

Geoscience for our changing Earth

UK silica sand resources for fracking

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**British
Geological Survey**

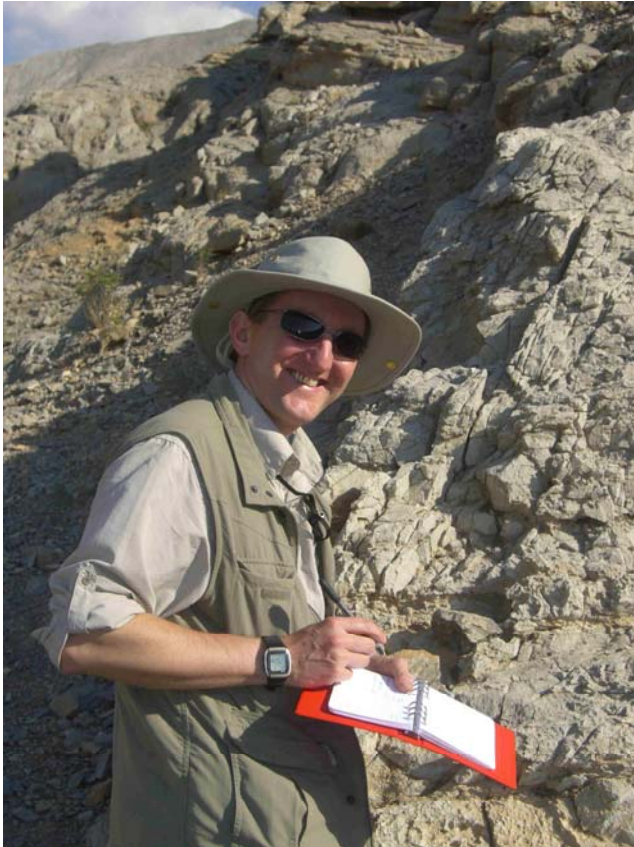
NATURAL ENVIRONMENT RESEARCH COUNCIL



Outline of presentation

- Minerals at the British Geological Survey
- What is Frac Sand?
- Frac Sand properties
- Potential sources of Frac Sand in the UK
- Is there a future for Frac Sand in the UK?
- Conclusions

Minerals at the BGS



Clive carrying out mineral resource assessment in the Middle East

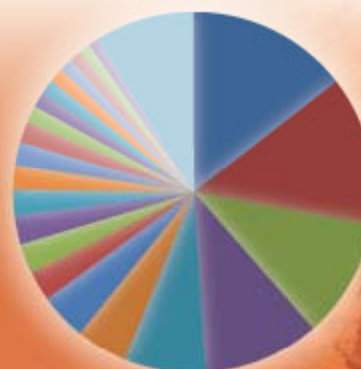
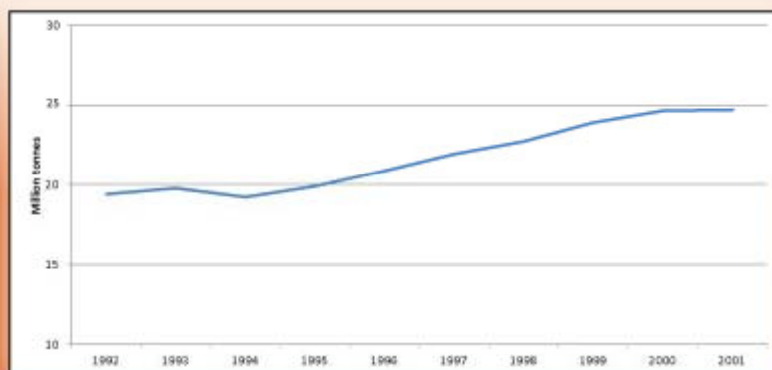
<http://www.bgs.ac.uk/staff/profiles/1159.html>

- We compile mineral statistics for the UK, Europe and the World. BGS is one of only two providers of global mineral statistics
- We are a major provider of spatial mineral resource information in the UK
- We carry out UK & International research in metallogenesis, land-use impacts of mineral extraction, resource security, industrial minerals and geomaterials
- We provide BGS minerals information as data tables, reports, maps, profiles and factsheets as FREE downloads via www.mineralsUK.com





World Mineral Statistics



Welcome to MineralsUK

MineralsUK is the British Geological Survey's [Centre for Sustainable Mineral Development](#). This website has a wealth of information on mineral resources, mineral planning, policy and legislation, sustainable development, statistics and exploration.

Minerals & you

Economic minerals – here you will find out what they are, where they come from and why they are important.

