Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Fluorspar

This factsheet provides an overview of ***fluorspar*** *supply in the UK. It forms part of a series on economically important minerals that are extracted in Britain and is primarily intended to inform the land use planning process. It is not a statement of planning policy or guidance; nor does it imply Government approval of any existing or potential planning application in the UK administration.*

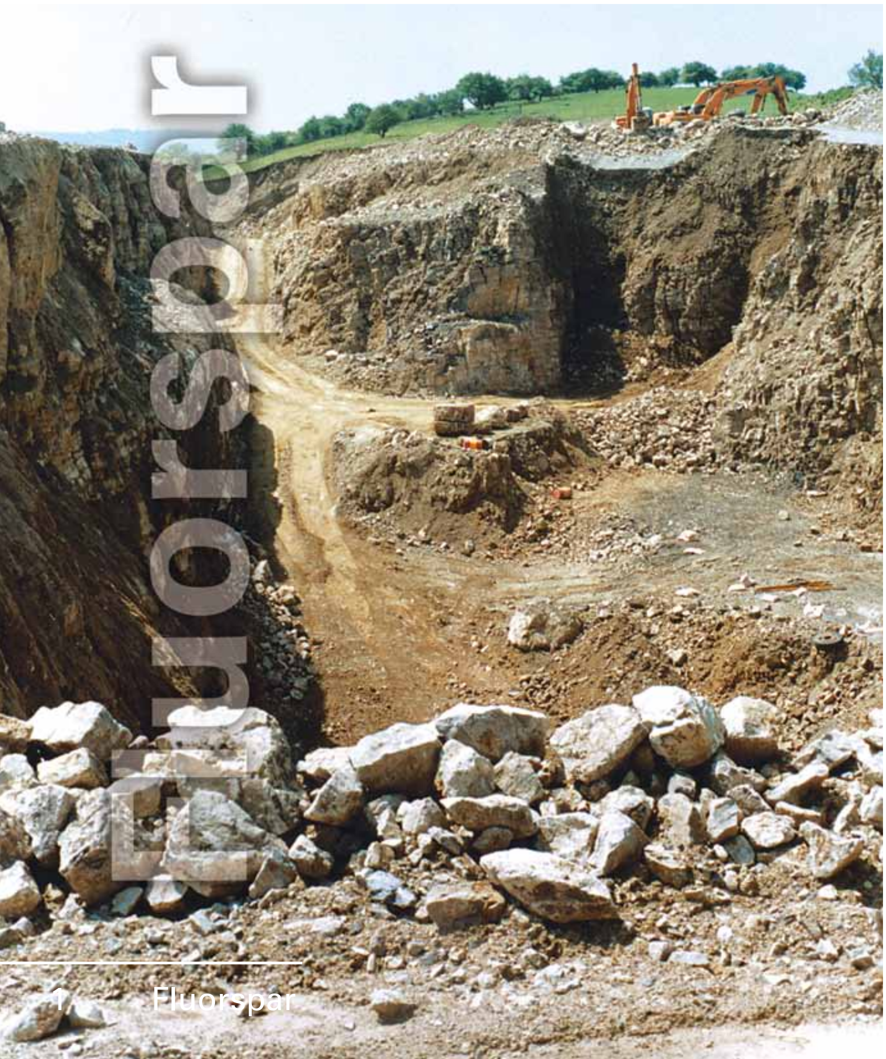
March 2010

Fluorspar is a commercial term for the mineral **fluorite** (calcium fluoride, CaF_2) which, when pure, contains 51.1% Ca and 48.9% F. It 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 in the production of **hydrofluoric acid (HF)**, the starting point for the manufacture of a wide range of fluorine-bearing chemicals.

Markets

Acid-grade fluorspar is a critical raw material for the UK fluorochemicals industry. Virtually all UK production 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 speciality fluorine-bearing chemicals, notably fluorocarbons.

Fluorspar working in Derbyshire.



