Chapter 2 The Lake District

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Introduction

The Lake District GCR Mineralogy Block is taken to include the mountainous fell country of the central Lake District, together with the adjoining iron orefield of west and south Cumbria.

This is an area of remarkably varied geology (Figure 2.1). The area has a long history of geological research with a very extensive literature. Excellent summaries of the essential features of the geology, with extensive references to earlier work, include those by Moseley (1978), and the British Geological Survey (1992). The following very brief summary, which draws on this extensive literature, provides a framework for the description of the mineralogical sites.

Within the central Lake District fells occurs a thick three-fold subdivision of Ordovician and Silurian sedimentary and volcanic rocks. The oldest of these, the Skiddaw Group, comprises a complex succession of more than 5 km of generally poorly fossiliferous marine turbiditic mudstones, siltstoncs and greywackes which range in age from Tremadoc to Llanvirn. The Skiddaw Group rocks occupy a wide outcrop across the north central Lake District, including Skiddaw itself Blencathra and the Buttermere fells. Smaller outcrops of Skiddaw Group rocks occur in the south of the district, in the Black Combe area and in Furness. In the north of the Lake District the Skiddaw Group is overlain unconformably by the Eycott Volcanic Group, believed to be of Llandeilo to early Caradoc age. The succession comprises at least 3 km of tholeiitic volcanic rocks in which a variety of lavas and volcanic sediments occur. The Eycott Volcanic Group crops out on the Caldbeck Fells, on Eycott Hill and Binsey. In the central part of the Lake District, the Skiddaw Group is overlain unconformably by the Borrowdale Volcanic Group, also of possible Llandeilo to Caradoc age.

The sequence is at least 6 km thick and comprises a complex succession of dominantly subaerial, calc-alkaline lavas and volcaniclastic rocks. It is divisible into a lower, pre-caldera sequence composed dominantly of basalt, andesite and dacite sheets, and an upper probably intra-caldera sequence of ignimbrites and volcaniclastic rocks including a thin unit of marine mudstone known as the 'Holehouse Gill Formation'. Rocks of the Borrowdale Volcanic Group give rise to the spectacular mountain country of the central Lake District including the Sea Fells, the Coniston Fells, the Langdale Pikes, Helvellyn and the High Street ranges. Overlying the Borrowdale Volcanic Group rocks unconformably in the southern Lake District is a thick succession of mudstones, siltstones and sandstones, collectively known as the 'Windermere Group'. This comprises a succession, more than 8 km thick, which records a resumption of marine sedimentation during late Ordovician and early Silurian times.

Much of the central part of the Lake District is underlain by an extensive Upper Ordovician to Lower Devonian granitic batholith of which the exposed granites of Eskdale, Ennerdale, Skiddaw and Shap form part. Well-developed contact aureoles are seen around some of these intrusions, while at the Water Crag GCR site, greisenization has led to the development of quartz-topaz greisen and a remarkable quartz-andalusite rock. Major basic intrusions are restricted to the Carrock Fell and Haweswater complexes. In addition, a number of minor intrusion suites are present, spanning the range of compositions from ultrabasic to acidic.

The Ordovician rocks are overlain unconformably in the Penrith area by the Mell Fell Conglomerate, of probable Devonian age. This is in turn unconformably overlain by conglomerates of the Carboniferous Basement Beds. A thick succession of Carboniferous rocks follows and forms an almost continuous outcrop surrounding the Ordovician and Silurian rocks of the central Lake District. Marine limestones, locally with some contemporaneous lavas, make up the greater part of the lower Carboniferous sequence. They are succeeded upwards by rocks exhibiting increasingly deltaic influences with a significant elastic component, culminating in the predominantly non-marine sediments of the Coal Measures of the Cumbrian Coalfield.