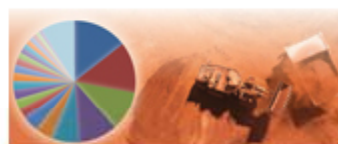
Top downloads

1. Cement Raw Materials
2. Rare Earth Elements
3. World Mineral Production 2006-2010

//What's new

[World Mineral Statistics Data Download](#)
Data from 1992 to 2011 are now available to download direct to Microsoft Excel format.

[more info](#)



//Whats new

[Critical raw materials](#)
A new web page of BGS's critical raw materials publications, advice and research collaborations.

[more info](#)



//Downloads

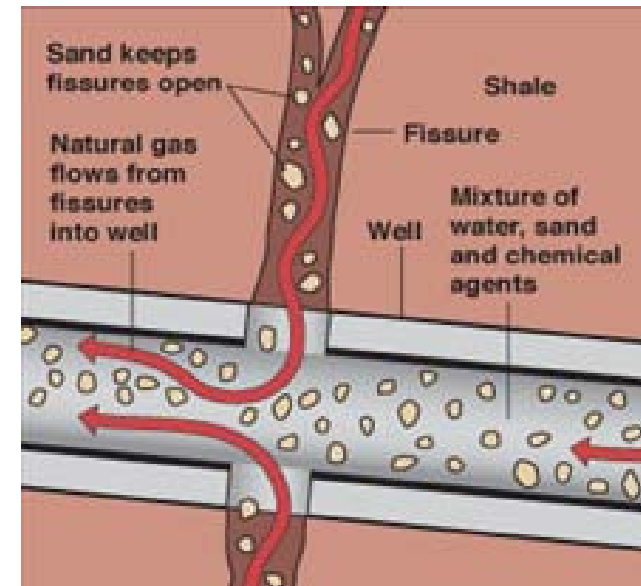
[Risk list 2012](#)
A newly updated supply risk index for chemical elements or element groups which are of economic value.

[more info](#)



What is Frac Sand?

- Silica sand used to 'prop' open fractures in oil & gas reservoirs to enhance recovery
- Also known as 'Proppant' sand
- Alternatives – resin coated sand and ceramics (made from alumina, kaolin or bauxite)



Silica: The basics



Quartz specimen from the Royal Geological Society of Cornwall Collection

(held at the British Geological Survey)

<http://www.bgs.ac.uk/collections/gallery.html>

- Silica is chemical compound silicon dioxide (SiO_2), 61% of earths continental crust
- Quartz is main form and polymorphs cristobalite & tridymite & cryptocrystalline varieties chert, flint, chalcedony & agate
- Rock forming mineral in granite, gneiss, sandstone, quartzite, pegmatites etc...
- Quartz is hard (Mohs 7), resistant to weathering and concentrated over many erosion cycles to form silica sand
- Silica sand ('Industrial sand') contains a high proportion of quartz and mainly for non-construction uses

Silica sand use in the UK



Main uses (2007 figures *):

