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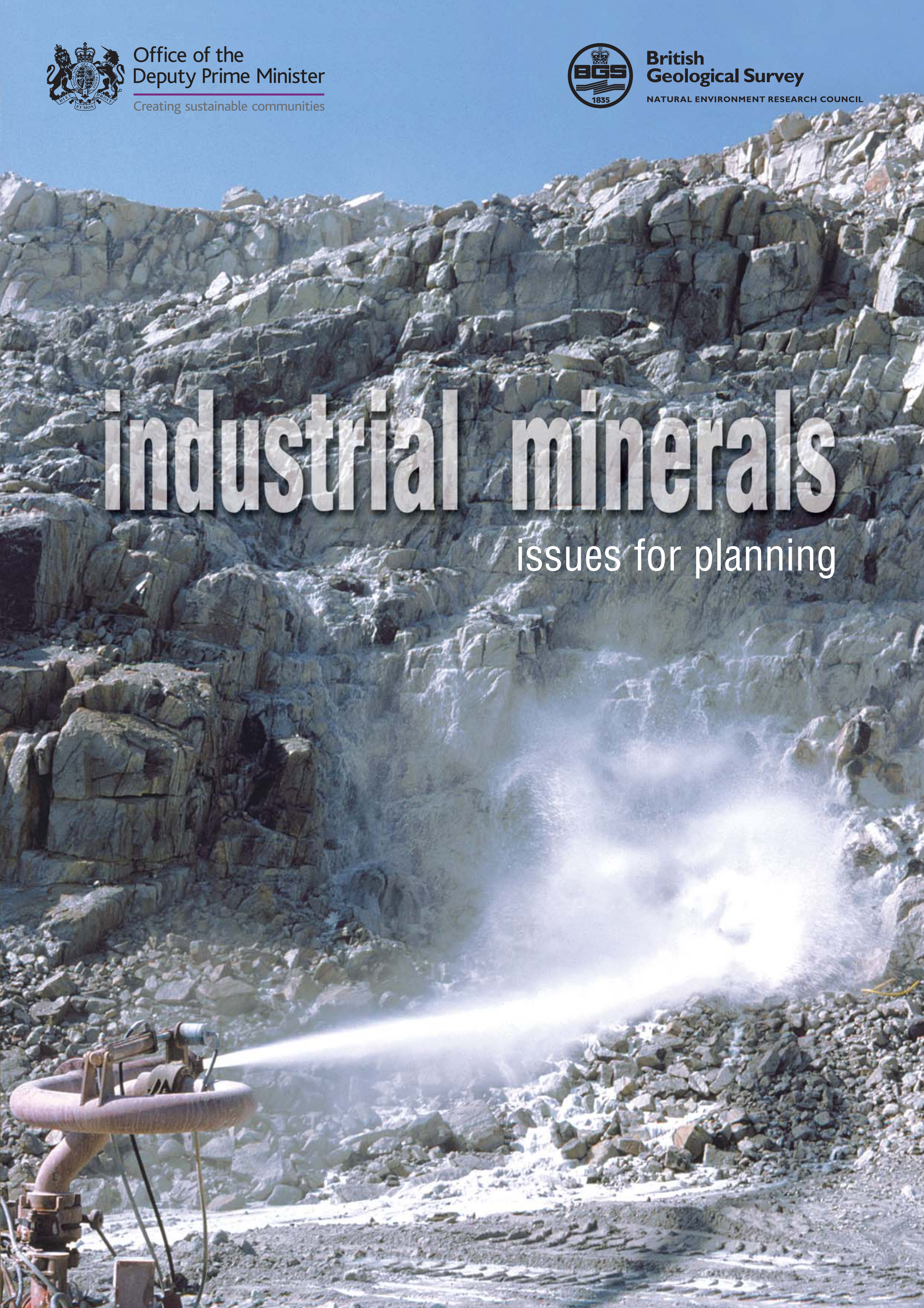
industrial minerals

issues for planning



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BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT CR/04/076N

'Industrial Minerals': Issues for Planning

Review of Planning Issues relevant to some Non-Energy Minerals other than Aggregates in England

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1 The United Kingdom is fortunate in being well endowed with a wide range of industrial minerals. Their extraction supports an important and diverse sector of the minerals industry, which makes a significant contribution to the national economy. The major part of this industry is located in England.

2 This report describes research commissioned by the Office of the Deputy Prime Minister (ODPM) on the planning issues associated with the provision of non-energy minerals other than aggregates in England. Throughout this report, these minerals are referred to as 'Industrial Minerals'.

3 Economic minerals included in the study are kaolin (china clay), ball clay, clay and shale (for cement manufacture only), limestone (limestone, chalk and dolomite for industrial purposes, including cement manufacture), silica sand, gypsum/ anhydrite, potash, salt, fuller's earth (bentonite), fluorspar, barytes, calcite, lead, zinc, other metals (tin, copper, gold), slate (industrial applications only), talc, serpentine and iron ore (hematite).

KEY CHARACTERISTICS

4 The industrial minerals sector in England is generally characterised by a small number of large businesses, with production of each mineral being dominated by one or a small number of companies. Many companies form part of major international groups. However, there are also a number of smaller producers, notably of industrial carbonates, silica sand and fluorspar, who are essentially single site operators.

5 Industrial minerals are widely distributed in England and occur in all Regions with the exception of London. However, the location of individual industrial minerals and their quality fundamentally reflects geology and many are highly restricted in their occurrence and, consequently, extraction. The restricted distribution of industrial minerals means that some are coincident with environmentally sensitive areas. Notable examples are fluorspar and potash, which are essentially confined to National Parks. Carboniferous limestones and the Cretaceous Chalk are the two principal limestone resources on which cement and industrial limestone production is based in England. These rocks also give rise to some of England's most attractive scenery and consequently extensive areas are covered by national landscape designations.

6 The pattern of consumption of industrial minerals by downstream industries is complex. Typically, individual industrial minerals are consumed in more than one sector and each market area requires a number of different minerals. The markets for industrial minerals are widely distributed throughout the country and are not confined to England, or even the UK.

7 There are marked differences in the geological occurrence, properties, markets, supply, demand and thus land-use planning implications of the extraction of the different industrial minerals. Diversity is a key feature that characterises the industrial minerals sector.

8 The geology of different industrial minerals greatly influences the size of a deposit and consequently, the amounts that can be produced and over what period. It will also dictate how a deposit is worked, notably by surface extraction or underground mining, as well as the way the industrial mineral has to be processed and the amount of associated waste that is generated. Geology, therefore, fundamentally influences the planning issues associated with the extraction of each mineral.

9 Industrial minerals are consumed in a wide range of end uses based on their diverse physical and/or chemical properties. Some industrial minerals are valued solely as sources of specific elements, or compounds, for example for use as chemical feedstocks, in cement-making or as plant nutrients.

10 The different markets for specific industrial minerals demand different combinations of properties. The same mineral will, therefore, be traded with different specifications depending on specific end use. Individual grades of industrial minerals are, therefore, often not interchangeable in use.

11 It is important to understand that industrial minerals are not like refined metals or chemicals, which are traded on the basis of purity and price; they are the products of natural processes. Subtle differences in their properties can make the performance of a specific industrial mineral quite different from one deposit to another. Consequently individual deposits may be aimed at particular products or markets and, as a result, some specifications for particular uses are written around specific deposits. In addition, whilst processing is capable of enhancing or modifying the properties of some industrial minerals, it cannot for example, fundamentally change the iron content, or whiteness, of limestone or dolomite, or the fluid properties of kaolin or ball clay.

12 Industrial minerals serve as essential raw materials that underpin many sectors of manufacturing industry, where the added value can be several times the cost of the mineral used. Indeed some industrial mineral producers are also major manufacturers and of the total production of industrial minerals (approximately 40 million tonnes) about 50% is not sold on the open market but used 'captively' in the manufacture of value-added products.

13 The fact that industrial minerals are valued for their physical and/or chemical properties, means that opportunities for substitution and recycling are variable and, often, complex.

14 Movement of the industrial minerals to market is by road, rail and sea, the latter to serve export markets, although some coastal movement of rock salt and agricultural dolomite to Scotland also takes place. Of the total marketable output of industrial minerals of 40 million tonnes it is estimated that over 25% is transferred by rail or ship, a much higher proportion than for aggregates.

ECONOMIC IMPORTANCE

15 The industrial minerals sector accounts for a relatively small proportion of Gross Value Added (GVA) in the UK economy (an estimated £788 million). However, it is important to consider the spatial dimension of where the GVA is created. Of the 69 main producing sites in the UK industrial minerals sector, 54 (78%) are located in either remote rural or accessible rural locations.

16 Employment figures for the industrial mineral sector are not that high (under 15 000 direct, indirect and induced). However, again it is important

to give consideration to where employment in the industry is distributed, with the sector making a significant contribution to employment in rural areas. The industrial minerals sector also makes an important contribution to maintaining a diversified rural skill base, a necessary requisite of a well-structured rural economy. Given the higher level of earnings paid by the sector than rival sectors in the rural economy, it can be argued that the industrial minerals sector contributes to raising the level of productivity in rural areas of the UK.

17 The importance of industrial minerals to the UK economy is not attributable solely to the value of production and the number of people who are directly or indirectly employed. They are also essential inputs to a wide range of downstream industries which make a much larger contribution to wealth creation in the UK.

PLANNING ISSUES

18 The planning context of industrial mineral provision at national, regional and local levels is examined in the report. Planning issues common to all industrial minerals include geological scarcity, level of demand, permitted reserves and sterilisation of mineral resources by planning controls, as are planning implications associated with extensions and new sites.

19 Planning issues important for some industrial minerals include factors such as mineral waste disposal, underground mining (including impacts of surface development and subsidence), longevity of operations, 'landbanks' and continuity of supply, along with the importance of maintaining supplies of a variety of mineral qualities. Other issues in this category include the planning response to restoration and dereliction from earlier operations.

20 There are a number of 'thematic' issues associated with planning for industrial minerals. One of the most important of these themes is the examination of the 'need' for industrial minerals and how they contribute to wealth creation at the local, regional and national scale. These issues require an appropriate planning response.

21 Another important theme is the environmental effects of mineral working. This includes issues such as transport, landscape, wildlife and heritage. The planning system also has a role in applying the principles of sustainable development with regard to industrial minerals. This includes factors such as best use of the resource (safeguarding from sterilisation, avoiding inappropriate end uses and better use of poorer quality minerals) and reduction in demand through substitution, reuse and recycling.

CONCLUSIONS

22 The recurring and central concern expressed by the industrial minerals sector is the need for assurance of a continuity of supply. This is the key to sustaining the UK industries which depend on these minerals as essential raw materials and from which wealth flows. Consequently, MPAs need to pay more attention to the downstream economic consequences of decisions on planning applications for industrial minerals. There is also concern about the increase in the number and extent of landscape, nature conservation and other designations, and the impact these may have on future supply options. This is particularly the case for minerals that are scarce and geographically restricted. However, it should be recognised by MPAs, industry and the public that there is no absolute prohibition on mineral working in these areas.

23 At the same time the messages about the environmental impacts of working industrial minerals are also clear. Here the requirement is for clarification of the circumstances when environmental constraints (which would be sufficient to deny the working of more ubiquitous minerals) might be overridden by the economic importance of a specific industrial mineral. In the absence of such advice, MPAs follow normal planning practice in resisting mineral development which would unduly damage protected areas and recognised environmental interests. Proposals for working industrial minerals in National Parks raise the most profound conflicts of interest. As well as concern about the impact of working in protected areas designated for a variety of purposes, there is substantial concern about the damaging impacts of the transport of minerals by road.

24 We are not convinced that 'more policy' from central Government will address these issues. There is a need for more policy on particular matters, set out below, but the more fundamental requirement is for more and better information on the economic importance of individual industrial minerals and their contribution to the UK economy.

Recommendation 1: Provide high quality, consistent and up-to-date information to assist the planning process.

25 We suggest that the Mineral Planning Factsheets which accompany this report could form the Technical Annex of any forthcoming *Mineral Policy Statements*. It is proposed that they be kept up-to-date, in terms of statistics and developments in the industry, so that they can provide a continuing source of reference for a wide audience. However, MPAs may require additional information on the economic importance of each mineral. This would require more detailed studies.

Recommendation 2: Improve guidance to Mineral Planning Authorities on the evaluation of the economic importance of industrial minerals.

26 MPAs are already well experienced at addressing the environmental aspects of mineral working proposals, but they have received little advice on the way in which they should address economic issues. A 'checklist' for MPAs for assessing the economic case for individual planning proposals is proposed.

Recommendation 3: Develop policy on integrated long term planning.

27 There is a need to establish a modus operandi which offers greater peace of mind for everyone, and positive planning for the benefit of both industries and the areas they affect. We consider this could be far better achieved by establishing in principle a commitment to sustain industrial minerals production (if required) in designated 'industrial minerals areas'. In designated areas, the principle of mineral working at some future date would be the priority issue when taking land use decisions in that area. Each industrial mineral benefiting from such a designation would be more assured of a continuity of supply than it is now, though there should not be an assumption that each industrial mineral must necessarily have its own designated area(s). From an environmental point of view, the purpose of the designation would be to prioritise local environmental benefit in return for recognising the commitment to future working. This would involve a commitment by the industrial minerals industries to long term planning, with investment in the movement of mineral by rail, waterway and pipeline rather than by road, so far as practicable. This would be justified by the investment in plant which itself could be guaranteed to be sustained with a supply of minerals. Likewise, to address foreseeable environmental and amenity concerns, there would be an expectation of forward planning for environmental mitigation and enhancement. This might involve the planting of screening woodlands (to mature before

mineral needed to be worked) and the creation of new habitat adjacent to existing habitat in order to allow colonisation and the creation of a more robust wildlife network within the area prioritised for working. 'Industrial minerals areas' would therefore not be 'sacrifice areas' but land within which a positive commitment by the planning authority and industry to long term environmental land management could be given proper effect. Because of different geology and the problem of defining the limits of some resources, it is unlikely that this approach would be appropriate in all cases. However, the procedure has to some extent already been adopted for ball clay in South Devon and may be beneficial elsewhere.

Recommendation 4: Broad end use controls should be formally established, where necessary, to ensure sustainable use of mineral resources.

28 Current mineral planning guidance (MPG1) aims '...to encourage efficient use of materials, including appropriate use of high quality materials...' Economic forces will in many cases support this principle of sustainable development, but cannot always be relied upon to do so and there have been cases where industrial minerals have been used for less than best purposes. Many development plan policies encourage end use controls, and conditions on individual developments have in some cases been imposed, or legal agreements reached, which achieve this purpose. Operators need flexibility in order to respond to changes in the market. As such, formal end-use controls should only be imposed with care. However, there remains uncertainty in national policy on the steps which MPAs can take to apply the principle. Clarification is needed that end use controls may be imposed by condition. In the unlikely event of any legal impediment being identified, the Government is recommended to take the necessary steps to overcome it.

Recommendation 5: Mineral planning guidance should encourage, where practicable, the use of lower quality resources, both to conserve higher quality resources and widen supply options.

29 It is a principle of sustainable development that lower quality resources should be used where practicable. This is, first, to conserve higher quality resources for those applications which can be served by no other reasonable means. Second, this is intended to widen the supply options and may reduce the pressure to work areas where there are significant conflicts of interest. The research indicated cases where this has clearly been achieved, usually through blending and additional processing by producers, but also by the end-user adapting to a lower quality (and lower cost) material.

30 The use of lower quality resources is a complex issue and the opportunities for using lower quality resources will depend on very specific and local circumstances. Guidance cannot be prescriptive, so the policy approach should encourage mineral companies and their customers to consider actively the scope available to them to make greater use of lower quality resources. It is unlikely that this would create significant difficulties for industrial mineral producers, many of whom are already using resources appropriately. National policy should invite MPAs to have regard to this issue when considering planning applications for working industrial minerals.

1 Introduction

1.1 This report describes a research project commissioned by the Office of the Deputy Prime Minister (ODPM) on the **Review of Planning Issues Relevant to some Non-Energy Minerals other than Aggregates in England** (Research Contract MP0711). Throughout this report these minerals are referred to as 'Industrial Minerals,' although it is recognised that cement raw materials are strictly construction minerals. The research was undertaken by the British Geological Survey, in association with Green Balance Planning and Environmental Services and DTZ Pieda Consulting, Economics.

1.2 The report provides information on the nature and economic importance of the industrial minerals sector and an analysis of the current planning response to the provision of these minerals. Where necessary, it also makes recommendations on alternative policy options. The research involved extensive information gathering and wide consultation with mineral planning authorities, industry and a range of other stakeholders. The interpretation of the resulting information, the summary of views and the conclusions and recommendations expressed in the report are those of the research team and do not necessarily represent the views of Government or of individual members of the Steering Group.

1.3 Economic minerals included in the study are as follows:

- Kaolin (china clay)
- Ball clay
- Fuller's earth (bentonite)
- Cement raw materials (limestone, clay and clay/mudstone)
- Limestone, including chalk, and dolomite for industrial purposes
- Silica sand
- Salt
- Potash
- Gypsum/anhydrite
- Fluorspar, barytes and calcite
- Miscellaneous minerals (iron ore/hematite, other metalliferous minerals, slate for industrial applications, serpentine and talc)

Background and objectives

1.4 Current Mineral Planning Guidance Note 1 (MPG1) *General considerations and the development plan system* makes only brief mention of industrial minerals, although specific detailed guidance on provision of cement raw materials and silica sand is set out in MPGs 10 and 15 respectively. It is likely that any future core guidance will be more general in nature, with specific minerals covered in associated generic documents, either dealing with specific minerals, or groups of minerals. This report has a dual role in informing the development of any new guidance by providing authoritative background information on the sector and by providing policy advice.

1.5 The report begins by providing an overview of the industrial minerals sector in England. This overview sets out the key characteristics of industrial minerals as they relate to land-use planning, along with the structure of the industry and the distribution of resources. It includes a series of maps which display the broad distribution of specific industrial mineral resources, together with other important information. This section also describes the context and importance of industrial minerals within the UK economy. The main body of the report deals with the planning context of industrial minerals provision. It examines issues common to all minerals, and identifies and analyses issues relevant to groups or individual industrial minerals. It also examines planning issues by theme (economic, social and environmental) and how the principles of sustainable development might be applied. The final section of the main report sets out conclusions and recommendations. The main Technical Annex (Annex A) consists of a series of '***Mineral Planning Factsheets'***. This series provides an overview of each economically important industrial mineral, excluding aggregates, which is extracted in England. It is primarily intended to inform the land-use planning process. Annex B sets out current mineral planning guidance as it pertains to industrial minerals. Annex C is the text of a paper on the ***'Economic Importance of Industrial Minerals for Planning Applications'*** produced by the Department of Trade and Industry in November 2003 as a contribution to this research.

Acknowledgements

1.6 This research has greatly benefited from the co-operation and help of many organisations and individuals. The authors gratefully acknowledge the invaluable advice and assistance given during this research by a large number of individuals and companies in the industrial minerals industry, civil servants in central government, regional and local planning officers, and a number of trade associations and environmental organisations.

The research was guided and peer-reviewed by members of an independent Steering Group appointed by the Office of the Deputy Prime Minister.

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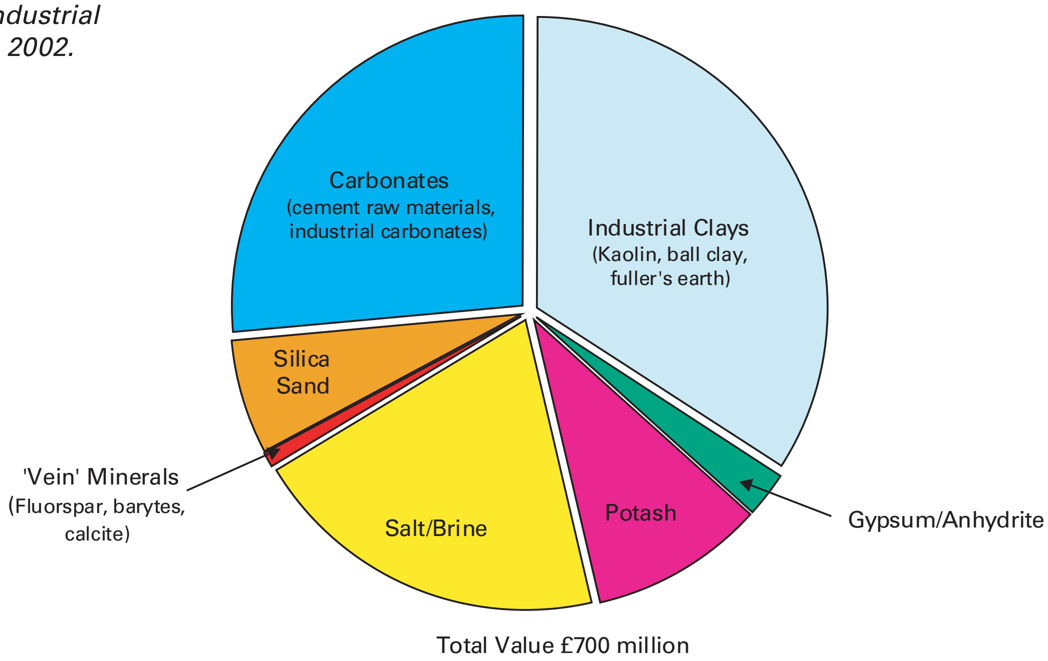
John Hernon, British Cement Association
Bob Fenton, UK Mining Association
George Muskett, Kaolin and Ball Clay Association
Colin Prosser, English Nature
Tony Cosgrove, English Nature

2 Overview of the Industrial Minerals Sector

2.1 The United Kingdom is fortunate in being well endowed with a wide range of industrial minerals the extraction of which supports an important and diverse sector of the minerals industry. This sector makes a significant contribution to the national economy. The major part of this industry is located in England. In 2002, the sector had an estimated total output of 40 million tonnes of saleable, or usable product, with an ex-works value of about £700 million (see Table 1). This value is largely dominated by the industrial clays, mainly kaolin, and the carbonate minerals, limestone, chalk and dolomite (Figure 1). By comparison, the total output of primary aggregates (sand and gravel, and crushed rock) in England was about 159 million tonnes in 2002, with a value at about £1 000 million.

Figure 1 *Value of industrial minerals in England, 2002.*



2.2 The value of industrial minerals on an ex-works sales basis does not truly reflect their overall importance to the UK economy. This is discussed further below.

STRUCTURE OF THE INDUSTRY

2.3 The industry is generally characterised by a small number of large businesses, with production of each mineral being dominated by one or a small number of companies (Figure 2). Many companies now form part of major international groups (see Table 2). However, there are also a number of smaller producers, notably of industrial carbonates, silica sand and fluorspar, who are essentially single site operators.

Table 1 *Production and value of industrial minerals in England, 2002.*

Source: United Kingdom Minerals Yearbook, British Geological Survey
N/A not available

INDUSTRIAL MINERAL	THOUSAND TONNES	VALUE £MILLION
Cement raw materials (limestone & chalk) (GB)	15 192	220
Cement raw materials (common clay & shale)	2 194	
Limestone/dolomite/chalk (Industrial use) (GB)	8 915	
Limestone/dolomite/chalk (Agricultural use) (GB)	1 639	
Gypsum, natural	1 700	17
Brine/Rock salt	5 500	140
Potash (refined potassium chloride)	900	68
Silica (Industrial) sands	3 349	46
Kaolin (China clay)	2 163	192
Ball clay	921	44
Fluorspar	53	5
Calcspar	N/A	N/A
Barytes	10	<1
Fuller's earth	44	5
Lead concentrate (metal content)	<1	N/A
Iron ore	1	
China stone	1.5	
TOTAL (estimated for England)	**40 000**	**700**
TOTAL AGGREGATES (England)	**158 967**	**1 065**

DISTRIBUTION OF RESOURCES

2.4 Industrial minerals are widely distributed in England and occur in all regions with the exception of London. However, the location of individual industrial minerals and their quality fundamentally reflects geology and many are highly restricted in their occurrence and, consequently, extraction. For example, potash is produced at only one site, the Boulby Mine in the North York Moors National Park. Kaolin and ball clay are confined to the South West (Cornwall, Devon and Dorset), fluorspar, barytes and calcite to the East Midlands (mainly the Peak District National Park), and salt essentially to the North West (Cheshire). Gypsum is produced in four regions, North West, East Midlands, West Midlands and the South East, whilst silica sand and industrial carbonates are more widely distributed. However, the North West dominates output of silica sand and industrial carbonates are worked principally in the East Midlands (Derbyshire and the Peak District National Park) (see Table 3 and maps).

2.5 The restricted distribution of industrial minerals means that some are coincident with environmentally sensitive areas. Notable examples are fluorspar and potash, extraction of which is essentially confined to National Parks. Carboniferous limestones and the Cretaceous Chalk are the two principal limestone resources on which cement and industrial limestone production is based in England. These rocks also give rise to some of England's most attractive scenery and consequently extensive areas are covered by national landscape designations. In addition, these calcareous rocks give rise to areas of considerable nature-conservation interest. The extent of the conflict between industrial mineral resources and designations can be seen on the map.

Above *Fluorspar vein hosted in Carboniferous limestone being worked at Longstone Edge in the Peak District National Park.*

Right *High purity limestone suitable for industrial use can also form areas of attractive upland scenery. Bee Low Limestone (Carboniferous) at Chee Dale in the Peak District National Park.*

COMPANY MINERAL	PARENT COMPANY	COMMENTS
IMERYS Minerals *Kaolin* *Ball clay* *Industrial carbonates*	IMERYS GROUP of France (Privately-owned company)	World's leading producer of kaolin - 25% of world market. Also a leading world producer of calcium carbonates
WBB MINERALS *Silica sand* *Ball clay* *Kaolin*	SCR Sibelco of Belgium (privately-owned company)	World's leading producer of high quality ball clay and silica sand.
Rockwood Absorbents (Baulking) *Fuller's earth*	Rockwood Specialities Inc. of the US	Company created when Kohlberg Kravis Roberts & Co acquired several divisions of UK-based Laporte PLC in November 2000
Steetley Bentonite and Absorbents *Fuller's earth*	Tolsa SA of Spain	Also produces bentonite in Spain and Morocco
INEOS Chlor *Brine*	INEOS (privately-owned)	INEOS is a global manufacturer of speciality and intermediate chemicals. Company formed in 1998 and acquired ICI's chlorine and fluorine businesses in 2001.
British Salt *Brine/white salt*	US Salt Holdings	
Salt Union *Rock salt/white salt*	Compass Minerals International of the US	
Cleveland Potash *Potash/Rock salt*	Israel Chemicals	Europe's second largest potash producer and the world's fifth.
British Gypsum *Gypsum/anhydrite*	BPB Industries of the UK	World's leading producer of gypsum building products
Lafarge Cement UK/Lafarge Aggregates *Cement* *Industrial limestone/dolomite*	Lafarge Group of France	World's leading producer of cement. Major producer of aggregates in the UK
Castle Cement *Cement*	Heidelberg Cement Group of Germany	Heidelberg is one of the world's largest cement producers
Rugby Cement *Cement* *Silica sand*	RMC Aggregates	Major aggregates producer in the UK
Tarmac Central *Industrial limestone* *Cement* *Silica sand*	Anglo American	Anglo American is a UK-based and one of the world's leading mining companies. The Tarmac Group is part of the company's industrial minerals business and the UK's leading producer of aggregates.
Hanson Aggregates *Industrial limestone* *Silica sand*	Hanson Group	World's leading producer of aggregates
OMYA UK *Industrial carbonates*	OMYA Group of Switzerland	World's largest producer of industrial carbonates
Glebe Mines *Fluorspar/barytes/lead*	Privately-owned	Formed in 1999 through the acquisition of most of Laporte Minerals' fluorspar assets. Only UK-producer of fluorspar.

Table 2 *Ownership of the major industrial minerals producers in England, 2003.*

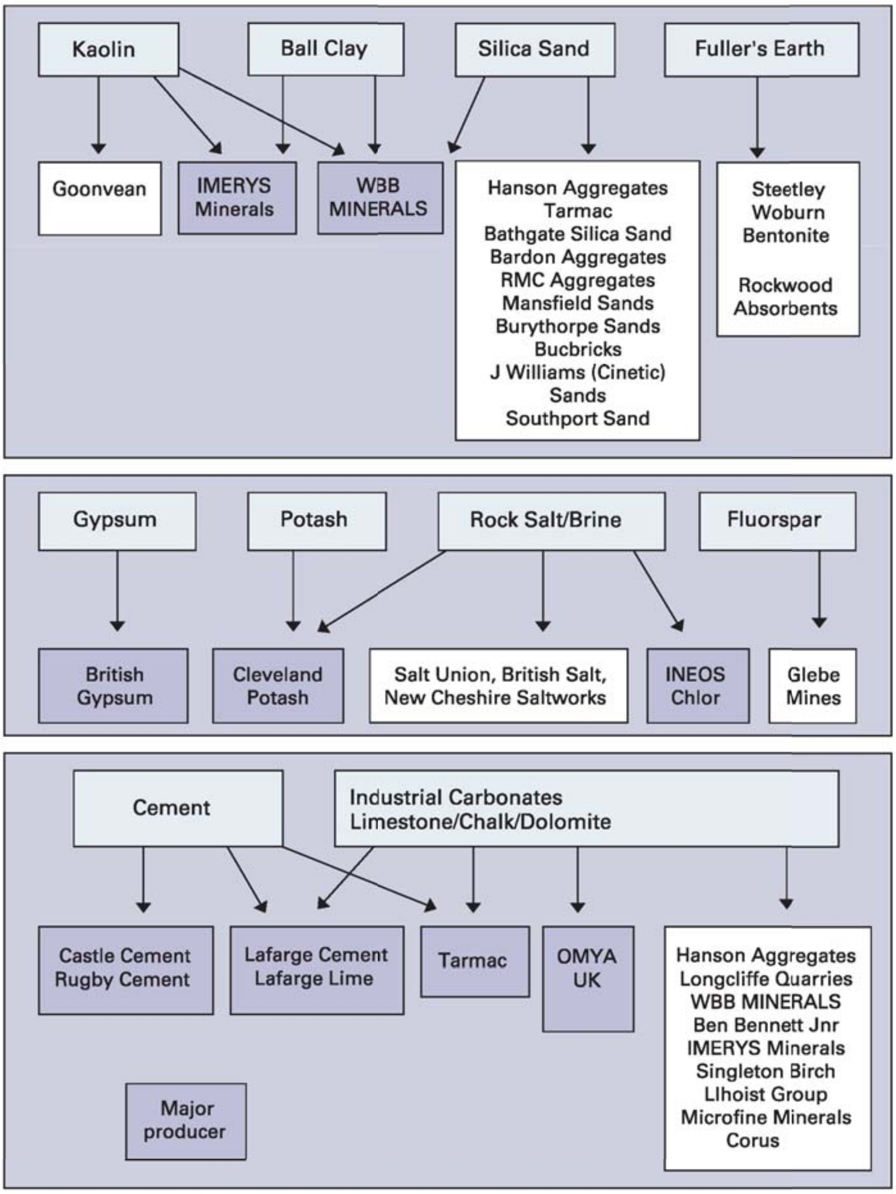


Figure 2 *Major producers of industrial minerals in England.*

MARKETS

2.6 A classification of industrial minerals in terms of the downstream industries in which they are consumed serves to illustrate their close links with important sectors of the economy (see Figure 3). Typically, individual industrial minerals are consumed in more than one market sector and each market sector requires a number of different minerals. For example, a number of industrial minerals are essential raw materials for the inorganic chemicals, ceramic and glass industries. Salt, in the form of brine, is an essential raw material for the manufacture of the heavy inorganic chemicals — chlorine and caustic soda (NaOH), and limestone and brine are used to manufacture soda ash (Na_2O_3). These chemicals are, in turn, basic feedstocks for a wide range of other industries. For example, chlorine is an essential intermediate in the production of plastics and polymers, such as PVC and nylon. Soda ash is an essential constituent of most commercial glasses, such as bottles and jars (containers) and flat glass (windows and automobile glazing). Similarly fluorspar, the only significant source of the element fluorine, is the feedstock for the production of hydrofluoric acid (HF), which is a key intermediate in the manufacture of all fluorine-bearing chemicals, as well as being an important product in its own right. Kaolin, ball clay and silica sand are all important raw materials

Table 3 *Location of major industrial mineral operations.*

INDUSTRIAL MINERAL	LOCATION (MPA)	REGION
KAOLIN	Cornwall	South West
	Devon	South West
BALL CLAY	Devon	South West
	Dorset	South West
FULLER'S EARTH	Bedfordshire	East of England
	Oxfordshire	South East
POTASH	North York Moors NP	Yorkshire & the Humber
SALT/BRINE	CheshireP	North West
	North York Moors N	Yorkshire & the Humber
GYPSUM	Leicestershire	East Midlands
	Nottinghamshire	East Midlands
	Staffordshire	West Midlands
	Cumbria	North West
	East Sussex	South East
FLUORSPAR/BARYTES/CALCITE	Peak District NP	East Midlands
	Derbyshire	East Midlands
SILICA SAND	Cheshire	North West
	Sefton	North West
	Norfolk	East of England
	Bedfordshire	East of England
	Essex	East of England
	Staffordshire	West Midlands
	Worcestershire	West Midlands
	Surrey	South East
	Kent	South East
	North Lincolnshire	Yorkshire & the Humber
	North Yorkshire	Yorkshire & the Humber
CEMENT RAW MATERIALS	Peak District NP	East Midlands
	Derbyshire	East Midlands
	Rutland	East Midlands
	Kent	South East
	North Lincolnshire	Yorkshire & the Humber
	West Midlands	Staffordshire
	Lancashire	North West
	Bedfordshire	East of England
	Cambridgeshire	East of England
	Essex	East of England
	Wiltshire	South West
INDUSTRIAL CARBONATES	Derbyshire	East Midlands
	Peak District NP	East Midlands
	Durham	North East
	Cumbria	North West
	North Yorkshire	Yorkshire & the Humber
	North Lincolnshire	Yorkshire & the Humber
	East Riding of Yorkshire	Yorkshire & the Humber
	Doncaster	Yorkshire & the Humber
	Cambridgeshire	East of England
	Kent	South East
	Wiltshire	South West
	Somerset	South West

used in the manufacture of high quality ceramic whiteware. However, the major markets for kaolin, accounting for over 80% of output, are as fillers and pigments, mainly in papermaking, but also as fillers in paints, rubber and plastics. Ground calcium carbonates compete with kaolin in these markets, in addition to having a wide range of other uses. The uses of limestone are many and diverse and it is often claimed to be the world's most versatile mineral. They include cement-making, lime manufacture (itself having many uses as diverse as steelmaking, chemicals feedstock, water and effluent treatment, and sugar refining), a flux in ironmaking, for flue gas desulphurisation and for a range of filler applications.

2.7 The markets for industrial minerals are widely distributed throughout the country and are not confined to England. The inorganic chemicals industry is mainly located in Cheshire in the North West and in relative proximity to its main raw materials, brine (sodium chloride), limestone and

Right Salt-in-brine from the Cheshire saltfield and high purity limestone from Derbyshire are essential ingredients in the manufacture of soda ash (sodium carbonate) at Northwich in Cheshire. Soda ash is a vital feedstock for the glass and chemical industries.

fluorspar. The chemicals industry is considered to be of strategic importance to the North West by the North West Development Agency. Ceramic whiteware production, which is dependent on kaolin, ball clay and silica sand, is largely located in the Stoke-on-Trent area and is very important for local employment. Similarly the glass container industry is mainly located in South Yorkshire and the important flat glass industry in St Helens and North Lincolnshire. The foundry industry is widely distributed but with a marked concentration in the West Midlands, Yorkshire and the East Midlands. Other important consumers of industrial minerals are the integrated iron and steelworks on Teesside, at Scunthorpe and Port Talbot in South Wales and the flue gas desulphurisation plants at the coal-fired power stations at Drax, near Selby and at Ratcliffe-on-Soar and West Burton in Nottinghamshire. The distribution of the main consumers of industrial minerals is shown on the maps in this section. Kaolin, ball clay and potash are also major exports.

KEY CHARACTERISTICS

2.8 There are marked differences in the geological occurrence, properties, markets, and supply and demand for industrial minerals, all of which have different land-use planning implications for the extraction of these minerals. **Diversity** is thus a key feature that characterises the industrial minerals sector. Some of these characteristics are summarised in Table 4 and considered in greater detail below in relation to land-use planning issues.

Table 4 Key characteristics of industrial minerals.

DIVERSITY OF GEOLOGY INFLUENCES
• the size of a deposit;
• the method of extraction (quarrying or underground mining); and
• the processing methods used and amount of waste produced
DIVERSITY OF PROPERTIES INFLUENCES
• the range of markets served based on different physical and/or chemical properties;
• the consequent need to meet a wide range of specifications;
• the need to be traded on the basis of specific properties, sometimes to meet a particular customer's requirements;
• the fact that individual qualities are often not interchangeable in use; and
• the need for producers to have close relationships with their customers.

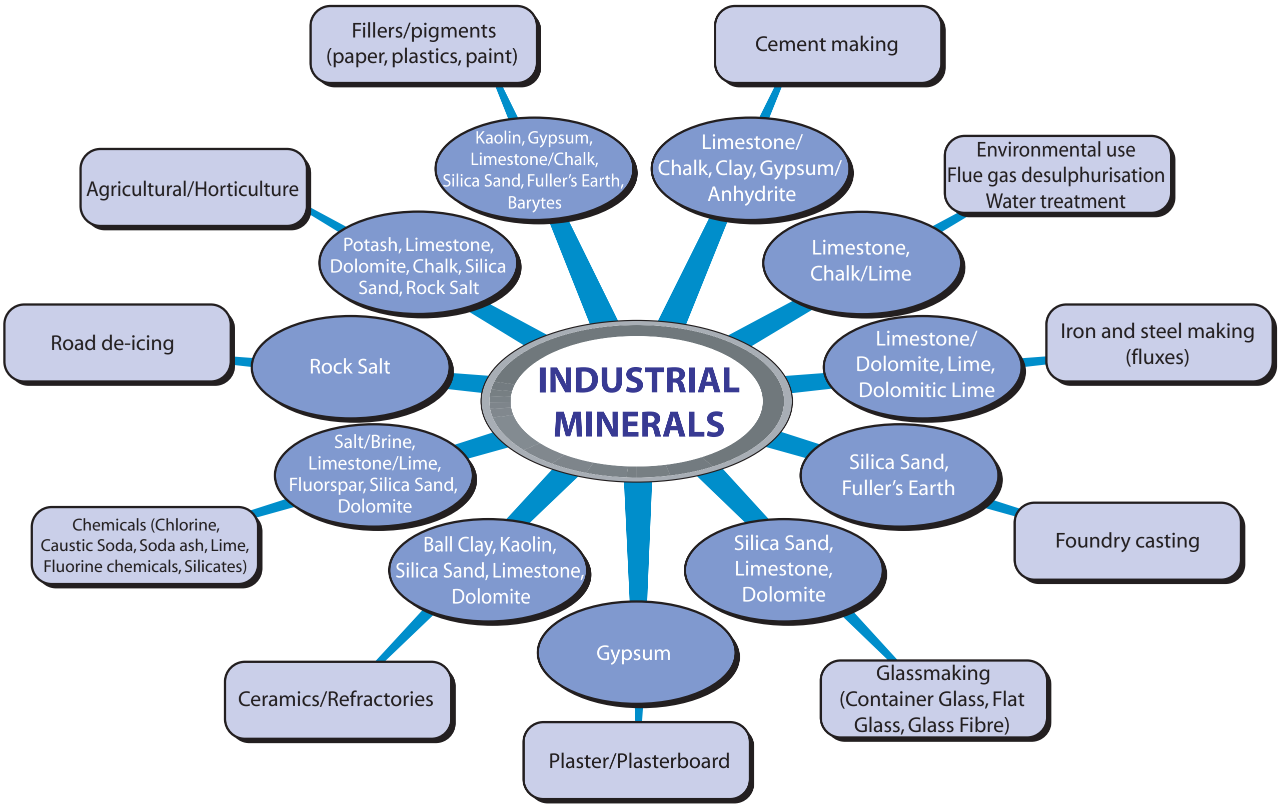


Figure 3 *Classification of the use of Industrial minerals by major market sectors.*

Geology

2.9 The geological mode of occurrence of the different industrial minerals, for example as thick flat-lying beds of limestone or as narrow linear mineral veins, greatly influences the size of a deposit and consequently the amounts that can be produced and over what period. It also dictates how a deposit is worked, notably by surface extraction or underground mining, the way the industrial mineral is processed and the amount of associated waste that is generated (Table 5). It also effects how a site can be restored. Geology, therefore, fundamentally influences the planning issues associated with the extraction of each mineral.

Left *High purity limestone quarried at Shapfell in Cumbria feeds kilns which supply lime to a number of iron and steel plants in England and Wales.*

Right *Resources of fuller's earth such as those, formerly worked at Clophill in Bedfordshire are now very restricted.*

2.10 With the exception of the 'vein' minerals — fluorspar, barytes and calcite — and kaolin, all the industrial minerals are sedimentary rocks that occur as bedded deposits in strata ranging from the Carboniferous to Recent in age (345 million to <10 000 years ago). Structurally, these deposits are comparatively simple and mostly occur in relatively flat-lying beds, which range in thickness from about 2 m (or less) to several tens of metres (some salt-bearing strata may be 200 m or more in thickness). Some deposits, like limestone and chalk, occur as essentially monomineralic rocks that are very extensive. However, ball clay and, notably, fuller's earth are scarce minerals and are very restricted in their geographical extent, a fact related to the unusual geological conditions required for their formation.

2.11 The evaporite minerals — salt, potash and gypsum/anhydrite — were all deposited from the evaporation of seawater. Consequently, all are soluble in water, with salt and potash particularly so. As a result they do not crop out at the surface in the UK because of solution by groundwater and can, therefore, only be worked by underground mining. The high solubility of salt means that solution mining can, in addition to conventional mining, also be used for extraction and indeed most (70%) salt is extracted as brine. The salt is extracted by injecting water into thick salt beds and

Right *Brine is produced by solution mining of salt below this wellhead at Holford in Cheshire.*

Above *High pressure water is used to wash kaolin (china clay) from altered (kaolinised) granite in the St Austell area of Cornwall.*

pumping out the resulting brine from specially designed underground cavities consistent with ground stability. Gypsum is slightly soluble, but it is formed by the hydration of anhydrite at, or near, surface. It is also produced mainly by underground mining. In contrast to minerals worked by surface methods, the underground extraction of evaporite minerals involves limited visual impact.

2.12 In sharp contrast, the kaolin (china clay) deposits of South-West England were formed by the *in situ* alteration of the feldspar component of the granites. Extraction is in very large open pits and subsequent processing involves separating the fine kaolinite particles from the coarser impurities present in granite (mainly quartz, unaltered feldspar and mica) by wet refining methods. The extraction and processing of kaolin thus involves the production of very large quantities of mineral waste, the disposal of which is a major planning issue.

Left *Chalk and Gault clay are blended to make cement at Ferriby in North Lincolnshire.*

MINERAL	GEOLOGY	EXTRACTION METHOD	PROCESSING WASTE
Salt	Sedimentary	Underground — rock salt mining and solution mining	Minor — returned to the solution cavities
Potash	Sedimentary	Underground mining	Soluble waste to sea; insoluble waste now being returned for disposal underground
Gypsum/anhydrite	Sedimentary	Mainly mining/one opencast	No mining or processing waste. Overburden is used for restoration.
Kaolin	Primary alteration	Surface open pit	Large volumes of extraction and processing waste stored in surface tips and in lagoons. Some is backfilled; increasing amounts of granular mineral waste being sold as aggregate.
Ball clay	Sedimentary	Surface quarries. Underground mining ceased in 1999 and is unlikely to resume.	Some extraction waste, including overburden and interburden. Some sand sold as secondary aggregate, other mineral waste backfilled to surface tips. No processing waste.
Fuller's earth	Sedimentary	Surface quarries	Overburden backfilled for restoration. No processing waste
Fluorspar	Vein	Surface open pits One small operating mine	Some processing mineral waste (limestone) sold as aggregate. Fines used for restoration or to waste lagoon
Silica sand	Sedimentary	Surface quarries	Very small amounts of mineral waste to lagoons. Overburden used in restoration
Cement raw materials	Sedimentary	Large surface quarries	Little waste, used in restoration.
Industrial carbonates	Sedimentary	Surface quarries. One operating mine	Little waste, lower quality material sold as aggregate

Table 5 *Summary of the basic geology and extraction methods for industrial minerals.*

2.13 The extraction of limestone, chalk and dolomite for industrial use and cement-making is by conventional surface quarrying methods, with the notable exception of the Middleton limestone mine in Derbyshire. Some of these operations, particularly those producing cement raw materials, are very large with outputs in excess of 1 million t/y and, exceptionally, 5 million t/y. However, some industrial chalk operations are relatively small with outputs of less than 100 000 t/y. The processing plants associated with these operations are generally large and require high capital investment, particularly for cement and lime manufacture. Similarly silica sand is produced by conventional quarrying, and the production of glass and foundry sands also requires extensive and costly processing facilities.

2.14 'Vein' minerals, principally fluorspar, occur mainly as infillings in faults that cut limestones of Carboniferous age. Fluorspar is always associated with other minerals, the most important being barytes and galena (PbS — lead sulphide) and indeed the only source of these minerals in England is as a by-product of fluorspar processing. The nature of fluorspar-barytes mineralisation (as narrow < 10 m, sub-vertical veins and associated replacement deposits in limestone) means that individual deposits tend to be relatively small. These range from 5 000 tonnes up to 1 million tonnes in size. Extraction thus tends to be short-lived. Consequently several deposits are required to supply a centralised processing plant and a continuous programme of exploration is required to identify new resources and to progress them through the planning system. This is in marked contrast to other industrial minerals operations, which are generally relatively long lived (sometimes measured in decades).

Properties

2.15 Industrial minerals are consumed in a wide range of end uses based on their diverse physical and/or chemical properties. Some industrial minerals are valued solely as sources of specific elements, or compounds, for example for use as chemical feedstocks, in cement-making or as plant nutrients. Examples include potash (K), fluorspar (F), salt (Cl and Na_2O) and limestone (CaO). For others it is a combination of physical properties, such as particle size and shape, natural and fired brightness (whiteness), plasticity, viscosity in suspension and density, that form the basis for commercial exploitation. However, in many cases it is a combination of physical and chemical properties that is desired. Silica sand is valued for its high silica content and low levels of impurities, notably of iron and refractory minerals such as chromite. In addition, specific particle sizes and, sometimes, grain shape are also required. Similarly ball clays are valued for their plasticity and unfired strength, which are related to particle size and

INDUSTRIAL MINERAL	PHYSICAL PROPERTIES
Kaolin	Whiteness, fine particle size, rheology
Ball clay	Plasticity, unfired strength, white-firing
Fuller's earth	Plasticity, bonding strength
Ground calcium carbonates	Whiteness, fine particle size, rheology
Barytes	High density, relative inertness and non-abrasiveness
Silica sand	Particle size and shape
Gypsum	Whiteness
	CHEMICAL PROPERTIES
Salt (NaCl)	Source of chlorine (Cl) and soda (Na_2O)
Potash (KCl)	Source of potassium (K)
Gypsum ($CaSO_4.2H_2O$)	Rehydration properties
Limestone ($CaCO_3$)	Source of lime (CaO) and carbon dioxide (CO_2)
Dolomite ($CaCO_3.MgCO_3$)	Source of magnesia (MgO)
Fluorspar	Source of fluorine (F)
Kaolin and ball clays	Low iron content
Silica sand	Source of silica (SiO_2)
Fuller's earth	Cation-exchange capacity, chemically active surfaces

Table 6 *Some important properties of industrial minerals.*

1 A high density aqueous suspension of insoluble solids.

Right *Ball clay products for the ceramics industry require careful selective mining and blending.*

mineralogical composition. Some are also valued for their ability to readily disperse in water to produce fluids slips[1]. However, they are also required to fire to a light or near-white colour, which is largely a function of low iron and titania (TiO_2) contents. Some of the important properties of industrial minerals are listed in Table 6.

2.16 Different markets for specific industrial minerals demand different combinations of properties. The same mineral may, therefore, be traded with several different specifications, each depending on specific end use. Individual grades of industrial minerals are, therefore, often not interchangeable in use. For example, silica sand sold for coloured container glass manufacture has an iron content of 0.25% Fe_2O_3, whereas for colourless containers the requirement is for less than 0.035% Fe_2O_3. These two grades cannot, therefore, replace one another, although both are classed as 'silica sand'.

2.17 Unlike refined metals and chemicals, which are traded on the basis of purity and price, industrial minerals are the products of natural processes. Subtle differences in their properties can make the performance of a specific industrial mineral quite different from one deposit to another. Consequently individual deposits may be aimed at particular products or markets and, as a result, some specifications for particular uses are written around specific deposits. Whilst processing is capable of enhancing or modifying the properties of some industrial minerals, it cannot for example, fundamentally change the iron content, or whiteness, of limestone or dolomite, or the fluid properties of kaolin or ball clay. The valuable, if not unique, combination of properties of certain qualities of ball clay occurring in the Bovey Basin of Devon has meant that about 50% of the world's production of sanitaryware contains English ball clay as an essential ingredient. In addition to price, therefore, quality may also be an important factor that determines whether a mineral is sourced domestically or from overseas.

2.18 A distinction can be made between the **grade** of an industrial mineral (the amount of useful mineral it contains) and its **quality** (suitability for a specific application). Both can markedly affect the economic importance of a particular mineral resource. For example, England has large resources of high chemical grade limestone, which are valuable for a wide range of chemical uses. However, despite their chemical purity, they are of relatively poor quality with respect to brightness (whiteness) and are, thus, unsuitable for important applications in papermaking. It is quality that ultimately defines the suitability of a mineral for a particular use.

Above *Thin, but extensive spreads of wind-blown silica sand are worked at Messingham in North Lincolnshire for use in a range of products including container glass.*

Grade and **quality** can be defined as follows.

- **Grade** — the amount of useful material a deposit or sample contains e.g. calcium fluoride (CaF_2), potassium chloride (KCl) or kaolinite content.
- **Quality** — the physical and/or chemical properties that determine the suitability of the material for specific end uses, e.g. whiteness of kaolin and calcium carbonate for use in paper, rheological (fluid) properties of ball clay for use in sanitaryware, and also the level of impurities such as arsenic in fluorspar or iron and chromite in silica sand.

2.19 Modern manufacturing technology is placing increasingly stringent demands on raw material quality. Variations in the properties of an industrial mineral beyond specified limits cannot be tolerated as it may result in increased production losses. This could have a major effect on the economics of a downstrean manufacturing process and threaten its viability. Production losses also waste resources, both mineral and energy. Quality thus also implies raw materials with **consistent** and **predictable** properties, in terms of both composition and performance. Indeed the consistency of a property, such as the iron content of a glass sand, may be more important than its precise value, as variations are difficult to control in the manufacturing process. Whilst consistency of quality is important for all consumers, it is a particular concern for some businesses when sourcing minerals from distant global locations where quality is more difficult to monitor.

2.20 The success of any business depends on its meeting customer requirements in terms of quality and price. In the case of industrial minerals this ultimately depends on the quality and price of the end product whether it be flat glass, cement or a ceramic product.

Captive use

2.21 Industrial minerals serve as essential raw materials that underpin many sectors of manufacturing industry, where the added value can be several times the cost of the mineral used. Indeed some industrial mineral producers are also major manufacturers and of the total production of industrial minerals (approximately 40 million tonnes) about 50% is not sold on the open market but used 'captively' in the manufacture of value-added products. The most important 'captive' use is limestone and chalk for cement manufacture. However, a selection of others is shown in Table 7 together with the value of the sales of the principal products that are based on these raw materials. The value of cement sales (Table 7) exceeds that of the total value of all other industrial minerals production. In addition, cement is only at the start of the supply chain, being an essential constituent of concrete and mortar, which are vital, and essentially irreplaceable, materials for the UK construction industry.

INDUSTRIAL MINERAL	INITIAL MANUFACTURED PRODUCT	PRODUCT SALES (£MILLION)
Limestone/chalk/clay	Cement	755
Limestone/dolomite	Lime/dolomitic lime	64
Natural Gypsum	Plaster	118
Brine (Salt- NaCl)	Chlorine and caustic soda	200 (e)

Table 7 *UK: Sales of selected products based on captive production of industrial minerals, 2002.*
(e) BGS estimate
Source: ProdCom, Office for National Statistics

Place value

2.22 Transport costs are a major component of the delivered price of many minerals and the lower the value of a mineral, the more profound are the effects of transport costs on the economics of an operation. Proximity to the market can, therefore, be very important and it applies a *'place value'* to a mineral deposit. A mineral with a *high place value* is one that commands a low price and is expensive to transport. Minerals with *low place values* are those that have a higher monetary value and may be internationally traded. Gold has a very low place value and a deposit of adequate size and grade can be worked almost anywhere with virtually no restriction on distance to market. Some industrial minerals command relatively high prices and are internationally traded, e.g. kaolin, fluorspar and ball clay. However, proximity to a seaport may also be important because of the high cost of overland transport. In contrast, limestone/ chalk for cement manufacture has a high

Right *Cement is an essential constituent of concrete and mortar. Both are vital materials used by the building and civil engineering industries.*

Right *Kaolin (china clay) is one of many industrial minerals which require sophisticated, capital-intensive processing. Superconducting magnets are used to improve the whiteness of some kaolin from Cornwall by removing small quantities of iron-bearing minerals.*

place value, which means that cements plants are mainly located in close proximity to their raw materials. Limestone could not be imported for cement manufacture. Thus without adequate reserves of cement raw materials to maintain domestic production the alternative would be to import manufactured cement. The result would be the associated loss of the value added by the cement manufacturing process (£371 million in 2001).

Added value

2.23 An important element of sustainable development is maximising the benefits derived from a resource and its subsequent use. This means 'doing more with less,' using resources efficiently and increasing added value. The industrial minerals sector is, by definition, supplying materials that are demanded by 'industry.' There are considerable opportunities for increasing the value of the minerals produced and it makes sound business sense for companies to increase the value derived from their mineral assets. Indeed adding value by upgrading the quality of a mineral will, in many cases, be a prerequisite if the mineral is to be sold for specific applications. A company's ability to take advantage of value-added opportunities depends on a number of factors, including the quality of its deposit, its processing technology, its marketing capabilities and the competitiveness of the market. Value added may be increased by;

- producer processing, e.g.:
  - particle size reduction (fine grinding, micronising);
  - increasing purity or grade (flotation, acid treatment, magnetic separation);
  - additional property modification (blending, calcination, surface coating).
- downstream manufacturing processes, e.g.:
  - manufacture of cement, lime, plaster, inorganic chemicals.

Price

2.24 A direct consequence of the costs of extraction and the degree of processing that an industrial mineral undergoes is that different minerals, grades and qualities may have markedly different prices. Some typical prices of industrial minerals are shown in Table 8. Compared with metals, industrial minerals generally show low price volatility.

Table 8 Typical prices of selected industrial minerals (2003).

MINERAL	PRICE RANGE
Kaolin	£60–£150/tonne, exceptionally £300/tonne
Ball clay	£15–£80/tonne, exceptionally £200/tonne
Fuller's earth	£100–£115/tonne
Silica sand	£10–£17/tonne, exceptionally £50–£150/tonne
Fluorspar	£120/tonne
Chalk, filler	£30–£50/tonne
Limestone	<£10/tonne
Cement	Approx £50/tonne

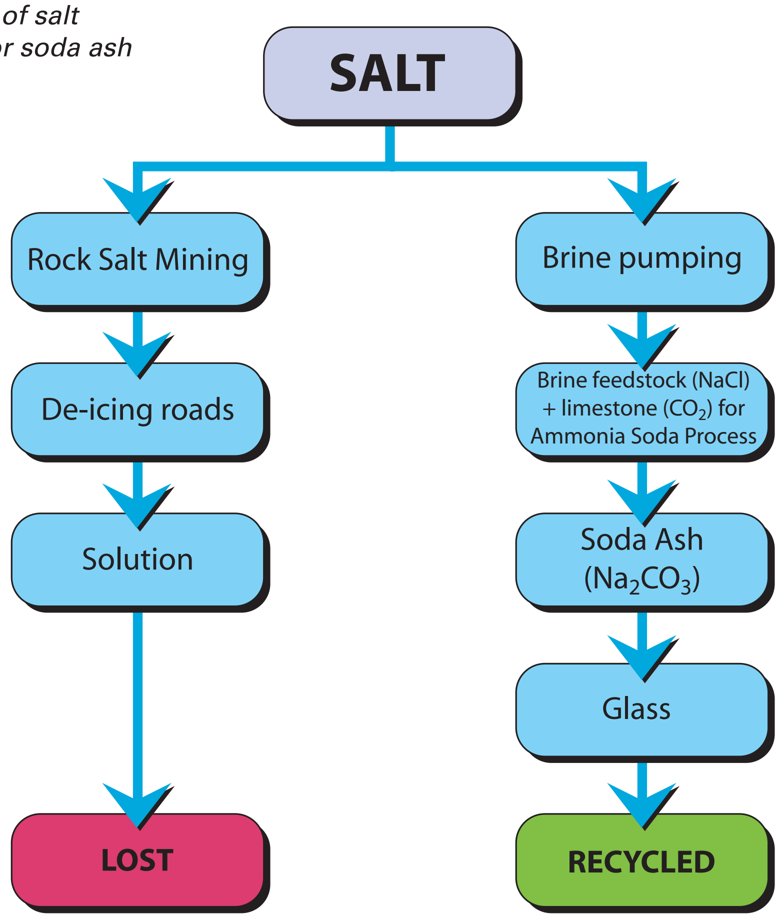
SUBSTITUTION/RECYCLING

2.25 The fact that industrial minerals are valued for their physical and/or chemical properties, means that opportunities for substitution and recycling are variable and, often, complex. As a general rule it is the physical properties of materials that can be more readily recycled. In the case of metals, for example, it is properties such as strength, hardness, thermal and electrical conductivity, and lightness that are of economic value. These properties remain intact in use and thus metals are available for recycling, often without loss of quality. Similarly with aggregate minerals physical properties, such as strength and abrasion resistance, are not changed irreversibly in use and can often be recovered, for example, in construction and demolition waste.

2.26 The life cycle of industrial minerals is often more complex. Foundry sands, which are valued for their particle size and shape, as well as chemical composition, can be recovered and, in part, re-used. However, other physical properties such as plasticity and viscosity in suspension, for example in ceramic clays, are either changed irreversibly in use (for example during firing) or dispersed and not readily recoverable in their original form. Minerals that are valued for their softness, whiteness and fine particle size, such as fine ground calcium carbonate and kaolin, may replace one another, notably in papermaking. If it were a case of straight substitution on the basis of cost alone then ground calcium carbonate would be used every time. However, calcium carbonate does not provide the same gloss and printability as kaolin. Substitution is thus often a compromise between cost and functional performance.

2.27 Minerals that are valued for their chemical properties alone are generally more difficult to recycle or replace. There is no alternative to potassium-bearing minerals as plant nutrients or salt as a source of both soda (Na_2O) and chlorine. Similarly, other than limestone/chalk there are no sources of lime (CaO) that are of sufficient abundance to be used for cement manufacture. Alternative sources of silica and alumina for cement-making are available and include by-products from other processes, such as pulverised fuel ash, a by-product of burning coal at power stations, and cement clinker kiln dust. In addition, there are also materials, referred to as additions, that partially replace the cement clinker or Portland cement. These additions thus reduce the amount of cement used per unit of concrete produced. The use of blended cements is increasing and these may contain, singly or in combination, a proportion of pulverised fuel ash, blastfurnace slag (a by-product of ironmaking) and limestone. The partial replacement of energy intensive clinker by an industrial by-product or a naturally occurring material not only has economic and environmental advantages but has the potential to produce concrete with improved technical properties, including improved long term strength and durability.

Figure 4 Life cycle of salt from de-icing and for soda ash manufacture.



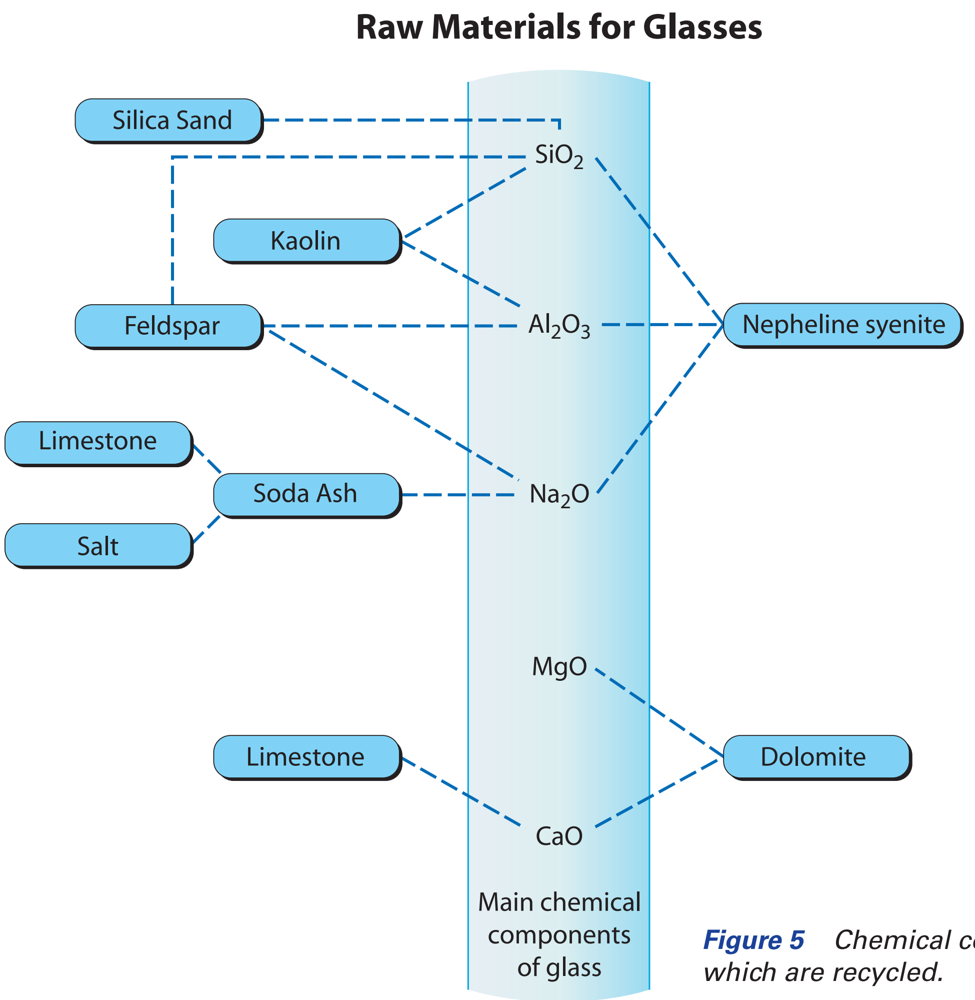


Figure 5 Chemical components of glass which are recycled.

2.28 Recycling of some industrial minerals valued for their chemical properties is impossible. A good example is rock salt used for de-icing roads where the mineral is dissolved and dispersed and thus not recoverable (see Figure 4). However, there are important exceptions. Silica sand is valued as a glassmaking raw material because of its silica content, which is typically >98% SiO_2. Most commercial glasses, such as glass containers, consist of soda-lime-silica glass containing between 70–74% SiO_2, the ultimate source of which is silica sand. Recycling of waste glass (known as cullet) is increasingly being used in making new glass, not only reducing the demand for new silica sand but also, because cullet melts more readily, saving energy and thus reducing emissions. Other industrial materials used in glassmaking, such as limestone, dolomite and soda ash, are also effectively recycled. Some, like nepheline syenite, which is valued for its alumina and soda contents, are imported (see Figure 5). In a similar way increased recycling of steel scrap will also reduce, in part, the need for limestone/ dolomite as flux. Calcium carbonate used as lime for sugar beet refining is ultimately recovered and sold as a soil conditioner.

2.29 The use of an alternative, such as an industrial by-product, for a naturally-occurring mineral may itself create a demand for another mineral. This is well illustrated by the calcium sulphate mineral gypsum, which in its natural form is mainly produced by underground mining. However, calcium sulphate is also derived as a by-product of certain industrial processes, the most important being flue gas desulphurisation (FGD). This process removes sulphur dioxide from the flue gases at some coal-burning power stations thus preventing 'acid' rain. The process involves absorbing the acidic sulphur dioxide in a water-based slurry of finely ground, high-purity limestone, which is ultimately converted into a product known as desulphogypsum. In England, this material is now a very important supplement to the supply of natural gypsum with some one million tonnes being produced in 2003 and additional quantities becoming available in 2004. Desulphogypsum is of higher purity than most natural gypsum produced in England and has almost entirely replaced domestically mined natural gypsum in the manufacture of plasterboard. (See Factsheet on Gypsum).

2.30 FGD requires large quantities of high purity limestone and approximately 0.7 tonnes are consumed per tonne of desulphogypsum recovered. Thus a mineral worked by surface quarrying has replaced one worked by underground mining with, arguably, a lower environmental impact. However, the real environmental gain is, of course, a reduction in sulphur dioxide emissions in line with Government targets.

TRANSPORT

2.31 Movement of industrial minerals to market is by road, rail and sea, the latter to serve export markets, although some coastal movement of rock salt and agricultural dolomite to Scotland also takes place. Of the total marketable output of industrial minerals of 40 million tonnes (Table 1) it is estimated that over 25% is transferred by rail or ship, a much higher proportion than for aggregates. Rail connected industrial mineral sites are shown in Table 9; some of the major mineral flows are shown on maps in this section. Although many companies would wish to increase industrial mineral movement by rail there remain significant economic and practical disincentives, not least network capacity. In addition, the Freight Facilities Grant Scheme, which assisted companies to invest in freight facilities such as rail sidings, has been suspended. A decision on re-opening the scheme has not yet been made.

Table 9
Industrial mineral sites with rail (including disused) rail links.

INDUSTRIAL MINERAL	RAIL CONNECTED INDUSTRIAL MINERAL SITES
Potash:	Boulby, North York Moors National Park
Silica sand:	Leziate, Norfolk Moneystone, Staffordshire (not in used for many years)
Gypsum:	Robertsbridge, East Sussex (import of desulphogypsum and natural gypsum) East Leake, Nottinghamshire (occasional import of desulphogypsum)
Cement:	Tunstead/Old Moor, Derbyshire/Peak District Hope, Peak District (50%) Barrington, Cambridgeshire (imports of coal/petroleum coke only) Ketton, Leicestershire (17%) Westbury, Wiltshire (15% in 1989, says MPG 10) Ribblesdale, Lancashire (sales ceased 1992, coal imports)
High purity limestone:	Shapfell, Cumbria Tunstead/Old Moor, Derbyshire/Peak District Dowlow, Derbyshire Quidhampton, Wiltshire Melton, East Riding (recently connected)
Dolomite:	Thrislington, Durham Whitwell, Derbyshire (not in use)
Ball clay:	Heathfield in S. Devon. Some other sites are rail linked but not used.
Kaolin:	Rail is used to transfer kaolin to Fowey for export and to serve some long distance markets in the UK and Europe

Cement

2.32 Cement raw materials are produced in the largest tonnages (Table 1). These are almost always supplied from quarries adjacent to cement plants to avoid the costs of transporting large quantities of a low cost raw material. The main exception is the Rugby cement plant in Warwickshire where chalk slurry is supplied by pipeline from the Kensworth quarry in Bedfordshire, a distance of 77 km. Clay is also transported 14 km by road from Southam. A pipeline is also used to transfer clay slurry from a site in Essex under the River Thames to the Northfleet cement works. However, the Northfleet plant will close in 2008 due to the exhaustion of chalk reserves. It is unlikely that pipelines will be used in the future to transport cement raw materials over long distances. This is due to their high cost and the economic disadvantages of cement manufacture using the wet or semi-wet process, which slurrying in water entails. Of the 11 cement plants in England, four have rail links to supply dedicated terminals elsewhere in the UK. A further rail-linked works is proposed (Medway, Kent). Obtaining planning permissions for cement terminals is a planning issue in itself.

