# Dirtlow Rake and Pindale, Derbyshire

[SK 152 818]

## Introduction

The Dirtlow Rake and Pindale area, south of Castleton in Derbyshire (see (Figure 4.14)), is a GCR site for the well-exposed range of mineralization features found there. Included in the site are the Dirtlow Rake itself, which is a major fissure-vein complex; the Pindale limestone quarry; which contains a transition from limestone to metasomatic quartz rock; and the Dirtlow Rake fluorite-barite orebody, which is hosted in limestone breccia.

Dirtlow Rake is one of the major hydrothermal fissure-veins of the South Pennine Orefield, and can be traced for over 6 km in a general ENE–WSW direction. It varies considerably in width (between 3 m and 12 m) and mineral composition. Old workings can be found over a distance of 2 km in and above Pindale, from [SK 144 815] to [SK 157 823], where they run at the north-east end into Pindale limestone quarry. The numerous small opencasts demonstrate the complex structural relationships better than anywhere else in the Peak District. Additionally, sections through the veins in these opencuts clearly show the multi-phase character of the mineral paragenesis. At Pindale Quarry (now disused) fluorite scrins (mineralized joints) and pipes can be observed at the south-west end, in Visean lensoid reef limestones. Adjacent crags farther south-west [SK 156 820] show the transition from unaltered limestone to quartz rock. More recently (in 1984), a fluorite-barite orebody was discovered hosted in limestone breccias adjacent to Dirtlow Rake, 1.5 km SSW of Castleton. It has been worked as an open pit. The host rock is a shelf carbonate sequence, within which collapse-breccia domes have formed.

The fluorite-barite deposits of the South Pennine Orefield have been described by numerous authors, including Dunham (1952, 1983), Ford and meson (1971), Ford (1976), Ineson and Ford (1982), and Ixer and Vaughan (1993). Genetic models proposed in the literature have been re-evaluated by Plant and Jones (1989), and Jones *et al.* (1991, 1994). Mineral deposits occur in veins and pipe complexes, many of which were originally worked for their lead mineralization, whereas other fluorite-barite deposits in the area are hosted in replacement flats and breccias, and have not been so extensively worked. As part of the intensively investigated mineralized area south of Castleton, the Dirtlow Rake and the Pindale deposits include examples of all the deposit types listed above, providing an opportunity to study the relationships between them.

The most detailed descriptions of the Dirtlow Rake area are those by Stevenson and Gaunt (1971), Carlon (1975), Butcher and Hedges (1987), and Jeffrey (1997). It has been a key location in the development of theoretical models explaining orebody genesis as well as models used as predictive tools for exploration.

## Description

### Dirtlow Rake Vein

The Dirtlow Rake Vein (see (Figure 4.15)) displays a multi-phase history of mineral deposition linked to fault movement and the concomitant dilatancy. On the vein walls, well-preserved horizontal slickensides can be seen, indicating principally strike-slip movement during the final major dilatant phase. During this final phase, the dominant columnar calcite fill was precipitated. Near the vein margins there are dark calcite bands with minor white barite and galena stringers. Towards the vein centre, cavities containing well-preserved scalenohedral calcite crystals have developed, often with manganese dioxide coatings. Cusps and ribs of fluorite and barite with minor galena are preserved near the vein walls, and are interpreted as earlier mineral phases (for example by Jeffrey, 1997).

The Dirtlow Rake Vein is dominantly a dextral shear with the strike-slip component estimated to be 100 m from evidence of displacement of the reef belt and the Namurian shale contact to the east (Jeffrey, 1997). The main limestone lithological units reveal dip-slip movement of approximately 25–30 m down to the south; however, a full structural interpretation of the deposit is lacking.

In the vicinity of the breccia-hosted ore-zone, the Dirtlow Rake Vein is a simple structure trending 060° and dipping between 80° and 90° south. To the west it forms a more complex structure, a splay zone, at the junction with thdow Rake. To the east the vein becomes involved in an extensional duplex connecting it to the Pindale Fault, with further splay terminations to the north.