These Palaeozoic rocks are unconformably overlain by a thick succession of sedimentary rocks of Permo-Triassic age. In west and south Cumbria the lowest members of the succession are breccias, known locally as 'brockram'. Similar breccias are present in east Cumbria although in much of this area an aeolian sandstone, the Penrith Sandstone, directly overlies the sub-Permo-Triassic surface. These deposits are overlain by mudstones and siltstones, locally with formerly economically important beds of anhydrite and gypsum, and these are in turn followed by the thick red sandstones and mudstones of the Sherwood Sandstone and Mercia Mudstone groups, known locally as the 'St Bees Sandstone Formation' and the 'Stanwix Shales Formation' respectively.

Within this broad geological framework there occurs a great diversity of rock types, some of which host a variety of mineral deposits, prominent amongst which are the metalliferous vein deposits of the central Lake District. Mineralized veins are numerous within the Skiddaw, Eycott Volcanic and Borrowdale Volcanic groups and the major intrusions, but are rare within the rocks of the Windermere Group. A close structural and genetic relationship between the form of the mainly concealed granitic batholith and the distribution of vein mineralization has been advocated (e.g. Dagger, 1977; Firman, 1978a; Stanley and Vaughan, 1982a). Veins appear to be concentrated above or close to ridges in the roof of the batholith, or to its north and south walls. This close correlation is consistent with the virtual absence of veins from the Windermere Group.

The origin of the mineralization has attracted research from an early date. Prominent works include those by Kendall (1884), Postlethwaite (1913), Eastwood (1921), Dewey and Eastwood (1925), Rastall (1942), Dunham (1952a), lneson and Mitchell (1974), Shepherd *et al.* (1976), Firman (1978a), Stanley (1979), Stanley and Vaughan (1980, 1982a), Lowry *et al.* (1991), and Millward *et al.* (1999). The geochemical atlas for the area (British Geological Survey, 1992) provides a useful descriptive and genetic summary of the main types of mineralization.

In the most widely accepted classification of Lake District mineralization, Stanley and Vaughan (1982a) recognized several mineralizing episodes. These range in age from early Devonian copper- and tungsten-bearing veins, through early Carboniferous lead-zinc mineralization, some barite emplacement in the late Carboniferous and the later formation of supergene assemblages, perhaps in part as early as the Jurassic. Millward *et al.* (1999) have presented evidence for the emplacement of at least some of the copper mineralization pre-dating the early Devonian regional cleavage-forming event, as for example at the Coniston Copper Mines, the Dale Head North and South Veins and the Seathwaite Copper Mines GCR sites, whilst the Birk Fell Hawse Mine GCR site exposes copper mineralization dominated by bornite of probable supergene origin. The major phases of mineralization are probably related to episodes of hydrothermal activity within the batholith. Studies of each of the major suites of mineralization have revealed evidence of different temperatures and fluid compositions for each episode. D.C. Cooper *et al.* (1988) have demonstrated that Skiddaw Group sedimentary rocks within the Crummock Water thermal aureole may have provided a source of ore metals in at least part of the area, as seen at the Long Comb GCR site. Isotopic studies by Lowry *et al.* (1991) have shown that sulphur in sulphides in the copper and lead-zinc suites was derived from Skiddaw Group rocks, whereas magmatic sulphur is a major component of the mineralization associated with the Lower Devonian Skiddaw and Shap granites. Carboniferous seawater or evaporites are probable sources of sulphur within much of the barite mineralization (Lowry *et al.,* 1991; Crowley *et al.,* 1997).

The hematite deposits of adjoining parts of west and south Cumbria have also been the focus of much research. Their formation has been the subject of investigation by numerous workers, including Kendall (1873–1875, 1881–1882, 1893, 1921), Smith (1924), and Trotter (1945). More recently Shepherd (1973), Rose and Dunham (1977), Evans and El-Nikhely (1982), Dunham (1984), Shepherd and Goldring (1993), and Rowe *et al.* (1998) have offered models for their genesis based in part upon geochemical, fluid-inclusion and palaeomagnetic studies. This mineralization is seen best at the Florence Mine and Nab Gill Mine GCR sites.

