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Mineral Planning Factsheet

Silica sand

This factsheet provides an overview of **silica sand** *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. 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.*

January 2020

Silica (industrial) sands contain a high proportion of **silica** (normally, but not exclusively, more than 95% SiO_2) and 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, very low levels 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 0.1 to 2 mm). For most applications, silica sands have to conform to very closely defined specifications, and consistency in quality is of critical importance. Particular uses routinely require different combinations of properties and attributes. Consequently, different grades of silica sand are usually not interchangeable in use. Silica sands command higher prices than construction sands and serve a wider geographical market, including exports.

Markets

Silica sands are essential raw materials for glassmaking and a wide range of other industrial and specialist horticultural applications (Figure 1). Historically an important market for silica sand was in foundry casting. However, the progressive decline in UK heavy manufacturing, and notably the foundry industry, resulted in a steady reduction in the demand for foundry sand (Figure 2). Over 4000 foundries were operational in the UK in the 1970s, this has now reduced to several hundred. This decline appears to have stabilised and there is a requirement for foundry sand to be of higher quality due to the more demanding applications now being served by UK foundries, (such as aerospace, military and precision automotive parts). Since 2006 there has been a decline in demand for glass sand which has been overtaken as the dominant use of silica sand by other industrial uses. In 2018 glass sand accounted for 29% of total sales of silica sand, foundry sand 5%, sand for other industrial uses 36% and sand for horticultural, sport and leisure uses 30% (Figure 2).

Glass bottle manufacture at Beatson Clarks's Rotherham plant. © Beatson Clark Ltd.

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 products contain between 70–74% silica (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). Although the silicon and oxygen content of glass is expressed as SiO_2, glass is a single non crystalline, vitreous substance which does not contain crystalline silica. The manufacture of glass also requires a number of other industrial minerals including limestone, dolomite, feldspar and salts such as sodium sulphate.

The principal glass products using silica sand include colourless and coloured containers (bottles and jars), flat glass, and glass fibre (for reinforcement and glass wool insulation). Glass manufacturers are principally concerned

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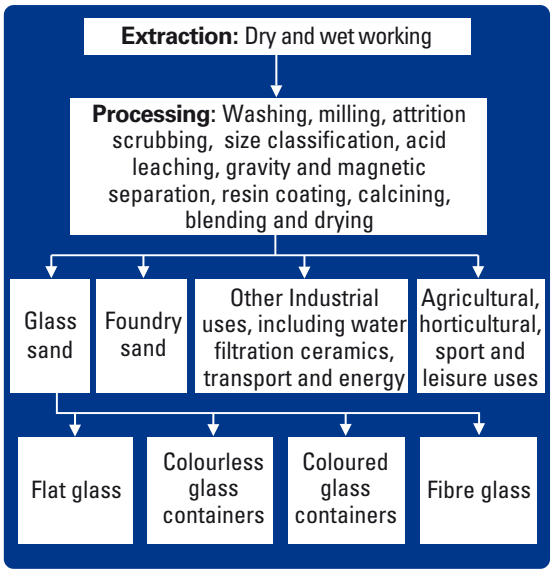

Figure 1 GB: Silica sand supply chain in 2020.

with the chemical composition of silica sands and particularly iron content, which affects the bulk glass colour and composition. They are also concerned with particulate contaminants of refractory minerals such as chromite, zircon, ilmenite and rutile which can give rise to glass defects. 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, (ferric iron oxide), for flat glass in the range 0.01 to 0.1% Fe_2O_3, and for coloured containers 0.25%–0.4% 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 content) of colourless glass cullet has to be balanced by lower iron content 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, there is little demand for such sands and the requirement 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, sanitary-ware, 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 such as additives to paints and coatings, water purification and cosmetics. In addition to a low iron content, a sand with a very low alumina content is also required for sodium silicates manufacture.

Other uses of silica sands include the production of silica flour for use as fillers in plastics, paints, glass fibre manufacture and rubber sealants where colour is important to maintain a consistent product. Sand is also used as a filler in tile adhesives and grouts where grain shape, size and colour are important to create the correct product. Silica sand can be a component of autoclaved aerated concrete (aircrete). Here it is included as a fine milled powder as an alternative to Pulverised Fuel Ash (PFA) to supply density and strength to the blocks. This application of silica sand may increase in the future due to the reduction in supply of PFA as coal fired power generation decreases. A specialist use that is seeing an increase in demand, caused by a rise in biomass energy generation, is fluidised bed boiler sands where silica sand acts as inert particles in which fuel is combusted. Silica sand is also used as proppants to enhance the production of oilfield reservoirs where the

