Mineralization in the Lake District

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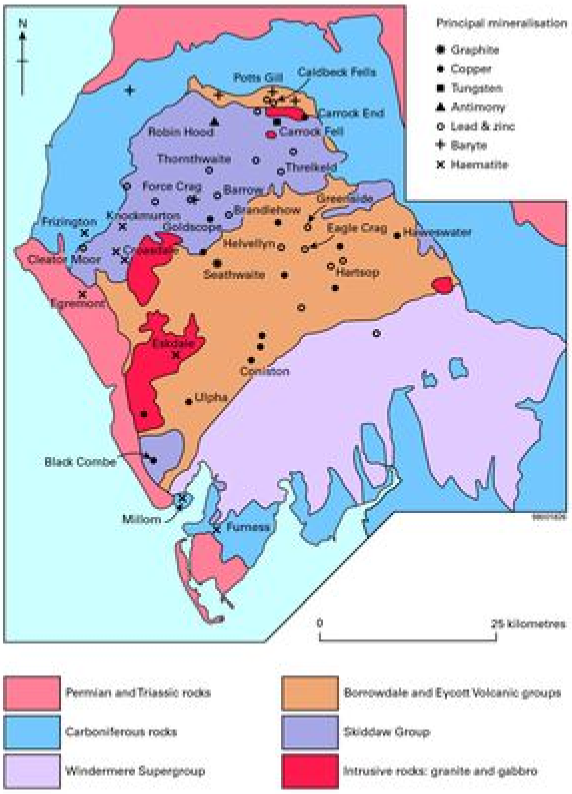
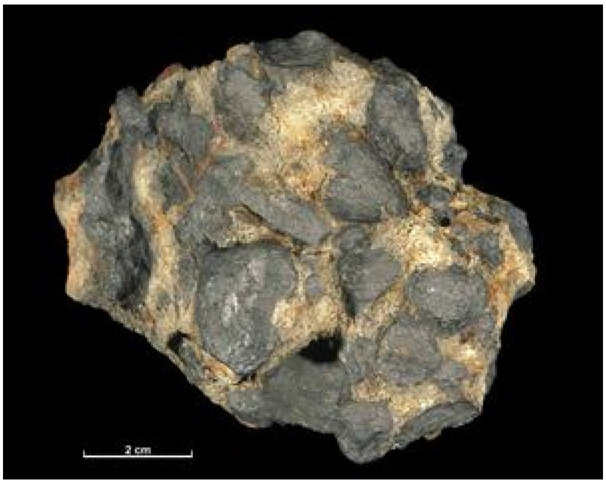
Introduction



Principal metalliferous mining sites of Cumbria and the Lake District. Named localities are those mentioned in the text. P916088.



Nodules of graphite set in altered dioritic rock, from the Seathwaite graphite deposit at Borrowdale, Cumbria. (P649471).


Tungsten mineralisation in the Harding Vein, at Carrock Fell Mine, Mosedale, Cumbria. Large, black, blade-like crystals of wolframite are set in a quartz gangue. In places, for example just above the hammer, wolframite is partly replaced by pale brown scheelite (arrowed). The hammer head is 17 cm long. (P220211).

Epigenetic mineralisation within the Lower Palaeozoic rocks of the Lake District inlier is largely confined to the Skiddaw, Eycott Volcanic and Borrowdale Volcanic groups and the major igneous intrusions (P916088); mineralisation is rare within the rocks of the Windermere Supergroup. Many of the metalliferous veins of the Lake District appear to exhibit a close structural, and perhaps genetic, relationship to the form of the largely concealed Lake District granitic batholith. Veins are typically concentrated above, or close to, ridges in the roof region of the batholith or above its north and south walls. The virtual absence of veins from the Windermere Supergroup is consistent with their close association with the batholith, which does not extend beneath that division.