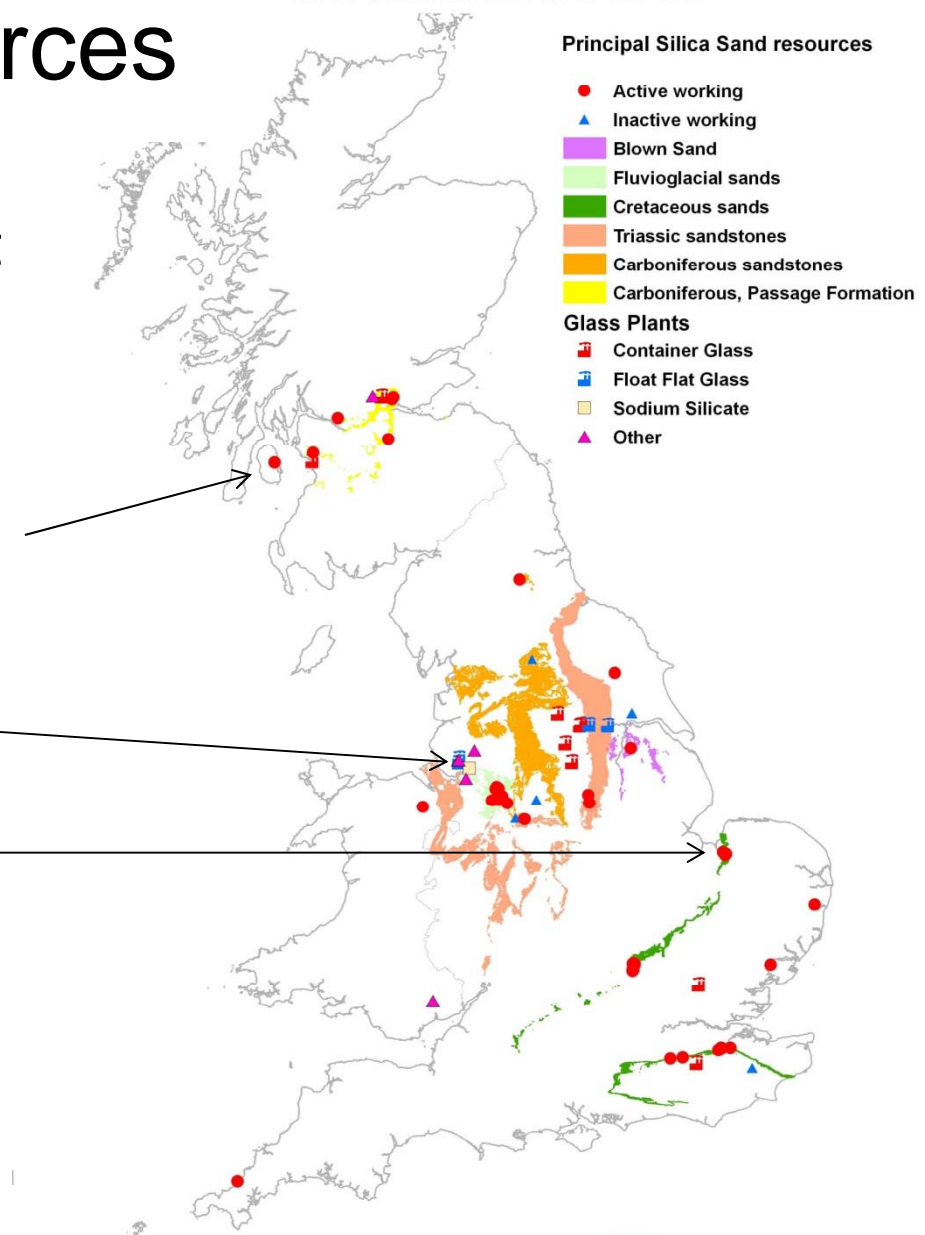
- Glass production (39%)
- Foundry sand (11%)
- Horticultural & leisure uses (26%)
- Other industrial uses (24%) including:
 - Abrasive and shot blasting
 - Filter drainage media
 - Production of bricks, ceramics, mineral filler, refractories & rock wool
 - Production of sodium silicate, fused silica, silicon carbide and other silicate reagents

UK silica sand resources

- The UK is nearly self-sufficient in silica sand
- 40 quarries produce 4Mt of silica sand (2010 figures*)
- Sandstone (weakly cemented)
e.g. Carboniferous Passage Fm , central Scotland (glass)
- Glacial sand e.g. Pleistocene Chelford Sand Fm, Cheshire (flat glass)
- Near shore marine/ coastal
(dune / beach) sand e.g. Lower Cretaceous Sandringham Sands Fm, Leziate, Norfolk (glass)
- Alluvial (river), lacustrine (lake), aeolian (wind blown) sand

* UK Minerals Yearbook www.MineralsUK.com

Silica Sand resources in the UK



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Map extract from the Silica Sand Mineral Planning Factsheet, 2009.
Sites as at 2009. Data BGS@NERC.

Mineral Planning Factsheet

- Factsheet for land-use planners & decision makers
- Economically important, for glass there is no alternative
- Resources may coincide with sensitive environments/nature conservation areas
- Strategic resource subject to 'Mineral Safeguarding', consider when deciding on other land use developments
- FREE download from: www.MineralsUK.com



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.

January 2006

Finished float glass, Pilkington's Greengate plant, St Helens.

Silica (industrial) sands contain a high proportion of silica (up to 99% SiO_2) in the form of quartz and they are used for applications other than as construction aggregates. They are produced from both loosely consolidated sand deposits and by crushing weakly-cemented sandstones. Unlike construction sands, which are used for their physical properties alone, silica sands are valued for a combination of chemical and physical properties. These include a high silica content in the form of quartz and, more importantly, 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 0.5 to 0.1 mm). For most applications, silica sands have to conform to very closely defined specifications and consistency in quality is of critical importance. Particular uses often require different combinations of properties. Consequently, different grades of silica sand are usually not interchangeable in use. Silica sands command a higher price than construction sands. This

allows them to serve a wider geographical market, including exports.

