Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Fireclay

*This factsheet provides an overview of **fireclay** 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.*

October 2006

Fireclays are sedimentary mudstones that occur as the 'seatearths' that underlie almost all coal seams. Seatearths represent the fossil soils on which coal-forming vegetation once grew and are distinguished from associated sediments by the presence of rootlets and the absence of bedding. Fireclays are, therefore, mainly confined to coal-bearing strata and are commonly named after the overlying coal seam. The term 'fireclay' was derived from their ability to resist heat and their original use in the manufacture of refractories for lining furnaces. Today the term 'fireclay' is used to describe seatearths that are of economic interest, irrespective of their refractory properties. They are mainly used in the manufacture of structural clay products, principally high-quality facing bricks (see **Brick Clay** factsheet). Fireclays are typically thin (normally <1 m, although rarely >3m) and are composed of the clay minerals kaolinite and hydrous mica (illite), together with fine-grained quartz in varying proportions; kaolinite is the key component. Typically these three minerals make up some 90% of the rock and their relative proportions, together with the amount and type of impurities present (carbon, sulphur and iron), greatly influences their ceramic properties. Fireclays are similar in basic composition to **ball clays** (see **Ball Clay** Factsheet). However, because of their much greater geological age they are not as plastic as ball clays and they are also not as light-firing, because of a higher iron content. These are the two principal properties for which ball clays are valued.

Buff-coloured chimney pots made from fireclay.

Demand

Fireclays were originally valued as refractory raw materials because of their relatively high alumina and low alkalis contents, which are related to the presence of kaolinite (the higher the alumina and lower the alkalis contents, the more refractory the clay). They were formerly widely used in the production of firebricks and other refractory goods. However, demand for refractory use has declined markedly in recent decades due to changing technology, notably in the iron and steel industry, and the severe operating conditions that modern refractories now have to withstand. Only very minor quantities of fireclay are now used for refractory applications. Consequently the demand for highly refractory fireclays is small.

The major use of fireclays is now in brickmaking. The suitability of a fireclay for brickmaking (or other ceramic use) depends on its behaviour during shaping, drying, and firing, and during its subsequent use. This largely depends on its composition. In contrast to other brick clays, which are normally red-firing due to the presence of significant amounts of iron oxides, fireclays have relatively low iron contents. Consequently they are now primarily valued for the production of buff-coloured facing bricks and pavers. These provide greater choice and style for architects and developers and contribute to good urban design in character with the surroundings. Bricks made from fireclay also exhibit superior technical properties, such as strength and durability (frost resistance), which is a function of their mineralogy and, specifically, the presence of the clay minerals, kaolinite and illite. Of the total production of bricks of roughly 3000 million a year, approximately 10% are buff or pale bodied and contain a proportion of fireclay. The demand for buff coloured bricks is likely to remain steady. Fired colour is the main criterion on which the suitability of a fireclay is judged for facing brick manufacture. Iron oxide contents should normally

be less than 2.5–3.0% Fe_2O_3 and on firing the fireclay should give a uniform buff/cream colour. Blending does allow lower quality clays to be used but is dependent on the availability of a range of clays. Carbon and sulphur are common impurities and should normally be less than 1.5% and 0.1% respectively.

Fireclays are also used in more specialised building products such as chimney pots, flue liners and firebacks, and pipe/drainage ware. In the manufacture of clay drainage pipes and fittings, fireclay is normally used as a blend with other clays. Fireclays improve the plasticity of the feed, assisting the extrusion process, and because fireclays are more refractory than normal brick clays, they extend the vitrification range (the temperature over which clay begins to partially fuse), thus providing greater control over the firing process. Fireclays also enhance fired strength and minimise porosity, both of which properties are essential for sewerage and drainage applications. Small amounts of fireclay are also used in the manufacture of stoneware pottery, sanitaryware and chemically resistant ware.

Minor quantities of fireclay are used to produce holloware (refractory pipes) for casting in the foundry industry, for making a refractory lightweight aggregate, and very minor quantities of siliceous fireclay is used in the manufacture of glasshouse pots. These are large crucibles used for melting glass for the handmade and crystal glass industries. Some low quality fireclays may be used for lining landfill sites.