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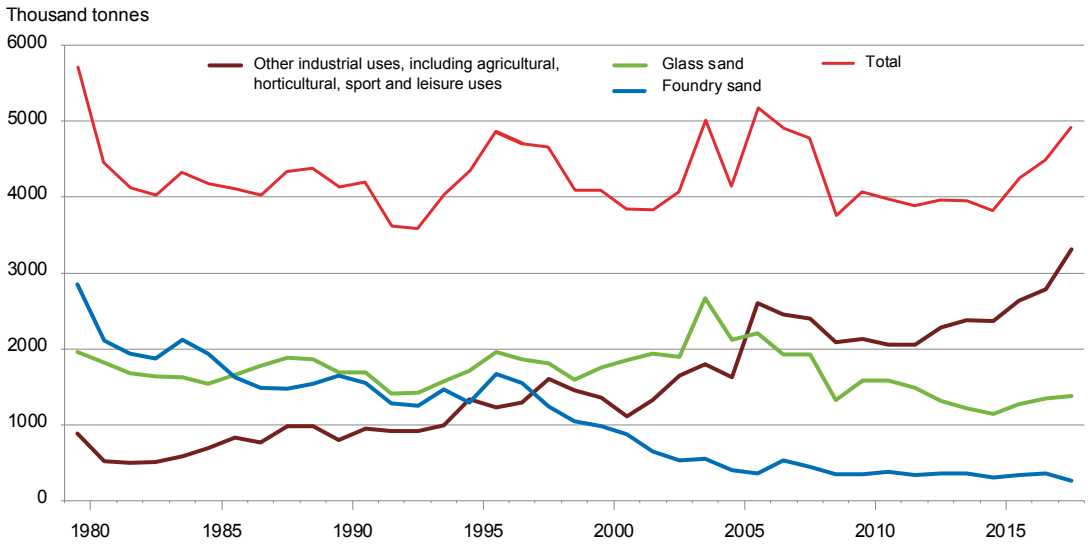

Figure 2 Great Britain: Production of silica sand 1980–2018. Source United Kingdom Minerals Yearbook, BGS.

Year	Glass sand	Foundry sand	Other industrial (a)	Total
2009	*1 321*	350	2 084	3 755
2010	1 582	353	2 135	4 070
2011	1 582	382	2 060	3 969
2012	1 489	340	2 059	3 888
2013	*1 320*	*356*	2 285	3 961
2014	*1 217*	*355*	2 376	3 948
2015	*1 147*	*306*	*2 370*	3 822
2016	*1 275*	*340*	*2 636*	4 251
2017	*1 347*	*359*	*2 784*	4 490
2018	1 379	263	3 317	4 914

Table 1 Great Britain, production of silica sand 2009–2018.

Figures in (thousand tonnes) italics have been estimated
Source: United Kingdom Minerals Yearbook
(a) Including agricultural, horticultural, sport and leisure uses

specification requires close control of grain size, shape and impurities. Another small, but important and safety critical use of silica sand is for use in rail braking systems and traction gels, where sand is used to increase grip when braking. All new trains are required to have sand braking systems fitted and much of the UK's rolling stock has been retrofitted with them. Closely-sized grades of silica sand are the principal filtration medium used by the water and food industries to extract solids from water. In contrast to other grades of silica sand, the particle sizes required are coarser, with 0.5 to 1.2 mm being a popular grading. In applications such as these, they form a vital part of industrial processes. Silica sand is critical to the clay brick, roof tile and pipe manufacturing process, where it is used for facing and demoulding, to ensure both a smooth finish and to prevent adhesion to moulds. It is valued for its technical and aesthetic properties, with products having different requirements. As a result, the sands used for manufacturing clay construction products are sourced from around 40 sites across the UK.

An increasingly important market for silica sand is specialist sports and leisure applications. Closely graded silica sand, in many cases mixed with organic matter, is used in top dressings, root zones and drainage channels for sports surface construction, for example for football and hockey pitches and golf course tees and greens. An 18 hole golf course may require 100 tonnes of sand per year for top dressing purposes. Other uses of silica sand in sports and leisure applications include eques-

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trian surfaces, golf course bunkers, synthetic soccer pitches, as play sands and in horticultural applications. 3G sports pitches are a rapidly growing market where coarse sand is required to weigh the artificial carpet down and act as a filler. Aside from requiring a low carbonate content there are no chemical constraints on these uses but they demand quality as well as consistency in grain size and colour. For example, tight controls on angularity and sphericity are required for golf bunkers and equestrian surfaces. These sands are often subject to value added processing, such as the addition of synthetic fibres to reinforce sands to increase durability for sports surfaces.

Supply

GB silica sand output was around 5 million tonnes in 2018 (there is no production in Northern Ireland). Peak production of silica sand in Great Britain was some 6.8 million tonnes in the mid-1970s, but following a decline in the early 1980s production steadied to between 4 and 5 million tonnes per year for a number of years (Figure 2 and Table 1). Of total output in 2018, just under 90% was produced in England, with the remainder from Scotland. This ratio has not significantly changed over the last 10 years due to rising production in England alongside development of silica sand resources in Scotland. With significant identified resources, Scotland is likely to continue to increase levels of supply in the future, subject to planning, production capacity, infrastructure investment and other economic constraints.

Output reflects activity in many different sectors of the economy. The decline in the total quantity of metals being cast, as the manufacturing sector of the UK economy has declined has resulted in a continued gradual decrease in the production of foundry sand (Figure 2). Production of glass sand mainly reflects production of glass containers and

Silica Sand Production	Tonnes		
	England	Scotland	Great Britain
Glass sand			
Flat glass	Confidential	Confidential	400 448
Colourless containers	624 175	251 460	875 635
Coloured containers	Confidential	Confidential	Confidential
Fibre glass	Confidential	Confidential	Confidential
Total glass sand production	**1 014 048**	**366 279**	**1 380 327**
Foundry and moulding sand (a)	**262 566**	**0**	**262 566**
Industrial uses			
Water filtration	30 945	0	30 945
Ceramics (including bricks, tiles and sanitaryware)	Confidential	Confidential	318 834
Agriculture & horticulture	Confidential	Confidential	159 833
Sports and leisure	1 099 884	97 943	1 197 827
Other industrial uses (b)	Confidential	Confidential	1 540 158
Total industrial uses	**3 221 059**	**289 104**	**3 510 163**
Total production	**4 235 207**	**655 383**	**4 890 490**

Table 2 Production of silica sand in Great Britain in 2018 by end use.

