Seathwaite Graphite Mine, Cumbria

[NY 234 127]

Introduction

The long-abandoned mine at the Seathwaite Graphite Mine GCR site at the head of Borrowdale is perhaps one of Britain's most famous old mines. This deposit of remarkably pure graphite, which is associated with a dolerite intruded into the Borrowdale Volcanic Group, appears to lack any counterpart in Britain or elsewhere.

Mining for graphite at Seathwaite can be traced back several centuries and it is likely that Seathwaite was the world's first commercial producer of graphite. Over this period the mineral has been known by a variety of names including 'black cawke', 'wad', 'black lead' and 'plumbago'. It has found a variety of uses, ranging from the marking of sheep, as a rustproof coating of metal, and even as a medicine. It was principally employed, however, in the making of crucibles and moulds for metal casting and in pencil making, although this latter use appears to have come comparatively late in the mine's working life. It was the availability of Borrowdale graphite which gave rise to the important pencil-making industry at Keswick. The date of the discovery of the deposit is not known, although the first documentary evidence of graphite working here dates from 1540 (Tyler, 1995). The mine was worked vigorously by the Elizabethans, and working continued, although with some short periods of inactivity, until 1891 when the workings were finally abandoned. The history of graphite mining at Seathwaite has been outlined by Postlethwaite (1913), and more recently by Adams (1988), Bridge (1992), and Tyler (1995).

The uniqueness of the deposit has attracted geological and mineralogical attention from an early date. Some of the earliest geological references to this occurrence are those of Woodward (1729), and Phillips (1819, 1844). Other important descriptions include those of Ward (1876b), Goodchild (1882), Postlethwaite (1913), and Strahan *et al.* (1917). In addition to giving descriptions of the deposit Strens (1962, 1965), Weis *et al.* (1981), and Parnell (1981) have all offered explanations of its origin.

Description

Ward (1876b) referred to the occurrence of graphite within eight 'veins' and inclined 'pipes' up to 1–3 m in cross-section and from 2 m to over 100 m deep. These are shown on the mine plan and sections (Figure 2.2). They occur as part of a complex fracture-system in a doleritic intrusion within the tuffs and andesites of the Whorneyside Formation of the Ordovician Borrowdale Volcanic Group. Strens (1965) recorded that graphite mineralization is confined to a 400 m length of the vein system within the intrusion, and commented that the mine plans suggest that the richest concentrations occurred at the junction with the volcanic rocks.

Sirens (1965) noted considerable alteration of the dolerite which hosts the graphite mineralization. He recognized a zone of relatively high-temperature alteration distinguished by a biotite-chlorite-quartz-albite-magnetite assemblage within, and extending for some distance beyond, the 'zone' of graphite mineralization. Low-temperature alteration, with the development of hematite-chlorite-quartz-calcite-mica-orthoclase rock, extends for up to 2 km beyond the belt of high-temperature alteration. Sirens (1965) also drew attention to the presence of an extensive fault system parallel with the graphite vein system and carrying galena, chalcopyrite, sphalerite, quartz and hematite veins.

According to Strens (1965) the altered dolerite, or 'veinstone', consists of numerous graphite nodules, mainly from 1 mm to 5 cm in diameter, embedded in a buff-coloured matrix of mica, chlorite and quartz (Figure 2.3). Most of the graphite nodules exhibit rims of brown chlorite up to 0.5 mm across and contain numerous inclusions of dark-brown chlorite and mica. The presence of chlorite and mica inclusions in these nodules, the occurrence of graphitized dolerite, especially in parts of the upper workings, and the appearance of the rock in hand specimen, all indicate that the graphite has replaced the rock, and was not deposited as a fissure-filling. Some inclusion-free graphite nodules were interpreted by Strens (1965) as filling hollows formed by dissolution of the dolerite during the alteration process. Firman (1978a) noted graphite nodules up to 1 m in diameter. Representative specimens of Seathwaite graphite are present in many mineralogical collections. A fine set of samples, together with examples of its use in pencil making, can be seen in Keswick Museum.

Parts of the underground workings remain accessible and are commonly visited by mine explorers, although there are understood to be few good exposures of graphite mineralization. Good specimens of graphite-rich rock, including comparatively pure nodules, are abundant on many of the spoil heaps.

Interpretation

The Seathwaite graphite deposit is almost certainly unique amongst such deposits in that it is clearly not associated with either regional or thermal metamorphism of carbonaceous material. Graphite mineralization here is intimately associated with a doleritic intrusion. A genetic association is suggested by K-Ar dating of the intrusion and vein alteration at 382 Ma and 376 Ma respectively, by Mitchell and Ineson (1975), and by the absence of graphite in veins remote from the intrusion.

