Treak Cliff, Derbyshire

[SK 134 831]

Introduction

Treak Cliff hill and caves are famous for the unique banded variety of fluorite (CaF_2) known as 'Blue John'. This rare mineral variety is found only at this location, although fluorite of a similar colour (but not the same banding pattern) is known from the Ashover and Matlock areas in Derbyshire, and at sites in the USA (Nevada), Iran, and China (Ford, 1994). The name 'Blue John' may derive from the French *Bleu Jaune* (blue-yellow), although there is no documentary evidence to support this (Ford, 1994). The unique blue-purple and white-yellow banded variety of fluorite has been mined and used for ornamental purposes since the 18th century. The deposits have been worked in open pits and shallow mines scattered over the hill of which Treak Cliff is the most prominent point, but the main sources at present are the two show caves of Treak Cliff Cavern and Blue John Cavern. The mineralization belongs to the South Pennine Orefield.

Description

The Treak Cliff GCR site lies 800 m west of Castleton in Derbyshire, at the northern edge of a large inlier (about 400 km^2) of Lower Carboniferous Dinantian rocks (see (Figure 4.20) for location and geological map). Most of the limestones present belong to the Asbian Bee Low Limestone Formation. Treak Cliff marks the transition between the shallow lagoonal limestones to the south and deep-water basin deposits to the north and east, and is chiefly composed of a massive reef limestone with a fore-reef slope on the basinward face (Broadhurst and Simpson, 1967, 1973; Stevenson and Gaunt, 1971; Aitkenhead and Chisholm, 1982). Broadhurst and Simpson (1967) were able to use the dip of sediment fills in fossils and cavities to show that the limestones at Treak Cliff were deposited on a steep slope with a contemporary dip of approximately 27°.

The contemporary deep-water basin sedimentary rocks are not exposed, although mine dumps at nearby Odin Mine do contain some fine-grained dark limestone fragments that may be part of this facies. Prior to the subsequent deposition of the Namurian Bowland Shale Formation (formerly the 'Edale Shales'), the limestone platform was exposed and some karstification occurred. As a result of this emergence, a boulder bed (up to 12 m thick) formed on the fore-reef slope which coincides very closely with the present surface topography of Treak Cliff (Simpson and Broadhurst, 1969). The karstification and boulder-bed formation continued into the early stages of deposition of the Bowland Shale Formation (Ford, 1969; Simpson and Broadhurst, 1969). The entire area of Treak Cliff was then completely covered by the Bowland Shale Formation and subsequent Namurian and Westphalian sediments.

The Blue John mineralization is an almost monomineralic fluorite deposit, with minor amounts of calcite, quartz, and barite, and a little galena. The mineralization is not restricted to any one facies and it has been found in the following situations (Ford, 1969; Simpson and Broadhurst, 1969): in voids between the boulders in the boulder bed just below the Bowland Shale Formation (particularly important in Treak Cliff Mine); as pipe-veins below well-fissured limestone in karstic solution of bedding planes (particularly important in Blue John Cavern); as small veins in joints in the underlying fissured limestone (see (Figure 4.21)); as metasomatic replacement of limestone boulders and solid rock (particularly porous shelly limestone); and locally as scattered cubes in the Bowland Shale Formation. The best-known and largest deposits of Blue John are those that formed in the voids and palaeokarstic solution cavities (up to 3 m in diameter) in the boulder beds (Ford, 1994). The basal part of the boulder bed, with some large cavities can be seen in the Witches Cave of Treak Cliff Cavern [SK 136 832].

Ford (1955, 2000) provided extensive descriptions of the mineralogy and texture of Blue John at Treak Cliff The mineral is found to occur in spheroidal nodular masses with a radiating crystalline structure containing blue bands of varying intensity and number, arranged concentrically, parallel to the nodular surface. In between these bands are colourless, yellow or pale-blue bands. The nodular surfaces are made up of large numbers of interpenetrating cubic crystals. The highest traces of blue fluorspar are found in the shale and crinoid-debris matrix of the upper parts of the boulder bed.

Near Odin Mine (at the northern end of 'Freak Cliff), these small cavities also contain glauconite and hydrocarbons (Young *et al.,* 1968). In the larger cavities of the boulder bed (~1 m or 2–3 m in diameter), where the shale matrix did not penetrate, nodular radiating crystalline Blue John with typical colour-banding is found (Ford, 1969). A fine-grained horizontally bedded quartz rock deposit is present at some cavity floors. These are horizontally bedded when unaffected by solution collapse. Blue fluorspar cubes have been observed occurring within these quartz layers, and appear to have precipitated from mineralizing fluids at successive intervals (Ford, 1969). Above the quartz layers, the remainder of the cavity is lined with Blue John, sometimes encrusted with calcite scalenohedra. Rare occurrences of galena encrustation of Blue John are also reported.

Ford (1969) postulated that the quartz needles were an authigenic replacement of calcite rhombic accumulations, into which fluorite cubes had precipitated. Some re-distribution of the fluorite was noted, indicated by overgrowths on the cubes, some of which enclose, the quartz needles. The margins of some limestone blocks in the boulder bed also show silicification in the form of chalcedony or quartz needles of authigenic aspect. Ford (1969) suggested that silicification and fluoritization occurred close together, and in places overlapped chronologically. Metasomatic replacement of limestone by blue fluorspar is sporadically developed in the more porous shelly limestone, whether in boulders or in the more fissured limestone beneath. Relatively resistant fossils are now surrounded by blue fluorspar.

