Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Ball clay

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

June 2011

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' (degree of structural perfection) and size of kaolinite crystals found in different ball clays can have 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.

Extraction of Ball clay at Petrockstow, Devon.

Other uses include kiln furniture, enamels and glazes, building bricks, and fillers and sealants. Ball clay is rarely used alone; the proportion used varies depending on the product. Other constituents of ceramic whiteware are kaolin (china clay), silica sand and a flux (a substance such as feldspar which reduces the melting point of the other ingredients). 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 is currently being driven by exports and 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 that utilise light-firing and low carbon clays. UK ball clay is often blended with clays produced elsewhere to improve performance in use. Demand for UK ball clay is heavily influenced by factors such as economic cycles, exchange rates and the availability and quality of clays from other European producers. In general, sales are now recovering following the global economic slowdown in 2008–2009 Sanitaryware sales are beginning to move away from traditional markets into those of developing nations. Sanitaryware clays represent about 40% of UK ball clay sales by volume.

Supply

Globally, high-quality ball clays, or 'plastic' clays, are relatively scarce because of the unusual combination of geological factors required for their formation and subsequent preservation. Different deposits may 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

Ball clay

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 were on a rising trend in the 1990s and reached a record 1.1 million tonnes in 2000. A period of decline followed the record sales of 2000, until 2004, at which point sales began to rise. Between 2005 and 2010 sales have remained stable, at around the one million tonnes per annum level, with the exception of low sales in 2009 as a result of the economic downturn (Figure 2).

The occurrence of ball clay is confined to three relatively small areas, all located in south west England. Ball clays were deposited in the Bovey and Petrockstowe basins in Devon and the Wareham Basin in Dorset (Figure 3). The Bovey Basin is the most important source, both in terms of total sales (50 per cent) and, more importantly, the diversity of the clays that are produced. The Wareham and Petrockstowe basins each contributed around 25 per cent of total sales in 2010. Of total production, therefore, over 70 per cent is supplied from Devon. The wide spectrum of clays available in the UK, some of which have unique properties, means that there is likely to be a continuing demand for UK ball clay into the foreseeable future.

Trade

The UK is a leading exporter of ball clay, and particularly of sanitaryware clays. Export sales have steadily grown and were 853 000 tonnes (83 per cent) of total sales in 2008 (generating in excess of £30 million in export sales), including 560 000 tonnes to the EU. UK ball clays are exported to a large number of countries worldwide, although mostly to countries within the EU. Exports are principally

