Bage Mine, Derbyshire

[SK 292 549]

Introduction

Bage Mine is a long-disused lead mine (see (Figure 4.16) for location map). Burr (1994) noted that deep mining at Bage ceased in 1907, but later attempts were made to work the mine at shallow depths. The mine is of international geological importance as the only British source of the very rare mineral matlockite (PbFCl), and is the type locality for that mineral (the type specimen is in the Natural History Museum, registered specimen BM89055). Phosgenite ($Pb_2CO_3Cl_2$) is also known from the mine, and was previously called 'cromfordite' on the basis of specimens from Bage Mine. The first sample of phosgenite, a relatively rare mineral worldwide, is believed to have been collected in approximately 1785 from 'the district of mines intended to be unwatered by the Cromford level' (Chenevix, 1801; Burr, 1992), although phosgenite had been collected previously elsewhere. The first confirmed discovery from Bage Mine was in 1851 (Greg, 1851), when some specimens of 'phosgenity and an unknown mineral' (matlockite) were found in the debris of an old mine shaft belonging to part of the Bage Mine and Cromford level workings. The main mineshaft to Bage Mine was re-opened in 1980, and some 2740 m of levels to a maximum depth of 115 m have been explored (Warriner, 1982). Only a few minute crystals of the rare minerals were found (not *in situ*), but as the exact site of the original discovery is unknown, a more thorough search and excavation, particularly of the lower levels of the mine, may reveal it. Surviving specimens in 19th century collections show some of the finest crystals known of these minerals.

Bage Mine lies on the eastern margin of the Dinantian, Carboniferous Limestone Supergroup, platform of Derbyshire, close to the contact with the overlying Namurian Millstone Grit Group; it also lies on the boundary between the barite and fluorite 'zones' of the Derbyshire ore-field (Dunham, 1952). At the time of the most recent published research on Bage Mine, the accessible workings of the mine and their surveys represented only a part of the original extent of Bage Mine (Burr, 1994). Most of the accessible workings now show barite veins, but little galena. There is little to be seen on the surface and the GCR interest is entirely underground.

Description

The present entrance to Bage Mine is the 92 m former main engine shaft, the Hard End Shaft, (see (Figure 4.17)) [SK 2915 5499] of the mine (Warriner, 1982), situated in the village of Bolehill on the western edge of Cromford Moor, 1.6 km south of Cromford and 1.6 km south-east of Middleton-by-Wirksworth (Burr, 1992) (see (Figure 4.16) for location map). The mine consists of workings on three levels: the 58-m, 72-m and 92-m levels. The presently accessible workings trend in a generally north–south direction, extending about 1 km towards Cromford. Workings associated with the 58-m levels were apparently active as early as 1752.

The mine levels were driven entirely in the Visean Eyam Limestone and Monsal Dale Limestone formations, and in the 72-m and 92-m levels the courses of intercepted natural watercourses were adopted where suitable. The limestones vary from a white crinoidal limestone to a hard buff-coloured limestone with discontinuous bands of black chert. Solution cavities in the limestone contain scalenohedral crystals of calcite, varying in size up to 30 cm long (Jones, 1982). Most of the workings were in the Butler, Bage and Wallclose veins (Warriner, 1982). Warriner (1982) described the re-opening of Bage Mine using the former main engine shaft, Hard End Shaft [SK 2915 5499], for an exploration of the mine down to a maximum final depth of 115 m.

Burr (1992), and Bridges and Smith (1983) provide full accounts of the occurrence of phosgenite ('cromfordite) and matlockite in the Bage Mine area. The term 'cromfordite' was introduced as a mineral name for phosgenite after it had already been described elsewhere (Warriner, 1982). Historical research suggests that phosgenite was the first mineral to be discovered at Bage Mine, probably around 1785 (Chenevix, 1801; Burr, 1992, 1994), from workings connected to Cromford Sough. At this time it appears that a local 'petrifactioner' collected specimens, most probably including phosgenite, for Sir Charles Greville, whose mineral collection was acquired by the Government on his death and is now a part of the Natural History Museum collections. The first chemical analysis of phosgenite was undertaken by Chenevix (1801), who described it as a lead chloro-carbonate, although its precise formula was not determined (Burr, 1992). Mawe's 'Mineralogy of Derbyshire' (Mawe, 1802) described a sample of what was probably phosgenite incorrectly as 'muriate of lead in perfect crystals of a beautiful transparent yellow colour'; a source location for this mineral was not given.

