Office of the Deputy Prime Minister
Creating sustainable communities

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Gypsum

*This factsheet provides an overview of the **gypsum** 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

Gypsum ($CaSO_4.2H_2O$) and **anhydrite** ($CaSO_4$) are, respectively, the hydrated and anhydrous forms of calcium sulphate. Gypsum is economically the most important. In nature they occur as beds or nodular masses up to a few metres thick and are the products of the evaporation of seawater. Gypsum is formed by the hydration of anhydrite at or near surface, but usually passes into anhydrite below 40-50 m, although this varies according to local geological conditions. Anhydrite is, therefore, more extensive at depth than gypsum.

Synthetic gypsum (calcium sulphate) may also be derived as a by-product of certain industrial processes. The most important is flue gas desulphurisation **(FGD)**, a process that removes sulphur dioxide from the flue gases at coal-fired power stations. The product, known as **desulphogypsum**, is now an important supplement to the supply of natural gypsum, both in the UK and elsewhere. This synthetic gypsum has a higher purity (gypsum content of 96%) than most natural gypsum (80%) in England. However, some very high purity natural gypsum does occur in England.

Continuous miner, Barrow-upon-Soar Mine, Leicestershire.

Demand

Gypsum is used mainly in the manufacture of building products—**plaster, plasterboard and cement**—and demand is principally driven by activity in the construction sector. The value of construction output continues to increase in real terms. Demand for new housing is increasing and in conjunction with the need for new schools, hospitals, offices and shops, there is likely to be increasing demand for gypsum building products for the foreseeable future.

When gypsum ($CaSO_4.2H_2O$) is ground to a powder and heated at 150° to 165°C, three-quarters of its combined water is removed producing hemi-hydrate plaster ($CaSO_4.1/2\ H_2O$), commonly know as **Plaster of Paris**. When this powder is mixed with water the resulting paste sets hard as the water recombines to produce gypsum again. This process can be repeated almost indefinitely with important implications for recycling.

The most important applications of gypsum are in the production of plaster and plasterboard. The mineral forms the basis of a large industry producing a wide range of building products. However, synthetic gypsum is now more widely used in the manufacture of plasterboard. Natural gypsum is especially suitable for the manufacture of building plasters because it contains clays that improve the workability of the plaster. High-purity natural gypsum is also used to produce special plasters, for example for use as plaster moulds in the pottery industry and for surgical and dental work. Small quantities of high-purity gypsum are also used in confectionary, food, the brewing industry, pharmaceuticals, in sugar beet refining, as cat litter and as an oil absorbent.

In contrast, anhydrite has limited uses, although large quantities of a mixture of anhydrite/gypsum are blended with cement clinker and finely ground to produce Portland Cement. Additions of about 5% are used to control the initial rate of reaction with water and to retard the setting time of the cement (see factsheet on **Cement**). Natural

Gypsum

gypsum/anhydrite has been the preferred material for cement manufacture. Synthetic gypsum is utilised, but its higher moisture content makes it more difficult to handle than natural gypsum. In addition, anhydrite reacts more slowly, assisting concrete to achieve full strength over 30 days.

Anhydrite was formerly mined on a large scale in England as a source of sulphur for the manufacture of the fertiliser ammonium sulphate and sulphuric acid. The last anhydrite mine devoted to sulphuric acid manufacture closed in 1975. Anhydrite has a few minor specialist uses and demand in the UK is currently very low. The Newbiggin anhydrite mine, in Cumbria closed in November 2005 due exhaustion of permitted reserves and loss of its main customer, the Dunbar cement plant in Scotland.

Demand for gypsum is being driven principally by the plasterboard sector and plasterboard is now the preferred internal lining in most buildings. Recent changes in building regulations, requiring improved thermal and sound insulation, means that thicker plasterboard is now required which in turn has increased demand for both gypsum and plasterboard capacity. A number of new plasterboard plants are currently being built or planned. Increasing quantities of desulphogypsum will be used in this sector. In addition, there has also been an increase in demand for natural gypsum for bagged plasters. The bagged plaster market is evolving rapidly due to changes in building practices. Plasterboard lining with a skim finish of coating plaster is currently the preferred interior finish. As a result the demand for finish coat plasters is increasing whilst demand for base coat plasters remains steady. The market demands pink coloured plaster of a consistent colour, most easily obtained from natural gypsum.