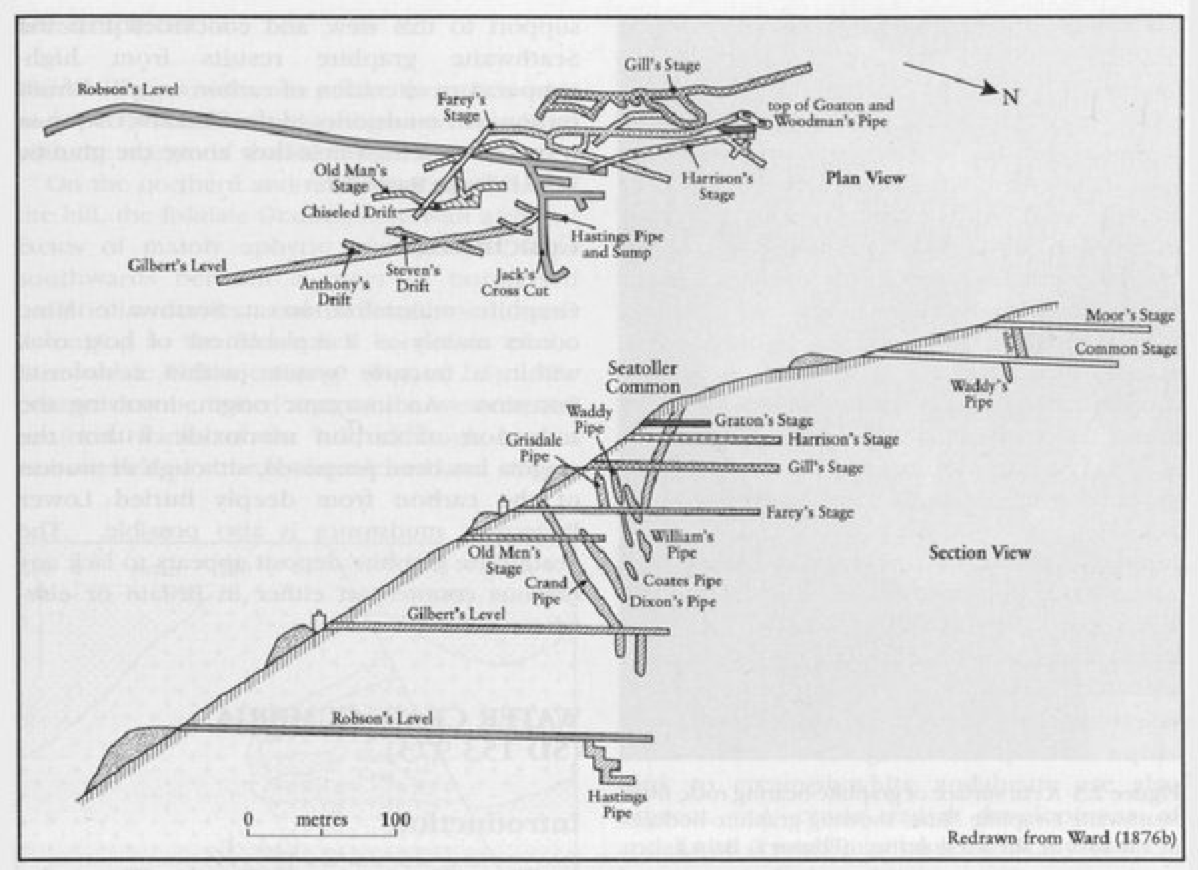
Early hypotheses on the origin of the graphite (e.g. Marr, 1916) suggested that mudstones of the Skiddaw Group, which underlie the Borrowdale Volcanic Group, could have been the source of the necessary carbon. This view was discounted by Sirens (1965), who advocated the reduction to elemental carbon of large volumes of carbon monoxide catalysed by pyrite, iron oxides, iron silicates and quartz at pressures of up to about 1000 bar and temperatures of between 400°C and 600°C. The common occurrence of pyrite or hematite replacing pyrite, and more rarely of cores of quartz, chlorite and mica, as cores to many of the graphite nodules was cited by Sirens (1965) in support of this theory.