Demand

Silica sands are essential raw materials for glassmaking and a wide range of other industrial and horticultural applications. Historically an important market for silica sand was in foundry casting. However, the progressive decline in UK heavy manufacturing, and notably the foundry industry, has resulted in a significant decline in the demand for foundry sand (Figure 1 and 2). In contrast there has been a recent increase in demand for glass sand. In 2004 glass sand accounted for 53% of total sales of silica sand in Great Britain, foundry sand 11%, sand for other industrial uses 19%, and sand for horticultural and leisure uses 17%.

There are many different types of glass with different chemical and physical properties. Most of the commercial glasses in everyday use, such as bottles and jars (containers), and flat glass (windows, mirrors and vehicle glazing), are soda-lime-silica glasses. These contain between 70–74% SiO_2 , the ultimate source of which is silica sand, although increasing amounts of silica are being recovered in the form of recycled glass (known as cullet). Sand by itself can be fused to produce glass, but only at very high temperatures (1700°C). The addition of sodium carbonate (Na_2CO_3) significantly reduces this temperature. Other components, such as calcium oxide (CaO), magnesium oxide (MgO) and alumina (Al_2O_3) are added (in the form of limestone, dolomite and feldspathic minerals) in order to give the glass stability and durability. Sodium carbonate is manufactured from salt and limestone, emphasising the dependence that some industries have on a number of industrial minerals.

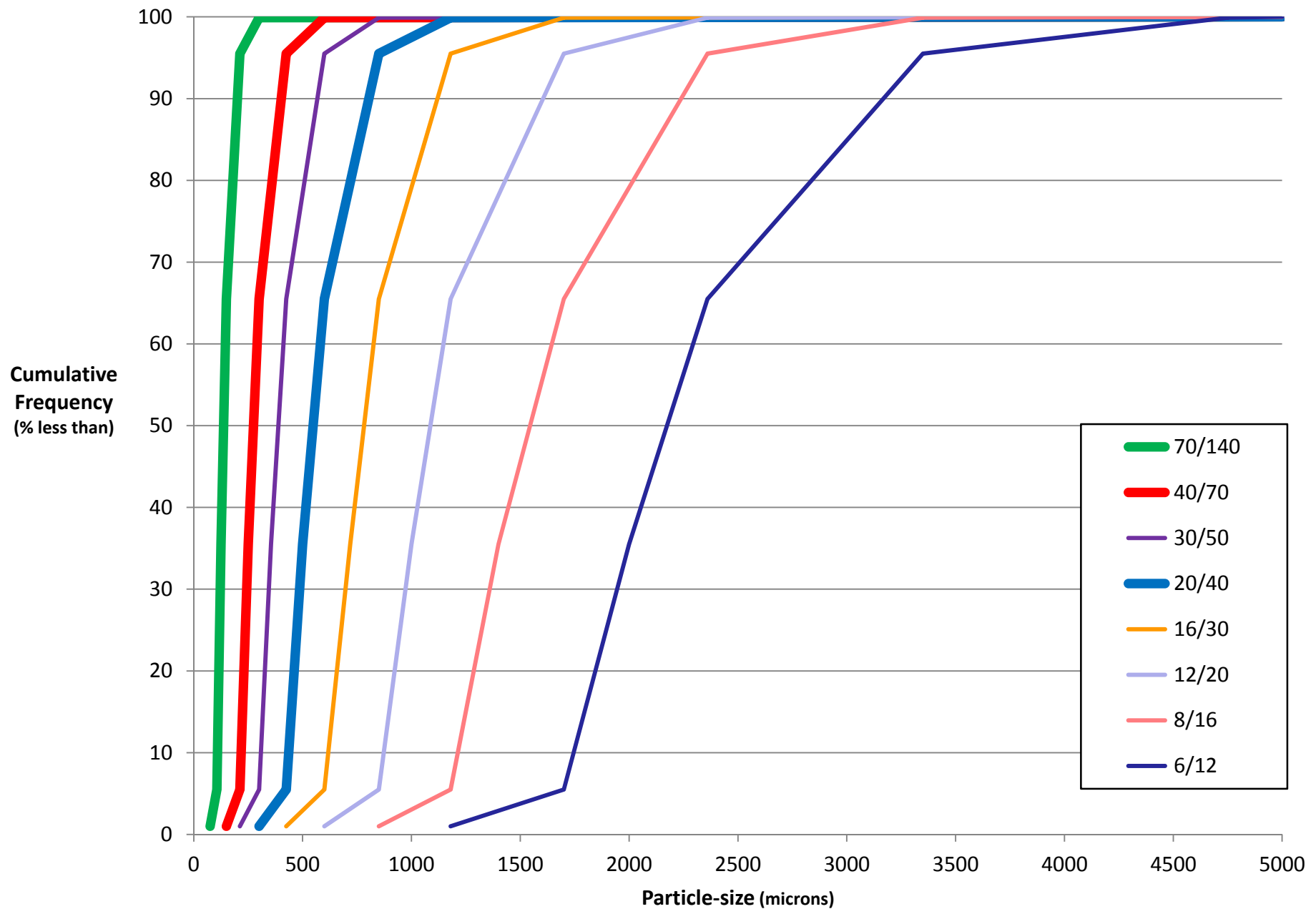
The principal glass products using silica sand include colourless and coloured containers (bottles and jars), flat glass, light bulbs and fluorescent tubes, TV and computer screens, and glass fibre, both for insulation and reinforcement. Glass manufacturers are principally concerned with the chemical composition of silica sands, and particularly iron, chromite, and other refrac-



