



Mineral Planning Factsheet

Fluorspar

*This factsheet provides an overview of **fluorspar** supply in the UK. It is one of a series on economically-important minerals that are extracted in Britain and It is primarily intended to inform the land-use planning process.*

January 2006

Fluorspar working in Derbyshire.

Fluorspar is a commercial term for the mineral **fluorite** (calcium fluoride, CaF_2) which, when pure contains 51.1% Ca and 48.9% F and is the most important and only UK source of the element **fluorine (F)**. There are three main grades — acid, metallurgical and ceramic. All UK output is **acid-grade fluorspar** (>97%, CaF_2), used principally in the production of **hydrofluoric acid (HF)**, the starting point for the manufacture of a wide range of fluorine-bearing chemicals.

Demand

Acid-grade fluorspar is a critical raw material for the UK fluorochemicals industry. Most (95%) is used in the manufacture of HF, which in addition to being an important product in its own right, is the key intermediate for the manufacture of all specialty fluorine-bearing chemicals,

notably fluorocarbons. Minor uses of acid-grade fluorspar include, the manufacture of welding rods, aluminium and steel.

Demand for fluorspar in the UK is principally driven by demand for HF and associated fluorochemical production. In the past this was for chlorofluorocarbon (CFC) production, but CFC production was banned in developed countries from 1st January 1996 because of the ozone depleting nature of the chlorine these substances contain. This resulted in a decline in demand for HF and, consequently, fluorspar.

Hydrochlorofluorocarbons (HCFCs) are used as raw materials to make fluoropolymers, the production of which is generally increasing globally. In addition, HCFCs are used as transitory replacements for CFCs. This use is being phased out and replaced by hydrofluorocarbons (HFCs), which contain much higher fluorine contents. Future demand for HF, and thus acid-grade fluorspar, will depend on the success of these alternatives in retaining and expanding market share and the growth of HFCs used as feedstock for fluoropolymer production. Fluorine chemicals have many uses, including in refrigeration and air-conditioning systems, as foam blowing agents, non-stick coatings, aerosols, including medical propellants, anaesthetics, in pharmaceutical products and for specialised cleaning applications. HF is also supplied to home and export markets for the manufacture of high-octane petrol, detergents, for metal pickling, as a specialised etchant for crystal glass, the production of silicon chips and other electronic applications, and in uranium processing.

Supply

Significant production of fluorspar in the UK began at the beginning of the 20th century with its use as a flux in steelmaking. Today steelmaking is a relatively minor use. Production increased with rising demand for fluorochemicals and peaked at 235 000 tonnes in 1975. Production has been on a downward trend since (Figure 1), because of a decline in demand by the chemical and steel sectors and the closure of some producers. However, production has now stabilised and increased somewhat.



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About 55 000 tonnes of acid-grade fluorspar with a total value of about £6 million were produced in the UK in 2005. There is no production of metallurgical fluorspar (metspar) in the UK, which is all imported.

Fluorspar production is confined to England, with the Southern Pennine Orefield, mainly within the Peak District National Park, historically being the principal source of supply. The only other significant source has been the Northern Pennine Orefield in Durham but mining ceased here in 1999.

Trade

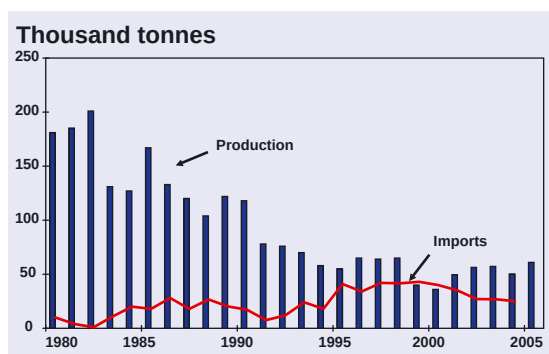


Figure 1 UK production and imports of fluorspar, 1980–2005. Source: UK Minerals Yearbook, BGS. (Imports not disclosed between 1983–2000. BGS estimates based on exporting countries and may be overstated).