(a) Silica, resin-coated and naturally bonded.

(b) Includes use in transport, energy, silica flour and cristobalite, sodium silicates/chemicals, adhesives, abrasives, paints, grouts and other prescribed industrial processes set out in the Aggregates Excise Notice.

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Region	Tonnes
South East England	723 583
East of England	1 121 476
East Midlands, West Midlands and Yorkshire and the Humber (a)	545 543
North West England	1 844 505
England Total	**4 235 107**
Scotland	**655 383**
Great Britain Total	**4 890 490**

Table 3 Production of silica sand in Great Britain in 2018 by region.
(a) Regions merged to preserve confidentiality.

flat (float) glass. Other sectors, such as special and technical glasses, including domestic and cosmetic glassware, glass wool insulation and glass fibre, are also significant consumers of silica sand. Consumption of silica sand for other industrial uses has significantly increased in recent years. Much of this is for specialist sports, leisure and horticultural uses but significant amounts also feed into industrial products and processes, as discussed in the Markets section.

Between 2005 and 2014, overall glass sand production decreased, this coincided with the closure of two float glass plants in St Helens and a general decline in UK manufacturing. However, production has been gradually increasing since 2014 driven by container glass production. It is possible that due to the reduction of single use plastics in the UK, container glass use may continue to drive demand.

A survey of silica sand production in Great Britain in 2018 was conducted by the BGS (Table 2 and Table 3). The survey received a response rate of over 90%. Informed estimates have been used for missing sites. It is possible that some sites producing silica sand were not included in the survey but the volumes are believed to be small. The Office for National Statistics also conduct a survey of a sample of sites and use this to estimate a total (PRODCOM data). This gives a slightly lower, but similar figure of 4 791 313 tonnes for 2018.

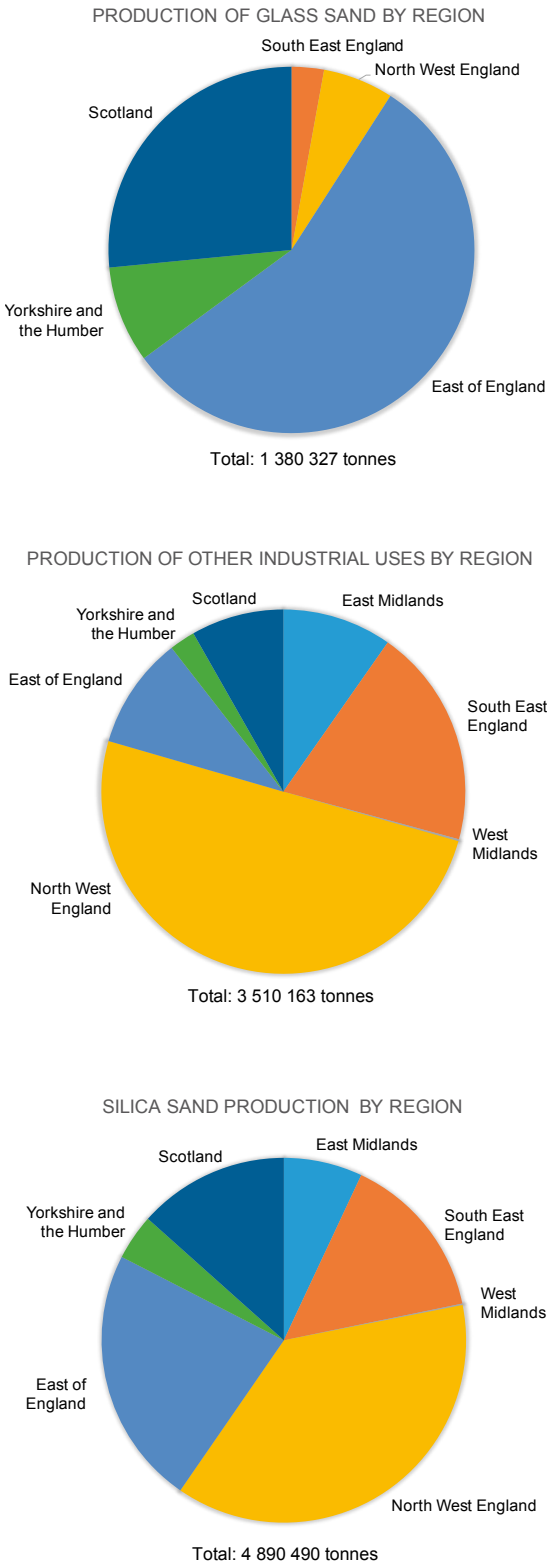

Figure 3 Production of silica sand in Great Britain in 2018 by region.