Supply

Fireclays formed the basis of an important extractive industry in Britain in the 19th and first half of the 20th centuries. Production was from most coalfields and almost all of the output was from small underground mines, many of which produced fireclay exclusive of coal. The introduction of opencast coal mining during the Second World War provided the opportunity for fireclay to be recovered by surface mining in association with coal. This, together with the decline in demand for fireclay in its traditional uses, resulted in the progressive closure of underground fireclay

Donnington Island coal and fireclay site, South Derbyshire Coalfield in 1980.

mines which are uneconomic in present circumstances. One small mine remains, but this works a very specific fireclay for the captive manufacture of a high value-added refractory product.

The close association of coal and fireclay means that the two minerals are normally produced together, either from operating opencast coal mines and, more importantly, stockpiles of fireclay derived from former opencast sites. Current and future fireclay supply is crucially dependent, therefore, on the future of the surface coal mining industry by making available clay that would not likely be economically recoverable. Fireclay is a low priced mineral but being worked with coal has mainly offset the costs of extraction. However, a critical factor in sustaining opencast coal production is a continuing supply of new planning permissions to replace depleted reserves. In England this has not been the case with a consequent decline in opencast coal output.

National planning policy urges the examination of the potential for fireclay recovery at proposed opencast coal sites and the safeguarding and stockpiling of resources. However, only a small proportion (less than 20%) of surface coal

Fireclay

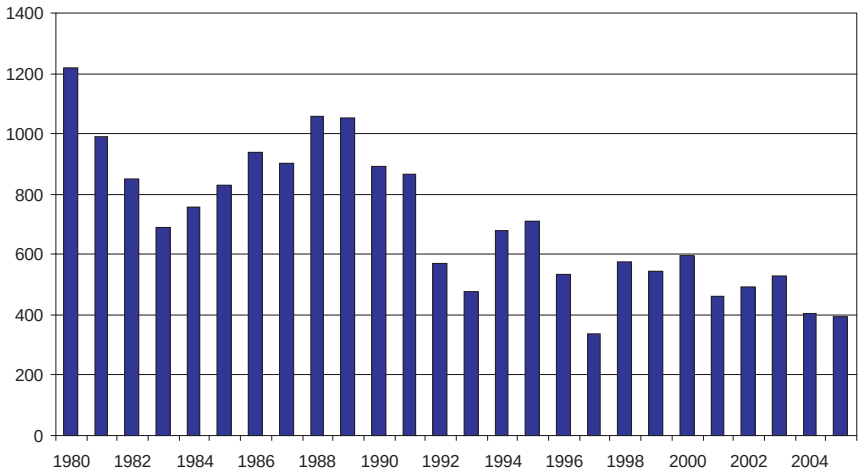

Figure 1 Great Britain: Sales of fireclay, 1980–2005.
Source: United Kingdom Minerals Yearbook, British Geological Survey

mining sites normally produce fireclay. This is due to the poor quality of many fireclays, but may also be the result of operational or planning restrictions. However, the size and speed of surface mining invariably creates a mismatch between potential supply and immediate market demand. Unless marketable fireclays can be stockpiled, either on or off site, they are usually backfilled with overburden and thus irrecoverably lost.

Sales of fireclay in Great Britain are shown in Figure 1. There has been a significant decline in production since the 1950s due mainly to the fall in demand for fireclay as a refractory raw material. Fireclay output has historically been dominated by England, which accounted for 88% of sales of 395 000 tonnes in 2005. The balance (49 000 tonnes) was from central Scotland. There is no production in Wales and Northern Ireland.

In England fireclay sales in the last 25 years have been dominated by the South Derbyshire Coalfield where an unusual concentration of coal and fireclay seams occur. In the 1970s to early 1980s large quantities of fireclay were selectively extracted with the coal but stockpiled separately according to clay quality (mainly by seam). The principal source of these fireclays was the Donington Island site, near Swadlincote which is where the current stockpiles are located. Originally some 7 million tonnes of fireclay were stocked, although about 2 million tonnes of poor quality clay was subsequently used for restoration. Significant quantities of fireclay have also been recovered from other sites nearby. Leicestershire has, therefore, dominated fireclay supply for many years and in 2005 the county accounted for about 31% of total sales in England. Other important sources have been the Northumberland and Durham coalfields in the north-east and the Coalbrookdale Coalfield in Shropshire. The latter has recently re-emerged as an important source of supply.

