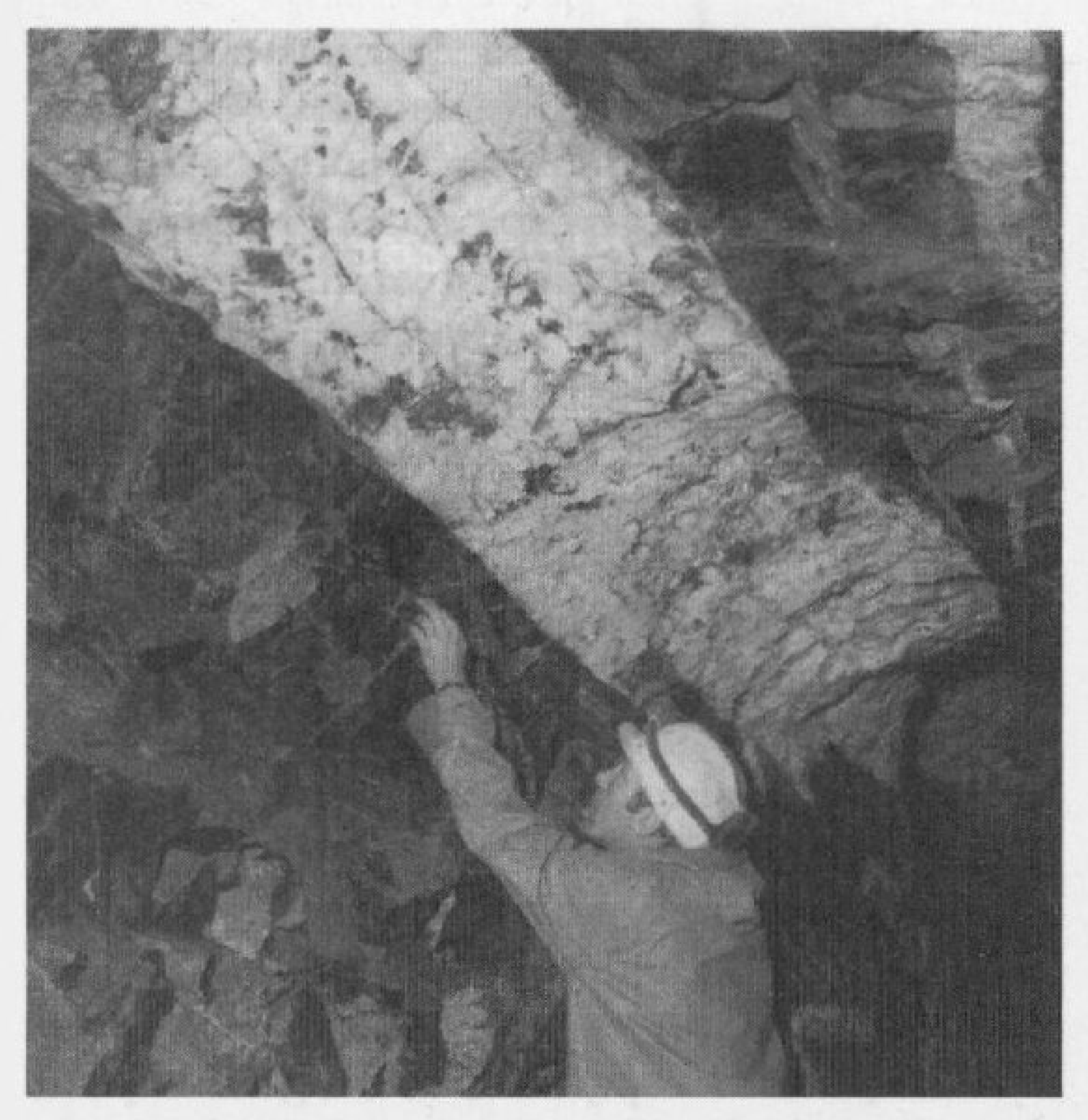
[References](#)



(Figure 2.12) Geological sketch map or the Carrock Mine–Brandy Gill GCR site.



(Figure 2.13) Harding Vein, between gabbro wall-rocks, exposed underground at Carrock Mine–Brandy Gill. Clusters of large wolframite crystals are prominent within massive white quartz. Other conspicuous constituents of the vein include arsenopyrite and a little scheelite. (Photo: T Bain, BGS No. D3957, reproduced by permission of the British Geological Survey, © NERC. All rights reserved. IPR/116–33CY.)



(Figure 2.14) Smith Vein, between gabbro wall-rocks at Carrock Mine–Brandy Gill. The vein here is composed mainly of white quartz in which a faint banding may be seen. The dark minerals are wolframite, arsenopyrite and scheelite. (Photo: T Bain, BGS No. D3945, reproduced by permission of the British Geological Survey, © NERC. All rights reserved. IPR/116–33CY.)