World production of fluorspar was 4.5 million tonnes in 2003 and China is the dominant producer accounting for roughly 50% of the total. It is also the dominant exporter, but with a decreasing availability over the last four years and particularly in 2003 because of a decrease in export quotas. In China there is now less extraction, less easily available deposits, higher environmental and safety considerations, and greater encouragement for domestic added value use. This has put upward pressure on world prices.

Prior to the mid-1980s the UK was a net exporter of fluorspar but subsequently became a net importer (Figure 1) as it became less competitive. More recently this trend has been

reversed. UK imports of acid-grade fluorspar are now only from Spain because of quality considerations. Imports of metspar are chiefly from Mexico and China.

Consumption

UK consumption of fluorspar is shown in Table 1. Acid-grade fluorspar is believed to account for about 90% of the total. The remaining 10% is mainly used in steelmaking and comprises imported metspar.

Economic importance

Total UK consumption	69 000 tonnes
Domestic sales	50 000 tonnes
Net imports	19 000 tonnes

Table 1 UK Consumption of acid-grade fluorspar, 2004.

Production of fluorspar and associated minerals in the Peak District generate revenues of about £6 million a year, much of which is spent locally. The downstream value of the products of those companies, who rely on UK fluorspar as an essential raw material for HF and fluoro-chemical manufacture, is very much greater and estimated at £150 million in 2004. Some 270 employees are dependent on this sector.

The chemicals industry is considered to be of strategic importance to the North West by the North West Development Agency. Domestic fluorspar plays a major role in underpinning this sector.

Structure of the industry

Glebe Mines Ltd, a privately-owned company, is the only producer of marketable fluorspar in the UK. The company, and its predecessors, have supplied the UK fluorine chemical industry for 68 years. Over the last 35 years there have been a number of other ventures to produce fluorspar, both in the Southern and

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Northern Pennine orefields. None have proved sustainable.

Glebe Mines operates the Cavendish Mill, near Stoney Middleton in the Peak District National Park. Fluorspar ore to supply the Mill is mainly derived from Glebe's own operations, but smaller, 'tributer' producers also supply some ore. The Cavendish Mill is the only source of marketable fluorspar in the UK. If it were to close it is extremely unlikely that sufficient reserves of fluorspar could be identified to justify the capital investment of a new plant at some future date.

The main consumer of fluorspar, accounting for some 95% of total sales, is the HF and fluorochemicals producers INEOS Fluor. INEOS Fluor (acquired from ICI in 2001) is a worldwide manufacturer of fluorochemicals with its headquarters and main manufacturing facility in Runcorn.

Rhodia formerly produced anhydrous HF at its plant at Avonmouth but this closed in October 2004. The company will continue to manufacture fluorochemicals at Avonmouth and HF will need to be sourced from other suppliers, including INEOS Fluor.

Resources

Fluorspar resources are restricted to two areas in England: the Southern and Northern Pennine orefields (see Figure 2). Fluorspar occurs mainly as vein infillings in faults that cut limestones of Carboniferous age. Intense alteration of limestone, and occasionally other vein wall rocks, has led to the formation of important replacement deposits adjacent to several major veins.

Fluorspar always occurs in association with other minerals, the most important commercially being barytes (BaSO_4) and galena (PbS). The proportion present can be highly variable depending on location within the orefield.

Since cessation of mining in the Northern Pennine Orefield in 1999, all production has been confined to the Southern Pennines in the Peak District National Park (see Figure 3).

In the Peak District, mineralisation is largely confined to the eastern half of the limestone outcrop. The F-Ba-Pb mineralisation occurs in major east-west veins (rakes) and stratabound replacement deposits (flats) together with some cave infill deposits (pipes). The richest mineralisation is concentrated in the uppermost limestones (Monsal Dale Limestones) beneath the overlying cover of mudstones (Millstone Grit), which acted as a cap rock to the mineralising fluids. Although mineralisation will extend under cover to the east, deposits could only be accessed by underground mining. This is not likely to prove economically viable for the foreseeable future.