### Breccia domes

Mineralized breccia domes are contained within the stratigraphical unit called the 'Monsal Dale Limestone Formation', of the Peak Limestone Group, largely below the Upper *Girvanella* Band and above a major volcanic horizon which has been correlated with the Upper Mlller's Dale Lava Member of the Monsal Dale Limestone Formation (Butcher and Hedges, 1987). The limestones comprise a series of predominantly light-coloured biosparites, locally with shell banks, and chert both in bands and as isolated nodules. Lowermost in the exposure is a massively bedded limestone unit, which is overlain by progressively thinner-bedded units on the north side of Dirtlow Rake Vein. To the south the uppermost unit is a darker, medium-bedded limestone that forms a roof to the breccia zone. Although most of the units are parallel-bedded, some channelled and cross-bedded units are also present. The greatest development of mineralized breccia is within the lower, massive, pale limestones with an apparent lithological control to the southern dome roof. Facies transitions in the limestone, from lagoonal through to a reef belt, may be observed in the nearby Hope and Pindale quarries, and are documented from the Cavedale and Winnats Pass (Parkinson, 1965; Stevenson and Gaunt, 1971).

Breccia domes are present on either side of the Dirtlow Rake Vein, with the central cores and upper reaches of the domes comprising the fluorite-barite ore-zone. The broad character of the northern breccia-zone was described by Butcher and Hedges (1987). The two domes are both elongate, partially dissected, bell-like structures, but the dome south of the vein is 25–30 m deeper. In detail the shapes of the two domes are different (see description by Jeffrey, 1997). Breccia blocks range in diameter from 1 cm to several metres, and in the upper portion of the dome the differences in bed thicknesses within the horizons intersected are reflected in the shapes of the breccia blocks. The degree of brecciation, disarticulation and rotation of the breccia blocks on the two sides of the vein is similar, and near the top of the dome the blocks can be shown to have moved only by small vertical distances with little rotation (Jeffrey, 1997).

The breccia is clast-supported, with fluorite and barite filling the interstices. At the contacts between mineral fill and limestone blocks, a range of alteration, crustification and replacement textures have developed. Most commonly, the blocks are relatively unaltered with a crustiform growth of goethite. In other cases the blocks are silicified, and fluorite has subsequently infilled the cavities or porous matrix. Some smaller blocks have been completely replaced by fluorite, with the outline of the block preserved as an iron-rich band formed from goethite and residual chert.

Jeffrey (1997), stated that 'doubt must remain over whether the breccia domes represent a single unit or two separate structures, especially in the light of the early dome formation and subsequent lateral movement on the main vein'.

### Replacement 'bow ties'

Structurally controlled wedges of mineralization ('bow tie' deposits) are found at bedding-plane–fracture intersections in the dome roof, within the uppermost 20 m of the massively bedded unit, on the northern upthrown side of the vein, dying out at the boundary with the thinner-bedded unit above. The fractures are a set of minor shears, which splay off the main fault. 'Bow tie' deposits host the full suite of minerals seen in the dome deposits, with the focus of replacement in the acute angle between the two planes. This was the site of increased permeability due to high fracture density or localized brecciation (see Jeffrey, 1997, for detailed diagrams and description).

### Pervasive replacement

Adjacent to the vein, on the north wall, silicified and fluoritized limestones occur in the dome roof-zone. The silicification is well developed in a competent, relatively fine-grained, unfractured unit; it has resulted in a highly porous, but not vuggy, rock with some preservation of limestone structures. Post-silicification fluoritization by purple fluorite is widespread. Examples of silicified limestone hosting well-preserved goethite pseudomorphs after marcasite can be found, the same as those seen overgrown by the earliest fluorite elsewhere in the deposit (Jeffrey, 1997).

### Pipe mineralization

There are a small number of pipes exposed on prominent bedding-planes at the top of the silicified wall-zone. The pipe cores consist of white fluorite above a floor zone comprising a purple fluorite replacement front in silicified limestone. Drilling has indicated that pipes may be present in the floor zone of the domes; it is suggested by Jeffrey (1997) that a concentration of these structures could have caused the instability needed to trigger the collapse of the dome.

## Interpretation

The paragenesis of mineralization at Dirtlow Rake is detailed by Jeffrey (1997), who stated that it is consistent with the general paragenesis of the South Pennine Orefield proposed by Ixer (1986), and also with a number of deposits examined by Quirk (1987). Silicification was the first stage in the mineralization, and the pores and vugs created in the process prepared the ground for further mineralization: fluoritization of unaltered limestone is not seen. The occurrences of limestone silicification around Dirtlow Rake and Pindale have been described by Ford (1967b), with the best example being the Pindale quartz rock, found 300 m to the north-west of the Dirtlow Rake open-pit next to the southern vein wall. It is a vuggy, occasionally hydraulically brecciated, silicified limestone with yellow and purple fluorite cavity infill. Orme (1974) showed from a detailed petrographic study of the Pindale quartz rock that the fluorite post-dated the major silicification event. Jeffrey (1997) interpreted the 'silica rock' occurrences as the root zones of subsequently eroded domal structures or failed dome precursors.