Silica sand

The survey results are also broken down by region, showing the North West to be the largest producing region with 38% of the total (Table 3).

Consumption

The UK is essentially self-sufficient in silica sand with a total consumption of between 4 and 5 million tonnes per annum. However, there are a decreasing number of sites producing the most specialist grades, and as a result, long-term supply of these is less certain.

Trade

International trade in silica sand is relatively small. Data for UK imports and exports are shown in Table 4.

Exports have gradually decreased over the last 11 years but, conversely, imports have risen over the same time period (with an unexplained spike in 2011). Data is not available for the end use of these imports and the cause of the increase is unknown. Imports are principally from the EU, with Belgium, the Netherlands and Portugal being the largest suppliers. There are also small volumes imported from elsewhere, the largest being from the USA. The vast majority of exports go to Ireland although smaller amounts are exported globally to over 30 countries.

Value

The value of UK silica sand sales was estimated at £82 million in 2017 up from £67 million in 2016 (PRODCOM data, ONS 2018). The official figure for employment in the silica sand industry in Great Britain in 2014 (the last year data were available) was 266, this has declined from around 500 in the early 2000s. However, these figures only includes employees working directly at extraction sites. The numbers employed by the industry as a whole, including other permanent employees at quarry sites and head office staff, is significantly greater.

The glass industry is an important consumer of silica sand, although the mineral is consumed in many other sectors of the economy. In 2017 the UK produced around 3 million tonnes of glass, UK sales of container glass were valued at £894 million, most of which was sold in the home market. The container glass industry employs around 5000 people and production has been increasing in terms of both value and tonnage in recent years.

	Imports		Exports	
Year	tonnes	£000s	tonnes	£000s
2008	48 112	8 045	156 451	4 614
2009	79 629	8 076	115 746	4 794
2010	148 619	10 603	100 773	4 325
2011	310 715	17 191	64 924	4 069
2012	137 761	10 188	88 376	4 013
2013	100 057	9 854	87 289	3 569
2014	139 874	15 682	93 849	5 039
2015	140 865	9 002	61 234	5 638
2016	111 060	9 900	63 227	4 222
2017	154 051	11 974	91 001	4 012
2018	139 980	10 545	83 315	3 948

Table 4 UK imports and exports of silica sand, 2012–2018. Source: HM Revenue and Customs.

The sales of flat glass in the UK in 2017 were valued at about £192 million, glass fibres at £435 million and technical glass products at £172 million. Sales for these products have followed a trend of either being level or gradually increasing over the last five years.

Value data for other industrial uses are not publicly available. However, the value that industrial sand provides to many downstream industries such as ensuring clean water supply, chemicals and ceramics manufacturing, safety critical systems in transport, as well as leisure uses, such as premium sports facilities, is significant.

Structure of the industry

There are a number of long standing silica sand producers in the UK, many of which have been in production for many decades. The largest is Sibelco UK Ltd, which accounts for over 46% of total production and an even greater proportion of production of colourless glass sand. Sibelco UK has silica sand operations in Cheshire, Surrey, Norfolk and North Lincolnshire.

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Other important producers in England are:

- Tarmac, Cheshire and Hampshire
- Bathgate Silica Sands Ltd, Cheshire
- Garside Sands (part of Aggregate Industries), Bedfordshire
- Grundon Sand & Gravel Ltd, Bedfordshire
- Mansfield Sand Company Ltd, Nottinghamshire
- Yorkshire Minerals Company Ltd, North Yorkshire
- Ferns Group Ltd, Kent
- L.B. Silica Sand Ltd (part of M O'Brien Group), Bedfordshire
- SRC, Essex
- Wildmoor Quarry Products Ltd, Worcestershire

The main silica sand producers in Scotland are:

- Aggregate industries, West Lothian
- Patersons Quarries Ltd, Fife
- O-I, Devilla Forest Quarry, Fife
- Hugh King Ltd, North Ayrshire
- Lochaline Quartz Sand Ltd, Morvern, Highland

A number of other companies supply small amounts of silica sand.

The Silica and Moulding Sands Association (SAMSA), part of the Mineral Products Association, is the trade association for the silica sand industry. It was originally established in 1941 to ensure security of supply of silica sand for industrial processes.

The glass container industry is mainly located in Yorkshire and central Scotland and the flat glass industry in St Helens and South Yorkshire/North Lincolnshire. With the exception of the O-I operation at Devilla Forest in Fife, glass manufacturers are not directly involved in the production of glass sand in the UK, although NSG (Nippon Sheet Glass Ltd) has a share in the LQS (Lochaline Quartz Sand Ltd) operation at Lochaline.

Foundries are widely distributed but with a marked concentration in the West Midlands, Yorkshire and the East Midlands. End users for other industrial uses are widespread throughout the country.

Silica sand used in horticulture applications as a growing medium. © Aggregate Industries.

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 the UK, only a small proportion of these possess the necessary 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. Sands that have the correct specifications for specific end uses (such as glass manufacture) are very restricted as the deposits that contain them are often heterogeneous. 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 restricted distribution.

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In addition, resources that are suitable for one market may not be suitable for another. For example, sands suitable for the manufacture of colourless glass containers are only produced at six locations in the UK.