The collection of data on fireclay sales is complicated by a number of factors and the reliability of the data has been questioned. Fireclay is primarily a by-product of opencast coal and sites often have short lives. Although most sites do not produce fireclay, others may do so only intermittently and these sales may not be identified. Similarly sales of fireclay from all stockpiles may not be registered by the *Annual Minerals Raised Inquiry* carried out by the Office for National Statistics, because they may not be recorded as mineral sites. Recording fireclay output, and more importantly actual sales has, therefore, proved difficult. Official statistics place recent fireclay sales in the range 400 000 to 600 000 tonnes a year. An independent survey of fireclay consumed by brick plants was carried out by the BGS in 1998 in connection with a study on *Brick clay: Issues for planning* on behalf of the then Department of Transport, Local Government and the Regions. Fireclay consumption in brick manufacture alone was 625 000 tonnes compared with total recorded output of 577 000 tonnes in 1998. It should not be assumed, therefore, that data collected by the *Annual Minerals Raised Inquiry* provides a precise indication of the size of the fireclay market.

Trade

International trade in fireclay is negligible.

Consumption

Fireclay is principally consumed as brick clay in the manufacture of buff-coloured facing bricks. In 1998 fireclay consumption in brick

manufacture was estimated to be about 625 000 tonnes. The market for fireclay is likely to fluctuate from year to year but it is estimated that total consumption, including in uses other than brickmaking, is in the range 500–600 000 tonnes a year.

Economic importance

The value of fireclay sales on an ex-quarry basis is small and placed at around £3.8 million in 2005. However, almost all fireclay is used in the manufacture of value-added structural clay products, notably bricks, pipes and related building products and, on a much smaller scale, refractory products. Continuing fireclay supplies help to underpin these important downstream industries which provide essential building products for the construction sector, as well as sustaining employment. The value of sales of structural clay products is shown in Table 1, although only a small proportion of these sales will be fireclay based.

Structure of the industry

Clay building bricks	£523 million
Other clay construction products	£16.6 million
Clay pipes	£45.9* million

Table 1 UK: Sales of selected structural clay products, 2004. (*2003)
Source: Product Sales and Trade, Office for National Statistics

There are very few companies that exclusively produce fireclay on a continuous basis, either for their own captive use or for external sale. A long-term source of fireclay has been the Donington stockpiles in Leicestershire which are owned by a consortium of companies. The most important suppliers from this site are Hepworth Building Products and Ibstock Brick, although Redbank Manufacturing Co Ltd also supplies clay. The Broseley Fireclay Co Ltd, with a site at Caughley in Shropshire, has recently become a major supplier. Ibstock Brick, the previous owners, are still removing clay stocks from the Caughley site. A number of clay factors market fireclay on behalf of the main producers.

Other suppliers/producers are:

Potclays Ltd, Staffordshire
Naylor Drainage Ltd, South Yorkshire (own use)
Parkinson-Spencer Refractories Ltd, West Yorkshire (own use)

A number of opencast coal sites operated by companies such as UK Coal and H J Banks in England, and The Scottish Coal Company in Scotland have the potential to produce fireclay.

There are four companies manufacturing bricks in Scotland, however, the volume of fireclay used relative to other materials is difficult to establish. Caradale Traditional Brick Ltd and Ibstock Brick produce fireclay in Lanarkshire and Ayrshire and Raeburn Brick operate a fireclay site in Lanarkshire.

The *British Ceramic Confederation* is the trade association for the ceramic manufacturing industry and deals with, amongst other topics, issues related to raw materials supply. The *Brick Development Association* is the trade association for the brick sector and deals primarily with technical standards, marketing and bricks in use. *The Confederation of UK Coal Producers* (CoalPro) is the trade association for the coal industry including opencast coal producers.