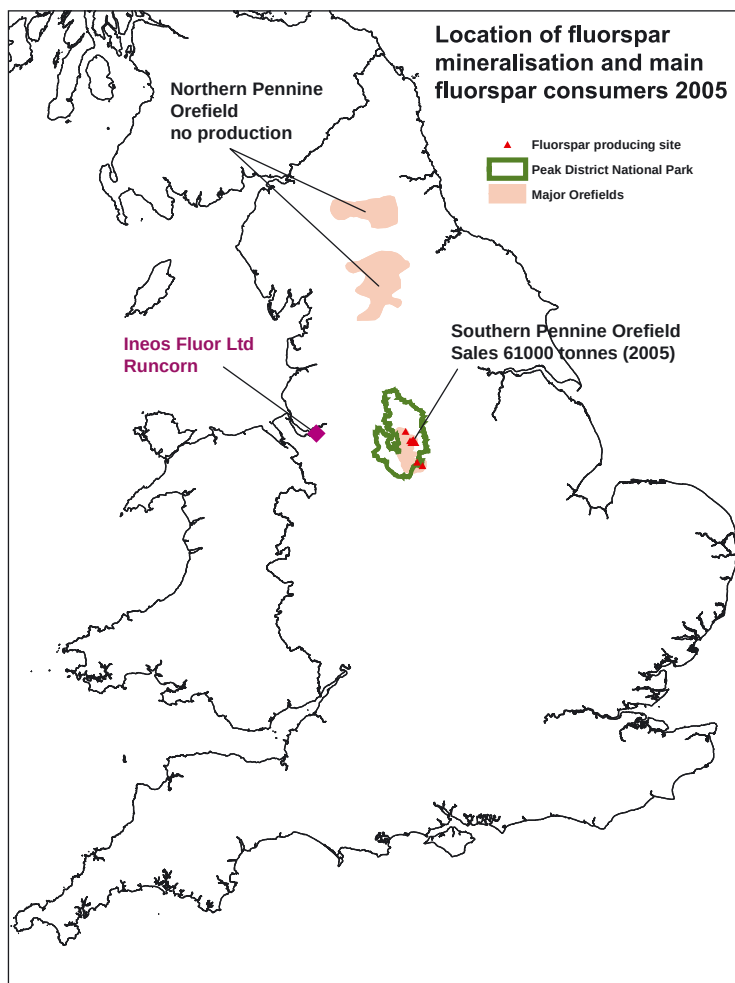


Figure 2 Location of fluorspar mineralisation and main fluorspar consumers in England, 2005.

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Despite a long history of extraction the major veins are still being worked as sources of fluorspar. However, any future exploration is likely to be directed towards finding larger, concealed orebodies in receptive horizons within the Monsal Dale Limestones. An additional objective is to review old sites operated by tributers that have not been fully exploited or restored. Individual deposits range in size from as little as 5 000 tonnes up to 1 million tonnes and a continuous exploration programme is required to identify new deposits. Fluorspar-bearing veins typically have varying widths and exhibit variable grades and mineralogy. This means that it is more difficult to assess the quantity of fluorspar that can be recovered economically than with many other economic mineral deposits.

Reserves

Permitted reserves of fluorspar ore within the main producer's control are about 1.8 million tonnes. Consequently there are sufficient permitted reserves for a further 4.6 years processing at Cavendish Mill at the current rate of ore usage of 400 000 t/y. An active exploration programme is also continuing and a number of deposits and targets have been identified to extend the life of the operation. Current permitted reserves consist of;

- open pit workings on Longstone Edge (Bow Rake, High Rake and Arthurton West) and near Winster;
- the Watersaw Mine on Longstone Edge supplying minor amounts of higher grade ore;
- historic tailings dams at the Cavendish Mill; and
- tributer suppliers, including fluorspar that is recovered from veins intersected in large limestone quarries.