Carboniferous sandstones

Important silica sand resources occur in central Scotland associated with medium to coarse-grained sandstones of the Carboniferous Passage Formation. The Passage Formation comprises a cyclic sequence dominated by coarse-grained sandstones, which are white, grey and pale yellow in colour, but also includes interbedded mudstones, siltstones, seatearths and thin coals. The sandstones were deposited and then exposed to weathering in a humid tropical environment, which resulted in the decomposition of less stable minerals to produce softer, friable sandstones composed mainly of quartz. The main silica sand sites are now located on the eastern side of the Central Basin, with workings at Burrowine Moor and Devilla Forest in Fife, and Levenseat in West Lothian. The sands have a range of industrial and construction applications. The sandstones are also capable of being processed to produce sand with less than 0.035% Fe_2O_3 for colourless glass manufacture. The operations in Fife supply container glass manufacturers in Scotland and Yorkshire. The sandstone resources of the Passage Formation are extensive and may become of increasing importance as a source of glass sand for the wider UK market in the future. Small quantities of silica sand are produced from a 10 m thick sequence of white sandstone occurring within the Carboniferous Upper Limestone Group at Hullerhill in North Ayrshire.

Some sandstones within the Carboniferous Millstone Grit Group have been important resources of silica sand in England in the past. They were previously worked in Staffordshire at Oakamoor (Moneystone Quarry) and from County Durham as a naturally bonded foundry sand as well as a glass sand and other industrial application such as for the manufacture of cristobalite and silica flours. A sandstone deposit of Carboniferous age was worked in the early 1990s at Blubberhouses, near Harrogate, North Yorkshire for the production of colourless glass sand. The operation at Blubberhouses is currently mothballed.

Silica sand grains. © Aggregate Industries.

There are limited resources of silica sand from Carboniferous sandstones in Wales. These are found on the northern flank of the South Wales Coalfield and in North Wales. They have relatively high silica contents and were worked for silica rock for refractory use in the past. However, they are hard, quartzitic sandstones which may be difficult to process to sand grades. Locally the sandstones have weathered to produce unconsolidated sand deposits. One such deposit near Llanarmon in Denbighshire was worked for silica sand but is currently inactive.

Triassic sandstones

Sands of Triassic age are worked in Nottinghamshire from the Chester Formation (part of the Sherwood Sandstone Group). The sandstone is friable and easily worked to produce sports sands, foundry sand and construction sand.

Jurassic sandstones

Resin-coated sands are produced from sandstones of Jurassic age at Burythorpe in North Yorkshire. Here the Scalby Formation consists

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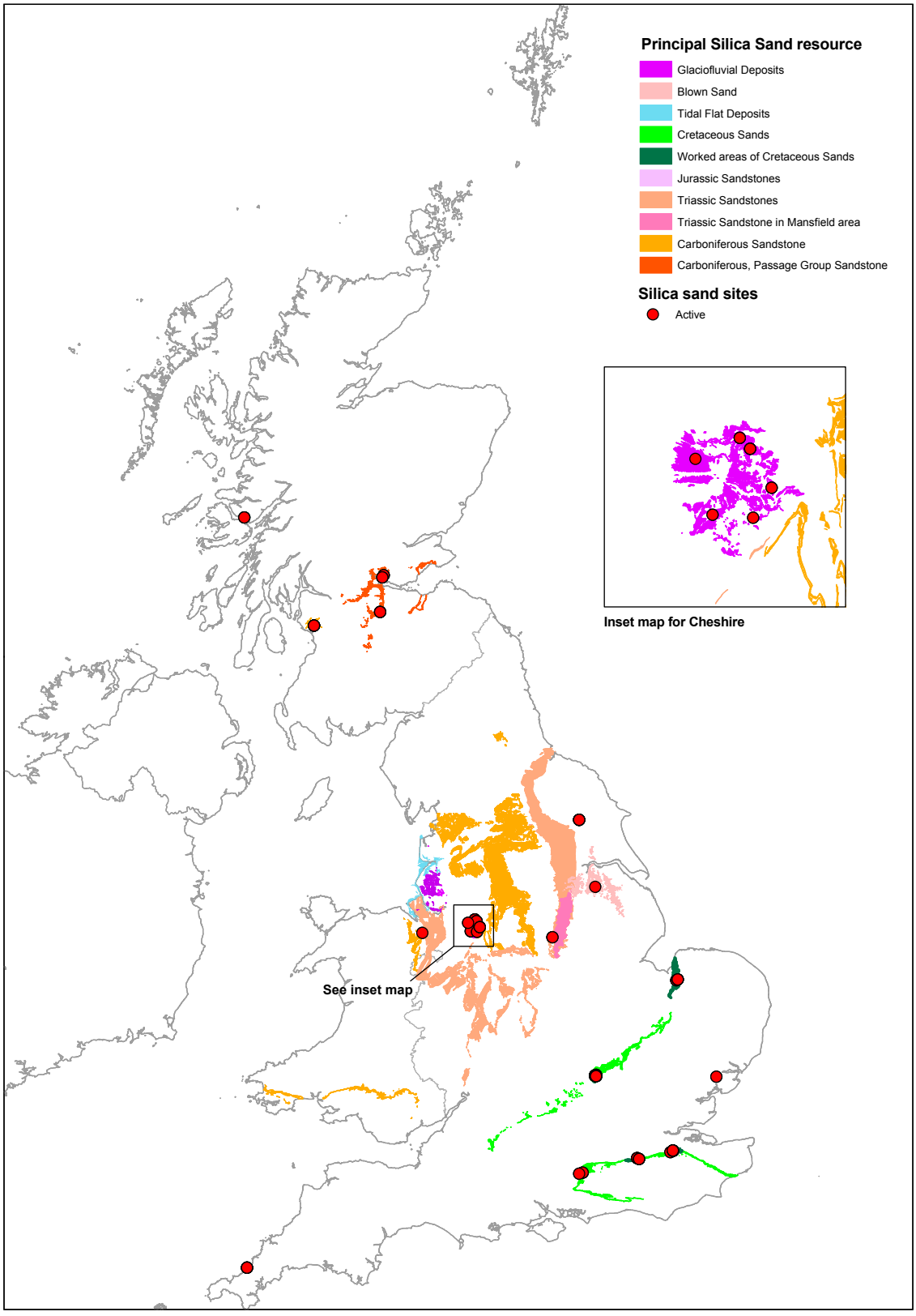