Supply

Production statistics on natural gypsum are limited as there is only one UK producer (see below). The BGS has published estimates for use in its United Kingdom Minerals Yearbook. These are shown in Figure 1 and output is currently thought to be about 1.7 Mt/y. UK production is confined to England, with output in Cumbria, Nottinghamshire, Leicestershire, Staffordshire and East Sussex. The East Midlands is the most important region. Production will increase in the next year or so due to increasing demand, notably to supply a new bagged plaster plant being built at East Leake in Nottinghamshire.

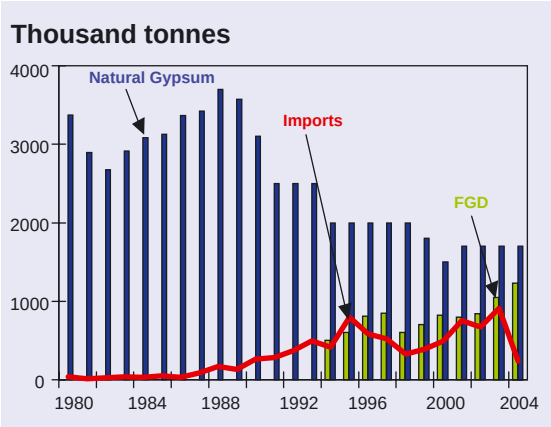

Figure 1 UK production and imports of gypsum, 1980–2004. *Source: United Kingdom Minerals Yearbook, BGS.*

However, the amount of natural gypsum extracted in Britain has declined appreciably in the last decade due to the availability, since 1994, of substantial amounts of desulphogypsum. Output of desulphogypsum was a record 1 228 000 tonnes in 2004 and will increase further as new FGD plants come on stream. However, increasing reliance on imported lower sulphur coals and the use of biomass fuels, which result in less desulphogypsum, may offset some production from new plants. The gypsum industry does not view desulphogypsum as a long-term source of supply due a lack of investment in coal powered electricity generation.

Titanogypsum, a by-product of the manufacture of titanium dioxide pigment, is another source of synthetic gypsum. UK titanogypsum production reduced by half in 2004 (to approx. 100 000 t/y) due to a reduction in plant capacity for titanium dioxide. The gypsum/anhydrite supply chain is represented in Figure 2.