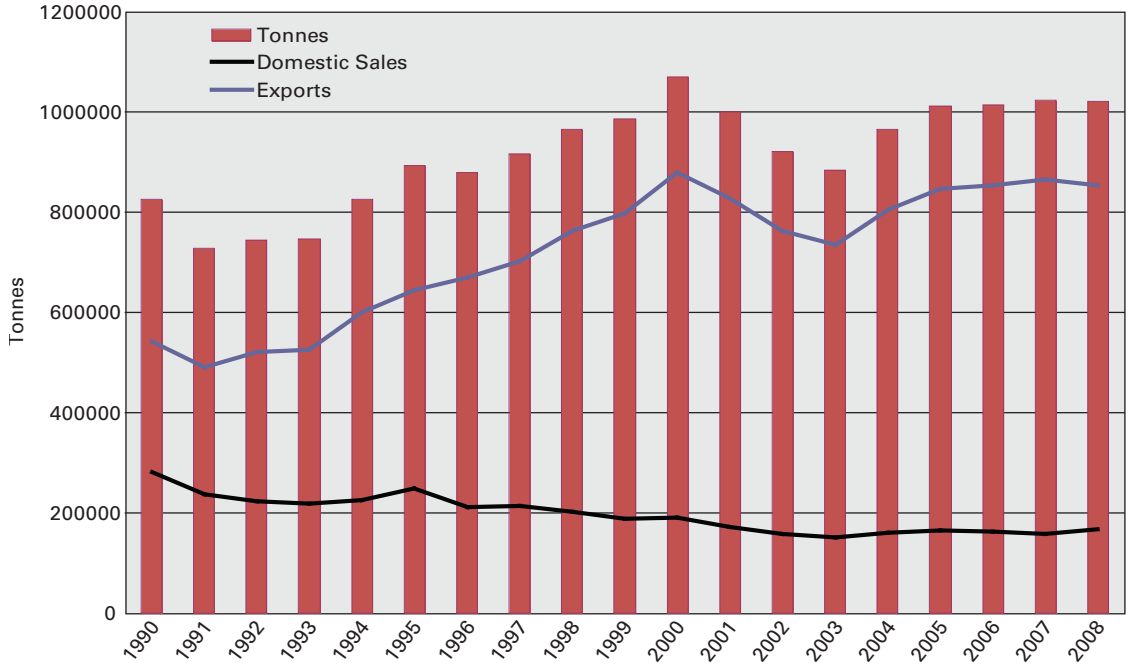

Figure 2 UK: Total sales, exports and domestic sales of ball clay, 1990–2008. *Source: Kaolin and Ball Clay Association.*

Ball clay

used in sanitaryware and tile manufacture. A significant proportion of the world's production of vitreous china sanitaryware contains UK-sourced ball clay as an essential ingredient. Imports of ball clay are negligible and 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, with less than 20 per cent of UK output sold to UK customers. Domestic sales were down from 282 000 tonnes in 1990 to 167 000 tonnes in 2008. This may partly reflect the increasing overseas competition that the UK ceramics industry has been facing, notably in the tiles and tableware sector.

Economic importance

The value of UK ball clay production in 2008 is estimated at to be about £82 million. The ball clay industry in Devon has about 211 direct employees whilst 50 people are employed directly in Dorset, with more local jobs supported in service industries. Domestic sales of ball clay help to underpin the UK whiteware ceramics industry. This industry had total sales of £340 million in 2009 (Table 1) and employs in excess of 7000 people. These jobs are primarily concentrated in Staffordshire, especially in Stoke-on-Trent. High specification UK ball clays are also important in underpinning the wider European ceramics industry.

Ceramic sanitaryware	£80.9 million
Ceramic household & ornamental ware	£185.5 million
Ceramic tiles & flags	£73.5 million
Total	**£339.8 million**

Table 1 UK: Sales of selected ceramic products, 2009. *Source: British Ceramic Confederation.*