Industrial carbonates

2.33 Major rail flows of crushed chemical grade limestone go from the large Tunstead Quarry in Derbyshire to FGD plants at Drax, Ratcliffe-on-Soar and West Burton coal-fired power stations. Another important flow (about 900 000 t/y) is from Tunstead to Brunner Mond's two soda ash plants at Lostock and Winnington in Cheshire. Some soda ash is transported to markets in Scotland by rail. Seasonal dispatches of crushed limestone are also sent by rail to East Anglia to be used by the British Sugar Corporation in sugar beet refining. Limestone is also transferred the short distance to Hindlow Quarry for lime burning. As a result some 40–45% of the 5 Mt/y output of Tunstead Quarry is dispatched by rail.

2.34 Lime from Corus' Shapfell Quarry in Cumbria is transferred by rail to the Redcar and Scunthorpe steel plants. Chalk slurry is moved by rail tank wagons from Quidhampton in Wiltshire to Workington, Mossend and Irvine for papermaking.

2.35 Most industrial dolomite is transported by road and only Thrislington Quarry in Durham is rail linked and in use. Dolomite flux is transferred to Port Talbot steelworks in South Wales by rail.

Gypsum

2.36 Plaster and plasterboard plants are normally located in close proximity to the gypsum mine and these products are then delivered by road. Gypsum/anhydrite for cement manufacture is now delivered by road. However, desulphogypsum has now replaced domestic natural gypsum in plasterboard manufacture. Rail containers transfer this material from the Drax power station to plasterboard plants at Kirkby Thore in Cumbria, East Leake in Nottinghamshire and, occasionally, Robertsbridge in East Sussex. The latter plant is also supplied by rail using imported gypsum through Southampton. Desulphogypsum from the West Burton power station in Nottinghamshire has recently started being transported by rail. Other plasterboard plants located on the coast are supplied by imports by sea.

Silica sand

2.37 Silica sand is mainly supplied by lorry and bulk tanker. However, rail is used to transport colourless glass sand from Leziate, near King's Lynn to container glass plants in South Yorkshire and Nottinghamshire, and to a new flat glass plant near Goole. The total tonnage supplied by rail is about 400 000 t/y.

Salt/brine

2.38 About 70% of the salt extracted in England is in the form of brine, which is then fed by pipeline for use directly in the manufacture of inorganic chemicals, or to produce white salt. Rock salt for de-icing roads is delivered by road. A small amount is subsequently sent by rail from Trafford Park in Manchester to Scotland. By-product rock salt at the Boulby Potash Mine is removed from the mine site by rail for onward transfer by road and ship from Tees Dock. For the rehabilitation of old brine filled salt mines beneath Northwich, some 900 000 tonnes of brine is to be removed and transferred by rail to British Salt's white salt plant at Middlewich. The void created will be filled with pulverised fuel ash to stabilise the site.

Potash

2.39 Nearly 90% of the potash produced at the Boulby Mine is transferred by rail to Tees Dock for export by sea or onward transfer in the UK by road. Approximately 1.4 M t/y of potash and rock salt from the mine are transferred by rail.

Right *Most of the potash and rock salt produced at Boulby Mine in North Yorkshire is transported from the site by rail.*

Right *Significant quantities of ball clay are exported by sea from a number of ports in south west England.*

Kaolin

2.40 Most of the production of kaolin is exported through the ports of Par and Fowey, the latter port being supplied by rail, both from the St Austell and Devon operations. Overall some 77% is transported by sea, 13% by rail and 10% by road transport. UK transfers by rail include clay slurry to paper mills in Scotland. About 50 000 t/y kaolin is also sent by rail to Cliffe Vale in Stoke on Trent which serves the ceramics industry and other clay users in the north west. About 30 000 t/y is also moved through the Channel Tunnel to markets in northern Italy.

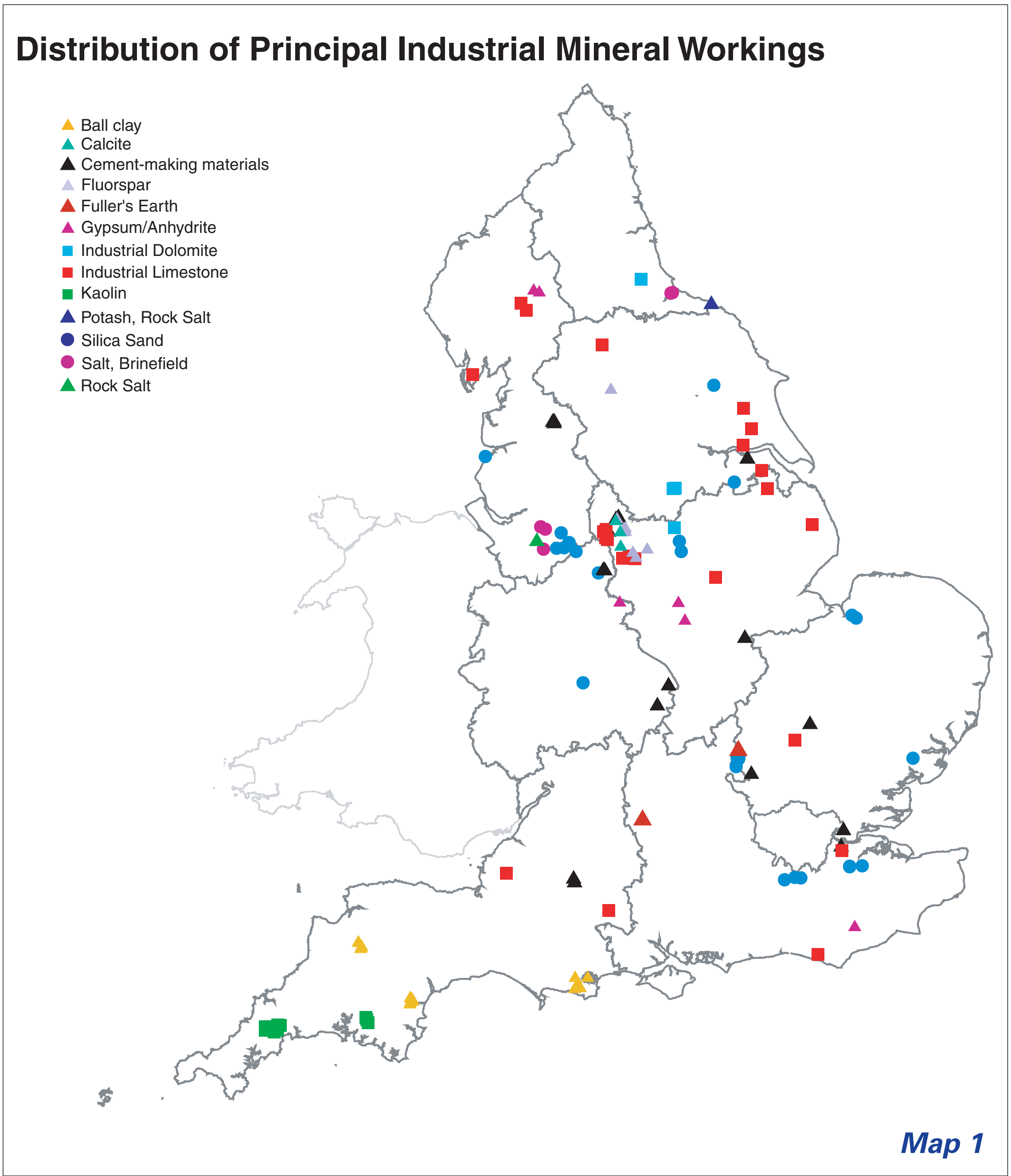
Ball clay

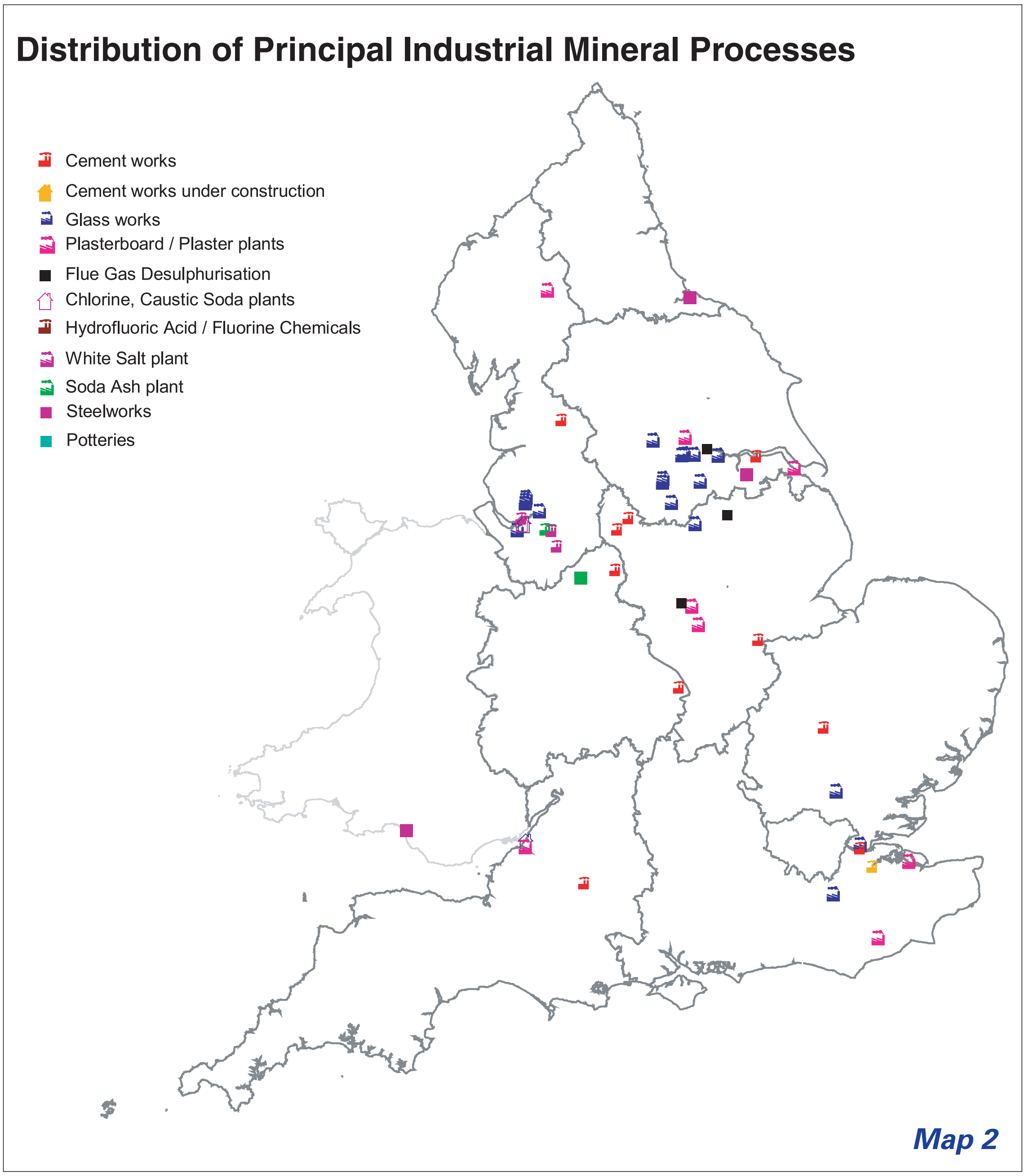
2.41 The majority of ball clay sales (> 80%) are exported mainly through the ports of Teignmouth, Bideford and Poole, which are, for economic reasons, supplied by road. Sales of ball clay in the UK are mainly transferred by road, although some is transported by rail from Heathfield in the Bovey Basin.

MAPS

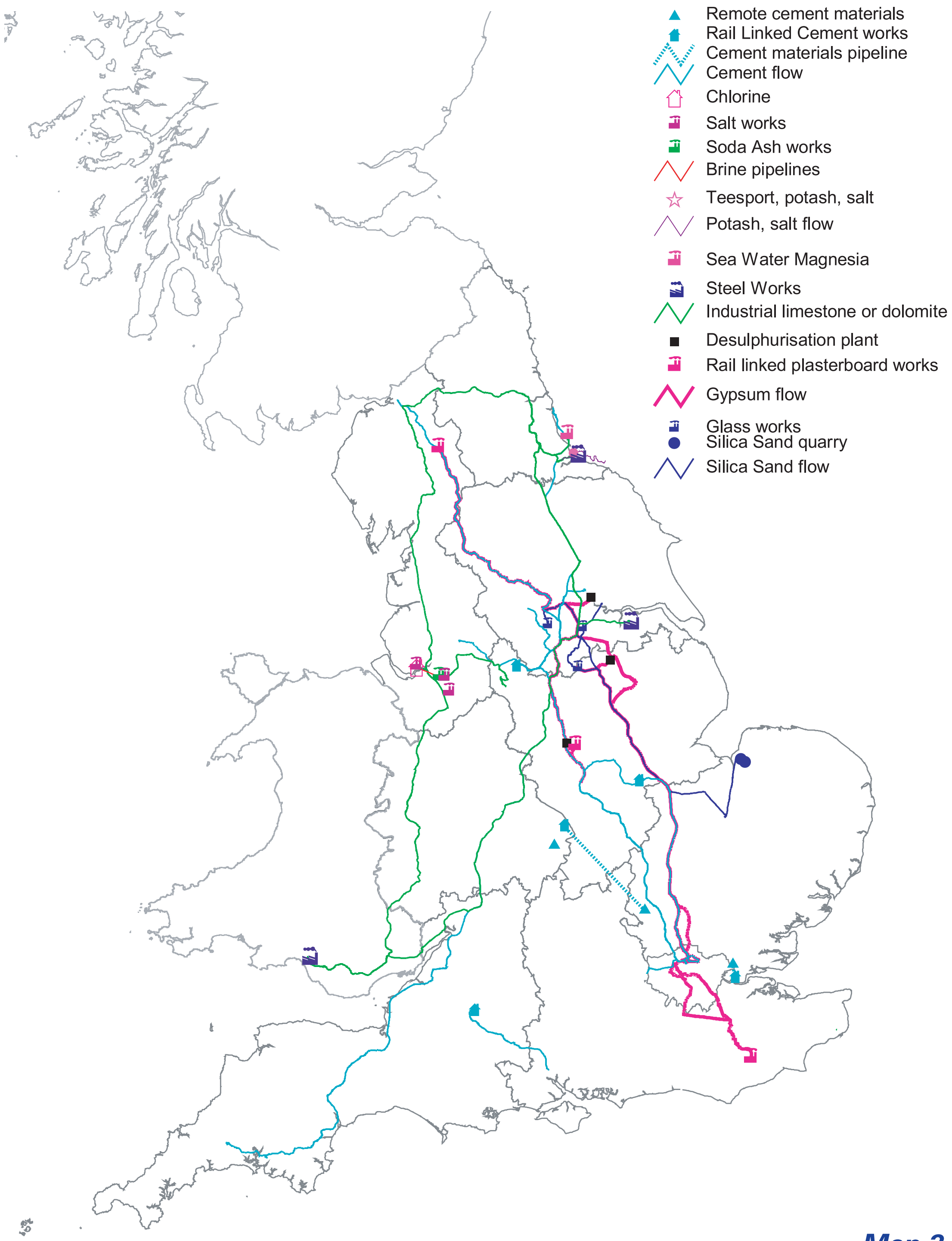
2.42 This sub section contains a series of maps which display the broad distribution of specific industrial minerals resources (see Mineral Planning Factsheets), together with the sites where they are worked and consumed, transport links and their relationship with a range of environmental designations.

2.43 The maps are derived from a Geographic Information System (GIS) which was designed as part of the project to facilitate the integration and analysis of spatially-related datasets relevant to industrial minerals in England. It is proposed that this be kept up-to-date to support any revision of the Mineral Planning Factsheets, as well as a resource for MPAs and the minerals industry.


Distribution of Principal Industrial Mineral Workings
Ball clay
Calcite
Cement-making materials
Fluorspar
Fuller's Earth
Gypsum/Anhydrite
Industrial Dolomite
Industrial Limestone
Kaolin
Potash, Rock Salt
Silica Sand
Salt, Brinefield
Rock Salt
Map 1

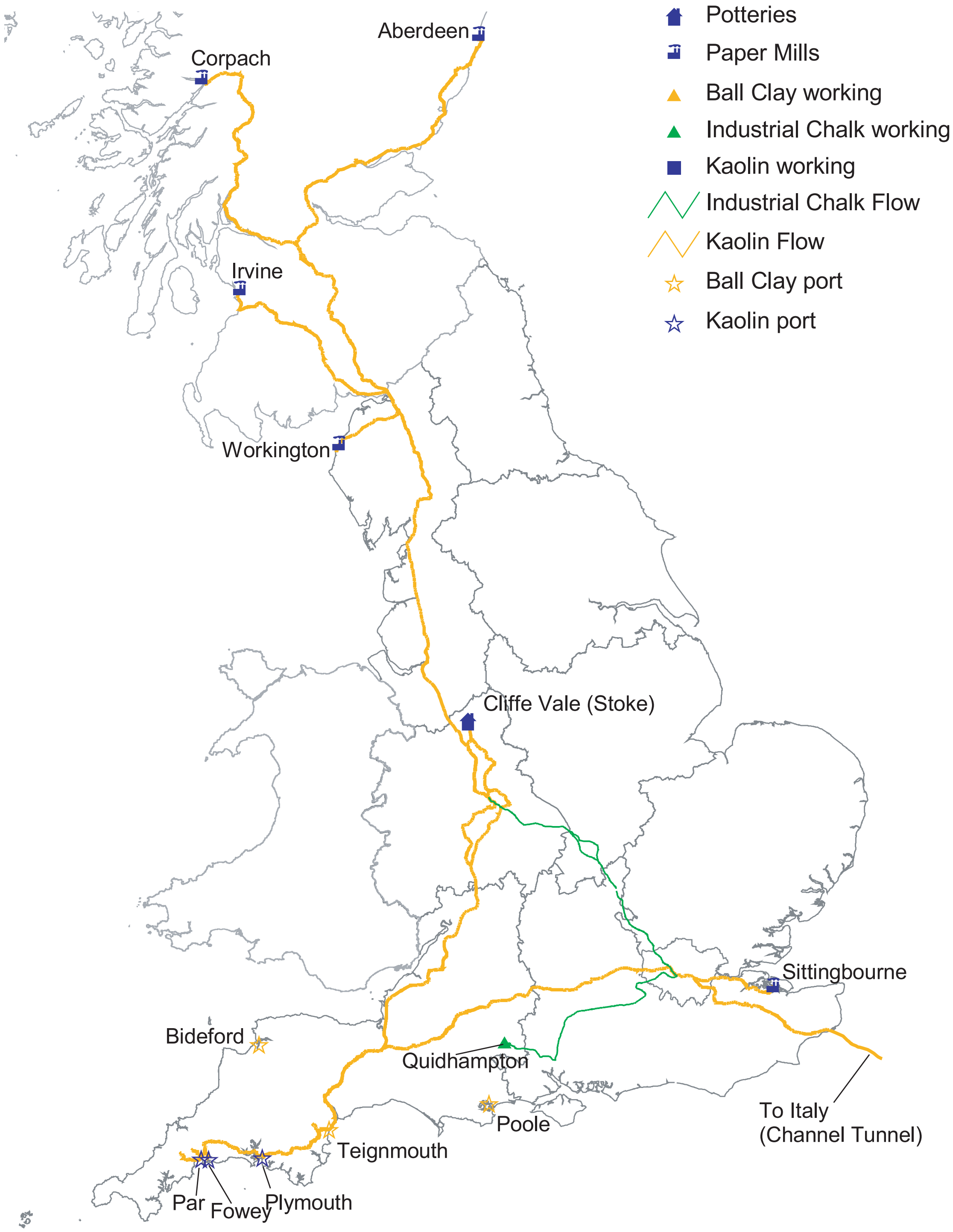

Distribution of Principal Industrial Mineral Processes
Cement works
Cement works under construction
Glass works
Plasterboard / Plaster plants
Flue Gas Desulphurisation
Chlorine, Caustic Soda plants
Hydrofluoric Acid / Fluorine Chemicals
White Salt plant
Soda Ash plant
Steelworks
Potteries
Map 2

Distribution of Principal Industrial Mineral Rail Links.
1 - Cement, Glass Sand, Gypsum, Industrial Carbonate and Salt



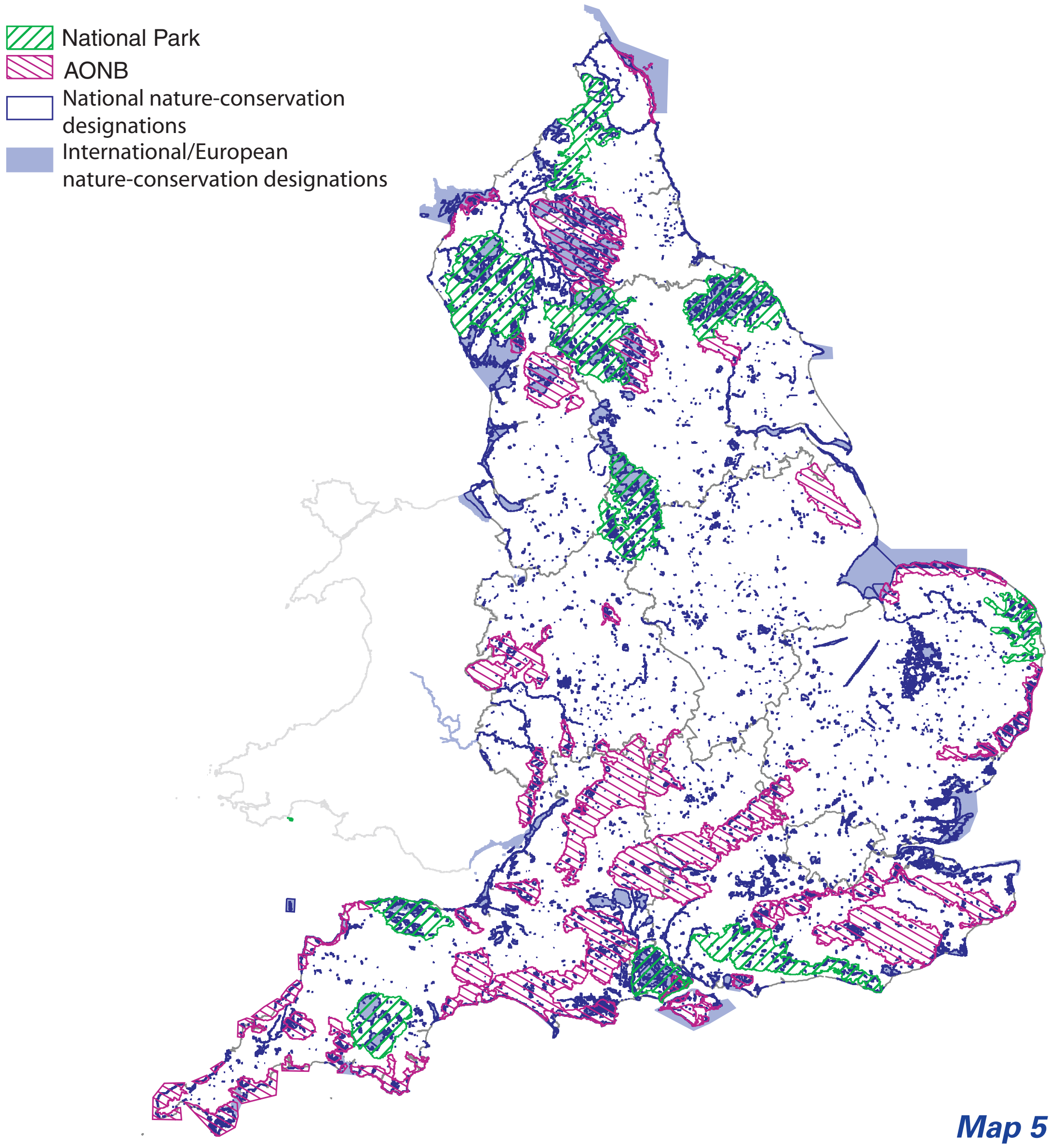
Map 3

Distribution of Principal Industrial Mineral Rail Links Sea Links.
2 - Ball Clay, China Clay, Industrial Chalk



Map 4

Extent of the major landscape and nature-conservation designations



Map 5

3 Economic Importance of Industrial Minerals

3.1 An essential element of formulating planning policy for industrial minerals, as well as evaluating individual planning applications, is to gain a better understanding of their contribution to the UK economy. In addition to presenting information on the broad value of industrial mineral sales (see Figure 1 and Table 1), the sector has also been analysed against a number of economic indicators. Where relevant its performance is benchmarked against other sectors chosen either on the basis of their characteristics or geographic location. This has helped to illustrate the relative performance of the sector and hence give an indication of its relative economic importance. The economic indicators considered are:

- Gross valued added
- Employment
- Productivity
- Contribution to down-stream industries

GROSS VALUE ADDED (GVA)

3.2 The importance of individual industries, including the extractive industries, to the national economy may be measured by their contribution to Gross Value Added (GVA). This is a key indicator of economic performance, which refers to an increase in ability to produce goods and services. Value Added is defined as the difference between the value of an output (e.g. revenue) and the cost of the bought-in inputs used to produce it (e.g. fuel and other raw materials, but not labour). In other words, it represents the enhancement in value added to a product or service by a company before the product is offered to customers. GVA is, therefore, different from the value of sales (or notional sales) revenues generated by the industrial minerals sector that is presented in Table 1. However, as minerals are at the start of the supply chain they are generally associated with a high value added. The GVA in an industry is simply the aggregation of all the values added by individual companies in that industry. The industry is measured in terms of contribution to GVA rather than GDP because the calculation of GVA measures the contribution of a firm or sector to national wealth before it is redistributed via taxes and subsidies.

3.3 The GVA of the minerals extractive industry as a whole is included in national accounts under the heading 'Mining and Quarrying,' which includes oil and gas extraction. Mining and Quarrying contributed £25 531 million to GVA in 2002 (Table 10). In 2002, Gross Value Added in the 'Other Mining and Quarrying' sector (essentially non-energy minerals, which includes the Industrial Minerals sector) was £2 251 million[2], of which approximately 35% is accounted for by the industrial minerals sector. This equates to £788 million[3]. Assessing the level of value added that

2 Source: Office for National Statistics National Accounts — GVA at current basic prices: by industry.
3 Estimate provided by BGS.

Table 10 *Gross Value Added of 'Mining and Quarrying' at current basic prices in 2002 by industry.*

SECTOR	£MILLION
MINING AND QUARRYING:	
of which: Mining of coal	539
Extraction of mineral oil and natural gas	22 743
Other mining and quarrying	2 251
(Industrial Minerals)	(788) (e)
Total mining and quarrying	**25 531**

Source: National Accounts, Office for National Statistics
(e) estimated
Note: The sub-sectors comprising 'Other Mining & Quarrying' (SIC 14) do not entirely coincide with the industrial minerals covered in this study. Consequently figures for the industry turnover have been estimated from data published in the BGS United Kingdom Minerals Yearbook.

the industrial minerals industry creates demonstrates, in part, the sector's contribution to net economic wealth (i.e. wealth creation).

3.4 The industrial minerals sector accounts for only 3% of the total national GVA created by the Mining and Quarrying sector (all energy and minerals extraction) in the UK. This contribution must, however, be set in context due to the fact that nearly 90% of the total Mining and Quarrying sector's GVA is accounted for by the very high value added sector of UK Oil and Natural Gas production (Table 10).

3.5 The industrial minerals sector, therefore, accounts for a relatively small amount of Gross Value Added in the economy. However, it is important to consider the spatial dimension of where this GVA is created. This spatial dimension issue is important and relevant to nearly all the economic indicators under consideration. Figure 6 shows that of the 69 main producing sites in the UK industrial minerals sector, 54 (78%) are located in either **remote rural** or **accessible rural** locations.

3.6 Rural areas are classified as either accessible or remote. In general, accessible rural areas are located closer to urban centres in the UK and therefore benefit from some degree of spill-over of economic activity, which manifests itself in a greater diversity of sectors. Remote rural locations, by definition, do not benefit from this spill-over effect to the same extent and therefore have more limited sectoral diversity.

Left *Significant quantities of ball clay are produced from Petrockstow in the heart of rural North Devon.*

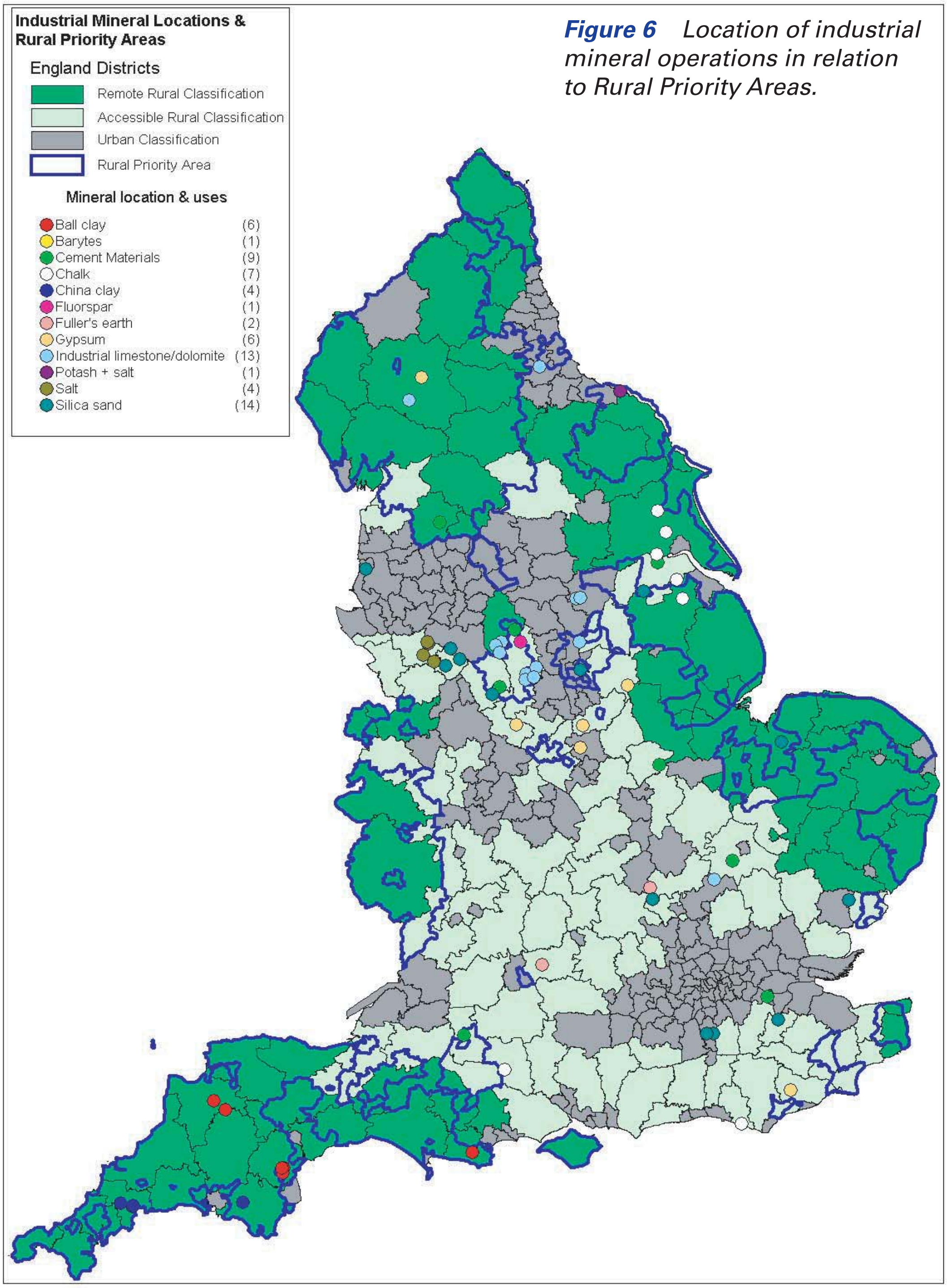


Figure 6 *Location of industrial mineral operations in relation to Rural Priority Areas.*

DTZ Pieda Consulting, Economics

3.7 This represents an important consideration in the economic case, given the current focus on the structure of rural economies highlighted by the recent upheavals in the rural economy caused by, amongst other things, the Foot and Mouth outbreak. The outbreak demonstrated that the economies of remote rural England had become heavily dependent on a limited number of sectors, primarily tourism and agriculture, and therefore the maintenance of a diverse industrial structure in these rural areas has become an important policy objective.

3.8 The Government's Rural White Paper aims to both maintain and further develop a 'working countryside' ensuring a diverse sectoral mix in the rural economy. Many of the companies in the industrial minerals sector are located in Rural Priority Areas (RPAs) which are a key focus for both Regional Development Agency (RDA) and Countryside Agency funding and assistance. The majority of RPAs are located in remote rural areas.

3.9 A specific task of the RDAs is to help regenerate deprived rural areas, focusing currently on the RPAs — the most seriously deprived rural areas. The presence of 32 of the main operating sites (46% of the total number of sites) in the industrial minerals sector in the RPAs is thus of noteworthy consideration, due to their wealth- employment- and productivity- generating effects in these locations.

EMPLOYMENT

3.10 The industrial mineral sector's contribution to employment is measured in three ways, namely the amount of direct, indirect and induced employment created.

- Direct impacts are the income and employment effects of industrial mineral extraction and related processing activities in the UK.
- Indirect impacts are the income and employment effects generated amongst suppliers to the industrial minerals sector. Companies in the industrial minerals sector purchase goods and services from suppliers in the UK, who in turn make further purchases of goods and services from their suppliers in the UK. As a result of the initial purchases of goods and services, additional employment is generated across many sectors of the UK economy.
- Induced employment impacts are the additional income and employment effects in shops and services due to the re-spending of incomes generated by direct and indirect expenditures. The level of induced employment in the UK is calculated using an assumed consumption multiplier.

3.11 In terms of direct employment generated by the sector, the latest figures for total employment in the UK minerals industry (excluding oil and gas) for 2001 was 36 238[4]. (Note: The Annual Business Inquiry gives a figure of 31 000 for Other Mining and Quarrying [SIC 14] for 2002). For the minerals under consideration in this study the employment figure was 9 111 in 2001, or 25% of total sector employment. (It is important to note that these employment figures are likely to be an underestimate of the actual direct employment attributable to the industrial minerals sector. For example, they do not include employment in associated processing facilities, or back office/administrative functions).

3.12 It is standard practice to estimate indirect and induced employment by use of an employment multiplier. The multiplier is an estimate of the economic impact (jobs, expenditure and income) associated with additional

4 Employment. The figures in the BGS UK Minerals Yearbook are taken from the ONS Annual Minerals Raised Inquiry (AMRI). They specifically relate, at least for GB, to employees subject to the Mines and Quarries Acts 1954 and 1961. The question in the AMRI form states:

- Number of people on site for week ending 7th September (say) 2002 (or in nearest normal week). — some quarries are worked on a campaign basis.
- It includes all directly employed persons.
- All lorry drivers using the site, whether or not directly employed.
- Contractors used for drilling, blasting, plant installation or modification etc.
- Persons employed on any operation subject to the provisions the Factories Act 1961 are excluded.

knock-on effects within the local economy. In most economic impact assessments the employment generated through indirect and induced effects are not separated out due to the difficulties inherent in multiplier analysis, and that is the case in this study.

3.13 The likely indirect and induced multiplier has been estimated based on past experience in economic impact assessment and an empirical review of other employment impact studies[5]. Uncertainty surrounds the true value of the multiplier of the UK economy, with the more plausible recent estimates varying between 1.6 and 1.9. The scale of the multiplier effects will be influenced in particular by the extent of supply chain linkages in the area of analysis. The linkages vary substantially by sector and area. Income is also an important factor in the level of the multiplier estimate. Specifically, it is the proportion of additional income that is spent within the area of analysis that has an important bearing on the value of the multiplier. These estimates of multipliers do not, however, include employment in downstream industries, which are dependent on industrial minerals as essential inputs.

3.14 Reflecting the above factors and the predominantly rural distribution of the sector, a multiplier of 1.6 for the UK economy has been used for the purposes of this report. Thus for the 9 100 direct jobs in the industry, it is estimated that a 5 500 indirect and induced jobs are created in the UK economy. The overall employment attributable to the industry is thus estimated at 14 600.

3.15 Once again, whilst the magnitude of the employment figures is not that high (under 15 000 direct, indirect and induced), it is important to give consideration to where employment in the industry is distributed. As already discussed, 78% of firms in the sector are located in either remote rural or accessible rural locations and many of these are in Rural Priority Areas. Assuming that this same percentage can be applied to the amount of direct, indirect and induced employment created (i.e. 11 400), then the sector makes a significant contribution to employment in rural areas.

3.16 Furthermore, there is also the dimension of the skills associated with the sector. The sector is comprised of both manual and non-manual employment and therefore contains a diversity of skills. This will therefore make an important contribution to maintaining a diversified rural skill base, which is a necessary requisite of a well-structured rural economy.

PRODUCTIVITY

3.17 Productivity is defined as the amount of output per unit of input (labour, equipment, and capital) over a set period of time. A country/region's potential output depends on the productivity of its factors of production. The faster the rate of growth in productivity, the faster is likely to be the country's rate of economic growth. There are many different ways of measuring productivity. For example, in a factory productivity might be measured based on the number of hours it takes to produce a good, while in the service sector productivity might be measured based on the revenue generated by an employee divided by the salary received.

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5 Most notably the study on *The economic importance of UK Ball Clay* which used a national economic multiplier of 1.8. Report prepared by SRK Consulting, DTZ Pieda Consulting, British Geological Survey and CERAM Research Ltd for the Kaolin and Ball Clay Association (KABCA) and DTI.

3.18 Improving the UK's performance in productivity is a key objective of the UK Government, arising from the UK's relatively poor performance in this economic measure against close competitors such as the US, France and Germany. According to HM Treasury, "*Increasing the sustainable rate of productivity growth and creating an enterprise culture across the UK is central to the Government's economic strategy*." Productivity growth, coupled with high and stable levels of employment, is an important driver of long-term economic performance.

3.19 One of the standard approaches for measuring labour productivity is GVA per employee, which gives an indication of the level of output generated by one worker in an industry. Comparing the industrial minerals sector with other sectors classified as primary industries shows that the sector's productivity is high. Using the SIC classification of 'Other Mining and Quarrying', GVA per employee in the sector in 2002 was £47 290, compared with £19 895 in agriculture/forestry and £21 113 in fishing. The sector's GVA per employee figure was also significantly higher than that of the average for UK manufacturing in 2002 which was £39 045.

3.20 The Department for the Environment, Food and Rural Affairs (DEFRA) have recently developed proposals for the measurement of economic under performance in rural areas. The measure, in essence, uses the earnings of residents in an area divided by the number of people of working age, excluding those in education. This is regarded as being a proxy for productivity in rural areas. Further research into this measure is currently underway by DEFRA. However, for the purposes of this study we have discussed the potential contribution of the industrial minerals sector to this measure.

3.21 The average gross weekly earnings in the sector[6] was £401 per week in April 2002, which was significantly above the average for other rural based sectors such as agriculture which had an average wage of £310. Using DEFRA's methodology as a proxy for productivity, given the higher level of earnings paid by the sector than rival sectors in the rural economy, it can be argued that the industrial minerals sector contributes to raising the level of productivity in rural areas of the UK.

CONTRIBUTION TO DOWNSTREAM INDUSTRIES

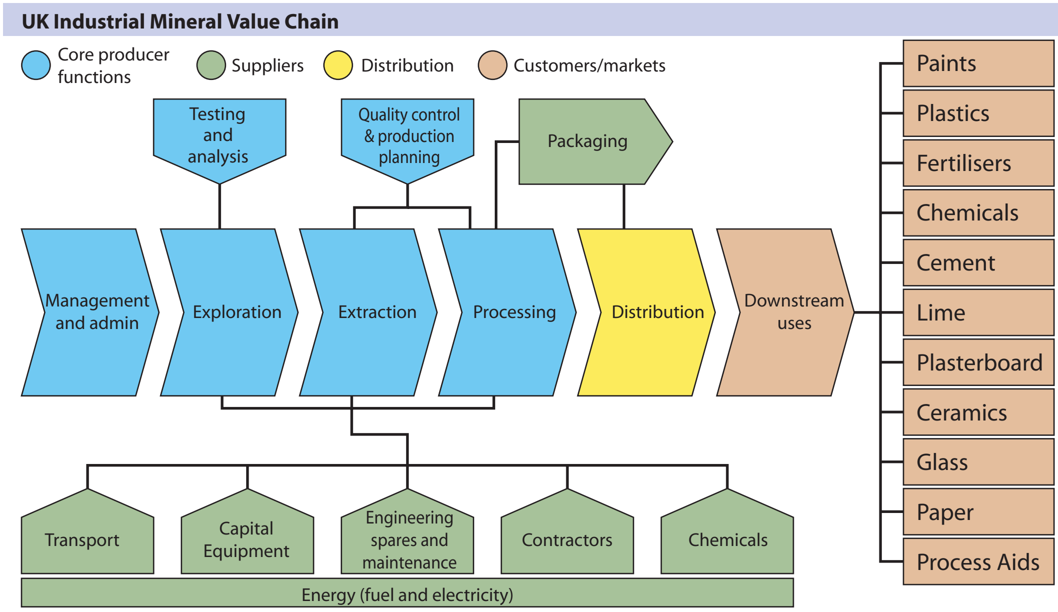
3.22 The importance of industrial minerals to the economy is not attributed solely to the value of production and the numbers of people who are directly and indirectly employed in their extraction and processing. Account also needs to be taken of their importance as essential inputs to a wide range of downstream industries, mainly within the manufacturing and construction sectors, but also in agriculture. Consideration thus needs to given to;

- the importance of these downstream industries to the UK economy;
- the importance of indigenously produced minerals to the competitiveness of these industries; and
- the number of jobs that may be at risk if there were an interruption or termination in the supply of indigenously produced minerals.

3.23 The industrial minerals sector contributes to a wide range of downstream industries (see Figure 3). Figure 7 presents a value chain diagram of the UK industrial minerals sector. This diagram shows, at a broad industry

6 Full-time manual males on adult rates.

Figure 7
Industrial mineral value chain.



level, each stage of the process required to produce the end products and the various inputs that are required at each stage of production. It also highlights some of the main downstream uses for the industrial minerals extracted in the UK.

3.24 National Statistics datasets present only a broad coverage of the downstream industries that are supported by the industrial minerals under consideration in this study. Table 11 presents a summary of a selection of the immediate downstream sectors, the numbers of firms operating in each sector and how many people they employ and their values in terms of GVA.

3.25 According to the Annual Business Inquiry, there are approximately 2 000 firms in the immediate downstream industries that the industrial minerals sector serves, employing approximately 85 000 people, and generating an estimated £3 600 million in Gross Value Added in the UK economy. Clearly, not all these downstream companies will use minerals extracted in the UK. Equally, companies in the sector also export minerals overseas. However, these statistics serve to illustrate the magnitude of the potential domestic market that UK industrial mineral producers serve. Industrial minerals impact on many other sectors of the economy, for example as fillers in paper, plastics and rubber and as process aids in a range of industries, not least in the foundry castings industry. However, in these industries industrial minerals form only a minor, albeit essential, input. The value of these inputs are difficult to identify in official statistics.

3.26 The key issue relating to downstream industries is whether or not it is sustainable for these firms to source minerals from overseas suppliers in the long term and if they do to what extent that will affect their future competitive position. Two key assumptions underlie this issue. Firstly, security of supply has to be ensured. If supply of industrial minerals cannot be guaranteed from sources outside the UK, then there is a prima facie economic case for continuing to source from UK-based producers. Secondly, there are important quality issues associated with these minerals. In a previous study undertaken on the UK ball clay sector, it was found that only ball clay extracted and processed in the UK was of the requisite quality for many downstream users, and that there were no substitutes for this without incurring substantial costs in altering the production processes.

3.27 Continued security of supply of minerals of the required qualities are fundamental assumptions and, if not met, will lead to an unsustainable situation for downstream companies who either will not be able to rely on the minerals to be delivered to meet their production schedules, or have to incur a cost to adjust their production processes to use minerals of a different or lesser quality.

STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODE	NUMBER OF FIRMS	NUMBER OF EMPLOYEES ('000)	GVA (£M) 2001
24			
24.13 Manufacture: Inorganic Chemicals	225	8	437
24.15 Manufacture: Fertilisers	89	3	167
24.30 Manufacture: Paints, Varnishes etc.	551	29	1,180
26			
26.11 Manufacture: Flat Glass (Stats. for 2000)	23	1	94
26.13 Manufacture: Hollow Glass	89	8	346
26.14 Manufacture: Glass Fibres	250	5	168
26.21 Manufacture: Ceramic Household Articles	366	17	290
26.22 Manufacture: Ceramic Sanitary Fixtures	57	6	231
26.23 Manufacture: Ceramic Insulators (1999 stats)	22	1	11
26.25 Manufacture: Other Ceramic Products	207	1	22
26.51 Manufacture: Cement	38	4	371
26.52 Manufacture: Lime (1999 stats)	10	NA	16
26.53 Manufacture: Plaster (1999 stats)	17	NA	9
26.62 Manufacture: Plaster for Construction	68	2	276
TOTAL	**2,012**	**85**	**3,618**

Source: Office for National Statistics Annual Business Inquiry 2001

Table 11 *Number and Value of **selected** Immediate Downstream Enterprises 2001.*

4 Planning Issues

PLANNING CONTEXT: CURRENT PLANNING POLICY FOR INDUSTRIAL MINERALS

4.1 Planning policy for industrial minerals can be considered at the national, regional and local level. The UK is signatory to a range of international agreements which could indirectly affect industrial minerals (such as agreements on wildlife) but there do not appear to be any affecting industrial minerals directly.

National policy

4.2 National policy for industrial minerals which affects the exercise of planning powers is set out primarily in Minerals Planning Guidance (MPG) notes issued by the Department of State with responsibility for the town and country planning system in England. This is currently the Office of the Deputy Prime Minister (ODPM). Policy can also be set out in other official documents such as White Papers, Planning Policy Guidance notes and good practice advice, each of which has a specific status and purpose.

Minerals Planning Guidance notes

4.3 Minerals Planning Guidance notes are issued at the discretion of the ODPM. None is required by law. The current set of MPG notes is listed in Annex B. The subjects covered range from themes across all minerals to aspects of planning procedure and to guidance on specific minerals. MPG 1 sets out overarching guidance on *General Considerations and the Development Plan System*. Just two of the MPGs deal with minerals relevant to the terms of reference of this project: MPG 10 on *Provision of Raw Material for the Cement Industry* and MPG 15 on *Provision of Silica Sand in England*. The other minerals in this project receive very little, if any, specific mention in MPGs. The references to them are more in the form of acknowledgements than policy advice. The statements are in MPG 1 Annex B which provides 'General Advice for Individual Minerals'. Relevant extracts are also reproduced in Annex B to the present report.

4.4 There is much advice in other MPGs which is as relevant to industrial minerals as it is to other minerals. This includes advice on the application of the principles of sustainable development to minerals and on the weight to be afforded to a range of competing interests for the use of land. Many of the main aspects of policy reside in MPG 1, but some aspects of broad policy are to be found in MPG 6.

Other official documents

4.5 The highest level of Government policy is the White Paper. There is no White Paper specifically devoted to minerals issues, though there are many which have a bearing on mineral planning generally and, to a degree, on planning for industrial minerals. For example, the 1999 White Paper *A better quality of life: A strategy for sustainable development for the UK* has a section on 'Minerals' as a resource management issue (pps.86–7) which has direct implications for the industry. Other policies in the White Paper have indirect consequences for minerals, such as support for reducing the materials intensity of goods and services, and for enhancing the recyclability and durability of goods (page 35).

4.6 Planning Policy Guidance (PPG) notes are a parallel series of Government policy alongside MPG notes. They likewise address planning themes, procedures and specific issues within planning. Some of them frequently have a bearing on mineral planning, notably PPG 7 on *The Countryside — Environmental Quality and Economic and Social Development* and PPG 9 on *Nature Conservation*. PPG 7 sets out policy advising local planning authorities how to evaluate development proposals which affect, amongst other things, National Parks, Areas of Outstanding Natural Beauty, landscape character and areas designated for their local landscape quality. Other PPGs may from time to time have relevance to specific minerals or sites, such as PPG 20 on *Coastal Planning*.

4.7 'Circulars' from the ODPM and its predecessor Departments advise local authorities on how to apply various aspects of the law. Those relevant to industrial minerals include Circular 11/95 on the *Use of Conditions in Planning Permissions* and Circular 1/97 on *Planning Obligations*. Although interpretation of the law is ultimately a matter for the Courts, Circulars provide an indication of how the Government would like to see the law applied.

4.8 The Government also issues advice on latest research and good practice in many aspects of planning. These are advisory and have less endorsement from the Government than policy statements. Research reports are typically commissioned from independent consultants, whose views may or may not accord with those of the Government. These may be essentially good practice guidelines, such as the report on *Reclamation of Damaged Land for Nature Conservation* (HMSO, 1996), or reports with a policy recommendation element. Examples of the latter relevant to planning for industrial minerals include *Sustainable development issues for mineral extraction — the Wareham Basin of East Dorset* (British Geological Survey, 2002) and *Appraisal of High Purity Limestones in England and Wales* (Department of the Environment, 1990).

4.9 Research and advice may be issued simultaneously. For example, in 1996 the Department of the Environment issued a research report on *The Reclamation of Mineral Workings to Agriculture* together with *Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture*.

National policy overview

4.10 Taken together, therefore, there is potentially a very wide range of documents which can influence policy, plans and individual decisions relevant to industrial minerals. In practice, this advice is limited, being centred on the Minerals Planning Guidance notes for cement-making materials and silica sand. This project has provided an opportunity for the Government to reassess whether the existing range of planning advice on industrial minerals remains satisfactory or if any changes are now merited.

Regional policy

4.11 Regional planning policy relevant to minerals can be set out in two ways. Policy may be set down in Regional Planning Guidance (RPG) notes or as regional elements within national planning policy for minerals (i.e. within MPG notes). Both of these are issued by the ODPM (and its predecessors). As with all policies of these kinds, whether or not to have any policy, and if so what it says, are ultimately at the discretion of the Government.

Regional Planning Guidance

4.12 All Regional Planning Guidance notes mention industrial minerals. The level of guidance they contain is very small, mostly recognising the special minerals within their areas but offering little commentary on them. It is difficult to see what function this serves. There may be merit in a particular region developing a policy on a particular industrial mineral in a way which offers advice to mineral planning authorities in that region. This might be appropriate for minerals which are entirely or principally confined to one region, such as kaolin and ball clay in the South West and salt in the North West. However, if this function cannot be served there would appear to be merit in RPGs ceasing to mention industrial minerals at all. Policy could then be left to the more suitable vehicles of MPG notes and individual local development plans.

Regional aspects of minerals planning guidance

4.13 Government policy may be specified at a regional level through MPG notes. By far the most significant development of policy at the regional level this way is for aggregate minerals. There are few other instances of such regional policy development, though MPG 10 on cement-making materials does include policy which has clear regional implications. In particular, a policy encouraging domestic production as a means of resisting imports has special implications for the South East region, which is the regional market most accessible to imports. MPG 15 on silica sand states that development plans should take account of regional as well as national needs for the mineral.

Regional policy overview

4.14 It is clear that most policy for industrial minerals planning omits any significant element at the regional level. There is modest policy at the national level and by far the most policy in development plans at the local level (discussed below). National policy for both cement-making materials and silica sand advocates site level supply policies which clearly omit intervention at the regional level.

4.15 There is a difference between regional policy which mentions industrial minerals because those minerals happen to be prominent in a particular region, and regional policy which aims to affect the supply and demand pattern in each region in relation to other regions. It is doubtful whether there are any minerals studied in this project, other than arguably cement-making materials, for which the latter kind of regional policy would be a practical proposition, due to their limited occurrence in England.

Local policy overview

4.16 There is extensive policy at the local level specific to industrial minerals. Local policy must be in accordance with higher level policy set out in national policy and in Regional Planning Guidance (if any is relevant). Local policy is set out in plans prepared by those authorities which are designated as Mineral Planning Authorities (MPAs). MPAs also decide planning applications for mineral working in their areas. MPAs comprise County Councils, National Park Authorities, London & Metropolitan Borough Councils, and unitary authorities created by local government reorganisation in the mid-to-late 1990s. For plan-making purposes, and therefore policy for industrial minerals, many of the new unitary authorities exercise their powers jointly with neighbouring authorities (often County Councils). As a result of the somewhat complex pattern of plan-making activity around England, local policy on minerals can be found variously in Structure Plans, in Unitary Development Plans [UDPs], in Minerals Local Plans [MLPs] (either in a two tier arrangement with a Structure Plan or in associaton with a Unitary Development Plan), and in National Park Local Plans.

4.17 The arrangement is therefore that plans containing policies relevant to industrial minerals may for the most part either be set out fully within single documents (e.g. the UDP for Doncaster MBC, the North Lincolnshire

Plan, and the East Riding of Yorkshire and Hull City Councils' Joint MLP), or in a pair of documents comprising a Structure Plan and a Minerals Local Plan covering the same areas (e.g. for Nottinghamshire, for Staffordshire & Stoke-on-Trent, and for Somerset & Exmoor National Park).

4.18 The breadth and detail of the commentary and policies on industrial minerals within any plan broadly reflects the perceived relative importance of these minerals to the planning of each area, although Minerals Local Plans will always be more detailed than any Structure Plan to which they are subsidiary. Most plans containing minerals policies set out for each industrial mineral at least an outline on its demand and supply prospects, the extent of permitted reserves, the issues most relevant to development control (e.g. transport, restoration, working methods, protection of amenities), arrangements to safeguard mineral deposits for possible future use, and, increasingly, how mineral resources could be managed more sustainably. Policies may be expressed on any of these matters or on other relevant issues. Plans are expected to provide sufficient policies and statements of objectives to explain the approach which MPAs will use when deciding planning applications for mineral working and when commenting on or deciding associated uses of mineral-bearing land (e.g. surface development proposals or after-uses of worked out sites).

4.19 Because local policies directly shape the likely uses of land they are subject not only to public involvement in their preparation but to assessment by an independent tribunal. In all cases except Structure Plans (which indicate broad land uses rather than identify uses for plots of land), anyone with an unresolved objection has a right in law for that objection to be examined by the independent tribunal. Coupled with legislation which gives primacy to policies in the development plan in shaping decisions on individual proposals, this confers on local policies in development plans considerable influence over the future uses of land.

4.20 This research included a study of all development plans affecting industrial minerals in England. Reference is made to the findings as relevant throughout this report and the accompanying Mineral Planning Factsheets.

PLANNING CONTEXT: REFORM OF THE PLANNING SYSTEM

4.21 The Planning and Compulsory Purchase Act 2004 received Royal Assent in May 2004. The Act introduces significant changes to the structure of policy making in planning, plus some amendments to the operation of the development control system. The Government is committed to the better integration of the planning system with other spheres of public policy, notably with the Community Strategies prepared by each local authority in England. This is accompanied by a new focus for the planning system to assist the delivery of 'sustainable development' and a new commitment to engage a wider range of public opinion in participatory procedures. Whilst much of the change will be in the implementation of legislation rather than in law itself, the Act creates a framework aimed at facilitating these changes.

4.22 The planning reform process includes the replacement of the series of PPG and MPG notes with Planning Policy Statements (PPSs) and Minerals Policy Statements (MPSs) respectively. The aim is to reduce the length of the existing documents by separating out from them (and publishing separately if necessary) the good practice guidance which has increasingly found its way into these documents. Those PPGs which the Government considers no longer necessary will be dropped without any replacement. The new PPSs and MPSs should therefore be more focused documents. The current expectation is for all draft PPSs to be consulted upon, if not issued, by July 2005. As the revision of policy is an administrative matter it is not mentioned in the current Act.

PLANNING ISSUES COMMON TO ALL INDUSTRIAL MINERALS

Introduction

4.23 This section examines the basic features, which will determine the future potential for working each industrial mineral in England. Fundamentally the geology of the resource in relation to the requirements of the market establishes the maximum future potential of each industry. This section therefore begins with a review of the geological scarcity of each mineral, followed by an assessment of demand. Continuity of supply depends on the availability of land with workable deposits having planning permission for extraction. The study indicates where possible the approximate number of years for which each industry can continue operations based on existing planning permissions. The policy approach to future planning permissions is also noted, and the implications considered for finding new mineral to work, whether by extensions to existing sites or at completely new sites.

4.24 Planning for each mineral is deceptively difficult and complicated by matters such as the following:

- **Resource availability:** The location of a mineral deposit, together with its size and quality, is fundamentally determined by geology. If there are no resources of a specific mineral then there can clearly be no production. A number of industrial minerals have very restricted distributions in England, whilst others are much more widespread (see paragraphs 2.4–2.5 and individual Mineral Planning Factsheets in Annex A). This has implications for geological scarcity, the availability of alternative options and ultimately on continuity of supply.
- **Quality:** The quality of an industrial mineral deposit in terms of its physical and/or chemical properties may vary significantly which affects its workability and the markets it serves (see paragraphs 2.15–2.20). This is an issue that affects all minerals to some extent. It is particularly important for industrial minerals such as ball clay, kaolin and silica sand where specific qualities are often only suitable for particular applications. Variations in properties also mean that it is desirable, for example in the case of ball clay, to have access to a

Right *Ball clay typically occurs in thin seams, each of which has different technical properties.*

range of different clays for blending purposes. This not only allows different markets to be served but also helps to smooth out the natural variations in the properties of the clays, allowing lower quality clay to be blended away and thus optimising the use of the resource.

- **Cost of production:** A mineral is only economically viable if it can be extracted, processed and sold at competitive prices compared with other sources both domestic and foreign (see paras 2.21–2.24). In the case of industrial minerals this price generally reflects the cost of production to marketable form. The more processing a mineral undergoes, in general, the higher the price. The ultimate price to the consumer will also depend on transport costs and any premium due to quality or scarcity. In a competitive economy there is always pressure to produce minerals at the cheapest prices. High cost methods of extraction, notably underground mining, which might be environmentally preferable to surface working, has consequently become uneconomic in the UK. For example, ball clay mining in Devon and Dorset ceased in 1999. In addition, there has also been a significant reduction in fluorspar mining, although this is mainly a reflection of the quality of the ore, which is particularly difficult to process, rather than the high cost of underground extraction.
- **Demand:** The requirements for industrial minerals depend on the requirements of the consuming industries. Demand for, and the production of, minerals are continually evolving due to changing economic, technical and environmental factors. For many of the industrial minerals under consideration there has been a decline in demand, for example for cement raw materials, industrial carbonates, kaolin and fluorspar. Ball clay is one of the few minerals where demand has increased appreciably and this has been driven by export markets whilst the domestic market has declined. Naturally bonded moulding sands have been replaced by washed foundry sands to which binders are added. However, demand for these has also declined significantly due to structural changes in the economy and the relative decline of UK manufacturing, notably the foundry and steel industries. In general these trends in demand have been gradual. Relatively few new, large markets have appeared, although notable examples include the use of high purity limestone in flue gas desulphurisation and the rise of horticultural applications for silica sand (see paras 2.6–2.7) and individual Mineral Planning Factsheets in Annex A).
- **Planning policy:** Planning policies themselves change over time, and in many respects have become more conservation-oriented in response to public pressure. Coupled with the increasing difficulty of finding sites suitable for working as the more acceptable ones are worked out, there is continuing pressure on the minerals industry to raise its standards.

4.25 These pressures of economics, geology, demand and planning policy rarely arise in isolation. Identifying which constraint is critical in shaping the opportunities available to the minerals industry can be difficult or impossible. Central to the difficulty facing the planning process is that planning policy constraints are the most obviously adjustable of them all. The planning system is continually under pressure to tighten or relent on its policies in the face of the more precise aspects of cost, geology and demand. The impact which this has had on the availability of otherwise workable mineral is briefly assessed in the subsection below.

4.26 However, the contribution of planning to the pattern of mineral supply is more complex. If a mineral site is refused permission for working, is this correctly viewed as the tight operation of planning policy? Might it better be viewed as a geological constraint (as such a satisfactory deposit was not available in a less constrained location)? Or is it an economic constraint (because a lower grade deposit in a more suitable location could not bear the extra costs to be worked)? Perhaps it is even a demand constraint (because the user had failed to establish a process which was capable of making use of different but more readily available minerals)?

Geological scarcity/level of demand/permitted reserves

4.27 The availability of the different industrial minerals reflects their geology. Some, such as limestone and chalk for cement manufacture, are very extensive. Others, and notably fluorspar and fuller's earth, are very restricted in their occurrence and both reserves and resources (see box for definitions) are limited. The geological scarcity of the various industrial minerals is summarised in Table 12 in broadly decreasing levels of abundance. However, there are difficulties with this approach. For example, kaolin and ball clay have a relatively restricted occurrence as a result of their geological origin, although permitted reserves are relatively large. In addition, the availability of tipping space for mineral waste is the key to being able to extract kaolin reserves. Furthermore, gross figures for ball clay include a wide range of qualities, with different properties, thus masking possible limited reserves of clay qualities that are essential for specific blends. In contrast, resources of limestone and chalk suitable for cement manufacture are very extensive, although permitted reserves at some sites could be limited.

4.28 The figures for permitted reserves (given variously in years' supply or million tonnes) must also be treated with great care. Gross figures for reserves mask the multiplicity of qualities in which industrial minerals are produced. Generally these are not interchangeable in use. Consequently permitted reserves at individual sites are the critical factor with respect to future supply. This is particularly the case with cement raw materials (limestone/chalk), where the reserve could only be utilised at the adjacent cement plant. Similarly site specific reserves of silica sand are often only suitable for a specific market.

Sterilisation of mineral resources by planning controls

4.29 Planning policy clearly has a significant impact on where minerals are worked. Refusal of a planning application for mineral working demonstrates

Resources and reserves

Mineral resources are natural concentrations of minerals, or bodies of rock that are, or may become, of potential interest as a basis for the economic extraction of a mineral product. They exhibit physical and/or chemical properties that make them suitable for specific uses and are present in sufficient quantity to be of intrinsic economic interest. The status of mineral resources in economic terms changes with time as markets decline or expand, product specifications change, recover technology is improved or more competitive (less costly) sources become available.

That part of a **mineral resource** which has been fully evaluated and is commercially viable to work is called a **mineral reserve**. The term **mineral reserve** should strictly be further limited to those minerals with legal access and for which a valid planning permission for extraction exists (i.e. **permitted reserves**). Without a valid planning consent, no mineral working can take place and consequently the inherent economic value of the mineral resource cannot be released and resulting wealth created. The ultimate fate of mineral reserves is to be either physically worked out or to be made non-viable by changing economic circumstances. Reserves, especially those with planning permission to work, are of crucial importance to a mineral company as they represent its future assets.

INDUSTRIAL MINERAL	DEMAND 2002 (THOUSAND TONNES)	PERMITTED RESERVES	RESOURCES	NOTES
Cement Raw Materials (Limestone/chalk)	15 200	11–>40 years depending on site	Very extensive	Reserves at individual sites are the critical factor.
Salt	5 500	> 40 years	Very extensive	
Industrial limestone	9 000	Probably >40 years but will vary from site to site.	High-purity limestone resources are extensive	
Kaolin	2 200	>40 years	Restricted outside current permissions Availability of	Reserves exceed the life of current planning consents. tipping space is a key factor in extracting these reserves
Ball clay	920	74 Mt	58 Mt	Reserve/ resource are gross figures that take no account of the widely different ball clay qualities and the balance between the ball clay bearing basins
Gypsum	1 700	> 50 Mt	Relatively restricted	Data does not include supply of desulphogypsum which is increasing
Potash	900	Approximately 30 Mt	Extensive	Resources are not accessible from existing mine site. Economic viability unknown.
Industrial dolomite	1 100	10–15 years	Resources suitable for industrial use are restricted	Reserves vary from site to site. Some only suitable for a particular market.
Silica sand	3 400	11 Mt colourless glass sand 35 Mt foundry and other industrial sand	Restricted	Reserves vary from site to site. Some only suitable for a particular market. Resources of sand suitable for use in colourless glass are relatively scarce
Fluorspar	53	Approximately 0.3 Mt*	Very restricted	*Estimated contained fluorspar. Resources are scarce and highly localised. Individual deposits tend to be small
Fuller's earth	44	0.35 Mt	Very restricted 2 Mt	

Table 12 *Reserves and resources of industrial minerals.*

that other public interests have outweighed the commercial interest in developing a site. This is not surprising. It is the role of the planning system to steer development to the more suitable locations and away from the less suitable ones. The planning system must also maintain quality of life by seeking high standards, both operational and restoration, at mineral sites. There may be special requirements on mineral companies to achieve unusual standards in particular places. Rather than simply resist development in principle, planning therefore provides a more sophisticated regulatory system by indicating that working may well be acceptable if certain requirements are met, specific to a site or area.

4.30 A hierarchy of designations is used to protect areas of important landscape, wildlife and other assets from the adverse effects of development. International obligations impose the strongest constraint, followed by nationally important constraints and then constraints of a more local nature. This is a loose grading system applied with discretion rather than by ticking boxes. The most well known national policy constraint in England, the Green Belt, is not particularly significant for mineral working. This is a tight constraint on most development, aimed at preventing urban sprawl. Most development here must demonstrate 'very special circumstances' to be allowed, with a 'presumption against' inappropriate development (the strongest constraint in planning). However, mineral working is considered a temporary activity in the Green Belt in planning terms. It is therefore not necessarily a challenge to the reasons for designating these areas, though a subsequent return to land uses compatible with the Green Belt would be expected. For mineral working, the constraints of much greater interest tend to be those associated with landscape, wildlife and heritage.

4.31 Also of increasing relevance is the understanding of local character: this is an approach which does not grade places in a hierarchy but values all places for their distinctiveness. It aims to nurture the differences between places which make each one special. This approach can be applied at any scale from the regional to the highly localised. A detailed description of the relationship between industrial minerals and landscape, wildlife and heritage designations can be found in paragraphs 4.125 to 4.147 and the Mineral Planning Factsheets (Annex A).