Gypsum

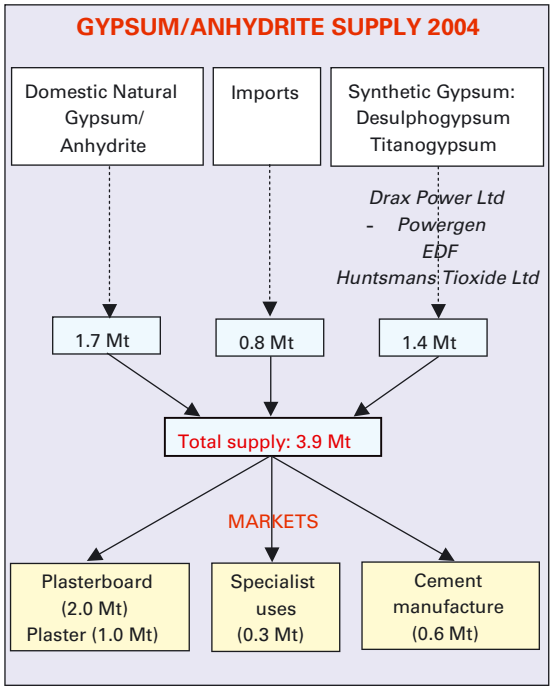

Figure 2 Gypsum supply chain, 2004
Source: BGS estimates

Trade

Until the late 1980s, the UK was largely self sufficient in gypsum. Since then gypsum has been imported in increasing amounts, partly to supply new plasterboard facilities by companies with no access to indigenous reserves. Imports consist of both natural and synthetic gypsum. Gypsum is mostly imported from south-eastern Spain and Germany aboard ships carrying loads of up to 20 000 tonnes. Increased freight costs are impacting on the economics of importing a low value raw commodity such as gypsum. Exports of gypsum are small. Official figures for gypsum imports are difficult to interpret but BGS believe they have been wrongly classified since 2001. In 2003 imports of gypsum were reported to be 47 751 tonnes whilst imports of calcined gypsum (plasters) were 855 317 tonnes. It is likely that the latter mainly comprise gypsum. Imports of plasterboard are small. There is some trade in special (industrial) plasters such as are produced at the Jericho works in Newark.

Natural gypsum	1.7 Mt
Synthetic gypsum	1.4 Mt
Net imports	0.8 Mt

Table 1 Estimated UK consumption of gypsum, 2004.

Consumption

UK consumption of gypsum/anhydrite in 2004 (domestic production of both natural and synthetic gypsum plus net imports) is estimated to be 3.9 million tonnes (Table 1).

Economic importance

Gypsum is a relatively low priced mineral. The value of UK production of natural gypsum has been estimated at £19 million in 2004. However, most gypsum is used captively in the manufacture of plaster and plasterboard or sold for cement manufacture. Total UK manufacturers' sales of the principal products of these industries are shown below (Table 2). Plaster products (plasterboard) are based on synthetic gypsum or imports. Gypsum is a relatively minor component of cement.

Plaster	£129 million
Plaster products (plasterboard)	£501 million
Cement	£831 million

Table 2 Downstream value of UK gypsum, 2004. *Source PRODCOM. Office for National Statistics.*

Structure of the Industry

British Gypsum is a wholly-owned subsidiary of BPB plc, a UK company which is the world's largest producer of gypsum building products. It is the only producer of natural gypsum/anhydrite in the UK, where it operates five mines and one quarry (Figure 3).

Gypsum

Synthetic gypsum is also produced in substantial quantities. Desulphogypsum was produced at three coal-fired power stations in 2004. The largest source (653 000 tonnes in 2004) is the 4000 MW Drax station in North Yorkshire, which is owned by Drax Power Ltd. A further 350 000 tonnes of desulphogypsum were produced at the 2000 MW Ratcliffe-on-Soar station in Nottinghamshire, owned by Powergen. The West Burton plant in Nottinghamshire owned by EDF came on stream in December 2003, producing 225 000 tonnes of desulphogypsum during 2004. FGD plants have also been fitted at British Energy's Eggborough power station near Knottingley and at EDF's Cottam station near Retford in Nottinghamshire; these were commissioned in 2005. Additional FGD plants are being planned for several other coal-fired power stations, including Fiddlers Ferry and Rugeley. British Gypsum has exclusive rights to purchase desulphogypsum from Drax, Ratcliffe and West Burton. Desulphuogypsum is increasingly becoming a commodity in its own right and commercial bidding now takes place to secure supply contracts.

Titanogypsum is produced by Huntsmans Tioxide Ltd at Grimsby and is supplied to Knauf at Immingham for plasterboard manufacture. Other plasterboard plants, operated by Knauf at Sittingbourne and at Avonmouth by Lafarge Plaster, are based on imported gypsum. The market share of plasterboard manufacturers in the UK are: British Gypsum (58%), Lafarge (21%) and Knauf (21%). British Gypsum is the market leader in bagged plasters.

Resources

Gypsum and, particularly, anhydrite are widely distributed in England in rocks of Permian and Triassic age, and to a lesser extent in strata of late Jurassic age (Figure 3). However, as gypsum is formed by the hydration of anhydrite, gypsum resources are much more limited than those of anhydrite. Gypsum is also soluble and dissolves rapidly at, or near surface, and its occurrence may be unpredictable. Anhydrite is highly unlikely to be of economic interest as a future source of sulphur. Interest will be primarily directed at gypsum and thus beds that are relatively near to the surface.