Figure 5 Principal silica sand resources.

Silica sand

of a grey to white, fine-grained, friable, pure quartz sandstone.

Cretaceous sands

In terms of current levels of production, sands of Lower Cretaceous age in eastern and southern England are some of the most important, accounting for around 40% of total output in Great Britain.

Silica sand is produced from deposits of Lower Cretaceous age at several locations in England. The Leziate member, near King's Lynn in Norfolk, is used in the manufacture of colourless glass containers, flat glass and for foundry sand. The Leziate Member is up to 30 m in thickness and consists of pale grey, fine- to medium-grained quartz sand with subordinate bands of silt or clay and pyrite nodules. 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 content (<0.1% Al_2O_3) making then suitable for the manufacture of sodium silicates. Although, no sites in the Folkestone Formation in West Sussex and the South Downs National Park have produced material for such end uses to date, recent studies show that, although variable, some parts of the formation have iron and aluminium contents in the range that are suitable as feedstocks for colourless glass sand and sodium silicates.

The upper part of the Woburn Sands Formation of the Lower Greensand in Bedfordshire and Cambridgeshire between Leighton Buzzard and Cambridge is a source of sand for foundry, rail braking, horticultural applications and water filtration. The formation is typically 30 to 60 m thick and mostly consists of fine to medium grained, yellowish, iron-rich and glauconitic quartz sandstone or loose sand. In a small area near Leighton Buzzard, there is a layer, up to 20 m thick known as the 'Upper Woburn Sands' or the 'Silver Sands'. This consists of white, well-sorted and well-rounded, medium- to coarse-grained quartz sand. Coarse-grained, well-rounded quartz sands are particularly suitable 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.

The highest purity silica sand in Britain occurs in the Cretaceous-age Lochaline White Sandstone Formation in the Morvern peninsula and on the Isle of Mull on the west coast of Scotland. This typically has Fe_2O_3 contents of less than 0.0085%. The underground mine at Lochaline has worked the deposit since the 1940s save for a period from 2008 to 2012 when it closed.

Tidal flat deposits

Sand has been worked previously around the Ribble Estuary, from an area known as Horse Bank, which consists of a wide intertidal expanse of sandbanks and flats. Working took place during periods of low tides when sand was exposed and the sand was used for grinding and polishing sands as well as foundry, sports and horticultural applications. This operation has now ceased production.

Blown sands

Sand for coloured glass containers is extracted from thin, wind-blown deposits of Recent age in the Messingham area of North Lincolnshire.

Glaciofluvial deposits

In terms of current levels of production silica sand resources of Pleistocene age in Cheshire are some of the most important, accounting for around 40% of total output in Great Britain.

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 silica sand applications. The Cheshire deposits occur as irregular sheets, which infill into troughs in the underlying clays and mudstones. They are themselves cut into by overlying boulder clay and impure

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sands that are only suitable for construction use. Despite their close association with glacial deposits, the roundness and sphericity of the sand grains is more consistent with an aeolian ('wind-blown') origin. The Congleton Sand is highly valued as a source of foundry sand. The Chelford Sand is purer and coarser and formerly was the most important source of sand for flat glass manufacture in the UK. It is now mostly exhausted and supplies only limited amounts of flat glass sand.

Other resources

Sands of the Tertiary age Poole Formation in Dorset have been used in the past for glass fibre manufacture.

Closely sized water filtration sands are produced from the Pleistocene Kesgrave Group of Essex, which is a regionally important resource of sand and gravel.

There are no significant silica sand resources in Northern Ireland.

Reserves

In land use planning, the term 'reserves' or 'mineral reserves' refers to material that has a valid planning permission for mineral extraction. Without a valid planning permission no mineral working can legally take place.

A survey of permitted reserves of silica sand at operational sites in the UK at 31st December 2018 was undertaken. The results are presented in Tables 5 and 6.

Over the last 10 years, 12 new permissions for extensions and new sites have been granted. An analysis of these newly permitted reserves shows that on average for this period the quantity of additional silica sand reserves has exceeded production. This analysis, however, does not take into account the wide variety of different specifications of products that individual sites are able to produce. Despite the healthy replenishment over this limited period, it is evident that future supply issues may occur

Permitted reserves 31st December 2018	Tonnes
Colourless glass sand	21 102 517
Other glass sand (coloured and fibre)	1 155 100
Foundry sand, sand for other industrial uses and for agricultural, horticultural & leisure uses	40 400 008
Total	**62 657 625**

Table 5 Permitted reserves of silica sand, 2018, by end use.