The mineralogical composition, chemical characteristics and structural relationships of the deposits give evidence for several mineralising episodes, in some cases within the same vein. Deposits range in age and composition to include: Late Ordovician copper-rich assemblages; Early Devonian tungsten-bearing veins; Carboniferous or early Permian lead–zinc mineralisation, locally accompanied by abundant baryte; widespread post-Permian haematite mineralisation; super-gene assemblages, possibly formed in Jurassic or later times. The earliest phases of mineralisation may be the result of hydrothermal activity during the closing stages of Ordovician magmatism, with subsequent episodes during the tectonic evolution of the region. The Lower Palaeozoic rocks of the Lake District, including the granitic batholith, and the Carboniferous and Permo-Triassic rocks of the adjoining basins appear to have been source rocks for the introduced minerals.

Two belts of extensive metasomatic alteration, which affect Skiddaw Group rocks, may give important clues to some of the mineralising processes. In the northern part of Black Combe and in the Crummock Water aureole are zones of intense metasomatic alteration and bleaching of the rocks which exhibit substantial net additions of such elements as As, B, K and Rb and locally Ca, F and Si, with dehydration and depletions of Cl, Ni, S, Zn, C and in places Cu, Fe, Li and Mn. The inferred presence of an elongate granitic body along the northern margin of the Lake District Batholith and the Early Devonian date for the Crummock Water metasomatism provide strong evidence that

Skiddaw Group rocks may have been a source of ore metals for some of the Lake District veins.

No clear uniformity of vein orientation is apparent within the Lake District, though it has been observed that copper-bearing veins are commonly orientated east–west with a southerly dip, whereas mainly lead–zinc veins typically trend within 45° of north and dip towards the east. However, there are many exceptions to this pattern. Although evidence exists for vertical zonation of constituent minerals in a few instances, most of the Lake District deposits show no obvious lateral or vertical zonation of constituent minerals. In this they differ from the commonly zoned veins of the nearby northern Pennines.

The following accounts review the deposits in order of their approximate age, with the oldest first.

Graphite deposits

The Seathwaite graphite deposit in Borrowdale (NY 232 125) is unique in the British Isles and has very few parallels elsewhere in the world. Mining here dates back to at least the 16th century and continued intermittently until 1891. The graphite is closely associated with a dioritic intrusion into the lowest part of the Borrowdale Volcanic Group. It occurs in veins and in a series of at least eight individual, steeply inclined, pipe-like bodies developed at the intersection of faults. The 'pipes' are each up to 1 m by 3 m across and from 2 m to 100 m in vertical extent. Within these, the graphite forms discrete nodules from 1 mm up to over a metre across, though nodules up to a few centimetres across were probably commonest (P649471). The nodules occur within a buff-coloured matrix of intensely altered dioritic rock. Graphite locally appears to replace the host. Within the nodules the graphite is compact, fine grained and remarkable for its purity. It is accompanied by small amounts of quartz, chlorite, pyrite and chalcopyrite.

The petrographical relationships and the inferred high formation temperature (c. 500°C) suggest a close genetic relationship between mineralisation and the intrusion. As all mafic intrusions in the Lake District are of Caradoc age (with the exception of the Early Devonian lamprophyres), the graphite mineralisation at Seathwaite is also likely to be of Caradoc age. The carbon was derived from organic-rich sediments within the underlying Skiddaw Group and was probably deposited from CO_2- and CH_4-bearing aqueous fluids.

Copper veins

Veins in which copper-bearing minerals are the main metallic constituents comprise an important suite of deposits that were formerly of considerable economic importance. The greatest concentrations of this type of mineralisation occur at Coniston (SD 280 970), Ulpha (SD 186 923) and Haweswater (NY 482 133), with examples more widely distributed at Black Combe, the Vale of Newlands, and in parts of the Caldbeck Fells (P916088). The peak years for Lake District copper production were firstly during Elizabethan times and then again during the 19th century. Very small amounts of copper ores continued to be raised at Coniston into the early years of the 20th century.