Matlockite was first discovered in 1851 by Bryce Wright in 'the debris of an old shaft belonging to the old Bage Mine and Cromford level workings' (Greg, 1851; Burr, 1992). Although the initial analysis suggested that it was a lead oxychloride (Greg, 1851), it is a lead fluoro-chloride. Later in 1851, Bryce Wright found samples containing both phosgenite and matlockite underground in 'one of the old shafts' of Bage Mine (Greg 1851; Burr, 1992, 1994). Rieuwerts (1982) used old mining records to trace the likely source of these rare minerals. A branch of Cromford Sough at approximately 92 m depth below Bage Mine was driven south along Wallclose Vein between 1777 and 1800, reaching its intersection with Butler Vein in about 1800, 34 m below the presently accessible workings on the 58-m level (Jones, 1982). The Bage branch of Cromford Sough was not driven until the 1807–1826 period and therefore did not exist at the time of the first discovery in the area of phosgenite in 1785. The original site of the discovery is therefore likely to have been in workings on Wallclose Vein (or associated sub-parallel- or cross-veins) near the junction with Butler Vein, and just below the level of Cromford Sough (Rieuwerts, 1982; Burr, 1992).

The samples of phosgenite and matlockite from Bage Mine are most characteristically associated with galena, barite and fluorite, with lesser amounts of cerussite, sphalerite, marcasite and/or pyrite present (Burr, 1992). Bannister (1934) found that in addition to galena and barite the specimens were also associated with anglesite, which is identical to the occurrence of matlockite crystals from Arizona (Abdul-Samad *et al.,* 1982). Some samples also how both matlockite and phosgenite separately enclosing crystals of clear fluorite. There are only a few samples of phosgenite and matlockite in direct association (Burr, 1992).

Jones (1982) described the veins present at Bage Mine. The Butler Vein courses approximately north–south, while Bage Vein courses north-west–south-east and is intersected by a number of smaller east–west veins and scrins. The Wallclose Vein crosses the Butler and Bage veins on a WNW–ESE orientation.

The workings on the lowest, 92-m level, south of the main shaft, are thought to be on Butler Vein. The vein here is rich in sphalerite but poor in galena. This is in contrast to most of the upper two levels of the mine, where galena is the dominant ore mineral and most primary sphalerite has been oxidized and undergone replacement to hemimorphite (Jones, 1982). At places within the Butler Vein, shales, possibly from the overlying Bowland Shale Formation, have been incorporated into the vein, which has formed a loose breccia with barite.

In the 58-m level the veins are poorly exposed, although there is one good exposure of the Bage Vein close to the entrance shaft. The vein here is 110 mm thick and consists of an outer 1 mm layer of calcite, a 3 mm barite string which contains some galena, followed by 20 mm intermixed barite and fluorite which contains most galena, and at the centre of the vein, calcite up to 50 mm thick which is barren of ore. At its northern extremity, Bage Vein splits into numerous 20 mm-wide scrins, most of which contain galena.

Barite is the main ore-bearing mineral in the mine, and it usually has a vuggy texture which accommodated the precipitation of galena, sphalerite and small clusters of white cockscomb crystals associated with small transparent cubic fluorite crystals. Other minerals found in the mine include hemimorphite, which occurs in crusts of brown sheaf-like crystal aggregates in barite, anglesite and malachite. Selenite and hydrozincite have been identified as secondary minerals that have formed since the cessation of mining (Jones, 1982). Selenite commonly forms stellate groups of lustrous transparent crystals, up to 30 mm long, encrusting the sides and roofs of the passages, particularly where shale is present in the higher parts of the 58-m level. A pale-green form of hydrozincite, an oxidation product of sphalerite, is located in the 92-m level. This mineral usually forms pure-white crystals, but in this case impurities of copper have altered its colour.

Interpretation

Bage Mine is in most aspects an example, of a typical South Pennine Orefield mineral deposit. However, it is the presence of the rare minerals matlockite and phosgenite which makes the mine of considerable interest. The study of formation of these minerals is significantly hampered by the absence of any currently accessible in-situ deposits and the vagueness of the descriptions of minerals collected in the 18th and 19th centuries. Most of the existing research has therefore focused on the mineralogy and attempting to locate the most likely sources of the minerals within the mines.