4.32 Actual or potential conflicts of interest between industrial mineral operations and land designated for a range of environmental purposes are not uncommon. It is difficult to gauge how effective the planning system has been at steering developers away from designated land in favour of environmentally less sensitive locations. However, there is evidence that, where mineral working is contemplated in or close to designated areas, the efforts by mineral companies and planning authorities to overcome the difficulties have been considerable and often effective. Many developments have been able to proceed within or adjacent to designated land on this basis. In other cases, genuine conflicts of interest remain, often because of the restricted geological occurrence of the industrial mineral concerned. In some cases, this has resulted in refusals of permission and in others, where the case for mineral working proceeding is sufficiently strong, approvals. Nevertheless, there is some concern in the industry about the cumulative impact of these constraints and the impacts these may have on future supply options.

Extensions and new sites: some planning implications

4.33 There has been an ongoing debate in mineral planning on the relative merits of extending existing sites or establishing new sites as the most appropriate means of gaining access to new mineral reserves. Extensions typically make use of existing plant, transport and other infrastructure, allow efficient phasing with existing workings, and possibly make use of pre-existing environmental controls. New sites typically help avoid concentrating the impact of mineral working, ensure that earlier workings are completed when originally promised, reduce mineral movement between quarry and plant, and may allow environmentally more manageable sites to be worked. This is a debate which is often of less relevance to industrial minerals than to aggregate minerals. There are various reasons for this.

- The size and cost of the processing facilities needed for some industrial minerals is so great that moving it for amenity reasons (rather than obsolescence or exhaustion of mineral reserves) is a highly unattractive economic option. MPAs identified the large scale of processing and associated plant, more than any other issue, as a distinctive feature of many industrial minerals operations. Plant for processing most industrial minerals is in effect permanently fixed so long as mineral can be delivered to it for processing. In the case of fluorspar, if the country's only processing plant at Cavendish Mill in the Peak District were to close for any reason, this would likely to be the end of the domestic fluorspar industry. This is because it is unlikely that sufficient reserves of fluorspar could be proved in advance to justify the scale of the investment required to commission a new plant.
- Very substantial areas have been permitted for the extraction of some minerals, notably kaolin in Cornwall and ball clay in Devon. These permissions have allowed the operating companies to work a number of sites simultaneously. Clays from a number of separate sites are blended at centralised plants to produce a range of products (see Mineral Planning Factsheets in Annex A). In this way, the companies can respond to changing market demands, and also optimise the use of the resource. Moreover, as the resource has a geographically restricted distribution, relocation of the industry is not possible. In the case of industrial limestone where resources are extensive, operations still tend to have a long term presence based on extensive permissions (such as the Tunstead/ Old Moor complex in Derbyshire and the Peak District). This is because the large investment in plant and transport infrastructure would make relocation difficult.
- The geology of some minerals dictates the choice between extensions or relocations of the industry when existing permitted reserves have been exhausted. Fuller's earth provides an extreme example. The industry was recently refused permission to extend a site in Bedfordshire into the only known remaining deposit in the county. In Surrey, the industry was refused permission to relocate to a pair of sites comprising the last known deposits in that county. The working of fuller's earth is now foreseeable at only one location in Oxfordshire, for which the industry has been granted planning permission. Fluorspar is an industrial mineral found in veins, where the choice is typically between extending development along a vein or relocating to another vein: though the veins can be close together, this is a mineral which in principle tends for geological reasons to encourage relocation to new sites as existing ones are worked out.
- The industrial minerals sector has to some extent mirrored the trend in much of the rest of the UK minerals industry towards concentration in fewer companies and at fewer sites, which tends to reinforce activity at existing large operations rather than at new sites (see Section on Structure of the Industry, para. 2.3). This is particularly evident in the cement industry, where many sites listed in MPG 10 (published in 1991) have now closed. There are also many fewer small scale 'tributors' supplying fluorspar ore to the Cavendish Mill from

small sites in the Peak District National Park than there were a decade ago. Only in the plasterboard industry have new firms appeared to supply plasterboard, but manufactured from imported raw materials or synthetic gypsum, rather than indigenous resources.

4.34 As a result, few major new industrial mineral operations have been commissioned on greenfield sites in recent years. The only large scale new proposal has been a cement plant at Snodland, Kent close to a pre-existing works (now closed), creating the first new cement site in England on a greenfield site for 30 years. There is also a notable relocation of silica sand processing plant from Redhill to a site at North Park Farm further east in Surrey at the foot of the North Downs.

4.35 This pattern of continuity and change in the supply of industrial minerals has important implications for future planning. Most industrial mineral plant sites are relatively long-lived, even in mineral planning terms. They pass through phases of seeking extensions to their working areas, into progressively more difficult sites which may be increasingly remote from the processing plant, and then experience an infrequent but somewhat traumatic need to relocate as geology or economics dictate. Long term planning could offer real benefits here, taking a positive role in identifying land for future working well in advance and finding sites to which the industry could relocate in due course.

4.36 The contribution of the mineral planning system to managing this process over the long term has been mixed. The tendency in mineral planning practice has been to ensure continuity of supply in the short to medium term, typically to provide a landbank of reserves with planning permission sufficient to last for the period of the plan and, usually, for a period thereafter. Details vary between minerals (especially according to the existence or otherwise of any Government policy on this point) and by mineral planning authority and site. This has resulted in proper consideration being given to continuity of supply on an 'as-needed' basis, but there has been little incentive to engage actively in long term planning.

4.37 There is little evidence of efforts to plan for enduring commitments to maintaining supplies to plant sites, or the environmental benefits which might be put in place in advance to ease the supply process in future. There appear to be no major forward planning exercises which set out firmly, but well in advance, when the working of sites will be required to cease. The statutory development plan system is not ideal for the purpose, though long term policies such as green belts and mineral consultation areas are well established and more could be done to assist long term land management for minerals. The Bovey Basin ball clay strategy in Devon is probably the best example of a systematic consideration of the needs of an industry over the long term, though wider terms of reference would allow more to be achieved.

4.38 The consequence of the current approach has been that decisions on individual mineral sites become all the more difficult when decisions can no longer be put off. The case for planning permission can become urgent, but runs into an environmental case to resist development that is all the more convincing for want of preparatory measures. When points of transition arrive in the industrial minerals industries they are particularly traumatic for everyone. This is well illustrated by the experience of the proposal for a new cement works at Snodland, Kent to replace the ageing works at Northfleet, Kent (see box).

4.39 The benefits of long term positive planning should not be seen in isolation. There is also a case for continuing with the present short to medium term approach. The demands for minerals may change, so

Planning for cement in north Kent

The Kent Minerals Local Plan (MLP) covering chalk and clay was adopted in 1997. It covered the period to 2011 and aimed to ensure that a landbank of permitted reserves for cement-making was available at the end of the plan period for a further 15 years. A slightly greater landbank would be needed for the Halling cement works as the site owner notified an intention to commission new plant there in 2008, (implying a need for minerals for a further 25 years working from then, in line with policy in MPG 10). Various sources of both chalk and clay were identified to meet these requirements, with some minor recognised deficiencies which the MPA and the industry agreed could be left for decision on a future review of the plan. The possibility of substituting elsewhere for the Northfleet cement works in due course was noted. A complicating factor was the uncertainty over the availability of chalk from Eastern Quarry. The plan included a policy to safeguard working areas here, in view of the considerable reserves available, but this was nevertheless a site where proposals for redevelopment for housing as part of the Thames Gateway might well in effect be given precedence over the interests of the cement industry.

Shortly after the MLP was adopted, an application was submitted by the owners of Northfleet cement works for a replacement cement works at Snodland in the Medway valley, close to the existing Halling works (owned by another company). The proposal straddled the boundary of Kent County Council and Medway Council, and was recommended for approval by the former and refusal by the latter. It was considered at public inquiries in 1999 and 2001.

The Inspector considered that the dominant impact of the cement works in the landscape "would render the proposals unacceptable in terms of the capacity of the landscape to absorb such dramatic change, unless other consideration were of such weight as to override the established policies safeguarding the countryside and the AONB." The conclusion of the Inspector from the first inquiry was that there had been an insufficient examination of alternative sites and that the possibility of suitable ones emerging could not be ruled out, so a sufficient case for development had not been proved. He recommended refusal primarily on these grounds. The Secretary of State reopened the inquiry for various reasons, and the Inspector returned to the issue of alternative sites. He criticised the applicants "who refuse to consider any alternative to Home Farm (Snodland) apart from a clinker import terminal…"

At the second inquiry, the Inspector considered timing of the solution to cement supply in South East England now to be the critical issue. There was pressure from the Thames Gateway strategy for the release of cement-related sites. Not only was Eastern Quarry required urgently for redevelopment, but so was the Swanscome peninsula (not mentioned in the MLP). This reversed his earlier view when he had considered there was time available to search for alternative solutions. A risk arose of a hiatus in cement production, not least because Halling cement works had closed by this time. If a permission was not given soon, there was a risk of the replacement of domestic production by clinker imports, contrary to MPG 10 which, if established, would effectively preclude investment in local production. Moving to the Halling site would add four years to the development process, and the applicant unsurprisingly considered that the economics of such a move were confidential.

This case illustrates on the one hand the almost complete failure of integrated long term planning (both the MLP and the planning application process), because there was inadequate consideration of alternative production sites and because a hiatus in production was nearly allowed to arise. On the other hand it illustrates the adaptability of last-minute decisions to politically more pressing priorities (in this case the Thames Gateway strategy).

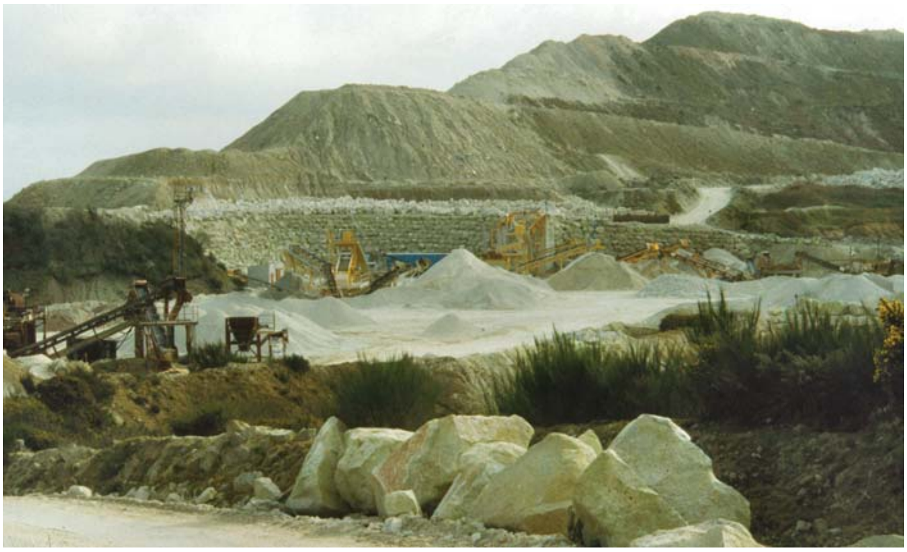
efforts to secure long term supplies may be wasted. The closure of many cement works (not replaced locally) illustrates the risks. Postponing decisions as long as possible ensures that the most up to date information and political imperatives are given appropriate weight. The long term planning approach too should therefore aim to keep options open and plan for the possibility of future needs arising, while postponing so far as possible decisions which would be bound to damage other interests.

PLANNING ISSUES IMPORTANT FOR SOME INDUSTRIAL MINERALS

Mineral waste disposal

The main issues

4.40 Some industrial minerals generate significant quantities of mineral waste, during extraction and/or subsequent processing (see Mineral Planning Factsheets in Annex A). Kaolin is the principal producer of such wastes, both because the usable clay comprises on average about 10% of the material excavated and because of the high volume of kaolin output (> 2 Mt/y). Vein minerals too form only a proportion of the quarried material, although here the volumes involved are much smaller. Of the annual 350 000 to 400 000 tonnes ore that is processed about 25% is finally disposed of to a tailings lagoon. An equivalent tonnage is dewatered each year for use in site restoration.



Left *Extraction and processing of kaolin (china clay) produces relatively large volumes of waste.*

4.41 A number of other industrial minerals have associated waste comprising overburden/interburden. Ball clay, gypsum (one quarry) and fuller's earth are examples. The small amounts of waste from purifying salt brine is returned to completed salt cavities and some insoluble waste (mainly clays) from potash refining is now (from 2003) being disposed of into disused mine workings. The soluble waste, mainly comprising sodium chloride, is pumped out to sea.

4.42 Disposal of unwanted mineral waste can be at least as much of a concern to MPAs as the workings themselves. In the case of kaolin about 22 million tonnes of mineral waste requires disposal annually, and there is over 500 million tonnes of waste in engineered tips in the St Austell area alone, covering 1 700 hectares. Of the waste (sand and crushed rock) a small but increasing proportion (about 10%) is being sold for aggregate and this is being encouraged. Sales of secondary aggregates are, generally, derived from waste currently produced. Some old mica residue dams are also being reprocessed to recover kaolin formerly discarded by old processing methods. Disposal of waste into kaolin pits is, in general, not possible, because kaolinisation continues at depth and consequently backfilling would sterilise future reserves. However, some disposal into abandoned pits is now taking place, where this will not affect reserves or the requirement for water holding facilities. As the surface extent of workings achieve their practical limits an increasing amount of backfilling is now becoming possible.

4.43 Unlike kaolin, all the waste associated with ball clay production is quarrying waste (overburden/interburden). Disposal of this has not proved to be a problem other than in the Bovey Basin where the volumes (0.9 million m^3 a year) involved are much larger and above ground tipping has been required. This has also been necessary to prevent sterilisation of reserves in depth and to ensure that the range of production grades is available. However, the waste will ultimately be used in site restoration. Some of the sands associated with ball clay seams are being sold for aggregate.

4.44 The construction of tailing lagoons in the Peak District National Park for the disposal of fluorspar processing waste has been a contentious issue in the past. However, old tailings dams are being reprocessed to recover mineral formerly lost and the current tailings production is in balance with their subsequent use in site restoration. The permission for tungsten mining at Hemerdon, near Plymouth in Devon would, if developed, require the disposal of over 100 million tonnes of mineral waste and cover 175 ha of Crownhill Down and the lower slopes of Hooksbury Valley, which would be visually intrusive.

Some solutions

4.45 The problems of the disposal of mineral waste from industrial mineral operations is being gradually addressed although for some minerals, wastes cannot be entirely removed. Sales of sand and crushed rock derived from kaolin extraction and processing is exempt from the Aggregates Levy and has given further stimulus to the increased use of this resource. The problem is one of access to markets but shipments are being made to London and the South East and there are plans to increase shipments from the port of Par. Nevertheless access to new tipping areas will continue to be required. Sales of sand as secondary aggregates from the interburden to ball clay extraction are also exempt from the Aggregates Levy. Sand is being sold for aggregate and industrial purposes.

4.46 At the Boulby potash mine returning some of the insoluble waste material (mainly clays which contain traces of heavy metals) into disused mine workings started in 2003, thereby reducing discharges into the North Sea.

4.47 In the case of fluorspar tailings it was proposed in the early 1990s that they should be disposed of into the underground Milldam mine at Great Hucklow in the Peak District. However, the mine is no longer in operation and tailings are now being dewatered and used for site restoration such that the existing tailings lagoon at Blakedon Hollow near the Cavendish Mill will be able to be used continuously.

Conclusion

4.48 The industrial minerals which generate significant volumes of mineral waste each have distinctive characteristics, which reflect the geology of the deposits. The local consequences for mineral waste disposal are well understood and specific to each area. It is doubtful whether further national policy is required on this matter.

Underground mining: surface development and subsidence

4.49 Underground working of industrial minerals in England is dominated by the evaporite minerals — potash, salt and gypsum/anhydrite. High purity limestone is worked by underground methods at only the Middleton mine in Derbyshire and vein minerals are worked on a limited scale by underground methods only at the Watersaw mine in the Peak District. Small amounts of iron ore (hematite) are also extracted by underground methods in Cumbria. Ironstone was formerly mined in the East Midlands, and the last underground tin mine in Cornwall closed in 1998, although there are proposals to re-open it.

4.50 In all cases, the scale of surface development is only loosely tied to the amount of mineral extracted from below ground. Underground mining tends to have environmental advantages, which has resulted in MPAs often preferring this to surface working. However, the implications of underground mining operations are distinctive to each industry.

4.51 In the case of Boulby potash mine, there is a very substantial quantity of surface development, including a 47 m high and intrusive stack. However, the facility is to all intents fixed and unlikely to expand significantly even if underground operations are extended. Surface subsidence due to mining is minor due to the depth of working at over 900 m. However, there is concern amongst some parties that minor subsidence may exacerbate rates of coastal erosion. Research is currently being conducted on this issue by the University of Durham and Cleveland Potash to gain a better understanding of the natural and anthropomorphic influences on the coast.

4.52 Salt extraction falls into four categories, each with different implications for surface development:

- rock salt mining by room and pillar methods: crushing and other processing takes place underground, but there are still buildings and storage at the surface, plus a risk of wind-blown salt;
- controlled brine pumping in which an underground cavity with carefully controlled features is created. This involves only minimal surface development in open countryside, (wellheads and pipelines);
- natural brine pumping: this method of working is now only on a very small scale at one site and is unlikely to be approved in the future because of the risk of subsidence (and, in the only location in Cheshire, is resisted by Policy 50 of the Cheshire Replacement MLP 1999); and
- salt mining as a subsidiary activity at Boulby potash mine (through which roadways are excavated): the surface consequences were noted above.

4.53 Subsidence is only a significant risk with natural brine pumping. There is a legacy of problems inherited from past operations of this kind. The zones of subsidence from natural brine pumping are unpredictable and can be considerable and dramatic (an experience particularly around Northwich in Cheshire and Droitwich in Worcestershire). With this in mind the MPA in Cheshire has indicated that for natural brine pumping it is:

- aiming to revoke old planning permissions;
- encouraging cessation of natural brine pumping; and
- supporting remedial measures to stabilise land affected by earlier mining.

4.54 Anhydrite is always excavated by underground methods and gypsum usually. The impacts of surface operations have not been a matter of major reported concern at the limited number of sites that have been worked by this method. Underground working is by room and pillar methods to avoid subsidence, though in some locations there are historic impacts of subsidence. For example, the Staffordshire and Stoke-on-Trent MLP notes there is a problem with ground instability associated with old gypsum workings (para. 3.98), e.g. in the old working areas of Fauld mine.

4.55 The industrial minerals worked by underground methods have features distinctive to each mineral, both in terms of surface development and subsidence implications. MPAs are familiar with the effects of developments in their localities, and we doubt that much additional assistance would be given to MPAs by additional national guidance.

Longevity of operations

4.56 There are essentially three aspects to this issue, the first two of which have been covered elsewhere:

- longevity due to the permanent nature of plant (e.g. Boulby, Cavendish Mill);
- longevity due to extensive planning permissions having been granted (e.g. kaolin, ball clay); and
- longevity due to granting more permissions for site landbanks.

Landbanks: a policy for continuity of supply

4.57 The Government's favoured policy for achieving continuity in the supply of minerals is the landbank of permitted reserves. The principle is that MPAs must grant sufficient permissions for future mineral working to ensure that the permitted reserves are adequate across a minerals industry within the authority's area to provide for at least a specified number of years' working. The size of the landbank (in years' supply) varies from one mineral to another. As the landbank is progressively depleted it is periodically replenished when further permissions are granted. The smaller the remaining landbank, the more the pressure on the MPA to grant planning applications when applied for.

4.58 Various safeguards are built into the interpretation of this policy. For example:

- the requirement to maintain a landbank is not absolute: environmental constraints and other interests do not have to be set aside if the landbank falls below the target minimum level, but the MPA will have to be clear where the mineral might reasonably be obtained;
- MPAs are not held responsible for unduly small landbanks if the industry has failed to submit sufficient applications in reasonable locations;
- there has to be pragmatism in the interpretation of landbank figures: for instance, large amounts of mineral providing for long term supply at a single site clearly do not contribute to the permissions readily available to the industry as a whole in the short term, and may therefore not assist continuity of supply.

Landbank policies for industrial minerals

4.59 Landbank policies are well established for aggregate minerals but are not standard in the industrial minerals sector. They have been introduced only for two groups of minerals: cement-making materials (in MPG 10) and silica sand (in MPG 15). In both of these cases there is a very significant variation on the normal policy approach outlined above. For these minerals the landbank is on a site by site basis, not authority-wide, as is the case with aggregate minerals. The details are set out at some length in the two MPGs, but the key points are:

- "Mineral planning authorities should... maintain landbanks of permitted reserves of raw materials for cement plants, providing that the industry come forward with sufficient environmentally acceptable proposals. These landbanks should include the industry's primary materials (chalk and limestone) and also secondary materials (clay and shale). There should be a landbank calculated for each site" (para. 57); and "The size of the cement industry's landbank should be directly linked to the scale of capital investment envisaged at a site, for an important feature of the industry is the high cost of investment and the long amortisation periods this entails. Mineral planning authorities should normally aim to maintain cement plant with a stock of permitted reserves of at least 15 years" (para. 58).
- "MPAs in areas containing silica sand deposits need to make an appropriate contribution to national requirements and should therefore aim to maintain landbanks of silica sand permissions, as far as this is possible and realistic, provided that the industry comes forward with suitable applications" (para. 45); and "it is important that each production site is appropriately provided for, unless exceptional circumstances prevail. In practice this will mean that most sites will require a reasonable level of reserves. MPAs should aim therefore to ensure that landbanks of at least 10 years are maintained for individual sites. However, ...The need for the mineral must be balanced against environmental constraints and there may be overriding environmental reasons why the stock of permitted reserves at some sites may not be replenished as they are used up" (para. 47).

4.60 The policy of site-based landbanks is supplemented by policy to allow more long-lasting permissions in cases where significant investment is being made in new plant, which may only pay for itself over a longer period than a normal site landbank. The policies are:

- For cement-making materials: "Where significant new investment (such as a new kiln) is agreed with the mineral planning authority, the plant should be provided with a stock of permitted reserves to provide for at least 25 years. New plant on a greenfield site should be provided with a stock of permitted reserves lasting more than 25 years" (MPG 10, para. 58).
- For silica sand: "In the case of significant new capital investment by the industry in existing or new sites, it may be necessary for the plant to be provided with a stock of permitted reserves to provide for at least 15 years, or substantially longer than this, for greenfield sites, depending on the circumstances" (MPG 15, para. 48).

Implementation of landbank policies

4.61 A study of development plans and a survey of MPAs suggests that the national landbank policies for both cement-making materials and silica sand have been strikingly effective. MPAs have adopted policies committing themselves in most cases to providing at least the levels of permitted reserves specified in national policies. Many cement plants are already served by planning permissions which have reserves well in excess of the 15 years supply indicated in Government policy (see Mineral Planning Factsheet on Cement). In these locations the national

Right *Cement manufacture requires very high levels of capital investment. Cement kilns at Hope in the Peak District.*

stimulus to maintaining supplies has not yet been called-upon. However, MPAs have responded positively to the policy to maintain supplies to those cement plants with lesser reserves, and the same is true of the many more silica sand plants affected. The result has been many quarry-by-quarry policies, often addressing environmental and other difficulties associated with possible extensions (see box).

4.62 Some authorities were explicit in accepting that environmental standards would be compromised to fulfil landbank policies. Kent County Council, for example was prepared to accommodate silica sand working in the Kent Downs AONB and the adjacent county-based Area of Great Landscape Value, even though building sand proposals there would be unacceptable. Norfolk County Council similarly accepted that in practice it had issued a permission extending silica sand working as a departure from the landscape protection policies in its MLP. It is nevertheless clear in some cases that further extensions to sustain existing sites will be very problematic or unacceptable. For example, the Nottinghamshire Replacement MLP (Revised Deposit Draft May 2003) indicates that there are 3 million tonnes of silica sand remaining at a site at Ratcher Hill, providing the necessary landbank, but that reserves are likely to be exhausted by 2013 and that no further extensions are considered possible beyond existing permissions: Policy M7.6 states nevertheless that "Planning permission will be granted for silica sand extraction that seeks to maintain an appropriate landbank of permitted reserves provided they do not have an unacceptable environmental or amenity impact".

4.63 The results of cases decided at the national level in the last 15 years reinforce the emphasis of national policy. All proposals for cement-making materials and silica sand have been approved apart from a small silica sand proposal at Addington in Kent in 1996. Of the two other silica sand cases, one at Southport, Sefton decided in 2002 was a special case which turned on whether or not the proposal would adversely affect the integrity of an internationally important wildlife site in the inter-tidal zone. The second was a proposed extension to Buckland pit in Surrey, where in 1997 the Inspector's decision placed considerable weight on the paucity of alternative supplies of the particular quality of glass sand in the site: he ruled that although there would be some harm to the Area of Great Landscape Value in which the site was situated, this would not be so significant as to preclude permission for the development. Two major proposals for cement-making materials were decided. One was an extension to Grange Top Quarry, Rutland to serve Ketton cement works: the MPA wished to keep the cement works in operation, but were unable to persuade the Inspector that the other alternatives could supply the quantity of mineral required or have any less environmental impact. The other was a new cement works, and associated minerals, at Snodland in Kent, approved in 2001 after two inquiries. Kent County Council had actively supported the scheme as the best solution, despite its enormous impact, though it had been opposed by Medway Council, the other MPA for the site.

4.64 National policy on landbanks is driving the continuity of supply of cement-making materials and silica sand by ensuring that reserves with planning permission are replenished. By focusing on landbanks at the site level, this policy has encouraged extensions rather than new sites, so the latter are infrequent. The objective of continuity of supply has been met. Recent patterns of development have inevitably reinforced historic patterns of working, with some sites being sustained despite what are now viewed as significant adverse effects of working. It is possible, though not capable of being proved, that this has significantly delayed the move of these two industries to less damaging locations. A more positive approach to long term forward planning might be able to bring this about.

4.65 Landbank policies for cement and silica sand have worked effectively. However, it should be noted that the cement industry, in particular, considers that a landbank of 15 years for established works and 25 years for new works has not kept pace with the high capital costs of improving the technical and environmental performance of existing plant and building new plant. Continuing investment at existing plant can be several million pounds a year and a large modern plant can cost over £150 million (see Mineral Planning Factsheet on Cement). Landbanks for cement raw materials in England are low by international standards.

Maintaining a site-based landbank

The Staffordshire and Stoke-on-Trent MLP 1994-2006 notes that Moneystone Quarry, at Oakamoor had silica sand reserves of 5.19 million tonnes in July 1998 (sufficient for 13 years), indicating a shortfall in the landbank towards the end of the plan period. Policy 56 provides "The landbank for silica sand for use as a raw material at the Moneystone Processing Plant only will be 10 years", but 'given the environmental sensitivity of the local area', "the maintenance of the landbank will depend on the availability of sites capable of being worked without causing an unacceptable adverse impact" (para. 11.19). Because of the quarry's national importance, a 'Proposal 7' identifies land with proven reserves (5.1 million tonnes over 26.5 ha) to serve Moneystone, even though this is within a Special Landscape Area and has a number of environmental constraints. The land is termed an 'area of search' as there is some uncertainty over its availability. Planning applications would be required to satisfy the environmental criteria of Policy 57, which is again specific to Moneystone Quarry.

Maintaining supplies of a variety of mineral qualities

4.66 For some industrial minerals, a number of different qualities may need to be available simultaneously, either because a blend of different materials is required to meet a customer's specification, or because different qualities have different end uses (or a combination of the two). The main minerals for which this is a relevant issue are: silica sand, high purity limestone, dolomite, ball clay and kaolin.

4.67 Numerous ball clay and kaolin sites and working areas within sites are in production at the same time for blending purposes. This is properly recognised in the development plans affecting these scarce resources:

- In Cornwall in 1998 there were 17 active china clay pits and a greater number of related tips in the St Austell area. The MLP (1998) comments that these operational elements have "complex and changing interrelationships, the clay being brought to central collecting and refining plants for processing and blending. The quality and type of clay varies spatially, so production must be maintained at a large number of pits to guarantee this variety, needed for specific uses and blending" (para. 7.8);
- The Dorset Minerals and Waste Local Plan 1999 notes that 16 different grades of ball clay are used, explaining why so many sites need to be open simultaneously;
- The Devon MLP noted that distribution of the various ball clays within the Bovey Basin in Devon was not in proportion to their current rate of utilisation, adding to the planning difficulties (Proposed Modifications 2003, para. 8.13.7).

4.68 Silica sand is effectively a series of different sands with different properties. Different sands may be required for their chemical properties (particularly according to the quantity of different impurities present) or their physical properties (grain size, grain shape, consistency of size or shape), or both. There are many silica sand workings around England, but the need for different qualities of sand for different purposes means that different sites cannot necessarily substitute for each other. Government policy in MPG 15 notes that "It will be important to have regard to special factors, for example, some industrial consumers may necessarily be exclusively dependent on a single source of supply" (para. 51) due to the specific qualities of the deposit.

4.69 Silica sand is the one industrial mineral where the significance of different qualities of deposits is not always reflected in development plan policies. This does not necessarily mean that MPAs are unaware of the significance of different qualities, but lack of attention to variability in the mineral in detail may be a consequence of the more simple policy requirement to maintain a landbank at existing sites. Fortunately, there is recognition of quality issues in the plans for key supplying areas. Norfolk, Staffordshire and Kent have development plan policies which refer explicitly to the quality of mineral as a consideration and some other supplying MPAs mention quality issues in the supporting text of their plans. However, neither of the MLPs for Cheshire or Bedfordshire, both important supplying areas, mention qualities of sand. There is more discussion of silica sand qualities in the section reviewing the potential for end use control (see paragraphs 4.167–4.189).

4.70 High purity limestone is available in principle from substantial areas of the Carboniferous Limestone in northern England, and there are substantial permitted reserves in many localities. For one of the main producing areas, the Derby and Derbyshire MLP 2000 indicates the wide variety of end uses to which the mineral is put, quarry by quarry. However, it goes on to note that "because of the wide diversity of these markets and the chemical variability within some deposits, shortages in the availability of some particular qualities of mineral may occur, giving rise to needs which may not have been predicted and for which provision is made in Policy MP25."

4.71 With the exception of silica sand in a few localities, there is generally a well-understood and formally recognised differentiation between different qualities within industrial mineral types. Where the minerals industry or its customers are concerned that their demands for minerals having particular qualities may not be fully appreciated by MPAs, then they should take steps to remedy this appreciation. This does not appear to be a matter on which any further Government advice is required, though the point could be clarified more emphatically in general guidance on planning for industrial minerals.

Restoration issues

4.72 The section on mineral waste disposal noted the difficulty of restoring kaolin pits due to the risk of sterilising reserves at depth and also the need to maintain many sites open for blending purposes. Pits are released for infilling only infrequently, and tipping therefore takes place on other land. The enormity of the restoration problem in kaolin areas is difficult to convey: this is both an historic legacy problem (noted in the subsection below) and an ongoing problem. However, following on from the UK Biodiversity Action Plan, attention is now being given to lowland heath restoration through a joint venture — the Cornwall Heathland Project — involving the two kaolin producers, IMERYS and Goonvean, and English Nature, Cornwall County Council and the Heritage Lottery Fund. A Tipping and Restoration Strategy, which was a joint exercise carried out by the industry and the MPA, was principally to consider the long term issues associated with tipping requirements, landform and after-use. It now forms part of supplementary planning guidance and incorporates the above initiatives in its consideration of after-uses. Similarly in Devon, the intention is that in future the tip form and after-use would provide a positive benefit to the environment of the area (Devon MLP, Proposed Modifications 2003, para. 9.5C.3). Whilst the main part of the plan is quite reserved in its comments on restoration, the proposals accompanying the Inset Map for the kaolin area make some clear suggestions.

- "The MPA will pay particular attention to the need for high quality restoration and landscaping of the workings due to the scale of the operations and the proximity to the National Park." Proposal: Inset 38.1
- "The MPA will encourage the increased use of the china clay sand as a source of secondary aggregate." Proposal: Inset 38.5.
- "In considering any new proposals for the disposal of china clay waste, the MPA will encourage the backfilling of disused pits in order to reduce the impact of tipping above ground, and to secure the reclamation of disused pits or parts of pits, and where such backfilling does not sterilise mineral or otherwise prejudice their working." Proposal: Inset 38.5.
- "The MPA will encourage the development of best practice for the design, construction, landscaping, restoration and aftercare of all china clay working and tipping sites, including the re-profiling of existing tips." Proposal: Inset 38.7.

4.73 Comparable benefits for habitats and informal recreation are being sought where possible in the restoration of ball clay sites in Devon and Dorset. In Dorset, ball clay sites have been restored to heathland for a number of years, including experimental work on wet heathland restoration.

4.74 Controlled solution mining of salt produces an underground cavity which may be used for storage. These cavities may also be designed for natural gas storage. This form of 'restoration' or after-use may have damaging environmental consequences because of the amount of associated development at the surface. The forthcoming Secretary of State decision at Holford is likely to comment on the weight which should attach to the use of solution cavities for gas storage. National policy should clarify when, in principle, gas storage is an acceptable afteruse of cavities created by controlled brine pumping. Solution cavities in salt may also be required for gas storage in areas where there is no market for the salt/brine (see Mineral Planning Factsheet on Salt).[7]

4.75 Quarrying for carbonates is often on a very large scale and creates substantial difficulties for the restoration of the large voids left behind. There are various initiatives to address the problem. The Peak District National Park Structure Plan 1994 (para. 8.11) refers to investigations into how rock blasting techniques can be adapted to leave final rock faces in a form which will merge more readily into the landscape and simulate as closely as possible the natural rock faces which are typical of limestone dales. The problems faced in restoring these quarries are the same as those faced when restoring the more numerous aggregates quarries in carbonate rocks: there is nothing specific to industrial minerals to which attention should be drawn, significant though the issue is.

4.76 A selection of other restoration problems at specific sites and in specific localities are noted for each of the industrial minerals, but these do not suggest themes which require national advice in addition to the attention already being given to them locally by MPAs. In addition, the industry has made, and continues to make, real improvements in restoration standards. It is therefore concluded that, important though the restoration difficulties are which face a number of industrial minerals, national policy would be likely to add little to local understanding of the issues in most cases. Only in respect of the acceptability of gas storage in salt cavities created by controlled brine pumping would a commentary be helpful.

Dereliction from earlier operations

4.77 The main problems facing MPAs arising from industrial mineral activities in the past concern kaolin, ball clay, metalliferous minerals, salt (natural brine pumping), and to a much lesser extent gypsum. The impacts of natural brine pumping on restoration were outlined in the section on ‘underground mining: surface development and subsidence’. Likewise, most of the restoration problems associated with mining for gypsum/anhydrite are associated with historical subsidence and were noted in the same section. However, the Replacement Nottinghamshire MLP (Revised Deposit Draft 2003) notes also a problem with inherited ugly overburden spoil heaps, of a kind not now allowed (para. 10.7).

4.78 The Cornwall MLP acknowledges that extensive areas of former derelict kaolin workings have contributed to a degraded landscape. Restoration has historically been tackled piecemeal. The legacy of old permissions with no or inadequate restoration conditions can now be tackled through the legislation covering the review of old mining permissions, but even so the previously described characteristics of the industry’s operation preclude simple solutions. Few pits have been exhausted and made available for backfilling. Furthermore, there has also been intensification of the use of many existing tipping areas, which has led to steep slopes and, with the sterile nature of the materials, severe conditions for establishing vegetation and after-uses. The Devon MLP (Proposed

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7 In May 2004 the First Secretary of State and the Secretary of State for Trade and Industry decided to grant planning permission to Scottish Power UK PLC and Scottish Power Gas Ltd to create underground cavities for natural gas storage and associated infrastructure at Holford Brinefield. In making their decision, the Secretaries of State considered that the proposed development is supported by national energy policy as it provides for a type of gas storage, which will add to the security of supply, and have a beneficial impact on the traded market for gas. The decision is now the subject of a claim before the High Court.

Modifications 2003) are equally clear that the overall effect of historic tipping has had an extensive influence on the moorland landscape: "Although the stark appearance of the tips does mellow with time, they are generally an intrusive part of the landscape with incongruous slope textures and footprints" (para. 9.8.7). The problems caused by ball clay workings are not as severe.

4.79 There are estimated to be 3 900 ha of metalliferous spoil heaps in Cornwall (Cornwall MLP para. 11.4). A Cornwall Land Reclamation Strategy has been prepared to tackle them (para. 11.15), but the problem is daunting. Some of the many abandoned tin mines in Cornwall continue to have adverse impacts on the environment, sometimes spectacularly (e.g. with the well known discharge of mine water from Wheal Jane mine in 1992). Some spoil heaps in Cornwall and elsewhere have biodiversity and archaeological interest and may be designated as such. There is similar interest in former lead mining sites in the Peak District.

4.80 Inherited dereliction remains, in varying degrees, a reminder of the poor operational standards of earlier mining activity. The legacy from working industrial minerals is well appreciated, even if the solutions are sometimes remote. However, it is questionable whether further policy would assist the management of this issue.

PLANNING ISSUES BY THEME

The 'need' for minerals: creating wealth

4.81 Minerals play a fundamental role in underpinning growth in the economy and contributing to the UK's high standard of living. Continuing supplies are thus essential for the sustainable development of a modern economy. The Department of Trade and Industry (DTI) has responsibility within Government for the sponsorship of energy and non-energy minerals, including the industrial minerals sector. The role of the DTI in these areas is to seek to enhance the productivity and competitiveness of UK industry in order to maximise wealth creation and promote continuing sustainable economic development and investment, regionally and nationally.

4.82 The Department have stated that the concept of 'national need' which has historically been advanced to underpin local and national policy for industrial minerals extraction, is ambiguous and does not fit with the current policy framework. Minerals, like other goods and finished products, may be traded globally and there are no subsidies (except for deep-mined coal through Investment Grant Aid) or national stockpiles to support indigenous production. The UK has a large demand for industrials minerals that underpins a broader manufacturing industry, both in the UK and elsewhere (see paragraphs 3.1–3.27). Indeed in some cases consuming industries would be at a competitive disadvantage or disappear (close or relocate abroad) if they could not source mineral locally in the UK. Thus mineral operations create economic and social benefits for the local and wider community in line with wider sustainable development practice. The DTI considers that there should be a presumption in favour of granting planning consent for mineral extraction in most cases, unless the relevant environmental impact cannot be mitigated satisfactorily. Planning decisions on the extraction of industrial minerals should be based on a careful consideration of the economic importance of the proposed development including the investment decisions of consuming industries.

4.83 Wealth creation and productivity are increasingly being placed at the centre of political attention. The EU is currently carrying out preparatory work for a quantitative assessment of the competitiveness of the EU non-energy minerals extractive industry. It is hoped that the results will help to identify policies and actions which would contribute to enhancing the competitiveness of the industry.

4.84 The extraction of industrial minerals inevitably leads to some adverse environmental impacts. These impacts will vary depending on the mineral being worked and its location, but in all cases will need to be minimised. The costs of mitigating these impacts and ensuring that satisfactory restoration takes place rightly falls on the mineral operator. This is in line with Government and EU policy on producer responsibility. However, it is rarely possible to mitigate all the adverse impacts of extraction, such as visual intrusion and transport; even the most innovative (and costly) restoration scheme cannot return a site to its original condition. This does mean, therefore, that there will be occasions when the environmental impacts of mineral extraction are not outweighed by the economic advantages. It is the role of the planning system, through the Mineral Planning Authorities, to attempt to balance the competing demands of development and environmental protection.

4.85 In considering the wealth creation issues of mineral extraction in cases where the environmental impact cannot be mitigated satisfactorily, the DTI have suggested a checklist, which MPAs should consider in assessing planning applications for industrial minerals (see Annex C). These are;

(i) Will the development make use of the existing extraction infrastructure for example processing facilities?

(ii) To what extent will the project add value to the local economy relative to alternative employment opportunities? Will new jobs be created, or others safeguarded? Will business opportunities for local firms (e.g. supply of contract services) be generated that otherwise would not arise?

(iii) What is the impact on customer industry sectors in the UK and elsewhere e.g. how critical is the particular quality/properties of the materials being extracted, will it enable users to operate in the UK resulting in additional wealth creation opportunities for the UK.

Implications for mineral planning

4.86 Mineral planning authorities are experienced at sustainability appraisal and assessing the environmental impacts of mineral development proposals, but have not generally examined the economic merits in as much detail as is proposed here. If assessment of economic issues is to be improved, then MPAs will need information and advice. The applicant can provide some of this, but independent input will also be required. In order to assist in this process, the criteria set out above can be refined and 'local economic effects' and 'wider economic effects'.

(i) Local economic effects

4.87 The following economic questions are local matters which the MPA is well placed to answer:

- What is the structure of the local economy?
- To what extent will the project benefit employment in the local area?
- Will local businesses benefit from the activities of the mineral extractor?
- Will the development make use of existing extraction infrastructure?

4.88 These questions are more detailed than would typically be asked of other kinds of developer (such as house builders and commercial developers). They also elevate the importance of the localness of economic benefit. This is generally more relevant in rural areas than in urban areas. In rural areas the choice will often be simply between a development proceeding or not proceeding, whereas in most urban areas there will be alternatives for the use of land if one particular development does not proceed.

4.89 MPAs' responses to the answers to the groups of 'local' questions will be affected by the likely choice of alternative locations for similar development. The adverse economic effects of resisting a development which would otherwise not happen at all would be different from the adverse effects of resisting a development which would otherwise in all probability come forward at an alternative rural location.

4.90 A study of development plans and a survey of MPAs demonstrated that they are likely to examine carefully the main local economic issues raised by mineral proposals. The following examples illustrate the importance attached to the maintenance of local industrial minerals activities:

- The enormous importance of the kaolin industry to Cornwall (one of England's most economically depressed counties) and to a lesser extent to Devon is emphasised in development plans. The Cornwall MLP 1998 notes that this industry contributes about £250 M/y to the balance of payments and £130 M/y to the local economy (para. 7.3). The Devon Structure Plan First Review comments that over half the 1,650 people employed in the minerals industry in Devon are in the china and ball clay industries (para. 8.155). An estimate of their contribution to the local economies of Devon and Cornwall is c£150 million in 1997 (para. 9.6.2) — suggesting c£20 M/y attributable to Devon.
- The report *The Economic Importance of UK Ball Clay* indicates that direct employment in the ball clay industry is 470, with a further 480 jobs generated indirectly.
- The East Sussex and Brighton & Hove Structure Plan 1999 identifies the importance of the various gypsum-related operations around Mountfield, which employ about 200 people and form one of the largest industries in the plan area (para. 6.7);
- The North York Moors Local Plan Review 2003 comments on Boulby potash mine that "With the very large number of people employed at the mine [over 800] any refusal would potentially have a serious effect on the local economy and this is also a matter which national guidance states should be taken in to account" (in support of Policy M1).
- The Kent MLP for Chalk and Clay/Oil and Gas 1997 noted that the Rochester and Northfleet cement works were the two largest in the South East region and the industry as a whole employed over 900 people.
- The County Durham MLP 2000 accepts that where it is important to maintain employment there may be a justification for extensions to existing quarrying operations even if there is no established local need (para. 4.15). This was perhaps reflected in the extension given to Eastgate Quarry, even though the Weardale cement works which it served closed only two years later.

4.91 Some MPAs have positively aimed to attract new mineral development as a means of creating employment and local wealth. In particular, the Cumbria Minerals and Waste Local Plan 1996–2006 (2000) notes that solution mining of a salt deposit below the Walney Channel took place at the end of the 19th century. Although there is currently no salt working in Cumbria, the MPA strongly supports the recovery of this salt, mainly because this would create about 100 jobs directly and more indirectly (para. 5.17.2). Policy 47 supports the establishment of salt mining in this location.

4.92 An MPA's treatment of the answers to these 'local' groups of questions will necessarily be influenced strongly by the size of the development. For example, the local employment effects of refusing a development which causes a major local employer to cease trading will obviously weigh more heavily than if only a modest number of jobs would be lost. Again, the likelihood of those jobs being replaced by investment in a similar operation within commuting distance of the operation threatened with closure would also be a consideration. The location of an operation in a rural area where alternative employment opportunities may be poor may also be relevant. There are plenty of examples of mineral operations being refused on environmental and other grounds, including on appeal, when the local economic benefits have been found to be modest and therefore did not weigh especially heavily in the decision. A notable example was the Secretary of State's decision to refuse permission for the extension of fuller's earth working at South Wavendon Heath in Bedfordshire in 2002. The Inspector took the view that local employment (at 27) was not a significant issue (paras. 7.78–81), and the matter did not feature as a determining issue in the Secretary of State's decision.

4.93 So far as the continued use of local infrastructure is concerned, there has been a well-established interest in mineral planning in maintaining continuity of mineral supplies to existing plant where practicable. Processing plant is not only often expensive to move, but may sometimes have associated transport infrastructure which it would also be undesirable to lose (though equally there are some sites with established but very poor transport links). The merits of extensions to existing mineral operations compared with relocation to new sites, including this topic, were discussed in an earlier section.

4.94 Some MPAs have policies devoted specifically to sustaining existing investment in plant. For example, the Norfolk MLP 1996 includes Policy MIN 30 on silica sand, which provides that "In the Leziate area... the County Council will seek to maintain an adequate level of reserves to supply the industrial plant on the site where this is appropriate in environmental terms. Extensions to the working will only be approved where they are part of a phased development, restoration and after-use programme for the quarry complex." The mineral operations in the area also help sustain the local railway line, which has social value beyond its economic merits for distributing silica sand.

(ii) Wider economic effects on downstream industries

4.95 In addition to the local economic importance of industrial minerals, consideration must also be given to their importance as essential raw materials for a wide range of downstream industries, including manufacturing, construction and power generation, and also specialist process aids. Important considerations are:

- the importance of these downstream industries to the UK economy;
- the importance of indigenously produced minerals to the competitiveness of these industries; and
- the number of jobs that may be at risk if there were interruption or termination in the supply of indigenously produced minerals.

4.96 For most proposals for industrial minerals, these issues will be at least as important as the local ones, and probably much more so.

4.97 MPAs are likely to have considerable difficulty trying to answer some of the subsidiary questions posed for any particular industrial mineral proposal, such as:

- What is the impact on customer industry sectors in the UK and elsewhere?
- How critical is the particular quality/properties of the materials being extracted?
- Will it enable them to operate in the UK resulting in additional wealth creation opportunities for the UK?

4.98 These difficult questions are some of the most important which MPAs will need to address on the demand side. The theme that underlies them is the case for a reliable continuity of supply of the qualities of minerals which industries need. Clearly the best which MPAs can do for the industrial minerals industries is to grant the planning permissions applied for. The greater difficulty is in appreciating the consequences if permission is refused. MPAs must therefore have a reasonably clear answer to the question 'what will happen if a particular proposal is refused'? This issue might best be addressed by breaking it down into the following questions:

- Would another site be used or proposed instead, and if so is that environmentally better or worse than the current proposal?
- Would the mineral be imported from overseas?
- Would the consuming industry use a different mineral specification instead?
- Would the manufacture of mineral products cease or relocate over seas (as well as the mineral supply)?
- If permission was granted, what would be the likelihood of these alternative arrangements coming about in any event – in other words, to what extent are planning decisions critical to the future of industry?

4.99 MPAs will need to appreciate the position of a proposed mineral operation within the framework of the downstream industries which it serves. This kind of study, like the study of local economic effects, is more detailed than planning authorities generally would expect to undertake for other major development proposals. In practice, the applicant will wish to make the economic case for development and so present much of the information which an MPA needs. The MPA will need to have or to obtain the expertise necessary to analyse this economic infomation.

4.100 The information presented in the accompanying Mineral Planning Factsheets (see Annex A) include an overview of the economic importance of each mineral and how they relate to downstream industries. It is proposed that these Factsheets be kept up-to-date so that they provide a continuing source of reference. However, more detailed studies on the economic importance of each mineral may also be necessary. These might be on the lines of the report on *The economic importance of UK ball clay,* which was produced in 2001 on behalf of the DTI and Kaolin and Ball Clay Association.

4.101 On the criteria presented above, greater weight would generally be given to sustaining those businesses (mineral suppliers and consumers) which contribute most to the economy. However, it is smaller businesses which are likely to be better placed to show that denying them a particular source of mineral will damage or even eliminate their viability. It would then be the planning system rather than the marginal viability of an industry which may be held to have taken the business to the edge (or over it). The message from the economic criteria we have adopted is that that would be an unfair analysis. The planning system is not a back-door social handout to weak industries: the Government has other means of stimulating business sectors it considers important, without compromising the planning system.

Other economic considerations

The costs of planning regulation to mineral companies

4.102 A number of firms have indicated that the real economic difficulty they face in obtaining planning permission is the cost of preparing supporting material for planning applications and, if necessary, appearing at public inquiries. Improved information would enable a more cogently argued judgement to be made by the MPA.

4.103 The House of Commons Select Committee on the ODPM has recently examined the economic impacts of the planning system on business and recognised that there can be a real problem for small businesses, especially occasional users of the planning system who are unfamiliar with it. The Committee recommended "that the Government should place particular emphasis on supporting small businesses' interaction with the planning system, as there seems to have been little consideration given to the needs of such businesses. This is an area where the Small Business Service could promote proactive measures" (*Planning, Productivity and Competitiveness*, January 2003, para. 30). The Government agreed, and a guidance booklet for small businesses has been revised, but none of the other steps taken or in prospect will have any significant bearing on the compliance costs of mineral companies with planning regulations.

4.104 It would be quite wrong to compromise the even-handedness of planning requirements in response to the difficulties faced by small mineral businesses. To the extent that the Government considers it appropriate to alleviate the difficulties of the regulatory compliance costs these firms face, assistance should be provided by other mechanisms. One possibility might be to have lower planning fees to accompany planning applications submitted by smaller businesses, unless this would fall foul of rules on economic assistance to businesses. However, there is currently no precedent for this in the planning process. There is also a risk that small businesses might subsequently be taken over by larger ones, so the benefits originally intended for small businesses would accrue to larger ones. If the Government considered that small mineral companies contribute disproportionately to a wider national interest, and that this should be formally appreciated, then a way of effecting assistance in a legally admissible and reliably effective manner would need to be found.

Planning for competitiveness

4.105 The planning system concerns itself with the broad economic effects of development, but not with the specific interests of individual firms. It could not legitimately grant permission for a development specifically to improve the competitive position of any particular business. The credibility of the system depends on even-handedness and on consistent application of policy relevant to the use of land. This means that claims by mineral companies that adverse planning decisions will threaten their business will have a bearing insofar as matters such as local employment and local/downstream economic activity are concerned, but not insofar as an individual company's viability is concerned. A general support for competitiveness in British industry does not inevitably mean that monopolies should be prevented by the planning system.

4.106 Competition issues were argued at a public inquiry into a proposed ball clay operation at Newbridge, Devon, decided by the Secretary of State in 1998. The suggestion was made that, if permission was not given, one firm would be forced out of the locality, leaving the market to another supplier who would be in a dominant position. The Inspector dismissed these arguments. First, planning policy in PPG1 was quite clear that the planning system does not exist to protect the interests of one individual or a group of individuals over those of another. In addition there was no compelling evidence that refusal would cause the appellant to cease operating or, if it did, that another firm could not win the resource on the appeal site, and fill the gap left in the market. There would be no inevitable loss or sterilisation of the ball clay resource in this case if permission was refused.

4.107 The Inspector secondly drew the reverse conclusion from the arguments presented by the appellants. Competition between the main suppliers in the area, (the appellants and another firm), was indeed holding down prices. However, this limited the on-costs which could economically be borne by ball clay working (e.g. to overcome environmental difficulties). Furthermore, although the risk of a dominant supplier appearing might argue for permission to be granted, a dominant supplier's ability to raise prices would be controlled by the import price, and the implications for British industry on a wider scale would be unlikely to be marked. The Secretary of State 'fully agreed' with this analysis.

4.108 The third aspect of the Inspector's conclusions noted that that there was an agreement in force between the two local suppliers such that where there was a mutual interest the companies would co-operate to maximise the winning of a resource. Following an analysis of the effects of the agreement insofar as it impinged on the proposed site for development, the Inspector concluded that "having regard to the greater emphasis placed on safeguarding the environment and ecology today, I do not think it is acceptable to continue sanctioning the ad hoc arrangement that currently exists, and which involves fuelling the competitive element of two companies at the expense of the historic environment." The Secretary of State did not comment on this point, as he did not consider it a 'main argument'.

4.109 These arguments are significant as the consolidation of the minerals industry into progressively fewer companies continues. In effect, the Competition Commission will aim to prevent the creation of monopolies by takeover, but the planning system has other issues to take into account when considering planning applications which may result in local monopolies emerging. The competition issue need not necessarily be the determining one for the planning system.

Maintaining 'strategic' reserves

4.110 The concept of 'strategic minerals' originated in the era of the Cold War. They were defined as minerals and metals that were both critical to a manufacturing sector and vulnerable to interruptions in supply. Military requirements were relevant but not dominant. By definition they were minerals for which there was no domestic supply and had to be imported. None of the industrial minerals considered here are, therefore, strategic minerals. This is not the case in other counties and the US Defense National Stockpile still contains 250 000 tonnes of fluorspar, in which the US is deficient. The UK maintained a small stockpile — about three months' supply — of a number of strategic metals (as both metal ores and refined metal) from 1983 until 1996, during which period they were progressively sold off.

4.111 Since the global market is assumed to be able to supply minerals to customers without significant risk of any interruption due to political factors, the idea of 'strategic minerals' is no longer considered appropriate by government. Nevertheless supply shortages could arise for other than 'political' reasons. For example, China has for several years dominated the world supply of a number of metals and industrial minerals, such as tungsten, magnesium, fluorspar and barytes. Any curtailment of exports of these materials caused by rising domestic demand driven by China's high rate of growth could significantly disrupt world markets. This is illustrated by the decrease in Chinese exports of fluorspar in recent years that has put upward pressure on prices.

4.112 However, security of supply issues are not solely confined to overseas sources of minerals and some consumers of domestically produced minerals do have concerns about continuity of supply. The term 'strategic' has, therefore, also been applied to indigenous minerals, the supply of which is deemed to be of vital importance to a particular sector of UK industry. Fluorspar for the fluorine chemicals industry and industrial dolomite for steelmaking are examples. However, as stated earlier, the concept of 'national need' and 'strategic' minerals does not fit with the current policy framework. This is not to say that in some cases a mineral might be of strategic value to a company, as opposed to the nation as a whole. In the past there were many examples of manufacturing companies having there own indigenous source of supply to provide a degree of security. However, this is far less common today as companies seek to confine their interest to 'core' activities.

4.113 One suggestion that has been proposed is that mineral should be kept in the ground as insurance against some perceived, but as yet undefined, future shortage. The proposal has mainly been made in respect of fluorspar. Such a proposal is ill-conceived because of the difficulty and cost (who would pay?) that proving sufficiently large deposits would entail with no guarantee that a future market would be available. In addition markets for minerals evolve and demand changes. There are many examples of minerals, for example iron ore, coal, and naturally-bonded moulding sand, where if this approach had been adopted the investment made would have been wasted.

4.114 Whilst there is no case for maintaining a strategic reserve of key minerals, it is important to stress that this is significantly different from keeping future options open by safeguarding possible deposits and by long term planning. Maintaining a strategic reserve involves at the very least the identification of a known workable deposit, requiring significant up-front investment. Safeguarding, on the other hand, involves far less pre-emptive expenditure and aims to postpone rather than take strategic decisions (see paragraphs 4.151–4.166).

Balance of payments

4.115 The contribution of domestic minerals to the balance of payments, either directly by exports or indirectly by moderating the need for imports, has historically been an important issue in planning for industrial minerals. It has been a material consideration weighing quite clearly in the balance when decisions have on some occasions been taken to approve mineral working despite damaging environmental consequences.

4.116 This view no longer prevails in Government and contribution to the balance of payments is no longer considered to be relevant. Under current economic thinking it is the creation of wealth in the UK which is the key issue. This is best served by using the cheapest source of minerals of the required quality rather than necessarily a domestic source.

THE ENVIRONMENTAL EFFECTS OF MINERAL WORKING

Transport

4.117 A recurring theme amongst MPAs affected by industrial minerals operations is the desirability they attach to replacing road movement of minerals by waterway, pipeline and, above all, rail. Some of the most serious impacts of mineral working arise from mineral transport, particularly from the processing plant to customer, but also in some cases from quarry to processing plant. Rail, waterway and pipeline are attractive in principle when large volumes of mineral are to be moved from a point source to a point destination on an ongoing basis. Mineral companies supplying large numbers of customers with small quantities of mineral, or on an intermittent basis, may find road transport the only realistic option. So far as railways are concerned, establishing a railhead at the processing plant site is clearly a necessary first step, but equally it is necessary for customers or suppliers to be also rail-connected.

Current use of non-road transport

4.118 Waterways are not generally used to transport industrial minerals, though Northfleet cement works on the Thames Estuary has the facility to import and export by sea. Chalk slurry is moved by pipeline from Kensworth Quarry in Bedfordshire to Rugby cement works in Warwickshire and clay slurry is pumped beneath the Thames from a site in Essex to the Northfleet cement works.

4.119 A number of industrial minerals sites are rail-connected and the current position is summarised in paragraphs 2.31–2.41. The experience of recent years is a net reduction in the number of sites using this mode. Government policy encourages the use of rail transport for cement: "The industry should keep under review the options for using rail transport and use it in preference to road transport wherever it is cost effective to do so...." (MPG 10, para. 53). However, rail-connected cement works have closed at Masons, Suffolk; Rochester, Kent; and Weardale, Durham. Others have ceased using their rail connections (e.g. Ribblesdale, Lancashire). Conversely, there has been interest in connecting Cauldon, Staffordshire to the rail network.

4.120 MPG 15 on silica sand also offers qualified support for encouraging a switch of silica sand from road to rail (paras. 73–77). However, only the King's Lynn site is directly rail connected, and there remain strong economic, as well as practical disincentives to a greater move to rail. Two quarries in the Yorkshire Dales National Park capable of selling limestone for its high purity are already rail-connected, at Swinden and Horton.

4.121 Two industries make minimum use of road transport: potash and kaolin. Potash movement by road is limited by condition to 150 000 t/y. In fact 90% of the potash output (1 Mt) is being sent by rail to Tees Dock for either export or final delivery to customers in the UK by road. For the kaolin industry, there is a modern arrangement of pipelines, railways, internal haul roads, and conveyors as well as use of public roads. The Cornwall MLP (2000) comments that "Given the enormous quantities of materials extracted and moved within the area, a surprisingly small proportion finds its way onto the public highway" (para. 7.17). Nevertheless, a significant volume of clay-related traffic still uses the public road network. This includes not only employees, maintenance, supplies and equipment, but increasingly the haulage of china clay waste to supply aggregates to the local building and construction industry (para. 7.19). In addition, china clay waste is being moved by sea to markets in the South East. Disused railways lines might be reopened in future, so both they and lines for road improvement and railway realignment are safeguarded, by Policy CC7.

Prospects for rail transport

4.122 Many MPAs have development plans which express an encouragement in principle for minerals movement by rail, waterway, pipeline or conveyor, but few have taken a proactive approach to the issue. Real interest has, however, been expressed in a few cases:

- The Staffordshire and Stoke-on-Trent MLP 1994–2006 indicates that any increase in output at Moneystone Quarry above 400 000 t/y "may necessitate further highway improvements and/or the utilisation of nearby rail facilities. The transportation of materials by rail should in any event be fully investigated prior to any further applications for extensions or increased output at the quarry. This should include an independent assessment of the viability of rail use, to be commissioned by the quarry operator" (para. 11.25).
- Cumbria County Council's supports in Policy 45 of its MLP (2000) a quarry at Stamp Hill if there is an insufficient supply of desulphogypsum: there was a larger permission from 1991 here which lapsed, but the new permission would be conditional on transport by conveyor to the Kirkby Thore plasterboard works.
- The East Sussex and Brighton & Hove Structure Plan 1999 Policy MIN12(c) states: "the import of desulphogypsum by rail for processing at Robertsbridge Works will be supported where the need is demonstrated." Policy 28 of the East Sussex and Brighton & Hove MLP 1999 "supports the retention of the rail link to the Robertsbridge Works and wishes to encourage its fullest use for all appropriate importing and exporting operations associated with mining and production activities." This seems to be aimed particularly at rail transport of the gypsum products, which currently all leave by road even though the railway used to supply Thamesside cement plants (para. 6.9).

4.123 A strategy to improve the transport planning of the whole of a minerals industry has been put forward for ball clay in Devon. Most movement of quarried ball clay for processing and processed material to market or export is by road, and the MPA recognises the importance of continued road transportation. However, Devon County Council is seeking through its MLP (Proposed Modifications 2003):

- movement of ball clay by rail to UK destinations (Statement of Intent S9);
- safeguarding of disused rail heads and existing rail links (para. 8.14.15);
- road improvements, notably construction of a realigned B3193 (Statement of Intent S10);
- consideration of ball clay transport by conveyor systems (Policy MP32);
- encouraging industries which use ball clay to locate in or adjacent to the Bovey Basin (para. 8.14.16);
- continued use of Teignmouth Docks for export (as ball clay provides half the port's business), including investigating a new railhead at the docks (para. 8.14.16).

4.124 Some MPAs are working to improve the prospects for non-road transport of industrial minerals, and many more would like this switch to happen but feel constrained by the realities of the market. This appears to us to be an area where long term planning could offer realistic opportunities for improvement.

Landscape

4.125 National policy giving recognition to special landscapes is expressed through the designation of National Parks and Areas of Outstanding Natural Beauty (AONBs). National Park designation confers the highest status of protection as far as landscape and scenic beauty is concerned. However, National Parks have a more all-embracing environmental standing, with PPG 7 stating that "Conservation of the natural beauty of the countryside, and of its wildlife and cultural heritage, should be given great weight in planning policies and development control decisions in the National Parks, the Broads and the New Forest Heritage Area" (para. 4.5). The paragraph goes on to state, with particular relevance to working industrial minerals, "Special considerations apply to major development proposals, which are more national than local in character. Major development should not take place in the National Parks, the Broads and the New Forest Heritage Area save in exceptional circumstances." Matters to be assessed are then listed.

4.126 The primary objective for the designation of Areas of Outstanding Natural Beauty is conservation of the natural beauty of the landscape. PPG 7 again sets out national policies to be applied in these areas, stating that "It would normally be inconsistent with the aims of designation to permit the siting of major industrial or commercial development in these areas. Only proven national interest and lack of alternative sites can justify an exception" (para. 4.8). In relation to major projects this has been amplified by an announcement by the Secretary of State that the assessment required by PPG 7 para. 4.5 in respect of National Parks will also apply in AONBs (Parliamentary Written Answer on June 13, 2000). PPG 7 goes on to say that "Applications for new mineral workings, or extensions to existing works, in AONBs must be subject to the most rigorous examination...." (para. 4.9), the same approach as applied to the means of assessing major developments in National Parks.

4.127 The main local designations of valuable landscapes are made at the county level, but may also be included in the plans prepared by unitary authorities (outside the shire counties). These are typically described as 'special landscape areas' or 'areas of great landscape value'. They indicate relative merit at the subregional scale, and can assume a disproportionate significance as a measure of value in those parts of the country without National Parks or AONBs.

4.128 Industrial minerals are found and indeed worked in these designated areas. Table 13 summarises the main occurrences.

4.129 Table 13 shows that the one potash mine, all vein mineral workings and — most significant in terms of area and quantity of mineral extracted — many high purity limestone sites are located in National Parks. Other minerals may be found occasionally in or close to National Parks and Areas of Outstanding Natural Beauty, and further sites are within areas designated for their local landscape importance.

4.130 The designation of a landscape in any of the categories listed is an expression of the importance to be attached to them in planning decisions. All the landscapes are 'lived-in' rather than wilderness or remote places, and economic and social issues are relevant within them as much as in other rural

INDUSTRIAL MINERAL	NATIONAL PARKS	AONBS	COUNTY LANDSCAPE AREAS	NOTES
Cement Raw Materials (Limestone/ chalk)	Peak District (*Hope*)	Chilterns (*Kensworth*)	Kent Downs (*Halling, Snodland*)	Proximity to Peak District NP (*Tunstead, Cauldon*); Proximity to North Wessex Downs AONB — Wiltshire (*Westbury*) Proximity to Forest of Bowland AONB (*Ribblesdale*)
Salt	North York Moors (*Boulby*)			
High purity limestone	Peak District, (*Old Moor, Ballidon);Lake* District (*Shap Beck*)	South Downs — East Sussex (*Tarring Neville*) Lincolnshire Wolds (*Mansgate, South Thoresby*) adjacent to: Mendip Hills — Somerset (*Battscombe*)		Proximity to Peak District NP (*Tunstead, Dowlow, Grangemill*); Proximity to North Wessex Downs AONB — Wiltshire (*Quidhampton*)
Kaolin				Proximity to Dartmoor NP (*Lee Moor*, Headon *Shaugh Moor*)
Ball clay		Dorset (*Povington, Arne, Dorey's, Furzeyground*)		
Gypsum & anhydrite		High Weald AONB — East Sussex (*Brightling*)	Staffordshire (*Fauld*: proposed area of search for an extension)	
Potash	North York Moors (*Boulby*)			
Silica sand		Nidderdale Moors (*Blubberhouses*)		Proximity to Surrey Hills AONB — Surrey (*Buckland, North Park Farm, Mercers* Farm) Proximity to Kent Downs AONB (*Addington, Aylesford*)
Fluorspar	Peak District (all sites)			
Fuller's earth			Bedfordshire: (*Wavendon Heath*)	
Tungsten				Proximity to Dartmoor NP
Slate				Proximity North Cornwall AONB (*Delabole*)

Table 13 *Industrial mineral operations affecting designated landscapes.*

areas. Designation does not preclude industrial mineral working. Rather, the case for working these minerals must meet progressively stiffer tests the more highly valued the landscape within which it falls. Particularly in locally designated areas, the emphasis is likely to be on the extent to which mineral working would damage purely the visual qualities for which those areas were designated: the concern is not to have an in principle objection to quarrying, but to ensure that development within the designated area does not compromise visual quality. The fact that many industrial mineral sites are located within designated areas, including National Parks, and that large numbers of planning permissions have been issued since these areas were designated, demonstrates the flexibility of the system. The fundamental issue is whether a proposed mineral development has taken sufficient steps to avoid or overcome landscape damage in these areas and, if it has, if the remaining impacts can be justified by the strength of the case for proceeding with mineral operations.

4.131 Landscape characterisation has become an established facet of our understanding of place. The Countryside Agency has published a complete map of England showing Countryside Character Areas, and many County Councils have tackled the more detailed process of refining this to smaller character areas at the local level. The special qualities of each locality can inform the way in which mineral workings are carried out and, in particular, how they are restored to reinforce the qualities of their location. Interest in landscape character assessment has recently been reinforced by the Council of Europe's European Landscape Convention, which emphasises the merit of identifying the uniqueness of all natural and cultural landscapes, urban as well as rural, and creating and managing landscapes as well as protecting them. This Convention has been ratified by sufficient member States to come into effect, though the UK has not yet ratified it for application here. The impact of the Convention in the UK, if ratified, will be as much as the Government allows it to be, since its implementation is entirely a domestic issue without either enforcement or resources from the Council for Europe.