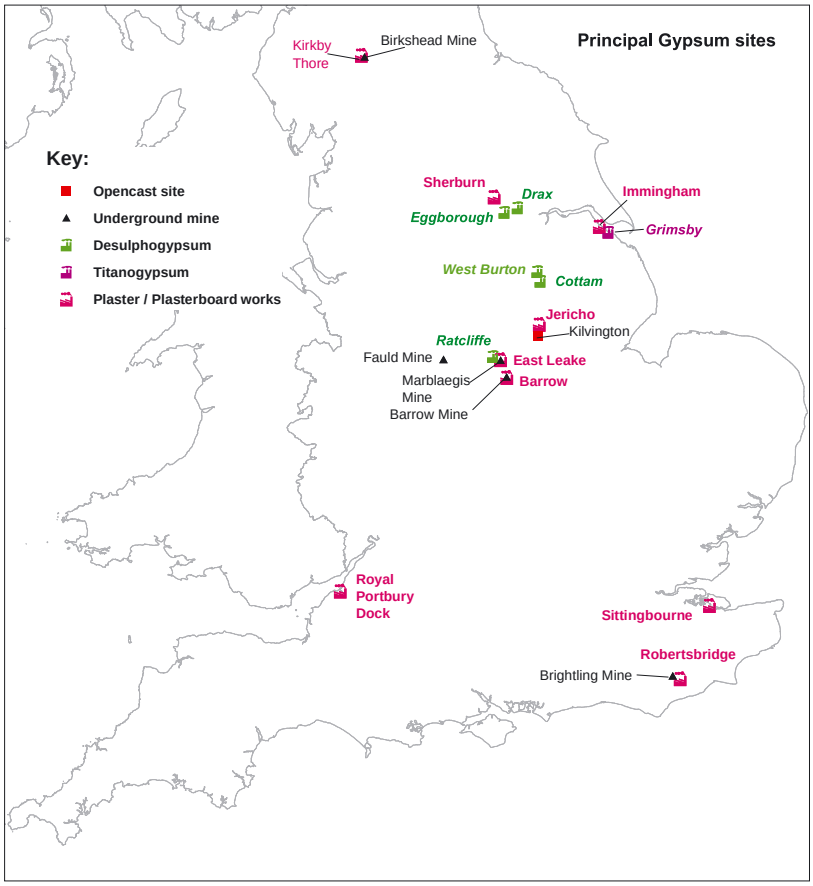

Figure 3 Principal gypsum and anhydrite producing sites.

The most important resources are those associated with the Tutbury Gypsum in Leicestershire, Nottinghamshire and Staffordshire and the Newark Gypsum in east Nottinghamshire. The former occurs as a single bed up to 3.5 m thick and is only worked by underground mining. In contrast the Newark Gypsum in Nottinghamshire comprises multiple beds and nodular bands of gypsum of variable thickness and purity, spread over some 15–18 m of strata. It is worked at Kilvington Quarry. The individual worked beds range from about 0.3 m to 1 m in thickness and are worked by opencast methods. Some of the beds are of very high purity and are the source of the highest quality gypsum produced in the UK.

The Tutbury Gypsum is worked by underground mining at the Barrow Mine in

Gypsum

Leicestershire, the Marblaegis Mine in Nottinghamshire and the Fauld Mine in Staffordshire. The large Barrow Mine supplies a co-located plant which supplies the majority of the UK's bagged plasters. The latter two mines supply the cement industry. However, output at the Marblaegis Mine is to be expanded to supply a new bagged plaster plant, which is being built at East Leake. Some of the gypsum is also used in plasterboard.

Gypsum at the horizon of the Tutbury/Newark Gypsum has been traced from North Yorkshire to Somerset and is also identified in the Carlisle Basin in Cumbria and in the Cheshire Basin. The thickness and quality of the gypsum is mostly unknown. However, potential exists in Leicestershire, which is likely to become a focus for future gypsum exploration in the UK, as is South-west England.