Weis *et al.* (1981) presented isotopic evidence for the organic origin of the carbon within the Seathwaite deposit. Parnell (1981) provided support to this view, and concluded that the Seathwaite graphite results from high-temperature alteration of carbon expelled from carbon-rich mudstones in the Skiddaw Group in response to a high heat-flow above the granitic Lake District Batholith.

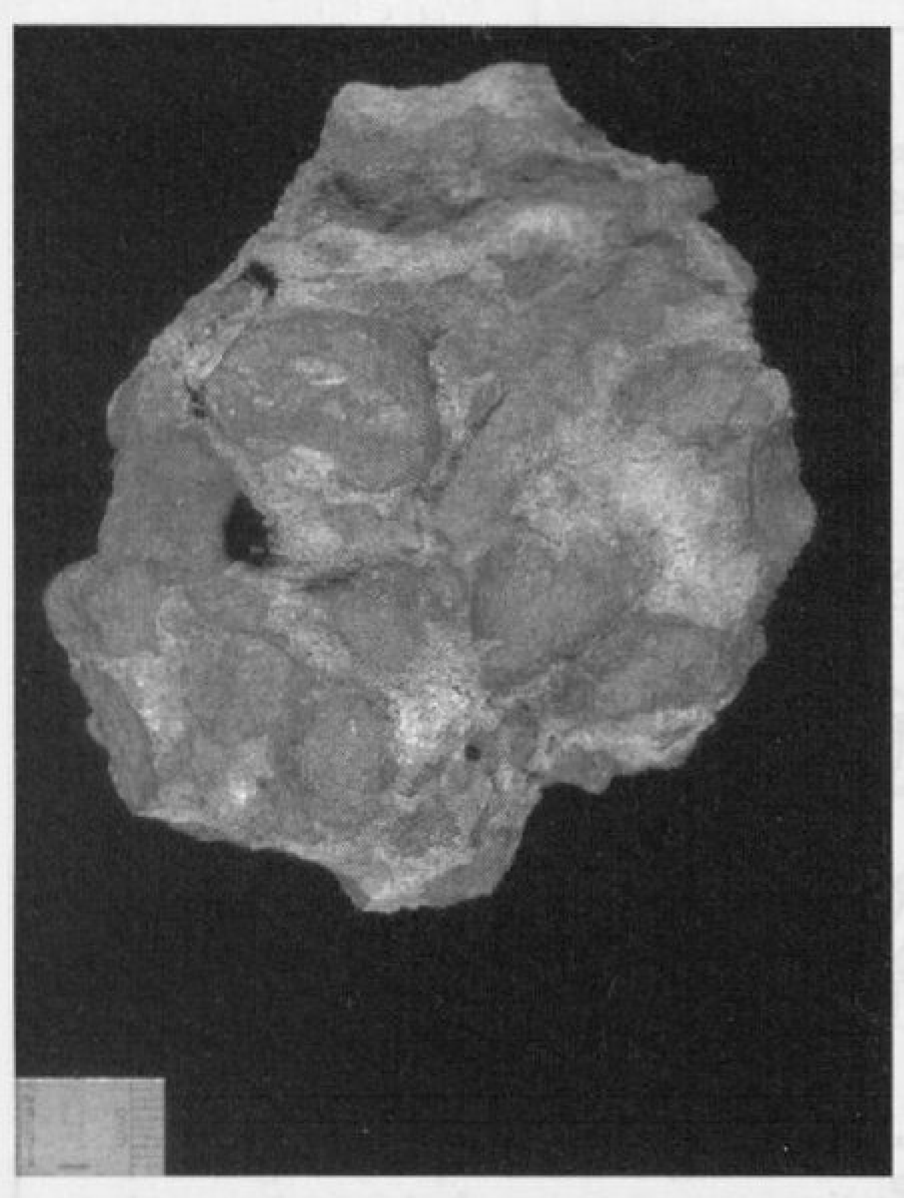
Conclusions

Graphite mineralization at Seathwaite Mine occurs mainly as a replacement of host rock within a fracture system within a dolerite intrusion. An inorganic origin, involving the reduction of carbon monoxide within the magma has been proposed, although derivation of the carbon from deeply burled Lower Palaeozoic mudstones is also possible. The Seathwaite graphite deposit appears to lack any obvious counterpart either in Britain or elsewhere.

References



(Figure 2.2) Plan and section of the workings at Seathwaite Graphite Mine. After Ward (1876b).



(Figure 2.3) A cut surface of graphite-bearing rock, from Seathwaite Graphite Mine, showing graphite nodules in a matrix of altered dolerite. (Photo: T. Bain.)