Wildlife

4.132 There is a sophisticated system of protection for wildlife, both of habitats and of species, from the international scale to the local level. This reflects not only a more established global environmental movement in the wildlife sector, but also the imperative of protecting species which migrate across international boundaries.

4.133 The principal international agreements on wildlife to which the UK is party are:

- the Ramsar Convention on Wetlands of International Importance especially as Wildfowl Habitat: the UK holds an internationally significant number of 'Ramsar sites';
- the Birds Directive (EC Council Directive on the Conservation of Wild Birds): the UK has a large number of Special Protection Areas (SPAs) of European importance designated under this Directive; and
- the Habitats Directive (EC Council Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna): the UK again has a large number of Special Areas of Conservation (SACs) of European importance designated under this Directive.

4.134 The European Directives have been transposed into UK law. They include remarkably strict rules, enforceable ultimately through the European Court of Justice, to ensure protection of key wildlife sites from inappropriate development. Broadly speaking, wildlife takes precedence in these designated areas. The Government has indicated that it will treat potential SPAs and candidate SACs as if the sites had been formally designated.

4.135 Primary exemplar wildlife sites of national importance are managed as National Nature Reserves, but far more extensive and significant in planning terms are Sites of Special Scientific Interest (SSSIs). All sites designated under international agreements are SSSIs, but so also are many other sites not of supra-national significance. To a large degree the SSSI designation is an expression simply of wildlife value. Although planning decisions are expected to pay careful attention to them as material considerations, there are limited powers to enforce the proper management of designated sites or to remedy or prevent damaging activities. As a result, the International Union for the Conservation of Nature (IUCN) has excluded SSSIs altogether from its lists of protected areas: only National and Marine Nature Reserves are included, as are National Parks as protected landscapes. The strengthened protection for SSSIs under the Countryside and Rights of Way Act 2000 may be sufficient to lift SSSIs *en bloc* into the IUCN lists.

4.136 The planning system is nevertheless one of SSSIs' key lines of defence, and appropriate regard must be had to the wildlife interests they contain when deciding planning applications for mineral working. Furthermore, regard is also to be had to proposals within predetermined 'consultation areas' around SSSIs, which may extend 2 km from a site, in order to ensure that development near a designated site does not have adverse effects within it (e.g. by changing groundwater levels or allowing changes in water quality to migrate into a site). Applications for mineral working "in or likely to affect SSSIs should be the subject of the most rigorous examination" states PPG 9 para. 40, using terminology familiar from the approach to National Parks and AONBs.

4.137 The designation of wildlife sites at the local level mirrors that at the national level. Local Nature Reserves are managed for their local wildlife value, but a much larger range of 'Sites of Importance for Nature Conservation' (or comparably named designations) is identified for its local wildlife value. Such sites are often included on maps in Local Plans and Unitary Development Plans, and depend for their protection substantially on the planning system. These sites do not attract the level of protection afforded to nationally or internationally important sites, but nevertheless express local qualities which should not lightly be overruled.

4.138 Beyond this, the Government is anxious to ensure that wildlife outside designated areas is not neglected: a robust wildlife heritage depends on the totality of habitats and not simply on oases of special value. With this in mind, English Nature has identified 'Natural Areas' of distinctive wildlife character which, like the Countryside Agency's counterpart Countryside Character Areas, cover the whole of England. Liaison between the bodies has ensured that the two kinds of character areas have compatible boundaries (though there is a greater differentiation of areas for Nature Conservation than for landscape).

4.139 As with designated landscapes, so with designated wildlife sites, mineral workings are to be found located in and adjacent to places special for wildlife. Table 14 lists the main locations. The identification of 'Natural Areas' does not appear to have had any significant impact to date on proposals for the supply of industrial minerals.

4.140 Table 14 shows that there are some significant interactions between industrial minerals supply and wildlife sites. Probably the most pressing conflict affects ball clay, especially on the Arne peninsula in Dorset. A site permitted here on appeal in 1977 has subsequently been designated as falling within five internationally important wildlife sites, and there are highly significant constraints on further workings in the Dorset ball clay area due to wildlife interests. Some 65% of the ball clay resource area in Dorset is affected by environmental designations, mainly for wildlife[8]. A further ball clay site at Newbridge in Devon was rejected on appeal due to the adverse impact on an SSSI. The most high profile consideration of industrial minerals supply in relation to wildlife interests since the designation of internationally important site arose at Southport, Sefton. Here a planning application to continue removal of silica sand from a foreshore designated for its international wildlife importance was determined in 2002 following an inquiry. The Secretary of State agreed with his Inspector that there was a sufficient degree of certainty that the integrity of the wildlife site would not be adversely affected (though had it been, the application would have been refused).

Table 14 *Industrial mineral operations affecting designated wildlife sites.*

INDUSTRIAL MINERAL	INTERNATIONAL SITES	OTHER SSSIs	COUNTY WILDLIFE SITES	NOTES
Cement Raw Materials (Limestone/ chalk)	Tunstead (cSAC) Wiltshire: preferred area in SPA/SAC	Cauldon Bellman Quarry (to supply Ribblesdale): geological SSSI	Bellman Quarry (to supply Ribblesdale)	
High purity limestone	Old Moor (cSAC)			
Industrial dolomite		Thrislington		
Kaolin				Extensive 'Areas of Special Environmental Concert' within china clay zone
Ball clay	Furzeyground (cSAC) Arne, Povington, Dorey's (SPAs, cSACs, Ramsar)			
Gypsum & anhydrite		Fauld (proposed area of search for an extension)		
Silica sand	Southport (SPA/cSAC/ Ramsar)		Moneystone	Moneystone (adjacent SSSI); Ratcher Hill (adjacent SSSI); Ardleigh (Essex) (adjacent SSSI)
Fluorspar	Peak District — many sites (cSAC)			
Fuller's earth			Wavendon Heath	

8 Highley, D E, Bristow, C R, Cowley, J F and Webb, N R. 2002. Sustainable development issues for mineral extraction — the Wareham Basin of east Dorset. *British Geological Survey Commissioned Report,* CR/01/137N.

4.141 Also of interest is the approach taken by the Secretary of State and Inspectors at planning inquiries where industrial mineral working proposals would affect designated wildlife sites of local importance only. Proposals for fuller's earth working at Wavendon Heath South, Bedfordshire were rejected on appeal in 2002 because of adverse impacts on locally designated wildlife and landscape areas: the Secretary of State was not satisfied that there would definitely be no alternatives if permission was refused (whether other sources or synthetic products), even though the applicant had argued that the mineral in the site was unique. In effect an extremely high hurdle was placed in the way of the applicant even though the environmental interests at risk were locally rather than nationally or internationally important. In contrast to this decision, however, the Secretary of State has approved vein mineral workings at Cop Mine in the Peak District National Park in 2000 despite conflict of the proposals with a cSAC and with the most heavily protected 'Natural Zone' of the Park, citing 'exceptional circumstances' based on the need to identify the extent of the mineral deposit.

Heritage

4.142 There is increasing attention to heritage issues at an international level. The World Heritage Convention is one of the oldest international environmental agreements, adopted in 1972. Its full title, the Convention Concerning the Protection of the World Cultural and Natural Heritage, is indicative of its aim to promote co-operation amongst nations to conserve natural and cultural heritage of 'outstanding universal value'. 721 sites were listed by the end of 2001 amongst the 167 States party to it, of which 24 are in the UK (15 in England). More sites are continually being proposed for designation, and, since 1992, a category of 'cultural landscapes' has been created, recognising the interrelation between man and nature. The World Heritage Convention is acting as a driver in this sphere, with the UK responding by proposing to designate the Lake District and the New Forest in this category. World Heritage Site designation carries with it the expectation of strict protection. Although no sites in England at present have any significant impact on the potential to exploit mineral resources, it is possible that they could in future, particularly in any cultural landscape. Interestingly, the heritage of metal mining and processing in Cornwall is inspiring the preparation of a bid for World Heritage Site status.

4.143 The European Landscape Convention similarly reflects the interaction between man and nature in its recognition of cultural landscapes, in what amounts to an integrated environmental approach to the appreciation of place. This Convention follows the earlier Council of Europe Convention on Archaeological Heritage (adopted in 1969, revised in 1992).

4.144 The heritage designations at a national level in England are wide-ranging in type and numerous, though for the most part restricted to sites rather than substantial areas:

- individual buildings may be registered as Listed Buildings of architectural or historic importance (in one of three grades), and protection extends to their settings as well as the buildings themselves;
- archaeological sites may be scheduled as Ancient Monuments;
- areas of historic or architectural importance may be designated as Conservation Areas (primarily but not exclusively in built-up areas), with regard to be had to views in and out of these Areas;
- historic parks and gardens may also be registered, though these are non-statutory;

- areas or archaeological importance are another non-statutory designation.

4.145 Proposals for working industrial minerals do not often raise conflicts of interest with designated heritage sites. The two potential conflicts most frequently noted are with the setting of listed buildings and with archaeology. The setting of listed buildings has occasionally been an issue in industrial minerals development proposals such as for an extension to Grange Top Quarry, Rutland to serve Ketton cement works. The development was permitted despite some adverse impact (partially mitigated). More frequent are actual or potential threats to archaeological sites. The main threat to archaeology from industrial mineral working is probably from the tipping of kaolin waste in both Cornwall and Devon, which is expected to damage sites of at least local importance. Shaugh Moor and Crownhill Down on the edge of Dartmoor National Park have exceptionally well preserved archaeological landscapes. On a lesser scale there is archaeological interest in the land above the Fauld mine in Staffordshire which is proposed as an Area of Search for an extension.

4.146 Archaeological interests are recognised as legitimate matters which must be investigated in advance of any mineral working which might affect historic remains, and which must be respected if finds arise during working. Industrial minerals are no different from others in this respect. There are various reports of actual or potential conflicts of interest arising, but these appeared largely to be occasional rather than systematic problems. Only in respect of kaolin was archaeology identified as a major issue of concern. The Devon MLP (Proposed Modifications 2003) records that "There is substantial and sensitive archaeological and industrial archaeological interest throughout the Mineral Site. Shaugh Moor and Crownhill Down have exceptionally well preserved archaeological landscapes." Proposal: Inset 38.2 states "The MPA will ensure that a comprehensive scheme of archaeological survey evaluation will be required in advance of the consideration of any future proposal"; and Inset 38.8 states "The MPA will establish and implement a comprehensive extraction and restoration programme to reduce conflicts with significant environmental, archaeological and historic landscape interests." This is also presented as a strategic objective for kaolin policy. The Cornwall MLP also indicates that tipping may need to take place on areas of county or local importance for archaeology (para. 7.41). There will be some scope to mitigate impacts of operations through reviews of old mining permissions particularly in 'Areas of Special Environmental Concern' where there are extensive planning permissions.

4.147 Identifying the possible need for any further advice on how to protect archaeological interests within the kaolin working areas has been beyond the capacity of this study. If any additional policy is required it will clearly be specific to this mineral industry. The Government, English Heritage, the minerals industry, the MPAs and other interested parties should consider together whether further attention is needed to this issue, and if so what that should be.

Other environmental effects

4.148 Research identified a wide variety of environmental impacts from actual or potential industrial mineral workings not covered under previous headings. These included:

- the desirability of avoiding working in particularly sensitive cultural landscapes (such as the South Downs — for high purity chalk, and Bodmin Moor — for kaolin);

- the adverse impacts of reworking waste tips from previous vein mineral workings (in Derbyshire and the Peak District National Park);
- problems of pollution control at many cement plants, which had implications for both land use and environmental regulations;
- impacts on the best and most versatile (BMV) agricultural land (noted at silica sand workings in Cheshire and Essex).

4.149 A few sites involve a wide range of environmental issues. For instance, Battscombe Quarry in Somerset, which is worked for industrial limestone, has a significant visual impact, has issues relating to traffic, access, and blasting, is in an AONB, abuts an SSSI, is in the Cheddar Springs Groundwater Source Protection Area, and close to several Scheduled Ancient Monuments.

4.150 The other issues are already covered by general mineral planning policy (such as impacts on BMV land), or are matters largely for local policy. None of the additional environmental issues noted appears to be specific to industrial minerals beyond the local level, and should therefore need not be addressed in Government policy.

APPLYING THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Best use of the resource: safeguarding from sterilisation

Current practice

4.151 Government policy on the safeguarding of industrial minerals from sterilisation by development on the land surface is clear. Both industrial minerals with MPGs (cement and silica sand) have their own mineral-specific safeguarding policies, including the following:

- "... local authorities should make every effort to safeguard in their development plans, and through development control, those deposits which are of economic importance against other types of development which would be a serious hindrance to their extraction... (MPG 10 para. 38);
- "silica sand deposits should not be sterilised by other forms of development which would make them unavailable for use by future generations without good land use planning reasons" (para. 30); "Silica sand is a scarce resource and MPAs should... safeguard deposits which are, or may become, of economic importance against other types of development or other constraints which would be a serious hindrance to their extraction" (MPG 15 para. 53).

4.152 A survey of MPAs showed that almost all had general policies to safeguard mineral deposits in the long term from sterilisation by inappropriate surface development. In shire areas, policies were frequently included in both the Structure Plan and the Minerals Local Plan. Many MPAs had safeguarding policies specific to the industrial minerals within their areas. The wording of policies inevitably varied from one MPA to another, but most made clear that the intention was to protect:

- potential deposits as well as known deposits;
- land which, if developed, could compromise mineral working or processing on adjacent land;
- land which might be needed for mineral transport, mineral processing, or the tipping of mineral waste, as appropriate.

4.153 Many policies made clear that the constraint on surface development was by no means absolute. The case for surface development might be more important than safeguarding mineral. In some cases specific reference was made to 'prior extraction' where practicable, i.e. taking out the mineral in advance of necessary surface development.

4.154 There are two ways in which these aspirational safeguarding policies were likely to be compromised in practice. First, some authorities added qualifications to their safeguarding policies which allowed a risk to continue of some deposits being sterilised. For example, the Oxfordshire Structure Plan 2011 (1998) has general Policy M6 which states: "The County Council will object to development where it would sterilise important mineral resources which could be worked under current development plan policies." 'Current development plan policies' for fuller's earth do not identify any land for working or searching for fuller's earth, even though the Oxfordshire Minerals and Waste Local Plan 1996 identifies deposits west of Baulking and north of Uffington (para. 2.34).

4.155 The second and more widespread limitation was that general safeguarding policies were not always given effect by comprehensive 'Mineral Consultation Areas (MCAs)', wherein planning applications for surface development would need to be referred to the MPA for comment. Without consultation areas, there would be a risk that surface developments capable of sterilising mineral might simply not be referred to the MPA. This risk is much reduced in unitary authorities which are responsible for deciding both minerals issues and surface development issues, though there still needs to be an effective internal arrangement for mineral planners to be consulted on surface development proposals. Practice varied considerably. There have been long established Mineral Consultation procedures, based on extensive MCAs for the kaolin and ball clay resource areas since the 1950s. Some MPAs had numerous MCAs, extending over many minerals and wide areas (e.g. in Cornwall). Some included industrial minerals which were not currently worked within the MPA area (e.g. celestite in South Gloucestershire, and tin and tungsten in Devon). Many of the minerals studied in this research were the subject of MCAs.

4.156 Elsewhere there were limitations:

- some authorities did not have MCAs, while others had not completed the process of identifying MCAs: plans in Cheshire and Cambridge shire recognised the need for MCAs for industrial minerals and made commitments to prepare them, but had not done so at the time (for salt and silica sand in Cheshire [Cheshire Replacement MLP 1999] and for cement-making materials in Cambridgeshire [Cambridgeshire Structure Plan December 1995]);
- some development plans had safeguarding policies with consultation areas for certain industrial minerals but not others. For example, the North Lincolnshire Local Plan 2003 has a specific Policy M18 to safeguard silica sand resources, but does not have a similar policy for cement-making materials. Likewise, Surrey County Council has an MCA for fuller's earth but not for silica sand.
- in some MPAs the MCAs were closely defined in ways which left a proportion of the resource at risk of sterilisation, particularly by limiting the MCAs to the likely future extent of specific existing quarries rather than covering the full extent of the known or likely deposit. This applied for example to Battscombe in Somerset, Thrislington in County Durham, Quidhampton in Wiltshire and the Marbleagis mine in Nottinghamshire). In the last of these cases, Policy M10.2 in the Replacement Nottinghamshire Minerals Local

Plan Deposit Draft 2002 specifically safeguarded 124 hectares west of Costock for underground gypsum mining, both in terms of sterilisation and as a phasing policy. As limited an area as this barely qualifies as safeguarding the resource.

4.157 Mixed views on the efficacy of sterilisation policies were expressed by MPAs in response to the survey. There was some belief that the policies worked well but equally a view that they did not add much to the planning process. Many authorities considered that the large landbanks they had for industrial minerals diminished the importance of safeguarding policies, and it was clear that significant surface developments in areas which authorities were monitoring were few. In environmentally sensitive areas there was little likelihood of permissions being granted for major surface development in any event. None of those who considered that the MCA system was working well elaborated on how this was achieved or on the sterilisation that had been avoided. Taken together, the evidence available and the MPAs' responses fell short of a ringing endorsement of current practice.

Commentary

4.158 In the large majority of MPAs, safeguarding mineral resources for possible future working is a reactive process, in which the prospective developer or user of the land surface comes forward with proposals requiring planning permission in just the same way as would happen outside a safeguarded area. Once the MPA has identified a safeguarded area on a map then, when a prospective surface developer comes forward, the onus is on the authority and industry to demonstrate that the deposit is likely to be required within the foreseeable future.

4.159 This is fundamentally unsatisfactory, for a range of reasons. Additional steps should be considered. First, the purpose of designating safeguarded areas should be to assert the primacy in principle of protection of any mineral resources for the long term. The onus should be placed on the intending surface developer or user to demonstrate that there is no mineral on the site or nearby which could be sterilised by the surface activity. Intending developers already expect to establish in advance of greenfield activities whether there are archaeological remains, wildlife of interest or other qualities in a site which might have a bearing on whether planning permission is granted or how the development is carried out. It should therefore be the norm for prospective surface users also to establish at their own expense whether there is industrial mineral in a site, based on independent investigations. Some mineral planning authorities already require this, but they are few (see box).

4.160 Second, the expectation should be that, if mineral deposits of even modest quality are found beneath a proposed site of surface development, then any surface development must be arranged in such a way as to give primacy to retaining the future availability of that mineral from the site if needed (e.g. by granting only temporary permissions). There should be no requirement on the industrial minerals industries to demonstrate an intention to work the site in the short or medium term. It is fundamental to the concept of sustainability that a long term view is taken about the potential use of scarce mineral resources. Unnecessary impediments should not be put in the way of future working by creating a future requirement for mineral companies to buy out surface developers (or, more likely, suffer sterilisation of the deposit).

4.161 It was established in the section above on the prospects for extensions to existing sites and the establishment of new ones that there has been no significant long term planning for continuity of supply. The conflicts of interest between the demand for industrial minerals and the impacts of working them are likely to become more intense rather than less intense over time. This is not only as the more accessible sites are worked out, but also if concern for the protection of the environment continues to increase. The third step to improve safeguarding would therefore be to integrate this protection with long term planning of mineral supply. There is a case for safeguarded areas for industrial minerals to take on a higher status. For the scarce minerals in particular, safeguarded areas should identify the entirety of the known or likely resource. Consideration should also being given to certain areas within them being more emphatically identified as preferred locations for future working well beyond the period of any existing development plan. This is only a modest step forward from the system of 'preferred areas' which most mineral planning authorities already identify.

Safeguarding minerals in Staffordshire and Leicestershire

The Staffordshire and Stoke-on-Trent MLP 1999 Policy 5 refers to existing Mineral Consultation Areas and to a requirement that "Where the proposed development falls within the Mineral Consultation Areas and may have a significant impact on mineral resources then the responsibility rests with the prospective developer to prove the existence or otherwise, quantity and quality of the mineral prior to the determination of the planning application." The text clarifies that "this may involve site investigations and/or drilling" (para. 3.17).

The Leicestershire MLP Review 1995 Policy 34 states that, of applications for surface development within mineral consultation areas, "Where reserves are believed to exist but are not proven, the CC may request the DC to obtain information from the developer information in respect of the existence or otherwise of the mineral deposit before any application for development is determined."

4.162 The perception of minerals as scarce resources will increase as the environmental constraints on supply become tighter. This applies both in England and internationally. It is increasingly difficult to find environmentally acceptable sites for mineral working, even where there are extensive resources (such as cement raw materials and industrial limestone). The options for some other industrial minerals are much less because resources are geologically restricted and therefore there is a limited choice of workable sites. A demand-led supply pattern into the indefinite future is not sustainable. A fourth step for the reform of safeguarding would therefore be a progressively stronger need for a more positive contribution from the planning system to establish where mineral working can and, just as important, cannot be expected to take place into the longer term. It is entirely foreseeable that parts, at least, of safeguarded areas will eventually become more definitive locations for mineral working. Here, the terms and conditions for mineral development are increasingly defined in advance of proposals coming forward. This will in effect assert the role of integrated planning above what has hitherto been a greater primacy of the market in dictating the location of mineral activities. With the location of long term working sites largely fixed, mineral companies would simply need to assess whether deposits were workable economically and, if so, whether their competitive position enabled them to acquire the mineral rights. Legislation already exists through the Mines (Working Facilities and Support) Act 1966 to allow an operator to explore for and work minerals in the national interest if the mineral rights owner would otherwise be unwilling to co-operate. However, there is an apparent conflict here between legislation and the current DTI view on 'national need' (see paragraph 4.82).

4.163 If this more assertive role for safeguarding were to arise, the end state would in effect be a new designation of 'mineral working areas'. These could be designated locally, nationally, or even internationally, just like wildlife and landscape designations. The purpose of designation would be to assure the long term future of mineral working, though of course not without the possibility of compromise in individual cases. It is anticipated that those minerals for which England is a globally important source, notably kaolin and ball clay, would command particular importance when weighing up the balance of competing economic and environmental interests. A more reliable and therefore sustainable pattern of industrial mineral supply internationally would become practicable through an international agreement on locations for the supply of scarcer minerals.

4.164 'Industrial minerals areas' would be safeguarded to allow future mineral development. This would be a more proactive activity than typical under the existing arrangements for avoiding the sterilisation of mineral. The onus would be placed on prospective surface developers to show that there was no potentially workable mineral beneath the surface activity or likely to be affected by it. If there was such mineral, the development would be time-limited in order to allow mineral working at a future date (though the temporary period could be decades, and therefore cover the life of a typical commercial building). Development plans would encourage activities and developments which in relation to mineral planning activities were only temporary. There would be no expectation that mineral identified beneath a site would have to be worked in the short term, and the safeguarding could extend to mineral deposits of lower grade than currently worked, if appropriate. Mineral companies would be expected to take a more proactive role in acquiring property in sensitive locations, and perhaps reselling it on short or medium term leases as appropriate.

4.165 There would be many parallels between areas designated for their environmental qualities and 'industrial minerals areas'. The presumption of protection of the designated area for the purpose identified would not be absolute, but would recognise that in special circumstances another interest might take priority. As with the existing policies which set out the criteria which have to be met before mineral working can be justified in National Parks or in European wildlife sites, for instance, so there would be stiff criteria in 'industrial minerals areas' which would have to be satisfied before other interests were held to be more important than protecting the mineral.

4.166 The very considerable advantages of 'industrial minerals areas' would not appear overnight but would have to be planned. Difficult decisions would have to be taken as there are many competing interests. For the most part 'industrial minerals areas' would extend across the known resource, moderated by settlements and other highly selected overriding constraints. In the case of National Parks and other constraints, decisions would have to be taken essentially in favour of either mineral working or environmental protection principally on the basis of which of the resources was most readily replaceable. However, by prioritising development within particular parts of 'industrial minerals areas', the aim would be for the most difficult decisions to be put off as long as possible. Under the proposed system, working ball clay in the Arne peninsula near Wareham in Dorset would clearly be one of the last resorts, not one of the first, in view of the international wildlife designations affecting the area. Similar fundamental decisions will be needed, for vein minerals, which arise almost exclusively in workable quantities in the Peak District National Park. Whilst it is not for us to offer policy judgements on such issues, the framework for reaching decisions has broadly been supplied by the pre-existing environmental criteria for mineral working in National Parks, AONBs and International Wildlife Designations and by the economic criteria identified above. The weight to give to each of those factors is a political decision rather than a matter for research.

Best use of the resource: avoiding inappropriate end uses

Sustainability principles

4.167 There is a widely recognised desire to keep high quality minerals for those end uses which require their special properties. National policy sets out sustainable objectives for mineral planning which include "to encourage efficient use of materials, including appropriate use of high quality materials" (MPG 1, para. 35). National policy on silica sand states "high grade materials..., wherever possible, should be reserved for industrial end uses which require such sand and for which there is no readily available alternative. It is in the national interest that such high grade sand should not be wasted and that its use in the construction industry should be minimised" (MPG 15, para. 31). Also, paragraph 30 states "high grade silica sands should as far as possible be conserved for use where they are required".

4.168 The central assumptions in this policy approach are that high quality minerals are scarce or difficult to replace and that there are low grade alternative uses to which they may be put. Using such minerals for less demanding applications increases the problem over time of finding new high quality mineral. As the pressure grows to work the remaining deposits, environmental constraints on development increasingly have to be compromised. There are therefore direct consequential environmental effects of allowing high quality mineral to be used for lower grade end uses. Defining 'high quality' is however, problematic. From the company's perspective, the best use of a mineral is that which makes the most money. In strictly economic terms, it is not the use to which a mineral is put, but the revenue arising from its production and use which defines the most desirable end use. Economic forces will in most cases support the principles of sustainable development, but this may not always be the case.

4.169 The assumption that higher quality equates with scarcity is broadly correct, though the relationship is complex and stronger for some minerals than others. High quality limestone is not a scarce resource in England. One complication is that the quality of some minerals is not exclusively a continuum from low to high and widespread to scarce. It is more differentiated, with different deposits each exhibiting a range of characteristics which are attractive for specific end uses. This particularly applies to silica sand, where different quarries supply glass-making sands for colourless glass containers, flat glass (windows) and television tubes, for example. Further quarries supply sands for water filtration and for making foundry moulds. Alongside this differentiation there are also some qualities that are clearly lower than others: sands for making coloured glass have more impurities (iron) than sands for making colourless glass, for example. High purity limestone for some end uses is widely available, but for uses requiring especially high chemical purity or specific qualities only one or two quarries may be suitable: the relevance of reserving 'high quality' minerals for 'high grade' end uses can therefore vary and will depend on very specific and local circumstances.

4.170 There has been particular concern about the use of high purity limestone and silica sand for aggregate, although this is partly a function of the large resources of high quality limestone in England. Although the highest qualities of silica sand are generally unsuitable for aggregate use (a function of grain size distribution), lower quality silica sands (such as some of those used in the manufacture of coloured glass) may be equally suitable for aggregate use.

4.171 The other industrial mineral which has been of interest for its potential use in a low grade end use is fuller's earth. Fuller's earth not only has high quality uses such as in bonding foundry sand and papermaking, but has in the past been used for pet litter. In recent years, producers have been keen to distance themselves from using extremely scarce deposits of fuller's earth for this purpose. The Secretary of State has also stated that it is not necessary to meet UK demand for this end use from UK sources. In his decision on a fuller's earth proposal at Waterhouse Farm, Bletchingley, Surrey in 1989 he stated in the same paragraph of his decision letter that wherever practicable, scarce resources of high grade mineral should be reserved for the most appropriate use.

4.172 There is clear evidence of high quality mineral being used for low grade purposes. Large permissions were granted in the Yorkshire Dales National Park for limestone quarries to serve primarily the steel and chemical industries, but almost all this mineral is now used for aggregates. After two public inquiries , a decision was made in 1987 to extend Coolscar Quarry in Wharfedale. Permission was granted because of the need to serve the seawater magnesia plant at Hartlepool, but no end use condition was imposed. However, the mineral company subsequently lost the contract and the mineral was sold as aggregate until the site's closure. That the customer found an alternative supplier within the Park gives cause for concern on the adequacy of the analysis of the need for the Coolscar extension. More significantly in planning terms the case illustrates how easily the best of intentions can be set aside for pragmatic reasons.

4.173 The loss of a market for a quarry's high grade product is typically the event which triggers concern about end use control, as the cases above illustrate. This has occurred on many other occasions too, as the following examples illustrate.

- When the Shoreham cement works in West Sussex closed, the absence of an end use restriction on Upper Beeding chalk quarry, which served it, meant that the chalk quarry could continue in operation serving other markets. This was despite the environmental objections to working the quarry, which would not normally have been justified by end uses such as construction and agriculture.
- In contrast, when Weardale cement works closed in 2002 this triggered the closure too of Eastgate Quarry serving it. This was because a condition had been placed by Durham County Council on an extension to Eastgate Quarry in 2000 which tied the output exclusively to use in the adjoining cement works.
- In Kent, the closure of Ryarsh Brickworks threatened Nepicar Sand Quarry, whose output was tied to the brickworks. In 1999 the MPA permitted alternative silica sand end uses to be served by the quarry.
- In Cheshire, permission was given for the working silica sand at Newplatt Wood for making coloured glass containers, but when the contract was lost the mineral was used in brickmaking.

4.174 Quarries capable of supplying high quality minerals are normally expected to supply specialist purposes because of the economic incentive to sell premium products at premium prices. In theory, lower grade uses of such mineral should therefore be infrequent. Allowance should also be made for the likelihood of any quarry producing material with a range of qualities. Often lower quality material may necessarily be excavated in the act of reaching higher quality material, whether as a function of the geology of the site or of the excavation and processing method. As a result, only a proportion of the output of a site may be suited to high grade end uses. The principle of sustainable development would argue for each grade of mineral produced being used for the highest grade purpose to which it is suited. Selling a proportion of an industrial mineral site's output as aggregate may well be consistent with the sustainable use of the resource.

4.175 In applying the principle of sustainable development, an MPA will wish to be assured that an unduly large proportion of mineral from an industrial mineral site is not in reality being sold into low grade markets. Aggregates too can be a profitable market. There are particular complications in the vein minerals industry, where deep, narrow veins within a limestone host rock may encourage mineral companies to work the adjacent limestone to gain safe access to deeper vein minerals, but just as possibly for the valuable aggregate by-product. There have been concerns that aggregates sales may become the principal driver for some of these operations.

Current practice

4.176 Many development plans contain policies or text emphasising a generalised statement of intent to reserve high quality minerals for high grade end uses (e.g. in Bedfordshire, Durham, Essex, Norfolk, North Yorkshire and Sefton). As might be expected, it is policies for the supply of silica sand and carbonates in which these statements feature most frequently. Those MPAs which have policies to control end use generally express them in terms of the issues which will determine the grant of permission. For example:

- "An application for the winning and working of minerals will not be permitted where it would involve the use of high quality minerals for low grade purposes" (Cheshire Replacement MLP 1999 Policy 5): the supporting text adds that "the County Council will require applicants to indicate the likely markets by proportion of the deposit" (para. 2.17);
- "Proposals for high quality limestone will only be permitted where there is a demonstrable national or regional need and it will be used primarily for non aggregate uses or where significant benefits would accrue to local communities or the environment", (Cumbria MWLP 1996-2006 (2000) Policy 36);
- "Proposals to extract 'industrial' limestone will not be permitted unless: (1) they are required to meet a proven need for materials with particular specifications which would otherwise be met, and the development is designed to maximise the recovery of the particular materials required to supply the need...", (Derby and Derbyshire MLP 2000, Policy MP25);
- "Extraction of limestone of a high chemical purity will not normally be permitted, except where the limestone produced is intended primarily for purposes for which high chemical purity limestone is essential" (Peak District National Park Structure Plan 1994, Policy M6);
- "the appropriate us of high quality minerals" will be encouraged where practicable (Staffordshire and Stoke-on-Trent Structure Planning 1996-2011 Policy MW3): the supporting text indicates that "nationally important reserves of silica sand will not be allocated in order to meet a shortfall in the landbank for sand and gravel" (para. 12.12);

- new permissions for silica sand working are likely in prospect areas "where the authority are satisfied that the primary purpose of extraction is to obtain specialist sand for industrial applications requiring particular physical/chemical characteristics" (Surrey MLP 1993 Policy 14).

4.177 Development plan commentary on how these policies will be implemented after permission has been granted is distinctly weaker. Surrey County Council indicates that in order to discourage inappropriate end uses "the Authority will seek to limit the extent of areas consented for working whilst having regard to the need of the industry for adequate reserves" (MLP 1993 para. 4.96). Cheshire County Council suggests retribution rather than prevention for misuse of resources: "The County Council will continue to monitor production and markets and the information will be assessed regularly and where appropriate will be considered in the determination of future applications" (MLP 1999 para. 2.17). This is comparable to the Government's policy which encourages a company's restoration record to be taken into account when considering subsequent mineral planning applications: see MPG 6 para. 89. Bedfordshire County Council sets out the difficulties it feels it faces "It is considered that these high grade industrial sands should only be used for the most appropriate high grade end use rather than for aggregate purposes, although it is recognised that this would be impossible to monitor and enforce" (MWLP 1996, para. 2.1.12).

4.178 The study of development plans was supplemented by a questionnaire to MPAs. MPAs were asked whether they planned for industrial minerals in any particular way according to the local, regional or national importance of operations in their areas, or if they monitored mineral conservation in the way industrial minerals were developed and used. Most MPAs took no action on end use issues at all. Those few who did express some concern argued either that there was no effective regulatory mechanism available to them or that regulations would be difficult to implement. This confirms the significant division between the effort which MPAs put into limiting grants of permission for working high grade mineral to sites where it will be used for high grade end uses, and the dearth of practical enforcement. The policies on end use constraint in development plans are therefore to some extent aspirational rather than working tools for mineral planning.

4.179 A number of sites have been identified where the MPA had effected control over the end uses of the minerals quarried. In particular, a legal agreement at Ballidon Quarry in the Peak District National Park requires 40% of the output to be used for non-aggregates purposes. Ballidon Quarry provides limestone primarily for industrial use in fillers and powders. At Shapfell in Cumbria, the MPA imposed a condition on the planning permission in 1993 requiring at least 80% of the quarry's output to "be used in the manufacture of lime and limestone products at the Shapfell works for use in the manufacture of steel". The use of a condition overcomes the possibility of a mineral company refusing to enter into a legal agreement. The output of the limestone quarry serving Hope Cement Works in the Peak District National Park is similarly tied to use in the cement works by condition.

4.180 Taken together, the experiences of MPAs offer mixed messages. Against a background of a widespread interest in constraining the use of high grade minerals to high quality end uses, most effort is focused on giving planning permissions only for sites when this objective appears to be met. For the most part little is done to monitor whether the mineral is, in fact, used for the intended purposes, and there is often a marked reticence to try to enforce the principle. On the other hand, a small number of authorities had specifically tried to tie down the outputs of individual sites to specific kinds of use or even specific customers. Some had used legal agreements, but others had simply imposed conditions. These acts of intervention suggest that a stronger regulatory opportunity is available to MPAs if they wished to use it.

Commentary

4.181 Current practice at the local level is unsatisfactory. There is a willingness on the part of MPAs to apply the principle of sustainable development that high quality minerals should be use for high grade end uses, and a number of them specifically asked for Government policy in support of this. The principle is broadly supported by the industrial minerals industries too, but is not matched by effective action in most authorities. Although this is broadly supported by the industrial minerals industry, it is not matched by effective action in most authorities. There is interest in requiring applicants to show that mineral will be used for a special end use before planning permission is granted (especially in sensitive locations), but little action is taken after permission has been granted. Many MPAs seem unclear whether the powers are available to them to impose end use conditions, and whether these would be enforceable in any event. This matter has been reviewed elsewhere[9].

4.182 There are a number of key points which demonstrate that sufficient powers are already available to MPAs. The first is that the Government itself imposes end use conditions from time to time on planning permissions for industrial mineral workings where permission would not have been granted for supplying aggregates or other lower grade end uses. In particular in 1985 the Secretary of State permitted the working of high quality silica sand at Blubberhouses Quarry, North Yorkshire, with the condition that:

"except with the prior agreement of the Mineral Planning Authority no mineral or other materials except silica sand for the production of colourless glass, ceramics, chemicals, high grade fillers and miscellaneous uses requiring similar specifications shall be extracted, produced or transported from the site" (ref. M/5069/42/6).

4.183 End use control already exists in one specific area of planning law, again confirming that the principle is sound. There is a special concession to allow mineral working on farms for their own agricultural use without the need to obtain planning permission. The *General Permitted Development Order 1995*, Schedule 2, Part 6C allows as 'permitted development' "The winning and working on land held or occupied with land used for the purposes of agriculture of any minerals reasonably necessary for agricultural purposes [i.e. an end use] within the agricultural unit [i.e. confined to a location] of which it forms a part."

4.184 MPAs were unforthcoming about the reasons for their belief that applying end use controls might be difficult, but one concern is known to be the problem of exercising control over minerals once they have left the mineral site. There is a normal expectation that conditions cannot control activities outside the area for which permission has been granted. The end use conditions above suggest that conditions can be worded to overcome this problem, but, even if that were to be shown to be wrong in law, there are alternative solutions.

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9 See: Green Balance, 1993, *Natural Assets: mineral working in National Parks*, Council for National Parks, pps. 134–140, and Bate, R., 1998, Controls over mineral end uses: a contribution to sustainability, in 'Mineral Planning in a European Context', eds. B. van der Moolen, A. Richardson and H Voogd, pps. 229–238.

4.185 The second argument for the sufficiency of existing powers is that planning authorities, and not least mineral planning authorities controlling quarries, are well used to making arrangements to tackle off-site problems which need to be resolved before a development can proceed (e.g. site accesses and road improvements). The established principle is that permission cannot be granted until a means has been found of resolving the problem. There may need to be a legal agreement between the applicant and the authority to address these. In effect, although it is not lawful to impose a condition requiring a legal agreement to be signed, no permission will be forthcoming without one if there is no other means of resolving the difficulty. It is clear from the examples above that some MPAs have found this a preferable route to take to regulate end uses.

4.186 The remaining key issue is whether end use controls are enforceable in practice. The principal controls must be supplemented by regulations to monitor sales. Details are required of quantities, mineral grades and customers/end uses. Weighbridge and other sales records would have to be made available. Conditions can be imposed on permissions requiring the provision of this information. Enforcement of the controls should be made as easy as possible by careful drafting of the monitoring arrangements, so that any failure on the part of the mineral company is identified rapidly and corrective action taken (or convincing explanation provided). Detection may be difficult in the worst cases, but it will never be impossible. Enforcement staff could, technically, follow lorries to their customers. In the same way as hours of operation are technically controllable by having enforcement staff on site morning and night, but are enforced in practice by occasional visits and by responding to complaints from residents, so with end use controls workable solutions can readily be found.

4.187 It can be concluded that there is at present no legal or practical impediment to MPAs exercising end use controls by the straightforward imposition of conditions. However, in view of the uncertainty which has dogged this issue for many years, it is recommended that the Government clarifies this in policy. In the unlikely event of any legal impediment being identified, it is recommended that the Government takes the necessary steps to overcome it. It is unacceptable to continue with an arrangement in which all responsible parties agree that high quality minerals should be reserved for high grade purposes but many regulatory authorities are reluctant to give this proper effect.

4.188 The findings of this research reinforce the case for end use control of minerals previously advanced in the Report of the National Parks Review Panel *Fit for the Future* under the chairmanship of Professor Ron Edwards in 1991. The Report recommended "To conserve the special mineral resource and to minimise working, we consider that minerals planning authorities (which are the national park authorities in national parks) should be able to impose conditions to specify the range of uses to which the mineral is put, so preventing the sale of low-grade material beyond that produced in immediate association with the special product, and should be given the information necessary to ensure that the conditions are kept. We are concerned to ensure that high-grade mineral (the reason for the permission in the first place) is not used for a variety of purposes requiring only low-grade material that could be obtained elsewhere" (page 79).

4.189 In view of the evidence and analysis presented here, this research report recommends that broad end-use controls should be formally established in mineral planning. However, the minerals industry take the view that end-use controls are unnecessary and inappropriate. The industry representatives on the project Steering Group have asked us to add the following text. "Although end use controls may only be used where necessary or exceptionally, the circumstances where this would be appropriate are considered to be very limited and should not be used in normal circumstances. The examples of such controls or where they might apply are relatively few, applying to specific examples in areas of national constraint and particular need and they may not in those cases even have resulted in any real change in outcome. There is no evidence that the market generally fails to ensure that minerals are used for purposes that they are best suited, since the normal economics of relatively scarce supply and demand for industrial minerals ensures this is the case. The planning system does not intervene to such a degree in any other area and to contemplate such market intervention would place an additional burden on authorities and producers which in the main cannot be justified by the vast majority of normal practice and operation."

Best use of the resource: better use of poorer quality minerals

4.190 Some MPAs are alert to the scope for trying to make the best use of lower quality industrial minerals, firstly as a means of conserving the higher quality resources and secondly to widen supply options which may reduce pressure to work areas where there are significant conflicts of interest. The main options are to encourage additional mineral processing either by the mineral company to upgrade the mineral or by the consumer to find a way of using lower quality products. A few examples of each have been reported.

4.191 Efforts by a mineral company to make use of lower quality sands was a consideration in the grant of permission in 1996 for an extension to silica sand operations at Martells Quarry, Ardleigh, Essex. An earlier application had been refused in 1995 partly on need grounds, but an otherwise very similar application in 1996 proposed to make more use of the sand for silica sand products. The proportion of the output to be used for silica sand was increased to 54% by this means, with correspondingly less being used for aggregates.

4.192 The Cumbria Minerals and Waste Local Plan 1996–2006 (2000) identified that permitted reserves at Shapfell Quarry were expected to last only 8–10 years (from 1996). However, an extension here was not possible due to geological and environmental constraints. The plan reports that British Steel (as it then was) was considering a number of options, amongst them the feasibility of altering its lime quality parameters to enable lower purity limestone to be used (para. 5.12.5).

4.193 Processing industrial minerals either to improve their grade (useful mineral content) or quality (properties) is established practice in the industry. The extent that this is feasible depends on the individual mineral. In the case of silica sand, for example, a hot acid leach can be used to remove iron to enable some sands to be sold for making colourless glass. There are, however, technical and economic limitations on the amount of processing that can be carried out. Processing cannot be used to lower the iron content of industrial carbonates but is used to ensure that a product with a uniform iron content is produced. That iron content depends on the inherent quality of the deposit worked. In contrast, although lowering the iron content of some sands may be technically feasible, the cost would be prohibitively expensive. The silica sand operation at Blubberhouses in North Yorkshire is currently mothballed, due to the difficulties and cost of processing the sand to marketable form.

4.194 Economic responses of this kind illustrate that the relation between geology and the market for industrial minerals is not fixed but influenced by price. That there may be scope to reduce the demand for high grade industrial minerals by better use of raw materials or by changing production processes argues for the creation of incentives for mineral companies and consumers to search out these opportunities more diligently.

4.195 From a mineral planning perspective, there is at present only modest scope for MPAs to drive forward the principle of sustainable development that lower grade deposits should be used where practicable and desirable. Furthermore, there are three complications which MPAs will need to take into account:

- the upgrading of lower quality minerals may in itself have or risk an adverse environmental impact, such as hot acid leaching of silica sand, so a decision will be needed on the balance of advantages in any individual case;
- more quarries may need to be open at any one time if each serves specific end uses than would be needed if a smaller number of higher quality sources supplied all the markets (including some lower quality ones): this can create a conflict of interest between resource management and local amenities;
- sites containing lower quality minerals can be just as constrained by other environmental interests as can sites containing higher quality minerals, perhaps more so. Each site must therefore be considered individually. However, the expectation is that, by creating a wider choice of potentially suitable sites (with lower quality minerals), that acceptable sites for working will more readily be found.

4.196 Planning guidance is required on industrial minerals inviting MPAs to have regard to the attention given by applicants for mineral planning permission to using lower quality deposits. This would encourage mineral companies and their customers to consider seriously and in each case the scope for making greater use of these minerals. The concept of a 'lower quality' deposit can be extended to those which underlie greater depths of overburden or which for other reasons entail greater working costs.

4.197 The use of lower quality resources is a complex issue and opportunities will depend on very specific and local circumstances. Guidance cannot be prescriptive, so the policy approach should encourage mineral companies and their customers to consider the scope for making greater use of lower quality resources.

4.198 As the economic aspects of using lower quality minerals are of prime importance in affecting how 'sustainably' they are used, consideration could be given to using financial incentives in support of planning policies.

Reducing the demand: reuse and recycling

4.199 The principle of mineral recycling is now well-established in the aggregates sector, and there is clearly potential for increased reuse and recycling of industrial minerals and the products derived from industrial minerals. The life cycle of an industrial mineral is complex. Although the properties for which industrial minerals are valued are often altered or irreversibly changed in use, some, such as silica sand used in foundry moulding sand, can be reused and recycled (see paras 2.25 to 2.30 and individual Mineral Planning Factsheets in Annex A).

4.200 More opportunity exists to reuse and recycle the products. Amongst these, a distinction should be drawn between those mineral products which can substitute for the original mineral product (e.g. a refilled glass bottle or a recycled glass jar) and those which substitute for a different mineral product (e.g. glass cullet being used as an aggregate in asphalt, rather than being used to make new glass products). Only the former group are relevant to this study.

4.201 The main opportunities for mineral product reuse and recycling lie with gypsum and silica sand. The principle use of gypsum is in making plasterboard. The technology and incentive for recycling of plasterboard scrap (and possibly demolition waste) is now at a point where substitution for raw materials is becoming practicable. There is a real opportunity for the mineral planning system to force the pace of recycling in this industry, just as it did for aggregates recycling. The only action being taken formally at present is through the East Sussex and Brighton & Hove MLP. This plan indicates that further permissions for the tipping of waste plasterboard will be unlikely. In Policy 29 the MPA discourages landfill "and would support the introduction of recycling processes or other appropriate means of dealing with this [plasterboard] waste at the site at the earliest opportunity". Perhaps surprisingly, no other MPA appears to have addressed this issue to date. However, the recent introduction of the EU Landfill Directive, which limits the amount of calcium sulphate that can be incorporated into landfill, will provide considerable incentive for more recycling of this material.

4.202 Considerable opportunities exist for the reuse and recycling of silica sand products. Government policy in MPG 15 establishes a responsibility for reuse and recycling to be pursued as an issue relevant to mineral planning by MPAs, mineral suppliers and their customers: "MPAs and the consuming industries should.... consider what steps they can take to encourage re-use/recycling where there are environmental benefits to be gained...." (para. 32, and see paras. 33–38); "The Government looks to the silica sand extracting and consuming industries to consider how they can increase re-use and recycling of silica sand and products made from silica sand, and how such efforts can be monitored" (para. 93).

4.203 The survey of MPAs suggested that authorities had taken no active role at all in response to this policy, although the container glass and flat glass industries had been more active in this area (see Silica Sand Factsheet Annex A).

Reducing the demand: substitution

4.204 Substituting alternative materials is a practical proposition for some of the industrial minerals, at least to some extent and for some end uses (see paragraphs 2.25–2.30 and individual Mineral Planning Factsheets in Annex A).

4.205 A number of plans refer explicitly to substitution. The Bournemouth, Dorset and Poole Structure Plan 2000 says: "it is important that the use of Dorset's mineral resources is managed so that they do not run out *before acceptable substitutes become available*. The sustainable approach is one where a supply of minerals is maintained but not at a level over and above society's real needs. A supply beyond these needs would inevitably lead to profligate and wasteful use of primary minerals" (para. 9.2) emphasis added.

4.206 Staffordshire and Stoke-on-Trent SP 1996–2011 Policy MW3 'The Efficient Use and Recycling of Minerals' provides a general statement: "The Mineral Planning Authority will encourage the efficient use of finite mineral resources and alternative materials, where practicable, by (a) the appropriate use of high quality minerals; (b) minimising the production of mineral waste; (c) the reuse and recycling minerals and their products; (d) the use of alternative lower quality or waste materials...."

4.207 Wiltshire and Swindon MLP 2001 mentions substitution of Portland cement by pulverised fuel ash (PFA) in paras. 6.4.1 and 6.4.7. MPG 10 also refers to PFA in para. 74:

"The cement industry can make a contribution to the objective of sustainable development. For example, through the use of pulverised fuel ash (PFA), a waste material produced by power stations. Although it has no hydraulic properties of its own it can be combined with Portland cement to produce a factory-made cement or added as a partial replacement for Portland cement at the concrete mixer. In addition there is potential, in a few cases, for PFA to replace clay as a raw material for cement production. Where the PFA contains a portion of unburnt carbon its use in the cement manufacturing process would help to conserve energy. The use of PFA will depend upon the quality and consistency of its chemical composition, the location of its source, and the cost and reliability of supply. Industry will continue to look for other such opportunities.

The cement industry can also use ground granulated blast-furnace slag, a by-production of iron production, in a similar manner to PFA as an additive to the cement or concrete mix. This material does have some inherent hydraulic properties and can be used at higher replacement levels than PFA.."

4.208 The British Cement Association has been actively facilitating a sustainable development strategy for the cement, concrete and concrete construction sector. The study team's Interim Report in February 2003 sets out progress being made throughout the lifecycle of cement and commits the industry to further action. (See Mineral Planning Factsheet on Cement).

4.209 There is remarkably little on desulphogypsum around the plans. East Sussex and Brighton & Hove Structure Plan 1999 Policy MIN12(c) states: "the import of desulphogypsum by rail for processing at Robertsbridge Works will be supported where the need is demonstrated." Rail-imported desulphogypsum "may continue to be a feature of the industry locally in the future" (para. 12.33). East Sussex and Brighton & Hove MLP 1999 notes that these imports were permitted in 1994 but reflects the industry view that desulphogypsum will not have a major impact on the mining of gypsum in the longer term (para. 6.6). This is because the locally mined gypsum is used in cement manufacture.

THE SCOPE OF POLICY INTERVENTION

4.210 This review section considers what Government policy may be needed to assist MPAs in planning for industrial minerals and the form this might take. The existing situation is one of very limited guidance for most industrial minerals but more detailed consideration of cement-making materials and silica sand.

Continuity of supply

4.211 A key aim of policy should be clarity about continuity of supply. There will be more certainty for everyone if the Government can decide in principle the degree of commitment to domestic production of each mineral. This commitment of course varies between minerals at present and can be expected to do so in future; for example, England is a major net exporter of kaolin, ball clay and potash (despite imports). It is also a net importer of cement, gypsum and fluorspar. For the other industrial minerals trade is broadly in balance or is modest in comparison to total output.

4.212 Policy cannot be unduly prescriptive in this arena. Domestic extraction will be influenced by the level of demand for a mineral and by the relative cost of domestic and other sources of supply and by resource availability. The best that the planning system can do is ensure that planning permissions will be forthcoming sufficient to meet the anticipated level of supply consistent with demand.

4.213 Policies in MPGs 10 and 15 press MPAs to allow the long term continuation of the existing broad pattern of supply (for cement-making materials and silica sand) had been highly effective. The requirement for maintaining site-based landbanks, subject to exceptional constraints, had worked well. In both cases MPAs' policies have adopted this approach as a means of sustaining domestic supplies for domestic end users.

4.214 Although some of these two groups of minerals were traded internationally, most was produced and consumed domestically. However, in the case of cement-making materials, the policy objective of competing effectively with imports, as a means of sustaining industrial activity within England, was much more clearly stated as an objective in its own right. As early as paragraph 3, MPG 10 states: "The Government places great importance on reducing the level of imports of building and construction material, and wishes to encourage domestic production to counter the rising import trend and to provide employment.... The Government therefore looks to mineral planning authorities to make provision for adequate supplies of raw material for the industry as it endeavours to meet future domestic demand". This is a theme throughout the MPG: for example, paragraph 63 states that "the Government takes the view that it is in the national interest to maintain and increase cement production, and to increase the scope for competition." However, MPG 10 was published in 1991 and a great deal of policy has changed since then.

4.215 By making available land with planning permission for cement-making materials, the planning system has made the contribution requested of it, including major extensions to quarries, supporting major new investment at some sites, and providing a major new greenfield site to replace the large but ageing Northfleet works in Kent. Despite this, the original objective of keeping out imports has not been achieved: imports have continued and account for about 10% of the UK market. Many cement works in England have closed since MPG 10 was published: Masons, Plymstock, Southam, Chinnor, Rochester and Weardale. The new permission at Snodland, Kent has not yet been implemented. The industry is clearly concentrating its operations onto a smaller number of sites. However, the loss of so many cement works in the South East especially (together with Shoreham and Pitstone cement works shortly prior to MPG 10) has to be seen in the context of a more international pattern of supply, in which multinational companies such as Lafarge take strategic decisions about how to serve particular markets. With import terminals available in the South East, there can be no certainty that the market will take up the opportunities for domestic production of cement-making materials for which the planning system has provided.

4.216 The experience of the cement industry suggests that little purpose is served by the Government using planning policy to try to drive wider economic aims: planning can offer only a modest contribution to such objectives, not take a determining role. Under currently expressed economic policies, the objective of resisting imports would not be a policy intention in any event. It is concluded that planning for continuity of supply can be a sensible objective for certain minerals through the planning system, though the Government should be cautious about attaching to this wider economic aspirations.

Other policy issues

4.217 The research indicated that some interested sectors desired policy guidance from central Government on other issues than continuity of supply. Some consultees amongst both MPAs and industry asked for clearer advice on the weight to be given to issues under the general heading of the 'need' for particular minerals. The approach set out in paragraphs 4.81–4.101 above suggests a systematic approach to identifying the economic issues in any particular case. However, this does not comment on how much weight should be given to each of the topics raised — either individually or compared with the weight which should be given to other relevant planning issues such as environmental impacts. There can be no mechanistic answer to this kind of question, and no two cases will be the same, but any additional clarity which the Government could bring to the dilemmas which MPAs face, through planning policy, would be appreciated by users of the planning system.

4.218 Husbanding the nation's resources of scarce and high quality minerals was a further matter on which both some MPAs and some industries wanted clearer policy intervention, or at least practical advice, from the Government. The desirability of policy was mentioned variously on improved safeguarding of mineral deposits, long term planning, end use control, better appreciation of the limited supplies of some minerals, and how the 'plan monitor and manage' approach developed originally for housing policy might usefully be applied to industrial minerals. Recommendations elsewhere in this report broadly address these concerns.

5 Key Conclusions and Recommendations

CONCLUSIONS

5.1 The recurring and central concern expressed by the industrial minerals sector is the need for assurance of a continuity of supply. This is the key to sustaining the UK industries which depend on these minerals as essential raw materials and from which wealth flows. Consequently, MPAs need to pay more attention to the downstream economic consequences of decisions on planning applications for industrial minerals. Chapter 3 'The Economic Importance of Industrial Minerals' and the Mineral Planning Factsheets in this report will be a useful starting point in this process. The report by BGS on *the Economic importance of minerals to the UK'*[10] will also provide a valuable overview of the issues involved.

5.2 In a related way, there is concern about the increase in the number and extent of landscape, nature conservation and other designations, and the impact these may have on future supply options. This is particularly the case for minerals that are scarce and geographically restricted. However, it should be recognised by MPAs, industry and the public that there is no absolute prohibition on mineral working in these areas.

5.3 At the same time the messages about the environmental impacts of working industrial minerals are also clear, (though their intensity varies between minerals and from place to place). Here the requirement is for clarification of the circumstances when environmental constraints (which would be sufficient to deny the working of more ubiquitous minerals) might be overridden by the economic importance of a specific industrial mineral. In the absence of such advice, MPAs follow normal planning practice in resisting mineral development which would unduly damage protected areas and recognised environmental interests. Proposals for working industrial minerals in National Parks raise the most profound conflicts of interest. As well as concern about the impact of working in protected areas designated for a variety of purposes, there is substantial concern about the damaging impacts of large scale transport of mineral by road.

5.4 Many representatives from industry and local government have suggested that the solution is 'more policy' from central Government to address these issues. We are not convinced that this will provide the easy answers that the parties would like. There is a need for more guidance on particular matters, set out below, but the more fundamental requirement is for more and better information to assist the planning process. In particular, MPAs need more information about the uses of industrial minerals, the particular requirements of the markets, and the economic importance of each mineral. Information on alternative sources of supply and

10 Highley D E, Chapman, G R and Bonel, K A. 2004. The economic importance of minerals to the UK. *British Geological Survey Commissioned Report*, CR/04/070N. 32pp.

the likely economic consequences of refusing particular schemes are also important.

RECOMMENDATIONS

Recommendation 1: Provide high quality, consistent and up-to-date information to assist the planning process.

5.5 The *Mineral Planning Factsheets* (Annex A) accompanying this report provide an overview of each mineral, including their economic importance and how they relate to downstream industries. We suggest that these (or a summary) could form the Technical Annex of any forthcoming *Mineral Policy Statements*. It is proposed that they be kept up-to-date, in terms of statistics and developments in the industry, so that they can provide a continuing source of reference for stakeholders. However, MPAs may require additional information on the economic importance of each mineral.

Recommendation 2: Improve guidance to Mineral Planning Authorities on the evaluation of the economic importance of industrial minerals

5.6 MPAs are already well experienced at addressing the environmental aspects of mineral working proposals, but they have received little advice on the way in which they should address economic issues. The most substantive existing guidance, in MPG 10 (on cement-making materials) and MPG 15 (on silica sand), is couched largely in terms of maintaining supply in support of domestic industrial users by continually replenishing landbanks of permitted reserves. Helpful though this is in meeting its objective, it does not demand any real appreciation of the economic interests of those industries. We welcome the Department of Trade and Industry's advice, as part of this research, on the aspects of industrial mineral planning, which matter most from a national economic viewpoint (See Annex C). These have been incorporated into our analysis and further refined to produce a 'checklist' for MPAs for assessing the economic case for individual planning proposals. The main headings of this checklist are summarised as follows;

- to what extent will the project benefit the local economy and employment in the area?
- will the development make use of existing infrastructure?
- to what extent will the project benefit downstream businesses regionally and /or nationally?
- how critical is the particular quality/ properties of the material being extracted?
- how important are these downstream industries to the wider UK economy (size, employment, competitiveness)?

5.7 If this is accepted by Government, the need for further planning policy advice on economic issues is modest and specific.

Recommendation 3: Develop policy on integrated long term planning.

5.8 The other main policy development required is in long term planning. The supply of industrial minerals in planning terms is not smooth but is characterised by periods of limited intervention followed by major applications when significant decisions have to be taken about where, how much or whether to extract minerals. This is as frustrating for local residents and local authorities as it is for the mineral companies and their customers. The planning system has been taking too reactive a role.

5.9 There is a need to establish a *modus operandi* which offers greater peace of mind for everyone, and positive planning for the benefit of both industries and the areas they affect. We consider this could be far better achieved by establishing in principle a commitment to sustain industrial minerals production (if required) in designated 'industrial minerals areas'. In designated areas, the principle of mineral working at some future date would be the priority issue when taking land use decisions in that area. Each industrial mineral benefiting from such a designation would be more assured of a continuity of supply than it is now, though there should not be an assumption that each industrial mineral must necessarily have its own designated area(s). From an environmental point of view, the purpose of the designation would be to prioritise local environmental benefit in return for recognising the commitment to future working. This would involve a commitment by the industrial minerals industries to long term planning, with investment in the movement of mineral by rail, waterway and pipeline rather than by road, so far as practicable. This would be justified by the investment in plant which itself could be guaranteed to be sustained with a supply of minerals. Likewise, to address foreseeable environmental and amenity concerns, there would be an expectation of forward planning for environmental mitigation and enhancement. This might involve the planting of screening woodlands (to mature before mineral needed to be worked) and the creation of new habitat adjacent to existing habitat in order to allow colonisation and the creation of a more robust wildlife network within the area prioritised for working. 'Industrial minerals areas' would therefore not be 'sacrifice areas' but land within which a positive commitment by the planning authority and industry to long term environmental land management could be given proper effect. Because of different geology and the problem of defining the limits of some resources, it is unlikely that this approach would be appropriate in all cases. However, the procedure has to some extent already been adopted for ball clay in South Devon and may be beneficial elsewhere.

Recommendation 4:-Broad end use controls should be formally established, where necessary, to ensure sustainable use of mineral resources

5.10 Current mineral planning guidance (MPG1) aims '…to encourage efficient use of materials, including appropriate use of high quality materials…' Economic forces will in many cases support this principle of sustainable development, but cannot always be relied upon to do so and there have been cases where industrial minerals have been used for less than best purposes. Many development plan policies encourage end use controls, and conditions on individual developments have in some cases been imposed, or legal agreements reached, which achieve this purpose. Operators need flexibility in order to respond to changes in the market. As such, formal end-use controls should only be imposed with care. However, there remains uncertainty in national policy on the steps which MPAs can take to apply the principle. Clarification is needed that end use controls may be imposed by condition. In the unlikely event of any legal impediment being identified, the Government is recommended to take the necessary steps to overcome it.

Recommendation 5: Mineral planning guidance should encourage, where practicable, the use of lower quality resources, both to conserve higher quality resources and widen supply options.

5.11 It is a principle of sustainable development that lower quality resources should be used where practicable. This is, first, to conserve higher quality resources for those applications which can be served by no other reasonable means. Second, this is intended to widen the supply options and may reduce the pressure to work areas where there are significant conflicts of interest. The research indicated cases where this has clearly been achieved, usually through blending and additional processing by producers, but also by the end-user adapting to a lower quality (and lower cost) material.

5.12 The use of lower quality resources is a complex issue and the opportunities for using lower quality resources will depend on very specific and local circumstances. Guidance cannot be prescriptive, so the policy approach should encourage mineral companies and their customers to consider actively the scope available to them to make greater use of lower quality resources. It is unlikely that this would create significant difficulties for industrial mineral producers, many of whom are already using resources appropriately. National policy should invite MPAs to have regard to this issue when considering planning applications for working industrial minerals.

Annex A Mineral Planning Factsheets

A.1 The purpose of these factsheets is to provide an overview of industrial minerals. The series describes economically-important industrial minerals, excluding aggregates, that are extracted in England and is primarily intended to inform the land-use planning process. The factsheets describe each mineral under a standard set of headings. These are:

- Demand
- Supply
- Trade
- Consumption
- Economic importance
- Structure of the industry
- Resources
- Reserves
- Relationship to environmental designations
- Extraction and processing
- By-products
- Alternatives/recycling
- Effects of economic instruments
- Planning issues

Annex B Minerals Planning Guidance Notes

MPG 1	1996	General Considerations and the Development Plan System
MPG 2	1998	Applications, Permissions and Conditions
MPG 3	1999	Coal Mining and Colliery Spoil Disposal
MPG 4	1997	Revocation, Modification, Discontinuance, Prohibition and Suspension Orders — Town and Country Planning (Compensation for Restrictions on Mineral Working and Mineral Waste Depositing) Regulations 1997
MPG 5	2000	Stability in Surface Mineral Workings and Tips
MPG 6	1994	Guidelines for Aggregates Provision in England [with partial 2003 revisions]
MPG 7	1996	The Reclamation of Mineral Workings
MPG 8	1991	Planning and Compensation Act 1991: Interim Development Order Permissions (IDOs) — Statutory Provisions and Procedures
MPG 9	1992	Planning and Compensation Act 1991: Interim Development Order Permissions (IDOs) — Conditions
MPG 10	1991	Provision of Raw Material for the Cement Industry
MPG 11	1993	The Control of Noise at Surface Mineral Workings
MPG 12	1994	Treatment of Disused Mine Openings and Availability of Information on Mined Ground
MPG 13	1995	Guidelines for Peat Provision in England including the place of alternative materials
MPG 14	1995	Environment Act 1995: Review of Mineral Planning Permissions
MPG 15	1996	Provision of Silica Sand in England

The following is an extract from the relevant paragraphs

'MPG 1 Annex B: General Advice for Individual Minerals

B.1 The following paragraphs provide advice and general information on the main minerals which mineral planning authorities (MPAs) may have to consider.

Non-agggregate Minerals

B.7 In preparing their development plans MPAs will wish to recognise the importance of maintaining a continuing supply of these materials (see below) and of the particular policy considerations that may arise in each case.

(i) *Construction minerals*

Slate

B.10 Slate is used for roofing, cladding and decorative materials and also for powders and granules for specialised applications, eg fillers, reconstituted slate tiles. Slate is quarried from geological formations which may be very restricted in occurrence.

B.11 Modern activity is often intermixed with structures and remains of activities from previous generations. The industry is concentrated in small areas and employment may be very significant locally. Requirements for traditional slate types or colours are common and they play an important role in the maintenance of local building character. Historically only roofing quality slate was worth processing for sale, and vast tips of waste slate were deposited. Today, producers aim to market as much slate and slate products as possible. Some producers sell slate wastes for use as bulkfill and in some cases construction aggregates, and in the production of slate powder and granules. The use for construction aggregates however, constitutes only a small proportion of annual arisings. Like dimension stone, working of slate may continue for very long periods.

Gypsum and Anhydrite

B.12 Gypsum is a naturally occurring form of hydrated calcium sulphate. It is an important raw material for the building industry, being used principally in the manufacture of plaster and plasterboard.

B.13 Anhydrite (the water-free form of calcium sulphate) occurs extensively in Britain, but there is only a small demand for the pure mineral for specialised uses. However a natural mixture of gypsum/anhydrite is used at the milling stage of cement manufacture to control the setting time, and for other specialised uses. It is an important mineral where high strength cements are required. Efforts should be made to safeguard mineral deposits which are, or may become, of economic importance against other types of development which would be a serious hindrance to their extraction.

Cement Minerals

B.15 The Government's policy on cement is set out in Minerals Planning Guidance Note 10 "Provision of Raw Material for the Cement Industry".

(ii) *Non-construction minerals*

B.16 Non-aggregate minerals, which are not used for construction purposes, include china clay, ball clay, potash, silica sand, salt, barytes, fluorspar, celestite, anhydrite, fireclay, dolomite and fuller's earth. These minerals are often in great demand but of limited occurrence and these factors have to be recognised in drawing up specific policies for their working in development plans.

China and Ball Clay

B.17 The UK is a leading world producer and exporter of china clay and ball clay and the industries make an important contribution to the national balance of payments. Both minerals have a very limited occurrence and it is important that adequate reserves are maintained for long term use. In each case the national importance of the mineral has been recognised by the establishment of China and Ball Clay Consultation Areas designed to ensure that clay bearing land is not unnecessarily sterilized by other forms of development (see Minerals Planning Guidance Note 2 "Applications, Permissions and Conditions"). Further advice on mineral consultation areas is at paragraphs 36–39 and paragraphs A1–A2 of Annex A.

B.18 The extraction of china clay results in a significant amount of waste - some 9 tonnes are produced for each tonne of clay — and most of the waste is deposited on land outside the confines of the pits. Some of the waste (mainly sand) is suitable for certain constructional purposes and Government policy is to encourage the maximum re-use of such waste. However major waste arisings will continue to be tipped and there are existing large areas of unrestored tips in the main china clay areas.

Silica Sand

B.19 The Government's policy on silica sand is set out in DOE Circular 24/85 "Guidelines for the Provision of Silica Sand" [subsequently replaced by MPG 15].

