# Masson Hill Mines, Derbyshire

[SK 290 587]

## Introduction

The mines and caverns at the Masson Hill Mines GCR site (see (Figure 4.13)), belonging to the South Pennine Orefield, are located around a complex anticline structure (over 2 km in length), which comprises interlayered limestones (part of which are dolomitized) and basaltic lava sheets ('toadstone'), folded over a volcanic vent (Ford, 2002). The majority of the mineralization is in the Monsal Dale Limestone Formation and in particular, in the lowest limestones of this group (formerly the 'Lower Matlock Limestone'), although there is a limited amount of mineralization in the overlying Eyam Limestone Formation (formerly 'Cawdor Limestone'). Two main lava-flows, the Lower Matlock Lava Member and the Upper Matlock Lava Member (also of the Monsal Dale Limestone Formation), extended from the volcanic vent, and these can be seen in the entrance passage to Rutland Cavern (Ford, 2002). The mineralization takes the form of rakes, pipes, flats and scrins (Warriner *et al.,* 1981), and contains fluorite, barite, calcite, bravoite, pyrite, marcasite, chalcopyrite, sphalerite and galena (Ixer, 1974). Mining for lead has taken place at Masson Hill since Roman times, and has largely focused on working a series of pipe-veins along an east–west axis across the summit of Masson I Iill, within the 'Lower Matlock Limestone' (Ford, 1967a). Significant fluorite flats have been worked both underground on the cast slope of Masson Hill, and in large opencuts on the summit of Masson Hill. The fluorite body lies in the basal 'Lower Matlock Limestone' immediately above the Lower Matlock Lava Member (Lower Toadstone unit) (Sylvester-Bradley and Ford, 1968; her, 1978b), and trends north-west-south-east along the strike of the limestone (Ford, 1967a).

## Description

Ford (2001) reviewed the mines of the Matlock area, including Masson Hill, placing them into an overall context and providing many photographs of underground and surface workings. The geological sequence related to the mineralization at Masson Hill consists of the Lower Matlock Lava Member (78 m), intervening Monsal Dale Limestone (36 m) the Upper Matlock Lava Member (21.5 m), the upper part of the Monsal Dale Limestone, and the Eyam Limestone Formation (formerly 'Cawdor Limestone') (Ixer, 1975, 1978b; Warriner *et al.,* 1981). The mineralization is restricted to two horizons, the Monsal Dale Limestone between the two lava horizons and the Eyam Limestone Formation, with the former being the most significant (Warriner *et al.,* 1981). The Monsal Dale Limestone contains four 'wayboards' (volcanic clay horizons or bentonites) up to 0.3 m thick; between wayboards 1 and 2 in the southern area of the Masson Hill Flat lies the Little Toadstone (0.80 m), which is also a volcanic clay horizon. Dolomitization is sporadic throughout the limestone and decreases towards the north-west where it is absent (Ixer, 1978b). In the opencast quarry and along the 'main rake' dolomitization is extensive, and only the basal 5.5 m of the Monsal Dale Limestone, lying above the Lower Matlock Lava Member, remains undolomitized. The boundary between the limestone and dolomite coincides with the Little Toadstone in the southern area of the Masson Hill Mine flats and at the equivalent stratigraphical level in the opencast quarry (Ixer, 1978b).

The limestones of the Monsal Dale Limestone Formation vary from fine-grained and porcellanous to coarse-grained and bioclastic. Jointing is poor in the limestone in relation to the overlying dolomites. The junction between the, limestone and the dolomite is very sharp, with the change from pure limestone to pure dolomite typically occurring within 15 mm (Ixer, 1978b). This sharp change is also observed immediately above wayboards 2–4, where the amount of dolomitization is substantially reduced in a zone of up to 0.5 m away from them.

The Lower Matlock Lava Member is a dark-green calcitized, chloritized, amygdaloidal olivine-basalt, the top portion (0.5 m) of which has been weathered to a grey clay with red or brown streaks and mottling (Ixer, 1975; Warriner *et al.,* 1981). X-ray diffraction analysis has shown the clay to be a mixture of kaolinite, mixed illite-montmorillonite and mixed chlorite-montmorillonite (Ixer, 1975).

Ixer (1975) provided a detailed examination of the sedimentary and volcanic rock succession of the Masson Hill ore deposit area. Bedding dips at between 20° and 25° towards the northeast, and with the angle of slope greater than this dip the youngest units are exposed to the east, at the bottom of Masson Hill (Ford, 1967a). The main Masson Hill Fault Zone trends northwest-south-east, and the faults are downthrown to the south-west with typical throws of less than 10 m. These faults are filled with clay-gouge, probably sourced from the altered basalts and wayboards, which has made them effectively impermeable barriers (Ixer, 1978b). Both the mineralized and the barren joints occur as a conjugate set, trending north-west-south-east and north-east-south-west. The master joints (314°) trend parallel to the main Masson Hill Fault Zone, with the subordinate joints trending 049°.