In these deposits, chalcopyrite is the most widespread primary copper sulphide mineral, though tennantite, chalcocite and bornite are locally abundant, the last in situations which suggest some secondary enrichment. Associated ore minerals commonly include abundant arsenopyrite, pyrite and pyrrhotite, with very much smaller amounts of native bismuth, bismuthinite, bismuth sulphoselenides and sulphotellurides, cobalt and nickel minerals, galena and sphalerite. Traces of gold have been identified in a few localities. Gangue minerals mainly comprise quartz, chlorite, dolomite, and locally, stilpnomelane. Magnetite, most of which appears to replace original haematite, is plentiful in a few veins, notably the Bonsor Vein at Coniston (P246074), where mine records suggest the proportion of this mineral increases with depth. Copper-bearing veins in the Consiton area appear to have been widest, up to several metres across, and were most productive where they cut silicic ignimbrites.

Within the Bonsor Vein, temperatures of 350–400°C have been suggested for the deposition of early arsenopyrite and replacement of early haematite by magnetite. Quartz, chlorite, stilpnomelane, calcite, dolomite, pyrrhotite, chalcopyrite, sphalerite and later arsenopyrite were probably deposited at temperatures of around 240°C, with later minerals including pyrite, native bismuth, bismuthinite and galena likely to have been deposited at temperatures as low as 200°C. Limited fluid inclusion studies on quartz from veins regarded as part of this suite in the Vale of Newlands suggest that the mineralising fluids were moderately saline brines (about 5–10 equiv.wt per cent NaCl). The Borrowdale Volcanic Group rocks have been proposed as the source of the metallic elements whereas the Skiddaw Group is considered the most likely source of the sulphur. These veins predate the regional Acadian cleavage and are therefore likely to have formed during or shortly after the final phases of caldera volcanism.

Tungsten veins

A small group of veins, formerly worked at the Carrock Fell Mine (NY 323 329) in Mosedale (P916088), comprise the only known occurrence of tungsten mineralisation in Britain outside of south-west England that has ever attracted commercial interest. Mining for tungsten appears to have begun here in the mid 19th century but proved unsuccessful. Subsequent attempts to resume working all failed, the latest ending in 1981.

The tungsten ores wolframite and scheelite are accompanied at Carrock Fell Mine (P220211) by arsenopyrite, pyrrhotite and pyrite in quartz–muscovite–apatite veins which strike approximately north–south through the Grainsgill cupola of the Skiddaw Pluton, the Carrock Fell Centre, and other rocks associated with them. Minor consitituents of the veins include native bismuth, bismuthinite, bismuth sulphotellurides, molybdenite (with a Re-Os age for mineralisation of about 392 Ma), iron-rich sphalerite and traces of gold. A few specimens of cassiterite have been reported. Significant tungsten mineralisation appears to have been confined to strike lengths of only 1 km centred around the mine, though panned concentrates from surrounding streams suggest that tungsten minerals may be more widely distributed.

The Carrock Fell veins are genetically associated with the Early Devonian Skiddaw Granite, much of which is here metasomatised to greisen. The mineralising fluids are interpreted as moderately saline solutions that were periodically charged with CO2 and enriched in tungsten. Fluid inclusion studies suggest temperatures of 240–295°C for the formation of the greisen, and 265–295°C for wolframite mineralisation. The tungsten-bearing veins are cut by later quartz and galena-bearing veins and there is abundant evidence of a complex series of mineralising events. Supergene alteration has produced a great variety of unusual mineral species.

Elsewhere in the Lake District, small crystals of scheelite have been found, together with some molybdenite, in drusy cavities in the Early Devonian Shap Granite; the molybdenite has given a Re-Os age of about 405 Ma for mineralisation. Scheelite also occurs, accompanied by rare wolframite, in a narrow quartz vein in the Ordovician Broad Oak Granodiorite at Buckbarrow Beck on Corney Fell (SD 135 910). This locality is of particular interest for the abundance of rare supergene species including cuprotungstite, russellite and bismutoferrite. Although relatively high concentrations of tungsten are known in greisen associated with the Eskdale Granite near Devoke Water, no tungsten minerals have been recorded there.

