Office of the Deputy Prime Minister
Creating sustainable communities

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Fuller's earth

*This factsheet provides an overview of **fuller's earth** supply in the UK. It is one of a series on economically important minerals that are extracted in Britain and is primarily intended to inform the land-use planning process.*

January 2006

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.

Final cut at Woburn, Bedfordshire, December 2004.

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.

As domestic production declined, however, many of these uses were taken over by imported material or have ceased altogether. In the last few years before production finally ceased in 2005, British fuller's earth was used as a fibre and filler retention aid in papermaking systems, mainly for the export market, and as a bonding agent for foundry sands. Small amounts were also used in the manufacture of carbonless copy paper.

Supply

Fuller's earth production has been confined to England, where is has been worked 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).

Sales were 26 000 dry tonnes in 2004 and 6 200 tonnes in 2005 when production finally ceased bringing to an end this long established minerals industry. Recent production was confined to Baulking in Oxfordshire and Woburn in Bedfordshire. Production at Baulking ceased in October 2005 and at Woburn in December 2004.

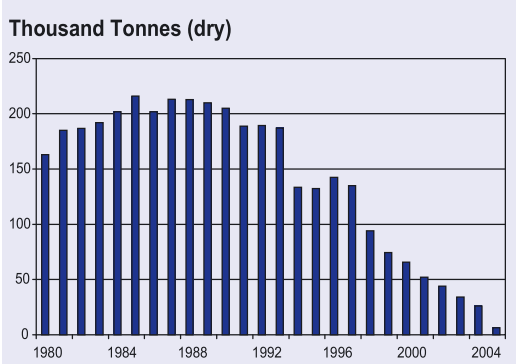

Figure 1 England: Production of fuller's earth, 1980–2005. *Source: United Kingdom Minerals Yearbook, BGS.*

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 and accounted for about 1.6 million tonnes of product. 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.

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 generally been on a rising trend, being 77 000 tones in 1980, 154 000 tonnes in 1990 and over 255 000 tonnes in 2000. However, since then imports have decreased, possibly reflecting declining use in the castings industry as foundries continue to close (Table 1).

	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	215 022	12 189
2003	75 099	19 179	198 434	10 102
2004	72 526	18 241	182 414	12 051

Table 1 UK: Imports and exports of bentonite, 1999–2004. *Source: HM Revenue & Customs.*

Consumption

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

Economic importance

The total value of fuller's earth sales in 2004 was estimated at about £2.6 million, but less than £1 million in 2005. Indigenously produced fuller's earth is no longer of economic importance in Britain following the cessation of production.

Structure of the industry

Fuller's earth was until 2004 produced by two companies in Britain; Rockwood Absorbents (Baulking) Ltd and Steetley Bentonite and Absorbents Ltd. Rockwood's operation was at Baulking in Oxfordshire. The original quarry was exhausted in summer 2002 and has been restored to a water feature. Until its closure in 2005 sales have been based on stockpiles of crude fuller's earth, both from Baulking and the company's former operation at Clophill. Baulking clay was converted to bentonite on site for use as a fibre and filler retention aid in papermaking and a bonding agent for foundry sand. The company used the Clophill clay internally as an additive to imported white bentonite used in the manufacture of carbonless

Fuller's earth

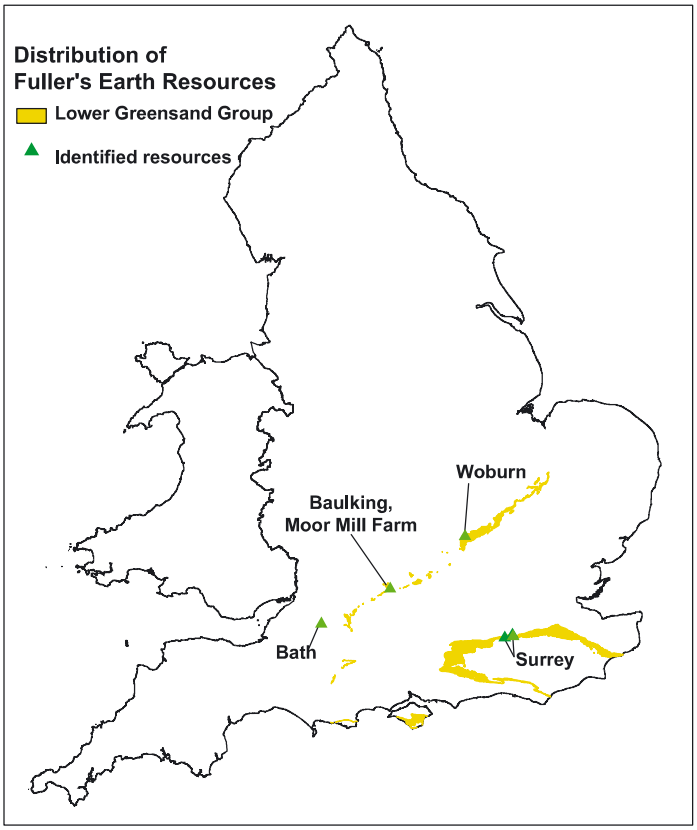

Figure 2 Distribution of fuller's earth resources.

copy paper. The Baulking operation was formerly owned by Laporte Absorbents but was acquired in 2000 by Kohlberg Kravis Roberts & Co, a US investment firm.

Steetley Bentonite and Absorbents, a wholly-owned subsidiary of Tolsa SA of Spain, has produced fuller's earth near Woburn in Bedfordshire since the early 1950s. However, production ceased in December 2004 due to the exhaustion of permitted reserves.

Resources

Smectite clay minerals are stable at the Earth's surface and in shallow sedimentary 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 Triassic age, 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 seawater. 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

Restored Baulking Quarry, Oxfordshire.

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 was mainly 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

Reserves of fuller's earth with planning permission are confined to a small satellite deposit at Moor Mill Farm, about 2 km from the plant at Baulking in Oxfordshire. The deposit, which contains the equivalent of about 300 000 dry tonnes of product, was granted planning permission in 1998 and was to have been opened up in 2004. However, a significant deterioration in the market for UK fuller's earth has rendered such a small deposit uneconomic and no working will now take place. The decline in the market has been due to the continuing contraction of the foundry industry and the loss of the papermaking market.

At Woburn, a planning application to work the southern and final 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.

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 past this processing involved acid activation or leaching with sulphuric acid.

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

By-products

There were 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 replace that destroyed in the casting process.

Transport issues

Fuller's earth products were 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 and uneconomic 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). Planning decisions in Surrey and Bedfordshire have been critical in forcing the closure of the industry, in what were its main producing areas. At Baulking in Oxfordshire a rapidly deteriorating market has resulted in previously permitted reserves becoming uneconomic to work.

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 recent production from England has been for 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.

Authorship and acknowledgements

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

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