Demand for fluorspar in the UK is principally driven by demand for HF and associated fluorochemical production. Historically this was for chlorofluorocarbon (CFC) production, widely used in aerosols and refrigeration. CFC production was banned in developed countries from 1996 because of its ozone-depleting effects. This resulted in a decline in demand for HF and, consequently, fluorspar. CFCs were replaced by hydrochlorofluorocarbons (HCFCs), although these still had some ozone-depleting effects. Consequently manufacturers developed hydrofluorocarbons (HFCs) which are chlorine-free and have no impact on the ozone layer.

Fluorocarbons have two main applications: 1. in foam blowing, a technique for treating plastics to improve their insulation properties; and 2. in cooling, freezing or other heat transfer processes including domestic and industrial refrigeration and air conditioning. Fluorocarbons are also used as a feedstock for fluoropolymer production, which is generally increasing globally. Fluoropolymers are used for a wide variety of coatings due to their unusual properties such as fire resistance, resistance to chemical attack, insulation and low resistance to movement. Consequently they are used for insulating wires and cables, in non-stick cookware and for waterproofing textiles The primary fluorocarbons produced in the UK are HCFC-22, extensively used in the production of polytetrafluoroethylene (commonly known as Teflon®) and HFC-125, a component in a blend of chemicals needed to produce refrigerants.

HF is supplied to home and export markets for the manufacture of a wide range of products. It is a critical chemical for the electronics industry in the manufacture of semi-conductors. HF is required for the processing of metals, including aluminium, stainless steel and uranium for nuclear fuel. HF is also used in the refining of crude oil.

Fluorine derived from fluorspar also has a wide range of uses in pharmaceutical, medical and consumer products including antibiotics, anaesthetics, asthma inhalers and toothpaste. HF is also used in the production of insecticides, herbicides and a wide range of cleaning products including detergents.

Metallurgical-grade fluorspar is used as a flux (to reduce melting temperature and remove impurities) in steelmaking. This is a relatively minor market in the UK.

Supply

36 801 tonnes of acid-grade fluorspar were produced in the UK in 2008. 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

The main fluorspar-producing countries are China, Mexico, Mongolia and South Africa. World production of fluorspar was 5.7 million tonnes in 2007 and China is the dominant producer accounting for about 57% of the total. China continues to restrict fluorspar exports. As a consequence, supply of high-quality fluorspar to the open market remains relatively tight. In China there is now greater encouragement for domestic added-value use in HF manufacture. In addition HF exported from China is subject to 15 per cent export tax.

Prior to the mid-1980s the UK was a net exporter of fluorspar but subsequently became a net importer as indigenous supplies became less competitive. UK imports of acid-grade fluorspar are now only from Spain because of the elevated levels of heavy metals and phosphorus in fluorspar from other sources. Imports of metallurgical fluorspar are chiefly from Mexico and China.

Consumption

UK consumption of fluorspar is shown in Table 1. Acid-grade fluorspar is believed to account for almost all of the fluorspar consumed, with a very minor amount used in steelmaking, comprising imported metallurgical grade fluorspar.

	2005	2006	2007
Total UK consumption	**56150 tonnes**	**53845 tonnes**	**48222 tonnes**
Domestic sales	56417 tonnes	49676 tonnes	44939 tonnes
Net imports	0 tonnes	4169 tonnes	3286 tonnes

Table 1 UK Consumption of fluorspar. *(imports include both acid-grade and metallurgical grade). Source: HM Revenue & Customs.*

Economic importance

Production of fluorspar and associated minerals in the Peak District generates turnover of about £8 million a year and employs about 65 people. The fluorine chemical industry, which relies on UK fluorspar as a raw material for HF and fluorochemical manufacture, is of much greater economic significance, with a turnover of £100 million and employing some 250 people.

Structure of the industry

Glebe Mines Ltd is the only producer of fluorspar in the UK and is owned by the UK-based chemical manufacturer INEOS. In February 2010, INEOS announced the sale of its fluorine chemical plant at Runcorn in Cheshire to the Mexican-owned chemical producer Mexichem. Glebe Mines remains under INEOS ownership.

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 fluorspar in the UK.

