SUMMARY

Fluorite-rich marble occurs within a large xenolithic raft in the Whin Sill of Barrasford Quarry, Northumberland. Fluorite has not hitherto been reported from the Whin Sill, or any of its contact rocks. Its occurrence in this unusual marble is likely to be the result of very localised fluorine metasomatism within the thermal aureole of the Whin Sill.

GEOLOGY OF THE WHIN SILL

The Whin Sill of North East England is generally regarded as the original or ‘type’ sill of geological science and as a result is the subject of a voluminous literature. Notable contributions include papers by Hutton (1832), Sedgwick (1827), Tate (1867; 1870), Topley and Lebour (1877), Teall (1884a,b), Holmes and Harwood (1928), Tomkeieff (1929), Wager (1929a,b), Smythe (1930), Dunham (1990) and Randall (1995). From this work it is clear that the Whin Sill cannot be regarded as a single, or simple, concordant intrusion, but rather as a complex assemblage of closely related transgressive sills and associated dykes, best described as the Great Whin Sill Complex (Johnson and Dunham, 2001). Excellent summaries of the essential features of the Whin Sill suite of intrusions, and comprehensive lists of the most significant literature references, are to be found in Dunham (1970), Randall (1995), Dunham (1990) and Johnson and Dunham (2001). From these literature sources the following very brief general observations may be made.

A remarkable feature of the Whin Sill is the striking uniformity in mineralogy, petrography and geochemistry across its extensive outcrop, though minor variations in texture and composition do occur locally. The dominant lithology is a fine- to medium-grained, dark grey quartz-dolerite composed essentially of orthopyroxene, clinopyroxene and plagioclase with scattered titano-magnetite, a little needle-like apatite, and smaller amounts of interstitial alkali-feldspar and micrographic intergrowths of quartz and feldspar. Hornblende, biotite and chlorite are common secondary minerals. Minor lithological variants include very fine-grained, tachylitic varieties close to the contacts as well as very coarse-grained dolerite pegmatites and fine-grained acid aplitic rocks forming veins within the thicker sills (Dunham, 1990; Randall, 1995).

The clear geological evidence for emplacement of the Whin Sill intrusions during the late Carboniferous (Stephanian) (e.g. Holmes and Harwood, 1928; Dunham, 1932) have been confirmed by K-Ar isotopic ages of 295± 6 Ma (Fitch and Miller, 1967).

Joints within the sill at numerous localities commonly exhibit coatings of calcite, quartz, chlorite and a variety of zeolite and zeolite-type minerals, including pectolite, analcite, prehnite, apophyllite, chabazite and stilbite, formed as a result of hydrothermal activity.
during the final cooling stages of the intrusion (Holmes and Harwood, 1928; Tomkeieff, 1929; Wager, 1929; Smythe, 1930; Fitch and Miller, 1967; Young et al., 1991).

METAMORPHIC EFFECTS OF THE WHIN SILL

Much of the published literature on the Whin Sill is concerned with aspects of the petrography, chemistry, age or mode of intrusion.

Although descriptions of the thermal effects of the intrusion on vitrinite reflectance and coal rank across the sill’s outcrop have been published (e.g. Trotter and Hollingworth, 1928; Edwards and Tomlinson, 1957; National Coal Board, 1965; Jones and Creaney, 1977; Creaney, 1980; Jones et al., 1995), the contact metamorphic effects on other country rocks have attracted surprisingly little research interest. Hutchings (1898) described metamorphic rocks in Teesdale, and more recently Robinson (1970) outlined soda-metasomatism and metamorphism in the Cowgreen area, also in Teesdale. Randall (1959a) described thermal metamorphism in the Oxford Limestone and adjoining sedimentary rocks at Barrasford Quarry, Northumberland, and further descriptions of the rocks then exposed at this site were given by Frost and Holliday (1980). In a brief review of Whin Sill metamorphism, Randall (1995) noted that andalusite, anthophyllite, biotite, cordierite, garnet, pyroxene, vesuvianite (idocrase) and wollastonite have all been recorded from contact rocks.

THE WHIN SILL AND ITS CONTACT ROCKS AT BARRASFORD QUARRY

Barrasford Quarry [NY916 748] is a large quarry in south central Northumberland at which Whin Sill dolerite is worked for the production of roadstone and aggregate.

The Whin Sill at Barrasford is approximately 30m thick and is intruded into the Oxford Limestone (Dinantian). The often complex relationships of the sill with its country rocks in this area are depicted on British Geological Survey 1:10 560 scale sheets NY97NW and NY97SW. Descriptions of the geology of the Barrasford area, including details of the Whin Sill petrography, have been given by Weyman (1910); Smythe (1930); Randall (1959) and Frost and Holliday (1980).