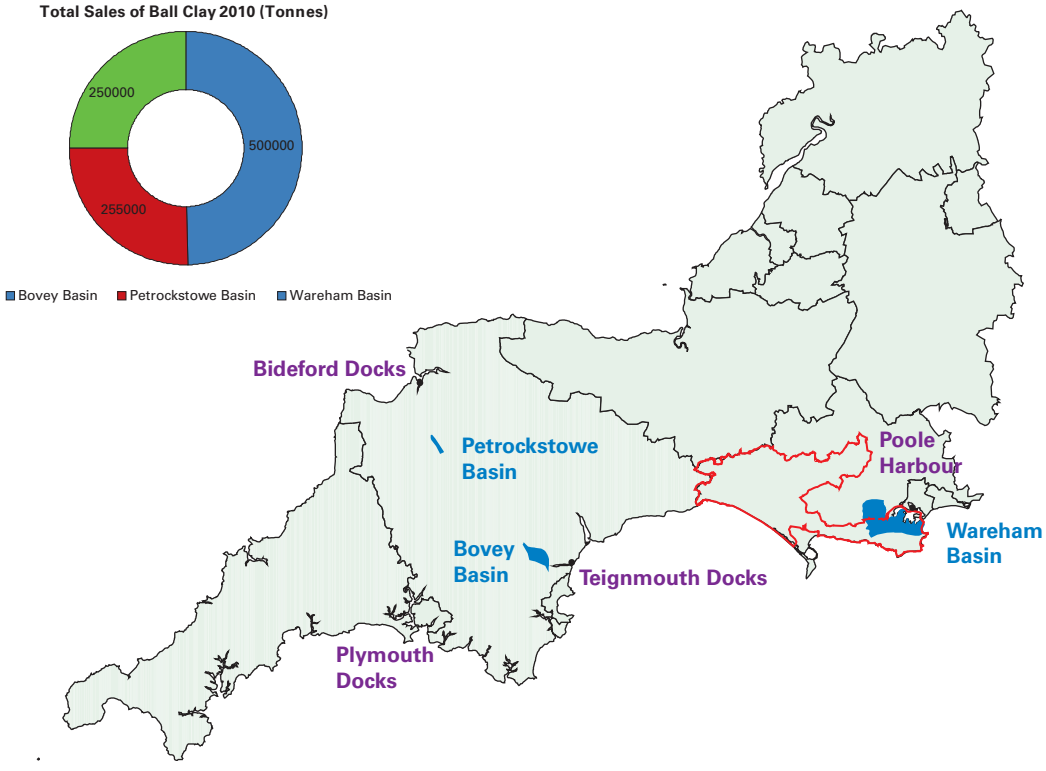

Figure 3 Ball clay-bearing basins in south-west England.

Ball clay

Structure of the industry

There are two producers of ball clay in the UK; Sibelco UK Ltd (formerly known as WBB Minerals) and IMERYS Minerals Ltd. Sibelco UK is a subsidiary of SCR Sibelco of Belgium (privately-owned) and IMERYS Minerals is a subsidiary of the IMERYS Group of France (listed on the Paris Stock Exchange). Both companies have extensive overseas interests. Sibelco is the largest producer of ball clay in the UK with operations in south and north Devon. It is also the largest producer in the world. IMERYS Minerals has operations in south Devon and Dorset, 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 ('Teriary') basins in south west England (Figure 2). Here they occur as beds of variable thickness, 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 also occur around Lough Neagh in Northern Ireland. However, they exhibit high iron contents and no resources have been identified in Northern Ireland 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 structural perfection, of individual kaolinite crystals 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 a rare geological phenomenon. The ball clay resources of Devon and Dorset are, therefore, of national and international importance.

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

Ball clays in the Bovey Basin contain both varieties 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 electro porcelains, refractories and kiln furniture.

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

Estimates of permitted reserves of ball clay for the three basins as of 2010 are shown in Table 2.

Permitted reserves of ball clay are large 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

Ball clay

Basin	Permitted Reserves (Mt)	Years	Unpermitted Resources (Mt)	Years
Bovey	44.7	136	19	55
Petrockstowe	6	23	35	138
Wareham	1	4	6	24
Total	**454**	**163**	**60**	**217**

Table 2 Estimated reserves and resources of UK ball clay in 2011. *Source: Imerys and Sibelco.*

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 up to 100 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. In contrast to Devon, levels of permitted reserves in Dorset are low.

Ceramic tableware and sanitaryware manufacturers often need to ensure long production runs. This requires the ball clay industry has long term access to 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.

Ball Clay Consultation Areas were established in Devon and Dorset in the middle of the last century in order to prevent unecessary sterilisation of clay-bearing land by other forms of development. Whilst this approach has been a significant factor behind the relatively high levels of reserves in Devon, other factors (notably environmental and landscape designations) have restricted access to ball clay in Dorset.

Relationship to environmental designations

The ball clay resources in both Devon and Dorset are associated with numerous environmental designations. The extent and manner of clay extraction in the Wareham Basin and the Bovey Basin are heavily influenced by these designations. The relationship between extraction and designations is particularly acute in Dorset where the Dorset Heaths AONB covers a major part of the Wareham Basin. The majority (about 75 per cent) of 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 per cent are constrained by nature conservation and other designations. Restoration and habitat recreation are used to encourage biodiversity at both active and former extraction sites.