### Development of the domes

The breccia domes are inferred to have formed due to collapse of the rocks above zones of intense dissolution and silicification. These zones were located directly above the boundary with the Upper Miller's Dale Lava Member, where the mineralizing fluids ponded due to the permeability contrast. The earliest fluids deposited chalcedony and/or quartz, marcasite and traces of calcite. At this stage, Dirtlow Rake Vein was a minor fracture, filled by calcite and small amounts of barite and fluorite (Butcher and Hedges, 1987). The fracture (fault) appears to have acted as the primary channel for fluids into the area.

The collapse of the dome formed a small void at its top. This now has an upper, relatively open breccia-zone with a more compact, silicified rubble floor. White fluorite infilled much of the void space provided at higher levels, whereas replacement of partially silicified breccia clasts was more prevalent towards the bottom of the collapse structure.

The onset of calcite mineralization occurred at a significantly later stage, associated with both dilation and re-activation of the fault. Minor phases of white barite and galena are persistent, and the latter was in sufficient abundance to have been worked by the old lead miners.

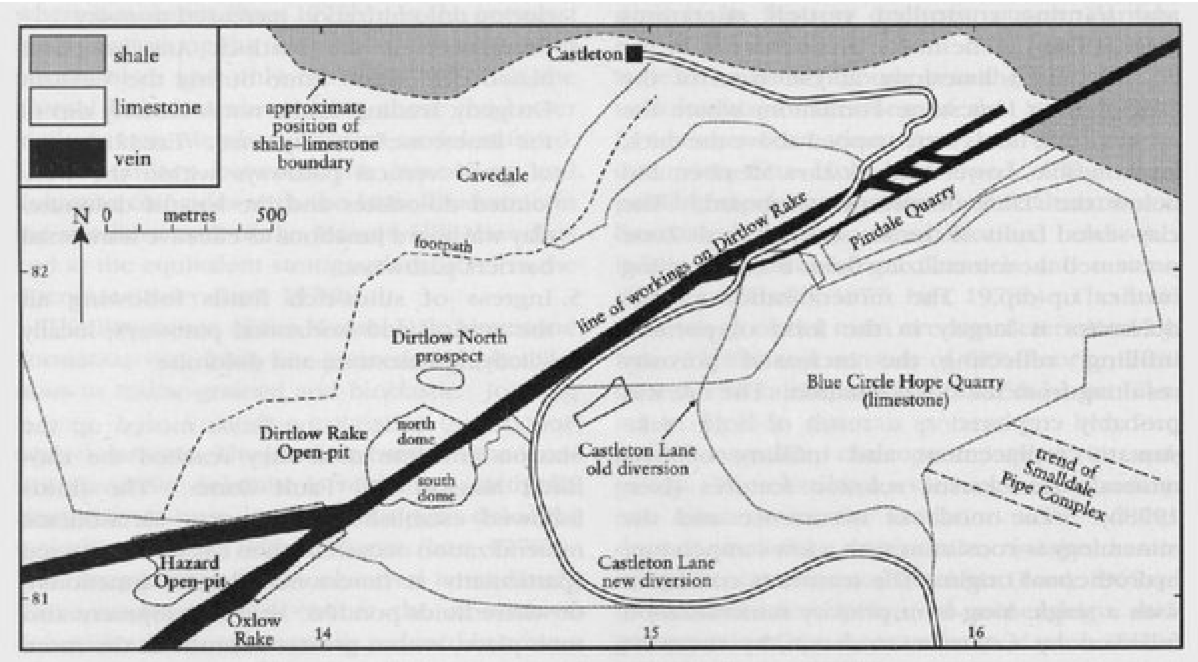
### Relationship of replacement styles

It is rare to see such a wide range of replacement mineral types well-exposed in a single deposit. The following general conclusions about their relationships were drawn by Jeffrey (1997). In easily replaced horizons (with respect to silica and fluorite) the residence time and geochemistry of the fluids dictated the form of the final deposit. Abundant fluid access without ponding resulted in diffusion-driven pervasive replacement. Where fluid-rock contact was prolonged (due to ponding), dissolution and replacement continued further until collapse and breccia dome formation occurred. Conversely, in unfavourable lithologies, replacement only occurred with the aid of strong structural controls: poorly mineralized fractures locally formed 'bow tie' structures where there was adjacent brecciation. Where little structural disruption was present, other than bedding or unconformity surfaces, pipe formation dominated, as mineralization was again restricted to the plane that permitted fluid access.