Apatite–chlorite veins with cobalt

A north-north-east-trending vein which cuts bleached Skiddaw Group mudstones within the Crummock Water aureole at Scar Crag on Causey Pike (NY 206 207) is unique amongst exposed Lake District veins in carrying, as its main constituents, quartz, apatite, chlorite and arsenopyrite with traces of the cobalt minerals alloclasite, cobaltite, glaucodot and skutterudite. Unsuccessful attempts were made in the 19th century to work the vein for cobalt ores. Similar quartz–apatite–chlorite veins, though without sulphides, occur at Brown How (NY 115 158) and Crag Fell (NY 095 148) in Ennerdale. The mineralisation is likely to be an Acadian phenomenon genetically associated with formation of the Crummock Water aureole above a concealed granite.

Tourmaline veins

Small amounts of tourmaline are associated with most of the larger granitic intrusions. However, numerous tourmaline-rich quartz veins up to 2 m wide are especially common within parts of the Crummock Water metasomatic aureole.

Antimony veins

In addition to their presence as minor components in other veins, or as minute inclusions within galena in the lead–zinc veins, antimony minerals comprise the main ore minerals in a small, but distinctive suite of veins within the Lake District. The best known occurrence of antimony mineralisation, and the only one known to have been of economic interest, is that at Robin Hood (NY 228 328), near Bassenthwaite, where a few tonnes of stibnite were mined during the 19th century from an antimony-bearing quartz vein in Skiddaw Group rocks. Other veins dominated by antimony ore minerals include a stibnite–berthierite–zinkenite-rich vein in Skiddaw Group rocks at Wet Swine Gill (NY 314 322), Caldbeck Fells, berthierite and jamesonite-bearing veins in Borrowdale Volcanic Group rocks at Hogget Gill (NY 389 112), near Brothers Water, and stibnite veins reported from St Sunday Crag (NY 360 130), also in the Borrowdale Volcanic Group. The Wet Swine Gill Vein may be associated with the nearby Carrock Fell Mine suite of tungsten-bearing veins. A boulder of pure stibnite weighing up to 50 kg, found in boulder clay near Troutbeck Station (NY 390 270), suggests that further antimony-rich veins could be concealed beneath glacial deposits in the northern Lake District. Few investigations have been undertaken on Lake District antimony mineralisation, the origins and age of which remain uncertain.

Lead–zinc veins

Veins in which lead and zinc minerals are the dominant ores form, like the copper-bearing veins, a very important suite of deposits in the Lake District, where they were formerly of considerable economic importance. The most significant concentrations occur in the Vale of Newlands, at Thornthwaite (NY 223 258), Brandlehow (NY 250 196), Helvellyn (NY 325 148), Hartsop (NY 410 125), Eagle Crag (NY 358 142), Greenside (NY 365 174) and Force Crag (NY 200 215), and around Threlkeld and in the Caldbeck Fells. The Lake District has had a long history as a lead producer: the area’s last major lead mine, Greenside, closed in 1962 though attempts at small-scale production of zinc ore with associated baryte continued at Force Crag until 1990.

Galena and sphalerite are the main primary ore minerals in these veins, accompanied locally by minor amounts of chalcopyrite and tetrahedrite. Minute inclusions of native antimony and antimony sulphosalts are common within the galena. Silver is almost invariably present within the galena, probably within minute inclusions of lead, copper and antimony sulphosalts. Assay values of up to 30 ozs of silver per ton of lead (838 ppm) have been recorded from the Caldbeck Fells and high concentrations of silver are known to be present in tetrahedrite at Eagle Crag and elsewhere. Small specimens of native silver have been reported from supergene assemblages within the near-surface parts of veins at Force Crag and Red Gill on the Caldbeck Fells. The Force Crag Vein contains significant concentrations of manganese oxide minerals in its upper, supergene zone: a few tonnes of manganese ore are understood to have been mined here. Gangue minerals in these veins include abundant quartz, baryte, calcite, dolomite and locally siderite. Baryte is especially common in the upper parts of the Force Crag Vein, which was worked partly for this mineral. Fluorite is a minor constituent of several veins but is present in substantial amounts in veins at Brandlehow and Whitecombe Beck, Black Combe. Quartz pseudomorphs and epimorphs after baryte are common, suggesting that baryte was formerly a major constituent of these deposits.