Relationship to environmental designations

Fluorspar mineralisation of potential economic interest is confined to the Southern Pennine Orefield most of which is located in the Peak District National Park (Figure 3). Almost all per-

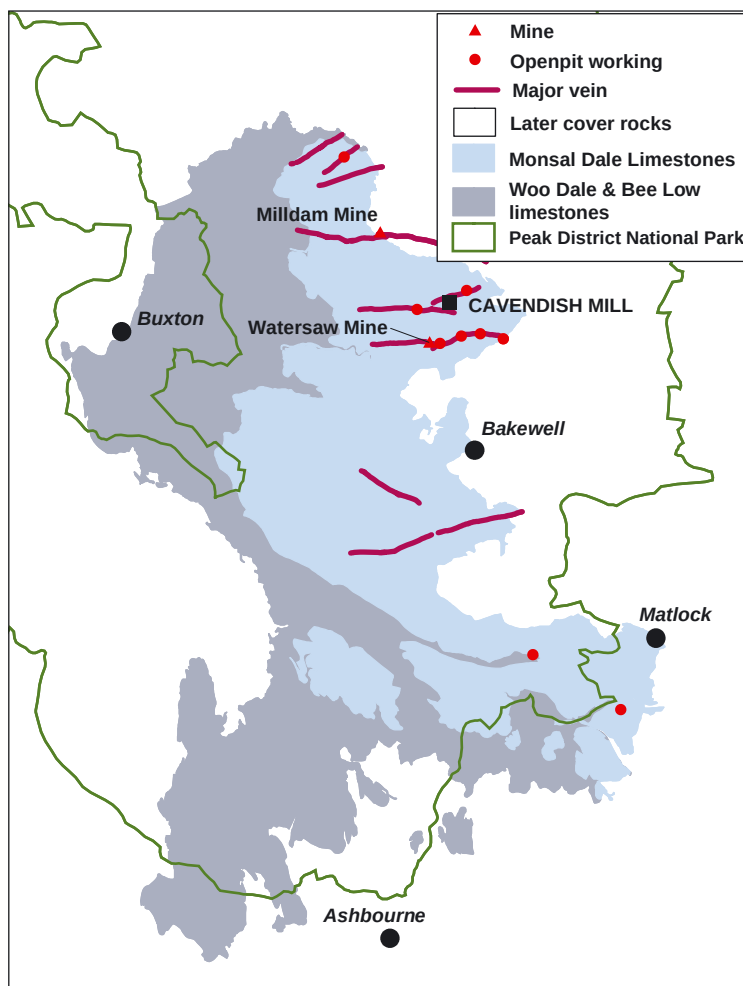


Figure 3 The Southern Pennine Orefield.

mitted reserves are located within the National Park. The principal fluorspar mineralisation in the Northern Pennine Orefield in Durham occurs within the North Pennines AONB

Extraction and processing

Historically ore has been derived from openpit and underground mines, with some of the openpit operations being worked by independent tributers. Fluorspar extraction is now almost entirely by open pit methods. Limited amounts of ore are extracted at the Watersaw Mine on Longstone Edge.

The importance of underground ore has declined significantly in recent years. The

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Milldam Mine at Great Hucklow is on a care and maintenance basis but contains *in situ* resources of over 1 million tonnes of fluorspar ore. The eastern part of the orebody has been largely worked out but some of the remaining mineralisation in this area consists of a fine intergrowth of fluorspar and silica, which is difficult to process to a saleable product. The feasibility of bringing the mine back into production is reviewed on an annual basis as part of overall mines development planning.

The nature of the fluorspar-barytes mineralisation as sub-vertical veins and associated replacement deposits in limestone means that open pit workings are long and narrow. The development of safety benches requires that some associated limestone is disturbed but the industry minimises this as part of the open pit design process and uses the limestone for restoration.