Interpretation

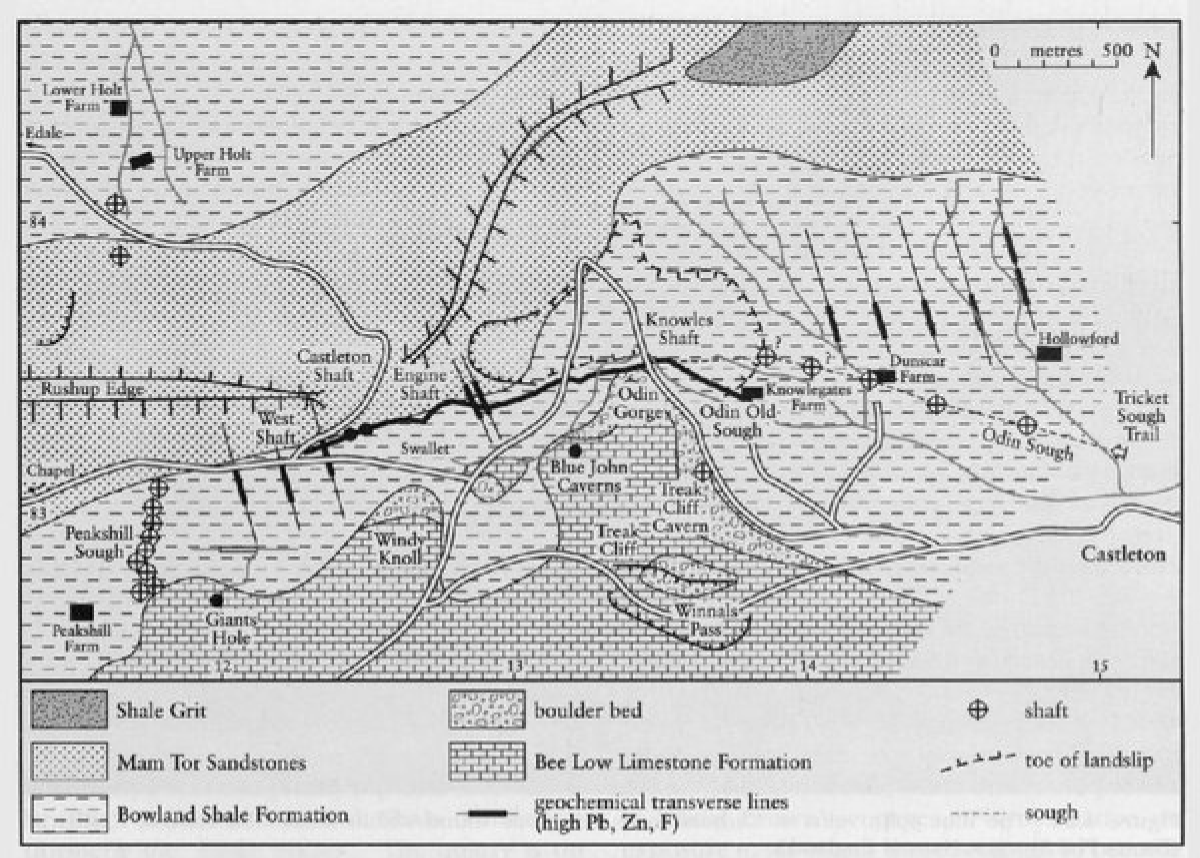
The mineralization at Treak Cliff is part of the Mississippi Valley-type orefield of the South Pennines. Generally this is a lead, zinc, barium, calcium and fluorine deposit sourced from dewatering of Carboniferous basins to the east (Ford, 1994), but here it is largely dominated by fluorite. The boulder-bed cavities would have provided a series of channels for the migration of mineralizing fluids and hydrocarbons which would have then been trapped by the overlying Bowland Shale Formation. What is not clear, however, is why the Treak Cliff deposit is almost entirely dominated by fluorite, despite extensive galena deposits in Odin Mine, just to the north of Treak Cliff. Fluid-inclusion data suggest that the mineral fluids were very saline at temperatures of between 80° and 180°C, and the likely timing of mineral emplacement was in late Carboniferous to Permian times (Ford, 1994).

A number of theories have been developed for the differing colours of the fluorite but none of them have been confirmed. The possibilities have been summarized by Ford (1994). The presence of manganese has been disproved by analysis, and although present in the fluorite, the hydrocarbon concentrations are low (Ewbank *et al.,* 1993, 1995), and have no relationship to the different colours. Other possibilities are that it forms as a result of colloidal calcium trapped within the fluorite, or molecular lattice distortion caused by uranium absorbed on hydrocarbons. More research is needed to establish the definite cause of the various colours of the Blue John fluorite. There is a similar lack of consensus on the cause of the varied banding of the Blue John in Treak Cliff and the formation of this banding has not been studied. Ford (1994), however, has described the most reasonable explanation as involving a complex system of flow variations and changes in fluid pressure in the palaeokarst and boulder-bed void systems. Repeated, irregular flushes of hot solution would then give potential for the different coloured bands. Periods of steady flow would give rise to a clear band, while frequent interruptions would yield the coloured bands. Slow growths of crystals with absorbed uranium and dislocations could give rise to intensely coloured bands.

Conclusions

The Treak Cliff Blue John mineralization contains a rare, coloured fluorite deposit which exhibits a pattern that may well be unique. Blue John has been used in jewellery manufacture and in many decorative ornaments. It formed as part of the mineralization of the South Pennine Orefield but the deposit consists almost entirely of fluorite. The structural setting of the Blue John fluorite has been studied in detail, but the cause of the colouration and the banding of the Blue John deposit has yet to be definitively determined.

References



(Figure 4.20) 'Freak Cliff location and geological map. After Ford and Rieuwarts (1976).

(Figure 4.21) The Blue John veins in Carboniferous limestone found within Treak Cliff Cavern, Castleton. (Photo: Phil Sturges, Natural England.)