The area has had a long history as a producer of mineral products. The celebrated graphite deposit at the Seathwaite Graphite Mine GCR site, in Borrowdale, was worked by the Elizabethans and was productive for many years in the 18th and 19th centuries. The central Lake District was a major source of copper in Elizabethan times and again in the latter half of the 19th century. Lead and zinc were mined well into the 20th century, seen for example at the Eagle Crag and Force Crag Mine GCR sites. The northern Lake District includes Britain's only worked tungsten deposit outside of the Southwest England province, at the Carrock Mine–Brandy Gill GCR site, where the mineralization is related to the

intrusion of the Skiddaw Granite, and is probably related also to minor antimony mineralization at the Wet Swine Gill GCR site. Although never exploited commercially, further tungsten mineralization is present in the extreme west of the area, at the Buckbarrow Beck GCR site, associated with the Eskdale Granodiorite.

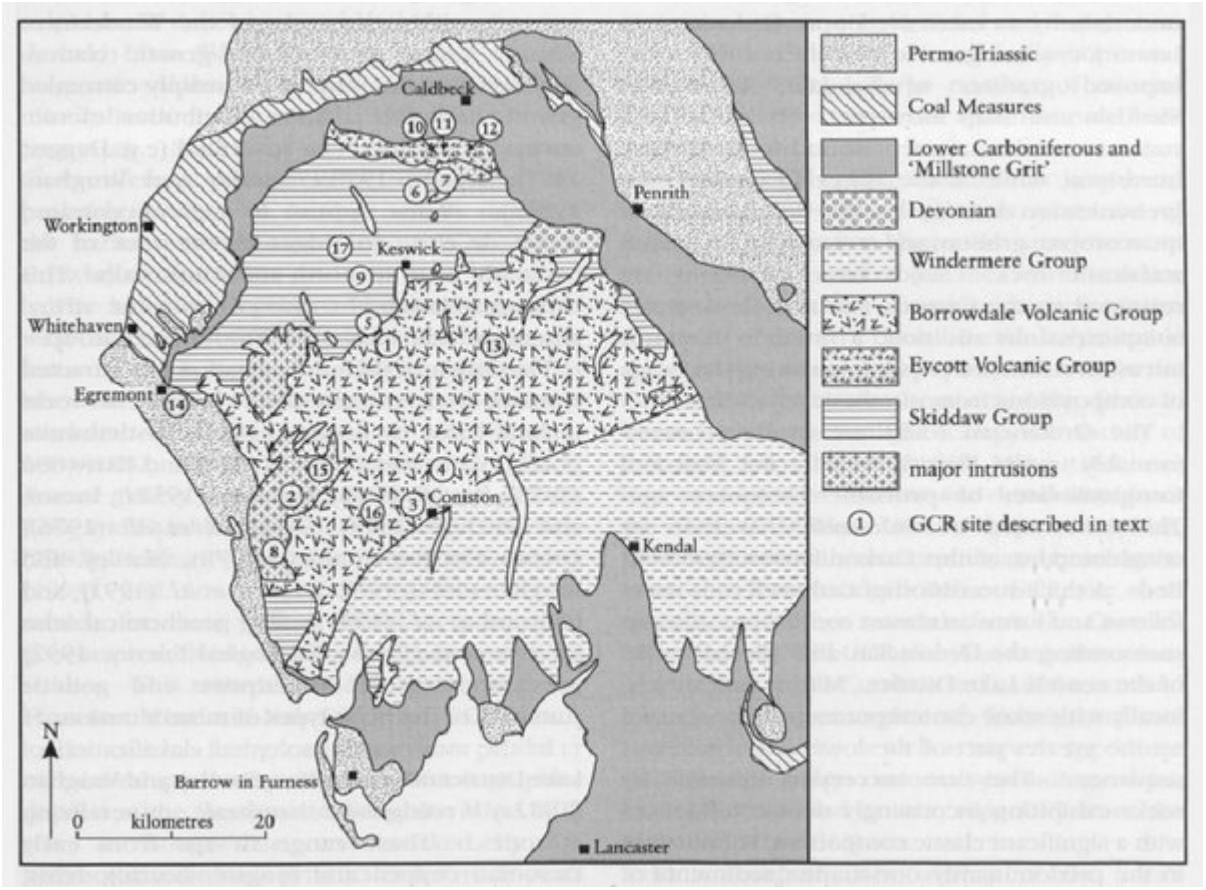
The area has also yielded a large tonnage of barite. The huge hematite deposits of west and south Cumbria provided many millions of tons of high-grade iron ore and formed the basis of the formerly important Cumbrian iron and steel industry. Small-scale extraction of hematite continued until 2007 at Florence Mine, near Egremont. Other mineral products, formerly worked on a small scale include ores of antimony, arsenic, cobalt, nickel and manganese.

