Strict specifications: UK frac sand potential

The UK is actively looking at the potential production of shale gas and, as a result, the country's extractive minerals industry is looking at the role it can play in providing minerals that could be used in hydraulic fracturing (fracking). One such mineral is silica sand, which is used as a proppant, commonly referred to as "frac sand". *Clive Mitchell, Industrial Minerals Specialist**, provides an educated guess as to where this frac sand could come from in the UK.

Frac sand is composed mainly of quartz grains. It is used in the fracking process, hence the name "frac" sand. The sand is entrained in water and is pumped under great pressure into fractures created in the reservoir rock. The sand is packed tightly into the fractures and props them open, hence they are also referred to as "proppants". This forms a permeable pathway for the oil and gas to escape from otherwise impermeable rock formations, such as shale.

Approximately 70% of the proppants used in fracking are naturally-occurring silica sand. Other types of proppants include resin-coated silica sand, and ceramic proppants, which are most commonly comprised of calcined bauxite or kaolin.

The current specification for proppants used in fracking in the UK is the British Standard (BS) European (EN) International Standards Organisation (ISO): 13503-2:2006 + A1:2009 petroleum and natural gas industries. Completion fluids and materials. Measurement of properties of proppants used in fracking and gravel-packing operations.

The standard covers the testing and specification of those properties that are important for a good quality proppant, such as frac sand. *Table 1* shows a summary of the properties required for proppant material, as specified in the standard.

Table 1 also shows some typical particle size distributions for frac sand. One of the most commonly used is 20/40. The particle size distribution required is relatively narrow, which means that the particles need to be more or less the same size in order to maintain a high permeability so that oil and gas can readily flow into the borehole.

The sand particles must also have a relatively high degree of roundness and sphericity to ensure that they flow unhindered into the fractures. An average roundness and sphericity of 0.6 is required for naturally-occurring frac sand, and 0.7 is required for resin-coated sand and ceramic proppants. The sand must also be capable of withstanding high pressures, up to 4,000-6,000 lbs per square inch (psi) or 28-42 megapascals (MPa), found at depths of several thousand metres below the surface.

UK frac sand sources

Silica sand in the UK is currently produced for several different end markets:

- Manufacture of glass and ceramics
- Foundry
- Production of sodium silicate and other silicon chemicals
- Mineral fillers
- Water filtration
- Horticulture
- Sports and other leisure activities

In 2012, a total of 3.9m tonnes silica sand was produced in the UK from 39 silica sand workings.

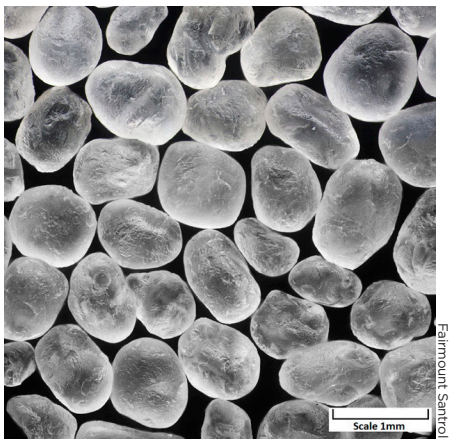
However, not all of these workings contain sand of the right specification for fracking. The silica sand product that is the closest equivalent to frac sand, in terms of its composition and physical properties, is foundry sand.

Frac sand and foundry sand are both composed of high-purity silica sand (greater than 98-99% SiO_2), consisting of well rounded, spherical sand grains with a narrow particle size distribution. The silica sand workings in the UK that produce foundry sand are therefore potential sources of frac sand and are listed as follows:

Upper Carboniferous sandstones

The Upper Carboniferous sands produced in Scotland were deposited in a shallow marine environment and form part of a cyclical sequence with siltstones and mudstones.

The Passage Formation is an extensive, important resource that occurs across the



Fairmount Santrol

20/40 frac sand sources in Illinois, US.

Table 1 Properties of frac sand

Property	Limits
Composition	>99% silica, SiO_2 (quartz or resin-coated quartz) or 100% ceramic
Particle-size	Narrow size-distribution – 90% within specified size ranges e.g. 12/20 mesh (1,700-850 microns) 20/40 mesh (850-425 microns) 40/70 mesh (425-212 microns) 70/140 mesh (212-106 microns)
Particle-shape	Well-rounded, spherical grains (>0.6 for quartz sand and >0.7 for resin-coated sand and ceramic proppants)
Crush resistance	Withstand compressive stress 4,000-6,000 psi (28-42 megapascals [MPa]), determined at 10% crush material
Acid solubility	Limits on acid soluble material (<2% ≥30/50, <3% <30/50, <7% for resin-coated sand or ceramic proppants)
Turbidity	Limits on clay (<2 microns) and silt (2-63 microns) content, maximum turbidity 250 FTU (Formazin Turbidity Unit)

Mesh size = number of openings per linear inch in a sieve.