Currently, the sole consumer of acid-grade fluorspar from this operation is the HF and fluorochemicals manufacturer of fluorochemicals with its headquarters and main manufacturing facility in Runcorn (see above and Figure 2). This site produces a range of fluorochemicals including HFC 134a, which is a replacement for CFCs and HCFCs, and relies almost entirely on fluorspar produced in England.

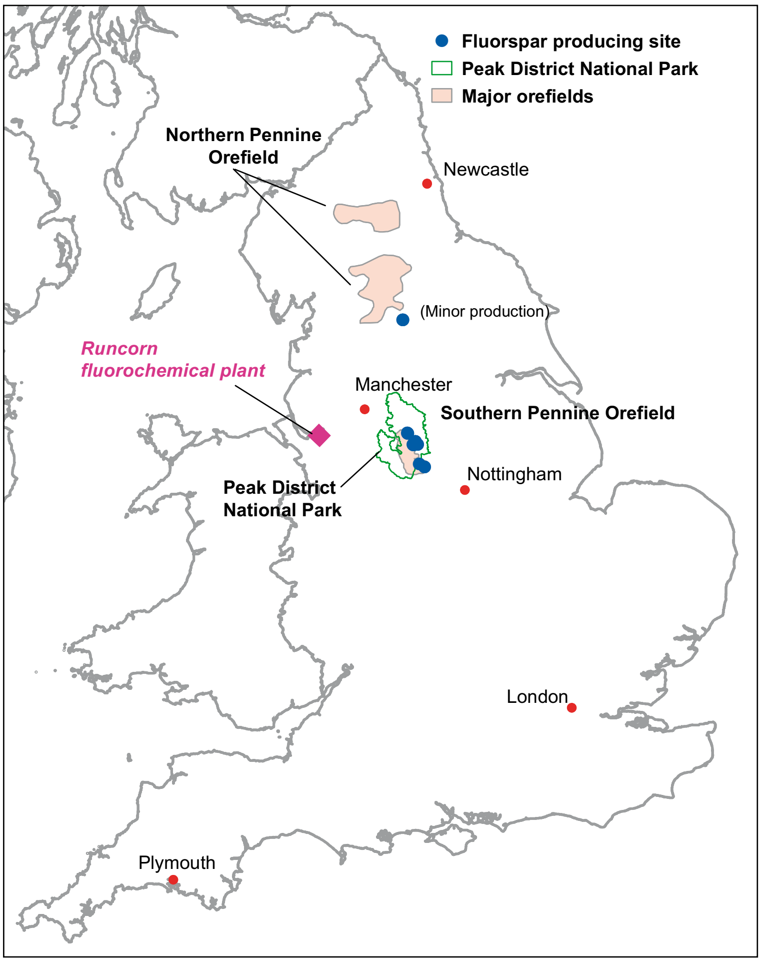


Figure 1 Location of fluorspar mineralisation and main fluorspar consumer in England.

Resources

Fluorspar resources are restricted to two areas in the UK: the Southern and Northern Pennine orefields (Figure 1). 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 2).

In the Peak District, mineralisation is largely confined to the eastern half of the limestone outcrop. The fluorspar-barytes-lead 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 extends under cover to the east, deposits can only be accessed by underground mining. However, new mines are not likely to prove economically viable for the foreseeable future.

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 5000 tonnes up to 1 million tonnes and a significant 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 minerals.

Reserves

Reserves of fluorspar available to the sole operator principally reside in a small number of planning permissions for open-pit and underground extraction, all of which fall within the Peak District National Park. The natural variability of fluorspar mineralisation described above, unpredictability resulting from a long history of surface and underground working, together with variations in the cost of extraction, processing and the global price of fluorspar, makes it difficult to measure precise reserve figures. The reserve estimates given below were made in October 2009.

A total of 1 215 000 tonnes of ore are accessible by open-pit working at Tearsall, Peak Pasture and High Rake. Consent for extraction at Tearsall was granted in 2009 for a duration of 6 years and working is likely to begin in 2010. High Rake is close to exhaustion and consent for extraction comes to an end in 2010. There is currently no working at Peak Pasture.

