Pike Law Mines, Durham

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Introduction

The Pike Law Mines GCR site comprises a closely spaced group of workings on a complex of veins which crop out over approximately 2 km^2 on the ridge known as 'Pike Law' on the north side of Teesdale. The site includes one of the densest concentrations of mineralization within the Northern Pennine Orefield, and is one of the finest surface localities in the orefield at which vein and associated replacement mineralization, together with supergene alteration features, may he studied. Details of the geology have been given by Dunham (1990), and more recently Bridges and Young (2007) have reviewed the mineralization in some detail.

The courses of several of the veins can be clearly traced through a series of deep opencast workings, commonly referred to as 'hushes', on either side of the Newbiggin to Westgate Hill road. Numerous nearby circular spoil mounds mark old underground workings on parts of the vein complex.

The date of the earliest working here is not known, although Dunham (1990) has suggested that the deposits may have been discovered and worked in ancient times. The oldest documentary records of working relate to mining between 1852 and 1891, by which time, according to Dunham (1990), the deposits were almost certainly nearing exhaustion. No further mining is known after 1891.

Description

Pike Law, the ridge that lies between Wester Beck and Flushiemere Beck, is composed of a cyclothemic sequence which comprises mainly limestones, sandstones and mudstones, belonging to the Alston and Stainmore groups of the local Carboniferous succession. Strata from the Four Fathom Limestone up to beds above the Firestone Sill sandstone crop out here. Particularly prominent is the wide outcrop of the Great Limestone, a grey bioclastic limestone approximately 19 m thick of Namurian age, which comprises the uppermost unit of the Alston Group. These Carboniferous rocks are cut by a remarkable concentration of mineralized veins which occupy normal faults which trend between east-west and northeast-south-west (Figure 3.11). Whereas Dunham (1990) noted a vertical displacement of up to 15 m on the Pike Law Old Vein, the amount of displacement on most of the other veins cannot be reliably determined, although, in common with similar veins elsewhere in the orefield, displacements are unlikely to exceed 5 m. Minor folding, both parallel and oblique to the trend of the veins, with dips locally reaching 30°, has been described by Dunham (1990).

The mineralized veins of the Alston Block occupy a remarkable pattern of conjugate fractures in which three principal trends may be discerned. The majority of the formerly most productive lead-bearing veins trend between north-east-south-west and ENE–WSW. Cutting these veins locally are several NW–SE-trending 'cross-veins'. These are also normal faults, although they typically exhibit larger throws, commonly over 10 m. Over much of the ore-field, these 'cross veins' are usually barren or only weakly mineralized. A third group of veins, with a predominantly east-west to WNW–ESE orientation, the so called 'Quarter Point' veins, intersects both of these trends. The Quarter Point veins typically occupy faults with a sinistral transcurrent displacement, and, although they are often strongly mineralized, usually carry low sulphide concentrations. Many of the largest and most valuable fluorite orebodies of the orefleld occur within Quarter Point structures.

The Pike Law vein complex includes fissures belonging to the first two vein orientations with a few roughly E–W-orientated veins perhaps representing an expression of the Quarter Point orientation.

So far as can be established from the remaining remnants of vein outcrops, the Pike Law veins, which rarely exceed 1 m in width, typically carry galena in a matrix of fluorite with smaller amounts of quartz. Limonitic pseudomorphs of supergene origin attest to the former abundance in the veins of an original iron carbonate mineral, either siderite or

ankerite, or both. Neither fresh ankerite nor siderite has been seen at Pike Law. A common feature of the mineralization of the Alston Block is the widespread occurrence of extensive metasomatic replacement of limestone wall-rocks by introduced minerals adjacent to many veins. Such alteration, forming so-called 'flat' deposits, is particularly conspicuous here at Pike Law where the Great Limestone has been intensely mineralized for several metres adjacent to most veins. Ankerite and/or siderite were clearly the most abundant introduced minerals in this wall-rock, although as in the veins, supergene alteration has left only limonitic pseudomorphs after the primary carbonate minerals. Much of the original limestone is seen today as massive, brown-weathering limonitic ironstone in which remnants of ankerite or siderite rhombs are commonly recognizable. Numerous cavities in the ironstone are lined with curved, saddle-shaped rhombic pseudomorphs after ankerite or siderite, well-formed cubes of fluorite, galena, quartz, and locally a little aragonite.