In addition to these economically important mineral products, a large number of mineral species are known from the area, not only from worked deposits but from numerous other occurrences. The Lake District has long been well-known to mineralogists as a source of Important and often beautiful specimens of many minerals. Most of the world's major mineral collections contain representative examples of many of these. Particularly notable are examples of several species from sites in the Caldbeck Fells in the northern Lake District. These include the unique 'campylite' variety of mimetite from the Dry Gill Mine GCR site, fine examples of linarite and leadhillite from the Red Gill Mine GCR site, pyromorphite, plumbogummite, hemimorphite and brochantite from the Roughtongill Mine GCR site, and scheelite and other minerals from the Carrock Mine–Brandy Gill GCR site. The hematite mines of west and south Cumbria are world-renowned for spectacular examples of 'kidney ore' and 'specular' hematite as well as superb specimens of associated gangue minerals including calcite, barite, fluorite and quartz, especially from the Florence Mine GCR site.

In a comprehensive review of the area's minerals and their distribution, Young (1987a) noted that approximately half of the mineral species then known to be present within Great Britain are to be found within the Lake District. Cooper and Stanley (1990) have produced a detailed description of the minerals of the Calbeck Fells mines and illustrate striking examples of many of them.

Ryback *et al.* (2001) have shown that the late A.W.G. Kingsbury falsified the localities of numerous rare mineral species. It seems that from about 1951 he began to pass off classic foreign material from old collections as having been found by him at British localities, including many in the Lake District. Discredited reports of several species from Carrock Mine are discussed below. In addition to these, in their detailed investigation of parts of the Kingsbury collection, held at the Natural History Museum, London, Ryback *et* al. (2001) have demonstrated undoubted false claims of adamite from the Sandbed, Netherow Brow, Potts Gill and Wanthwaite mines; and plancheite from Driggith Mine. Although not yet investigated in detail, it seems likely that many other falsely labelled specimens await discovery in this collection. This is almost certainly so in the case of many, if not all, of Kingsbury's specimens of gold said to have been obtained from numerous Lake District locations. Serious doubt must therefore be attached to many of Kingsbury's claims, especially where these have not been duplicated or substantiated by more-recent collectors.

References



(Figure 2.1) Geological sketch map showing locations of GCR sites. 1 — Seathwaite Graphite Mine; 2 — Water Crag; 3 — Coniston Copper Mines; 4 — Birk Fell Hawse Mine; 5 — Dale Head North and South Veins; 6 — Wet Swine Gill; 7 — Carrock Mine–Brandy Gill; 8 — Buckbarrow Beck; 9 — Long Comb; 10 — Red Gill Mine; II — Roughtongill Mine; 12 — Dry Gill Mine; 13 — Eagle Crag; 14 — Florence Mine; 15 — Nab Gill Mine; 16 — Seathwaite Copper Mines; 17 — Force Crag Mine.