Depositional temperatures in the range 110–130°C have been suggested. Metals may have been derived from rocks of the Skiddaw Group, the granitic batholith or from Carboniferous sediments in the adjoining Solway–Northumberland Trough by a process of convective leaching involving Carboniferous sea water. Sulphur isotope studies support derivation of sulphur from Carboniferous evaporites present at depth in north Cumbria. The Lake District lead–zinc veins are known to cut and thus postdate the copper-bearing veins, and a limited number of K-Ar determinations of altered vein wallrock has given ages of between 360 and 330 Ma. However, many aspects of the veins invite close comparison with those of the Northern Pennine Orefield and it is possible that the lead–zinc veins of the Lake District may be members of the same suite of veins as their Northern Pennine counterparts, but exposed at a deeper structural level within Lower Palaeozoic wall rocks. If so, a Late Carboniferous or Early Permian age of emplacement seems probable since this has been well established for the northern Pennines area. Evidence from boreholes in the Sellafield area suggests that lead–zinc mineralisation may be similar in age to the main phase of haematite mineralisation in west Cumbria, which is likely to be Permo-Triassic or later as discussed below.

Baryte veins

Baryte is a common gangue mineral in several of the lead–zinc veins but is present in unusually great abundance in several veins in the Caldbeck Fells, notably at Potts Gill, where it was an important commercial mineral. There, the baryte is accompanied only by quartz and manganese oxides with traces of sulphide minerals. These veins, and perhaps the baryte mineralisation at Force Crag, may represent a separate episode of baryte mineralisation, perhaps postdating the lead–zinc mineralisation.

Haematite veins

Although haematite is locally a constituent of a variety of veins within the Lake District, it is the dominant mineral within a distinctive suite of veins within the Lower Palaeozoic rocks. Notable formerly economic concentrations of haematite veins include those within Skiddaw Group rocks at the Knockmurton and Kelton Fell mines near Loweswater and within the Eskdale Granite in mines near Boot. Other less economically significant veins include those within Borrowdale Volcanic Group rocks at Ore Gap (NY 241 072), Grasmere (NY 341 098) and Deepdale (NY 390 150), and in the Ennerdale intrusion. Vein widths of up to 7 m were encountered at Kelton Fell. All of these veins are typically filled with haematite with very small amounts of quartz, dolomite or calcite comprising virtually the only gangue minerals. Haematite is usually present as the mammillated fibrous crystalline variety known as ‘kidney ore’, though compact, massive and crystalline forms (specular ore) are found locally. The characteristic form of the haematite and the almost monomineralic nature of the serves to link them genetically with the very large replacement bodies of haematite within the Carboniferous limestones of west and south Cumbria. Their origin and Permo-Triassic (or younger) age are considered below.

Gold

Although claimed from a number of locations within the Lake District, many of these reports must now be regarded as unreliable. Nevertheless, gold has been reliably recorded from a variety of deposits of different ages including the Carrock Fell tungsten deposit, from a gossan in the Black Combe area, in copper veins in the Coniston area, at Dale Head in the Vale of Newlands and in panned concentrates from various streams in the Cockermouth area. The name 'Goldscope Mine' (NY 226 185) in the Vale of Newlands is almost certainly a corruption of an old German name and appears to have no connection with the presence of gold. There is no evidence for any gold ever being recovered commercially from the Lake District.