Source: British Standard BS EN ISO 13503-2:2006 + A1:2009

Midland Valley of Scotland. A thick alternating sequence of fine- to coarse-grained, friable sandstone is worked at Levenseat Quarry near Fauldhouse, West Lothian, and Burrowine Moor and Devilla Forest quarries near Kincardine-on-Forth, Fife.

The Upper Limestone Formation occurs in North Ayrshire, Scotland. It is characterised by a cyclical sequence of limestone, mudstone, siltstone and sandstone. A 10-metre thick sequence of white sandstone is worked at Hullerhill Sand Quarry.

Lower Triassic sandstone

The Nottingham Castle Sandstone Formation, part of the Sherwood Sandstone Group, occurs in Nottinghamshire and south Yorkshire and is a thick sequence (100 metres) of pinkish-red or buff-grey, medium- to coarse-grained, friable sandstone. The sand was deposited by fast-flowing braided rivers in an actively subsiding continental basin. It is currently worked at Two Oaks Farm Quarry, 4km south of Mansfield.

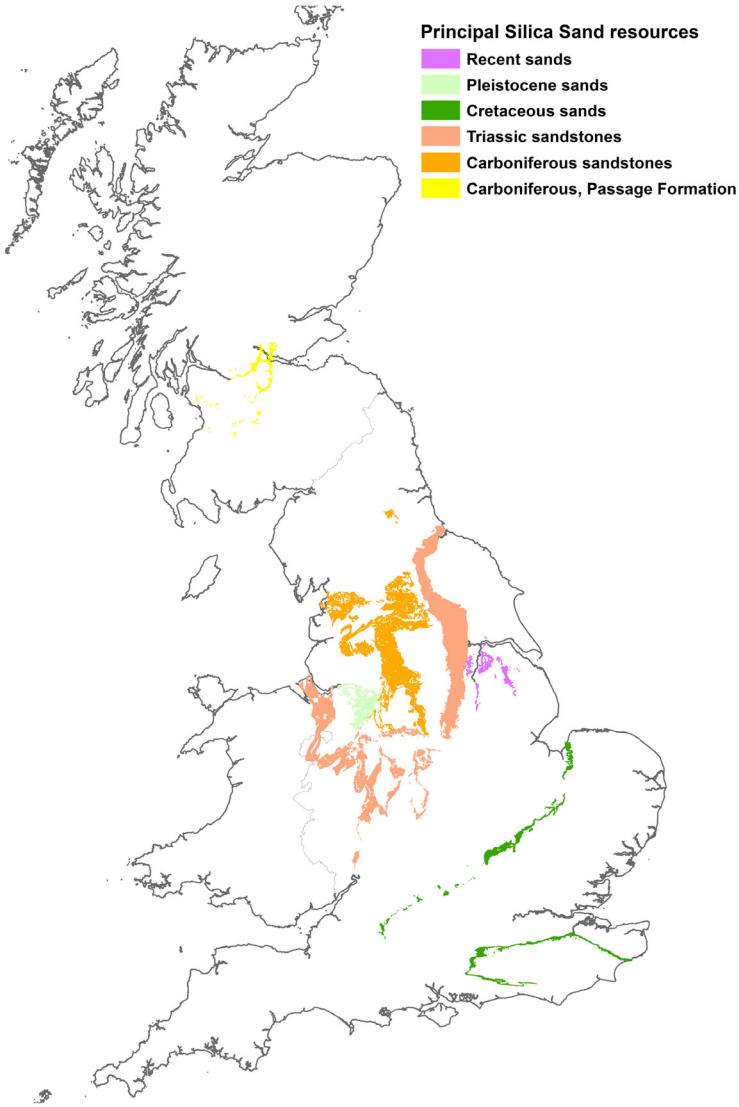
Middle Jurassic sandstone

The Scalby Formation in North Yorkshire is represented by medium- to coarse-grained sandstone with thin siltstone and mudstone beds up to 60 metres. It is worked at Burythorpe Quarry near Malton and is a small occurrence of sand with only local importance.

Lower Cretaceous sands and sandstones

Collectively, the Lower Cretaceous sands and sandstones of eastern and southern England are significant sources, accounting for approximately 40% of the silica sand used in the UK.