About 3 000 000 tonnes of fluorspar ore are accessible from underground mines at Milldam and Watersaw West. Neither mine is currently operating. Glebe Mines is working toward re-opening Milldam Mine where the bulk of these reserves are located and which is permitted until the end of 2013. Watersaw has planning consent for extraction until 2015.

Planning consent is being sought to allow reworking of up to 4 20 000 tonnes of tailings from the No1 tailings dam close to Cavendish Mill to recover fine-grained fluorspar. This material is fine-grained and has a high moisture content which limits the capacity of the processing plant to accept no more than about 10% of this material as total throughput.

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 2). Almost all permitted reserves are located within the National Park.

Extraction and processing

Historically ore has been derived from open pit and underground mines, with some of the open pit operations being worked by independent tributers. Fluorspar extraction is now almost entirely by open pit methods although the sole operator is now moving toward re-opening Milldam Mine at Great Hucklow.

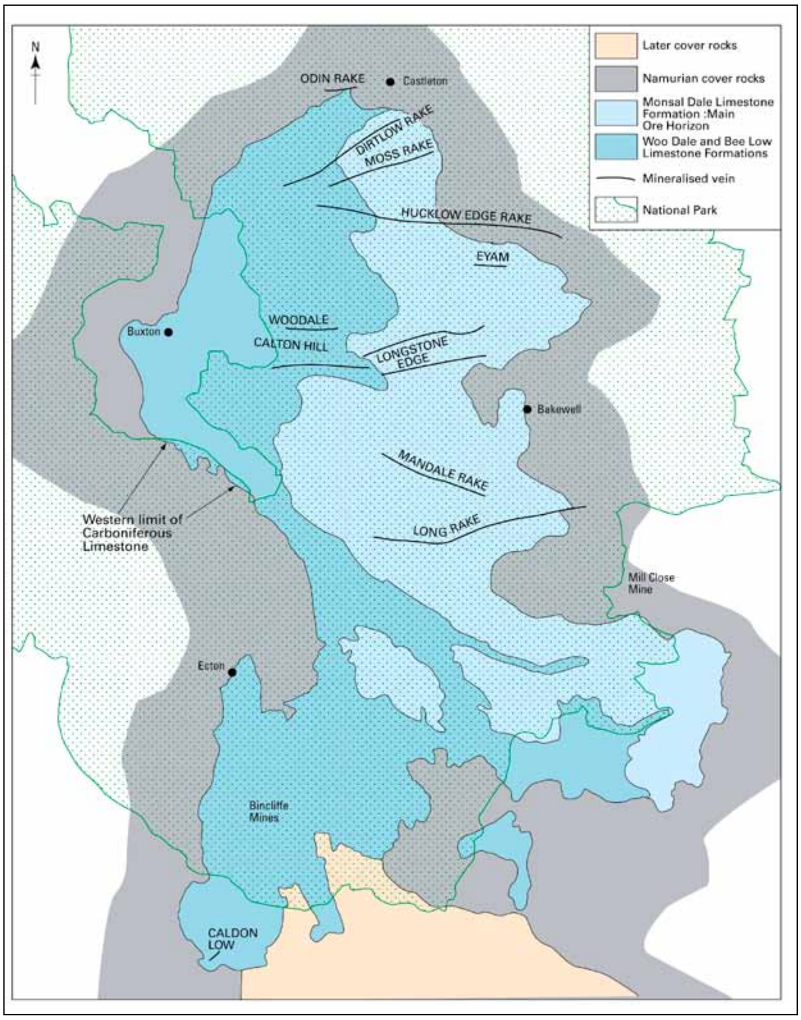


Figure 2 The Southern Pennine Orefield.

The morphology of the fluorspar-barytes mineralisation in 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 removed. In practice the industry minimises this through the design of the open pit 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 higher cost ore from underground mining and more distant surface operations, and local, lower cost surface ore and reprocessed tailings. Current fluorspar ore requirements are up to about 400 000 t/y, depending on ore quality. 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 tonnes of acid grade fluorspar 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 should also be below 3 ppm.

The fluorspar supply chain is summarised in Figure 3.