Region	Glass sand tonnes	Other industrial uses tonnes	Total tonnes
South East England (a)			5 089 537
East of England			9 540 000
East Midlands, West Midlands and Yorkshire and the Humber (b)		Confidential	12 585 146
North West England	646 288	11 734 154	12 380 442
England Total	**1 787 617**	**37 807 508**	**39 595 125**
Scotland	**20 470 000**	**2 592 500**	**23 062 500**
Great Britain total	**22 257 617**	**40 400 008**	**62 657 625**

Table 6 Permitted reserves of silica sand, 2018, by region.

a) includes small amounts from the South West

b) Regions merged to preserve confidentiality

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for some key end uses that have narrow grade specifications, for example colourless glass sand. A recent survey also showed that new reserves are concentrated in a small number of sites which are not evenly distributed across the country. This could also lead to future supply issues.

Relationship to environmental designations

One site in Bedfordshire works the Cretaceous Woburn Sands within a SSSI (designated for geological conservation) and two sites working the Folkestone Formation in Surrey and Kent respectively lie partly within the Surrey Hills and Kent Downs AONBs. The former Blubberhouses site lies within the Nidderdale Moors AONB. A number of other sites are in close proximity to AONBs.

The Cretaceous Folkestone Formation extends into the South Downs National Park. Whilst there are no active silica sand sites, there is a dormant planning permission at Coates Pit and two sites, Kingsley and Frith End, are adjacent to the Park boundary.

A number of sites have adjacent nature conservation designations, some of which have been created by the restoration of former silica sand workings. Examples include former operations at Messingham Quarry in North Lincolnshire (SSSI) and Wicken North in Norfolk (County Wildlife Site).

Extraction and processing

The extraction of silica sand is almost exclusively by surface quarrying, by both dry working and suction dredging (the exception to this being the mining operation at Lochaline). Harder sandstone deposits are, wherever possible, now worked by ripping rather than by drilling and blasting. Loosely consolidated sands, where the sand is either unconsolidated or forms weakly cemented sandstones, can be extracted using front end loaders, bulldozers equipped with rippers or specially designed self-elevating scrapers. At some workings the extraction takes place underwater by suction dredging equipment mounted on pontoons floating on a lagoon. The raw sand is transferred via conveyors or slurry pipes to the processing plant. Worked

Silica sand quarrying from the Carboniferous Passage Formation. © BGS.

thicknesses range from over 30 m for some glacial and sandstone deposits to less than 2 m for wind blown sands. Silica sand deposits lie beneath variable thicknesses of overburden.

Silica sand processing typically requires a high capital investment in plant and is of varying degrees of complexity, depending on the end use of the sand. Processing is aimed at improving both the physical and chemical properties of the sand to meet strict user specifications. Typically several grades of sand are produced from one site either by selective extraction and/or processing. At most operations processing involves washing, attrition scrubbing and size-classification such as hydrocycloning and elutriation 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 colourless glass sand, more sophisticated processing is required to remove contaminating impurities such as heavy iron-bearing minerals and chromite, either from the sand and/or from the surfaces of the individual sand grains. Additional processing may be used such as gravity separation to remove heavy iron-bearing minerals and chromite, froth flotation to remove mica and feldspar and high intensity magnetic separation which is being

Silica sand

increasingly used to remove iron-bearing impurities. Hot sulphuric acid leaching is used at Devilla Forest in Scotland, to remove iron oxide and other minerals coating the individual sand grains. A cold acid leach is also used at King's Lynn for the production of sand for flat glass and container glass. Techniques such as hot acid leaching and froth flotation in an acid environment (previously used at Reigate in Surrey) to remove heavy minerals and iron coating of sand grains are energy intensive, have potential environmental impacts and require complex processing facilities on site. As a result, operations using these techniques have decreased in recent years, which limits the range of applications for higher iron sands. Most foundry sands have to be supplied dried and drying facilities are a substantial capital investment.

For foundry use selected grades of silica sand are also coated with resin binders producing a high value-added product. Silica sand proppants are also coated with resin to increase their compressive strength for use in secondary hydrocarbon recovery at greater depths. 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 generally involves the production of less than 10% waste. Yields of saleable product (including by-products — see below) are on average about 90%, excluding overburden removal, which is usually used in site restoration.

The sand products are either stored in open air stockpiles or they may be dried in kilns and stored in silos or undercover to keep the sand dry. Sand is sold as bulk loads, this can be loose, in tankers or tippers, or in 'bulk bags' and for certain applications in smaller 12–25 kg bags.

By-products

Due to the complex sedimentary environments in which they were formed silica sand deposits are very likely to contain sands with different physical and chemical properties with variations both laterally and vertically, sometimes over small distances.

Maximising extraction from any permitted site (while ensuring the restoration of an appropriate landform with long-term afteruse provision) is likely to be the best environmental option. This may mean that defined areas of inferior quality are worked, processed and sold, usually as construction sand.