Frac sand properties

| Property | Limits |
|--|--|
| Silica (SiO ₂) | >99% (Quartz) |
| Particle-size | Narrow size-distribution - 90% within specified size ranges: 12 / 20 # (1700 – 850 microns) 20 / 40 # (850 – 425 microns) 40 / 70 # (425 – 212 microns) 70 / 140 # (212 – 106 microns) |
| Particle-shape | Well-rounded, spherical grains are preferred |
| Crush resistance | Withstand compressive stress 4000 - 6000 psi (28 - 42 MPa) |
| Acid solubility | Limits on acid soluble material e.g. carbonates such as calcite |
| Turbidity | Limits on clay (<2 microns) and silt (2 - 63 microns) content |
| BS EN ISO 13503-2:2006 + A1:2009 Petroleum and natural gas industries. Completion fluids and materials. Measurement of properties of proppants used in hydraulic fracturing and gravel-packing operations (related to API RP-56:1995) | |

Frac Sand Particle Size



Frac sand sporting analogy



Footballs = 20/40
(850 – 425 microns)



Tennis balls = 40/70
(425 – 212 microns)

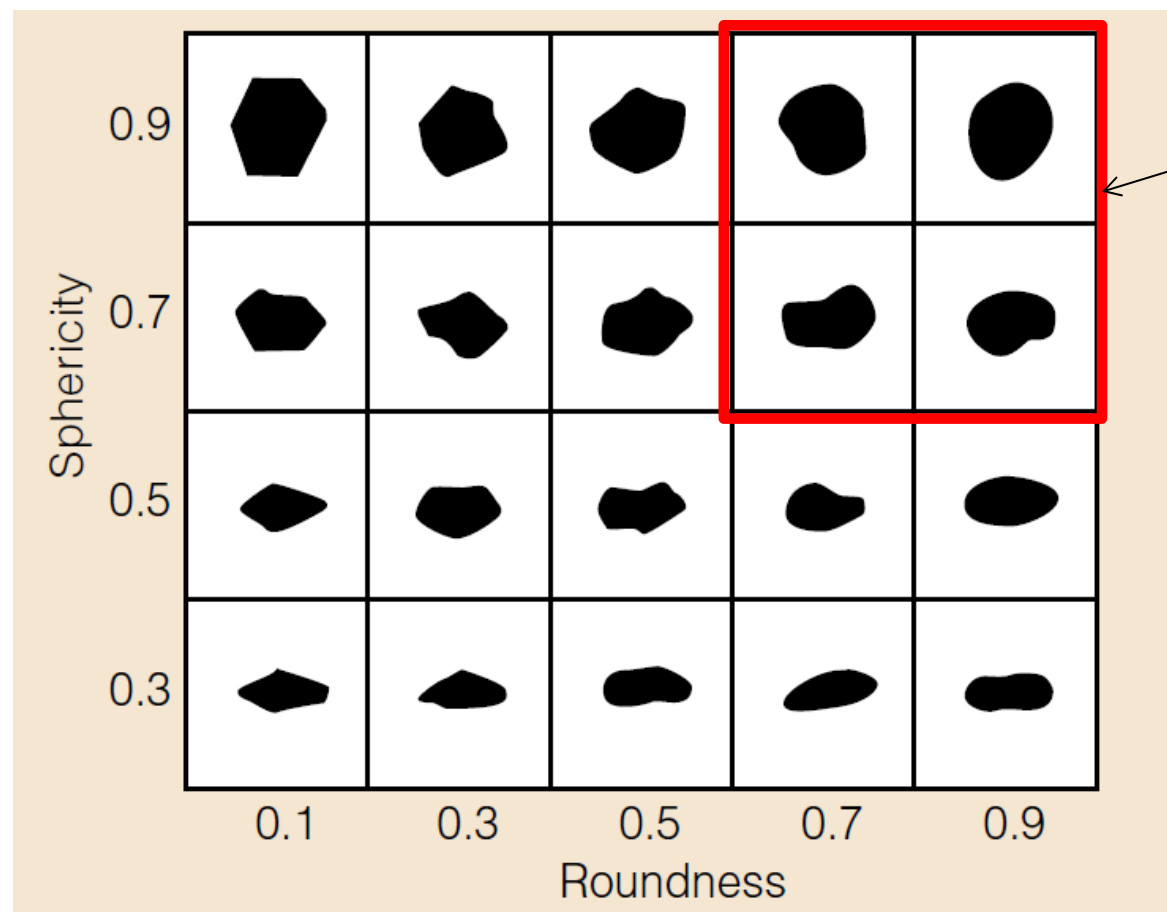


Golf balls = 70/140
(212 – 106 microns)



NB Ratios are roughly equivalent between the diameters of the balls and those of the sand grains

Roundness & Sphericity



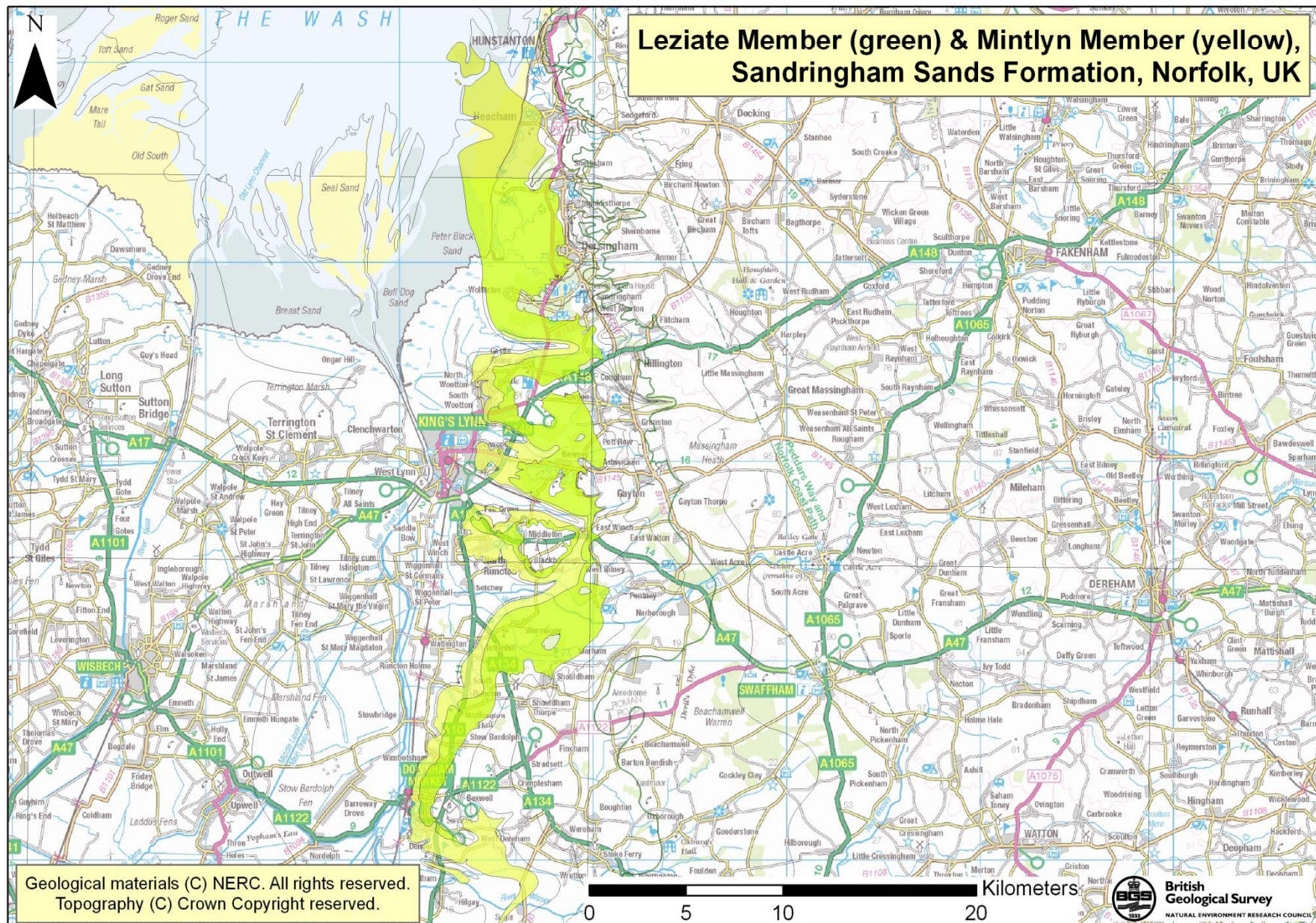
0.6 Sphericity
&
0.6 Roundness

Reference: Krumbein, WC & Sloss, LL (1963) Stratigraphy and Sedimentation, 2nd Edition (Freeman, San Francisco)



UK frac sand resources?