All of the ore is processed at the Cavendish Mill, near Stoney Middleton. The ore varies significantly in its physical character and grade and requires blending to ensure, as far as possible, a homogeneous and optimum feed to the plant. Blending also allows a balance to be made between the higher cost ore from underground mining and more distant surface operations, and local, lower cost surface ore. Current fluorspar ore requirements are some 400,000 t/y. The typical feed grade is 28% CaF_2 , 8-9% BaSO_4 and <1% Pb.

Processing the ore at Cavendish Mill involves crushing, washing and heavy media separation, and finally froth flotation to produce a high purity acid-grade fluorspar (> 97% CaF_2) product.

HF is produced by heating acid-grade fluorspar and concentrated sulphuric acid. Typically about 2.2 t of acid spar are required per tonne of HF produced. Deleterious impurities in fluorspar are silica, carbonates, sulphides, arsenic and phosphorus. Silica is particularly undesirable as it causes losses in the yield of HF. Arsenic levels also need to be below 3 ppm. UK fluorspar is of consistently high quality and is preferred by the UK HF producers. It can also be used to blend away lower quality imported material.

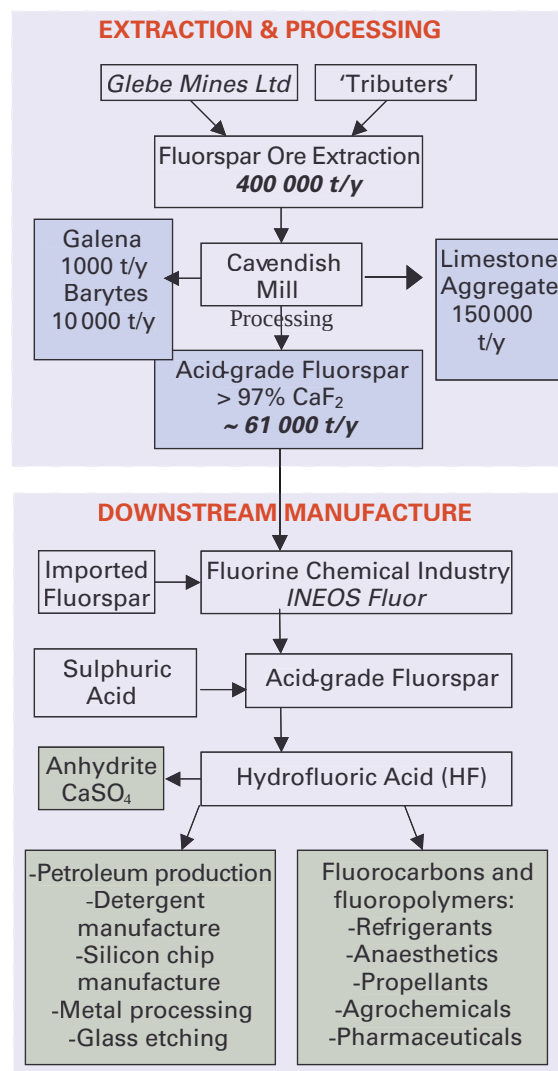


Figure 4 Fluorspar supply chain, 2005.

The fluorspar supply chain is summarised in Figure 4.

By-products

Barytes and lead concentrates are by-products of fluorspar processing. The barytes (92-95% BaSO_4) is sold locally for valued-added processing to a finely ground product for filler applications in paints and plastics. Some is sold for use in oil well drilling fluids. The Cavendish Mill is the only source of barytes in England (see Factsheet on **Barytes**).

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The lead concentrate is also the only source of lead in the UK and is sold locally.

Limestone is also recovered as a by-product of fluorspar processing and is sold as secondary aggregate.

Alternatives/recycling

Fluorspar is essentially consumed in use and recycling or reuse is not usually feasible.