Resources

The close association of coal and fireclay means that fireclay resources are mainly confined to coal-bearing strata. In Britain economically important coals principally occur within the Coal Measures Group of Carboniferous age. A characteristic feature of Coal Measures strata is the pronounced cyclicity of the sedimentation, with coal seams and seatearths appearing at irregular intervals. The occurrence of potential fireclays as usually relatively thin, widely-spaced beds in close association with coal seams means that surface coal mining operations provide one of the few viable sources of the clay. Fireclay resources in Britain are, there-

Fireclay

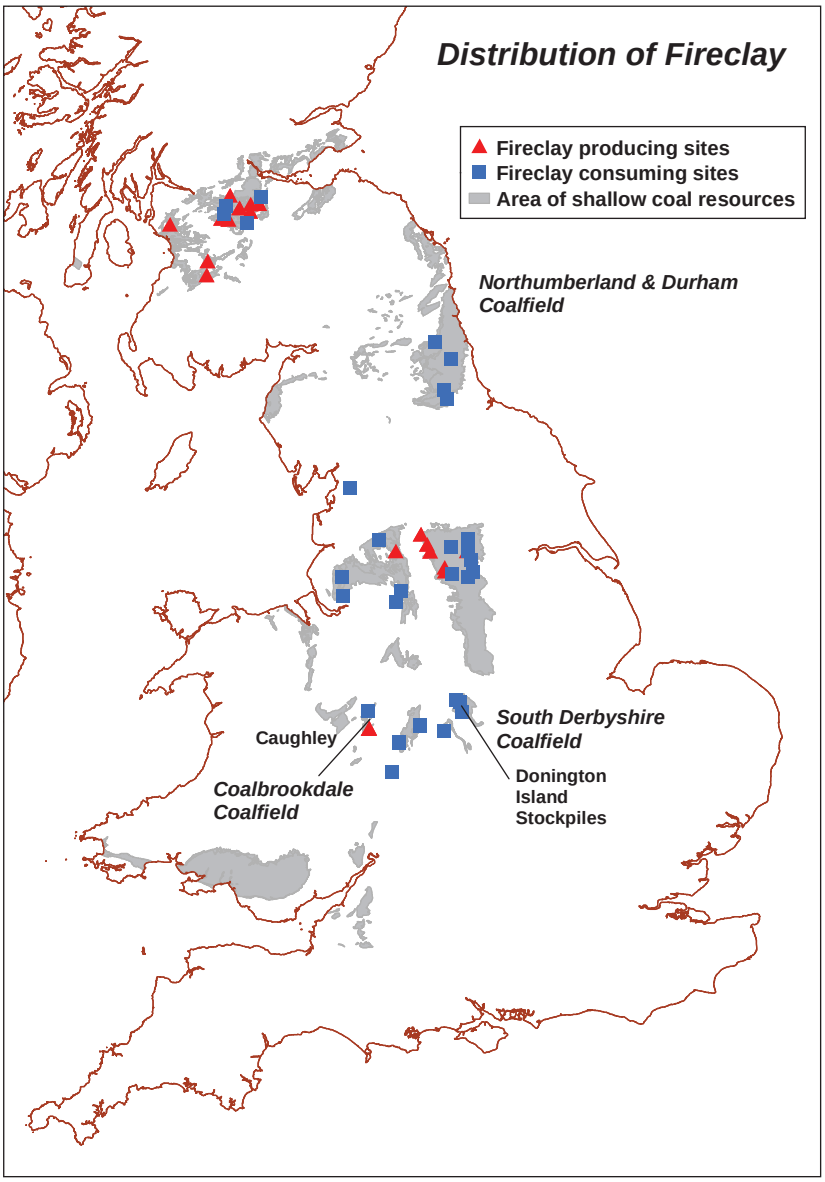

Figure 2 Distribution of shallow coal resources and brick plants consuming fireclay.

fore, with few exceptions largely coincident with shallow coal resources (Figure 2).

Although fireclays occur in similar geological environments they exhibit a wide range of mineralogical compositions. Seatearths may also exhibit rapid vertical and lateral variations in composition. All are contaminated to a greater or lesser extent by impurities, which render part, or the whole, of a seam unusable. Siderite (iron carbonate) and carbonaceous matter, present as coaly matter and fossil debris, are common constituents. They may represent serious impurities in commercial fireclays and restrict their use. Iron affects fired colour and can cause 'spotting' whilst carbon causes firing problems. Sulphur, in the form of pyrite, causes problems with emissions. Consequently only a proportion of seatearths have the desirable properties to be considered as commercial fireclays and production has tended to be localised.

The South Derbyshire Coalfield in Leicestershire, the Coalbrookdale Coalfield in Shropshire, the Durham and Northumberland coalfields and, to a lesser extent the Yorkshire Coalfield have been the principal sources of fireclay in England. Modest quantities of fireclay have also been produced in Scotland. Some thick and highly refractory fireclays, with no associated coal, were formerly mined in Scotland but these are no longer of economic significance. A highly siliceous fireclay (the Halifax Hard Bed) is also worked on a very small scale near Halifax for the manufacture of glasshouse pots.