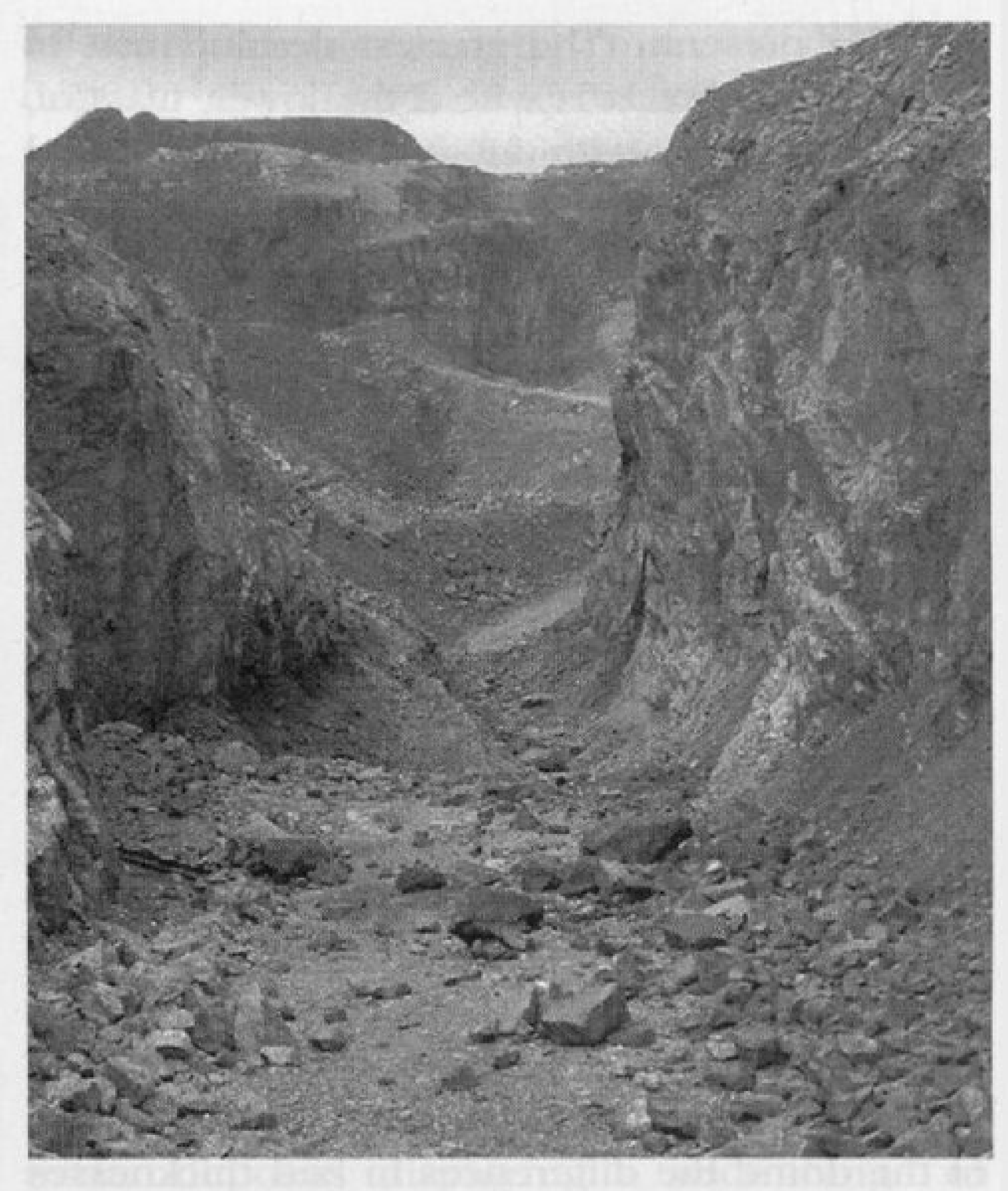
## Conclusions

The Dirtlow Rake and Pindale area is within the South Pennine Orefield, and contains fluorite-barite deposits displaying a wide range of mineralization styles. It is rare to see such a range of replacement mineral types well-exposed in a single deposit, and the locality therefore provides an opportunity to study the relationships between them. The numerous small disused opencasts created by lead and early fluorite-barite mining in this area are perhaps the best exposures in the Peak District for the demonstration and study of the complex structural relationships and the multi-phase character of the mineral paragenesis. Such studies have led to improvements in the understanding of the orefield genesis (Jeffrey, 1997), and to the development of useful prospecting models (Butcher and Hedges, 1987).

[References](#)




*(Figure 4.14) Sketch map of the Dirtlow Rake and Pindale area.*



*(Figure 4.15) The Dirtlow Rake Vein. (Photo: M.L. White.)*