The Pike Law deposits lie within the fluorite zone of mineralization, although close to its margin with the outer barium zone. Traces of barite reported from the horizon of the Firestone Sill (Dunham, 1990) may provide evidence of an upward passage into the barium zone which has been removed by erosion here at Pike Law. A lateral passage into the barium-rich zone, in which both barite and witherite are present, is indicated by the presence of these as the principale gangue minerals in the veins worked at the Flushiemere mines about 0.5 km east of Pike Law.

Although the solid geology is concealed beneath a substantial mantle of glacial deposits west of Pike Law, there is little evidence for intense mineralization persisting far west of Wester Beck. The Pike Law vein complex appears to terminate eastwards against the NW–SE-trending Flushiemere Great Vein structure.

The veins and associated 'flat' deposits at Pike Law have been worked on a spectacular scale from the complex of opencast excavations and 'hushes', including West End Hushes, Leonard's Hush, Pike Law Hush and Flask Hushes, that scar the bench-like outcrop of the Great Limestone on either side of the Newbiggin to Westgate Hill road. Parts of these old workings provide fine sections through both the veins and the highly mineralized limestone wall-rock. In addition, numerous heaps of mine spoil contain an abundance of richly mineralized rock and veinstone. Good examples of all the constituent primary, or hypogene, minerals are easily seen. Fluorite is locally abundant, commonly in well-formed interpenetrant twinned crystals. Like much of this mineral in the Northern Pennines, purple is the commonest colour at Pike Law, although yellow crystals are also present, a feature consistent with Dunham's (1990) observation that this colour tends to be prominent in the outermost parts of the fluorite zone. Coarsely crystalline galena is common, in places exhibiting euhedral crystal faces in cavities.

'Hushing' is a term applied to an early form of hydraulic mining or prospecting in which rock and veinstone are claimed to have been excavated by the repeated release of huge torrents of water from specially constructed reservoirs higher up the hillside. The resulting gullies, or 'hushes', some of which are very large, are common features in the Northern Pennine lead mining landscape. However, it is clear that the largest of these features could not have been created solely by this method. It is now thought more likely that in most instances manual excavation of rock and veinstone were periodically aided by the 'flushing' of the excavation with water released from hushing reservoirs. The comparatively modest size of the hushing dams and reservoirs remaining at Pike Law indicate that these would have been quite unable to deliver sufficient water to create the associated hushes, but perfectly adequate to have flushed loose material from the floors of the workings.

The site is also of importance for the abundance of supergene minerals typical of vein and replacement orebodies of this type. Supergene alteration of primary ankerite and/or siderite has yielded huge quantities of goethite, mainly present as earthy limonitic ironstone replacing original limestone, as well as in altered veinstone. Saddle-shaped goethite pseudomorphs are abundant in cavities in both the veins and the ironstone, and small crusts of mammillated crystalline goethite are seen locally. Although fresh galena is common, cerussite and anglesite are common in the highly oxidized limonitized limestone. The former occurs both as compact crystalline masses and also as acicular white 'jack straw' crystals. A feature of the site is the presence of well-crystallized anglesite as white crystals up to 20 mm long (Bridges and Young, 2007). Supergene oxidation of galena has also produced small yellowish-grey powdery masses of bindheimite, indicating the presence of small quantities of antimony in the primary galena (Bridges and Young, 1998). The presence of zinc within the deposits is revealed by the local occurrence of hemimorphite as crusts of tiny colourless radiating crystals, and of smaller amounts of smithsonite as tiny globular crystalline masses and cellular 'dry bone' aggregates (Bridges and Young, 2007). The apparent absence of sphalerite suggests that supergene alteration of zinc

has been complete at the levels of exposure seen at this locality. Further evidence for the intensity of supergene alteration is provided by the presence of fluorite cubes showing deeply etched faces, a feature noted elsewhere in the orefield by Dunham (1990).