In the South Derbyshire Coalfield, and in sharp contrast to Coal Measures strata elsewhere, an unusually high concentration of thick fireclays occurs in the Pottery Clays of the Pennine Upper Coal Measures. The fireclays are associated with thin coals within a thickness of a 100 m or so of strata and each coal seam, and its associated fireclay, is numbered in descending order with the prefix 'P'. The base of the Pottery Clays is taken at the P40 coal. The high concentration of relatively thick fireclays has meant that during former and recent opencast coal operations very large tonnages of fireclay have been extracted and stockpiled for future use. The largest site was Donington Island which ceased coaling in 1984. More recently additional quantities of fireclay were stocked from an adjacent site. Some of the lower quality fireclays have been used for site restoration but the remaining stockpiles are the principal source of fireclay in Britain. Substantial quantities of fireclay were also produced from the nearby Hicks Lodge opencast site, which closed in 2004. However, fireclay recovery was

restricted to the life of the site and no stocks remain. There are some remaining resources of fireclay within the Pottery Clays.

The Coalbrookdale Coalfield has historically been an important, long-term source of fireclay. Whilst to the north of the Severn the coalfield has been largely exhausted, to the south of the river, fireclay and coal have been produced for many years at the Caughley Quarry, near Broseley. Here a concentration of fireclays occurs in 20 m or so of strata within the Lower Coal Measures, between the thick fireclay to the Little Flint Coal and the New Mine Coal.

A highly siliceous fireclay (the Halifax Hard Bed) is worked on a very small scale near Halifax.

Modest quantities of fireclay are also produced from the Carboniferous coalfields in the Midland Valley of Scotland mainly as a by-product of opencast coal extraction. Some thick and highly refractory fireclays, with no associated coal, were formerly mined in Scotland but these are no longer of economic significance.

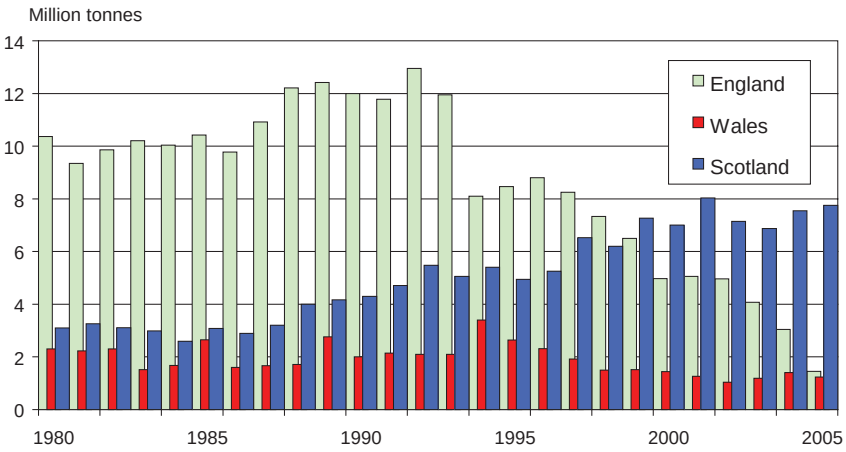

Figure 3 Great Britain: Opencast coal production, 1980 – 2005
Source: The Coal Authority

Reserves

In mineral planning, the terms 'reserves' or 'mineral reserves' refer to mineral that has a valid planning permission for extraction. Without a valid planning permission no mineral working can legally take place. There is no definitive information on the size of permitted reserves of fireclay in Britain. In the course of preparing their development plans, Mineral Planning Authorities are required to undertake assessment of reserves for their areas. However, it may not be possible to publish such data due to commercial confidentiality concerns, although reserves may be otherwise identified in planning applications. Stockpiles of fireclay at the Donington Island site in Leicestershire, which were originally built up in the 1970s and early 1980s, have been a major element of fireclay supply. Permitted reserves on stock are about 1.5 million tonnes, equivalent to 5 to 12 years supply depending on clay quality (based on individual seams). However, the current planning permission for the site expires in 2013. At the Caughley Quarry in Shropshire permitted reserves of fireclay, and associated clays, are about 2 million tonnes, equivalent to about 8 years supply at current rates of production. Exploration of an easterly extension to the site has identified even larger resources of fireclay and, additionally, red-firing clays. The Caughley area is now the most important source of buff-firing fireclays in Britain. Elsewhere clearly defined reserves of fireclay are probably small.