Metallliferous Minerals

B.22 Although the UK has to rely on imports of most of these minerals, either in unwrought metal or as concentrates, indigenous resources of metalliferous and other ores are not insignificant and the British Geological Survey (BGS) holds extensive information on areas with promising potential. MPAs should consult BGS, where necessary, and make provision in their development plan policies to safeguard such resources where they exist. As the extraction, processing and beneficiation of metalliferous minerals can cause environmental hazards and localised heavy metal pollution, MPAs should carefully balance the economic needs for these minerals against the environmental implications.

High Purity Limestone

B.23 Limestones can be categorised on their chemical purity in relation to the industrial uses to which they may be put. However it is neither practical nor desirable to categorise limestone resources for planning purposes on the basis of their chemistry to the degree of accuracy possible for defining industrial uses of limestone. (See the report *Appraisal of high-purity limestones in England and Wales: A Study of resources, needs, uses and demands*, DOE, 1991.)

B.24 For planning purposes, limestone resources with potential for use in high purity applications, a minimum calcium carbonate content of 97% is appropriate. However a single definition of high purity limestone should be used with caution as there are many different qualities of limestone, including physical properties and consistency, that need to be considered in determining what is fit for particular purposes. What is high purity to one user may be considered as ordinary grade by another user. In the excavation of high grade limestone, rock of all grades will necessarily be produced.

Fuller's Earth

B.26 Fuller's earth is an important industrial mineral consisting essentially of the clay mineral calcium smectite. Smectite clays possess a unique combination of physical-chemical properties suiting them to a wide range of industrial applications. Fuller's earth has a very restricted geological occurrence in Britain and it is extremely unlikely that economically workable fuller's earth deposits exist outside areas of known resources.'

Annex C Text of DTI Paper on Economic Importance of Industrial Minerals for Planning Applications

Economic Importance of Industrial Minerals for Planning Applications

C.1 The DTI strategy seeks to enhance the productivity and competitiveness of UK industry, including the industrial minerals sector, in order to maximise wealth creation and promote continuing sustainable economic development and investment, regionally and nationally. The concept of 'national need', which has historically been advanced to underpin local and national policy for industrial mineral extraction, is ambiguous and does not fit the current policy framework. There are no longer any national stockpiles of minerals, which, like other commodities, are mostly traded in a global marketplace. (In addition finished products from indigenous sources are traded internationally). However the UK has a demand for these materials that underpin broader manufacturing industry in the UK and elsewhere. Indeed in some cases user industries would be at a competitive disadvantage or disappear (i.e. relocate abroad) if they could not source these minerals locally in the UK. In addition while the deposits can be economically mined in the UK without subsidy, they create economic and social benefits for the local community in line with sustainable development practice. Therefore planning decisions should be based on careful consideration of the *'economic importance' of the proposed development, including inward investment decisions of consumer industries, in the context of HMG's sustainable development policy. Indeed the whole planning process should be as transparent as possible.*

C.2 Economic theory normally indicates that the firm (in this case the mineral extractor) is the best judge of the economic benefit of its activities. In mineral extraction, there is the complication that extraction may have an adverse environmental impact on a location. This is clearly of importance to MPAs. Just which environmental impact costs planners consider relevant and why, will vary depending on a variety of location factors. It is not unreasonable to expect the minerals extractor to implement measures to mitigate these impacts but the extent to which this responsibility should fall on the extractor will vary according to the location in which the extraction is to take place and the type of extraction that is taking place.

C.3 Applications should as a minimum include provision for an acceptable level of restoration of sites and other environmental obligations during site activity, closure and aftercare. This is in line with HMG and EU policy on producer responsibility. Therefore there should be a presumption in favour of granting planning consent for the extraction by the MPA in most cases unless relevant environmental impact cannot be mitigated satisfactorily. In such cases the MPAs should clearly indicate where and to what extent the mitigation falls short of being satisfactory. MPAs should then consider what other compensatory measures could be taken by the developer to ensure an appropriate acceptable sustainable development balance is achieved upon the granting of planning permission. In these exceptional cases, as well as addressing environmental measures further consideration should be given to the importance of the level of existing activity/investment on the site and associated sites; existing infrastructure (e.g. processing facilities); impact on the local economy; impact on the customer sectors in the UK (and abroad), in particular their investment decisions; future plans the extractor and local authorities have for the region and other stakeholder views.

C.4 A checklist for MPAs to make decisions on Industrial Minerals applications should involve: -

Wealth Creation

(i) Will the development make use of the existing extraction infrastructure, for example processing facilities?

(ii) To what extent will the project add value to the local economy relative to alternative employment opportunities? Will new jobs be created, or others safeguarded? Will business opportunities for local firms (e.g. supply of contract services) be generated that otherwise would not arise?

(iii) What is the impact on customer industry sectors in the UK and elsewhere e.g. how critical is the particular quality/properties of the materials being extracted, will it enable them to operate in the UK resulting in additional wealth creation opportunities for the UK.

Environmental Impact

(i) Is the development a sustainable use of national resources?

(ii) Can the impact on the local environment of the extraction operation be brought within acceptable levels i.e. dust creation, noise, water use, road movements etc?

(iii) Are the proposed restoration/aftercare proposals acceptable?

(iv) In relation to National Parks, an acceptable level for (ii) and (iii) is likely to be more critical than for other sites but should be agreed between the developers and approving authorities before the development takes place

C.5 As far as possible MPAs should protect unworked industrial mineral deposits against sterilisation by other forms of development except where there are overriding planning reasons for releasing this land for other purposes and the mineral cannot be worked prior to the alternative development taking place. Deposits, which are, or may become, of economic importance, should be safeguarded against other types of development by virtue of appropriate identification through planning policy.

C.6 The DTI recognises that in areas such as National Parks the MPAs may feel the environmental impact should take precedent over the wealth creation criteria. However in line with sustainable development practice an appropriate balance needs to be struck, and the DTI will work with all the relevant stakeholders to ensure this is achieved. To minimise the burden on business and indeed to ensure prudent use of public funds it would seem sensible that permission should be granted for extensions to existing workings either above or below ground provided the level of previously agreed acceptable environmental impact is not going to increase significantly. The MPAs should make their reasoning as transparent as possible e.g. by making explicit estimates of any environmental impacts which would not be covered by remediation or restoration work and being prepared to negotiate any additional environmental mitigation.

C.7 In addition, we like the idea of individual annexes for each industrial mineral as we believe that each industrial mineral has to a degree its own uniqueness and qualities. It may be that decisions on economic importance could be mineral specific and we would like to discuss this further when it is opportune.

DTI — Materials and Engineering Unit

14 November 2003

Office of the Deputy Prime Minister
Creating sustainable communities

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Ball clay

*The purpose of this factsheet is to provide an overview of the mineral **ball clay**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Ball clays are fine-grained, highly plastic sedimentary clays, which fire to a light or near white colour. They are used mainly in the manufacture of **ceramic whiteware** and are valued for their key properties of plasticity, which makes them easy to mould, their unfired strength and the fact that when fired they have a light colour. Normally sedimentary clays fire to a reddish colour. Some ball clays are also valued for their ability to readily disperse in water to produce fluid slips (high solids aqueous suspensions). Ball clays exhibit highly variable compositions and consist not of a single mineral but a mixture of mainly three minerals; kaolinite, mica and quartz, with each mineral contributing different properties to the clay. The clay mineral **kaolinite** is the key component. The crystallinity of the kaolinite, in terms of being well-ordered (less plastic and coarser) or disordered (highly plastic and fine grained) also has a marked influence on ceramic performance.

Demand

Ball clays are almost entirely used as ceramic raw materials. The principal types of ceramic whiteware that contain ball clay are:

- sanitaryware;
- wall and floor tiles, and
- tableware

These sectors of the ceramics industry account for over 80% of total sales. Other uses include refractories, kiln furniture, electrical porcelain, enamels and glazes, building bricks, fillers and sealants. Ball clay is rarely used alone, the proportion used varying depending on the product. Other constituents of ceramic whiteware are kaolin (china clay), silica sand and a flux. Ball clay can be a vital ingredient in a particular ceramic product even though it may account for only a small proportion of the total raw material used.

In a ceramic body, ball clay acts as a binding agent and contributes to plasticity, workability and strength in the pre-fired state. This allows the ceramic body to be formed and handled safely between the shaping and firing process, and also provides strength in the fired body. Some ball clays are particularly valued for their fluid and casting properties, which are important for slip casting, especially in the manufacture of sanitaryware.

Demand for UK ball clay over the last decade has been driven by exports and increasing sales into the sanitaryware and floor tile sectors. The latter is mainly due to a move away from red-bodied tiles to white-bodied tiles (unglazed porcelain stoneware tiles) that utilise light-firing and low carbon clays. Sales to other sectors have declined. Thus the most important market for UK ball clays, both in terms of volume and value is sanitaryware, which in 2000 accounted for some 40% of total UK sales. Clays used in this sector are the premium products of the ball clay industry and undergo more complex processing and consequently command a higher price. Clays used in the floor tile sector are facing increasing competition in European markets, particularly from the Ukraine. This has resulted in a decline in total export sales in the last two years.

Supply

High-quality ball clays, or 'plastic' clays, are relatively scarce globally because of the unusual

Extraction of ball clay at Petrockstow, Devon.

Ball clay

combination of geological factors required for their formation and subsequent preservation. Deposits elsewhere exhibit widely differing properties and they are not necessarily suitable for use in all applications.

Ball clay has a long history as an economic mineral in the UK. Production dates back at least to the early 17th century, but the mineral became important during the late 17th and early 18th centuries when Staffordshire potters, notably Josiah Wedgwood, recognised the attributes of ball clay for the manufacture of whiteware pottery. The ceramics industry has remained the major market for ball clay to the present day.

There are no authoritative figures for world production and trade in ball clay because of the difficulty of classifying these clays in a uniform and directly comparable way in terms of quality and use. However, the UK is a leading world producer and exporter of high-quality ball clays. UK ball clay sales have been on a rising trend for many years and reached a record 1.1 million tonnes in 2000 (Figure 1). Sales have, however, since declined to 0.885 million tonnes in 2003.

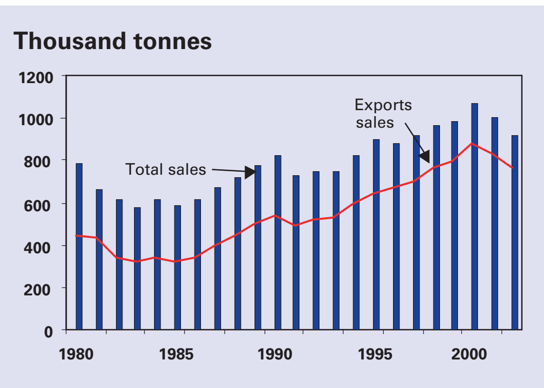

Figure 1. UK Total sales and exports of ball clay, 1980–2002. *Source: UK Minerals Yearbook, BGS.*

The occurrence of ball clay is confined to three relatively small areas, all in the South West Region of England; the Bovey and Petrockstowe basins in Devon and the Wareham Basin in Dorset (Figure 2). The Bovey Basin is the most important source, both in terms of total sales (72%) and, more importantly, the diversity of the clays that are produced. The Wareham and Petrockstowe basins contributed 17% and 11%, respectively in 2002. Of total production, therefore, over 80% is supplied from Devon.

The wide spectrum of clays available in the UK, some of which have unique properties, means that there will be a continuing demand for UK ball clay into the foreseeable future. However, with increasingly competitive markets, total sales may yet decline further before stabilising.

Trade

The UK is a leading exporter of ball clay, and particularly of sanitaryware clays. In contrast to domestic sales of ball clay, which have declined, export sales have steadily grown and were 763 000 tonnes, or 83% of total sales, in 2002. UK ball clays are exported to some 80 countries worldwide, although mostly to countries of the EU, with Spain and Italy being the most important. Exports are principally used in sanitaryware and tile manufacture. Over 50% of the world's production of vitreous china sanitaryware contains a proportion of UK ball clay as an essential ingredient. Imports of ball clay are negligible. Ball clay makes a small positive contribution to the UK balance of payments.

Consumption

The key domestic markets are sanitaryware, wall tiles, tableware and refractories. In contrast to exports domestic sales of ball clay have been declining for many years. Less that 20% of UK output is sold to UK customers. Domestic sales were down from 337 000 tonnes in 1980 to 158 000 tonnes in 2002. This partly reflects the increasing overseas competition that the UK whiteware industry has been facing, notably in the tiles and tableware sector. However, sales have also declined in other sectors.

Economic importance

The value of UK ball clay production in 2002 is estimated at to be about £44 million. Domestic

Ball clay

sales of ball clay help to underpin the UK whiteware ceramics industry. This industry had total sales of about £800 million in 2001 (Table 1) and employed some 20 000 people. These jobs are concentrated in Staffordshire, especially in Stoke-on-Trent.

Ceramic sanitaryware	£199 million
Ceramic household & ornamental ware	£515 million
Ceramic tiles & flags	£100 million

Table 1. UK Sales of selected ceramic products, 2001. *Source PRODCOM.*

A study on *the Economic importance of UK ball clay* (see Further information) concluded that without UK ball clay a number of UK (and EU) ceramic manufacturers would suffer a loss of competitiveness.

Structure of the industry

There are two producers of ball clay in the UK; WBB MINERALS Ltd and IMERYS Minerals Ltd. WBB is owned by SCR Sibelco of Belgium and IMERYS Minerals is a subsidiary of the IMERYS Group of France. Both companies, which are privately owned, have extensive overseas interests. WBB MINERALS is the largest UK producer of ball clay with operations in south and north Devon. It is also the largest producer in the world. IMERYS Minerals has operations in all three basins, in addition to overseas interests. Both WBB MINERALS and IMERYS Minerals are members of the trade association known as the Kaolin and Ball Clay Association (UK).

Resources

Ball clays have a limited distribution both in the UK and globally. Economic deposits of ball clay are confined to three Palaeogene basins in the South West Region of England (Figure 2). Here they occur as beds of variable thickness,

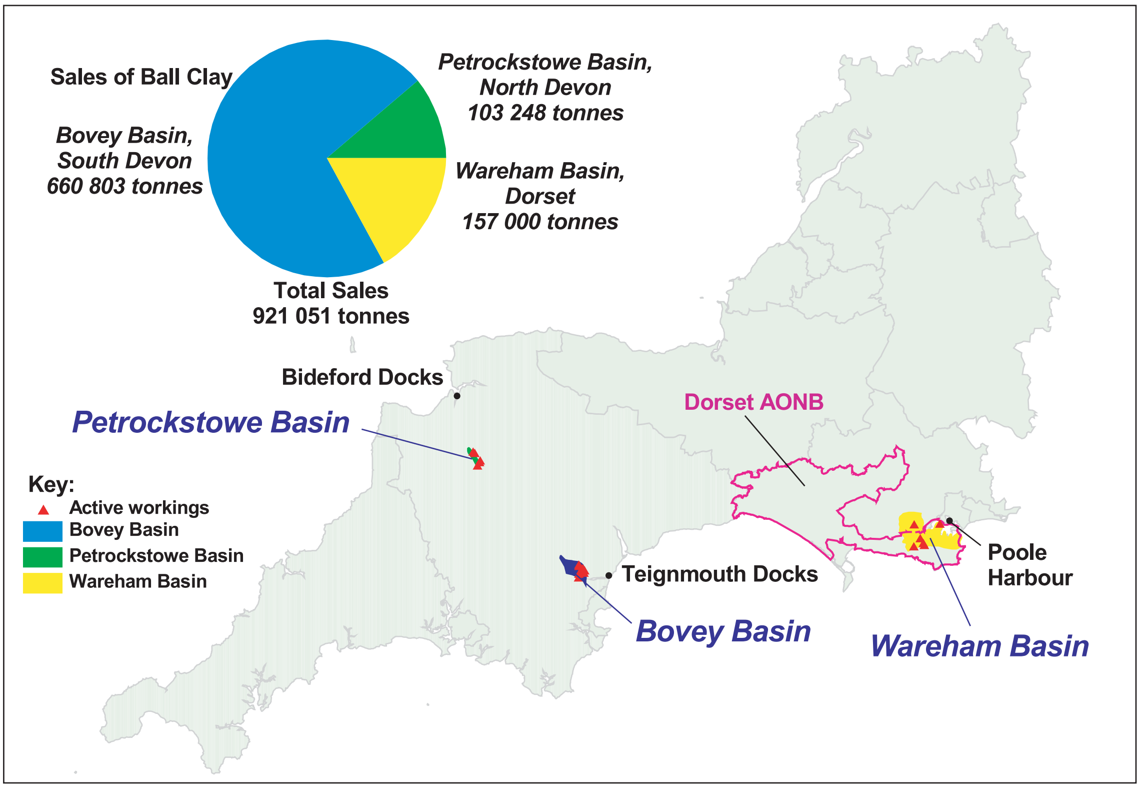

Figure 2 Ball clay-bearing basins in SW England.

interbedded with silt, sand, lignite and clays that have too high a carbon and iron content for economic use. Plastic clays with a similar age and character to those in Devon and Dorset occur in Northern Ireland. However, they exhibit high iron contents and no resources have been identified that would be acceptable to ceramic producers.

The wide variation in the mineral composition and particle size of ball clays, together with the crystallinity, or degree of order, of the kaolinite, results in differing ceramic and rheological (fluid) properties. This natural variability occurs both between and within seams, and from basin to basin. It is related to the origin of the clays and is caused mainly by differences in source rocks, the degree of weathering, and the environment in which the clays were deposited. The availability of such a wide range of clays, some of which are unique, is rare. The ball clay resources of Devon and Dorset are, therefore, of national and international importance.

Fired colour is a function of iron and titania (TiO_2) contents, whilst unfired strength and plasticity is largely related to fineness of particle size and the crystallographic ordering of kaolinite. Fine-grained, highly-disordered kaolinitic clays tend to have the highest plasticity and unfired strengths. In contrast the best fluid (fast casting) properties are associated with coarser, well-ordered kaolinites. These latter clays were probably derived from weathering profiles developed on the Dartmoor Granite and some resemble kaolin in character. The highly disordered kaolinites were more likely to have been derived from mudstones and slates.

Ball clays in the Bovey Basin contain both well-ordered and disordered kaolinite, which accounts for the diversity of their properties. They include the whitest-firing and most fluid UK ball clays, which is important for sanitaryware and tableware manufacture. Ball clays from north Devon include seams of high silica clay, which are coarser than those in south Devon and Dorset. They are mainly used in tiles but also sanitaryware blends.

Dorset clays are noted for their high plasticity and unfired strength, and also low carbon contents. They are particularly suited for tile manufacture and also in refractories and kiln furniture.

Basin	Permitted Reserves (Mt)	Years	Resources unpermitted (Mt)	Years
Bovey	63.1	114	16.7*	34
Petrockstowe	8.8	37	32**	135
Wareham	2.5	11	9.6	40
TOTAL	**74.4**		**58.2**	

* *Only resources in the east of the Basin. There is also potential in the central and western parts of the Basin.*
** *Permitted but not fully explored.*

Table 2 Estimated reserves and resources of UK ball clay in 2001. *Source Kaolin and Ball Clay Association.*

The availability of a wide range of clays is an essential feature of ball clay supply. It provides the industry with a greater degree of flexibility through blending to give the desired properties, and matching customer needs.

Reserves

Following the establishment of Ball Clay Consultation Areas in the 1940s and 1950s, in Devon and Dorset, and the granting of widespread permissions (especially in Devon), there are extensive reserves. The Consultation Areas are designed to ensure that clay-bearing land is not sterilised by other forms of development. Estimates of permitted reserves of ball clay for the three basins are shown in Table 2.

Overall there are large reserves of ball clay, particularly in Devon, although there is an imbalance between producers. The Bovey Basin has by far the largest permitted reserves and unpermitted resources of the three basins, together with the greatest diversity of clays. It will continue to be the major source of ball clay for the foreseeable future. However, the gross figures shown in Table 2 include a large range of ball clay qualities, with widely differing properties. With over 120 production clays being extracted from individual seams, or parts of seams, the figures mask possible limited reserves of individual clay qualities that are essential for specific blends and applications. Of particular importance are the clay qualities that form the basis of santitaryware blends.

A particular requirement of many ceramic manufacturers is the need to ensure long production runs, thereby enabling them to provide their customers with a regular and consistent product. This is of particular importance for tableware and sanitaryware. This requires the ball clay industry to be able to demonstrate the long-term adequacy of reserves of suitable grades of clay. This has implications in the need to maintain a series of operational areas, and faces in operating areas, and the need to provide, through the planning process, sufficient long-term security of supply of a range of clays.

Relationship to environmental designations

Both the Wareham Basin and the Bovey Basin contain numerous statutorily designated constraints that may restrict future opportunities for developing resources and for waste tipping. The situation in the Wareham Basin is particularly acute where the Dorset AONB covers a major part of the basin. The majority of the production grades of ball clay can only be found within the AONB. In addition, there is also a multiplicity of both international (SPA, SAC and Ramsar sites) and national (SSSI and NNR) nature-conservation designations. Of the total resources in Dorset shown in Table 2, some 65% are constrained by nature conservation and other designations. The habitats created after ball clay extraction, in many cases, provides alternative biodiversity benefits.

Extraction and processing

Ball clay is now worked entirely by open pit methods as underground mining in both the Bovey and Wareham basins ceased in 1999. Yields were low by this method of extraction, giving poor resource utilisation and there were

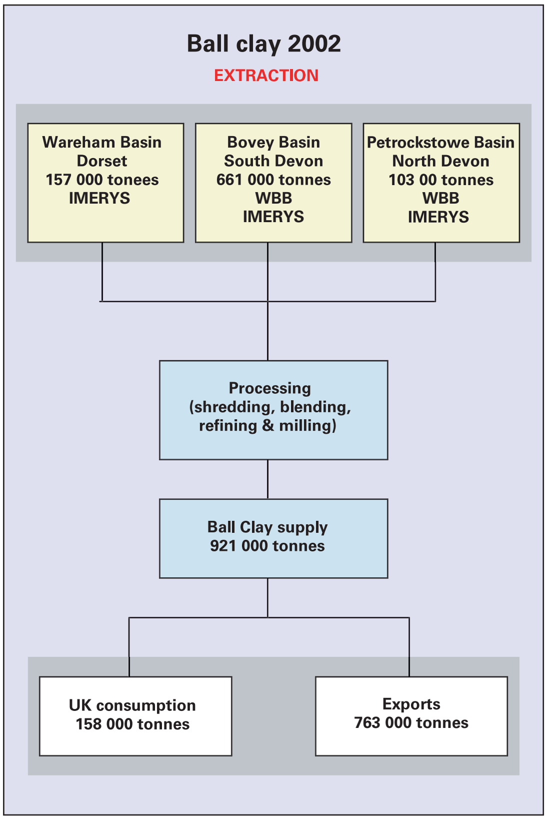

Figure 3 Ball clay supply chain, 2002.

also health and safety implications that made this method of extraction uneconomic. Open pit extraction involves hydraulic excavators and dump trucks to selectively dig, load and deliver individual production clays to storage and blending facilities. Overburden and interburden, comprising silt, sand, lignite and impure clay are removed and tipped for use in future restoration. The ratio of waste (overburden and interburden) to ball clay is very variable between basins and from quarry to quarry. In the Bovey Basin yields at the different quarries range from 20% to 80%. Large tips are required in places, which have implications for sterilising reserves, as continuous backfilling is not, in most cases, feasible. Overall clay to waste ratios for the industry are about 1 to 1.5.

Ball clays undergo only limited processing. Almost all ball clay is shredded and some 70%

is sold in this form. Shredding involves cutting the clay lumps into small pieces, which allows the clays to be more easily handled, blended and, most importantly, homogenised. The blending process is very important as it reduces the natural variability of the clays. It allows lower quality clays to be incorporated in blends, thus conserving higher quality clays and optimising the use of the resource at each pit. It also allows the production of consistent and new grades with reproducible characteristics. The process involves the production of no mineral waste.

The fine particle size of ball clays, together with the close association of the main constituent minerals, means that it is impractical to alter significantly their fundamental mineralogy or to reduce colouring oxides, notably iron. This is in sharp contrast to kaolin processing (see Factsheet on Kaolin). However, some ball clays with a high lignite and /or sand (quartz) contents are treated by a combination of dry and wet processing (refining), which removes some of the particulate lignite and coarse quartz. This process is used for the production of sanitaryware clays. Some ball clays are also dried and milled to fine powders for subsequent bagging.

Modern ceramic manufacturing technology, with the trend towards automation and fast-firing, has placed increasingly stringent demands on clay consistency. Raw materials with predictable and consistent ceramic properties are required and changes in composition, and thus ceramic behaviour, cannot be tolerated. Variations may result in production losses, which can have a major impact on the economics of downstream manufacturing operations. It also wastes energy. The properties of UK ball clays, together with the consistency and quality of blended products, are highly regarded globally.

By-products

Sand interburden to some of the ball clay seams in the Bovey Basin is being worked for secondary aggregates and industrial purposes. This is an efficient use of all minerals that is supported through local mineral plan policies. Similar operations have commenced in Dorset.

Small amounts of lignite (an organic material intermediate between peat and coal) are also sold for horticultural use.

Alternatives/recycling

Upgrading lower quality clays, particularly those contaminated with iron, is in general neither technically nor economically feasible. This is because of their very fine particle size. In addition, substitute materials for ball clay have not, as yet, proved viable. However, the use of chemical binders to provide plasticity in tableware compositions has been considered. Changing fashions in the design of floor tiles, for example to glazed tiles, may affect the demand for white-firing clays.

Although alternatives to ceramics, such as plastics, will continue to be used in some applications, ceramics have technical, hygienic and aesthetic advantages, which make it unlikely that they will be replaced.

Some recycling of ceramic waste is feasible.

Effects of economic instruments

Sales of secondary aggregates (sand) derived from ball clay extraction and processing are exempt from the Aggregates Levy, which was introduced at the rate of £1.60/t in April 2002. Sand sales are currently confined to the Bovey Basin and are about 100 000 t/y. There are no saleable processing wastes.

Transport issues

Blended ball clays are transported in bulk, although a substantial amount is bagged, either in one tonne or 25 kg bags. Ball clay to UK consumers is transported mainly by road, despite some plants being rail linked. Rail freight is generally uneconomic, although some ball clay is transported by rail from Heathfield in south Devon. However, the majority (>80%) of ball clay is exported. Clay is taken by road to local ports, principally Teignmouth, Bideford and Poole for shipment to ports in Europe. Ball clay is a significant proportion of the traffic through some of these ports. For destinations outside

Europe clay is transported in containers from the main container ports.

Planning issues

There is a continuing demand for a wide variety of consistent quality ball clay blends. Production of these blends generally requires that numerous working faces are kept open at the same time. This inhibits backfilling with waste from the extraction process, generates a need for tipping space, and delays restoration to alternative uses. These problems may be compounded as workings tend to concentrate and/or merge, resulting in operations that are larger, deeper and longer-lived. The availability of tipping space is a particular issue in the Bovey Basin.

There are extensive reserves in the eastern part of the Bovey Basin. In Dorset, however, remaining reserves are heavily constrained by environmental designations. Overall, the industry has adequate permitted reserves for the foreseeable future. However, a number of premium grade clays (mainly Grade 1 light type clays) are in short supply and will need new permissions. Future land for ball clay working appears to be adequately safeguarded from sterilisation by surface development, and both Dorset and (especially) Devon Mineral Planning Authorities are interested in reviewing the Consultation Area boundaries.

There are considerable environmental constraints on new sites for ball clay extraction. This is especially so in Dorset, where there are outstanding landscape (AONB) and international and national habitats constraints covering much of the Ball Clay Consultation Area. Dorset CC is encouraging a northward shift of the industry outside the AONB. However, ball clay resources in this area are generally of lower quality and do not provide the range of clays that can sustain the industry. Both Mineral Planning Authorities are keen to provide a sustainable approach and in particular:

- encourage the use of waste sand as secondary aggregate where environmentally acceptable;
- Dorset has a strong end use control policy, while Devon has a 'best use' objective and is also proposing an objective to ensure that all possible available grades of ball clay within existing planning permissions are fully utilised before new permissions are granted.

The greatest constraint on ball clay extraction, particularly in Dorset, is the extent of European nature conservation designations (Special Areas of Conservation and Special Protection Areas), which restrict and potentially sterilise large parts of the Wareham Basin.

Devon has applied an environmental capacity approach to its ball clay strategy, using the Environmental Capital approach supported by The Countryside Agency and others.

The time horizon for the future planning of ball clay is longer than statutory development plans. A non-statutory *Strategy for the Bovey Basin* has been developed to provide guidance for the extraction of ball clay and associated activities, both for the short term and longer term (i.e. 100 years). An overall strategy for the three basins would be desirable.

Further information

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Authorship and acknowledgements

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Mineral Planning Factsheet

Ball clay

'Review of Planning Issues Relevant to Some Non-Energy Minerals other than Aggregates, in England' (2004).

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 and Deborah Rayner.

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

Ball clay

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Mineral Planning Factsheet

Barytes

*The purpose of this factsheet is to provide an overview of the mineral **barytes**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Barytes (barium sulphate, $BaSO_4$), also referred to as barite or baryte, is the most abundant and economically important barium mineral produced in the UK and worldwide. **Witherite** (barium carbonate, $BaCO_3$) was mined commercially in England in the northern Pennines until 1969; worldwide deposits are rare.

Barytes, when pure, contains 58.8% barium and 41.2% sulphate and with a specific gravity (SG) of 4.5 it is often referred to as 'heavy spar.' Inclusions of other minerals may reduce (or in the case of metallics increase) the SG, but a high density, chemical inertness and widespread occurrence are the properties that are valued for barytes most important application as a weighting agent in drilling fluids. Colour and chemical purity are important properties when considering the suitability of barytes for non-drilling applications.

In England barytes is now only produced as a by-product of fluorspar mining and processing. The principal planning issues associated with barytes production are, therefore, identical to the more economically important mineral **fluorspar (CaF_2)**. The factsheet on **Fluorspar** should be consulted for more detailed information on these issues.

Demand

The most important use of barytes, accounting for about 85-90% of total world consumption is as a weighting agent to increase the density of drilling fluids, principally for oil and gas exploration. Finely ground barytes is added to the drilling fluid and its function is to confine high formation pressures due to oil, gas and water liberated by drilling and thus prevent 'blowouts'. The suitability of barytes for this purpose is based on a combination of properties, in addition to a high SG (minimum 4.2). These include low abrasiveness, chemical inertness, a non-magnetic character, and being clean and easy to handle and grind. Barytes is also cheap and readily available and although alternatives are available, some of which are used for specialised applications, barytes is the standard weighting agent used in drilling fluids throughout the world. Demand is essentially a function of oil and gas exploration activity. Most of the barytes produced and imported into the UK is finely ground for use in hydrocarbon exploration mainly on the UK Continental Shelf.

Non-drilling applications of barytes are comparatively small, although still important because of their higher value. High purity

Oil rig.

Barytes

grades of bartyes with fine and controlled particle sizes are used as fillers in marine and industrial paints, in brake lining/friction materials and in plastics. A specialised use of barytes based on its high density and ability to absorb radiation, is as an aggregate in dense concrete for shielding applications in the nuclear industry and hospital radiation departments.

Supply

Over 80% of total barytes production in the UK of some 57 000 tonnes in 2003 was derived from the Foss Mine, near Aberfeldy in Scotland. The output is mainly used in drilling fluids, although some is used as an aggregate for radiation shielding. Following the recent closure of two small open-pit barytes workings in the Northern Pennine Orefield, at Closehouse in Durham and Silverband in Cumbria, production in England is now confined to the Southern Pennine Orefield. The mineral is derived as a by-product of the processing of fluorspar ore at the Cavendish Mill, near Stoney Middleton in the Peak District National Park. Output is dependant on the barytes content of the fluorspar ore, which varies depending on the deposit being worked. Production was some 10 000 tones in 2003 most of which was sold locally for value-added processing by fine grinding (micronising) for filler applications in paints and plastics. Some was sold for use in oil well drilling fluids.

Trade

The UK has been a significant net importer of barytes for many years. Imports are mainly used in drilling fluids, although a proportion is also imported for fine grinding for filler applications. Imports have been in the range 60 000 to 210 000 t/y over the last 20 years, the level of imports essentially reflecting exploration activity on the UK Continental Shelf. However, in recent years imports have declined due to a general decrease in exploration activity (See Table 1). Exports are modest and have been between 5 000 and 10 000 tonnes in most years. However, since 2000, exports have reportedly been much larger. These figures are difficult to account for and may be erroneous.

	Imports		Exports	
	Tonnes	*£thousand*	*Tonnes*	*£thousand*
1996	82 656	3 938	5 433	1 270
1997	138 499	5 712	9 438	1 847
1998	98 480	4 394	6 579	1 384
1999	65 356	2 833	8 148	1 516
2000	57 244	2 845	28 472	2 843
2001	77 153	3 431	58 952	3 880
2002	74 843	3 117	37 759	3 163

Table 1 UK: Imports and exports of barytes, 1996-2002. *Source: H M Customs & Excise.*

Consumption

Barytes consumption in the UK mainly reflects the level of exploration activity on the UK Continental Shelf. Following the discovery of hydrocarbons in the North Sea in the early 1970s consumption of barytes increased to a peak of 260 000 tonnes in 1990–91, the major proportion of which consisted of imports. More recently consumption has been in the range 100 000 to 200 000 t/y due to a decline in exploration activity. Consumption of barytes for fine grinding for filler applications is about 20 000 t/y. Some of the material is exported.

Economic value

Although barytes production generates only modest amounts of direct revenues its recovery is an integral part of the economic viability of fluorspar mining and processing in the Peak District. Moreover, the high purity product recovered is further processed by fine grinding in Derbyshire for filler applications yielding additional sales of £1.5 to £2 million.

Barytes

Structure of the Industry

Glebe Mines Ltd, a privately-owned company, is now the only producer of barytes in England following the closure of two small open-pit operations in the northern Pennines in 2000 and 2002. The company operates the Cavendish Mill, near Stoney Middleton, where barytes is a by-product of processing fluorspar ore. Some of the barytes is sold into the drilling fluids market but most is sold to Viaton Industries Ltd, a Derbyshire-based company specialising in the fine grinding (micronising) of both domestically produced and imported barytes for filler applications. The Cavendish Mill supplies about half of the company's barytes requirements.

Resources

Barytes has been worked in many parts of the UK. In recent years the most important resources have been in the Southern and Northern Pennine orefields, but significant production was formerly recorded in other areas, notably Shropshire, the Lake District and south Devon. In England barytes occurs mainly as vein infillings in faults which cut a variety of rock types. The most important are limestones of Carboniferous age but veins cutting slates, mudstones and volcanic rocks of Precambrian, Lower Palaeozoic and Devonian age have also been worked. Intense alteration of limestone wall rocks has also led locally to the formation of replacement deposits adjacent to major veins in the Northern and Southern Pennines. However, individual deposits tend to be small.

In contrast, bedded or stratabound deposits are larger. A stratabound baryte deposit near Aberfeldy in Scotland, which occurs in highly folded metasedimentary rocks, is the major source of barytes in the UK today. The possibility that similar styles of mineralisation could be found in England cannot to discounted.

Reserves

Barytes extraction ceased in the Northern Pennines in 2002, due to economic factors. All the production of barytes in England is now as a by-product of fluorspar mining and processing in the Southern Pennine Orefield. Reserves of barytes are, therefore, confined to fluorspar deposits, where the barytes content is variable depending on location within the orefield. (See Factsheet on **Fluorspar**).

Extraction and processing

The typical feed grade to the Cavendish Mill contains 28% CaF_2, 8-9% $BaSO_4$ and <1% Pb. Extraction is geared towards maximising the recovery of fluorspar, which is the most valuable product. Barytes is recovered by a combination of heavy media separation and froth flotation to produce a final product grading 92-95% $BaSO_4$. In addition to fluorspar, a lead (galena) flotation concentrate is also produced which is sold locally.

Relationship to environmental designations

Bartyes mineralisation of current economic interest is confined to the Southern Pennine Orefield most of which is located in the Peak District National Park.

Alternatives/recycling

Small quantities of hematite and ilmenite are used as alternatives to barytes as weighting agents in drilling fluids. New developments with synthetic-base fluids allow the cuttings to be discharged offshore whilst the drilling fluid is returned to a shore base for remediation and re-use. This is resulting in an overall reduction in new barytes consumption per metre drilled.

Planning issues

Barytes production in England is now confined to the Southern Pennine Orefield where it is recovered as a by-product of fluorspar processing in the Peak District National Park. The planning issues associated with the extraction and processing of barytes are identical to those for fluorspar. The former barytes workings in the Northern Pennine Orefield were located in the North Pennines AONB.

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Mineral Planning Factsheet

Barytes

Authorship and acknowledgements

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Barytes

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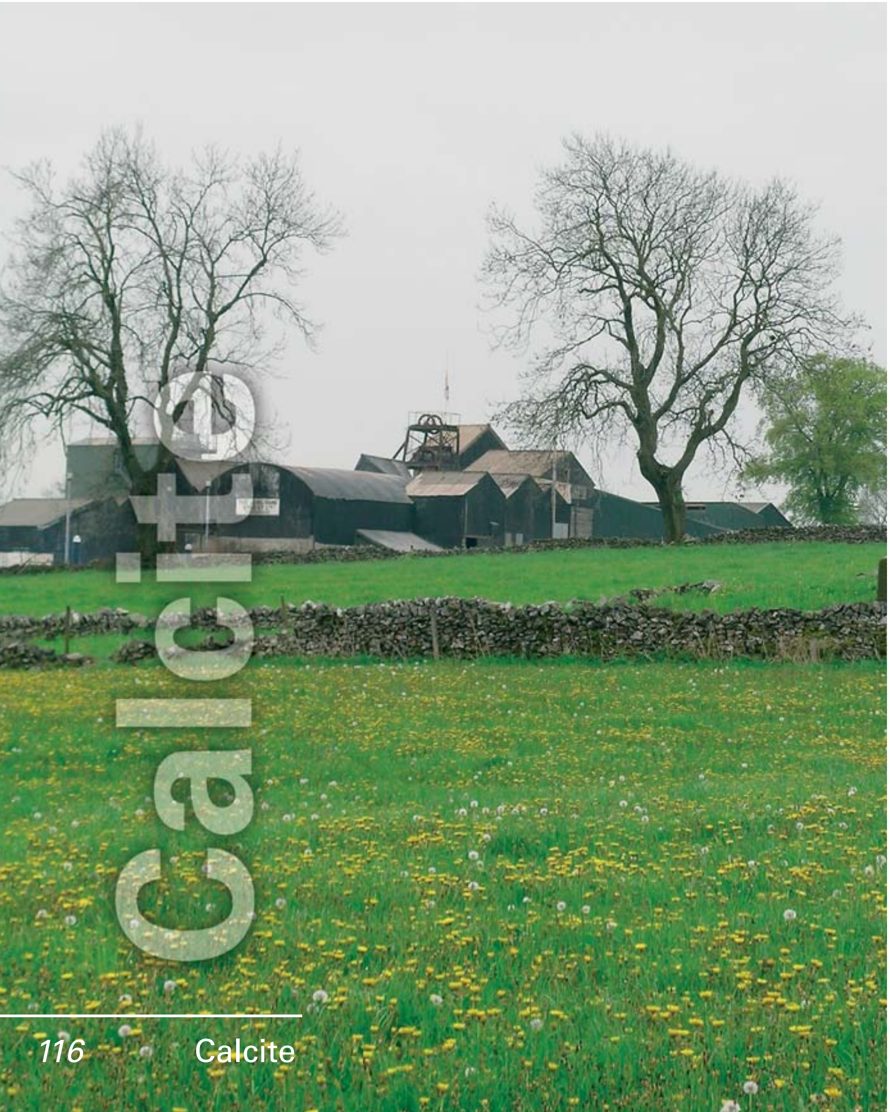
Mineral Planning Factsheet

Calcite

The purpose of this factsheet is to provide an overview of the mineral ***calcite****. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Calcite, calcium carbonate ($CaCO_3$), is a common rock-forming mineral. It is the principal constituent of all limestones, including chalk, which largely consist of the fossil remains of marine organisms. Limestones are worked on a large scale and are important sources of aggregates, cement raw materials, lime (CaO), and material for a range of industrial and agricultural uses. Some limestones, particularly chalk, are valued for their high whiteness and are used for a range of filler applications. Limestone and chalk for non-aggregate applications are considered in more detail in the factsheets on ***Cement Raw Materials*** and ***Industrial Limestone***.

Crystalline calcite, which is the focus of this factsheet, is a common component of many mineral veins. It is associated with those veins carrying fluorspar-baryte-lead mineralisation that occur in limestones of Carboniferous age, particularly those in the Peak District of Derbyshire. Where these minerals are worked, the calcite is treated as waste. However, in some veins, calcite is present almost to the exclusion of all other minerals. These have been exploited in their own right to form a small extractive industry quite separate from the large-scale extraction and use of limestone and also quite distinct from the extraction of fluorspar with associated barytes and galena.



Long Rake calcite Mine, Peak District. A former source of vein calcite.

Demand

Vein calcite, or calcspar and 'Derbyshire Spar' as it is locally known in the Peak District, has its own distinctive character and supplies a small niche decorative market throughout the UK. The calcite has an off-white/cream colour. A distinctive feature is its sparkling surface produced by reflections on the cleavage surfaces of the coarsely crystalline calcite. Vein calcite is used principally as a decorative mineral aggregate in a range of applications, including incorporation into reconstituted stone, exposed concrete panels, dry dashed building finishes, loose and bitumen-bonded path/drive surfacing, in terrazzo tiles and as reflective finishes for flat roofs.

Supply

Workable deposits of vein calcite have a restricted distribution in England. The Peak District has traditionally been the most important source, with production starting in the mid-19th century. The area has been the sole source of supply since the 1980s. Outside the Peak District, calcite has been recovered from waste heaps from former lead mining operations at Snailbeach in Shropshire and from small mines working calcite veins in the Halkyn Mountains of North Wales. The last mine in North Wales closed in 1982.

Production data are incomplete, because of the limited scale of the industry. However, output has typically been a few thousand tonnes a year and has not exceeded 15 000 tonnes in recent years.

Mineral Planning Factsheet

Calcite

Trade

Calcite, mainly in the form of marble, is imported into the UK, both for decorative aggregate purposes and as a source of high whiteness filler, for example, for use in papermaking. In 2002 imports were about 254 000 tonnes valued at £4.9 million.

Consumption and economic value

As records of production are incomplete and imports are of forms of calcite with somewhat different properties, it is likely that consumption is essentially the same as production being a few thousand tonnes a year. The value of production is small and the total turnover of the industry is unlikely to exceed £0.5 million a year.

Structure of the industry

There are two main suppliers of vein calcite in England, Long Rake Spar Company Ltd and Derbyshire Aggregates Ltd. Both companies have processing plants located to the west of Youlgreave on the sites of former lead mines, which subsequently were worked for calcite. The last mine closed in 1981. In both concerns the supply of locally produced calcite forms only a part of their business, which includes the supply of a wide range of decorative aggregates. The Long Rake Spar Company Ltd operates surface workings to supply its calcite requirements whilst Derbyshire Aggregates is supplied by Moss Rake Calcite Works with surface workings on Moss Rake, near Bradwell.

Resources

Calcite is a common mineral occurring in many mineral veins but was treated as waste in former metal mining operations. Only rarely does it occur in sufficient concentrations to be economically viable. Resources are confined to the Southern Pennine Orefield in the Peak District where steeply inclined, generally E-W trending fissure veins ('rakes') occur in limestones of Carboniferous age. There is a distinct mineral zoning within the veins with fluorspar being dominant in most veins in the eastern part of the orefield, and barytes and calcite becoming more dominant westward. In some veins calcite occurs almost to the exclusion of all other minerals. The calcite veins may be up to several metres wide. Dirtlow Rake, near Castleton and Moss Rake, near Bradwell have been the principal sources of supply for many years.

Reserves

Permitted reserves of calcite are not quantified but considered to be small. Some calcite extraction is from unpermitted operations in the Peak District National Park.

Relationship to environmental designations

The calcite-bearing veins of current economic interest are confined to the Peak District National Park.

Extraction and processing

Calcite was formerly extracted by underground mining but the last mines in the Peak District (Long Rake Mine) and in North Wales closed in the early 1980s because of the high cost of this method of extraction. Since then production has been by surface working of mineral veins. The vertical and narrow nature of the veins has meant that at some sites there have been safety concerns about extraction from a narrow and deep trench. As a result removal of the host limestone forming the wall rocks to the vein has taken place at some sites. The limestone has been sold as construction aggregate and concerns have been raised about the ratio of calcite to limestone from such operations. Consequently limestone has been produced in much larger quantities than calcite, raising the issue of what is the primary product.

Calcite processing consists of crushing, washing and screening to produce different size fractions from 12 mm down. Some finer sizes are dried and bagged.

By-products

Limestone, forming the wall rocks to a calcite vein, may be a significant by-product of calcite extraction. This is considered to be undesirable as there are already large permitted reserves of limestone within the Peak District National Park and any limestone from the extraction site should be used for site restoration. Where any associated fluorspar mineralisation is present, the ore may be sold to the Cavendish Mill, near Stoney Middleton, for processing to recover fluorspar (see Fluorspar Factsheet).

Planning issues

Calcite resources of current economic interest are found exclusively in veins that cut Carboniferous limestones in the Peak District National Park. This limestone forms attractive scenery with considerable ecological significance and amenity value. The industry, therefore, operates in a highly sensitive area.

Surface working of calcite, especially to significant depths, also raises issues of the surface storage of limestone wall rock and its sale, sometimes in large quantities, for construction use. There is, therefore, an important issue concerning the ratio of calcite to limestone that will be produced from a given site, and their relative economic value. In addition, calcite working is located in areas where limestone extraction would not normally be permitted. There are already large permitted reserves of limestone in the Peak District National Park, and additional reserves are not required.

Some calcite operations have been worked over long periods and restoration has been inadequate.

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Mineral Planning Factsheet

Cement

*The purpose of this factsheet is to provide an overview of the raw materials used in **cement** manufacture. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Cement is a manufactured product consisting essentially of a mixture of calcium silicates and calcium aluminates. These compounds react with water and in so doing cause the cement to set. The requirement for calcium is supplied by limestone, or chalk, and clay/mudstone is the source of most of the silica and alumina. Cement is produced by firing a carefully controlled mixture of limestone and clayey raw material at sufficiently high temperatures to produce **cement clinker**. The finished cement is produced by finely grinding together about 95% cement clinker and 5% gypsum/anhydrite; the latter helps to retard the setting time of the cement. This factsheet considers the principal raw materials used in cement manufacture, notably **limestone** (calcium carbonate, $CaCO_3$), including **chalk,** and also **mudstone** (clay/shale**).** (See also Factsheet on **Gypsum/anhydrite**).

Ordinary Portland Cement is the most widely produced cement, both in the UK and elsewhere. Other types of cement include rapid-hardening and sulphate resistant cements. In addition, **blended cements** are produced by finely grinding cement clinker with pulverised fuel ash, granulated slag and/or limestone, as well as with gypsum/anhydrite. The term 'Portland' Cement was so named by its inventor in 1824 because of the resemblance of the set material to Portland Stone, the well-known natural building stone.

Cement kiln.

Demand

Cement is an essential constituent of concrete, which is a mixture of cement, and coarse and fine aggregate. When mixed with water, this material can be placed *in situ* or cast in moulds. It is a highly versatile building material valued for its high compressive strength, fire resistance, mouldability, impermeability and durability. Mortar (a mixture of cement, fine aggregate and water) is used for joining structural block and brickwork, and plastering. Both concrete and mortar are vital, and essentially irreplaceable, construction materials for the building and civil engineering industries. They are widely used in all construction sectors, including the national house-building programme, road construction, bridges and dams, and in other infrastructure projects, such as railways, airport facilities, hospitals, schools, new offices and shops. Demand for cement is a function of economic activity as a whole, but construction activity in particular, which can be highly cyclical.

Supply

The cement industry in the GB consumed some 15.2 million tonnes of limestone and chalk and about 2.2 million tonnes of clay/mudstone in 2002, together with about 0.6 million tonnes of gypsum/anhydrite and much smaller quantities of ancillary materials, including silica sand, pulverised fuel ash (PFA) and iron oxides. Cement plants have clinker capacities of between 0.25 Mt/y to 1.4 Mt/y. They are, therefore, major consumers of mineral raw materials with, approximately 1.6 tonnes of dry raw materials being required for each tonne of clinker produced. However, the total quantity of raw material may vary depending on local circumstances. [Note: Separate statistics for England are not available. The figures quoted refer to Great Britain or the UK.]

The industry had its origins in South East England in the mid 19th Century, where it was based on chalk. This was because of the ease with which chalk and clay could be converted to a uniform slurry with the equipment then available. The industry became concentrated along the Thames, east of London, and in the Medway valley of Kent. The later introduction of more efficient grinding mills made the use of harder limestone and mudstone possible. In addition, rising energy prices favoured the use of the dry process based on limestone instead of chalk using the wet process. Consequently, whilst the consumption of limestone has remained fairly constant, there has been a declining use of chalk in an overall declining market (Figure 1). In 2002, limestone accounted for about 65% of the total requirement for calcareous raw material. Plant closures have been mainly those based on chalk. However, a proposed new works in the Medway valley of Kent will be based on chalk. The existing Northfleet works in Kent, which is also based on chalk, will close in 2008.

Over the last 20 years UK cement clinker production has been in the range 15 Mt/y to 10 Mt/y but with a generally declining trend. Clinker production was some 10.3 Mt in 2002 (GB). Production of finished cement is shown in Figure 2.

Trade

In the late 1970s and very early 1980s, the UK was a significant exporter (> 1 Mt/y) of cement. However, increasing competition in overseas markets has led to a decline in exports and from 1987 onwards, the UK has become a net importer due to insufficient domestic production capacity (Table 1). UK imports of cement (clinker and Portland cement) were valued at about £75 million in 2002 compared with £21 million for exports. Cement imports can be cyclical and affected by excess availability in exporting countries where, in periods of low domestic demand, producers are forced to export to maintain volumes to cover high fixed costs.

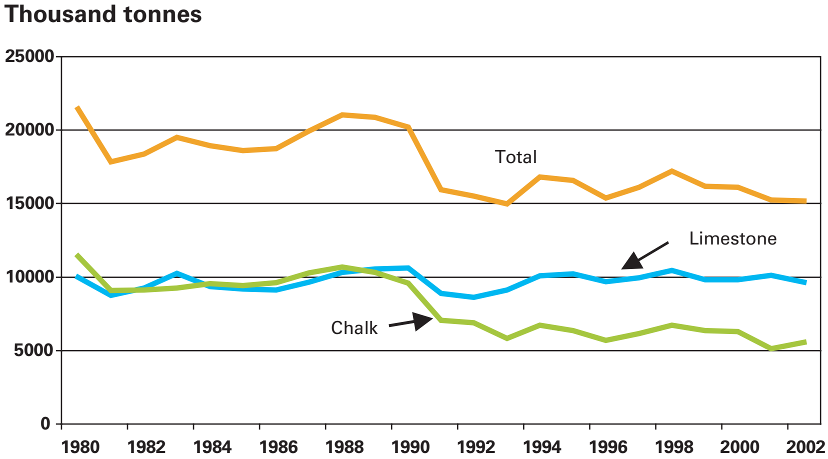
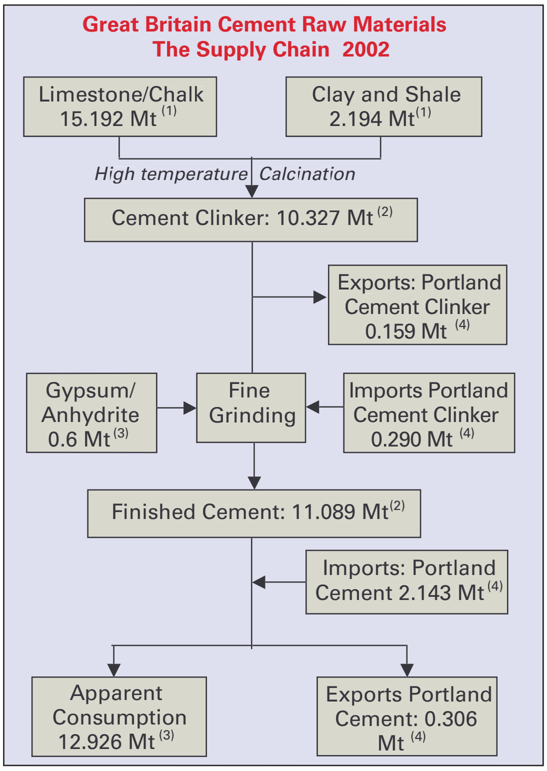


Figure 1 Great Britain: Production of limestone and chalk for cement manufacture, 1980 – 2002. *Source: United Kingdom Minerals Yearbook, BGS.*



1 Annual Minerals Raised Inquiry, ONS
2 Monthly Statistics, Building Materials and Components, DTI
3 BGS estimate
4 HM Customs and Excise (UK)

Figure 2 Cement raw materials supply chain, 2002.

Cement

	Exports	Imports	Exports	Imports
	Thousand Tonnes Cement clinker		Thousand Tonnes Portland cement	
1997	341	346	604	1011
1998	564	319	601	1259
1999	456	445	914	1149
2000	256	351	570	1420
2001	169	387	327	1182
2002	159	290	306	2143

Table 1 UK: Imports and exports of cement clinker and Portland cement, 1997–2002. *Source: HM Customs & Excise.*

Consumption

UK consumption of cement includes cement made from indigenously produced cement clinker, cement made from imported clinker and imports of finished cement (see Figure 3.) Total UK consumption of cement is 12-13 million tonnes a year, of which 90-92% is supplied by the UK industry and the remainder is imported. Forecasts of demand for cement raw materials published in Mineral Planning Guidance Note 10 *Provision of Raw Material for the Cement Industry* published in 1991 have proved to be too high. This is due to a reduction in domestic capacity, increased imports and the increasing use of blended cements (in which a proportion of the cement is replaced by PFA and granulated blastfurnace slag). Total consumption of cementitious material (including blended cement) was 14.6 million tonnes in 2001.

Economic importance

Cement raw materials are not sold on the open market, but are entirely consumed captively in the manufacture of cement. The value of UK sales of Portland cement, including blended cements, was £671 million in 2002. Some 3000 people are employed in the industry. Cement is an essential material for the UK construction industry, which is a major sector of the econo-

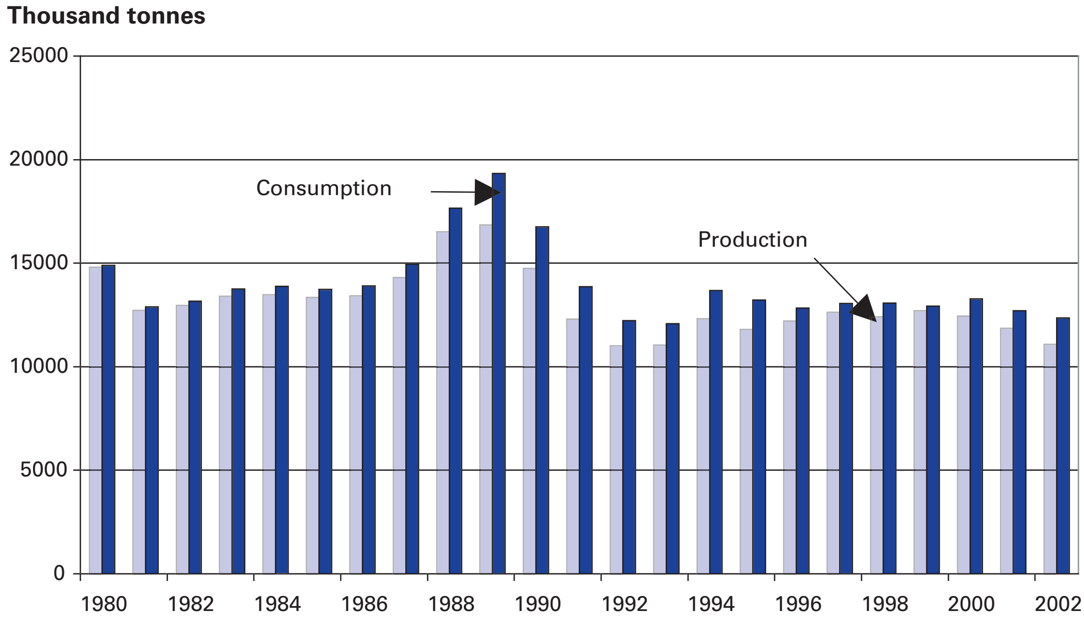


Figure 3 UK: Production and apparent consumption of cement, 1980–2002. *Source: Monthly Statistics, Building Materials and Components, DTI. (2002 GB only).*

my. Its importance to the UK economy was recognised in MPG10. In 2002 the total value of the work done in the construction sector in Great Britain was £83.6 billion: £45.3 billion of new work and £38.3 billion repair and maintenance.

Company	MPA	Plant	Clinker capacity (Thousand tonnes/year)	Process	Raw materials	Transport
Lafarge Cement UK	Staffordshire	Cauldon	920	Dry	Carboniferous/ limestone and mudstone	Road
	Peak District National Park	Hope	1400	Dry	Carboniferous limestone and/ mudstone	Road/Rail
	Kent	Northfleet	1250	Semi-wet	Chalk and London Clay	Road
	Kent/Medway	Medway (planned)	1200	Dry	Chalk and Gault clay	Road/Rail
	Wiltshire	Westbury	720	Wet	Chalk and Kimmeridge Clay	Road/Rail
	Vale of Glamorgan	Aberthaw	500	Dry	Jurassic limestone/ mudstone and Carboniferous limestone	Road
	East Lothian	Dunbar	1000	Dry	Carboniferous limestone/ mudstone	Road/Rail
Castle Cement	Rutland	Ketton	1300	Dry	Jurassic limestone and mudstone	Road/Rail
	Lancashire	Ribblesdale	1300 (current) 750 (future)	Wet Dry (planned)	Carboniferous limestoneand/ mudstone	Road
	Flintshire	Padeswood	500 (current) 800 (future)	Dry planned	Carboniferous limestone and colliery spoil	Road
Rugby Cement	North Lincolnshire	South Ferriby	750	Semi-dry	Chalk and Kimmeridge Clay	Road
	Cambridgeshire	Barrington	250	Wet	Chalk and Gault clay	Road
	Warwicks/Beds	Rugby	1250	Wet	Chalk and Jurassic mudstone	Road
Buxton Lime Industries	Derbyshire	Tunstead	750 (under construction)	Dry	Carboniferous limestone and/ mudstone	Road/Rail

***Table 2** Cement plants in England, (and Wales and Scotland) clinker capacity and raw materials.*

Cement

Structure of the industry

There are four producers of cement in the UK. These are (with their very approximate market share in 2003); Lafarge Cement UK (46%), Castle Cement (24%), Rugby Cement (24%) and Buxton Lime Industries (2%). However, Buxton Lime Industries is currently commissioning a new 0.75 Mt/y works at Tunstead, which will replace its existing old plant, which has a capacity of 0.215 Mt/y. Those cement plants that are located in Great Britain are listed in Table 2 and shown on Figure 3. Cement plants in Wales and Scotland are part of the national supply structure and are shown for completeness. The British Cement Association is the trade association for the industry.

There have been a number of cement plant closures in recent years due to rationalisation and concentration on larger works. Recent closures by Lafarge Cement have included Masons in Suffolk, and Plymstock in Devon, both in 1999, and Weardale in Durham in 2001. Rugby Cement closed plants at Rochester, Kent and Southam in Warwickshire after the new Rugby Works came into full production in 2000.

Lafarge Cement UK is part of the Lafarge Group of France, which is the world's largest cement producer. Castle Cement is a subsidiary of the Heidelberg Cement Group of Germany and Buxton Lime Industries is part of Tarmac, a subsidiary of the Anglo-American Corporation. Rugby Cement is a subsidiary of the RMC Group. With the exception of Castle Cement, all the cement manufacturers are also large producers of aggregates in the UK.

Resources

The availability of suitable raw materials is normally the determining factor in the location of cement works. The manufacture of Portland cement requires raw materials that contain four main components; lime, silica, alumina and iron oxides. Limestone, or chalk, is the main source of lime (CaO) and typically accounts for 80–90% of the raw mix. Clay or mudstone accounts for some 10–15% and provides most of the silica, alumina and iron oxides. However, limestone, depending on its purity, may also contribute some of these constituents. Depending on the raw materials used, it may also be necessary to introduce silica sand and iron oxides to optimise the mix. The quality of the cement clinker is directly related to the chemistry of the raw materials used. Elements such as magnesium (Mg), sodium (Na), potassium (K) and sulphur (S) are acceptable if kept within certain limits. However, cement with excessive amounts of magnesium (>5% MgO) would not meet specification and the cement would suffer from expansion. An excess of alkalis (K_2O and Na_2O) would also be unacceptable because of durability problems with the concrete (the alkali-silica reaction). However, a high alkali cement is desirable for certain markets due to its reactivity with slag/PFA admixtures, helping with early strength. An excess of sulphur can cause operational problems. Thus the raw materials used in cement manufacture must meet relatively stringent quality requirements and, most importantly, be carefully controlled.

Limestones of various geological ages are widely distributed in England (Figure 4). They vary considerably in their chemistry and thickness and thus their suitability for cement manufacture on a large scale. Dolomites and magnesian limestones are unsuitable for cement manufacture, because of their high magnesia (MgO) contents. Limestone should contain less than 3% MgO. This precludes the use of limestones of Permian age.

Cement manufacture is based primarily on Carboniferous limestones and on the Cretaceous Chalk. The former is the most important (see Figure 1). Carboniferous limestones are relatively extensive and occur as thick deposits that are easy to work and which are generally of relatively high purity. The Peak District of Derbyshire has extensive resources and the limestones are characteristically flat-lying and are noted for their uniformity over wide areas. Large areas of the northern Pennines and the fringes of the Lake District are also underlain by Carboniferous limestones, some of which are relatively thick, pure and consistent in quality. Elsewhere, Carboniferous limestones occur mainly in the Mendips, although here they do not exhibit the same degree of purity.

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Limestones of Jurassic age occur in a belt extending from the Dorset coast, north-eastwards through central England to the Yorkshire coast. The limestones of Middle Jurassic age are the most extensive, although individual beds are comparatively thin. Currently Jurassic limestone (Lincolnshire Limestone) is worked at only one site in England, at Ketton, in Rutland. As limestones generally have low porosities, and thus low moisture contents, the dry process is used in cement manufacture from these resources. Limestone of Devonian age, which have a restricted distribution in Devon, were formerly worked at Plymstock, near Plymouth, but this small works closed in 1999.

The Cretaceous Chalk is a soft, fine-grained, white limestone and occurs extensively in eastern and southern England. It is composed of the calcareous debris of planktonic algae, largely in micron-sized plates. It is generally of high purity with a uniform composition. Small quantities (1%) of clay are present throughout the Chalk, and centimetre thick beds of calcareous mudstones also occur. However, the lowest 25–60 m of the Chalk has a higher clay content and it is this material that was formerly extensively worked as a natural cement mix. The Chalk is up to several hundred metres in thickness. It is generally highly porous and has a high moisture content. Consequently wet or semi-wet manufacturing processes are normally used to make cement from chalk. However, the proposed new Medway works will be a dry process.

Resources of clay and mudstone suitable for cement manufacture are widespread and normally obtained from quarries adjacent to cement plants. One major exception is the use of the London Clay at Ockendon in Essex, which is slurried with water and piped beneath the Thames to supply the Northfleet cement works. Jurassic mudstones are worked at Southam in Warwickshire for transport to the Rugby cement plant.

Reserves

Cement plants are highly capital intensive. The construction of new plant costs about £15 million for each 100 000 t/y of cement capacity.

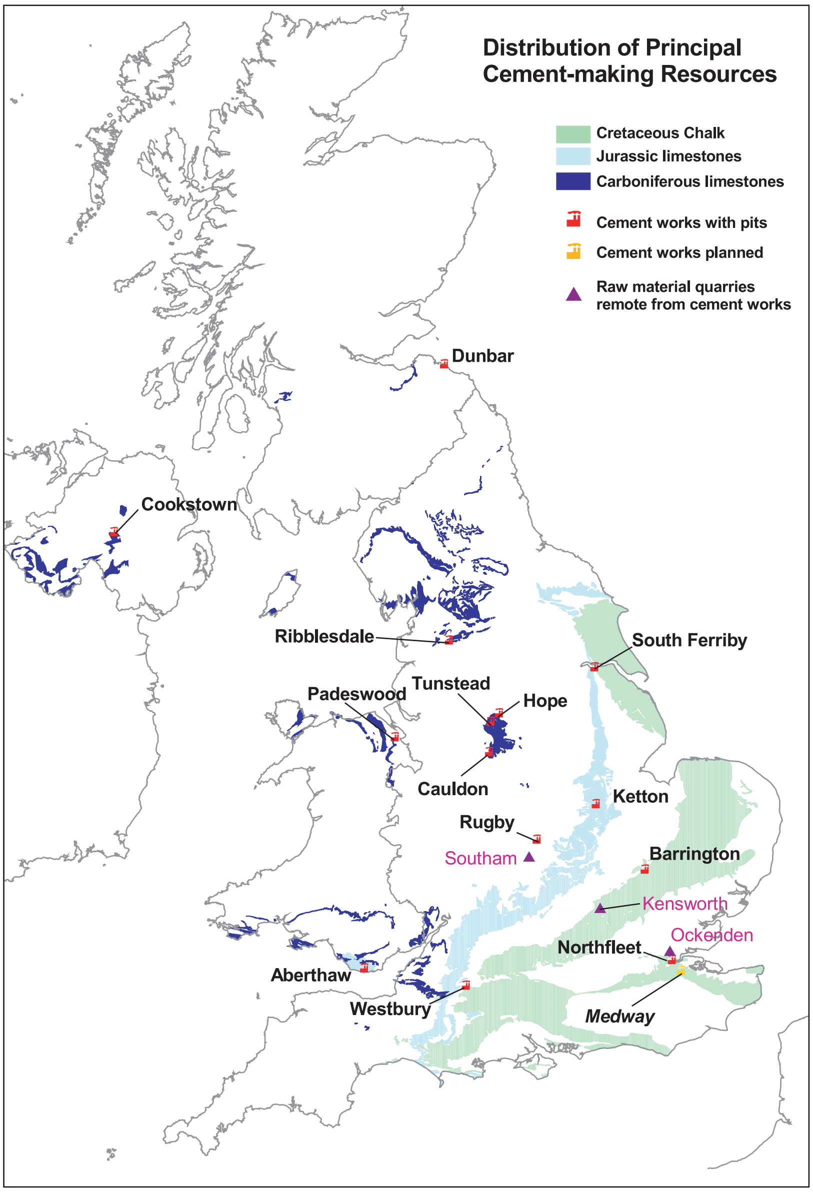

Figure 4 Distribution of the main limestone resources in UK and the location of cement plants.

Large modern plants can, therefore, cost over £150 million. Ongoing capital investment at individual plants can also typically amount to several million pounds a year.