Small amounts of calcium fluoride are recovered from the waste streams in HF manufacture and recycled. Some limited recycling of HF is feasible in downstream applications.

Fluosilicic acid, a by-product of the manufacture of phosphoric acid for fertiliser production, is used as a limited source of fluorine in some countries for uses other than HF production. Phosphoric acid will continue to be produced for the foreseeable, although there is no production in the UK. However, fluosilicic acid is not currently seen as a cost effective alternative to fluorspar for HF manufacture.

Effects of economic Instruments

The nature of the fluorspar mineralisation as sub-vertical veins and replacement deposits in limestone means that the associated extraction of limestone is often unavoidable. This limestone is obtained in two quite distinct ways. During openpit extraction, limestone is produced as waste rock and material that is not used in restoration is crushed, screened and sold as aggregate. This material is subject to the Aggregates Levy of £1.60/t. Although as much as possible of the coarse limestone is removed from the ore prior to transfer to the Cavendish Mill, significant quantities still remain. This limestone is separated from the rest of the ore in the heavy media process and is sold as a low quality secondary aggregate, providing an additional income stream. This limestone is exempt from the Aggregates Levy.

More than a decade of anti-dumping measures imposed on Chinese fluorspar imports into the European Union ended in September 2005. The duty was imposed to ensure that the EU's

fluorspar industry remained viable. However, reduced availability of Chinese fluorspar and rising prices has put the price of fluorspar well above the minimum import price.

Planning issues

Fluorspar resources in England are found exclusively in mineralised veins in Carboniferous limestones. These limestones tend to form attractive scenery with considerable ecological significance and amenity value. The veins are linear in form and can extend over considerable distances, often in elevated and/ or highly visible locations.

Almost all permitted reserves in the Southern Pennine Orefield lie within the Peak District National Park. The fluorspar industry thus operates in a very sensitive area. The now defunct operations in the Northern Pennine Orefield lie exclusively within the North Pennines AONB.

Surface working of fluorspar and other vein minerals, especially to significant depths, raises issues of surface limestone storage and possible sale as aggregate. Some sites may be located in places where limestone working would not normally be permitted. Both the Peak District National Park Authority and the industry are seeking to minimise any associated production of limestone.

Fluorspar is different from most of the other industrial minerals produced in the UK in that deposits are more difficult to identify and evaluate. In addition, individual deposits tend to be relatively small and isolated. A continuous programme to identify and evaluate new deposits and progress them through the planning process is required to maintain an adequate reserve base. However, operations tend to have a short life when compared with other industrial mineral workings and, due to their limited extent, are often easier to integrate back into the landscape.

There are permitted resources of fluorspar which are accessible by underground mining, and there is scope for further deposits being identified at depth. However, the high cost of

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proving underground reserves, together with the high cost of this method of extraction (which also requires relatively high grade ore) means that future commercial interest is likely to be confined to sites suitable for surface extraction. However, the feasibility of increasing underground extraction is being considered.

There is a chance that operators of small-scale, short-term fluorspar workings in environmentally acceptable locations may discover more extensive resources that are capable of further excavation, either laterally or in depth. Extensions to operations may then have the effect of increasing the scale of the activity and prolong development longer than was originally intended. This may, sometimes, be less environmentally acceptable than when permission was first granted. There are also a number of planning permissions for vein minerals in the Peak District National Park which were granted many years ago with operating and restoration conditions that are inadequate by modern standards. The reactivation of some of these would have significant environmental effects. However, the industry has sought to consolidate old permissions to remove any ambiguity on how they are worked. This has resulted in modern conditions of working and, importantly, restoration to be agreed where formerly there were none.

Fluorspar has economic importance well beyond the extraction locations. It has a downstream value far in excess of the value of crude production as an essential raw material for the

UK fluorine chemical industry. With constraints on world supplies of fluorspar, access to an indigenous source of supply is very important to the future of fluorochemical manufacturing in the UK.

Authorship and acknowledgements

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