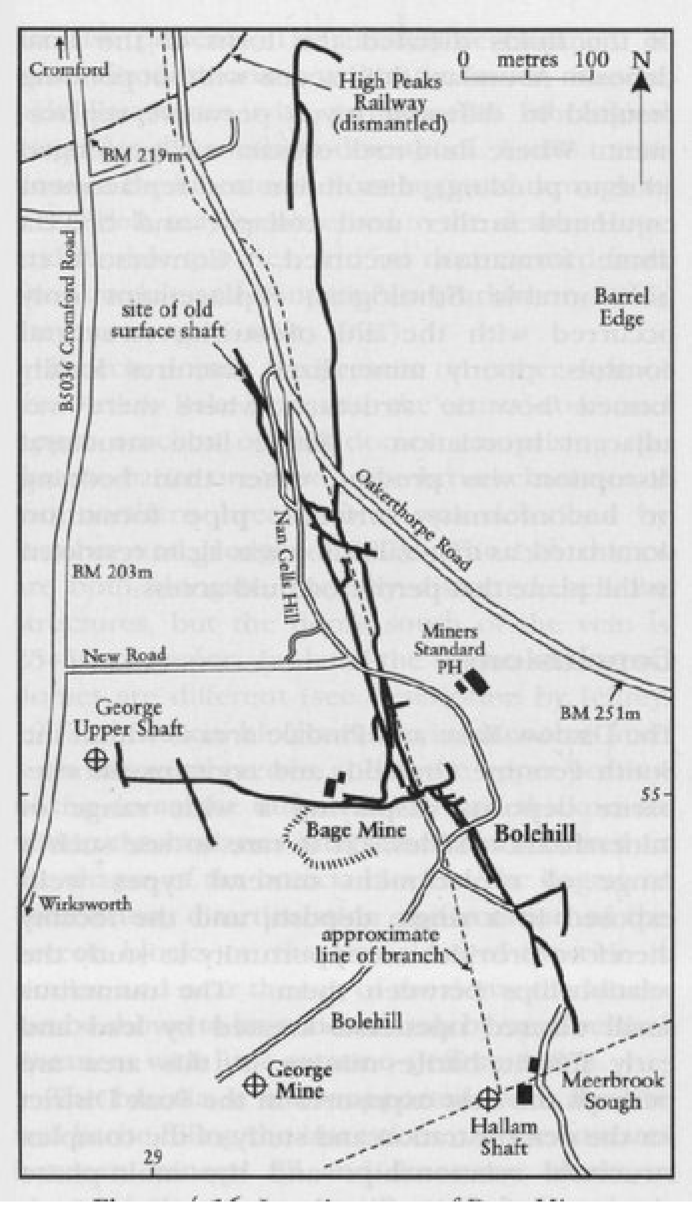
Burr (1992) determined that the likely source of the matlockite and phosgenite is on the Wallclose Vein close to the junction with the Butler Vein in the north of Bage Mine. Although this general area of the mine is now accessible, all of the workings below the level of Cromford Sough are now flooded. Investigations of the accessible mines in this area have yet to find any in-situ matlockite or phosgenite. During explorations in 1981 a small single specimen of phosgenite was found in an old 'kibble' or tub, high up in a stope above the 58-m level (Jones, 1982). The crystal was found within small cavities in a sample of galena which also contained anglesite. No other samples of phosgenite, matlockite or anglesite were found in the upper area of the mine adjacent to this location (Jones, 1982). Burr (1992) believes that, as most of the original specimens from Bage Mine are associated with small amounts of marcasite and pyrite, they are most likely to have been sourced from the less-oxidized, lower, parts of the mine. However, two of the Bage Mine specimens of matlockite, and phosgenite have matrices of galena which exhibit smooth water-worn faces coated with layers of grey-white cerussite (Burr, 1992). This suggests that they could have come from the upper 58-m and 72-m level workings, which Jones (1982) identified as being driven partly along natural karstic water-courses.

The Bage Mine deposits lie at the boundary between the barite and fluorite zones of the ore-field, close to the boundary with the overlying shales. It is not evident how this may have contributed to the formation of phosgenite or matlockite.

Conclusions

The present evidence suggests that the rare minerals matlockite and phosgenite occur at Bage Mine, although no current in-situ deposits are known. However, Bage Mine is the recognized type locality for matlockite, with the type specimen preserved in the Natural History Museum. Burr (1992) concluded that the locality where phosgenite and matlockite were originally collected in the Bage Mine was in a part of the Wallclose Vein (or associated sub-parallel- or cross-veins), probably near its junction with the Butler Vein and just below the level of Cromford Sough. The possibility of these minerals having been found in the higher mine-workings, however, cannot be discounted. Continued exploration of the mines may well result in the discovery of further examples of matlockite and phosgenite. The mode of formation of the minerals has not been determined.

References



(Figure 4.16) Location map of Bage Mine.

(Figure 4.17) Bage Mine entrance (at the former main engine shaft). (Photo: M.L. White.)