Cement raw materials must be available in sufficiently large quantities to justify these large capital investments. Current policy in MPG 10 is that the stock of permitted reserves should provide at

Cement

MPA	Plant	Clinker capacity (thousand tonnes/year)	Reserves (Mt)	Reserve Life (Years)
Staffordshire	Cauldon	920	117	49.2
Peak District National Park	Hope	1400	45	28
Kent	Northfleet	1250	9	5(a)
Kent/Medway	Medway (planned)	1200	71.3	32.5
Wiltshire	Westbury	720	9.4	9.1(b)
Ketton	Rutland	1300	na	23
Ribblesdale	Lancashire	1300 (current) 800 (future)	na	24
North Lincolnshire	South Ferriby	750	na	Many
Cambs	Barrington	250	na	Many
Bedfordshire	Kensworth	1250	na	Many
Derbyshire	Tunstead	750	na	40

Table 3 England: Permitted reserves of limestone and chalk for cement manufacture in 2003.
(a) Northfleet will close when remaining reserves are exhausted. (b) Planning application planned for 2004 based on existing Mineral Local Plan will increase reserves to 29.5 Mt and reserve life to 28.5 years.

least 25 years supply for a new plant or new kiln. Elsewhere the stock of permitted reserves should be maintained at least at 15 years. These figures are low by international standards.

Permitted reserves of limestone and chalk for cement manufacture at 2002 are shown in Table 3.

Relationship to environmental designations

The Carboniferous Limestone and Cretaceous Chalk are the two principal resources on which cement production is based in England. These two resources give rise to some of England's most attractive scenery and consequently extensive areas are covered by national landscape designations (Figure 5). In addition, these calcareous rocks give rise to areas of conservation

	% National Park	% AONB	% SSSI	% Outside national designation
Chalk	5	25	5	66
Jurassic Limestone	4	26	2	70
Carboniferous Limestone	42	17	16	39

Table 4 Proportion of limestone and chalk resources covered by landscape and nature-conservation designations. *(SSSIs occur in both National Parks and AONBs).*

Cement

interest, both geological and biological. Consequently, extensive areas are also covered by national and international nature-conservation designations. The approximate proportion of the outcrop covered by some of these designations is shown in Table 4. Nature-conservation designations and landscape designations are not mutually exclusive.

Extraction and processing

The raw materials used in cement manufacture are all extracted in large quarries with outputs of up to 2.5 Mt/y at some sites. Large reserves of feedstock, particularly limestone/chalk, are required to provide security of supply and these are normally quarried in close proximity to the works. Clay/mudstone may be worked in the same, or an adjacent quarry, or transported from more distant sites.

Cement clinker is manufactured by heating a carefully controlled and homogenised mixture of finely ground calcareous and clayey raw materials to partial fusion (typically at 1400°–1500°C) in a rotary kiln. Small amounts of other materials, such as silica sand, may be added to optimise the mix. These raw materials supply the lime (CaO), silica (SiO_2), alumina (Al_2O_3) and iron oxides (Fe_2O_3) necessary for the formation of the calcium silicates and smaller quantities of calcium aluminates that constitute cement clinker. The clinker is cooled and then finely ground, typically with 5% gypsum/anhydrite, to form the final cement. Gypsum/anhydrite is introduced to control the initial rate of reaction with water and to allow concrete to be placed and compacted before setting commences. Depending on how the material is handled prior to being fed into the cement kiln there are three basic types of process; the dry, semi-wet/semi-dry and wet processes. The moisture content of the raw material (3% for hard limestone and over 12–16% for chalk) is the main criteria governing the process used. In the dry process the feed material is in powdered form. It is either preheated by the kiln hot exit gases prior to entering the kiln (preheater kiln) or, if fuel is added in a special combustion chamber, the calcination process can almost be completed before the feed enters the kiln (precalciner kiln). In the wet process the feed is made by wet grinding and the resulting slurry is fed directly into the kiln. In the semi-dry/semi-wet processes water is either added to the feed or removed by filter pressing. Over the decades there has been a move away from the wet process to the more energy efficient dry process. The finished cement is transported in bulk or in bags to the market.

Cement manufacture results in the production of large amounts of carbon dioxide, mainly through the calcination of limestone/chalk to produce calcium oxide and also by the fuel burn required for this energy intensive process.

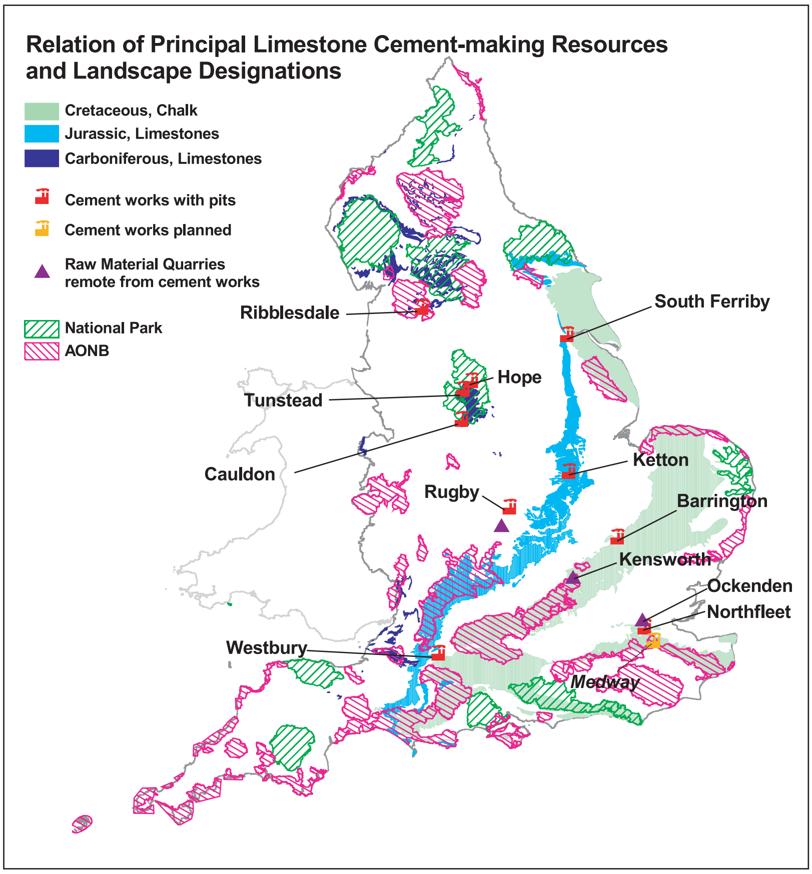

Figure 5 Distribution of the main limestone resources in England and their relationship to main landscape designations. *(The South Downs and New Forest are 'proposed' National Parks).*

By-products

Quarries extracting limestone/chalk and clay/mudstone for cement manufacture do not normally sell these materials for any other use. However, small amounts of associated minerals are produced at some sites.

At Hope Quarry in the Peak District National Park, the limestone is cut by mineral veins, which carry fluorspar-barytes-lead mineralization. Fluorine is a deleterious impurity in cement manufacture and has to be kept below specified levels. An independent company works the veins and the partially processed ore is sold for the production of acid-grade fluorspar at the nearby Cavendish Mill.

Depending on the specific horizons in the Chalk being worked, flints are common in some of the quarries working chalk as feedstock. At the Northfleet Quarry in Kent, washed flints are supplied for off-site processing into specialised aggregates. Elsewhere recovered flints are used for fill.

At Tunstead Quarry, near Buxton in Derbyshire the original cement works, which is currently being replaced, was built to utilise the waste slimes from washing limestone for lime burning. In effect, therefore, cement is a by-product of the industrial limestone operation. It is an effective means of disposing of a waste and maximising the use of the resource. However, with the plant expansion additional clays will have to be brought in. At Ketton Quarry in Rutland, parts of the Lincolnshire Limestone are suitable for use as building stone. The limestone is sold in small quantities as Ketton Stone to a local company for cutting and shaping. Some of the finished stone has been exported.

Alternatives/recycling

The principal objective of using alternative raw materials in cement manufacture is to optimise the mix to make best use of available materials. Other than limestone/chalk, there are no calcium-bearing sources that occur on a sufficiently large scale to be used as alternatives. Clay/mudstone is the main source of silica, alumina and iron oxides because of its availability and low cost. However, clay/mudstone often does not supply the correct chemical balance of constituents and bought in supplements are often required. These may include silica sand, PFA, and iron oxides. PFA has a higher alumina to silica ratio than most mudstones, and also lower alkalis. It is used at some cement plants to add alumina so that higher silica limestone can also be utilised. This has extended reserves. It is also used to reduce alkalis in the clinker. Ash from the fuel burn also contributes to the overall chemistry of the cement feed. Increasingly blended alternatives are being used to replace mudstone/clay or the more expensive bought in materials such as sand and iron oxides.

Cement manufacture is energy intensive and coal, often imported, was the traditional fuel used. Alternative fuels are increasingly being introduced and include; recycled and blended waste solvents from printing and cleaning processes, tyres, paper, carpet and plastic offcuts, packaging waste, animal waste, sewage pellets, meat and bone meal. All these fuels have to meet strict specifications laid down by the Environment Agency. The use of these alternatives fuels is not only less costly, but also reduces emissions and the amount of waste that otherwise would be landfilled.

The production of blended cements is increasing. These may contain for instance, singly or in combination, a proportion of pulverised fuel ash (PFA: a by-product of coal-fired power stations), blastfurnace slag (a by-product of ironmaking) and limestone. These act mainly as lower cost diluents, their main purpose being to reduce the amount of cement clinker used per unit of concrete produced. However, their use may also impart additional technical properties as both PFA and slag have cementitious properties that improve the long term strength and durability of concrete. In the production of blended cements the amount of cement clinker, and thus the amount of primary feedstock required, is reduced by the proportion of the PFA, slag or limestone used. Indirectly, therefore, these additions also reduce the environmental impact of clinker production per unit of concrete.

Effects of economic instruments

Limestone, including chalk, and clay/mudstone used in cement manufacture are not included within the scope of the Aggregates Levy.

The UK Government introduced the Climate Change Levy on the 1st April 2001, which applies to fuels used by energy intensive sectors, including the cement industry. In exchange for an 80% rebate from the Levy, the UK cement industry has agreed to reduce its primary energy consumption by 25.6% per tonne of cement produced by 2010 from a 1990 baseline figure. This target will be progressively met by a combination of replacing older plant, introducing alternative fuels (see above) and alternative materials, such as PFA and slag.

Transport Issues

The principal raw materials used in cement manufacture are almost always supplied from adjacent quarries in order to avoid the high costs of transporting large tonnages of low cost raw materials. In England the only major exception is the Rugby works in Warwickshire, where both the calcareous and clay raw materials are transported into the plant. The cement industry in Warwickshire was originally based on local impure Jurassic limestones, but these are unsuitable for modern cementmaking. Since 1965 a slurry pipeline from Kensworth Quarry in Bedfordshire has been the source of chalk into the county. Clay is also transported by road to Rugby from Southam. A pipeline is also used to transport clay from Essex beneath the Thames to the Northfleet cement works. It is unlikely that pipelines will be used in the future to transport raw materials, because of their high cost and the economic disadvantages of the wet or semi-wet process, which slurrying in water would entail. Four of the cement works in England currently use rail transport.

Planning issues

Modern cement operations tend to be large-scale and long-lived. The economies of scale required in order to make individual operations profitable mean that production has tended to concentrate on units which require large inputs of limestone and clay. This means that there has been a trend toward more extensive quarries and larger processing plant.

Cement manufacture requires complex plant, which is expensive to install and requires ongoing capital investment to maintain. As a consequence, operators require security of supply of both limestone and clay/mudstone over relatively long periods of time (see Reserves above). Individual extraction and processing sites can, therefore, be long lived relative to other mineral operations. Individual planning authorities have been largely successful in following current guidance in bringing forward reserves to maintain security of supply. However, the length of time it takes to obtain permissions, together with the resulting uncertainty, is of concern to the industry.

The domestic cement industry has contracted and the UK is a modest net importer from elsewhere in Europe. The cement producers are seeking to maintain their market share from UK production capacity and do not consider it to be prudent to rely on imports for cost, quality and security of supply reasons.

Environmental issues relating to emissions and air quality are not mineral planning issues. However, major investment is required to meet strict environmental standards set by the Environment Agency, which further reinforces security of supply issues and the need for long-term reserves to justify this investment.

A number of cement works remain entirely reliant on road transport.

Further information

Minerals Planning Guidance 10: *Provision of Raw Material for the Cement Industry*. Department of the Environment. Welsh Office. (London: HMSO, 1991).

The UK cement and concrete sector is currently addressing the ways in which sustainable thinking can be applied to its manufacturing processes and to concrete construction. See *Sustainable development in the cement and concrete sector*. Project summary 2003. British

Cement Association and The Concrete Centre. www.concretecentre.com and www.bca.org.uk

The cement sustainability initiative: our agenda for action. Executive summary. July 2002. World Business Council for Sustainable Development. www.wbcsdcement.org.

Authorship and acknowledgements

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Office of the Deputy Prime Minister
Creating sustainable communities

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Dolomite

*The purpose of this factsheet is to provide an overview of the mineral **industrial dolomite**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Dolomite is a sedimentary carbonate rock, which consists entirely or mostly of the mineral dolomite ($CaMg(CO_3)_2$). (The term dolostone is also used). Rocks containing only 10–50% of the mineral dolomite are called dolomitic. Most, if not all, dolomite is a replacement of pre-existing limestone and this replacement process is known as **dolomitisation**. The process is often incomplete and rocks termed 'dolomite' are usually a mix of dolomite, dolomitic limestone and limestone. Dolomite deposits are, therefore, usually associated with limestones. This fact, together with the presence of variable amounts of impurities, such as silica, iron oxides and alumina, has an important bearing on the suitability of dolomite for specific applications.

Dolomite has a number of uses, the most important of which, by volume, is in construction, where it may substitute for limestone. However, for some uses dolomite is specifically valued for its magnesia (MgO) content, and chemical composition is all-important.

Dolomite is used as a soil conditioner in agriculture.

Industrial dolomite is a commercial term for dolomite used for non-construction purposes where its chemical properties (or degree of whiteness) are important. The MgO content of dolomite is commonly expressed after calcination (heat treatment involving the removal of carbon dioxide). Pure dolomite has an MgO content of about 40%. However, glass manufacturers normally use pre-calcined MgO content for control purposes and there is a theoretical maximum of about 21.8% MgO. Dolomite for industrial purposes accounts for a relatively small and decreasing proportion of total dolomite output. Like limestone, dolomite is a low-value commodity, which does not normally lend itself to long transport distances, although this may not be true for high-quality industrial dolomite.

Demand

The principal uses of industrial dolomite, firstly as a refractory and later as a flux, have been linked with iron and steelmaking since the latter part of the 19th century. For this reason industrial dolomite has been regarded as of vital importance to the iron and steel industry. The other major markets for dolomite are in glassmaking and for agricultural use (Figure 1).

Raw dolomite and calcined dolomite have a number of different uses in the iron and steel industry. However, changes in iron and steelmaking technology during the 20th century have had a marked effect on the demand for specific uses and the market continues to evolve.

The principal uses of dolomite are those that utilise the mineral in the calcined form (dolomitic lime). The most important of these is as a steelmaking slag flux, where the dolomitic lime replaces some of the quicklime (CaO) used in slag production. In addition to increasing slag fluidity, the presence of magnesia also helps to protect, and thus improve the life of, the steel furnace's refractory linings, which are made of magnesia. The total quantity used has been declining in line with a fall in steel production. Some 220 000 tonnes of calcined dolomite were used for this purpose in 2002.

Hard burnt dolomite, which is subsequently formed into pellets and fired again to achieve a higher bulk density, is used in the manufacture of dolomite refractory bricks. Dolomite refractory bricks are no longer produced in the UK but calcined dolomite is exported to Germany and Turkey for this purpose. Low levels of silica and iron oxides are required for this use. Another form of calcined dolomite with added iron oxide is used to repair furnace linings.

Dolomitic lime was formerly used on a substantial scale for the manufacture of seawater magnesia principally for refractory use at a plant in Hartlepool. However, the production of refractory magnesia recently (2002) ceased and current, smaller output is now for the production of chemical grade magnesium oxide powders and magnesium hydroxide suspensions, which have a range of industrial uses.

The use of raw dolomite as part of the flux burden in ironmaking has been replaced by an igneous rock containing a high proportion of the mineral olivine [$(Mg, Fe)_2SiO_4$], which in addition to supplying magnesia, also contributes silica. However, raw dolomite may be introduced as a flux directly into the Basic Oxygen Steelmaking vessel where it also replaces steel scrap as a coolant.

For many of the applications in the iron and steel industry there are strict limits on the chemistry of the dolomite used, which mainly needs to be low in silica (often <0.55% SiO_2), with low iron (<0.55% Fe_2O_3), sulphur (<0.1%) and phosphorus (<0.02%).

Another important market for industrial dolomite is in glassmaking. Most commercial glasses consist essentially of silica together with soda (Na_2O) and lime (CaO), the lime being partly replaced by magnesia (MgO) for some purposes. Lime is introduced into the glass melt as limestone ($CaCO_3$) and magnesia by adding dolomite [$(CaMg(CO_3)_2)$]. However, in the flat glass industry most lime is introduced with the dolomite and only a little limestone is used to balance the CaO/MgO ratio. Lime and magnesia improve the durability of the glass but magnesia also inhibits the devitrification process, which is particularly important in the manufacture of flat glass. Dolomite is also used in container glass. A critical factor in the supply of any glassmaking raw material, including dolomite, is iron content as this is a serious impurity in the manufacture of colourless glasses. In contrast to silica sand, mineral processing cannot effectively lower the iron content of dolomite (or limestone). Although the UK has high quality limestone resources with very low iron contents, there is a deficiency of low iron dolomite resources, which only rarely have iron contents as low as 0.2–0.25% Fe_2O_3. Imported dolomite, with iron contents of less than 0.03% Fe_2O_3, is required for the manufacture of colourless glass containers and, sometimes, low iron float glasses.

Dolomite is relatively soft and easily crushed to a fine powder, which is used as agricultural lime ('aglime') by farmers to reduce soil acidity and also to adjust magnesium deficiencies. Dolomite is equally good as limestone in neutralising soil acidity but magnesium is also an important element itself as a plant nutrient. Two types of aglime are produced (unburnt and calcined).

Dolomite is also used for a range of filler applications in plastics, paints, rubbers, adhesives and sealants. Dolomite is finely ground to precise size specifications. Pure white (high brightness) filler grades are preferred but these are rare in the UK.

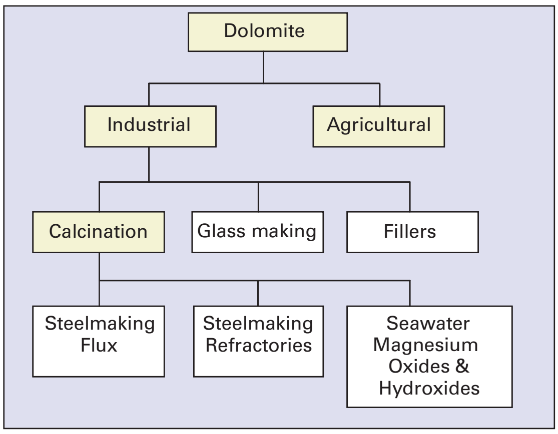

Figure 1 Principal uses of dolomite and dolomitic lime.

Dolomite

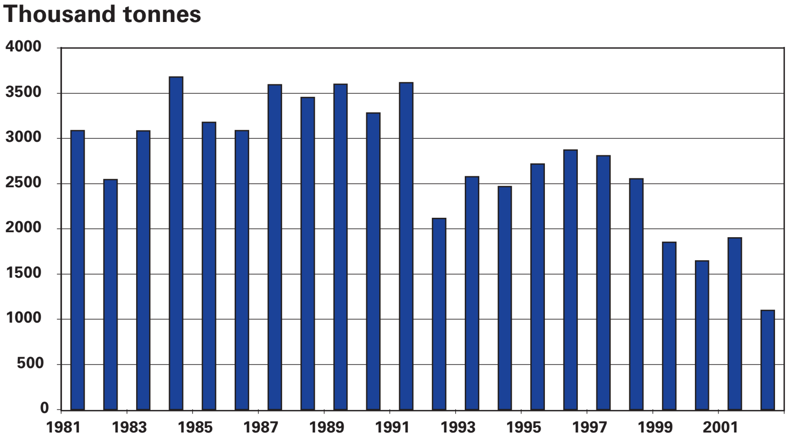

Figure 2 Great Britain: Dolomite production for industrial and agricultural purposes, 1981–2002. *Source: Annual Minerals Raised Inquiry, Office for National Statistics.*

Most markets for industrial dolomite are mature markets, or are in decline, due to the decline in UK manufacturing. A notable exception is the manufacture of flat glass. Export markets for dolomite are, therefore, of considerable importance.

Supply

Production data for dolomite for industrial and agricultural use has not been disclosed separately for a number of years, because of commercial confidentiality considerations. However, a combined figure is available and about 1.1 million tonnes of dolomite were reportedly produced for industrial and agricultural use in 2002. Total production of dolomite in Great Britain in 2002 was nearly 13 million tonnes, most of which was used in construction. Almost all of the dolomite is produced in England, mostly sourced from quarries working the Permian Magnesian Limestone in Durham, South Yorkshire and Derbyshire. Minor quantities are produced from dolomites of Carboniferous age in Shropshire and Derbyshire, although not for industrial use. Dolomite is an important soil conditioner but the largest industrial uses are in the production of calcined dolomite (dolomitic lime) and for glassmaking. Production of dolomite for industrial use has decreased significantly in recent years (Figure 2) due to an overall decline in iron and steel production following the closure of the Ravenscraig and Llanwern iron and steelworks and the cessation of dolomite refractory brick production. In addition, the use of dolomite for sinter feed for ironmaking has been replaced by imported olivine.

The seawater magnesia plant in Hartlepool was formerly also a large consumer of calcined dolomite produced at Thrislington Quarry in Durham. However, the production of refractory grades of magnesia ceased in 2002 and output is now concentrated on smaller quantities of

	Exports		Imports	
	Tonnes	£thousand	Tonnes	£thousand
1998	137 128	8 076	219 824	6 235
1999	91 489	4 358	228 874	4 198
2000	112 875	4 947	174 353	3 798
2001	131 073	4 653	188 312	3 671
2002	104 126	4 393	184 948	3 694

Table 1. UK Imports and exports of dolomite, 1998–2002.
Source: HM Customs and Excise.

high purity magnesium hydroxides in slurry form.

Trade

The UK is, by value, a small net exporter of dolomite (Table 1). Exports, consisting of both calcined dolomite for use in steel-making and refractories, and agricultural dolomite, are to a number of countries, but mainly Sweden and Germany. Imports are of high purity, low-iron dolomite from Spain and Norway, mainly for use in glass manufacture. Imports of calcined dolomite are minimal.

Consumption

Most (85%) of the dolomite used in the UK is for construction use where chemistry and magnesium content is not important. Magnesium oxide content and the levels of impurities present are important for industrial and agricultural uses. Total consumption for these applications has declined significantly in recent years and is about 1.1 million tonnes, although this figure is believed to be somewhat underestimated. No major increases in demand are anticipated.

Economic importance

The long association of dolomite with the iron and steel industry has meant that the mineral has been regarded as of considerable economic importance. Despite a decline in usage, steelmaking remains the major market for dolomite both for use as a flux and refractory raw material. Because of the restricted distribution of suitable quality dolomite for these applications, certain sites will remain of considerable economic importance. In addition, dolomite is an important raw material in the glass industry where it is used notably as an essential constituent of flat glass.

Structure of the industry

There are a limited number of industrial dolomite producers in England (Figure 3). Lafarge Aggregates Ltd (including Lafarge Lime Ltd) dominates output and the company produces industrial dolomite at three quarries; Whitwell Quarry in Derbyshire, which supplies refractory products and steelmaking flux, Thrislington Quarry in County Durham, which produces industrial dolomite for steel flux and magnesium hydroxide production, and Cadeby Quarry near Doncaster, which supplies dolomite for the glass industry and filler applications. Lafarge is the only producer of dolomitic lime (calcined dolomite), which is produced at Whitwell and Thrislington quarries. Warmsworth (The Dolomite) Quarry, also near Doncaster, is operated by WBB MINERALS Ltd and supplies dolomite to the glass industry, principally for flat glass manufacture. All of these sites also produce dolomite for agricultural use, some for export, and crushed rock aggregate. Dolomite fines produced at several other crushed rock aggregate quarries are also sold for agricultural use.

Resources

The Permian Magnesian Limestone is the main source of dolomite in Britain and is a resource of national and regional importance. Dolomite also occurs in some parts of the Carboniferous Limestone sequence but in most areas the dolomitisation is not sufficiently extensive, or of consistently high grade, to form a resource of industrial dolomite. In sharp contrast to the large resources of high-purity limestone that occur in England, dolomite resources are of lower chemical purity notably with respect to iron content which only very rarely will contain 0.2–0.25% Fe_2O_3. However, a low iron content is not critical for all applications.

The Magnesian Limestone of late Permian age crops out as a narrow, easterly dipping, north-south belt running for some 230 km from Newcastle to Nottingham (Figure 3). It comprises a series of dolomites, dolomitic limestones and limestones up to 300 m thick. The Magnesian Limestone is highly variable, both regionally and locally, in its geology, and chemical and physical properties and thus in its suitability for particular applications. Impurities such as silica, iron oxides and alumina are a prime consideration in the selection of dolomite for industrial applications, and some industrial uses also require a relatively hard stone. Dolomites with sufficiently low levels of impurities to be used as a flux in steelmaking,

Dolomite

Dolomite

for refractory use and glassmaking are comparatively scarce in Britain

In north-east England (County Durham), the Raisby Formation and Ford Formation are important carbonate resources. The Raisby Formation at Thrislington Quarry is a major source of high-grade dolomite for steelmaking. Other quarries in these formations provide local sources of aggregates, with quarry fines being used as aglime. In South Yorkshire, Derbyshire and Nottinghamshire, the Permian sequence is made up of two carbonate units (the Cadeby and Brotherton formations) separated by calcareous mudstone. The total thickness (mostly <125 m) is much less than in County Durham. The Cadeby Formation is between 30–70 m in thickness and consists of a varied sequence of dolomites and limestones. Most quarries in the formation produce aggregate, but locally near Doncaster it is of higher purity, with a low iron content, and is extracted for glassmaking at Warmsworth and Cadeby quarries. It is also of relatively consistently high quality near Worksop where it is quarried at Whitwell for use as a flux and for refractory products. The quality of the stone is variable and selective quarrying of specific horizons is required to ensure that the stone meets the differing raw material requirements.

Distribution of Principal Industrial Dolomite Resources

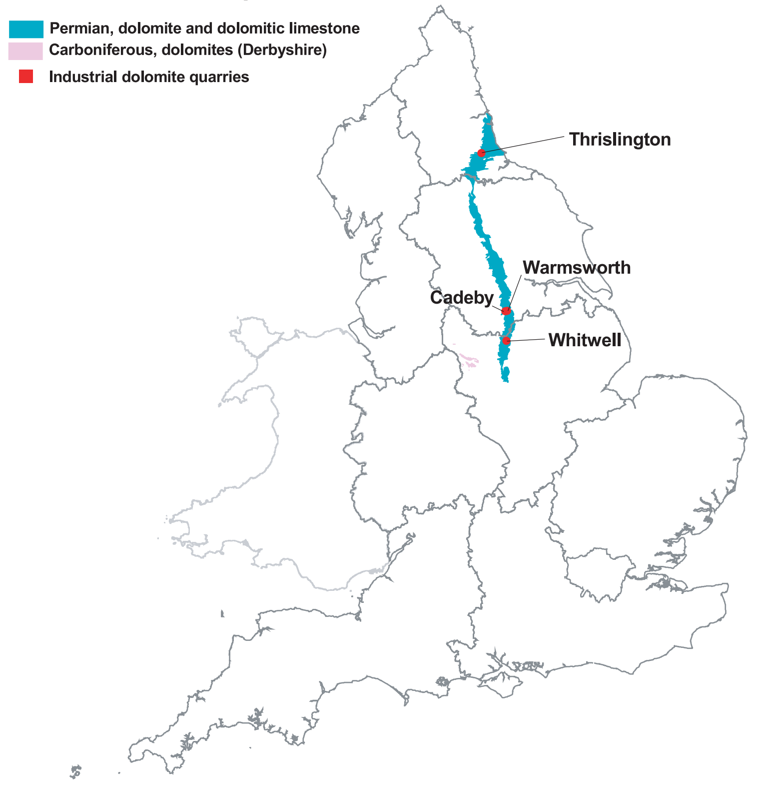

Figure 3 Distribution of principal industrial dolomite resources.

The Carboniferous Limestone has been dolomitised, or partially dolomitised, in many parts of its outcrop and in some areas the dolomitisation is sufficiently extensive to form a dolomite resource. In the Peak District of Derbyshire a large area of Carboniferous Limestone between Matlock, Monyash and Brassington has been dolomitised, although it is of variable thickness and quality. There is currently no production of industrial dolomite from these rocks, although they are locally of relatively high purity and may be of sufficient quality locally to be suitable for glassmaking. Dolomitic limestone of Carboniferous age is also extracted near Oswestry in Shropshire mainly for construction use, although some is sold as aglime.

Reserves

Permitted reserves of industrial dolomite need to be considered on a site-by-site basis, and also by their suitability for specific applications. Permitted reserves at current sites range from less that 10 years to some 15 years supply. Plants producing industrial dolomite, and particularly those with kilns for calcining dolomite, require a large capital investment of the order of tens of millions of pounds. Ongoing capital investment is over one million pounds a year. Permitted reserves should reflect this investment.

Relationship to environmental designations

The Permian Magnesian Limestone is not covered by any national landscape designations but resources are constrained in part by nature conservation designations. However, at Thrislington Quarry an SSSI (limestone grassland) was successfully translocated to another piece of land within the company ownership. Cadeby Quarry is a geological SSSI and the type locality for the Cadeby Formation. The adjacent Sprotborough Gorge is an also SSSI. The Creswell Crags SSSI bounds Whitwell Quarry to the south.

Extraction and processing

Dolomite is extracted by surface quarrying using drill and blast techniques although breaking by impact hammer is used at one operation. The dolomite is quarried at several distinct levels, known as 'benches', to manage the stone quality, which may vary considerably in chemistry and hardness. Processing can be simply divided into crushing, screening, grading and storage prior to loading and transportation. However, various grades of dolomitic lime are produced at Thrislington and Whitwell quarries by burning the stone in rotary kilns at very high temperatures in the range 1450°C–2000°C. Residence times in the kiln are between 3.5 and 6 hours. At such high temperatures the dolomite is transformed from the double carbonate ($CaCO_3.MgCO_3$) to the oxide form (CaO.MgO), with carbon dioxide being driven off as a gas. Dependent on the product, additives, mainly iron, are also injected into the kiln. For refractory brick manufacture the dolomite goes through a second sintering (firing) stage after being pelletised to achieve the high bulk densities necessary for refractory use. Lower temperature calcination produces a more reactive dolomitic lime suitable for use as flux. Distinct size fractions (typically 38 mm–19 mm and 19 mm–8 mm) are required for burning. This is a factor of some practical importance in that the yield from crushing to achieve suitably sized stone for burning can be as low as 45% because of losses into the fines. These fines, including fines generated in the kiln, are sold for agricultural use.

A critical factor in dolomite used for glassmaking is consistency in quality and notably in iron content. A major feature of processing is, therefore, achieving a consistent product by carefully controlled blending.

By-products

All industrial dolomite quarries also produce significant quantities of crushed rock aggregates. The largest quarries producing industrial dolomite are Thrislington and Whitwell and each quarry produces over 1.2 million tonnes annually. The proportion of dolomite going for industrial use is generally less than 50% of the total. The fines from quarrying dolomite both for industrial and construction use are typically sold as aglime.

In Durham the Permian Basal Sands crop out intermittently at the base of the Magnesian Limestone escarpment and dip to the east beneath the dolomite. They consist of fine to medium-grade sand and comprise a resource of fine aggregate mainly used as building sand. The sand is mainly worked in association with the overlying dolomite, for example where they are exposed in the base of Thrislington Quarry.

Alternatives/recycling

Dolomite is valued for its magnesia (MgO) content and it is this, which distinguishes it from limestone. It can be partly substituted for by limestone for certain applications, although in practice it is dolomite that tends to replace limestone. Dolomite and limestone both neutralise soil acidity but only dolomite can correct magnesium deficiencies in the soil. Magnesium, like calcium, is a plant nutrient. As a flux in steelmaking dolomitic lime also contributes magnesia and this imparts additional benefits, notably protection of the vessel linings from chemical wear. In ironmaking, however, olivine has largely replaced dolomite as a lime-free source of magnesia for use as a flux and slag conditioner.

In glassmaking both lime and magnesia improve durability, but magnesia is essential in improving the devitrification properties of some glasses (e.g. float glass). Dolomite is an essential raw material for float glass manufacture and there is normally no economic alternative.

One of the main advantages of dolomite as a raw material is that it is relatively inexpensive. Dolomite, because of its low price, remains the popular choice when available locally. However, the use of dolomite over its limited mineral alternatives is dependent on

Dolomite

Dolomite

the mineral's purity and its proximity to the market.

Effects of economic instruments

Dolomite that is used for prescribed industrial and agricultural processes is not subject to the Aggregates Levy.

Transport issues

Most dolomite is transported by road, using backhaul opportunities where feasible. Both Thrislington and Whitwell quarries have rail links, but only the rail link at Thrislington Quarry is in use. Substantial quantities of steel flux are transported by rail to Port Talbot steel works in South Wales. Some dolomite is transported by rail to Scotland for soil conditioning. Elsewhere dolomite is transported by road, either loose or in bulk tankers, or packed in individual bulk bags. Some bulk shipments are made overseas but mostly it is exported in sealed containers.

Planning issues

Resources of higher purity dolomite and dolomitic limestone are more scarcely distributed than high purity limestone. However, the demand for dolomite is significantly lower. Industrial dolomite is currently produced at only four sites in the UK but constraints on quality mean that indigenous dolomite is not of sufficient purity for all applications and imports are required. The close association of the uses of dolomite with iron and steelmaking, both as a flux and refractory, has meant that the mineral is considered to be of considerable national importance. Both Derbyshire and Durham have made provision to protect resources at the two main sites (Whitwell and Thrislington). Consequently, in allocating reserves, Mineral Planning Authorities, have wished to see these maximised for industrial end uses. However, all sites also produce substantial amounts of aggregate from inferior quality dolomite unsuitable for industrial use. In addition, because of particle size requirements for kiln feed material, the yield of calcined product can be as low as 50%.

Processing dolomite, and particularly high temperature calcination, requires substantial capital investment in plant. Longer-term security of supply issues are, therefore, of concern to the industry.

Authorship and acknowledgements

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Fluorspar

*The purpose of this factsheet is to provide an overview of the mineral **fluorspar**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

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.

Fluorspar working in Derbyshire.

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About 56 000 tonnes of acid-grade fluorspar with a total value of nearly £6 million were produced in the UK in 2003. There is no production of metallurgical fluorspar (metspar) in the UK, which is all imported.

Output 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. Very minor quantities are also produced near Pateley Bridge in North Yorkshire.

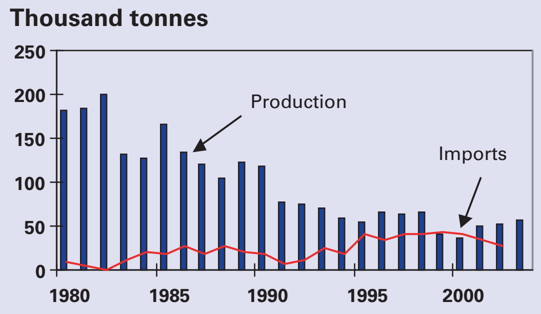

Figure 1 UK production and imports of fluorspar, 1980–2003. *Source: UK Minerals Yearbook, BGS. (Imports not disclosed between 1983–2000. BGS estimates based on exporting countries and may be overstated).*

Trade

World production of fluorspar was 4.3 million tonnes in 2001 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.

Total UK consumption	**80 000 tonnes**
Domestic sales	53 000 tonnes
Net imports	27 000 tonnes

Table 1 UK Consumption of fluorspar, 2002.

Economic importance

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 fluorochemical manufacture, is very much greater and estimated at £150 million in 2003. Some 460 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

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have been a number of other ventures to produce fluorspar, both in the Southern and 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 two main consumers of fluorspar, who account for some 95% of total sales, are the HF and fluorochemicals producers INEOS Fluor, the largest consumer, and Rhodia. INEOS Fluor (acquired from ICI in 2001) is a worldwide manufacturer of fluorochemicals with its headquarters and main manufacturing facility in Runcorn. Rhodia have announced that it is to close its HF manufacturing facility at Avonmouth in October 2004. Production of fluorochemicals will continue with HF sources from other suppliers.

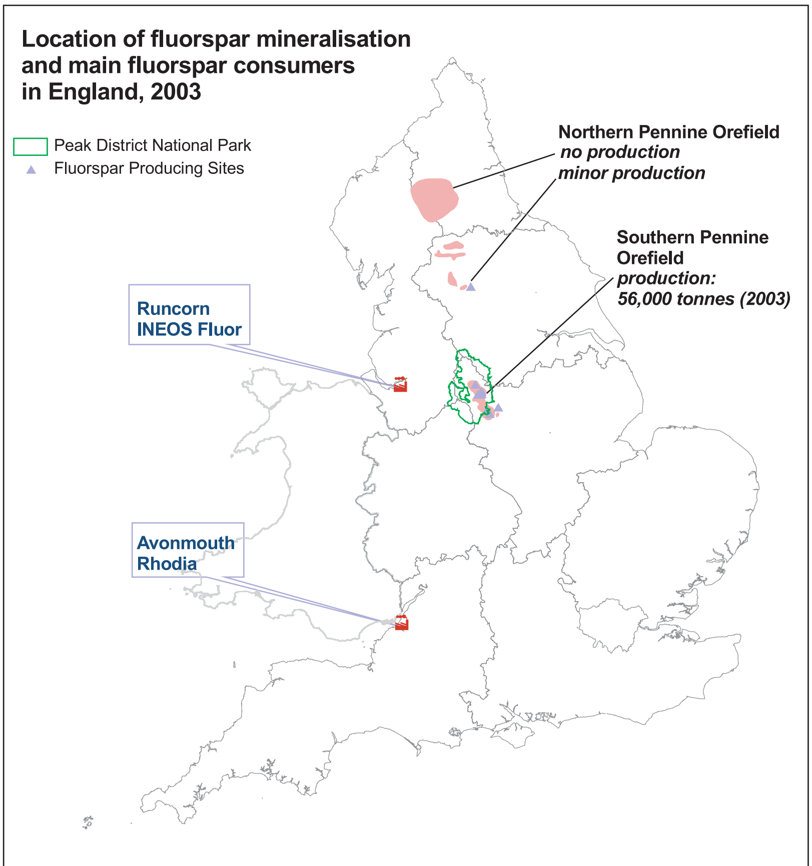

Figure 2 Location of fluorspar mineralisation and main fluorspar consumers in England, 2003.

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, almost all production has been confined to the Southern Pennines in the Peak District National Park (see Figure 3). Small amounts are produced in adjacent parts of Derbyshire and in Yorkshire.

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.

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.

Reserves

Permitted reserves of fluorspar ore within the main producer's control are about 3.5 million tonnes. For operational reasons these can only supply at the rate of about 250 000 t/y. However, the Cavendish Mill requires 350 000 t/y of ore in order to operate economically. The shortfall is being made up with supplies from tributers and reprocessing old tailings. An active exploration programme is also continuing and a number of deposits and targets have been identified to meet this shortfall. 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 permitted reserves are located within the National Park. The principal fluorspar mineralisation in the Northern Pennine Orefield in Durham occurs within the North Pennines AONB

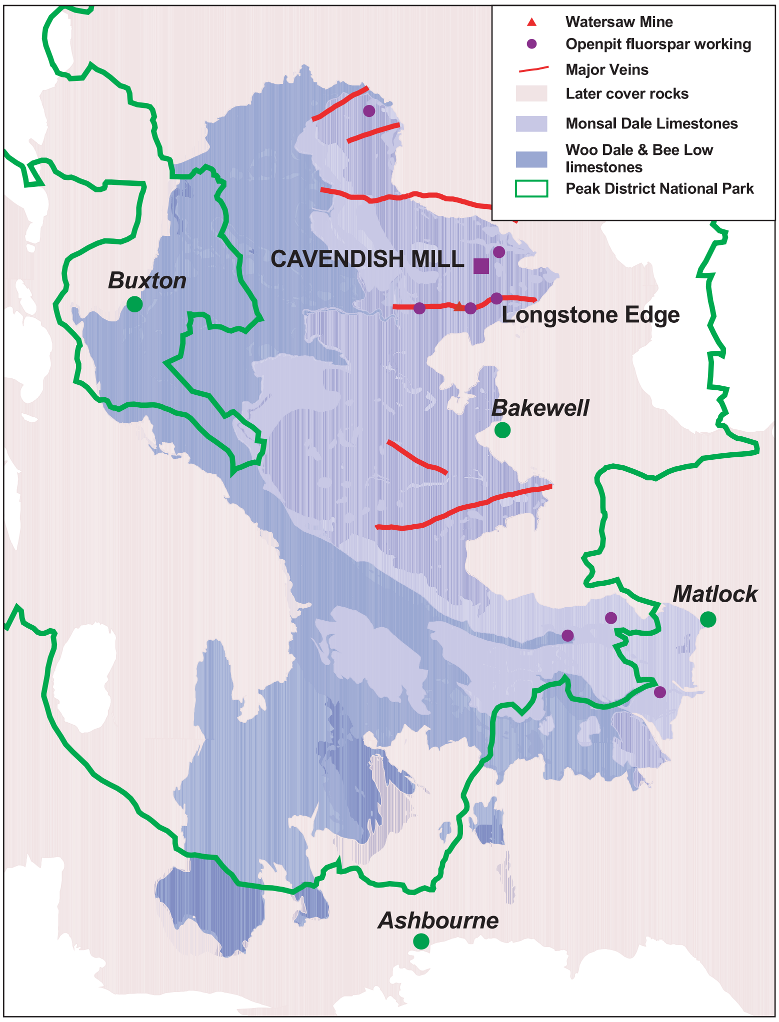

Figure 3 The Southern Pennine Orefield.

Extraction and processing

Historically ore has been derived from openpit and underground mines, with some of the openpit operations being worked by independent tributers. The importance of underground ore has declined significantly in recent years. The Milldam Mine at Great Hucklow is on a care and maintenance basis. Easily accessible ore has been worked out and the remaining mineralisation consists of a fine intergrowth of fluorspar and silica which is difficult to process to a saleable product.

Fluorspar

Fluorspar extraction is almost entirely by open pit methods. Limited amounts of ore are extracted at the Watersaw Mine on Longstone Edge but the Milldam Mine is closed and is unlikely to reopen on technical and cost grounds.

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 production of some associated limestone is inevitable but the industry is now seeking to minimise this and to use the limestone for restoration.

All of the ore is processed at the Cavendish Mill, near Stoney Middleton. Current fluorspar ore requirements are some 350,000 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.

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

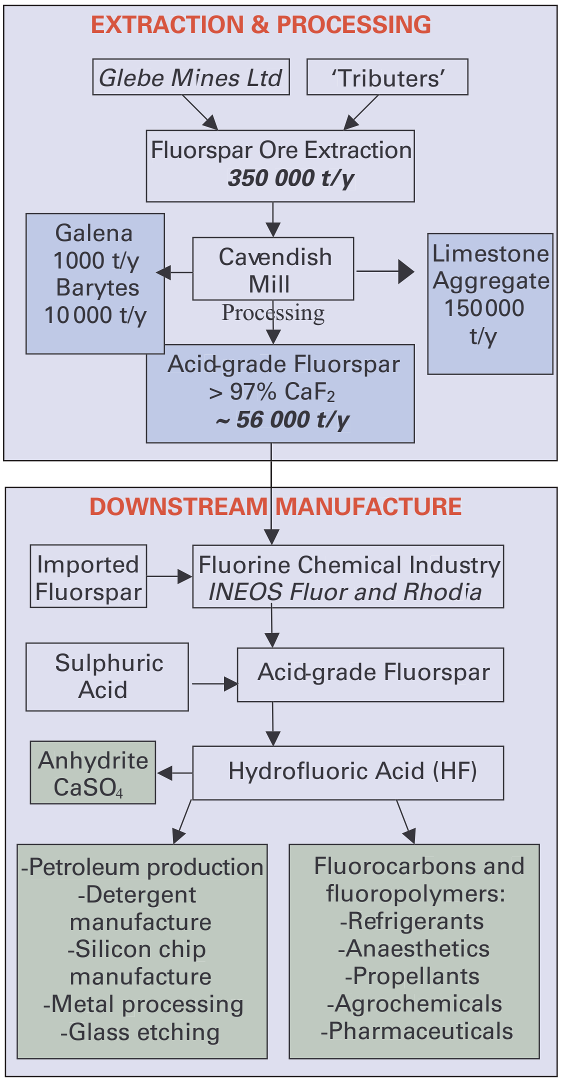

Figure 4 Fluorspar supply chain, 2003.

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.

The EU has imposed anti-dumping measures on Chinese acid-grade fluorspar. In addition, the Chinese export licence fees and reducing fluorspar availability from China has ensured that fluorspar production in the EU remains economically viable. This helps to underpin an important sector of the UK chemicals industry.

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 fluorspar 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.

There are permitted reserves of fluorspar which are accessible by underground mining, and there is scope for further deposits being 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) means that future commercial interest is likely to be confined to sites suitable for surface extraction.

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

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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.

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 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 and Deborah Rayner.

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

Fuller's earth

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Mineral Planning Factsheet

*The purpose of this factsheet is to provide an overview of the mineral **fuller's earth**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Fuller's earth is a sedimentary clay that contains a high proportion of clay minerals of the **smectite** group. The most commonly occurring smectite clay mineral is **montmorillonite** and this is the essential constituent of British fuller's earths. However, the term smectite is used in this factsheet. One of the properties of smectite is a high 'cation-exchange capacity', in which exchangeable cations, usually calcium (Ca^{2+}), magnesium (Mg^{2+}) or sodium (Na^{+}) are loosely held on the inter-layer clay crystal surfaces. Depending on the dominant cation present the clay has markedly different properties and industrial applications. **Ca-smectite** is the principal constituent of British fuller's earths and those that have been worked in recent years commonly contain some 80–85% smectite. A common impurity is quartz. Ca-smectite can readily be converted to **Na-smectite**, by a simple process involving the addition of small amounts of sodium carbonate. It is commercial practice in Britain to refer to the sodium-exchanged clay as bentonite, which exhibits markedly different properties than fuller's earth. Outside the UK, the term **bentonite** is commonly used to describe smectite-rich clays irrespective of whether they are Ca or Na-smectite.

Fuller's earth extraction.

Demand

Smectite clay minerals are characterised by a unique combination of properties on which their wide range of industrial applications are based. These properties include small crystal size, high cation-exchange capacity, large chemically active surface area, high plasticity, swelling characteristics, and water sealing and bonding properties. The suitability of fuller's earth (and bentonite) for specific applications is dependent on mineralogy and on the physico-chemical properties of the smectite clay. Not all fuller's earths will exhibit the same properties and some may be more suitable for one application rather than another.

Until the latter part of the 19th century, fuller's earth was used primarily for cleaning or 'fulling' woollen cloth. However, not all these clays constituted fuller's earth as defined today. During the 20th century, the uses of fuller's earth expanded. The most important applications included a bonding agent for foundry sands, in civil engineering and oil well drilling fluids, for pet litter, water stable carriers for pesticide and herbicides, for refining edible oils and fats, the manufacture of carbonless copy paper and as a fibre and filler retention aid in papermaking.

With the decline in domestic production, however, many of these uses have been taken over by imported material or have ceased altogether. Current production is used as a fibre and filler retention aid in papermaking systems, mainly for the export market, and as a bonding agent for foundry sands.

Supply

Fuller's earth has been produced in England since Roman times. Official records began in 1854 and it is estimated that cumulative output since then has been about 9.3 million tonnes. Peak output was 216 000 dry tonnes in 1985 but output has since declined as reserves with planning permission have been depleted (Figure 1). Production was 34 000 dry tonnes in 2003 and it seems likely that production will cease entirely by about 2010.

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Fuller's earth

Current production is confined to Baulking in Oxfordshire and Woburn in Bedfordshire. Output at Woburn will cease in spring 2005. Historically, the deposits in the Redhill-Nutfield area of Surrey have been the most important source, accounting for about 65% of the total cumulative output. However, production ceased in Surrey in 1998. The deposits between Woburn and Woburn Sands in Bedfordshire were the second most important source. Elsewhere fuller's earth has been worked at Clophill, also in Bedfordshire (production ceased in late 2000) and, on a modest scale in Kent, where production stopped in 1983. Underground mining in the Bath area ceased in 1979.

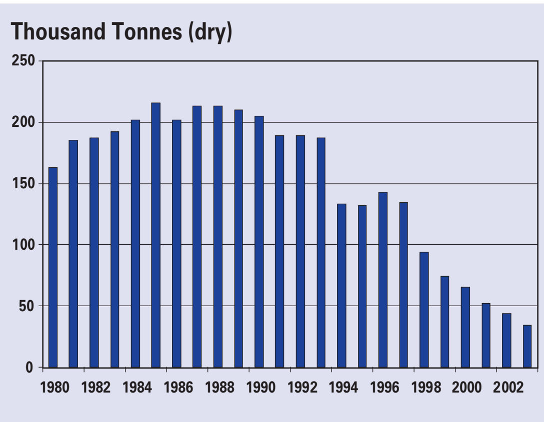

Figure 1 England: Production of fuller's earth, 1980–2003. *Source: United Kingdom Minerals Yearbook, BGS.*

Trade

UK trade is believed to be mainly in the form of bentonite. With the depletion of indigenous reserves and a consequent decline in production, imports of bentonite have been on a generally rising trend, being 77 000 tones in 1980, 154 000 tonnes in 1990 and over 255 000 tonnes in 2000. At the same time exports have been generally falling (Table 1).

Consumption

UK consumption of fuller's earth/bentonite is currently believed to about 180 000 t/y.

	Exports		*Imports*	
	Tonnes	*£000*	*Tonnes*	*£000*
1999	76 459	17 784	246 341	13 021
2000	75 472	15 774	255 942	14 129
2001	72 983	16 314	235 517	14 731
2002	81 707	17 538	216 021	12 189

Table 1 UK: Imports and exports of bentonite, 1998–2002. *Source: HM Customs and Excise.*

Economic importance

The total value of fuller's earth sales in 2002 is estimated at just over £5 million. The mineral has value added uses in papermaking systems mainly for the export market, with associated sales of polymers and equipment, and also in the castings industry. Although the paper industry in the UK is small, the castings industry remains important with total sales of £2.7 billion.

Structure of the industry

Fuller's earth is produced by two companies; Rockwood Absorbents (Baulking) Ltd and Steetley Bentonite and Absorbents Ltd. Rockwood Absorbent's operation is at Baulking in Oxfordshire. Output is currently from stockpiles of fuller's earth, which is converted to bentonite on site for use as a fibre and filler retention aid in papermaking and a bonding agent for foundry sand.

Steetley Bentonite and Absorbents, a wholly-owned subsidiary of Tolsa SA of Spain, has produced fuller's earth near Woburn in Bedfordshire since the 1950s. However, production will cease in spring 2005 due to the exhaustion of permitted reserves.

Resources

Smectite clay minerals are stable at the Earth's surface and in shallow sedimentary

Fuller's earth

Fuller's earth

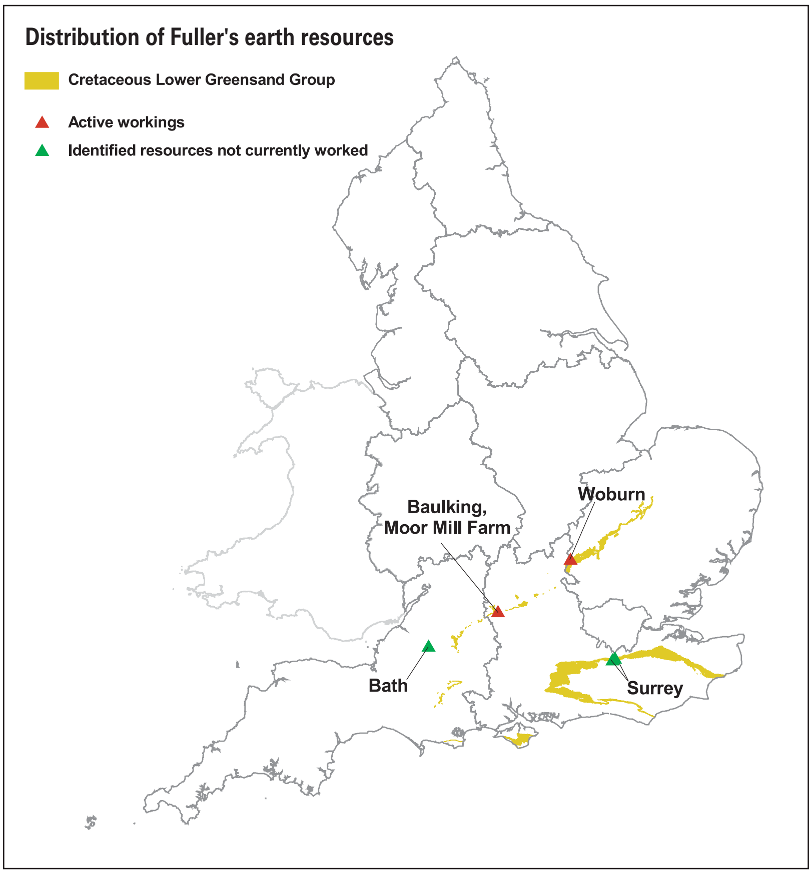

Figure 2 Distribution of fuller's earth resources.

basins, but with increasing depth of burial they progressively alter to other clay minerals with no useful properties. Discrete smectite is effectively absent in British sedimentary rocks that are older than the Triassic, largely because such rocks have been buried more deeply. This precludes the occurrence of fuller's earth over large tracts of western and central Britain where the rocks are almost exclusively of pre-Jurassic age. In addition, although smectite is abundant in the clay fraction (<2 microns) of many sediments of post-Triassic age, in most of these the clay fraction only forms a small part of the whole rock. Overall concentrations of smectite are small and even in mudstones (clay-rich rocks) only very rarely exceed 30%.

Fuller's earth deposits were formed by the alteration of volcanic ash deposited in sea-water. The accumulation and, more importantly, preservation of volcanic ash to form fuller's earth beds of sufficient thickness for commercial extraction involved a complex set of geological processes. In Britain these conditions have occurred only rarely and over geographically-restricted areas. Consequently, fuller's earth deposits of potential economic interest have a very restricted distribution in Britain.

Fuller's earth beds range in thickness from a few centimetres up to some 5 m, although 2–3 m is more typical of worked deposits. The beds are often lens-shaped and some may only persist over a few tens of metres. However, others are more extensive and in rare cases beds can be traced for several kilometres. Different beds may have different properties depending on the amount of contaminating impurities present and the inherent characteristics of the smectite clay mineral. This may be due to small differences in the way that the clay originally formed from volcanic ash.

Fuller's earth deposits that are, or have been, of commercial interest in Britain occur only in sediments of Middle Jurassic (Bathonian) and Lower Cretaceous (Aptian) age in southern England (Figure 2). Jurassic resources are confined to a single bed (the Fuller's Earth Bed) which is up to 3.3 m thick and occurs 3 m to 10 m below the top of the Fuller's Earth Formation at the base of the Great Oolite. The extent of the Fuller's Earth Bed is fairly well defined to the south of Bath where resources are several million tonnes. These resources are considerably more extensive than the Lower Cretaceous deposits in the Lower Greensand but are only workable by underground methods. Mining ceased in 1979 for economic reasons and because of the low quality of the fuller's earth, which contains a high proportion of calcite with smectite contents of only some 60%. Fuller's earth production is now confined to deposits in the Lower Cretaceous Lower Greensand which have accounted for most of cumalative output.

The deposits in the Redhill-Nutfield area of Surrey have been by far the most important, with those between Woburn and Woburn Sands in Bedfordshire being the second most important source. Elsewhere deposits have been worked at Clophill, also in Bedfordshire, at Baulking in Oxfordshire and, on a modest scale, at Maidstone in Kent. A number of fuller's earth occurrences have been identified in West Sussex and Hampshire but none are considered to be of economic interest.

The British Geological Survey undertook a detailed appraisal of fuller's earth resources in England in 1990–91. During the course of this appraisal a number of new occurrences of fuller's earth were discovered. The majority of these were thin beds, often of low grade and of no economic interest. More significant discoveries included extensions to the already known deposits in the Godstone-Tandridge area in Surrey and a satellite deposit in the Baulking area in Oxfordshire.

The examination of a large volume of data collected over many years, together with up-to-date geological knowledge on the origin and occurrence of fuller's earth has also shown that large parts of the Lower Greensand are not prospective for fuller's earth. Moreover, no fuller's earth deposits comparable to those in the Bath area appear to exist elsewhere within Jurassic strata in England.

The conclusions of the BGS study were that the best prospects for finding thick fuller's earth deposits were in those areas near to known deposits. In addition, the BGS stated that in view of the large body of data now available it is extremely unlikely that deposits of a size comparable to the Redhill and Woburn deposits remain undetected. Since the publication of the 1991 report the BGS is not aware of any new discoveries of fuller's earth and believe that the conclusions to their report remain valid.

Reserves

Permitted reserves of fuller's earth are very limited, being less than 350 000 dry tonnes, almost all of which is confined to the Baulking area of Oxfordshire. Proved resources in Surrey and Bedfordshire of nearly 2 million dry tonnes have been refused planning permissions for extraction. The bulk of these are in Surrey. The original Baulking Quarry was exhausted in summer 2002. Current sales are based on clay stocks.

Remaining permitted reserves of fuller's earth at Baulking are confined to a small satellite deposit at Moor Mill Farm, about 2 km from the plant at Baulking. The deposit has reserves of about 300 000 dry tonnes. This deposit, which was granted planning permission in 1998, will be opened up in spring 2004, with anticipated first production in the third quarter 2004.

At Woburn, a planning application to work the southern extension of the fuller's earth deposit was refused planning permission in July 2002 following a public inquiry. The site (Wavendon Heath South) contains 320 000 dry tonnes of fuller's earth.

In Surrey, an application to extract a reported one million dry tonnes of fuller's earth at the Waterhouse Farm site, near Bletchingley and 0.59 million dry tonnes at the Jackass Lane site, near Tandridge was refused in 1989 following a public inquiry. These two deposits represent the largest unworked resources of fuller's earth in Britain that are likely to be of commercial interest.

Relationship to environmental designations

Extensive parts of the Lower Greensand of the Weald, particularly in west Surrey, parts of Hampshire and West Sussex, occur within AONBs. Much of the remainder of the Lower Greensand outcrop lies adjacent to these areas. The Surrey deposits are adjacent to the Surrey Hills AONB. The Bath deposits partly lie within the Cotswolds AONB.

The Woburn deposit occurs in a locally-designated Area of Great Landscape Value. This was a major factor in the refusal of the planning application to work the final southern extension of the deposit. The need for the mineral was held to be insufficient to outweigh the environmental drawbacks given the alternative solutions likely to be available to the papermaking industry.

Extraction and processing

Since 1979, when underground mining of the Jurassic fuller's earth near Bath ceased for economic reasons, extraction has been solely by opencast methods. Overburden to mineral thickness ratios depend on the nature of the overburden and the ease, and thus cost of removal; ratios of 20 to 1 have been feasible in soft sand.

Fuller's earth is never used in raw form but undergoes processing essentially to modify its properties for a particular use rather than to increase the smectite content of the clay. In the recent past this processing involved acid activation or leaching with sulphuric acid. However, production of acid-activated fuller's earth has now ceased in Britain.

Fuller's earth is characterised by a high moisture content of up to 40%. Initial processing consists of crushing and drying prior to being milled to a fine powder. The air swept grinding mills used means that there is some removal of coarse sand particles. Almost all fuller's earth extracted in Britain is converted to bentonite. This involves the introduction of small amounts of sodium carbonate (usually 2 to 4%) to the wet clay prior to drying and grinding which converts the Ca-smectite to Na-smectite by cation exchange.

By-products

There are no by-products of fuller's earth extraction. In the past calcareous sandstones associated with the fuller's earth beds in Surrey were used as a local source of low-grade crushed fill. Elsewhere the Woburn Sands overlying the fuller's earth bed at Woburn are too fine-grained for commercial use.

The large void created by the extraction of fuller's earth at Redhill has been used for landfill.

Alternatives/recycling

Other fibre and filler retention systems are used in the paper industry, although none have a manufacturing base in the UK.

In the foundry industry most metal is cast in 'greensand' moulds in which a mixture of silica sand and bentonite is mixed with water to give sufficient plasticity for the mould to be formed. Volume producers of castings use automatic systems in which the used mould is disaggregated and the sand recycled with a small addition of new bentonite to make good that destroyed in the casting process.

Transport issues

Fuller's earth products are transported by road in bulk or in bags.

Planning issues

The geology of fuller's earth in England means that workable deposits are very restricted in their geographical and geological extent. A significant proportion of known deposits are now exhausted. Those that remain are either small, or in areas where the need for the mineral was held to be insufficient to override the harm to local amenities (principally landscape), despite the fact that none of these are in areas designated as nationally significant (although the Surrey sites are overlooked by an AONB). Recent planning decisions in Surrey and Bedfordshire have been critical in forcing the closure of the industry in what were its main producing areas. Fuller's earth is, therefore, the first extractive industry to close due to planning restrictions. However, given the shortage of workable deposits, it may be that planning controls brought about this closure only a decade or so before resource depletion would have achieved the same result.

The closure of the Bath deposits was a result of geology and economics, relating to the high costs of underground mining, and not planning related. However, any future scope for surface working would be limited by both economics and planning.

Although the use of domestically-produced fuller's earth as pet litter has been an issue in the past, all current production from England is now used in the higher value applications described earlier in this factsheet.

Further information

An appraisal of fuller's earth resources in England and Wales. B S P Moorlock and D E Highley. ***British Geological Survey Technical Report***. WA/91/75. 87pp.

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Office of the Deputy Prime Minister
Creating sustainable communities

Mineral Planning Factsheet

Fuller's earth

Authorship and acknowledgements

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Fuller's earth

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Mineral Planning Factsheet

Gypsum

The purpose of this factsheet is to provide an overview of the mineral ***gypsum****. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

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. 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 known as **Plaster of Paris**. When this powder is mixed with water the resulting paste sets hard as the water recombines to produce gypsum again. 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. Natural gypsum/anhydrite has been the preferred material for cement manufacture. Synthetic gypsum could be 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.

Demand for gypsum is being driven principally by the plasterboard sector, which is growing because of the thermal and acoustic benefits of plasterboard. Increasing quantities of desulphogypsum will be used in this sector, because, being purer, it produces a lighter, stronger wallboard. There has been an increase in demand for natural gypsum for bagged plasters and cement.

Supply

Production data on natural gypsum are confidential as there is only one UK producer (see below). The BGS have published estimates for use in its *United Kingdom Minerals Yearbook* and these are shown in Figure 1. Output is currently thought to be about 1.7 Mt/y. Natural gypsum/ anhydrite production is confined to England, with output in Cumbria, Nottinghamshire, Leicestershire, Staffordshire and East Sussex. The East Midlands is the most important region.

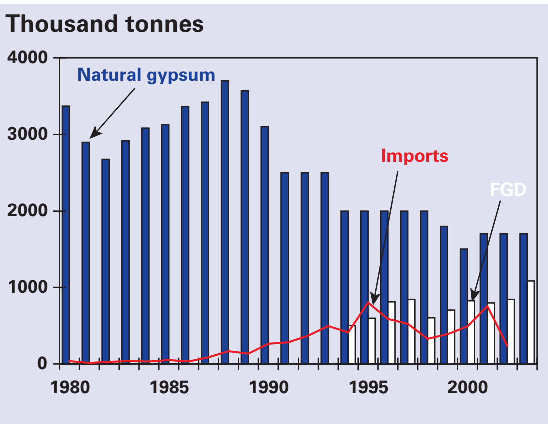

Figure 1 UK production and imports of gypsum, 1980–2003. *Source: United Kingdom Minerals Yearbook, BGS.*

The amount of natural gypsum extracted in Britain has declined appreciably in recent years due the availability since 1994 of substantial amounts of desulphogypsum. Output of desulphogypsum was a record 1 083 000 tonnes in 2003 and will increase further as new FGD plants come on stream. Titanogypsum, a by-product of the manufacture of titanium dioxide pigment, is also a substantial source (200 000 t/y).

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. Exports are small. Imports have a negative effect on the balance of payments, which was some £6.2 million in 2002.

There is little trade in plasterboard as it is relatively heavy and easily damaged. There is some trade in special (industrial) plasters.

Consumption

UK consumption of gypsum/anhydrite in 2002 (domestic production of both natural and synthetic gypsum plus net imports) is estimated to be some 3.7 million tonnes comprising:

Natural gypsum	1.7 Mt
Synthetic gypsum	1.2 Mt
Net imports	0.8 Mt

Table 1 UK Consumption of gypsum, 2002.

Economic importance

Gypsum is a relatively low priced mineral. The value of UK production of natural gypsum has been estimated at £17 million in 2002. 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 overleaf (Table 2). Plaster products (plasterboard) are based on

Gypsum

synthetic gypsum or imports. Gypsum is a relatively minor component of cement.

Plaster	£118 million
Plaster products (plasterboard)	£351 million
Cement	£757 million

Table 2 Downstream value of UK gypsum, 2002. *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 six mines and one quarry (Figure 2).

Synthetic gypsum is also produced in substantial quantities. Desulphogypsum is produced at three coal-fired power stations. The largest source is the 4000 MW Drax station in North Yorkshire, which is owned by Drax Power Ltd. Desulphogypsum is also 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. It is anticipated that it will produce some 400 000 tonnes of desulphogypsum in 2004. An FGD plant at Eggborough power station near Knottingley is due to come on stream in October 2004. Further FGD plants are being planned for several more coal-fired power stations, including, Cottam and Rugeley. British Gypsum has exclusive rights to purchase desulphogypsum from Drax and Ratcliffe and the new FGD plant at West Burton.

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.

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 2). 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.

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 to 18 m of strata. It is worked at the Kilvington Quarry. The individual worked beds range from about 0.3 m to 2 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 Leicestershire, the Marblaegis Mine in Nottinghamshire and the Fauld Mine in Staffordshire. The 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.

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. The 'A' Bed is worked at the Birkshead Mine and anhydrite forming the 'B' Bed is extracted at the Newbiggin Mine.

Gypsum

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, that 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.

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. 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 could go as high as 1:15. Overburden is used to reclaim the void, which may also be used for landfill.