In Cumbria, several gypsum/anhydrite beds occur in mudstones of late Permian age in the Vale of Eden. Gypsum and anhydrite mining is now confined to the Kirkby Thore area where two beds, 'A' Bed and 'B' Bed, are worked for plaster, plasterboard and cement manufacture.

In East Sussex, gypsum is found within a series of small 'inliers' of Jurassic rocks in the Robertsbridge area of the High Weald AONB. Gypsum occurs in four beds at the base of the Purbeck Limestone Group. Production is from the Brightling Mine, where two beds are currently worked for use in cement manufacture. Although this mine formerly provided all the gypsum for the manufacture of plaster and plasterboard for the nearby Robertsbridge Works, this works now relies on desulphogypsum and imports.

Reserves

Total permitted reserves of gypsum/anhydrite In England are in excess of 50 Mt. The largest reserves are in East Sussex and Leicestershire. Reserves in East Sussex are between 15 Mt and 20 Mt and at the large Barrow Mine in Leicestershire 18-19 Mt, sufficient for some 20 years at current increased rates of production. At the Fauld Mine in Staffordshire reserves are some 4 Mt with a similar quantity at Marblaegis Mine. In Cumbria gypsum reserves are mainly associated with the 'A' Bed and amount to 6 Mt. Opencast reserves in the Newark area amount to some 10 Mt, although only half of these have the benefit of planning permission for extraction. Increasing emphasis is being placed on the production of higher purity gypsum, although this may have a negative effect on reserves, as lower purity gypsum no longer falls in the reserve category. Alternatively lower quality gypsum can be blended with high purity desulphogypsum, allowing material that would not have been mined in the past to be classified as reserves. Desulphogypsum is transported to the Barrow site for mixing with lower quality natural gypsum.

Relationship with environmental designations

The operations near Robertsbridge in East Sussex are located in the High Weald AONB.

Extraction and processing

Gypsum/anhydrite are produced predominantly (80%) by underground mining using pillar and stall mining methods that gives extraction rates of up to 75%. This mining method does not give rise to subsidence and no significant waste is produced. The impact of the workings is confined to the surface facilities at the mine. Continuous miners are becoming increasingly common in underground gypsum mines. Lack of vibration allows working of deposits close to housing and better reserve recovery is possible in conjunction with selective mining. Opencast working has largely been confined to Nottinghamshire, although some surface working has been carried out in the Kirkby Thore area of Cumbria in the past. Mineral to overburden/interburden ratios can be as high as 1:15. Overburden is used to reclaim the void, which may also be used for landfill.

Gypsum is normally only screened to remove fines (mainly mudstone), then crushed and finely ground. Gypsum/anhydrite for cement manufacture is supplied in crushed form for further fine grinding with cement clinker. For plaster manufacture, the finely ground gypsum is heat treated in 'kettles' to remove three-quarters of the combined water to produce hemi-

hydrate plaster. Emissions consist only of steam. There is, therefore, little or no waste associated with the extraction and processing of natural gypsum.

By-products

There are no by-products of gypsum/anhydrite mining and processing.

Alternatives/recycling

Calcium sulphate is produced as a by-product of a number of industrial processes. The most important of these is FGD, which involves the removal of sulphur dioxide contained in the flue gases at coal-fired power stations. Sulphur dioxide is one of the principal gaseous pollutants emitted by human activity. It can impact on human health and give rise to acid deposition on a local, regional and national basis.

There are a number of FGD processes. The Limestone-Gypsum Process is the most commonly employed worldwide and in the UK. It involves absorbing the acidic sulphur dioxide in the flue gases into a water-based slurry of finely ground limestone. The amount of desulphogypsum produced at FGD plants is dependent on two main factors, the electricity output of the station and the sulphur content of the coal. Production from both Drax and Ratcliffe has been lower than anticipated, because of the use of lower sulphur coals and lower electricity output, because of the increased cost of production due to FGD. About 0.7 tonnes of high purity limestone are required for every tonne of desulphogypsum produced. The high purity limestone used at the Drax, Ratcliffe and West Burton power stations is derived from Tunstead Quarry in Derbyshire. As other coal-fired plants are retrofitted with FGD plant additional quantities of desulphogypsum will become available.