Interpretation

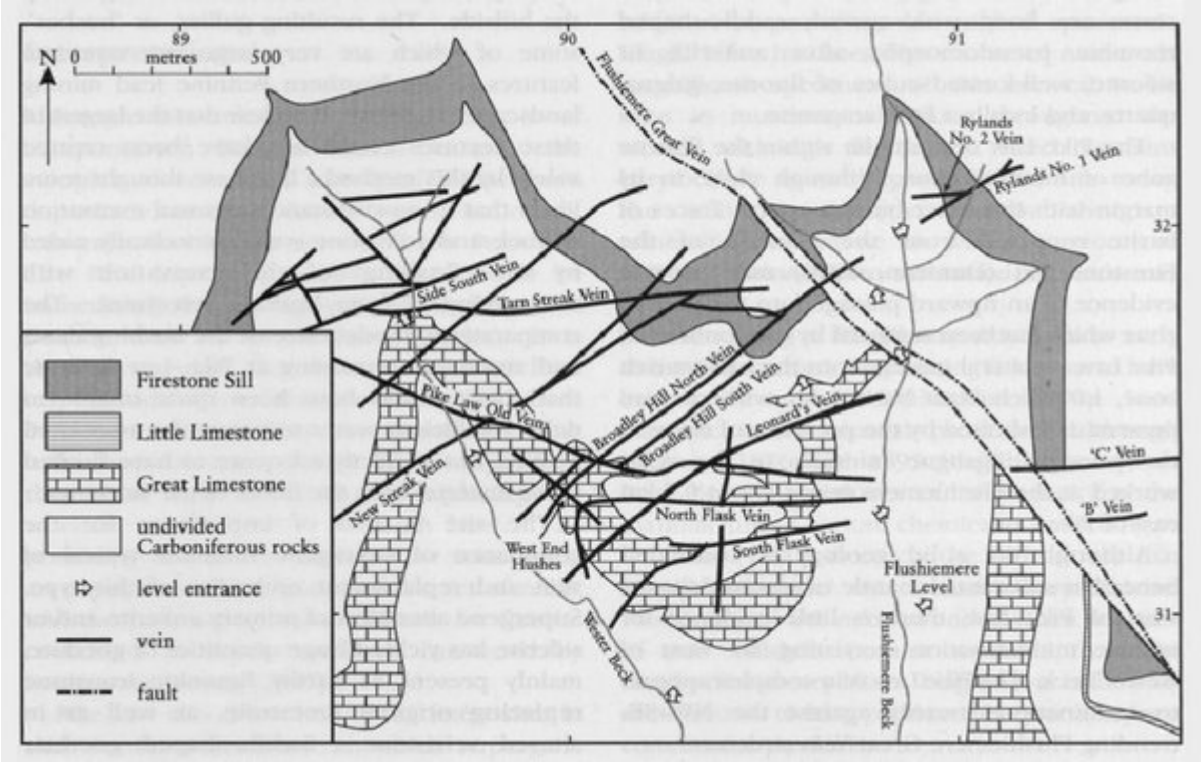
Although mineralization at Pike Law is of comparatively limited lateral extent, the complex of veins and associated replacement deposits is one of the densest concentrations of mineralization known in the Alston Pennines. The Pike Law vein complex appears to lie immediately above a high point on the Weardale Granite close to its southern margin. It is therefore possible that the mineralization here may coincide with an emantive centre of Northern Pennine mineralization, a possibility that influenced Dunham (1990) in his suggestion that there may be merit in exploring for workable mineralization at depth here. The possibility of some of the Pike Law veins being an expression of the Quarter Point set of veins, and the potential of these as hosts for fluorite orebodies at depth has been canvassed by Bridges and Young (2007).

Pike Law also offers one of the finest sites in the Northern Pennines at which supergene alteration of vein and associated replacement mineralization may be examined, both in *situ,* and in adundant mine spoil. Bridges and Young (2007) have proposed a multi-stage development of supergene mineralization here. An early stage of oxidation of ankerite and/or siderite by meteoric water produced porous 'limonite', perhaps accompanied by the formation of some cerussite, which was then followed by oxidation of galena to anglesite.

Conclusions

Pike Law is an important site at which a dense concentration of mineralized veins and associated replacement deposits, showing also the effects of supergene alteration of these, may be examined both in *situ* and in abundant mine spoil.

References



(Figure 3.11) Geological map of Pike Law Mines. Courtesy of British Geological Survey.