The orebody consists of a series of intermittent flats and pipes along a 2 km transect parallel to the Masson Hill Fault. The largest pipe is in Masson opencast quarry (largely extracted), which is 500 m long, and 240 m wide. The main orebody is in the basal 6 m of undolomitized limestone of the Monsal Dale Limestone Formation (Ixer, 1978b), where extensive flats have developed. The flats possibly represent the metasomatic alteration of limestone during mineralization, and the infilling of palaeokarstic channels and cavities (Ford and Worley, 1977; Ixer, 1978b). The bulk mineralogy of the main ore was determined by Ixer (1978b) and consists of 60% fluorite, 20% quartz, 15% calcite, and less than 5% barite. The main sulphide minerals present are bravoite, pyrite, marcasite, chalcopyrite, sphalerite and galena. There is also a wide range of secondary ore minerals in the oxidation zone of the deposit, including smithsonite, rosasite, hemimorphite, cerussite and cinnabar (Ford, 1967a). A detailed description of mineralogy and paragenesis of the fluorite flat at Masson Hill is provided in Ixer (1974).

Post-mineralization karstification at Masson Hill occurred by solutional enlargement of voids left by the hydrothermal fluids, and these then acted as pathways for groundwater movement. This phase is thought to have initiated during late Tertiary or early Pleistocene times when incision of the Derwent Gorge commenced and the necessary hydraulic gradients became established (Ford and Worley, 1977). Some of these solution features were infilled with sediments of both surface inwashed glacial clays and sands, and also galena and fluorite from the orebodies. Noel *et al.* (1984) measured the palaeomagnetism of the glacial sediments in Old Jant Mine, at Masson Hill and determined that the earliest sediments may date from the Brunhes/Matuyama reversal event of 730 000 years ago.

## Interpretation

The fluorite mineralization at Masson Hill represents the eastern extent of a pyritic-fluoritic zone that characterizes the south-eastern region of the South Pennine Orefield (Sylvester-Bradley and Ford, 1968). The mineralization is largely hosted within the Monsal Dale Limestone Formation of Lower Carboniferous age. The location and extent of the ore deposit is controlled by the distribution of replaceable limestone, dolomites, basaltic lavas and ash bands ('wayboards') which controlled the lateral movement of the ore fluids, whilst the faulting and jointing controlled vertical migrations (Ixer, 1978b). The major orebodies are in the coarse-grained limestone at the base of the Monsal Dale Limestone Formation, where the mineralizing fluids were trapped above the thick, impermeable, Lower Matlock Lava Member, and below the 'Little Toadstone' wayboard. The clay-sealed faults of the Masson Hill Fault Zone prevented the mineralizing fluids from migrating further up-dip. The mineralization of the dolomites is largely in the form of porosity infilling, reflecting the increased porosity resulting from the dolomitization. The ore was probably emplaced as a result of both metasomatic replacement and infilling of pre-mineralization karstic solution features (Ixer, 1978b). The mode of occurrence and the mineralogy is consistent with a low-temperature hydrothermal origin. The texture is consistent with a single long-term primary mineralization followed by extensive oxidation by meteoric waters (Ixer, 1974).

As most of the boundaries between the limestone and dolomites are parallel or sub-parallel to the bedding, it is likely that the intensity of the dolomitization reflects the primary texture or chemistry of the original limestone beds (Ixer, 1978b). The cause of the dolomitization has been speculated as being derived from the downward circulation of brines associated with the Permian Zechstein Sea (Ford, 1967a). However, Weaver (1974) suggested that the jointing is related to late Carboniferous, Variscan ground movements, and as the jointing varies between the limestones and dolomites, Ixer (1978b) deduced that the dolomitization must pre-date the jointing and therefore be of Carboniferous age.

Ixer (1978b) proposed a five-stage sequence for the formation of the Masson Hill mineral deposits, namely:

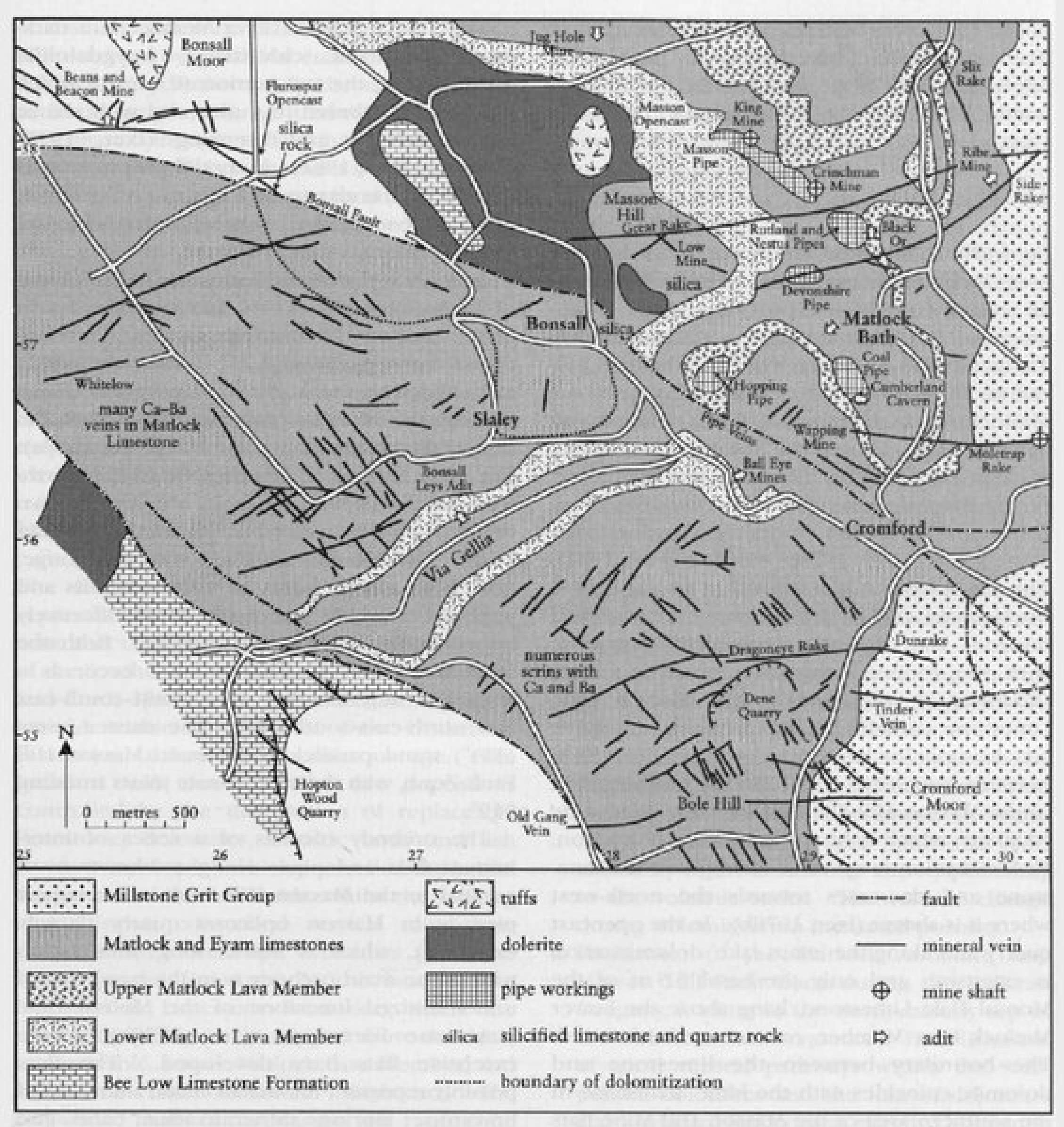
1. Deposition of coarse-grained limestone and intermittent volcanic ash bands and emplacement of two main lava-flows.
2. Groundwater circulation producing cavities by dissolution of limestone adjacent to limestone-volcanic rock junctions.
3. Dolomitization of coarse-grained limestone by magnesium-rich fluids following established bedding and lithological horizons. Dolomitization controlled by the grain-size and chemistry of the limestones and by proximity to the volcanic rocks. The volume change during dolomitization increased porosity.
4. Formation of the Matlock Anticline and Masson Hill Fault Zone during the Variscan Orogeny, leading to the north-easterly dip of the limestone/lava sequence. Establishment of good vertical pathways within the well-jointed dolomites and the loss of dolomite/clay wayboard junctions as effective horizontal barriers/pathways.
5. Ingress of silica-rich fluids following all the vertical and horizontal pathways, locally silicifying limestone and dolomite.

Hot, dense, mineralizing fluids moved up the Masson Anticline until they reached the day-filled Masson Hill Fault Zone. The fluids followed established pathways. Metasomatic mineralization occurred when calcite was passed (particularly at limestone/dolomite junctions), or where fluids ponded. Void development also took place, with a greater amount in the more porous and jointed dolomite.

## Conclusions

The Masson Hill mineralization is a good example of a Mississippi Valley-type deposit hosted in a mixed limestone/dolomite sequence with interbedded and bounding basalt and volcanic ash horizons. The mineralization in the limestone is mostly in the form of flats, which probably formed by a combination of metasomatic replacement by the mineral fluids and infilling of palaeokarstic features. The mineralization of the dolomite is mostly in the form of infilling of the secondary porosity associated with the dolomitization.

**References**




*(Figure 4.13) Location and geological map of the Masson Hill Mines and surrounding area.*