Year ending	2004	2005
	Thousand tonnes	
England	4 744	3 090
Scotland	12 015	6 037
Wales	36 557	29 202
TOTAL	53 315	38 329

Table 2 Great Britain: Total permitted reserves of opencast coal in worked and unworked sites, 2004 and 2005.
Source: The Coal Authority

Permitted reserves of opencast coal up to the end of December 2005 are shown in Table 2. However, there is no direct relationship

Fireclay

between opencast coal reserves and fireclay reserves, as most opencast coal sites do not produce fireclay. Commercial fireclays have a more restricted distribution, as the majority of seatearths will not be of marketable quality. More importantly, the market for fireclay is principally in England and it is opencast coal sites in England that have been the principal source of fireclay. Virtually no fireclay has been obtained from opencast coal sites in the South Wales Coalfield and comparatively little from Scottish sites. The current uncertainty about the future of the opencast coal industry in England is thus a major concern to the brick and fireclay industries.

Figure 3 demonstrates the significant decline in opencast coal production in England, which has implications for future fireclay supply.

Relationship with environmental designations

Areas of fireclay resources do not generally coincide with national landscape designations such as National Parks and Areas of Outstanding Natural Beauty. For the most part nature-conservation designations also do not occur extensively in fireclay resource areas.

Extraction and processing

Fireclay extraction is not normally commercially viable on its own and almost all production (except that recovered from existing stockpiles) is as a co- or by-product of opencast coal production. However, only a small proportion of opencast coal sites will have associated fireclay recovery. Fireclays (except that beneath the lowest excavated coal) form part of the overburden in opencast coal operations and have to be removed whether they are marketed or not. Where fireclay is recovered for sale it must be worked carefully to ensure there is no contamination with associated rocks. Under favourable conditions fireclay can be worked down to bed thicknesses of 0.3 m. Fireclays are then normally stocked by seam, although subsequent blending with other clays (both fireclays and other brick clays) to provide a range of properties, as well as feedstock with consistent and predict-

Blending fireclays using layered stockpiles.

Fireclay

Fireclay extraction, Caughley Quarry, Broseley, Shropshire.

able properties, is normal commercial practice. For this reason it is highly desirable that a range of clays are available to the brick maker so that bricks with different colours and textures can be produced.

The only fireclay mine now operating in Britain is in the Shibden valley, near Halifax, where the siliceous Halifax Hard Bed fireclay is extracted on a small scale. This unusual fireclay has been used for nearly 200 years in the manufacture of glasshouse pots. Fireclay from the Shibden mine is blended with a similar clay quarried near Oxenhope, near Keighley.

Fireclays undergo no processing other than blending.

By-products

There are no by-products of fireclay production. Fireclay is almost invariably a by-product of opencast coal production.

Alternatives/recycling

With similar mineralogical compositions, some lower quality ball clays could be used for brick production and small quantities are used for this purpose. However, the ball clay deposits in Devon and Dorset are a long way from the main brick manufacturing plants in the Midlands and this would add substantially to the cost of the material if delivered to existing brickworks.

A number of waste materials are also being examined by the brick industry but none has yet proved to be a complete substitute. Filter cake waste from the manufacture of sanitaryware, which contains both ball clay and china clay, is being used to improve the quality of fireclay blends.

Effects of economic instruments

Fireclay is exempt from the Aggregates Levy.

Fireclay

The UK Government introduced the Climate Change Levy (CCL) on the 1st April 2001, which applies to some fuels used by energy intensive industries including the brick industry. In exchange for an 80% rebate on the Levy the brick industry has agreed challenging energy reduction targets through energy saving measures.

The EU Emissions Trading Scheme (EU ETS) came into effect in 2005 with the objective of reducing the EU's carbon dioxide emissions. The brick industry is eligible for EU ETS and an allowance on carbon dioxide emissions has been allocated for almost all brickworks in Britain, although, as low CO_2 emitters most brickworks have been given a temporary exclusion from the Scheme until 1st January 2008. Allowances can be traded if they are not reached or exceeded.