The Whin Sill here mainly comprises fine- to medium-grained quartz-dolerite typical of much of the sill’s outcrop. Randall (1959a; 1989) has described pink to red acid aplitic veins and pockets of coarse-grained pegmatitic dolerite associated with amygdales. Amygdales are a common feature of the sill in the Barrasford area. Those seen here today are filled, or partially filled, mainly with quartz and/or calcite, though Randall (1959a) has recorded datolite and pectolite, the latter in part replaced by stevensite (Randall, 1959b), from amygdales found in Barrasford Quarry.

A feature of the Whin Sill in this part of Northumberland is the presence within it of large xenolithic ‘rafts’, often several metres across, of the adjoining Carboniferous country rock (Randall, 1959a; Frost and Holliday, 1980). Rafts at Barrasford comprise mainly limestone and shale.

The Oxford Limestone in this part of Northumberland is typically a grey bioclastic limestone, up to about 6m thick, commonly rich in corals and brachiopods (Frost and Holliday, 1980). It is usually overlain by mudstones. Adjacent to the Whin Sill contact in the Barrasford area, much of the limestone has been altered into saccharoidal marble, in places with abundant granular grossularite and euhedral, prismatic vesuvianite (idocrase),
together with aggregates of chlorite, and quartz (Smythe, 1930; Randall, 1959a; Frost and Holliday, 1980). Despite this alteration the outlines of fossils are still commonly recognisable. Very small fibrous crystals within one sample were tentatively identified as fibrolitic silliminate, though this has not been confirmed. Frost and Holliday (op cit) also describe a ugrandite-chlorite-quartz-vesuvianite-micocline-plagioclase marble from a xenolithic raft of limestone within the sill. The mudstones associated with the Oxford Limestone have been shown by Frost and Holliday (1980) to comprise intergrowths of smectite with albite-oligoclase with accessory leucoxene. They have also described fine-grained rocks consisting of quartz and chlorite with ‘spots’ of feldspar and stellate aggregates of white mica.

**FLUORITE-BEARING MARBLE**

During 2000, several large blocks over 1.0m across, derived from a large xenolithic raft then being worked in the north face of the quarry, were conspicuous for their very distinctive bright lilac-purple colour, due to an abundance of disseminated fluorite. The raft from which the fluorite-bearing rock was derived was approximately 20m across, 4m wide and 10m high. It comprised mainly marble and a small amount of hornfelsed mudstone in which the bedding was almost vertical and orientated N-S. Unfortunately, by the time the presence of fluorite had been recognised, quarrying had destroyed the remaining portions of the fluorite-bearing rock and it was not possible to record or study the field relationships in detail. However, sufficient examples of this highly distinctive and unusual lithology were recovered to allow the following description. Quarrying of the face a few metres north of the site of the fluorite-bearing marble subsequently revealed a further striking xenolithic raft composed of hornfelsed mudstone several metres across, though without any sign of mineralisation.

In hand specimen the fluorite-bearing marble is typically a compact very pale purplish grey, to lilac-purple, medium- to coarse-grained crystalline rock. It has numerous rather irregular, discontinuous streaks and patches of moderate to deep purple or vivid lilac-purple colour. Rather irregular cavities, mainly up to 15mm across, are locally present. These are typically lined with white to colourless rhombic crystals of calcite, up to about 1.0mm across, intergrown in places by similar sized, colourless quartz crystals consisting of short prisms with pyramidal terminations. A few rather larger (up to 20mm) crystals of calcite comprising combinations of scalenohedra and rhombohedral were found in some cavities. Very small (mainly between 0.2 and 0.5mm) medium to deep purple, euhedral fluorite crystals locally project into some cavities. The crystals appear to be mainly simple cubes with rather rough or irregular faces, though a few exhibit clear faces which form rhombic dodecahedra \{110\} and octahedra \{111\}. Rather patchy colour zoning in shades of deep purple occurs in some crystals. The fluorite exhibits no fluorescence under either long or short wave ultra violet radiation. The minerals in some cavities are coated with small (< 0.25mm) rounded globules of a hard, brittle, black hydrocarbon. In some specimens this black hydrocarbon fills almost the entire cavity. The composition of this hydrocarbon has not, so far, been determined.