Of equal importance are co-products. These are derived when the mineral operator is required to process the raw sand to customer specifications which results in the coarser and finer ends of the grain-size distribution being removed (this is particularly true for glass sands of all types). These coarse and fine fractions are sold, if markets exist, possibly for an industrial end use. This is generally the most sustainable use of the reserve (subject to site restoration considerations).

Although the silica sand deposits are, by definition, of relatively uniform grain size and have low levels of colouring impurities, it is unlikely that more than 65 to 70% of the raw feed will report to finished product for a glass sand, although dependent on the geological properties, this can be higher.

Alternatives/Recycling

Glass is a permanent material which can be recycled indefinitely without any loss of quality. Recycled glass (cullet) from containers is increasingly used to make new glass. In 2016 (the most current data), UK- manufactured glass containers contained an average 38.5% recycled content, a figure that has gradually increased from 35.5% in 2009.

Increasing the use of cullet forms a key part of the glass sector decarbonisation plan. Every tonne of cullet recycled saves 250kg of CO_2 during the manufacturing process. This is because cullet replaces carbonate minerals which decompose during the melting process to form CO_2 and cullet takes less energy to melt therefore reducing fossil fuel use. Using cullet reduces the demand for raw materials and

every tonne of cullet saves 1.2 tonnes of raw materials. When the whole life cycle is taken into account 580kg of CO_2 are saved for every tonne of cullet used in container glass manufacture.

Only good quality, colour sorted cullet with low levels of contamination is suitable for glass manufacture. Developments in colour sorting technologies and removal of contaminants in recent years have increased the amount of cullet suitable for glass manufacture.

The other main market for cullet is aggregates, in materials such as asphalt, although this has a much lower environmental benefit compared with closed loop glass recycling. A small volume of cullet is also used for other applications such as water filtration, abrasives, kitchen worktops and top dressing.

Flat glass is recycled into glass containers, glass fibre 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 risk of contamination, although the potential for recovery of this type of glass is being considered. The industry does however, utilise flat glass cullet recovered from downstream fabricators, such as the automobile industry and double-glazing manufacturers, where better quality control is feasible.

In the foundry industry, 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. Alternatively sand is mixed with a chemical binder to give rigidity. 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 binder 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. Sand in artificial sports pitches can be re-used

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. Sands sold for construction use are, therefore, subject to the Aggregates Levy.

Spent foundry sand is subject to the Landfill Tax, if it is disposed of at a landfill site, although a high proportion of this material is now recycled for use as aggregate.

Transport

Most silica sand is transported by lorry and bulk tanker. The only silica sand operation with a dedicated rail link is Leziate quarry near King's Lynn in Norfolk. Here rail is used to transport sand to glass manufacturers in Yorkshire and the North West of England. Lochaline Mine uses a dedicated ship loading facility to fill vessels which transport sand cargoes to a number of ports in Great Britain and Europe.

Unlike sand used for construction purposes, silica sand can travel long distances due to demand for specific characteristics and the restricted distribution of resources.

Transport costs can still form a significant proportion of the final product price, the majority of glass plants are in close proximity to areas of silica sand resources.

Planning issues

Compared to construction sand, silica sand has a number of distinctive characteristics which are relevant to land-use planning:

- **Economic importance** — Silica sand is recognised in the National Planning Policy Framework as a mineral of national importance, necessary to meet society's needs. The importance of silica sand as a raw material is recognised in the UK Mineral Strategy, pub-

Silica sand

lished in July 2018 by the UK minerals and mineral products industry;

- **Economic value** — silica sands have a range of applications with many different specifications. They are important for a broad range of downstream, value-added manufacturing industries. Individual grades are often not interchangeable in use and tonnages produced tend to be relatively low;
- **Alternatives** — other than glass cullet, there are no alternative raw materials for glass manufacture;
- **Processing plants** — the processing of silica sand is complex requiring a high level of capital investment. In many cases processing plants operate on a continuous (24 hours) basis, which means that the siting of such plants has to take account of the impact on local residential amenity;
- **Length of planning permissions** — individual sites may have long lives, and therefore have to be subject to regular reviews of conditions;
- **Impact on designated areas** — some silica sand resources may coincide with sensitive environments and habitats, such as heathland. Government policy permits the working of silica sand in some designated areas in exceptional circumstances;
- **Stocks of permitted reserves** — Government policy, as stated in the National Planning Policy Framework (2019) specifically requires that permitted reserves of silica sand of at least 10 years are maintained for individual sites and at least 15 years for sites where significant new capital is required;
- **Transport** — there is pressure to establish greener transport alternatives to road at well-established sites with a long term future;
- **Ancillary products** such as construction sand are often an important element of the economic and environmental consideration of a site, influencing quarry design and restoration. Utilisation of sands, which fall outside industrial sand specifications, is the most sustainable use of the total mineral reserve;

Silica sand extraction. © Aggregate Industries.

- **Mineral safeguarding** — Silica sand is a scarce resource. The National Planning Policy Framework states that planning policies should define Minerals Safeguarding Areas and adopt appropriate policies so that known locations of specific mineral resources of local and national importance (which include silica sand) are not sterilised by non-mineral development where this should be avoided. Planning policy also requires the safeguarding of existing, planned and potential sites for bulk transport, handling and processing of minerals.

Further information

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