The extent to which both CCL and ETS will have on raw materials requirements is difficult to judge at this stage.

Transport

All fireclay is transported by road to brick/pipe manufacturing plants. Because of the higher intrinsic value of fireclay compared with most other brickmaking raw materials, it is sometimes transported considerable distances with up to 120–140 km being reported. Transport is thus an important element in the delivered price of fireclay. The ephemeral nature of supply from most sites means that there is little alternative to road. However, it is desirable, on economic and environmental grounds, that fireclay is sourced from operations that are in close proximity to manufacturing plants.

Planning Issues

The key planning issue concerning fireclay is that supply is mainly an ancillary operation to the extraction of opencast coal. It is, therefore, future planning permissions for opencast coal extraction, particularly in England, that will essentially govern future fireclay supply. The associated recovery of fireclay may provide additional support for an opencast coal proposal on the grounds of making the best possible use of the resource, in line with the principles of sustainable development. However, it is also likely to generate some additional impacts, such as increased lorry movements, adjustments to the restoration programme and, perhaps, some uncertainty about the actual timing and rate of working of individual extractive operations. Unlike brick clay extraction, opencast coal operations tend to be rapid and short lived such that fireclay is made available over concentrated periods. There is invariably a mismatch between potential fireclay supply and the requirements of the market, raising the issue of stockpiling on or off site. Stockpiling ensures that fireclay reserves can be made available rather than lost. However, it creates the potential for further impacts as the development of a stocking site, as at Donington Island, may be used over a long period.

More limited scale and specialist refractory uses may justify fireclay extraction on its own. Such operations mimic typical brick clay operations both in extent and in the range and level of planning issues.

Recent planning guidance (Mineral Policy Statement 1, Annex 2: *Brick clay provision in England*) is focussed on the use of fireclay as 'brick clay.' It recognises that fireclays are nationally scarce, and that the level of opencast coal extraction in England has major implications for future fireclay supply. It acknowledges that changes in the technology of clay-based products, the introduction of EU standards and the demand for new products have led to an increased demand for premium brick clays, including certain fireclays. It requires that Mineral Planning Authorities should safeguard and, where necessary, stockpile clays, such as fireclay and, where practical, encourage prior extraction where built development is proposed. In terms of permitted reserves provision may be required to secure reserves for scarce clays, such as fireclay, that will serve a number of works. To ensure supply Mineral Planning Authorities should encourage opencast coal producers to make the best possible use of any fireclay in their sites by finding appropriate markets and where none is immediately available to give consideration to the potential

of stockpiling the clay on an environmentally acceptable site, either on or in the ground. Mineral Planning Guidance Note 3 (revised), *Coal mining and colliery waste disposal*, sets out policy for opencast coal mining in England. Since it states that there should be a presumption against development, unless a proposal can meet a number of tests, this guidance is also relevant to future fireclay supply.

Welsh planning policy for fireclay is set out in *Mineral Planning Policy Wales (MPPW).* The draft *Mineral Technical Advice Note 2 (Wales)* for coal does not address coal-related minerals such as fireclay. MPPW seeks to ensure an appropriate contribution to need and to safeguard minerals from sterilisation. It draws attention to the need to consider potential recovery of fireclay from opencast coal operations and prior extraction before development. Particular concerns are the requirement to control operations in proximity to residential areas by proposed buffer zones around opencast coal sites.

Scottish planning policy (SPP4 *Planning for Minerals*) states that consideration of planning issues for fireclay produced from opencast coal sites is devolved to SPP16 *Opencast Coal*. This is the policy document most relevant to fireclay, although there is no policy that specifically addresses fireclay. SPP16 requires planning authorities to identify where opencast coal, and by inference fireclay, extraction may be acceptable. Policy for opencast coal is very similar to that in England in that there is a presumption against development unless extraction proposals demonstrate community benefits. SPP16 states that coal related minerals 'capable of being extracted in accordance with this SPP' should not be sterilised unnecessarily and, where practicable, should be extracted prior to permanent development and that planning authorities should take a long-term view on the potential for extraction.

Further information

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Fireclays in ceramic production. British Ceramic Confederation www.ceramfed.co.uk/and Confederation of UK Coal Producers www.coal-pro.co.uk/

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