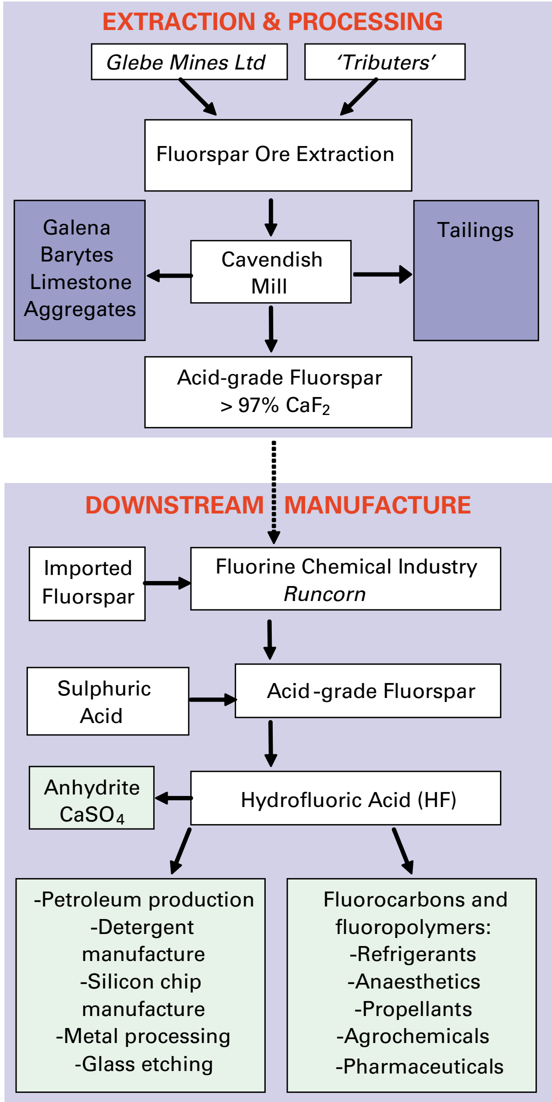


Figure 3 Fluorspar supply chain.

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 now the only source of barytes in England (See Factsheet on **Barytes**).

The lead concentrate is currently the only commercial source of lead ore in the UK.

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

Alternatives and 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 phosphate fertiliser production, is used as a minor source of fluorine in some countries for uses other than HF production. Phosphoric acid will continue to be produced for the foreseeable future, 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 open pit extraction, limestone is produced as waste rock. Most of this material is used in restoration, although some may be crushed, screened and sold as aggregate. This material is subject to the Aggregates Levy of £1.95/tonne. 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, the reduced availability of Chinese fluorspar and rising prices has put the price of fluorspar well above the minimum import price.

Planning issues

Coincidence with environmental and landscape designations — Fluorspar resources in Britain are found exclusively in mineralised veins in Carboniferous Limestone. 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.

Limestone working and stockpiling — 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.

Scale of working and identification of reserves — 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 adequate reserves.

Underground mining —There are permitted resources of fluorspar which are accessible by underground mining, and there is potential for further deposits to be identified at depth. However, the high cost of proving underground reserves, together with the high cost of this method of extraction (which also requires relatively high grade ore), are significant issues in assessing the viability of such operations.

Old mineral permissions —There is a chance that operators of small-scale, short-term fluorspar workings in environmentally acceptable locations may discover more extensive resources that may be accessible through further excavation, either laterally or in depth. Extensions to operations may then have the effect of increasing the scale of the activity and prolonging 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 may only go ahead after a review of these permissions to ensure that operating and restoration conditions reflect modern environmental standards.

Fluorspar

Tailings dams — Fine-grained waste material which remains following the separation of fluorspar and barytes, galena and limestone by-products must be stored in tailings dams. These relatively large, visually-intrusive structures are essential to allow the tailings to dewater over a number of years. Dewatered material from older dams is used extensively to backfill exhausted open-pits.

Authorship and Acknowledgements

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Mineral Planning Factsheets for a range of other minerals produced in Britain are available for download from www.mineralsUK.com

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http://www.bgs.ac.uk/downloads/start.cfm?id=1357