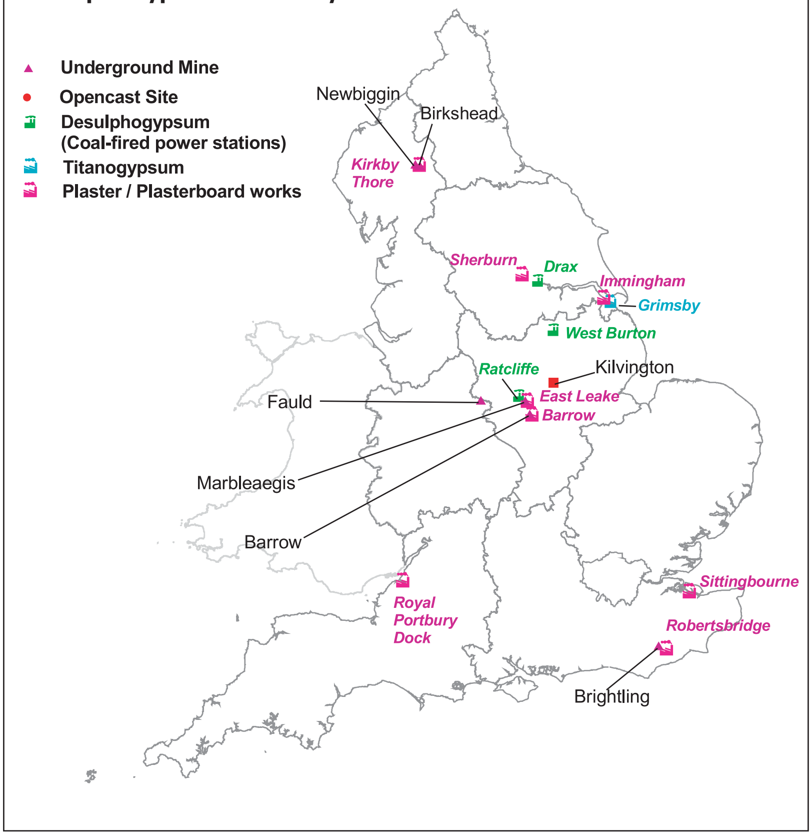

Figure 2 Principal gypsum and anhydrite producing sites.

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 hemihydrate plaster. Emissions consist only of steam. There is, therefore, little or no waste associated with the extraction and processing of natural gypsum. The gypsum/anhydrite supply chain is presented in Figure 3.

By-products

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

Gypsum

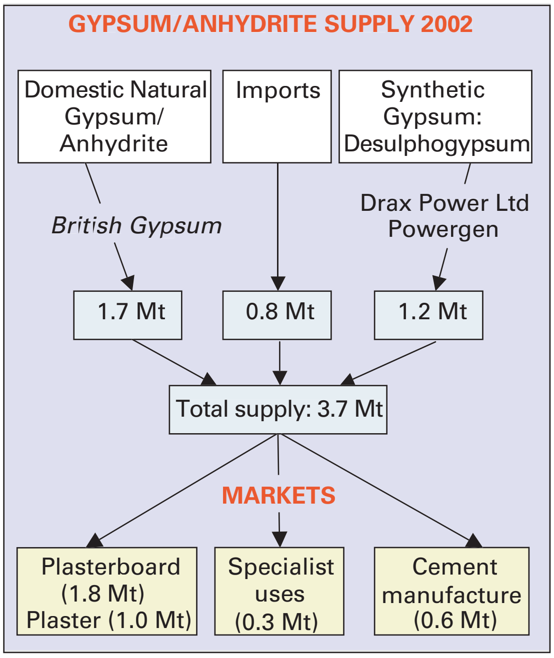

Figure 3 Gypsum supply chain, 2002.

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; and
- indigenous coal generally has a higher sulphur content than imported material and the latter is currently being consumed in preference.

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 200 000 t/y of high purity gypsum is produced and used at Immingham for plasterboard manufacture.

Calcium sulphate (anhydrite) is also produced as a by-product of the manufacture of hydrofluoric acid from fluorspar and sulphuric acid. Total production is believed to be some 150 000 t/y which is used by the building industry. Finely ground limestone and water is used to remove sulphur dioxide from gases at the Ribblesdale cement plant. The limestone is converted into gypsum, which replaces a small proportion of the natural gypsum used in the process.

Small amounts of plasterboard scrap generated during manufacture are recycled. 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. 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 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.

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

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Mineral Planning Factsheet

Kaolin

*The purpose of this factsheet is to provide an overview of the mineral **kaolin**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

China clay or **kaolin** is a commercial clay composed principally of the hydrated aluminosilicate clay mineral **kaolinite**. The term **kaolin** is used here. The commercial value of kaolin is based on the mineral's whiteness and its fine, but controllable, particle size which may be optimised during processing. Particle size affects fluidity, strength, plasticity, colour, abrasiveness and ease of dispersion. Other important properties include its flat particle shape, which increases opacity or hiding power, its soft and non-abrasive texture, due to the absence of coarser impurities, and its chemical inertness. These key properties distinguish kaolin from the other kaolinitic clays produced in Britain, such as ball clay and fireclay.

Hydraulic mining of kaolinised granite.

The kaolinite content of processed grades of kaolin varies, but is generally in the range 75 to 94%. Associated minerals may have a considerable influence on the suitability of the clay for a particular application. Kaolin from different deposits in Britain, and from around the world, have markedly different properties.

Demand

Kaolin has a range of industrial applications, which are grouped in three main market areas; paper, ceramics and 'performance minerals'. Demand is dominated by the paper industry, which accounts for about 70% of total sales. Kaolin performs two quite separate functions in the manufacture of paper. As a filler, (37%) it is incorporated into the paper web, both reducing its cost and improving its printing characteristics. It is also used as a coating pigment (33%), enhancing the surface properties of the paper, such as brightness, smoothness, gloss and ink receptivity, and thus allowing accurate reproduction in colour printing. Since kaolin improves the printing characteristics of paper, its major outlet is in the manufacture of printing and writing paper. Of particular importance is high-quality paper for colour printing for advertising and promotional literature, although other paper types are also important. Lightweight coated papers can contain up to 35 to 40% kaolin both as a filler and coating medium.

The ceramics industry is the second most important sector, accounting for about 22% of total sales. Main markets are in the UK, France, Italy, Spain, Germany and Asia. Kaolin is used in the manufacture of whiteware ceramics where its main function is to confer whiteness to the ceramic body. Its major uses are in vitreous-china sanitaryware, tableware (earthenware, bone china and porcelain), wall tiles, electrical porcelain and glazes. Fired brightness, strength and (in sanitaryware) rheological properties are the key parameters for ceramic whiteware. Properties such as strength that are desirable in ceramic manufacture may be detrimental in paper-coating applications. Kaolin is also used in refractories, where it is valued for its high alumina content.

Kaolin

'Performance mineral' applications use kaolin as fillers in paint, rubber, plastics and adhesives and sealants, and pharmaceuticals. Other uses include the manufacture of white cement and glass fibre, where kaolin is used as a source of alumina.

Supply

The UK is the world's second largest producer and exporter of kaolin after the USA. Total sales were 2.1 million dry tonnes (moisture free basis) in 2003, a significant decline on peak sales of 2.78 million dry tonnes in 1988. Since then the industry has faced difficult market conditions as a result of increasing competition in Western European paper markets from imports of kaolin from the USA and, more recently, the Amazon Basin in Brazil, which now account for a third of the total market. In addition, alternative white pigments, in particular fine ground calcium carbonates, also compete with kaolin. The future of the industry depends on the continuing supply of high-quality clay at competitive prices.

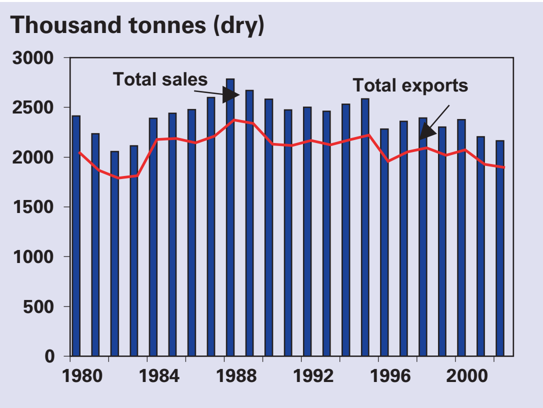

Figure 1 UK total and export sales of kaolin, 1980–2002. *Source: UK Minerals Yearbook, BGS.*

Kaolin production is confined to the granites of south-west England, principally the western and central parts of the St Austell Granite in Cornwall and the south-western margin of the Dartmoor Granite in Devon. The St Austell Granite is the most important, accounting for about 85% of total sales. Minor output from the Land's End Granite ceased in 1991 and from the Bodmin Moor Granite in 2001. The kaolin deposits of south-west England have yielded some 160 million tonnes of marketable product since production began in the mid-18th century.

Trade

For many years, kaolin has been Britain's most important mineral export after hydrocarbons. In 2002 some 88% of total sales valued at about £187 million were exported, principally to destinations in Western Europe. This will continue to be the main market. There are no significant imports.

Consumption

UK consumption of kaolin is relatively small in comparison to total sales. Home sales have declined from some 450 000 t in 1990 to 244 000 t in 2003. The comparatively small home market is due to an absence of a significant domestic papermaking industry and the weakness of the domestic whiteware ceramics industry in the face of increasing overseas competition.

Economic importance

The kaolin resources of south-west England are a major economic asset. The total annual value of UK kaolin sales is placed at some £200 million and exports make a considerable positive contribution to the UK balance of payments. Some 2 400 people are directly employed by the industry and it is the largest private employer in Cornwall. Although domestic sales are modest in comparison to exports, they do help to underpin the UK whiteware ceramics industry. Despite facing severe competition, the industry had total sales of £839 million in 2001 and employed some 20 000 people. These jobs are concentrated in Staffordshire, especially in Stoke-on-Trent.

Structure of the industry

There are three kaolin producers in the UK; IMERYS Minerals Ltd, WBB MINERALS Ltd and Goonvean Ltd. They are members of the trade

Kaolin

Kaolin

association known as the Kaolin and Ball Clay Association UK. IMERYS Minerals Ltd is by far the largest producer accounting for over 85% of the total output with operations in both Cornwall and Devon. The company is a subsidiary of the IMERYS Group of France, the world's largest kaolin producer with major operations in the USA, the Amazon Basin and elsewhere in the world, and with about 25% of the world market. WBB MINERALS, with UK operations only in Devon, is owned by SCR Sibelco of Belgium. Goonvean is a privately-owned company with operations only in the St Austell Granite. It is also the UK's only producer of china stone which is a largely unkaolinised granite composed of feldspar and quartz and used in glazes for the ceramics industry and as a mild abrasive. Output is small (1 500 t/y).

Resources

Kaolin resources in Britain are confined to the granites of South-west England and the deposits are world famous for their size and quality. All the main granite intrusions have been worked to some extent in the past, but production has historically been based on the central and western parts of the St Austell Granite and the south-western margin of the Dartmoor Granite (Figure 2). The St Austell Granite is by far the most important source, accounting for most of the high-brightness, speciality paper-coating grades. It will continue to be the principal source in the future.

The kaolin deposits are of primary origin and were formed by the *in situ* alteration of the feldspar (mainly plagioclase) component of the granites. The kaolinisation process involved the decomposition of feldspar by hydrothermal fluids and surface weathering to form kaolinite and mica. Most other minerals are largely unchanged by this process. The clay mineral smectite may sometimes form as an intermediate product between feldspar and kaolinite. Its presence, even in very small amounts, is com-

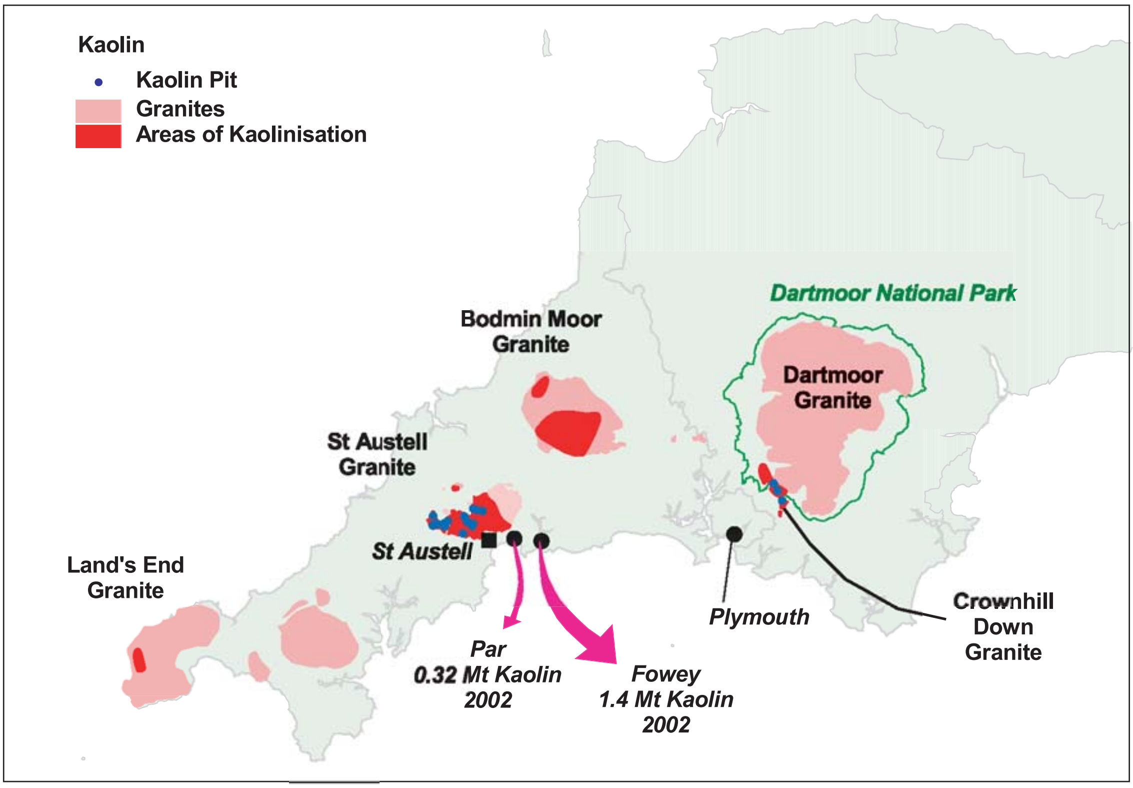

Figure 2 Granite outcrops and areas of kaolinisation, SW England.

mercially important as it has a detrimental effect on the performance of paper-coating clays, although it increases the strength of ceramic clays, which is beneficial to some ceramic bodies.

Zones of commercial kaolinisation are generally related to permeable fracture and vein systems through which the kaolinising fluids circulated. The kaolinised zones are funnel or trough-like in form narrowing downwards (Figure 3) but merging of funnels gives more extensive zones of kaolinisation. Kaolinisation may extend to depths of over 250 m, although 100 m is more typical, a fact that has important practical implications for kaolin production since opportunities for progressive backfilling of pits is limited.

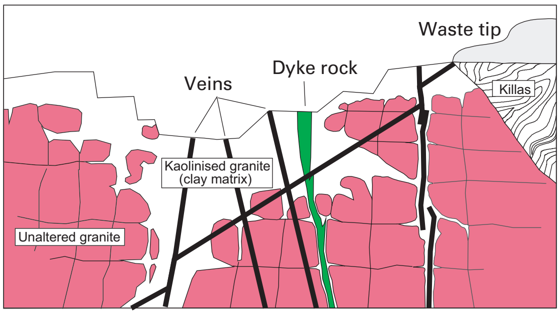

Figure 3 Cross section of a kaolin deposit.

Kaolinised zones contain a wide spectrum of rock types from hard, unaltered granite through to a soft kaolinised 'clay matrix' consisting of a friable aggregate composed principally of quartz, mica, unaltered feldspar, tourmaline and fine-grained kaolinite which mainly occurs in the < 20 micron fraction. The kaolinite content of the clay matrix is variable but typically in the range 15–25%. However, because of the presence of hard, unaltered granite and quartz/tourmaline veins, known locally as 'stent,' overall recovery of kaolin may be as low as 10%.

The St Austell Granite covers an area of about 93 km^2 and is extensively kaolinised in its central and western parts over an area of about 63 km^2. The western part of the St Austell Granite has traditionally supplied ceramic clays, the central part paper-coating clays and the eastern part filler clays. Blending and improved processing technology now make this statement an oversimplification.

Kaolin is also produced on the extreme south-western edge of the Dartmoor Granite and on the adjacent, but separate, Crownhill Down Granite. Kaolinisation has been intense. There is a higher proportion of sand and less rock than in the St Austell Granite. The kaolin also has lower iron and potash contents than in Cornwall and a larger proportion of sales are used in ceramics and as performance minerals. There is also a significant output of calcined kaolin for which the clays are well suited. This involves heating the clay at different temperatures to produce clays with enhanced brightness.

Reserves

A figure for total permitted reserves of kaolin is not available for commercial reasons. However, sufficient proved reserves of kaolin exist in and around existing pits both in Cornwall and Devon to sustain current rates of production, using existing technology, for at least 40 years. Reserves thus exceed the life of current planning consents. In detail the figures differ by grade, area and company. The projected life of reserves in Devon exceeds those in Cornwall. However, a critical factor in considering reserves is the availability of tipping space for mineral waste. Without this the industry could be considerably constrained unless current sales of these wastes as secondary aggregate increase very substantially. Reserves will be sterilised unless additional tipping space is permitted

Relationship to environmental designations

Kaolinisation on the south-western part of the Dartmoor Granite is adjacent to and extends into the Dartmoor National Park. In 2001, the two companies working in the area announced their intention to relinquish their planning permissions within the National Park because of the impact that would have on a sensitive area.

Operations in Cornwall are subject to national environmental designations and, on the periphery, European designations, which could possibly restrict future development.

Extraction and processing

The extraction and processing of kaolin in south-west England involves the production of very large quantities of mineral waste. The disposal of this waste is a major problem because of the large areas that are required and the visual impact. The waste produced is of two main types. Coarse material comprising sand (mainly quartz) and rock waste, which if not sold is disposed of in large tips or backfilled into pit voids, where sterilisation of unworked reserves will not result. A fine slurry waste called mica residue is disposed of in large lagoons and abandoned kaolin pits. In the lagoon the mica settles out and the water is pumped off for reuse.

Kaolin extraction has traditionally been by hydraulic mining in which high-pressure jets of water are used to disaggregate the weak, kaolinised granite and disperse the kaolinite particles, together with the other components of the granite, into a slurry. Ripping, drilling and blasting of the granite are also used to improve yields and unkaolinised material is removed for tipping , although some is processed into aggregate. Recently, dry mining has been introduced in some areas, notably in the Dartmoor Granite. This allows more selective extraction and improved yields. The kaolinised granite is extracted by shovel and truck and is transported to a primary screening process to remove large oversize material. The undersize is disaggregated by high-pressure jets of water for subsequent processing in the conventional way.

Separation of the fine kaolinite particles from the coarser waste, consisting mainly of quartz, unaltered feldspar and mica, is by a series of wet refining techniques. Ultrafine flotation is used to recovery coarse kaolinite. Some older mica lagoons are being reworked to recover coarser kaolinite formerly lost in processing. Additional techniques are used to improve the brightness (whiteness) and particle size of specific grades of clay. These include blending, fine grinding, chemical reductive bleaching and/or the removal of iron-bearing impurities using superconducting magnets. Some clays are also calcined at specific temperatures to give different products. Finally the clay is dried to a powder or pellets, or supplied in slurry form as a suspension of clay in water

The disposal of the sand and other waste products is a major, and increasing, problem because of the large areas that are required and the visual impact. Backfilling of pits has not, in general, been possible because this would result in the sterlisation of reserves in depth. However, some disposal into abandoned pits is now taking place where this will not affect reserves or the requirements for water holding areas. As the surface extent of workings reach their practical limits an increasing amount of backfilling is now becoming possible.

The kaolin supply chain is summarised in Figure 4.

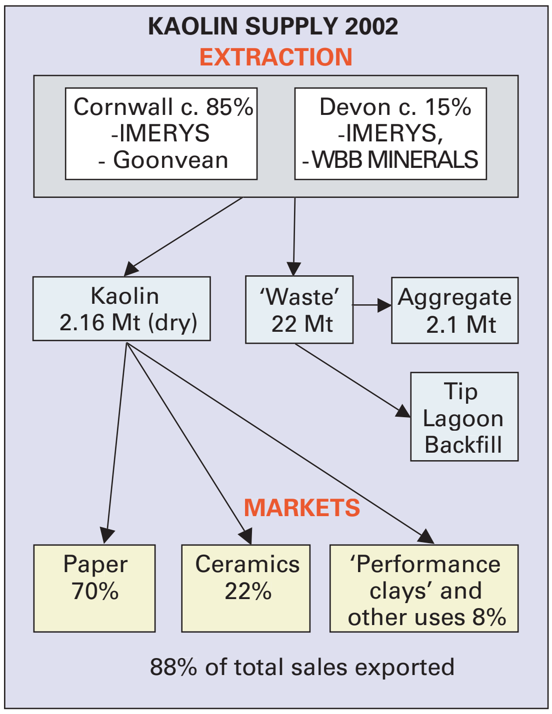

Figure 4 Kaolin supply chain, 2002.

By-products

Each tonne of marketable kaolin recovered typically produces up to 9 tonnes of waste, comprising approximately 4 tonnes of granular waste (sand), 2.5 tonnes of rock waste (stent), 1.5 tonnes of overburden and 1 tonne of micaceous residues. Total industry waste arisings are some 22 million tonnes a year, of which some 10 million tonnes is sand. The total industry 'stockpile' has been estimated at over 600 million tonnes, although much of this is now in tips that have been engineered and landscaped. Currently just over 2 Mt/y of waste are sold, as a source of secondary aggregate. These sales are mainly derived from waste currently produced.

Alternatives/recycling

Kaolin itself is used as a substitute in filler applications, for example to replace more expensive fibre in papermaking and polymers in plastics. In addition, it imparts improved functional properties to these materials.

Alternative white minerals are also used as fillers in paper, paint and plastics and as coating pigments in paper. The most important is fine ground calcium carbonate (chalk, limestone and marble), which is widely available, but talc is also used in some countries. Precipitated calcium carbonate is also finding increased use. The former dominant position of kaolin in the paper industry has been eroded by the change from acid to alkaline and neutral papermaking systems, which allow the use of calcium carbonate as a filler. The introduction of finely ground calcium carbonates also allowed their use in paper coating. Consequently, calcium carbonate now has some 50% of the paper market, although the growth in the total size of the market has meant that demand for kaolin has remained static. However, this substitution may now have reached its limit because the platey structure of kaolin remains a desirable property for many applications.

Recycling of paper allows some of the mineral components to be recovered.

Effects of economic instruments

Sales of sand and crushed rock derived from kaolin extraction and processing are exempt from the Aggregates Levy, which was introduced at the rate of £1.60/t in April 2002. This has given a further stimulus to their increased usage and some 2.1 million tonnes were sold in 2001, almost all locally, although small quantities were shipped to London and the South East. However, the local market is effectively saturated and increasing sales will depend on raising the level of shipments through Par Harbour. Some 137 000 t of aggregate was transported through Par in 2002, almost three times the level in 2001. Some shipments were to Europe. There are also plans to further increase shipments to 750 000 t/y by 2006. However, larger shipments will depend on building new deepwater jetties to accept larger ships. Plans for shipping aggregate from the Devon operations through Plymouth are also under consideration.

Kaolin production is subject to the Climate Change Levy (CCL), which is primarily aimed at reducing carbon dioxide emissions, but via its proxy—energy use. Kaolin production is energy intensive and thus is siginificanly affected by the Levy. However, as most (88%) kaolin is exported the industry considers that it has been placed at a competitive disadvantage with respect to other players in the global market who are not subject to the Levy. The CCL was a contributing factor to the transfer of some kaolin production to the Amazon Basin.

Transport

As the bulk of production is exported through the ports of Par and Fowey, most shipments are by sea. Overall some 77% is transported by sea, 13% by rail and 10% by road.

Planning issues

The disposal of very large quantities of sand and rock waste is the main planning issue associated with kaolin extraction and processing.

Finding suitable tipping space to accommodate this waste remains a continuing problem and

Kaolin

may be the main constraint on the future of the industry rather than the extent of reserves.

The waste is a major aggregate resource, but the problem remains in getting aggregate to the main market in south-east England. Exports out of Cornwall are increasing but large investment in ship loading facilities will have to be made in order to make a major impact (see above).

Restoration of both tips and pits is also a major planning issue. In order to maintain flexibility and conserve reserves at depth, some individual pits may have considerable longevity. This can sterilise void space that might otherwise be used for backfill. However, increasing amounts of waste will be backfilled in the future as pits are exhausted. In addition, the requirement for the industry to seek new permissions for waste tipping from time to time does provide opportunities to tackle the legacy of degraded landscapes, past environmental damage and lack of alternate land uses. Significant areas are being restored to heathland.

Concentration of working and their cumulative impact on the landscape is linked to the problem of waste material. In Cornwall, active and legacy workings, together with associated tips, are concentrated in a relatively small area (less than 90 km^2). This has had a major intrusive effect on the St Austell area. The Devon workings are largely located on high ground, close to the border with the Dartmoor National Park, with consequent issues over visual intrusion, as well as impacts on sensitive moorland ecology and archaeology.

Further information

Vision for the Future. Blueprint for Cornwall 2003. IMERYS Minerals Ltd.

Authorship and acknowledgements

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Kaolin

Office of the Deputy Prime Minister
Creating sustainable communities

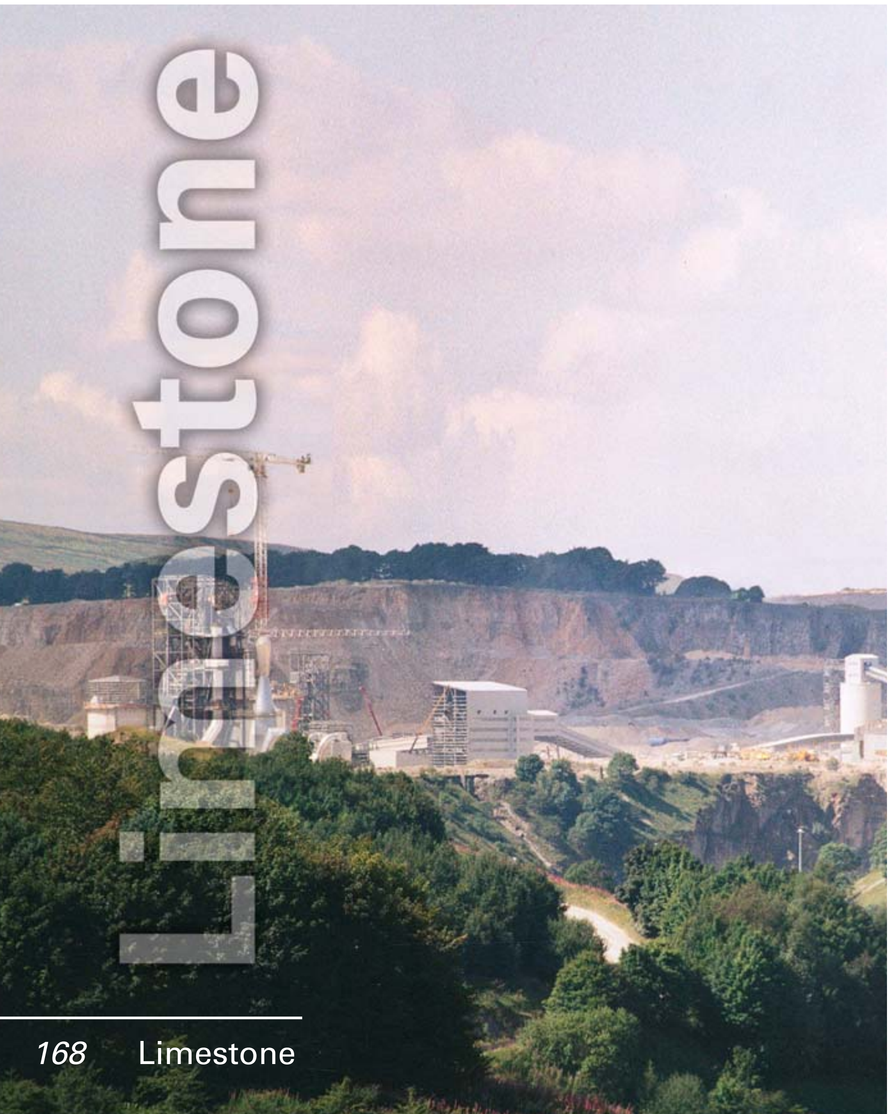
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Limestone

*The purpose of this factsheet is to provide an overview of the mineral **industrial limestone**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Three types of carbonate rock are produced in England for industrial (and agricultural purposes) – **limestone**, **chalk** **and dolomite**. Dolomite is considered separately (see factsheet on **Industrial Dolomite**). Limestones are sedimentary rocks consisting principally of calcium carbonate ($CaCO_3$). With an increase in magnesium carbonate ($MgCO_3$), limestone grades into dolomite ($CaMg(CO_3)_2$). Chalk is a type of very fine-grained limestone. Most limestones contain varying amounts of impurities in the form of sand, clay and iron-bearing materials. These impurities are usually present in very small proportions in industrial limestones, which are generally valued for their high purity (generally >97% $CaCO_3$). However, for many applications it is the amount of specific impurities present (such as iron, sulphur, silica and lead) and overall consistency that is important, rather than absolute values for calcium carbonate content.



Tunstead Quarry, Derbyshire.

Limestone is an important raw material and it is often said to be the world's most versatile mineral. It has a wide variety of applications, but its primary use is in the construction industry where it is the principal source of crushed rock aggregate in England. It is also an essential raw material for cement manufacture (see factsheet on **Cement Raw Materials**), and a source of building stone. Industrial limestone (Figure 1) is a commercial term for limestone used for non-constructional purposes, where its chemical properties or degree of whiteness are important. Limestone used for industrial purposes accounts for a relatively small but important proportion of total limestone output (about 9%).

Demand

Total demand for limestone and chalk for industrial and agricultural use was 7.3 million tonnes and 2.1 million tonnes respectively in 2002 (see Table 1). In addition, net imports of marble, were about 250 000 tonnes in 2002.

Industrial limestone is an important raw material in iron and steel making, glass manufacture, sugar refining, and numerous chemical processes, notably the manufacture of soda ash (sodium carbonate). It is also used as a mineral filler in paper, paints, plastics, rubbers, pharmaceuticals and cosmetics, and in agricultural and environmental applications. In these industrial applications, limestone (or lime, derived from the calcination or 'burning' of limestone) may be used either as a chemically reactive raw material ('chemical stone'), or as an inert filler or pigment ('limestone powder'). For almost all of these applications, the limestone must have a high chemical purity. Most markets for industrial limestone are mature markets or are shrinking due to the decline in UK manufacturing. One growth area is limestone (or lime) for environmental applications and, in particular, for flue gas desulphurisation.

Chemical stone

Limestone is used in a number of industries where its chemical properties as a basic oxide, flux, neutralising agent or source of calcium are important. Glassmaking, sugar refining and flue gas desulphurisation use raw limestone, but most of the remaining processes use limestone that has been 'burnt' to produce quicklime (CaO) or hydrated lime ($Ca(OH)_2$). Most lime sold in the British market is quicklime. UK lime production is around 2.5 million tonnes per year. About 1.7 tonnes of limestone are required to produce 1 tonne of quicklime. Tunstead Quarry in Derbyshire is the largest producer of chemical stone in the UK. Other major producing units include Shapfell in Cumbria, Batts Combe in Somerset, Hindlow in Derbyshire and Melton Ross in North Lincolnshire.

Limestone powders

Limestone and chalk are relatively soft and easily ground to a fine powder. This is non-toxic and usually white in colour. These properties ensure that limestone powders are extensively used as fillers in a diverse range of products where the primary purpose is to add low cost bulk. Some limestone powders also make use of the chemical properties of the stone. Examples include acting as a source of calcium in animal feeds, and as an acidity regulator in some agricultural and pharmaceutical products. Powder made from chalk is usually known as 'whiting'.

Many high-volume applications of limestone powders, (such as agricultural lime, carpet backing and asphalt manufacture) do not require pure limestone and are sourced from a variety of limestone quarries across Britain. In contrast, powders used in applications such as pharmaceuticals and food must be of very high purity. These are generally made by dissolving limestone or lime in acid and then precipitating pure calcium carbonate from solution. This precipitated calcium carbonate (PCC) has a very high brightness and other desirable properties related to particle size and morphology. There are three plants in England producing precipitated calcium carbonate. These mostly utilise high purity Carboniferous Limestone from Derbyshire as feedstock.

Limestone powders used as fillers in paper, plastics and high quality paints typically require particle sizes within a closely defined range, along with high brightness (whiteness), good rheological (fluid) properties and low oil absorption. There are several producers of ground calcium carbonate powders in Britain, generally from Carboniferous Limestone or Chalk. Some marble and dolomite is imported and processed to meet demand for very high specification carbonate fillers.

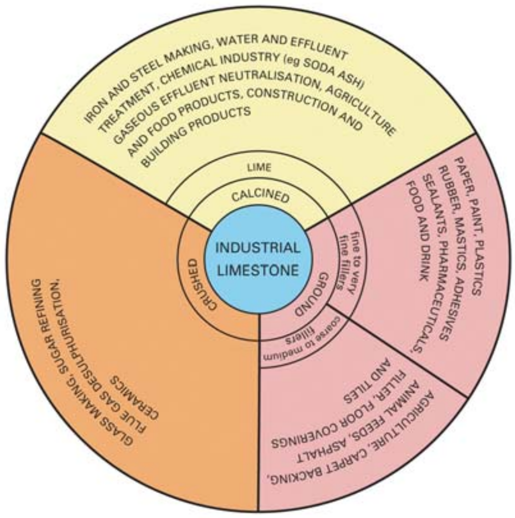


Figure 1 Industrial uses of limestone.

Supply

Detailed production data for limestone and chalk for industrial and agricultural purposes by individual use are not publicly available because of confidentiality considerations. However, in 2002 a total of 9.5 million tonnes were produced in Great Britain, of which 77% was limestone and 23% chalk (Table 1). All of the chalk and the bulk of the limestone was produced in England. Industrial limestone accounted for 69% (6.5 million tonnes) of the total (Table 1). A large proportion of this output was from Derbyshire and the Peak District National Park. The production of limestone and chalk for industrial and agricultural purposes between 1980 and 2002 is shown in Figure 2. There has been an overall decline in the use of limestone. Chalk production shows a modest increase over the same period. The proportion of limestone and chalk used for industrial and agricultural purposes as compared to overall consumption is shown in Table 1. Only 9.6% of total limestone production in 2002 was for

Limestone

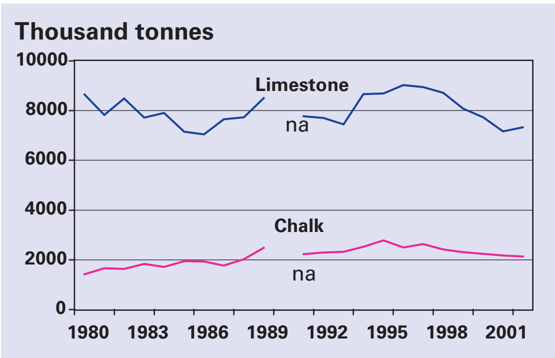
industrial and agricultural use, compared with 26% for chalk.

One of the largest uses of limestone and lime is in the iron and steel industry. Limestone is used as a flux in iron making and some 1.6 million tonnes was used for this purpose in 2002. Lime is used as flux in steelmaking and some 0.5 million tonnes was used in 2002. Consumption has been decreasing in line with a decline in steel production.

Mineral	Limestone	Chalk
	Thousand tonnes	
Constructional uses (a)	59 206	905
Cement making	9 642	5 550
Agricultural uses	789	na
Industrial uses	6 536	2 131(b)
Total	**76 174**	**8 587**

(a) Aggregates and building stone
(b) Agricultural and industrial use
na not available

Table 1 Great Britain: Production of limestone and chalk by broad end use category in 2002. *Source: Annual Minerals Raised Inquiry, ONS.*



na not available

Figure 2 Great Britain: Production of limestone and chalk for industrial and agricultural applications, 1980–2002. *Source: UK Minerals Yearbook.*

Trade

The UK is a modest net exporter of limestone, chalk and lime for industrial purposes, the latter contributing some £9 million to the balance of trade in 2002. The UK has no significant marble resources (a metamorphic rock produced by the alteration of limestone at high temperatures/pressures). Marble has superior optical brightness properties compared to chalk. Significant quantities of marble, valued at £4.9 million, are imported principally for use in the paper industry. Net trade in these minerals is shown in Table 2.

Year	Limestone (a)	Chalk (a)	Marble (b)	Lime (a)
		Tonnes		
1997	55 916	10 159	53 198	64 492
1998	191 113	129	103 462	91 583
1999	143 398	25 958	122 491	122 953
2000	228 445	19 700	144 631	121 913
2001	73 906	20 487	234 568	109 876
2002	71 824	21 039	254 433	75 041

(a) Net exports
(b) Net imports. Marble crushed and powdered.

Table 2 UK: Net trade in limestone, chalk, marble and lime, 1997–2002. *Source: HM Custons and Excise.*

Economic importance

The total value of sales of limestone and chalk for industrial use and agricultural use is of the order of £100 million. However, this figure greatly undervalues their true economic importance because of the multiplicity of downstream industries that rely on these minerals as essential raw materials. They are, for example, essential for the production of quicklime and UK sales of lime produced from limestone and chalk are some £70 million. However a significant proportion of the lime produced in the UK is produced for captive use, for example in the manufacture of soda ash, for sugar beet refining and for use as flux in steelmaking. The production of soda ash by Brunner Mond is reliant on two principal feedstocks, brine and limestone. The company's turnover from UK operations based on these feedstocks is some £104 million. The iron and steel, and glass industries are other sectors that are highly reliant on limestone as an essential raw material. Other important downstream users are the paper, paint, rubber and plastics industries.

Structure of the industry

There are about ten principal industrial limestone and chalk producers in England. The largest is the Tarmac Group, which is part of the Anglo American Corporation. Tarmac Central Ltd is the main industrial limestone producer with the main output based on the Tunstead-Old Moor Quarry complex, near Buxton that straddles the Derbyshire-Peak District National Park boundary. The company is the largest lime producer in the UK and currently is the only supplier of high purity limestone for flue gas desulphurisation. The company also supplies all the chemical stone for Brunner Mond's soda ash factories in Cheshire. This company is the UK's only producer of soda ash (sodium carbonate) and limestone is one of the principal raw materials used in the process (see also factsheet on **Salt**). Tarmac Central produces industrial limestone powders at Ballidon Quarry also located in the Peak District National Park. Tarmac Northern produces industrial limestone at Stainton Quarry in south Cumbria mostly for export to Norway. The company also produces limestone for use as a flux in ironmaking at Wensley Quarry, near Leyburn in North Yorkshire.

Hanson Aggregates produces lime for use in steelmaking in South Wales at its Batts Coombe Quarry in Somerset and also supplies limestone from Shap Beck Quarry to Corus for lime production at their Shapfell Quarry. Corus Steel operates the Shapfell (Hardendale) Quarry in Cumbria primarily for the production of lime for steelmaking.

Longcliffe Quarries Ltd and Ben Bennett Jnr Ltd, produce high purity limestone for a range of applications at, respectively, their Brassington Moor and Grangemill quarries in Derbyshire.

Lhoist UK operates the Hindlow Quarry in Derbyshire for the production of lime.

OMYA UK produces chalk for filler applications at Melton Quarry in the East Riding of Yorkshire, Steeple Morden Quarry in Cambridgeshire and Cliffe Quarry in Kent. The company also produce industrial limestone powders in Derbyshire at the Middleton Mine, Ashwood Dale Quarry and at Dowlow Quarry. At Dowlow, the company's plant is supplied by Lafarge Aggregates, who operate the quarry.

Singleton Birch Ltd is an important producer of chalk for lime production at Melton Ross Quarry in North Lincolnshire and also produces chalk for use as a flux in ironmaking and other industrial uses.

IMERYS Minerals Ltd produces chalk for filler applications at Queensgate Quarry in the East Riding of Yorkshire and at Quidhampton Quarry in Wiltshire. Microfine Minerals Ltd also produce chalk for filler applications at the Lund Quarry in the East Riding of Yorkshire.

In addition, a number of other companies produce some limestone and chalk for use as agricultural lime.

The British Calcium Carbonates Federation and the British Lime Association (part of the Quarry Products Association) are the relevant trade associations.

Resources

Although limestones are widely distributed in England, many are unsuitable for industrial use because of their chemical and/or physical properties. The only important resources of industrial limestone in England are the Carboniferous Limestone and Cretaceous-age Chalk (Figure 3).

Carboniferous Limestone is the major source of both construction (aggregate) and industrial

Limestone

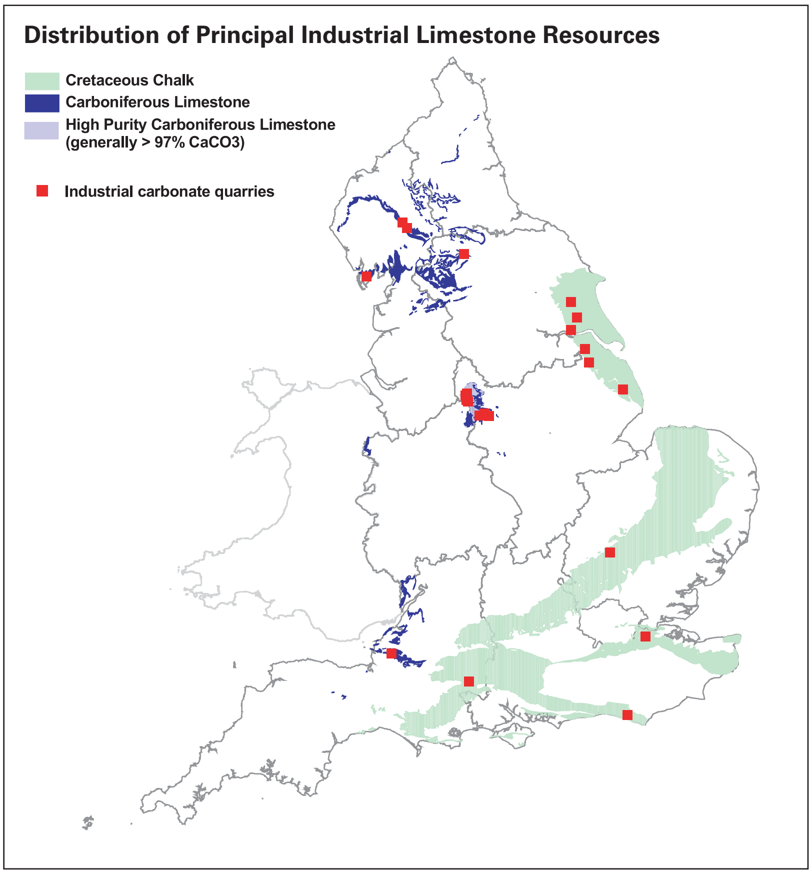


Figure 3 Distribution of principal Industrial Limestone Resources, England.

Geological Age and lithology	%
Cretaceous Chalk	9.1
Jurassic and Cretaceous limestones	6.0
Permian limestone and dolomites	14.7
Carboniferous limestones	66.7
Devonian limestones	2.7
Silurian limestones	0.8

Table 3 Great Britain: Production of limestone for all applications by geological age.

limestone raw materials in England (Table 3). This is due to the quality, consistency and thickness of these limestones, as well as their extent and location relative to their markets. These factors make Carboniferous limestones relatively easy and cheap to work. As such, they are the preferred raw material for construction and industrial use, and cement manufacture. Unfortunately, the Carboniferous Limestone is also associated with high quality landscapes.

Carboniferous limestones are extensively quarried in the Mendips, the Peak District, parts of the northern Pennines and around the fringes of the Lake District, as well as in adjacent areas of both North and South Wales.

A high proportion of the limestones worked in the Derbyshire Peak District are used for industrial purposes. They are characteristically flat lying and are noted for their uniformity over wide areas. The Bee Low Limestone is the most extensively quarried unit and is consistently of very high purity and of consistent chemistry throughout the region. In contrast, Carboniferous limestones in the Mendip Hills are typically steeply dipping and highly faulted. This feature constrains their non-constructional usage, since the resultant clay-filled fault zones, joints and fissures tend to contaminate the resource.

Large areas of the northern Pennines and the fringes of the Lake District are underlain by Carboniferous limestones, some of which are relatively thick, pure and consistent in quality. Notable units of high purity limestone include the Cove Limestone, which crops out widely in the southern part of the Yorkshire Dales; the Park Limestone in south Cumbria and north Lancashire and the Knipe Scar Limestone at Shap on the eastern side of the Lake District. Relatively small amounts of industrial limestone are extracted, but lime for the steel industry is produced on a large scale at Shap.

The thick and extensive deposits of the Chalk of eastern and southern England constitute an important source of limestone raw materials which are used in the manufacture of cement, in agriculture and for the production of chalk 'whiting'. Approximately 8.5 million tonnes of

Limestone

chalk are quarried annually, including around 2 million tonnes produced for industrial purposes (chiefly 'whiting', although lime produced from chalk is used by the steel industry at Scunthorpe in Lincolnshire).

Reserves

Figures for total permitted reserves of industrial limestone and chalk are not available. Permitted reserves at most of the major sites are believed to be extensive, although there are limited reserves at Shapfell Quarry near Shap. There are also reserves of limestone that would be suitable for industrial use at quarries that currently do not produce limestone for non-aggregate purpose.

Relationship to environmental designations

The Carboniferous Limestone and Cretaceous Chalk are the two principal resources on which industrial limestone production is based in England. These two resources give rise to some of England's most attractive scenery and consequently extensive areas are covered by national landscape designations (Figure 4). In addition, these calcareous rocks give rise to areas of conservation interest, both geological and biological. Consequently, extensive areas are also covered by national and international nature-conservation designations. The approximate proportion of the outcrop covered by some of these designations is shown in Table 4. Nature-conservation designations and landscape designations are not mutually exclusive.

Extraction and processing

Because of economic and safety considerations, almost all industrial limestone extracted in England comes from surface quarries. There is one mine producing industrial limestone in Britain, Middleton Mine in Derbyshire, which operates pillar and stall methods and produces high quality industrial limestone for fillers and glass manufacture.

Processing of limestone can be simply divided into crushing/grinding, sizing and storage prior to loading and transportation. Chemical stone is sold as lime or lumpstone of a specified particle size. Lime is produced by burning the stone in specially designed rotary or shaft kilns. During this process, the calcium carbonate is calcined.

	% National Park	% AONB	% SSSI	% Outside national designation
Chalk	5	25	5	66
Carboniferous Limestone	42	17	16	39

Table 4 Proportion of limestone and chalk resources covered by landscape and nature-conservation designations (SSSIs occur in both National Parks and AONBs).

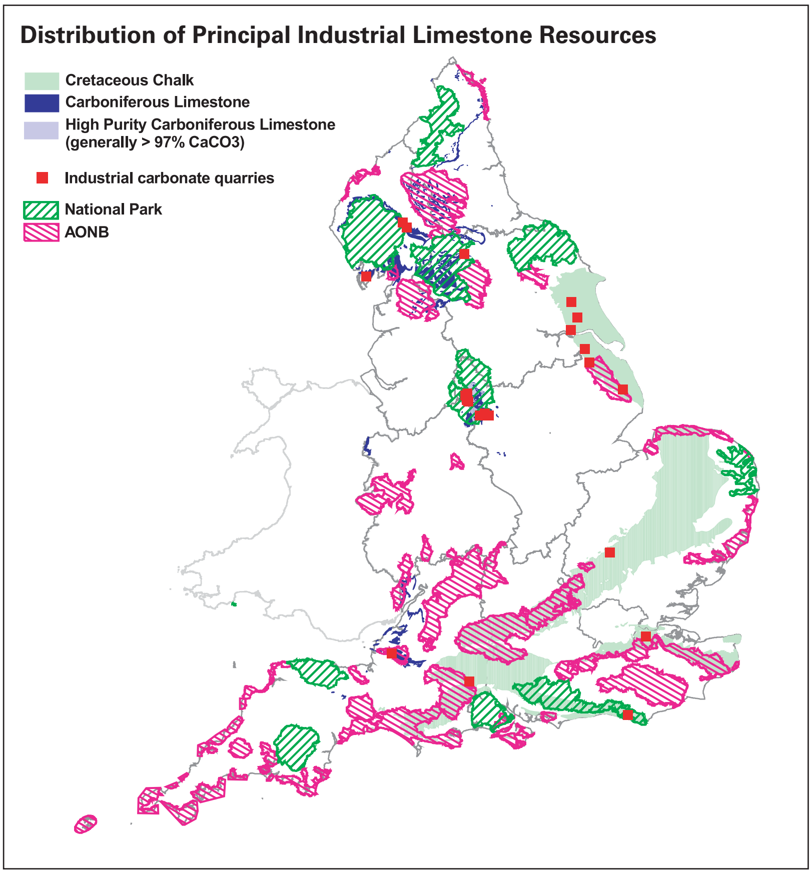


Figure 4 High-purity limestone and environmental designations.

At about 900°C, the carbon dioxide component is driven off as a gas, leaving behind calcium oxide or 'quicklime'. This is then sold as lump lime, pulverised lime, or is hydrated and sold as hydrated lime to meet specific customer requirements. *Limestone powders* for use as fillers are produced by dry grinding the limestone to a fine powder. They might be then further refined by air classification. Particle sizes range from relatively coarse grades, with 90% less than 50 microns, to fine grades with material mostly less than 5 microns (Table 4).

The price of a limestone product is largely governed by the cost of extraction, processing and transportation. The high capital costs of quarrying, due to the high investment in machinery to work and process the stone, has led to the development of large quarries that can produce large outputs over long periods of time. Because transport costs may exceed production costs, it is important for the quarry to have good road, rail and/or water transport links and for the most appropriate form of transportation to be used.

Coarse fillers (generally low value); 75 micron to several millimetres	- agricultural lime - animal feedstuffs - asphalt - fertilisers.
Medium fillers (generally medium value); less than 50 microns	- carpet backing - floor tiles - sealants - adhesives and putties.
Fine fillers (generally medium value); maximum particle size 50 microns; 50% less than 2 microns	- paper fillers - rubbers and plastics - cheaper paints.
Very fine fillers and pigments (generally high value); maximum particle size 10 microns; 90% less than 2 microns	- paper coatings - paints - rubbers and plastics.

Table 4. Limestone powders for filler applications

By-products

Most producers of industrial limestone from Carboniferous limestones also produce aggregates in order to obtain sales for most of the grades of limestone produced. The largest producing unit (5.5 million tonnes annually), Tunstead and Old Moor quarries, near Buxton, produces about 45% aggregates. In most cases, aggregates production accounts for between one-third and one-half of quarry output. Wastage can markedly affect the economics of a quarrying operation. It can be as low as 2% in an integrated operation such as Tunstead where quarry waste is utilised on-site in cement manufacture, to a typical value of around 10-20% and to over 20% in quarries such as Hardendale near Shap, which principally supplies lime kilns.

The Cretaceous Chalk is generally too soft to produce aggregates.

Alternatives/recycling

Because of its intrinsic properties as a neutralising agent and/or as a source of alkali, there are few opportunities for substitution or recycling of limestone used in the manufacture of chemicals. However, calcium carbonate is recovered from the sugar refining process and sold for agricultural purposes.

Limestone and chalk powders used as fillers compete with other minerals such as kaolin or talc. Because limestone and chalk powders tend to be of lower cost relative to these other minerals, limestone has tended to increase it's market share relative to many other minerals in the filler market. Recycling of paper and some plastics allows the mineral component to be recovered. Recycling glass also recycles lime (CaO) and soda ash used in their manufacture.

Effect of economic instruments

Limestone and chalk that is used in prescribed industrial and agricultural processes is not subject to the Aggregates Levy. Limestone that is

Limestone

unsuitable for these applications is produced as an ancillary product at all industrial limestone sites and is generally sold for construction use. This material is subject to the Aggregates Levy. The Levy was introduced at the rate of £1.60/t in April 2002. Some operators also claim that the Levy has made it more difficult to sell waste 'scalpings' for construction use and, as a result these are building up at the quarry and may be sterilising reserves.

Transport

Four industrial limestone operations are rail linked (three in Derbyshire/ Peak District National Park) and one in Cumbria. All other industrial limestone and chalk operations rely on road transport.

A number of limestone quarries that are capable of producing high-purity limestone are also rail linked.

Melton chalk quarry in the East Riding of Yorkshire has recently been rail linked.

Planning issues

The outcrop areas of the Carboniferous Limestone and Chalk in England are extensive. Many of these resources have a high calcium carbonate content and are potentially suitable as raw materials for industrial purposes. However, local variations in small (but significant) impurities such as iron may preclude the use of these resources in some applications. Nevertheless, England has large resources of high-purity limestone.

Both Carboniferous Limestone and Chalk give rise to landscapes and habitats which are designated for their quality. The majority of working sites, as well as sites which could potentially produce industrial limestone and chalk, are located within or immediately adjacent to National Parks (Peak District, Lake District, Yorkshire Dales) or AONBs (South Downs, Mendip Hills). These designations create inevitable conflicts of interests and this is a key planning issue for industrial limestone. Mineral Planning Authorities are likely to prefer development outside rather than within protected areas wherever practicable.

Carboniferous limestone and, to a lesser extent, chalk are versatile minerals which are also valued as aggregates and cement-making raw materials. All industrial limestone quarries also produce aggregate as a by-product, although end-use control is often applied by mineral planning authorities to ensure that the limestone is used as far as possible for high-quality end uses. A limited number of aggregate quarries working Carboniferous limestones have the potential to produce industrial limestone.

Authorship and acknowledgements

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Limestone

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Mineral Planning Factsheet

Miscellaneous

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South Crofty Tin Mine, Cornwall.

Talc and serpentine

Talc is a hydrated magnesium silicate mineral with a characteristic soft and greasy feel, hence its alternative name, soapstone. Commercial grades contain variable amounts of talc and associated minerals. Talc has not been produced on any significant scale in England and there are no resources of any importance. The only source of talc in the UK is on the island of Unst in the Shetland Islands, where small quantities (about 5 000 t/y) of low-grade talc are produced for coating fertiliser prills.

At Polyphant near Launceston in Cornwall a highly altered, soft igneous rock has been worked at least from Norman times as an ornamental stone (Polyphant Stone) for carvings in churches and other buildings. Very minor quantities are produced since time to time for use as a sculpture stone. The small intrusion has been extensively altered over geological time and the rock contains about 40% talc. It has been investigated in the past as a potential source of low-grade talc. However, the rock is too highly contaminated with iron oxides to be of economic interest. Small, discontinuous veins of talc occur in the Lizard serpentinite in Cornwall and these have been worked historically on a very small scale.

Serpentine, as a mineral name, is applied to a group of hydrated magnesium/iron silicate minerals. The principal occurrence of serpentine minerals is a type of altered igneous rock, known as serpentinite. Such rocks are not common in Britain, but in England do occur in the Lizard peninsula in Cornwall. On the Lizard peninsula, serpentinite is worked for ornamental use and supports a small local industry producing souvenirs. Although planning permissions cover a large area within the Lizard Area of Outstanding Natural Beauty, operations consist of very small, short-term pits within limited areas of the permission.

There are no currently no significant planning issues associated with the extraction of either talc or serpentine.

Iron ore

There has been a long history of iron ore extraction in England with peak output of 20 million tonnes in 1942. Substantial, although declining, production continued until 1980 when the Corby Works in Northamptonshire was closed. The Corby Works was the last integrated iron and steel plant in the UK based entirely on domestic ore. Small-scale extraction of ironstone continued at Scunthorpe until 1988 and near Banbury in Oxfordshire until 1992, the latter for use at the Llanwern Works in South Wales. In both cases the ironstone was primarily valued for its fluxing properties (lime content) rather than iron content. All of these operations were based on ironstones of Jurassic age. Iron and steel manufacture in the UK is now based entirely on imported iron ore (about 15 Mt/y), although iron and steel scrap continues to be an important element of supply.

Although a wide range of iron ores have been worked in Britain, the principal ores extracted during the 20th Century were of two main types. The first were the Mesozoic (mainly Jurassic) sedimentary ironstones of central and eastern England. These occur as flat-lying beds of wide lateral extent but of limited thickness (<10 m). The ores were of low grade (< 40% Fe), and had relatively high phosphorus contents. The second were the replacement hematite (Fe_2O_3) deposits that occur principally in Carboniferous limestones. The most important of these occur in west and south Cumbria, although similar deposits were also worked in South Wales. The deposits have iron contents of about 45-55% Fe and very low phosphorus contents. Their extent is small compared with the Jurassic ironstones and they were worked almost entirely by underground mining. The last hematite mine, the linked Florence-Beckermet Mine, near Egremont, closed in 1980. However, small-scale mining at the Florence Mine was revived shortly afterwards and continues to the present day. The hematite is not used for ironmaking but as a pigment and in the heat treatment of certain types of cast iron. Production is modest at about 1 000 tonnes a year. The Florence Mine is also a tourist attraction and a well-known source of mineral specimens.

Large resources of Jurassic ironstone remain but they are of a grade and quality that are unsuitable for use by modern iron and steel-making technology. The hematite deposits are essentially exhausted. It is difficult to envisage any economic circumstances in which large-scale iron ore extraction would be revived for ironmaking. However, extensive planning permissions remain in some counties for the extraction of ironstone and 'overlying minerals.' In some counties, such as Northamptonshire, this includes limestone, which is used as a source of crushed rock aggregate. In Oxfordshire, ironstones near Banbury are an important local source of crushed rock aggregate as well as building stone.

The planning issues associated with the extraction of iron ore are minimal. However, ironstones permissions have been used to extract both ironstone and overlying minerals, such as limestone, as crushed rock.

Other metal ores

Metalliferous minerals were formerly extensively mined in Britain, mainly from vein deposits, which occur as linear, sub-vertical deposits infilling faults and fissures that cut rocks of various geological ages. Vein deposits were worked in Cornwall and Devon, the Mendips, North and Central Wales, Shropshire, the Northern and Southern Pennine Orefields, the Lake District and the Southern Uplands of Scotland. They formed the basis of the non-ferrous metal mining industry in Britain, which reached its zenith in the mid-19th Century when the country was a leading world producer of tin, copper and lead. A number of other metals were also produced including zinc, arsenic, tungsten, silver, gold and antimony. However, the industry gradually declined in the face of the high cost of working this style of mineralisation and competition from lower cost producers overseas. Only modest production survived into the 20th Century. The last mine worked solely for lead and zinc closed in North Wales in 1978 and the last tin mine, South Crofty Mine at Camborne in Cornwall closed in 1998.

Today the only metalliferous mineral extracted is galena (PbS, lead ore), which is derived as a by-product of processing fluorspar ore in the Peak District National Park (see Factsheet on **Fluorspar**). Output is about a 1 000 t/y. Very small amounts of cassiterite (SnO_2, the ore of tin) are produced by tin streaming near St Agnes in Cornwall for use in craft products.

A planning application by Baseresult Holdings Ltd, the owners of the South Crofty Mine and processing plant, in February 2004 to reopen the mine was refused by Cornwall County Council. The application included a housing and leisure complex. Currently the mine is used as a tourist attraction but its future has an important bearing on the redevelopment of the site.

Miscellaneous

A large deposit of tungsten and tin at Hemerdon Ball just to the north east of Plymouth in Devon was granted permission for working by openpit methods with the associated tipping of waste in June 1986 for a period of 35 years. However, there are no plans to open the mine and none are anticipated in the foreseeable future. The deposit is the only significant tungsten resource in the UK with indicated resources of 45 million tonnes of ore at 0.18% tungsten and 0.025% tin.

The vein-style mineralization, on which most of the former base metal mining was based, is unlikely to attract commercial interest as a source of metals in the future. This is because of their relatively small size and the high costs of mining such deposits. This does not, however, preclude exploration for other styles of metallic mineralization, such as stratiform base metal sulphide deposits, and disseminated and vein-style gold deposits, that are more amenable to lower cost extraction methods. There continues to be interest in the metallic mineral potential of Britain and mineral local plans need to be sufficiently flexible to take this possibility into account. The planning issues associated with any new discovery would depend on the circumstances, principally location and whether extraction is by surface or underground methods.

Slate powder and granules

Slate is a fine-grained metamorphic rock. It is the metamorphosed equivalent of mudstone and shale and formed by heat and pressure applied to these mudrocks. This results in the formation of a well-marked slaty cleavage due to the recrystallisation and realignment of platy clay minerals along a single set of micron-spaced parallel planes. It is along these planes that the rock can be split and this is the fundamental property of slate, which is of considerable economic importance. Slaty cleavage controls the splitting properties and thickness of slate tiles or flagstones used for roofing or other architectural purposes.

Bodies of commercial slate generally have a restricted occurrence within more extensive masses of less perfectly cleaved rock, which accounts for the large tips of waste material that are commonly associated with slate working. In more general usage, therefore, the term 'slate' may be applied to mudstones exhibiting a weak slaty cleavage that would be unsuitable for cleaving into thin slates. These may cover extensive areas, for example in Cornwall, and may be worked for walling, paving, rockery construction and general fill.

There are large accumulations of slate waste associated with slate working. A small quantity is used in the production of slate powders and granules, which is the subject of this section. Production of slate waste for industrial use is mainly confined to Wales. In England commercial slates are worked in Cornwall and Devon from strata of Devonian age and in the Lake District from rocks of Lower Palaeozoic age, comprising volcanic rocks of the Borrowdale Volcanic Group (Lakeland green slate) and mudstones of the Windermere Supergroup (Lakeland blue slate). Substantial quantities of slate waste may be associated with their production. However, the use of this waste for industrial purposes is confined to the Delabole slate quarry in north Cornwall. Here all the slate that is quarried is either utilised or backfilled. Use of the waste includes the production of slate granules for coating roofing felt, and powders for filler applications, such as in bituminous paints. No slate is produced in the Lake District for industrial purposes.

There are important planning issues associated with the extraction and processing of slate, and the large quantities of waste that may be produced. However, none of these are related to the small quantities of slate produced for industrial purposes. These applications are beneficial in disposing of modest quantities of waste material.

Slate is exempt from the Aggregates Levy and because of this exemption there may be an increasing use of slate waste for aggregate use.

Authorship and acknowledgements

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Mineral Planning Factsheet

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Miscellaneous

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Mineral Planning Factsheet

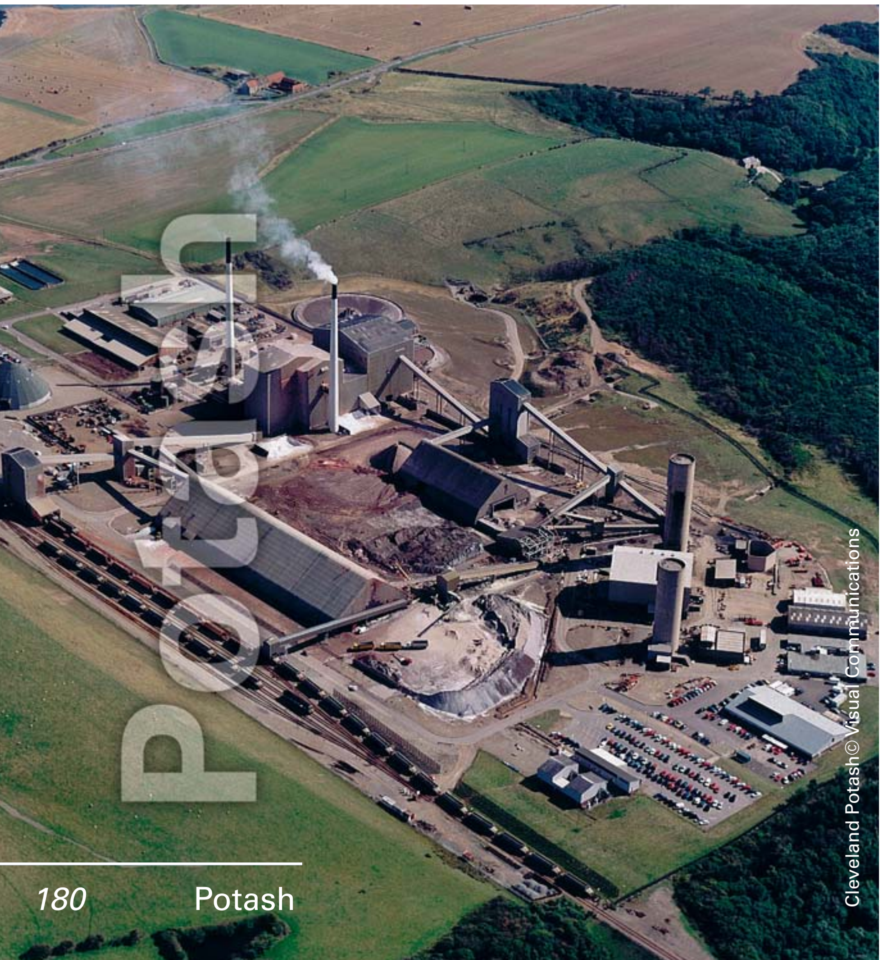
Potash

*The purpose of this factsheet is to provide an overview of the mineral **potash**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Potash is a generic term for a variety of potassium-bearing minerals and refined products. There are many potassium-bearing minerals but only those that are water-soluble are of significant commercial interest. **Sylvine** (potassium chloride, KCl) is by far the most important source of potash worldwide, because of its solubility and high potassium content, and accounts for all the potash produced in the UK to date. Potassium minerals rarely occur in pure form and the mined material is invariably a physical mixture of salts. **Sylvinite** is a mixture of **sylvine** and **halite** (salt, NaCl) in varying proportions and this is the material that is mined in the UK. K_2O, a compound not found in nature, is the basis for comparing all potassium compounds. Marketable potassium chloride contains about 60% K_2O.

Sylvine is a relatively scarce mineral, which occurs in the UK in beds up to a few metres thick. It occurs in evaporite deposits, which were formed by precipitation from brines resulting from the extreme evaporation of seawater. Other potassium-bearing evaporite minerals found associated with sylvine are carnallite (hydrated potassium, magnesium chloride) and polyhalite (hydrated potassium, magnesium, calcium sulphate). These minerals have much lower K_2O contents. Potash does not crop out at the surface and in the UK, deposits only occur at depths in excess of 800 m.

Boulby Mine, North York Moors National Park.



Cleveland Potash© Visual Communications

Demand

Potassium is one of the three primary nutrients essential for plant growth (the others being nitrogen and phosphorus). These nutrients form the basis of fertiliser porduction in the UK and throughout the world. Potassium is used in the production, transport and accumulation of sugars in plants, and assists their hardiness and resistance to water stress, pests and diseases. Potash applied as fertiliser replaces potassium removed from the soil through plant harvesting and animal grazing.

About 90% of UK potash production is consumed in the manufacture of fertilisers. Of this, some 95% is used as a blend or compounded with other nutrients, principally nitrogen and phosphorus. Small quantities of potash are also used by the chemical and pharmaceutical industries for the manufacture of a wide range of goods, ranging from soaps, the production of glass for television screens, drilling fluid additives, and as a flux in secondary aluminium smelting.

Since most potash is used as a fertiliser, demand is primarily linked to agricultural productivity.

Supply

Potash is produced in only a few countries. Canada, Russia, Belarus and Germany are the main producers, followed by Israel, Jordan, the UK and the USA. In Europe, Spain is a small producer, but production in France ceased in 2003. World production of potassium chloride is currently increasing and was about 26.3 million tonnes K_2O in 2002. A high proportion of this (21 million tonnes) entered world trade because there are so few producers.