Despite an increase in supply over the short term there remains a question about the longer term (+10 years) availability of desulphogypsum:

- FGD is a parasitic load on electricity generation at coal-fired power plants, reducing their efficiency;
- indigenous coal generally has a higher sulphur content than imported material and the latter is currently being consumed in preference;
- the cost of desulphogypsum is comparable to natural gypsum and with escalating freight costs could soon become more expensive.

There have been no coal-fired plants built in the last 30 years and the longer term future of coal-fired electricity generation in the UK is not assured. If the supply of desulphogypsum declines it is likely that gypsum for plasterboard manufacture will be partly sourced from overseas on quality and cost grounds.

Titanogypsum is produced by neutralising acid effluent with chalk arising from the manufacture of titanium dioxide pigment by the Sulphate Process at a plant in Grimsby. Some 100 000 t/y of high purity gypsum is produced and used at Immingham for plasterboard manufacture.

The EU Landfill Directive, which was recently introduced, is driving the issue of recycling. Waste separation has become a legal requirement and landfill sites cannot accept waste containing more than 10% calcium sulphate. There is limited provision for the disposal of high sulphate waste in the UK. However, a major advantage of gypsum is that it is infinitely recyclable for use in plasterboard. Plasterboard has a long life in buildings and is not currently recycled from demolition sites in the UK, although some potential exists. Waste plasterboard/plaster produced at new building developments accounts for about 20% of all waste filling skips at these sites. British Gypsum has introduced a service for returning this waste to plasterboard plants for recycling along with waste produced during manufacturing. The plasterboard is broken down into a fine powder which is then re-introduced, in a controlled blend, into the manufacturing process. Tonnages derived from this source are increasing.

Transport Issues

Plaster and plasterboard plants are normally located close to the mine site and thus only

Gypsum

bagged plaster and plasterboard are transported by road. Gypsum/anhydrite for cement manufacture is mostly transported by road.

Desulphogypsum from the Drax power station is transferred in rail containers to Kirkby Thore, East Leake and, occasionally, Robertsbridge in East Sussex. Rail shipments of desulphogysum have also recently started from West Burton station. Desulphogysum from Ratcliffe power station is transported the 8 km by road to East Leake.

Planning issues

The uncertainties surrounding the long-term security of supply of desulphogypsum mean that future requirements for natural gypsum are difficult to predict. Should the domestic supply of desulphogypum decline significantly, the production of natural gypsum may need to be increased significantly (along with imports) in order to substitute for the synthetic material currently used in plasterboard manufacture. The companies producing gypsum based products are seeking greater control over the supply of raw materials. With future uncertainties surrounding synthetic gypsum supply and increasing import costs the most effective way of ensuring security of supply is through the discovery and working of indigenous resources.

If, however, supplies of desulphogypsum are maintained, then questions remain regarding the need to supply large quantities of limestone for use in the flue gas desulphurisation process. In effect, mineral produced by surface working (high-purity limestone) is replacing mineral normally won by underground mining (natural gypsum).

Authorship and acknowledgements

This factsheet was produced by the British Geological Survey for the Office of the Deputy Prime Minster to support the research project 'Review of Planning Issues Relevant to Some Non-Energy Minerals other than Aggregates, in England' (2004). It was updated under the research project 'ODPM-BGS Joint Minerals Programme'.

It was compiled by David Highley, Andrew Bloodworth (British Geological Survey) and Richard Bate (Green Balance Planning and Environmental Services), with the assistance of Don Cameron, Fiona McEvoy, Paul Lusty and Deborah Rayner (BGS)

The invaluable advice and assistance of the minerals industry in the preparation of this factsheet is gratefully acknowledged.

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