In thin section (E71601 and E71602*) the rock is seen to be a medium- to coarse-grained aggregate of carbonate and quartz (Figure 1). Carbonate forms anhedral to irregular crystals which range up to 1.7mm in size. The ready effervescence of the rock in cold 10%

*BGS Thin Section Number in the English Sliced Rock Collection.
Figure 1 Thin section of typical fluorite-bearing marble from Barrasford Quarry. The rock is a medium to coarse-grained aggregate of carbonate with some quartz. Fluorite is scattered abundantly throughout the rock and is especially conspicuous as black isotropic grains in the view under crossed polars. Field of view approximately 5mm. (E71601).

1a Plane polarised light.

1b Crossed polars.
hydrochloric acid suggests that calcite is the dominant, or perhaps only, carbonate present. Quartz is strained and, in general, forms anhedral to irregular crystals, though crystal faces are seen on some anhedral to subhedral grains. The quartz appears to be intergranular to carbonate and may form slightly larger sieve-textured/poikiloblastic crystals. Fluorite occurs as grains up to 0.75mm across. It is colourless to very pale purple in colour (under plain polarised light) and is characteristically isotropic with a high relief. It occurs in sieve-textured patches which contain small rounded inclusions of both quartz and carbonate. Rare, subhedral fluorite crystals possessing well-developed crystal faces were noted locally, typically associated with irregular patches of coarser grained quartz. Dendritic or branching fluorite and quartz intergrowths are present locally.

Traces of fluorite have previously been observed at two other locations within the quarry. A few purple octahedra up to 4mm across were collected from altered limestone adjacent to a 0.5m wide lobe of dolerite at the base of the sill [NY9200 7486]. Pale green cubo-octahedra up to 10mm across, accompanied by quartz and calcite, were also seen at the top contact of the sill [NY9200 7515]. In both instances only a few fragments were collected and it was not possible to record details of the occurrences in situ.

**DISCUSSION**

Although it is extremely disappointing that this rock could not be examined in situ, the samples obtained are significant and invite comment. Fluorite has hitherto not been recorded as a component of the Whin Sill or any of the metamorphic rocks within its thermal aureole. Neither has it been described as a member of the suite of late stage hydrothermal minerals found within amygdales or coating joints within the sill. We have been unable to trace any analysis of the Whin Sill which indicates the presence of fluorine. The only known record of a fluorine-bearing mineral associated with the Whin Sill is that of fluorapophyllite found in association with analcite and chabazite within late stage joint coatings at Cambokeels fluor spar mine, Weardale, Co Durham (Young *et al*., 1991). Although the fluorapophyllite at this locality clearly appears to be part of the distinctive suite of late-stage joint filling minerals formed during the final cooling of the Whin Sill, its occurrence so close to major fluorite-bearing veins within the central zone of the Northern Pennine orefield may be significant. Indeed, Young *et al* comment on the apparent overlap of estimated dates for the emplacement of the Whin Sill at 295 ± 6 Ma (Fitch and Miller, 1967) and the onset on northern Pennine mineralisation at 284 ± 40 Ma (Dunham *et al*., 1968).

Barrasford Quarry lies several kilometres north of the northernmost margins of the Northern Pennine orefield, and at least twenty-four kilometres north of the nearest known fluorite mineralisation. It thus seems extremely unlikely that northern Pennine mineralising fluids could have had any role in providing the fluorine necessary for the small concentration of fluorite described here from Barrasford Quarry.

It must therefore be concluded that thermal metamorphism of limestone in the Barrasford area may have been accompanied, very locally, by metasomatism involving rare concentrations of fluorine-rich fluids. It is perhaps worth pointing out that the fluorite, reported here, only came to the authors’ attention because of its striking purple colour. Less strongly coloured fluorite would almost certainly have been overlooked. In view of the discovery of this mineral in this environment at Barrasford, and in view of the comparatively lit-
tle attention so far paid to the metamorphic rocks within the Whin Sill’s thermal aureole, a careful search should be made for the presence of fluorite in similar situations elsewhere across the extensive outcrop of the Whin Sill.

ACKNOWLEDGEMENTS

Tarmac Northern Ltd are thanked for allowing access to Barrasford Quarry.

It should be noted that Barrasford Quarry is an operational site and therefore a dangerous place. Any casual and unauthorised visits are prohibited and may result in prosecution. Prior to any visit written permission must be sought from the operating company, currently Tarmac Northern Ltd.

B Young and E R Phillips publish with the approval of the Executive Director of the British Geological Survey (N.E.R.C.).

REFERENCES


NATIONAL COAL BOARD (1965). Scientific Department, Coal Survey Seam Maps.