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The UK has emerged as an important world producer of potash in the last 25 years with the development of the Boulby Mine near Loftus in the North York Moors National Park. Shaft sinking for the Boulby Mine began in 1968 and was completed for production in 1976, although some production was possible from a single shaft from 1973. Output has steadily increased (Figure 1), with some declines, and was a record 1 040 000 tonnes of refined KCl in 2003. The Boulby Mine is the UK's only potash mining operation. Two other proposals to extract potash in North Yorkshire, one of which involved solution mining, were permitted in the late 1960s, but were never implemented.

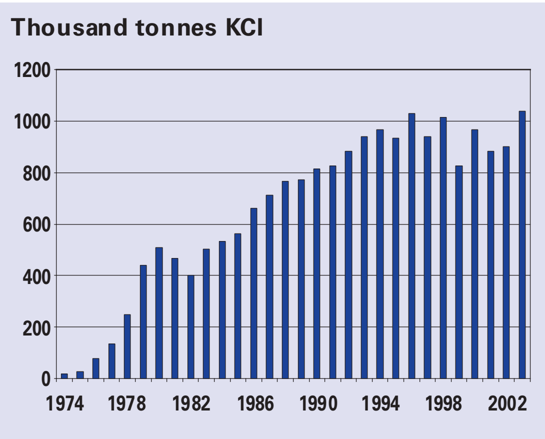

Figure 1 UK sales of refined potassium chloride, 1974–2003. *Source: UK Minerals Yearbook, BGS.*

Trade

The UK is a net exporter of potassium chloride, the main potassium fertiliser material. Official figures for exports of potassium chloride have been withheld for a number of years for commercial reasons, but exports figures have been estimated by BGS (Table 1).

In 2003 some 62% of the output of the Boulby Mine was exported through Tees Dock. Exports are mainly to Western Europe, with France being the largest single market. Imports of potassium chloride are almost entirely from Germany. The Boulby Mine is operating in a world market and has to remain competitive by optimising mining costs to achieve lower costs per tonne of final product.

	Exports		Imports	
	Tonnes	£000	Tonnes	£000
1996	540 000 e	N/A	462 630	45 640
1997	540 000 e	N/A	331 300	33 868
1998	570 681	39,183	209 519	23 313
1999	420 000 e	N/A	232 983	30 144
2000	630 000 e	N/A	255 572	24 824
2001	530 000 e	N/A	335 398	26 679
2002	440 000 e	N/A	372 030	19 462
e = BGS estimate. N/A = not available				

Table 1 UK: Imports and exports of potassium chloride, 1996–2002. *Source: HM Customs and Excise.*

Consumption

UK consumption of potash has declined from 567 600 tonnes K_2O in 1995 to 368 000 tonnes K_2O in 2002, equivalent to about 614 000 tonnes of potassium chloride. This is believed to be partly an effect of a decline in agricultural production, but also to an overall loss in potassium levels in soils. This deficiency in application will presumably have to be made good at some stage.

Economic importance

The Boulby Mine is the single most important non-hydrocarbon mineral operation in Britain generating total sales of £98 million in 2003, including by-product rock salt.

The mine employs 860 people, over half working underground and it is the largest employer in the North York Moors National Park, with over 90% of employees living within 30 km.

Exports are valued at about £50 million.

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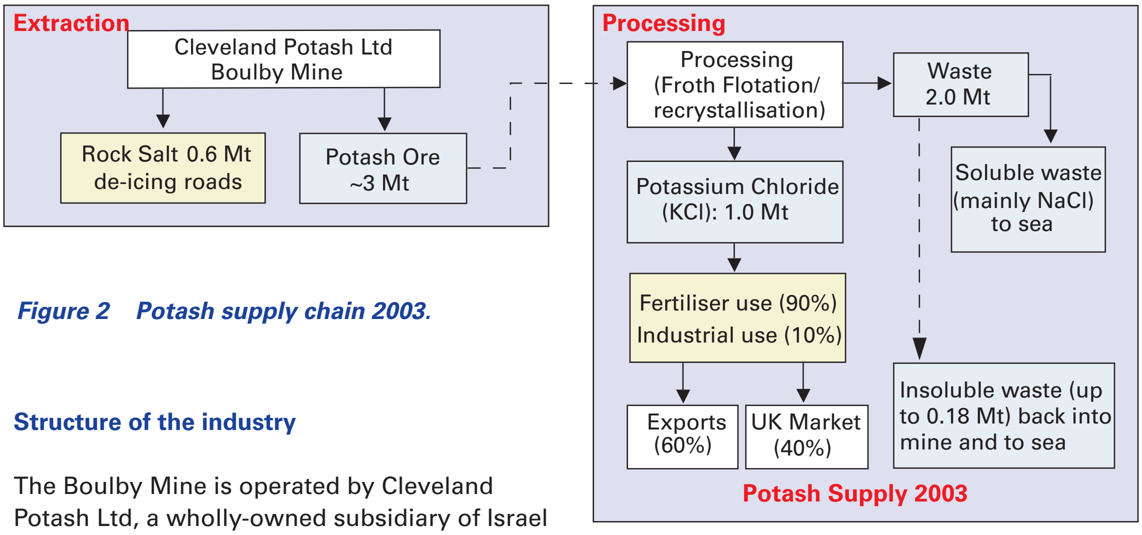

Figure 2 Potash supply chain 2003.

Structure of the industry

The Boulby Mine is operated by Cleveland Potash Ltd, a wholly-owned subsidiary of Israel Chemicals Ltd following the acquisition of the company from Anglo American plc in April 2002. With a total output of some 5 Mt/y, Israel Chemicals Ltd is now Europe's second largest potash producer and the fifth largest in the world. The potash supply chain is summarised in Figure 2.

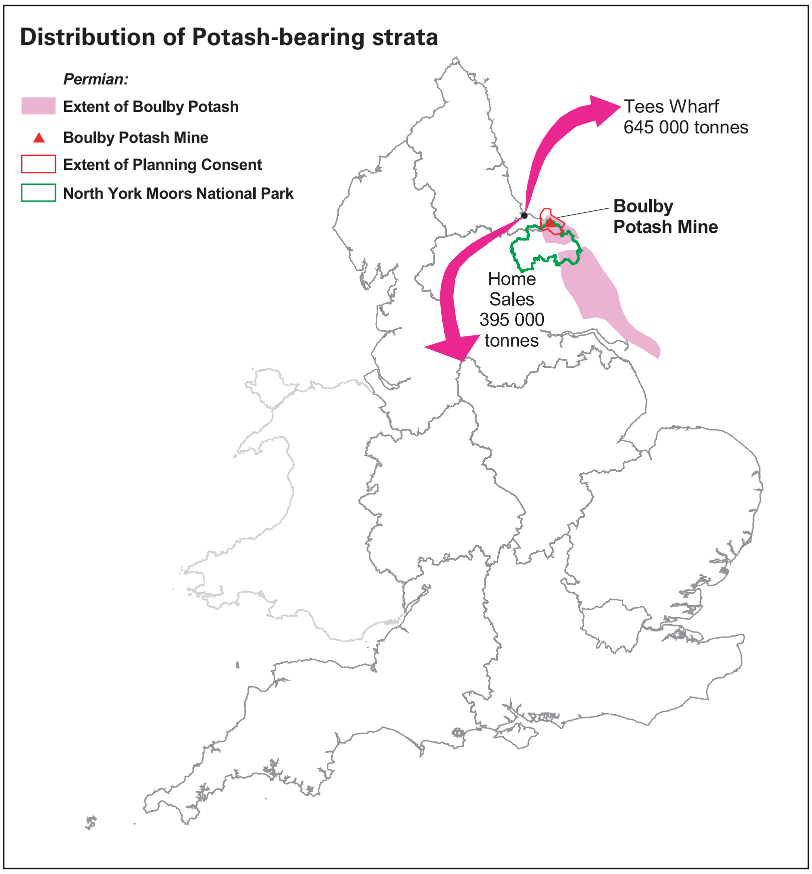

Figure 3 Distribution of potash bearing strata, England.

Resources

Potash resources were first discovered in England at depth near Whitby in North Yorkshire during exploration for oil in 1939. Further exploration was undertaken in 1948 and later in the early 1960s. The potash is of late Permian age and occurs at two main horizons; the Boulby Potash, which is the most extensive, and a higher horizon, the Sneaton Potash. In both these beds sylvine is the main potassium mineral present. Potash in the form of carnallite ($KCl.MgCl_2.6H_2O$) and polyhalite ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) also occurs.

The sub-surface extent of the Boulby Potash and its conjectured western limit is shown on Figure 3. The bed underlies extensive parts of east Yorkshire but is only worked at the Boulby Mine. Mining is confined to a single bed, the Boulby Potash Member, which occurs at the top of the Boulby Halite Formation at depths of over 1200 m in onshore areas. The bed dips at a shallow angle from north-west to south-east. Mining operations extend some 13.5 km and cover an area of about 20 km^2. They reach 5 km offshore to the north where they are approximately 800 m below the seabed. In the south a combination of seam dip and topography leaves the workings almost 1300 m below the land surface.

Potash

The Boulby Potash averages 7 m in thickness but ranges from nil to over 20 m. The bed consists of sylvinite with minor clay minerals and anhydrite, and traces of other minerals. The material mined is of high grade by international standards with a mean KCl content of 34% (21% K_2O). However, grade varies both vertically and laterally. The potash bed has a sharp basal contact with the underlying rock salt and a sharp, but undulating upper contact with the overlying Carnallitic Marl. However, potash flow can have a marked effect on ore grade and thickness, which can range from a complete absence in some areas to grades of 60% KCl in others. The Carnallitic Marl is a weak rock and 1.5 metres of potash are left in the roof for safety reasons.

The Boulby Halite beneath the potash bed achieves a total thickness of about 40 m. About 8–10 m below the potash bed is a bed of pure and strong halite through which the mine's arterial roadways are driven to access current mining areas and to explore and develop new areas for potash production.

Evaluation of carnallite ($KCl.MgCl_2.6H_2O$), a potential potassium resource, lying offshore at Boulby, is under investigation. Construction of a pilot plant was started in 2002 and mining and processing trials will follow, initially for the recovery of potassium chloride in solution. The recovery of magnesium salt may also be feasible.

A stratigraphically higher, but less extensive evaporite succession in north-east England, the Sneaton Halite Formation, also includes the Sneaton Potash Member. These deposits are not currently of economic interest.

Reserves

Proved reserves of potash at the Boulby Mine are reported to be sufficient for 9 years output and 25 years, including probable reserves. Reserves are evaluated by drilling long horizontal holes and by driving exploration headings in the underlying Boulby Halite.

Relationship to environmental designations

The Boulby mineshaft and associated facilities, together with the southern mining area, are located in the North York Moors National Park, which is the Mineral Planning Authority. The northern mining area extends into Redcar and Cleveland outwith the Park and the eastern and parts of the northern mining area also extend out under the sea (Figure 3). The Crown Estate is responsible for potash occurring beneath the seabed.

Extraction and processing

Potash is worked by underground mining methods. The potash bed is accessed by two 5.5 m diameter concrete and cast-iron lined shafts, which are each about 1150 m deep. One shaft is for raising the potash ore and rock salt and the other is for men and materials. Remotely controlled continuous mining machines are used to extract both the potash ore and rock salt. Potash mining areas are subsequently abandoned because of roof stability considerations. The ore is loaded into shuttle cars to feed an underground primary crusher which reduces the potash to less than 150 mm. This material is then conveyed to the shaft bottom for raising to the surface. The surface plant is capable of treating about 3 Mt/y of ore.

The ore is a mixture of sodium and potassium chloride crystals with occasional inclusions of insoluble material, usually clays. Composition is typically 38% KCl, 52% NaCl and 10% insoluble matter. A small proportion of the sylvinite ore is sold directly as a fertiliser for sugar beet. However, the vast majority is crushed and ground and potassium chloride is recovered from the salt and other constituents by froth flotation. The product is then dewatered, dried and screened. A granular product is made by the compaction of standard grade material. A high-grade soluble product for both industrial and agricultural use is produced by preferentially dissolving potassium chloride for subsequent re-crystallisation. Four potash products are thus produced; soluble (95-98% KCl), standard (95% KCl), granular (95% KCl) and sylvinite (32% KCl). The most important products are standard and granular.

The waste from the extraction process, comprising insoluble clay minerals, calcium sulphate and sodium chloride, are formed into a slurry with brine and pumped out to sea from an outfall 1.8 km from the cliffs. Virtually all the components dissolve except the clays. However, the clays contain traces of heavy metals, including cadmium and mercury. These discharges, which currently amount to about 180 000 t/y, have to be substantially reduced. Returning the insoluble waste into disused mine workings was started in 2003 thereby reducing discharges into the North Sea. Infrastructure and development work for the project was part funded by a European Commission grant.

The company use natural gas for drying and operates the largest Combined Heat and Power plant on a single site in the UK. It was installed to reduce dependence on heavy fuel oil and reduce carbon dioxide emissions.

The ground surface in the vicinity of the mine has been monitored since mining began. This shows that some minor subsidence (0.5 m) does occur in a uniform and gentle manner in areas where potash has been mined. This is because of the depth of the workings, the geological conditions and the mining method used. Damage to building and structures are unlikely to be caused, because damaging strains are not developed by the uniform subsidence. Similarly, natural land drainage is unlikely to be affected.

By-products

Rock salt is produced through driving roadways in the Boulby Halite, which lies beneath the potash bed. The salt is suitable for de-icing roads and substantial quantities are produced for this purpose. Output of rock salt was 590 000 tonnes in 2003. The Boulby Mine is one of only two mines producing rock salt in England (see Factsheet on Salt).

Alternatives/recycling

Potassium fertilisers are essential for healthy plant growth and there are no substitutes and the mineral cannot be recycled. Unconventional sources of potassium, such as glauconitic sands, potassium feldspars and some slags, have been examined in the past but without success. In the north-west Highlands of Scotland a bed of mudstone, which has an unusually high potassium content in the form of a very fine-grained feldspar, has been used as a direct application fertiliser for organic farming. However, production is very small.

Transport issues

The railway track between Boulby and Skinningrove was reinstated when the mine was developed so that the environmental impact of road transport could be minimised. Today about 87% of the refined potash is transferred by rail from the Boulby Mine to Tees Dock for export by sea or onward distribution to fertiliser manufacturers in the UK. Nearly 100% of the rock salt is similarly transferred by rail to Middlesbrough for distribution.

Planning issues

Planning issues arising from potash extraction relate largely to the geographical location of the mine. The Boulby Mine is located in the North York Moors National Park. However, it lies at the boundary of a number of authorities and two regions, Yorkshire and the Humber and the North East. The Park Authority adopted in 2003 a supportive Local Plan policy for the Boulby Mine which is: 'Proposals for the extraction of potash at Boulby will be permitted provided that any detrimental effect on the environment or landscape, or residential or visitor amenity can be moderated to a level considered acceptable in a National Park in the context of and overriding need for the development.'

The proximity of underground workings to the sensitive coastline of the National Park has become an issue. This is because of concern amongst some parties that minor subsidence at the surface associated with extraction might exacerbate rates of coastal erosion. If mining is not permitted beneath the coastal zone, then considerable reserves of potash will be sterilised. Cleveland Potash has entered into a collaborative research and development project with the University of Durham to gain a better understanding of the natural and anthropomorphic influences on the coast.

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Mineral Planning Factsheet

Potash

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Mineral Planning Factsheet

Salt

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Salt (sodium chloride, NaCl), occurs in nature in solid form as **rock salt** (halite), or in solution as **brine**. Rock salt occurs in beds, commonly associated with mudstone, ranging from a few centimetres up to several hundred metres in thickness. The purity of individual salt beds depends on the extent of mudstone interbedding. Salt-bearing strata do not crop out at the surface in the UK because of dissolution by groundwater. Natural brine is produced by the dissolution of salt-bearing strata by circulating groundwater. Brine is also produced by solution mining by injecting water into salt beds and pumping out the resulting salt solution. This may contain up to 26% NaCl when fully saturated.

Demand

Salt is used in solid form as rock salt and, more importantly, as brine. Of total salt production in England, approximately 30% is used as rock salt, principally for de-icing roads, although small tonnages are used as a fertiliser for sugar beet and as an additive to animal feeds. The remaining 70% is consumed as brine. Most (60%) brine production is used directly by the heavy inorganic chemicals industry as an essential basic feedstock. The remainder is evaporated using a vacuum process to produce white salt.

Brine wellhead.

As a chemical feedstock in the heavy inorganic chemical industry, salt-in-brine is used in the electrochemical process for the production of chlorine and caustic soda (sodium hydroxide), and in the Ammonia-Soda Process for the production of soda ash (sodium carbonate). A by-product of the electrolysis of brine is hydrogen, which is used as a fuel for power generation and as a process gas.

Chlorine is essential to the world's chemical industry. Up to 60% of all chemical manufacturing in Western Europe depends on the element. It is an essential intermediate in the production of plastics and polymers, such as PVC, nylon and polyurethane, and is used in sewage and industrial effluent treatment, water disinfection and in household and industrial bleaches. A wide range of other chlorine derivative products is also produced. Caustic soda is used in soap and detergents manufacture, in alumina production and papermaking, but has also a wide range of other uses. Soda ash is used mainly in the manufacture of glass and detergents; other uses include industrial chemicals, aerospace alloys, water purification and effluent neutralisation. Calcium chloride liquor is a by-product of the process, which amongst other uses, is used in the formulation of oil well drilling fluids.

White salt is sold as a chemical feedstock, for food processing and table use, for water softener regeneration, tanning and in the production of animal feeds.

Salt-bearing strata are ideally suited for the creation of storage cavities for gas, compressed air and certain fluids. Completed brine extraction cavities are used for storage purposes, although cavities have also been specifically created for gas storage. The high flow capability of salt cavities is ideal for peak sharing and daily balancing needs. On Teesside completed brine cavities are used for the storage of products such as ethylene, ethane and naphtha, as well as natural gas and hydrogen. At the Holford Brinefield in Cheshire, abandoned brine cavities are used for ethylene storage, and one is currently used for natural gas. Cavities have been used for oil storage in the past. Completed brine cavities are, however, not ideally shaped or spaced apart for gas storage. Gas cavities should be more spherical or cylindrical with domed roofs and with a grid spacing related to their size (diameter). At the Warmingham Brinefield in Cheshire, smaller cavities have been specially designed for gas storage. The brine created is used for salt production, thus maximising the use of the salt resource. Similar proposals have been made at the Holford Brinefield. At Atwick, near Hornsea in the East Riding of Yorkshire, cavities were specifically created for the storage of high pressure natural gas at depths of around 1800 m. Current UK gas storage capacity is, by international standards, small. As the UK becomes a net importer of natural gas by 2005/6, there will be a requirement to develop further storage facilities to cope with peak demands. If any are distant from existing brine consumers, then any brine generated will need to be disposed of into the sea.

Supply

The UK is a large salt producer with a total output of some 5.6 million tonnes in 2003, over 95% of which was produced in England. The remainder is rock salt mined in Northern Ireland. Of total output, about 70% was extracted as brine and the remainder mined as rock salt. Following the cessation of brine pumping on Teesside in 2002, salt is now only produced in two areas in England; Cheshire and the North York Moors National Park. The Cheshire Basin accounts for over 85% of the total. In the North York Moors National Park, rock salt is mined as an ancillary product at the Boulby Potash Mine (see Factsheet Potash).

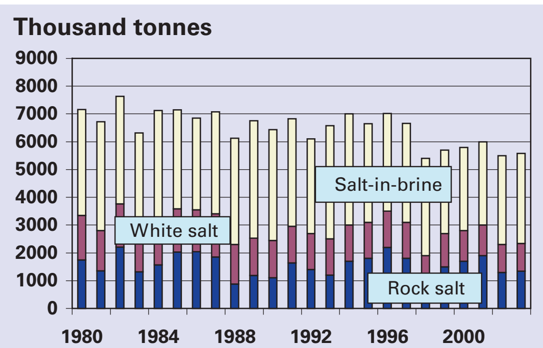

Figure 1 UK production of salt, 1980–2003. *Source: UK Minerals Yearbook, BGS.*

	Exports		Imports	
	Tonnes	**£000**	**Tonnes**	**£000**
1996	47 154	21 419	316 796	13 010
1997	284 571	18 639	242 368	11 796
1998	485 815	18 274	237 284	11 807
1999	276 402	22 125	261 434	11 573
2000	307 899	16 548	N/A	N/A
2001	299 607	17 466	N/A	N/A
2002	327 760	20 135	306 488	12 870

Table 1 Imports and exports of salt, 1996–2002. *Source: HM Customs and Excise.*

Brine extraction ceased in Lancashire in 1993, because of the closure of the chlorine plant at Hillhouse in Fleetwood, and also in Staffordshire in 1970 and in Worcestershire in 1971 because of subsidence problems. Very minor quantities of sea salt are produced by the evaporation of seawater at Maldon in Essex.

Output of salt-in-brine, brine (white) salt, which is produced by the evaporation of brine, and rock salt, has not been disclosed for a number of years because of the limited number of producers. However, the BGS has produced estimates for the *United Kingdom Minerals Yearbook* (Figure 1). Apart from rock salt production, output has remained relatively static but with an overall declining trend. Salt-in-brine production may have been slightly underestimated.

Production of rock salt is largely a function of the severity of the weather (demand for de-icing salt goes up in cold winters) and output is thus variable. Demand for white salt is fairly static, if not declining, at about 1 Mt/y.

Salt

Trade

The UK is essentially self-sufficient in salt. Historically exports have exceeded imports but trade is currently roughly in balance, although exports have a higher value (Table 1). Exports include white salt and rock salt.

Consumption

Total UK consumption of salt has declined from about 7 million tonnes in 1980 to just less than 6 million tonnes in 2002.

Economic importance

The total value of salt production in all forms (rock salt, white salt and salt-in-brine) in the UK was £140 million in 2002 according to official statistics. Total employment in salt production is estimated to be about 370. Salt-in-brine is, however, a critical raw material for the heavy inorganic chemicals industry in north-west England. For example, the Runcorn site operated by INEOS Chlor is highly integrated and chlorine/caustic soda production is at its core. The turnover of INEOS Chlor is some £500 million, the major proportion of which is ultimately derived from brine production in Cheshire. About 1 450 people are employed at the Runcorn site, but the company estimate that 133 000 jobs are indirectly supported by the Runcorn site. The company has recently announced a £390 million modernisation programme at Runcorn, mainly to replace existing mercury-based cells for chlorine manufacture by state-of-the-art cellrooms using environmentally-friendly membrane technology.

Brunner Mond, which is also critically dependent on brine as a basic feedstock for the manufacture of soda ash, employs 480 people in its UK operations, which have a turnover of £104 million.

Structure of the industry

Two companies produce rock salt in England; Salt Union Ltd, which operates the Winsford Mine at Winsford in Cheshire, and Cleveland Potash Ltd, which produces rock salt as a by-product of potash mining at the Boulby Mine in the North York Moors National Park. Salt Union is a wholly owned subsidiary of Compass Minerals International of the USA.

Three companies, all based in Cheshire, produce brine. INEOS Chlor Ltd, a privately-owned group, is by far the largest. The company acquired the ICI Chlor-Chemicals business in 2001 and operates the Holford Brinefield at Lostock Gralam in Cheshire and formerly extracted brine at Saltholme on Teesside. This operation ceased in June 2002 with the closure of the Wilton chlorine plant, thus removing the need for brine. The company produces some 3.2 Mt/y of contained salt-in-brine. Brine from the Holford field is supplied to the company's own plant at Runcorn for the electrolytic manufacture of chlorine and caustic soda. Permitted chlorine production is some 737 000 tonnes and 831 000 tonnes of caustic soda, although output is less. In addition, brine is also supplied to Brunner Mond (UK) Ltd at Lostock and

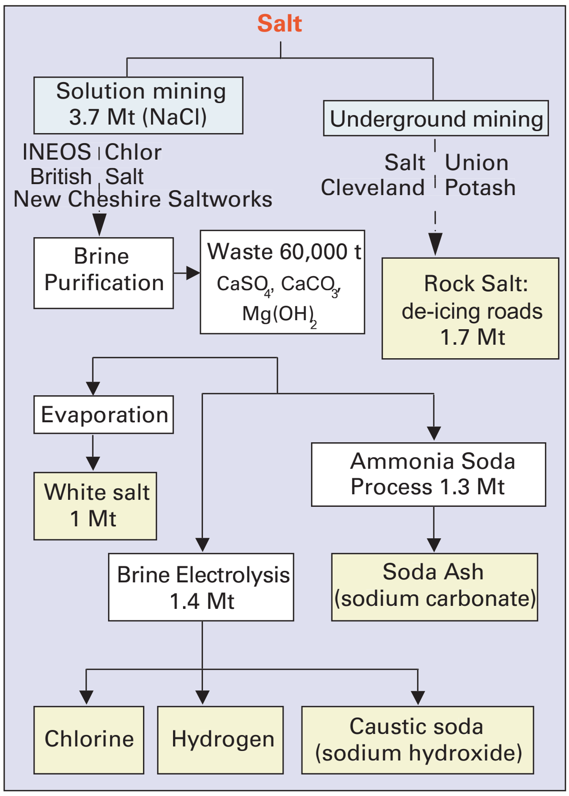

Figure 2 Salt supply chain, 2002.

Winnington for the manufacture of soda ash (sodium carbonate) of which the company is the UK's sole manufacturer and Europe's second largest producer. INEOS Chlor also supplies brine to the Salt Union plant at Runcorn for the manufacture of white salt.

Brine is also produced by British Salt, a subsidiary of US Salt Holdings, at the Warmingham Brinefield in Cheshire for use in the manufacture of white salt at its Middlewich plant. The New Cheshire Saltworks Ltd is a very small producer of white salt at Wincham, near Northwich.

The salt supply chain is summarised in Figure 2.

Resources

The UK has huge resources of salt, which mainly occur in England, with only limited resources in Northern Ireland. Salt-bearing strata of Permian and Triassic age underlie extensive areas (Figure 3). Resources of Triassic age are economically the most important and account for some 90% of total production, all of which is now derived from the Cheshire Basin. Permian deposits are only worked at the Boulby Mine.

Triassic

The most important salt resources in England occur within the Triassic Mercia Mudstone Group, which has a widespread outcrop. However, salt-bearing strata generally only occur where the Mercia Mudstone thickens in major depositional basins. The most important of these, and the source of some 90% of total salt output, is the Cheshire Basin, which also extends into north Shropshire.

There are two salt-bearing formations in the Cheshire Basin, a lower Northwich Halite Formation and an upper Wilkesley Halite Formation. Production is entirely confined to the former. The maximum known thickness of the formation is some 280 m and the salt occurs in beds that are virtually pure halite and in others where there are varying amounts of mudstone and siltstone. It has been estimated that some 25% of the formation consists of mudstone. The Wilkesley Halite Formation is even thicker and has a known thickness of some 405 m. The upper half of the Wilkesley Halite Formation is somewhat purer than the Northwich Halite.

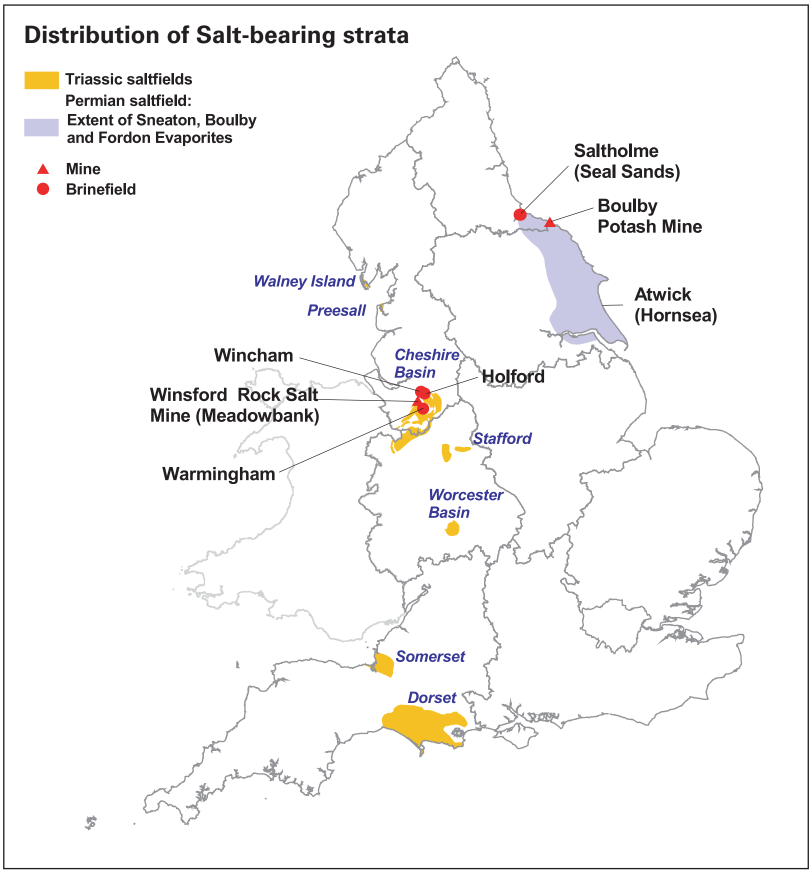

Figure 3 Distribution of salt bearing strata and principle producing sites.

Triassic saltfields have also been worked in the past at Preesall in Lancashire, in Worcestershire, Staffordshire, on Walney Island in Cumbria and in Somerset. Extensive areas of salt-bearing strata also underlie Dorset. It is highly unlikely that any of these deposits will become of commercial interest as a source of salt in the foreseeable future. However, where thick (>100 m), relatively pure beds of salt occur they may be of interest for creating cavities for storage purposes.

Permian

Salt-bearing strata of Permian age extends at depth from Teesside beneath much of east

Yorkshire and into north Lincolnshire. Deposits occur at several horizons, the most extensive being the Boulby Halite, which is also the only UK Permian salt of current economic importance. It was exploited by brine pumping on Teesside and is mined at the Boulby Potash Mine. Thick salt deposits also occur lower in the Permian sequence within the Fordon Evaporites. At Hornsea in east Yorkshire these deposits have been used to create cavities some 100 m high and 100 m wide at depths of between 1710 m and 1840 m for use in natural gas storage. A stratigraphically higher salt horizon, the Sneaton Halite, occurs above the Boulby Halite but is less extensive.

Reserves

A figure for total permitted reserves of salt is not available. At the Holford and Warmingham brinefields in Cheshire there are sufficient reserves with planning permission until at least 2042, when the current consents expire. However, new cavities have to be created to sustain brine production. At Holford no new cavities have been created since 1982 and there is now a requirement for a phased development, particularly as they take several years to produce saturated brine. The sinking of new boreholes and the associated infrastructure requires planning agreement.

Proved reserves of rock salt at the Winsford Mine are sufficient for 70 years, although the current planning consent expires in 2011. Rock salt reserves at the Boulby Mine are dependent on potash reserves, which are reported as 9 years of proved and 25 years including probable reserves.

Relationship to environmental designations

The Boulby Potash Mine is located in the North York Moors National Park. Elsewhere operations are not associated with any major environmental designations.

Extraction and processing

Salt-bearing strata do not crop out at the surface, because of dissolution by groundwater, and are absent to depths of about 70 m. The boundary at which solution is taking place is called the 'wet rock-head', and the overlying collapsed strata may lead to possible subsidence at the surface. Where salt-bearing strata are too deep to be affected by groundwater circulation, the normal contact between the salt and overlying rock is known as the 'dry rock-head.'

Natural brine springs have been exploited at least since Roman times. Brine was boiled in open pans to produce salt. In 1670 rock salt was discovered at depth in Cheshire and this led to considerable commercial exploitation both by mining and drilling to the wet rock-head to pump natural or 'wild' brine. Shallow mines subsequently became flooded and pumping of the resultant brine caused the solution of roof pillars leading to catastrophic subsidence and damage at the surface. Natural brine pumping also led to unpredictable subsidence some kilometres from the point of extraction. Damage caused by this method of extraction led to the cessation of salt extraction in Worcestershire and Staffordshire. Remedial work to infill and stabilise the flooded salt mines beneath Northwich has recently started.

Both underground mining and solution mining are used to extract salt. Rock salt mining is undertaken at two locations in England, at the Winsford Mine in Cheshire and the Boulby Mine in the North York Moors National Park. The latter is as a by-product of potash mining (see Factsheet on Potash). Salt mining at the Winsford Mine began in 1844, but the mine was closed between 1892 and 1928. Since 1928 it has been the major source of rock salt in the UK. Mine capacity is about 2.25 Mt/y, but averages about 0.9 Mt/y. Extraction is by room and pillar mining and is currently from the Bottom Bed of the Northwich Halite Formation at a depth of about 140 m. The salt is extracted from galleries 8 m high and 20 m wide. Pillars are 20 m x 20 m giving an extraction rate of 75%. Formerly drill and blast methods were used for salt extraction. A continuous mining machine was, however, introduced in 2002, which is used to extract the top lift of 4.5 m, with either bench blasting or the continuous miner being used for the bottom 3.5 m. The rock salt is crushed to either - 6 mm or -10 mm underground and treated with an anti-caking agent to keep it free flowing. Rock salt mining produces no waste.

The mine is dry and stable; room and pillar mining does not create any surface subsidence. However, in 1968 the intersection of a borehole caused serious flooding. Protection barriers of 75 m are now left around boreholes. The salt contains about 92% NaCl and the presence of some mudstone provides a protective coating to outside stockpiles and prevents dissolution.

Almost all solution mining is now by controlled brine pumping. The method was introduced by ICI in the 1920s and involves the creation of stable cavities in suitable salt strata by the introduction of water under carefully controlled conditions, thus preventing subsidence. The process recovers up to about 25% of the total salt reserve. Brine is extracted from cavities up to 145 m in diameter and up to 200 m in height. The size and shape of the cavities are designed to maintain the stability of the overlying strata and so avoid surface subsidence. Each cavity is developed through a single borehole with a triple tube system. Water is pumped into the cavity and brine is continuously displaced through the centre tube. Once the cavity has enlarged sufficiently, usually after a couple of years, this process produces saturated brine, containing 26% NaCl. The position of the water injection tube and the depth of a compressed air blanket, which is used to prevent upward development, control the area of salt dissolution. By changing the position of these during development, the final size and shape of the cavity can be controlled. Cavities are developed from the base upwards and during development their size and shape is monitored by sonar techniques. Insoluble mudstone falls to the bottom of the cavity. The brine wells are laid out on a regular grid with new wells being drilled some 200 m apart. Completed solution cavities are left full of saturated brine, although some are used for both waste disposal and storage purposes. Controlled brine pumping take place at the Holford and Warmingham brinefields from the Northwich Halite Formation at depths of over 250 m. At Holford up to 50 cavities are currently being used for brine extraction.

Only very minor quantities of natural brine are now produced at Wincham, near Northwich.

The brine produced by solution mining requires purification before it can be used either as a chemical feedstock or in the production of white salt. The purification process involves precipitating calcium sulphate, calcium carbonate and magnesium hydroxide, and these insoluble wastes are disposed of into worked out salt cavities. The waste is subject to the landfill tax at the lower rate of £2/t applying to inactive or inert waste. Disposal of waste in this way is believed to be the Best Environmental Option. Total production of these wastes is estimated to be of the order of 60 000 t/y.

By-products

There are no currently useable by-products in the strict sense, although the use of the wastes from brine purification have been looked at periodically and warrant further study. However, salt extraction both by conventional and solution mining creates large, stable voids that are themselves important economic assets both for storage purposes and waste disposal. The Winsford Mine, with some 26 million m^3 of space, has a constant temperature and humidity and is dry and gas-free. Part of the mine is currently being used for secure document storage. A proposal to use part of the mine for the permanent storage of hazardous wastes was granted planning permission in December 2003. Strict criteria will be used for the type of material stored, which will be dry waste that is non-flammable, non-biodegradable and non-radioactive.

Alternatives/recycling

The chemical uses of salt are directly related to its composition and it is unlikely that any other source of sodium and chlorine ions could be used as an alternative in the UK. Other materials (e.g. urea) have been used for de-icing roads in special circumstances, such as on bridges to avoid corrosion, but on cost grounds, rock salt is unlikely to be replaced for road treatment.

Salt is valued for its chemical properties and is thus consumed in use. Some recycling of the products derived from salt takes place. For example, soda ash is an essential component in the manufacture of soda-lime-silica glass, the most common glass composition. Recycling glass thus also recycles soda (Na_2O) in addition to silica and lime.

Transport issues

Brine from both the Holford and Warmingham brinefields is supplied to downstream processing operations entirely by pipeline. Rock salt is delivered by road from the Winsford Mine, although a small proportion (5%) will be subsequently transferred to rail for movement to Scotland. At the Boulby Potash Mine rock salt is removed from the site by rail for onward transfer by lorry and ship from Tees Dock.

Planning issues

Modern methods of underground solution and rock salt mining do not cause subsidence and raise only modest planning issues at surface. Pumping of natural brine is unlikely to be permitted in future, although some old permissions are still in operation and there is still a legacy of subsidence from historic working by this method.

It is likely that in the future, the major planning issue will not be the extraction of salt itself, but the subsequent use of the void created for waste disposal and for storage purposes. Of particular interest is the scale of the impact of these additional operations at surface. The 'need' argument will centre around the national requirement for storage of fuel gas/liquid hydrocarbons and compressed air, or safe disposal of hazardous waste, rather than the demand for brine or rock salt.

There is a European Standard EN 1918-3:1998 on Gas supply systems — Underground gas storage — Part 3: Functional recommendations for storage in solution-mined salt cavities.

Authorship and acknowledgements

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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 and Deborah Rayner.

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

Office of the Deputy Prime Minister
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NATURAL ENVIRONMENT RESEARCH COUNCIL

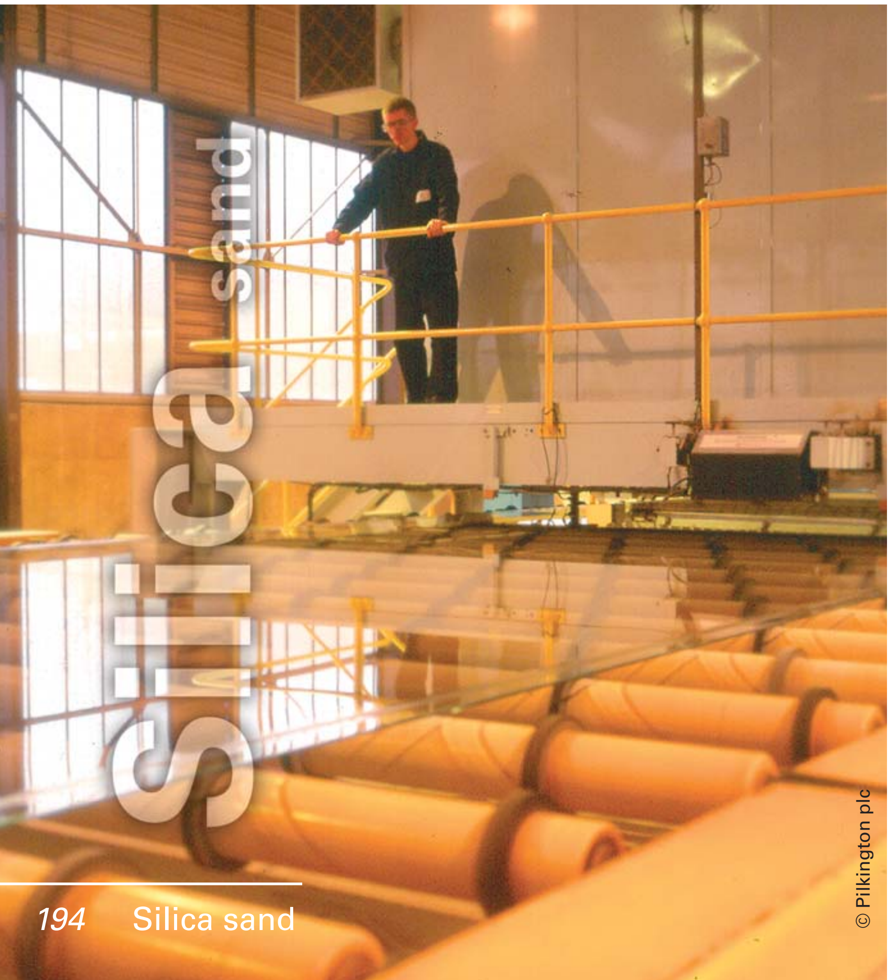
Mineral Planning Factsheet

Silica sand

*The purpose of this factsheet is to provide an overview of the mineral **silica sand**. It forms part of a series on economically-important industrial minerals, excluding aggregates, that are extracted in England. It is primarily intended to inform the land-use planning process.*

Silica (industrial) sands contain a high proportion of **silica** (up to 99% SiO_2) in the form of **quartz** and they are used for applications other than as construction aggregates. They are produced from both loosely consolidated sand deposits and by crushing weakly-cemented sandstones. Unlike construction sands, which are used for their physical properties alone, silica sands are valued for a combination of chemical and physical properties. These include a high silica content in the form of quartz and, more importantly, an absence of deleterious impurities, particularly clay, iron oxides and refractory minerals, such as chromite. They typically have a narrow grain-size distribution (generally in the range 0.5 to 0.1 mm). For most applications, silica sands have to conform to very closely defined specifications and consistency in quality is of critical importance. Particular uses often require different combinations of properties. Consequently, different grades of silica sand are usually not interchangeable in use. Silica sands command a higher price than construction sands. This allows them to serve a wider geographical market, including exports.

Finished float glass, Pilkington's Greengate plant, St Helens.



Demand

Silica sands are essential raw materials for glassmaking and foundry casting. Although there has been a significant decline in the production of foundry sand, these two sectors remain the most important markets for silica sand (Figure 1). Glass sand accounted for 40% and foundry sand 21% of total sales in England in 2002. However, silica sands have a wide range of other industrial uses.

There are many different types of glass with different chemical and physical properties. Most of the commercial glasses in everyday use, such as bottles and jars (containers), and flat glass (windows, mirrors and vehicle glazing), are soda-lime-silica glasses. These contain between 70–74% SiO_2, the ultimate source of which is silica sand, although increasing amounts of silica are being recovered in the form of recycled glass (known as cullet). Sand by itself can be fused to produce glass, but only at very high temperatures (1700˚C). The addition of sodium carbonate (Na_2CO_3) significantly reduces this temperature. Other components, such as calcium oxide (CaO), magnesium oxide (MgO) and alumina (Al_2O_3) are added (in the form of limestone, dolomite and feldspathic minerals) in order to give the glass stability and durability. Sodium carbonate is manufactured from salt and limestone, emphasising the dependence that some industries have on a number of industrial minerals.

The principal glass products using silica sand include colourless and coloured containers (bottles and jars), flat glass, light bulbs and fluorescent tubes, TV and computer screens, and glass fibre, both for insulation and reinforcement. Glass manufacturers are principally concerned with the chemical composition of silica sands, and particularly iron, chromite, and other refractory mineral contents. Quality requirements depend on the type of glass being manufactured (principally whether it is colourless or coloured) and to some extent on the requirements of the individual glass manufacturer. Glass sand for colourless glass containers generally has an iron content of <0.035% Fe_2O_3 , for flat glass in the range 0.060 to 0.1% Fe_2O_3, and for coloured containers 0.25%–0.3% Fe_2O_3. However, it is the overall composition of the glass batch that is important and lower levels of iron in one component may be offset by higher levels in another. For example, the generally lower quality (i.e. higher iron) of colourless glass cullet has to be balanced by lower iron contents in the colourless glass sand.

In the foundry industry, silica sand is used as the main mould and coremaking material for both ferrous and non-ferrous castings. The physical and chemical properties of the sand are important and depend on a number of factors, such as the metal and product being cast and the type of binder used. In the past naturally-bonded moulding sands were widely used. These contained sufficient clay to give the mould strength without the addition of a bonding agent. Today such sands are of less economic importance and demand is principally for clay-free (washed) sands, which are high in silica. They should also have a uniform (narrow) size distribution, and grains with a generally high sphericity. A binding agent, either clay (usually bentonite) or a chemical, such as resin, is added to the sand.

Low iron silica sands, some of which are calcined (heat treated) to convert the quartz to cristobalite (a high temperature form of silica) are also ingredients of clay-based whiteware ceramic bodies, such as tableware, sanitaryware, and wall and floor tiles. They are also a component of ceramic glazes and enamels. Silica sand is the starting point for the manufacture of water-soluble sodium silicates, and other downstream silicon chemicals, such as silica gels, silicones, silanes and zeolites, which have a wide range of applications. In addition to a low iron content, a low alumina sand is also required for sodium silicates manufacture. In addition to being a component of glass, silica sand is also used as a grinding and polishing medium for the production of polished wired safety glass.

Other uses of silica sands include enhancing the production (as proppants) of oilfield reservoirs, and in the production of silica flour for use as fillers in plastics, paints and rubber sealants. Closely-sized grades of silica sand are the principal filtration medium used by the water industry to extract solids from water. In contrast to other grades of silica sand, the particle sizes required are coarser, with 0.5 to 1.0 mm being a popular grading. An increasingly important market for silica sand is sports and leisure applications. Closely graded silica sand, in many cases mixed with organic matter, is used in top dressings and root zones for sports surface construction, for example for football and hockey pitches, and golf course tees and greens. Other uses of silica sand are for equestrian surfaces, for golf course bunkers, synthetic soccer pitches, as play sands and in horticultural applications demanding quality as well as consistency.

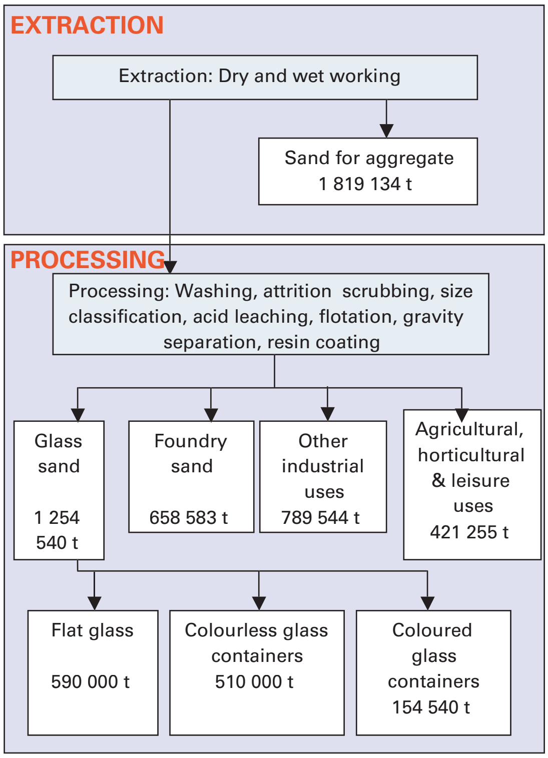


Figure 1 Silica sand supply chain, England, 2002.

Supply

In comparison to the production of construction sand (about 38 Mt in England in 2002), silica sand output is relatively small. Peak production of silica sand in Great Britain was some

Silica sands

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Silica sand

6.3 million tonnes in the mid-1970s, but output has declined since and has averaged some 4 Mt/y for a number of years (Figure 2). Of total output in 2002, over 87% was produced in England, with almost all of the remainder from Scotland.

Output reflects activity in many different sectors of the economy. There has been a very marked decrease in the production of foundry sand. This is due to a decline in the total quantity of metals being cast, as the manufacturing sector of the UK economy has declined. Production of glass sand mainly reflects production of glass containers and flat (float) glass. Other sectors, such as special and technical glasses, including TV screens, lighting, domestic, laboratory and cosmetic glassware, fibreglass both for insulation and reinforcement, are also significant consumers of sand.

Overall glass sand production has declined slightly but demand for sand for float glass manufacture is increasing with two new plants recently coming on stream.

A survey of silica sand production in England in 2002 by major end use was conducted by the Silica and Moulding Sands Association (SAMSA) specifically for this research (see Table 1). Members of SAMSA account for almost all of the silica sand produced in England.

Trade

International trade in silica sand is small. Data for UK imports and exports are shown in Table 2.

Consumption

The UK is essentially self-sufficient in silica sand. Imports are mainly into Northern Ireland and exports are principally from Scotland. Small quantities of water filtration sands and resin-coated foundry sands are also exported.

Economic importance

The value of UK silica sand production is estimated at £53 million in 2002. The numbers employed by the industry in England only, including permanent employees and perma-

Glass sand (a)	Tonnes
For flat glass	590 000
Colourless containers	510 000
Coloured containers	154 540
Total glass sand	1 254 540
Foundry sand (b)	658 583
Other industrial uses (c)	789 544
Sand for agricultural, horticultural and leisure uses	421 225
Total production	**3 123 892**

Table 1 England: Production of silica sand, 2002.
(a) Excluding fibreglass
(b) Silica, resin-coated and naturally bonded
(c) Silica flour and cristobalite, sodium silicates/chemicals, fibreglass, ceramics, water filtration and other prescribed industrial processes set out in the Aggregates Levy.
Source: Silica and Moulding Sands Association.

	Imports		Exports	
	Tonnes	£thousand	Tonnes	£thousand
1998	31 784	5 492	52 672	5 508
1999	46 934	6 095	42 935	4 042
2000	33 209	6 489	28 796	3 779
2001	46 500	6 624	54 419	4 809
2002	104 232	13 020	39 816	5 250

Table 2 UK Imports and exports of silica sand, 1998 – 2002. *Source : HM Customs and Excise.*

nent contractors at quarry sites, drivers and head office staff, is reported to be 908 in 2002 for SAMSA members only. This figure is appreciably larger than the only official figure for employment in the silica sand industry of 838 for Great Britain as a whole. The latter only includes employees that are subject to the Mines and Quarries Acts and thus underestimates total employment.

The glass and foundry industries are the most important consumers of silica sand, although the mineral is consumed in many other sectors of the economy. In 2002 the UK produced about 1.9 million tonnes of container glass valued at £680 million, most of which was sold in the home market. Of the total nearly 70% was colourless containers, 18% green and 12% amber.

The production of flat glass was around 0.85 million tonnes with a value of about £265 million, although this will rise in the near future, as a new flat glass plant, near Goole, has recently come on line. There are about 5 500 people employed in the container glass sector and 2 000 in flat glass.

Despite a considerable decline in the foundry industry, there are currently about 500 foundries in the UK employing 40 000 people. These foundries produce 1.7 million tonnes of castings with a value of the order of £2.7 billion. About 50% of the production is for the automotive sector. Some 20–25% of the tonnage is exported and 73% of the exports go to the EU. About 88% of the companies are SMEs. Of the total number of foundries, 28% produce grey iron castings, 23% produce aluminium, 20% steel, 12% copper alloy and 8% zinc. All use silica sand to some extent.

Structure of the industry

There are a number of silica sand producers in England. The largest is WBB MINERALS Ltd, which accounts for over 50% of total production and an even greater proportion of colourless glass sand. The company is a wholly-owned subsidiary of SCR Sibelco, a privately owned Belgian group with silica sand interests worldwide. WBB MINERALS has silica sand

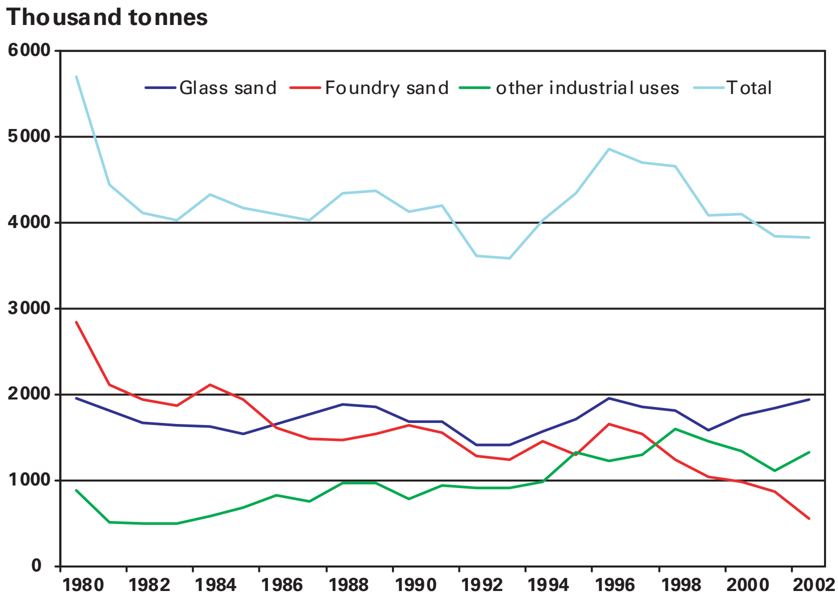

Figure 2 Great Britain: Production of silica sand, 1980–2002*. Source: United Kingdom Minerals Yearbook, BGS.*

operations in Cheshire, Staffordshire, Surrey, Norfolk, North Lincolnshire and Bedfordshire.

Other important producers in England are;

Hanson Quarry Products, Surrey and Kent
Tarmac Central, Cheshire
Bathgate Silica Sands Ltd, Cheshire
Garside Sands—Bardon Aggregates, Bedfordshire, Dorset
RMC Aggregates (Southern) Ltd, Kent
Mansfield Sands Ltd, Nottinghamshire
Burythorpe Sands Ltd, North Yorkshire
Bucbricks Co Ltd, Essex
J Williams (Cinetic Sands) Ltd, Worcestershire
Southport Sand Co Ltd, Sefton.

The Silica and Moulding Sands Association, part of the Quarry Products Association, is the trade association for the silica sand industry.

The glass container industry is mainly located in Yorkshire and the flat glass industry is located in St Helens and South Yorkshire/North Lincolnshire. Foundries are widely distributed but with a marked concentration in the West Midlands, and Yorkshire and the East Midlands.

Silica sand

Resources

Silica sands are produced from loosely consolidated sands and weakly cemented sandstones ranging from Recent to Carboniferous in age. Although sand and sandstone deposits are widely distributed in England, only a small proportion of these possess the desired physical and chemical properties to be considered as potential sources of silica sand. These, in turn, will differ appreciably in purity, particle size and thickness. All of the sand resources will require some form of processing to upgrade them into marketable form. A critical factor, therefore, in defining a sand or sandstone deposit as a silica sand resource is its inherent particle size and the ease with which impurities can be removed, together with the level of losses incurred in this process. The special characteristics of the markets for silica sand, and the costs of processing, means that silica sand resources have a fairly restricted distribution. In addition, resources that are suitable for one market may not be suitable for another. For example, sand suitable for the manufacture of colourless containers is only produced at four locations in England.

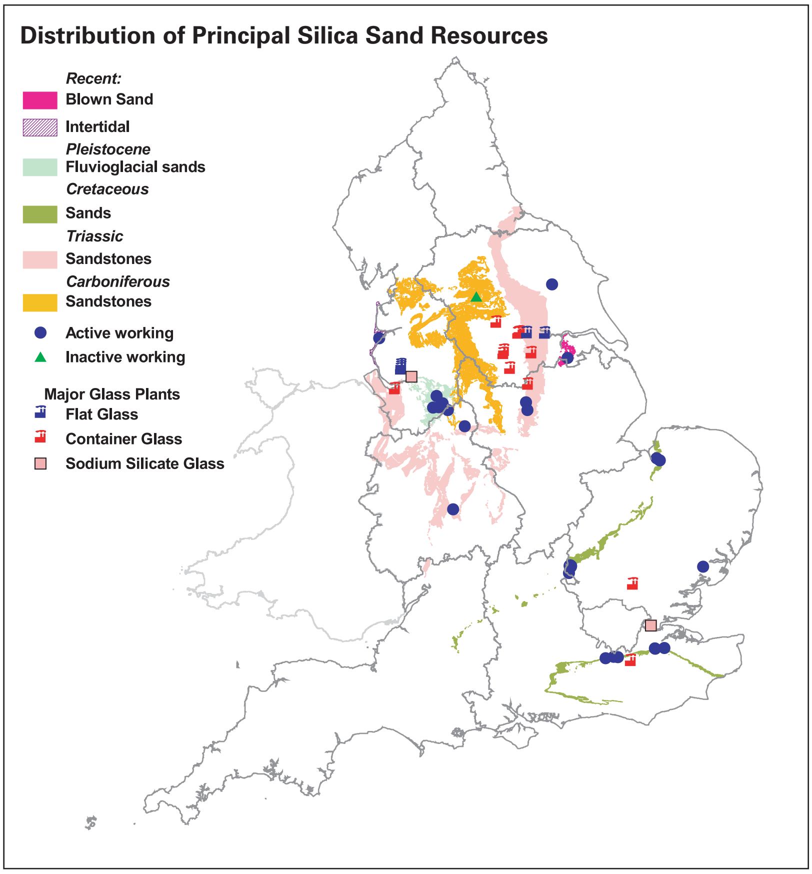

Figure 3 Principal silica sand resources and location of major glass sand consumers, England.

Silica sand resources of Pleistocene age in Cheshire and those of Lower Cretaceous age in eastern and southern England are the most important, with each accounting for nearly 40% of total output in England (Figure 3).

The Congleton and Chelford sands in Cheshire are unusual for glacial deposits in having a uniform particle size and being largely free of impurities. Glacial deposits generally tend to be very heterogeneous in character and are not normally suitable for use as silica sand. The Cheshire deposits occur as irregular sheets, which infill troughs in the underlying clays and mudstones. They are themselves cut into by overlying boulder clay and impure sands only suitable for construction use. The Congleton Sand is highly valued as a source of foundry sand. The Chelford Sand is purer and coarser and is the most important source of sand for flat glass manufacture in the UK.

Silica sand is produced from deposits of Lower Cretaceous age at several locations in England. The Leziate Beds of Lower Cretaceous age, near King's Lynn in Norfolk are used in the manufacture of colourless glass containers, flat glass and for foundry sand. It is one of the very few deposits where there is no associated production of construction sand. In contrast the Folkestone Formation of the Lower Greensand Group of the Weald is a regionally important source of construction sand. However, between Buckland and Godstone in Surrey and Maidstone and Borough Green in Kent, it is also an important source of silica sand. The Surrey deposits in particular have low iron contents making them suitable for the production of colourless glass sand. These sands are also unusual in having a low alumina contents (<0.1% Al_2O_3) making then suitable for the manufacture of sodium silicates.

Silica sand

The upper part of the Woburn Sands Formation of the Lower Greensand in the vicinity of Leighton Buzzard, Bedfordshire is a source of sand for foundry and horticultural applications, and water filtration. Coarse-grained, well-rounded quartz sands are particularly suited for water treatment and are produced by the selective screening of sands from a number of quarries. Construction and silica sands are normally derived from the same quarry and their production is interdependent. Closely-sized water filtration sands are also produced from the Pleistocene Kesgrave Group of Essex, which is a regionally important resource of sand and gravel.

Sandstone within the Carboniferous Millstone Grit Group in Staffordshire is worked for silica sand principally at Oakamoor. The sandstone has a high iron content for a source of silica sand, but the impurities are present mainly as iron oxides coating the surface of the quartz grains and also as discrete iron–bearing minerals. Hot acid leaching removes most of the surface contamination and together with spirals to remove heavy minerals, yields a high quality silica sand containing 0.035% Fe_2O_3 which is required for colourless glass and ceramics manufacture. The sand is also used in a wide range of other industrial applications and is also calcined to produce cristobalite. A similar sandstone deposit of Carboniferous age was worked at Blubberhouses, near Harrogate, North Yorkshire for the production of colourless glass sand. This operation is currently inactive.

Sand for coloured glass containers are produced from thin, wind blown deposits of Recent age in the Messingham area of North Lincolnshire. Sand for a variety of industrial applications, including flat glass polishing, is produced from the intertidal zone of the Ribble Estuary off Southport. Sands of Triassic age are worked in Nottinghamshire and Worcestershire and resin coated sands are produced from sandstones of Jurassic age in North Yorkshire. Sands of the Tertiary age Poole Formation in Dorset are used in glassfibre manufacture.

Reserves

For the purposes of this study a survey of permitted reserves of silica sand at operational sites at 1st January 2003 was undertaken by SAMSA. The results are presented in Table 3.

Permitted reserves 1 January 2003	*Thousand tonnes*
Colourless glass sand	11 060
Foundry and other silica sand	35 189
TOTAL	**46 249**

Table 3 England: Permitted reserves of silica sand, 2002. *Source: SAMSA.*

Total reserves include a wide range of different qualities of silica sand, many of which are not interchangeable in use. For example, the figure for colourless glass sand includes material suitable for both container glass and flat glass manufacture. However, the two uses have very different quality requirements, and a higher iron sand can be tolerated in the latter. In total the overall stock of permitted reserves is less than the 15 years supply currently recommended in Mineral Planning Guidance *15 Provision of Silica Sand in England*. The position at individual sites will, however, vary considerably.

Processing plant for silica sand generally requires high capital investment. Sufficient permitted reserves are required to reflect this investment.

In addition to permitted reserves of silica sand at operational sites, there are also permitted reserves of colourless glass sand at the Blubberhouses Quarry, near Harrogate in North Yorkshire. The quarry closed in 1991 after being operational for only some three years.

Relationship to environmental designations

Two sites working the Folkestone Formation in Surrey and Kent respectively, lie partly within AONBs. A number of other sites are overlooked by AONBs. The inactive Blubberhouses Quarry lies within the Nidderdale Moors AONB.

A number of sites have adjacent nature-conservation designations and some of these may have been created by restoration of former silica sand workings.

The sand extraction operations on the Horsebank in the Ribble Estuary are within a Ramsar site, a Special Protection Area and a candidate Special Area of Conservation. A recent planning application to extend the operations was granted following a public inquiry.

The industry is concerned about the cumulative impact of environmental and other land use designations, both at national and local level. This can have a significant impact on obtaining planning consents for a relatively scarce resource, such as silica sand.

Extraction and processing

In England the extraction of silica sand is exclusively by surface quarrying, by both dry working and suction dredging. There is one silica sand mine in Scotland. Hard sandstone deposits tend now to be worked by ripping rather than by drilling and blasting. Loosely consolidated sands can be easily removed. Worked thicknesses range from over 30 m for some glacial and sandstone deposits to less than 2 m for wind blown sands. Sand recovered from the intertidal zone in the Ribble Estuary is in strips to a depth of 0.5 m.

Silica sand processing is of varying degrees of complexity, and depends on the end use of the sand. It typically requires a high capital investment in plant. Processing is aimed at improving both the physical and chemical properties of the sand to meet user specifications. At most operations this involves washing, attrition scrubbing and size-classification to remove the coarse and very fine fractions and to obtain a clean sand with the desired particle size distribution. Blending of lower and higher quality material is undertaken to optimise the use of the reserves. For the production of selected grades of colourless glass sand, more sophisticated processing is required to remove contaminating impurities, either from the sand and /or from the surfaces of the individual sand grains. Froth flotation and/or gravity separation may be used to remove heavy iron-bearing minerals and chromite. Hot sulphuric acid leaching is used at King's Lynn, Norfolk and Oakamoor, Staffordshire, to remove iron oxides coating the individual sand grains. A cold acid leach is also used at Kings' Lynn for the production of sand for flat glass. Froth flotation in an acid environment is used at Redhill and Reigate in Surrey to remove heavy minerals, including iron coating the sand grains. Most foundry sands have to be supplied dried and drying facilities are a substantial capital investment. Selected grades are also coated with resin binders producing a high value-added product. A wide range of grades are produced based on different particle sizes and resin types.

Some silica sand is calcined to convert quartz to cristobalite, which is a higher temperature form of silica more suitable for use in ceramics. Both cristobalite and dried silica sand are finely milled to produce various grades of silica flour.

The extraction and processing of silica sand involves the production of only small amounts of waste. Yields of saleable product are on average about 90%, excluding overburden removal, which is used in site restoration.

By-products

Silica sand producers seek to maximise the use of the mineral in the ground and most operations also produce some construction sand as an ancillary product. A few construction sand quarries may also have an associated output of silica sand. Construction sand is produced from specific beds, including overburden, that cannot be processed to produce marketable silica sand, and from coarse and fine material removed during processing. In 2002, 1.8 million tonnes of construction sand were produced in association with silica sand extraction in England.

Alternatives/recycling

Recycled glass (cullet) from bottles is increasingly used to make new glass. The use of cullet has a number of environmental benefits. It not only reduces the demand for new silica sand but, because cullet melts more readily, it saves energy and reduces emissions. However, it is important that glasses of different colours are not mixed and that, as with silica sand, the cullet is free from impurities, in particular metals and ceramics. Currently the UK recycles some 33% of glass containers. There is a surplus of green cullet, some of which is exported and some used as an aggregate in materials such as asphalt. Recycled, crushed and closely-sized glass from coloured bottles is also being developed as an alternative to sand for water filtration.

Flat glass is recycled into glass containers, glassfibre and rolled plate glass. Flat glass manufactured by the float glass process is highly sensitive to impurities, in particular refractory materials that do not melt. For this reason window glass is not taken from demolition sites because of the risks of contamination. The industry is, however, looking at utilising flat glass from fabricators, such as the automobile industry and double-glazing manufacturers, where better quality control is feasible.

In the foundry industry most metal is cast in 'greensand' moulds in which a mixture of silica sand and bentonite is mixed with water to give sufficient plasticity for the mould to be formed. Volume producers of castings use automatic systems in which the used mould is disaggregated and the sand recycled with a small addition of new bentonite to make good that destroyed in the casting process. Foundry sand used with chemical binders is also reclaimed using attrition and thermal processing and most is re-used with the addition of some new sand. Spent foundry sand is increasingly used for alternative applications including as asphalt filler, in cement manufacture and in building blocks. About 180 000 tonnes were used for these purposes in England in 2001.

Effects of economic instruments

Silica sand that is used in prescribed industrial and agricultural processes is not subject to the Aggregates Levy. Sands that are unsuitable for these applications are produced as ancillary products at many silica sand sites and sold for construction use. Of total sales of 4.9 million tonnes of sand from sites operated in England by SAMSA members in 2002, 37% (1.8 Mt) was subject to Aggregates Levy. The Levy was introduced at the rate of £1.60/t in April 2002.

Spent foundry sand is subject to the Landfill Tax. However, commercial pressures were already encouraging the re-use of foundry sand in other applications.

Transport

Most silica sand is transported by lorry and bulk tanker. Rail is used to transport sand from Norfolk for container glass manufacture in Yorkshire. A new flat glass plant, near Goole, is also being supplied by rail from King's Lynn. Some consuming industries require deliveries to service 24 hour operations.

Planning issues

Compared to construction sand, silica sand has a number of distinctive characteristics which are relevant to land-use planning:

- the style of deposit worked is variable;
- silica sand has a range of applications with many different specifications;
- individual grades are often not interchangeable in use;
- output volumes tend to be relatively low;
- other than glass cullet, there is a lack of alternative materials;
- the importance of the sand to a broad range of downstream manufacturing industries;
- processing plant is often complex and generally requires a high level of capital investment;
- in many cases, processing plant operates on a continuous (24 hours) basis;
- individual sites tend to be long-lasting;
- some silica sand resources can coincide with relatively sensitive environments and habitats;
- there is pressure to establish less damaging transport alternatives to road at well-established sites with a long term future; and

Silica sand

- permitted reserves at some quarries are less than the 15 years recommended in current mineral planning guidance.

Further information

Minerals Planning Guidance 15: *Provision of Silica Sand in England.* Department of the Environment. (London: HMSO, 1996).

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