Supergene mineralisation

Parts of the Lake District, particularly the Caldbeck Fells, are famous for the abundance, variety and beauty of supergene minerals within the near-surface parts of the veins. Whereas many of these are the products of weathering related to modern water-table levels, the presence of such minerals at depths well below the present oxidation zone may be the result of earlier supergene processes, perhaps as early as the Jurassic.

Bibliography

Bouch, J E, Naden, J, Shepherd, T J, McKervey, J A, Young, B, Benham, A J, and Sloane, H J. 2006. Direct evidence of fluid mixing in the formation of stratabound Pb-Zn-Ba-F mineralisation in the Alston Block, North Pennine Orefield (England). *Mineralium Deposita*, Vol. 41, 821–835.

Cooper, M P, and Stanley, C J. 1990. *Minerals of the English Lake District – Caldbeck Fells.* (London: British Museum, Natural History.)

Crowley, S F, Bottrell, S H, McCarthy, M D B, Ward, J, and Young, B. 1997 δ^{34}S of Lower Carboniferous anhydrite, Cumbria and its implications for barite mineralization in the northern Pennines. *Journal of the Geological Society of London*, Vol. 154, 597–600.

Fortey, N J, Ingham, J D, Skilton, B R H, Young, B, and Shepherd, T J. 1984. Antimony mineralisation at Wet Swine Gill, Caldbeck Fells, Cumbria. *Proceedings of the Yorkshire Geological Society*, Vol. 45, 59–65.

Ixer, R A, Stanley, C J, and Vaughan, D J. 1979. Cobalt-, nickel-, and iron-bearing sulpharsenides from the North of England. *Mineralogical Magazine*, Vol. 43, 389–395.

Ixer, R A, Young, B, and Stanley, C J. 1996. Bismuth-bearing assemblages from the Northern Pennine Orefield. *Mineralogical Magazine*, Vol. 60, 317–324.

Lowry, D, Boyce, A J, Pattrick, R A D, Fallick, A E, and Stanley, C J. 1991. A sulphur isotopic investigation of the potential sulphur sources for Palaeozoic-hosted vein mineralization in the English Lake District. *Journal of the Geological Society of London*, Vol. 148, 993–1004. 272

Millward, D, Beddoe-Stephens, B, and Young, B. 1999. Pre-Acadian copper mineralisation in the English Lake District. *Geological Magazine*, Vol. 136, 159–176.

Milodowski, A E, Gillespie, M R, Naden, J, Fortey, N J, Shepherd, T J, Pearce, J M, and Metcalfe, R.

1998. The petrology and paragenesis of fracture mineralization in the Sellafield area, west Cumbria. *Proceedings of the Yorkshire Geological Society*, Vol. 52, 215–241.

Shepherd, T J, and Goldring, D C. 1993. Cumbrian hematite deposits, northwest England. 419–443 in *Mineralization in the British Isles*. Patrick, R A D, and Polya, D (editors). (London: Chapman and Hall.)

Stanley, C J, and Vaughan, D J. 1982. Copper, lead, zinc and cobalt mineralization in the English Lake District: classification, conditions of formation and genesis. *Journal of the Geological Society of London*, Vol. 139, 569–579.

Vaughan, D J, and Ixer, R A. 1980. Studies of the sulphide mineralogy of north Pennine ores, and their contributions to genetic models. *Transactions of the Institution of Mining and Metallurgy*, Vol. 89, B99–100.

Young, B. 1985. The distribution of barytocalcite and alstonite in the Northern Pennine Orefield. *Proceedings of the Yorkshire Geological Society*, Vol. 45, 199–206.

Young, B. 1987. *Glossary of the minerals of the Lake District and adjoining areas*. (Newcastle upon Tyne: British Geological Survey.)

Young, B, Styles, M P, and Berridge, N G. 1985. Niccolite-magnetite mineralization from Upper Teesdale, North Pennines. *Mineralogical Magazine*, Vol. 49, 555–559.

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