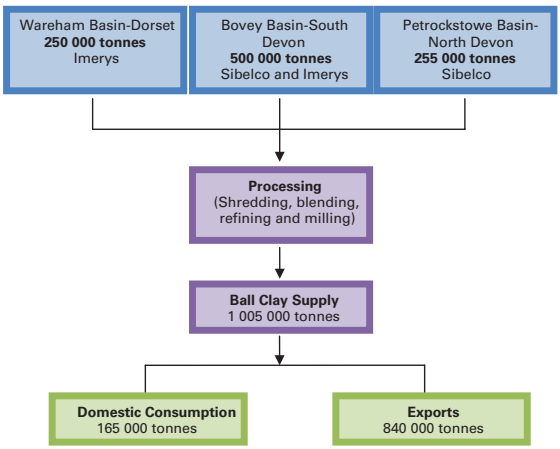

Figure 3 Ball clay supply chain, 2010 Extraction and processing. *Source: Imerys and Sibelco.*

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 also health and safety issues that made this method of extraction uneconomic. Open pit extraction involves using 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 45 per cent to 100 per cent, with an average recovery of around 80 per cent. 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 per cent 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. No mineral waste is produced by this process.

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.

By-products

Sand interburden found between ball clay seams in the Bovey Basin is worked for secondary aggregates, and also industrial and horticultural purposes. Sales of some interburden and overburden sand also have planning consent in Dorset. Small amounts of lignite (an organic material intermediate between peat and coal) from Devon 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. However, there are currently no saleable processing wastes.

Effects of economic instruments

Sales of secondary aggregates (sand) derived from ball clay extraction and processing are exempt from the Aggregates Levy (currently set at £2.00 per tonne).

Ball clay

Transport issues

Blended ball clays are transported in bulk, although a substantial amount is bagged, either in one tonne or 25 kilograms bags. Ball clay for UK consumers is mainly transported by road, despite some plants being rail linked. Rail freight is generally uneconomic. However, the majority (>80 per cent) of ball clay is exported. Clay is taken by road to local ports, principally Teignmouth, Plymouth, 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

Access to clays with different properties There is a continuing demand for a wide variety of consistent quality ball clay blends which are manufactured by combining different ball clay grades extracted from the same site,or from different sites in the same basin or, in some cases, from sites in other basins. Production of these blends generally requires access to a number of ball clays with different properties occurring within the geological sequence at a given extraction site. As such, there is often a requirement to keep a number of working faces open at the same time. This can inhibit backfilling with waste from the extraction process which, in turn, 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 can be extensive, deep and long-lived. The availability of tipping space is a particular issue in the Bovey Basin.

Reserves distribution Reserves are unevenly distributed in terms of location and quality. Although the industry has adequate overall permitted reserves for the foreseeable future, a number of premium grade clays are in short supply and will need new permissions. There are extensive reserves in the eastern part of the Bovey Basin in Devon. However, remaining reserves in Dorset are low and are very constrained by environmental designations.

Nature conservation and landscape designations On occasion, ball clay resources coincide with multiple environmental and landscape designations. This is especially so in Dorset, where there are outstanding landscape (AONB) and international and national habitat designations covering much of the Ball Clay Consultation Area. Although the Dorset Ball Clay Consultation Area extends northwards outside the AONB, clays in this area are inferior in quality to those which occur within the designation.

Further information

Minerals Policy Statement 1: Planning and Minerals. Department for Communities and Local Government. November 2006. http://www.communities.gov.uk/documents/planningandbuilding/pdf/152993.pdf

Minerals Policy Statement 1: Practice Guide. Department for Communities and Local Government. November 2006. http://www.communities.gov.uk/documents/planningandbuilding/pdf/153421.pdf. Note particularly Para 163 on 'Other minerals'.

Sustainable development issues for mineral extraction — the Wareham Basin of East Dorset. D E Highley, C R Bristow, J F Cowley and N R Webb. *British Geological Survey Commissioned Report* CR/01/137N. 2001.

Bovey Basin Strategy. Devon County Council WS Atkins Consultants. December 2000.

Economic importance of UK ball clay. *Report prepared for the Kaolin and Ball Clay Association and the Department of Trade and Industry*. December 2001.

Authorship and Acknowledgements

This factsheet was produced by the British Geological Survey for the Department of Communities and Local Government as part of the research project 'DCLG- BGS Joint Minerals Programme.' It was compiled by Richard Shaw and Andrew Bloodworth with assistance from Don Cameron and Deborah Rayner (BGS).

Ball clay

The advice and assistance of DCLG, and the ball clay industry is gratefully acknowledged.

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

Ball clay