Principal silica sand resources in the UK



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The Leziate and Mintlyn members occur in west Norfolk and form the upper part of the Sandringham Sands Formation. The Leziate Member is up to 30 metres in thickness and consists of pale grey, fine- to medium-grained quartz sand with subordinate bands of silt or clay. The Mintlyn Member is up to 15 metres in thickness and consists of glauconitic, clayey, grey and green sands. It is thought that the sands were derived from Carboniferous sandstones to the west and were deposited in a near shore marine environment adjacent to the north-south trending coastline. They are currently worked at Leziate Quarry near King's Lynn.

The Folkestone Formation, part of the Lower Greensand Group, occurs around the circumference of the Weald basin in south east England, from Hampshire in the west, to Kent in the east. It consists of fine- to coarse-grained, well-sorted sands and weakly cemented sandstones. It was deposited in a shallow marine, near shore environment and varies in thickness from 0.5-85 metres. The formation is worked at eight quarries in Kent and Surrey.

The Woburn Sands Formation, part of the Lower Greensand Group, occurs in Bedfordshire and Cambridgeshire between Leighton Buzzard and Cambridge. This formation was deposited in a shallow marine basin and is typically 30-60 metres thick. It mostly consists of fine- to medium-grained, yellowish quartz sandstone or loose sand. In Leighton Buzzard, the upper part contains a layer, up to 20 metres, of pure white sand known as the Upper Woburn Sands or the Silver Sands. This sand is worked at 14 quarries in Bedfordshire.

Palaeogene sands

The St Agnes Formation occurs as an outlier of Palaeogene sand, thought to be of marine origin, near St Agnes Head, Cornwall. It is approximately 10 metres in thickness. The sand occurs interbedded with clay with both being worked at Beacon Pit on a small scale.

Pleistocene sands

The Chelford Sand Formation, which includes the Congleton Sand, in Cheshire, is a significant source, accounting for approximately 40% of the silica sand used in the UK.

The Chelford Sand Formation occurs as irregular sheets of quartz sand, which infill troughs in the underlying Triassic Mercia Mudstone Group. The formation is up to 20 metres in thickness and consists of white- to buff-coloured, well-sorted, well-rounded medium-grained quartz sand.

It is thought that the sands are an aeolian deposit derived from sandstones to the west of the Cheshire basin, such as those in the Carboniferous Millstone Grit and the Permo-Triassic Sherwood Sandstone groups. The sand is currently worked at Arclid Quarry near Sandbach, Bent Farm and Eaton Hall quarries near Congleton, and Dingle

Bank Quarry near Lower Withington. The Chelford Sand Formation is the only sand to have been used in exploratory fracking of shale in the UK at the Preese Hall-1 well, Lancashire, in 2011.

The Lowestoft Formation in Suffolk is a chalky till of variable thickness that contains outwash sand and gravels. It is worked at Blyth River Pit near Mells.

The future for UK frac sand

Given that the scale of any shale gas development in the UK is likely to be modest in the near future, it seems likely that the UK has the resources and the production capability to meet the domestic demand for frac sand.

At this stage, it is difficult to predict the amount of frac sand that would be required if the UK shale gas industry developed at pace. The experience from production in the US is that each well would require in the order of 2,000 to 10,000 tonnes frac sand depending on the length of the well and the number of fracking treatments.

It is estimated that the demand for frac sand in the UK could be as little as 10,000 tpa or as large as 380,000 tpa, depending on the amount of fracking carried out (Mitchell, 2015).

Conclusions

The UK is actively looking at the potential for the production of oil and gas from shale. As a result, many companies in the UK extractive industry sector are looking to see how they could meet the potential future demand for frac sand if development goes ahead.


BGS

Stockpile of silica sand at a quarry in eastern England.

The key parameters for frac sand are: a high silica content (quartz); a narrow particle size distribution; sand grains with a high sphericity and roundness; resistance to crushing; and a low silt and clay content. Existing sand resources that meet these requirements do exist in the UK, with the closest parallel being those used to produce foundry sand.

The most likely sources for the future production of frac sand in the UK are the Upper Carboniferous sandstones in the Midland Valley of Scotland, the Lower Cretaceous sands and sandstones of eastern and southern England, and the Pleistocene sands of Cheshire.

It is difficult to predict the amount of frac sand that will be required. It depends on the number of wells that are drilled, their length and the number of fracking treatments carried out. The amount of frac sand required could be as little as 10,000 tpa or as much as 380,000 tpa. Before this point is reached, many years of exploratory drilling and fracking are needed before the first shale hydrocarbon production goes ahead in the UK.

Reference

Mitchell, CJ 2015 UK Frac Sand Resources. In: Hunger, E.; Brown, T; Lucas, G, (eds.) *Proceedings of the 18th Extractive Industry Geology Conference.* Extractive Industry Geology, 17pp (*in press*). Available to download from the NERC Open Research Archive (NORA).

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