- Where will the frac sand come from?
- Foundry sand is the closest equivalent - requires high quartz content (98%), round grains with good sphericity & similar size range (100-500 microns)
- 20 quarries produce foundry sand in UK, the main sources are the :
 - Sandringham Sand Formation (Norfolk)
 - Woburn Sand Formation (Bedfordshire)
 - Folkestone Formation (Surrey & Kent)
 - Chelford & Congleton Sands (Cheshire)
 - Wind blown sand (North Lincolnshire)

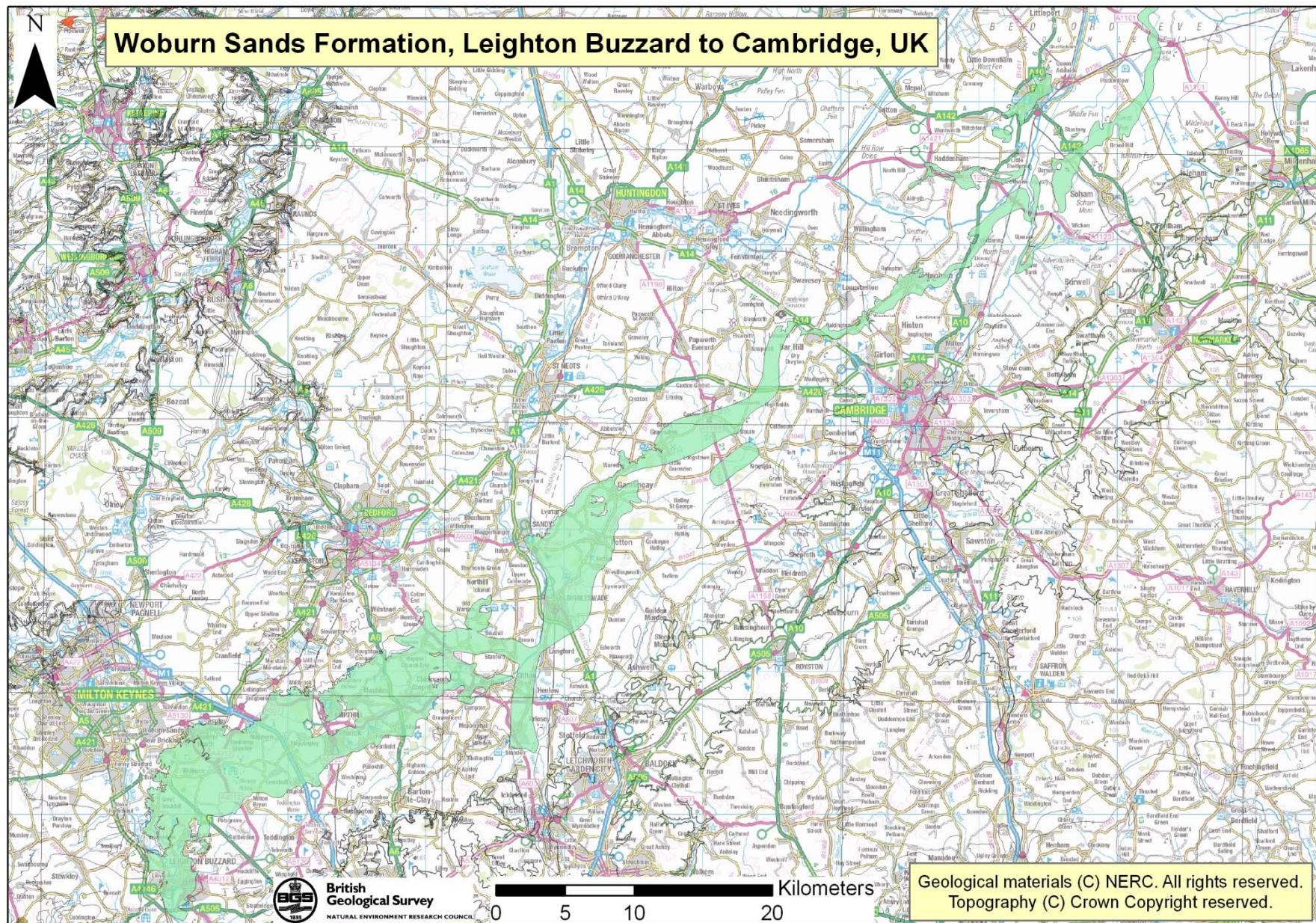




Sandringham Sand Formation: Silica sand quarry, Norfolk, UK

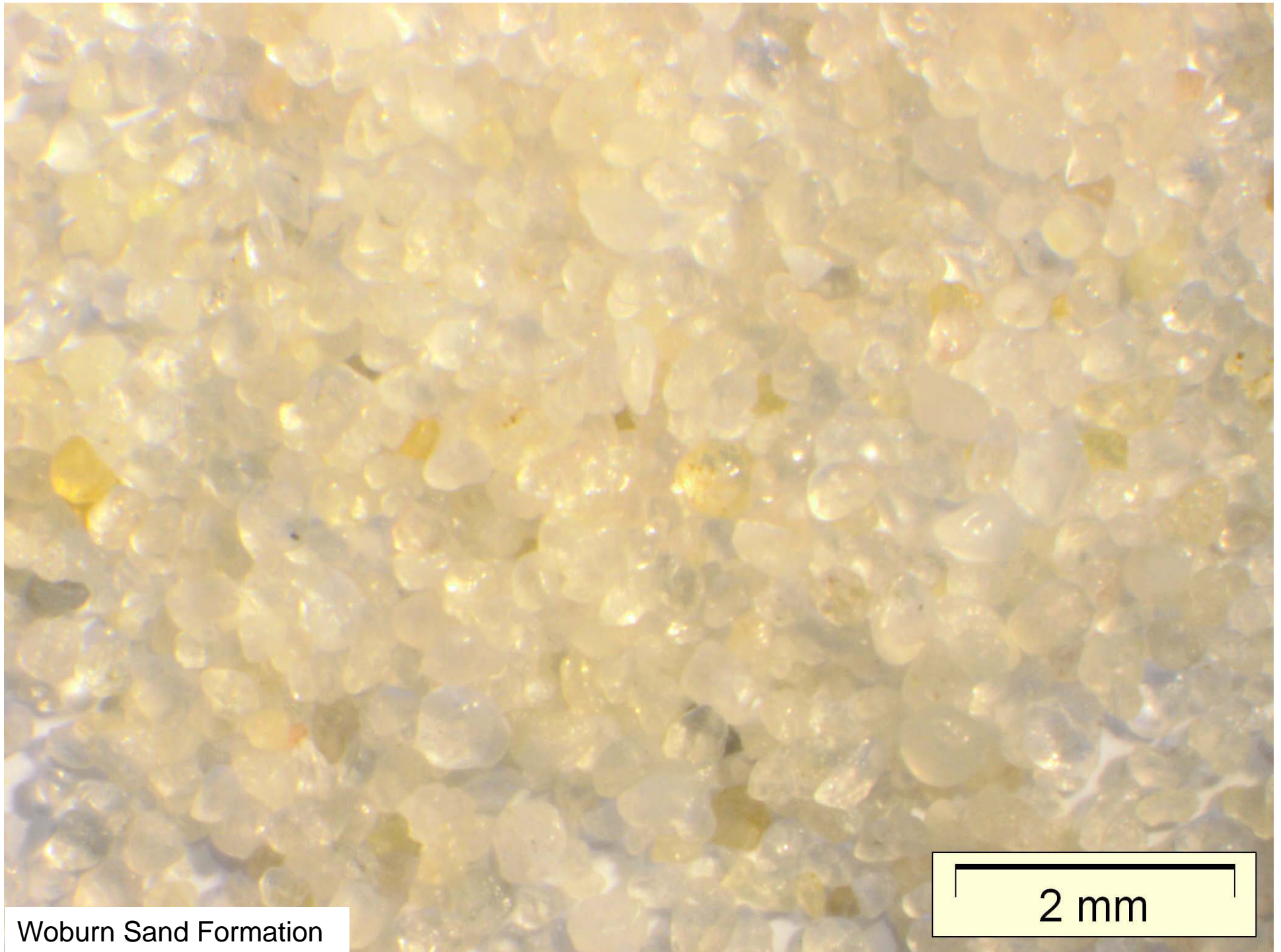


Sandringham Sand Formation: Silica sand stockpile, Norfolk, UK





Woburn Sand Formation: Silica sand quarry, Bedfordshire, UK



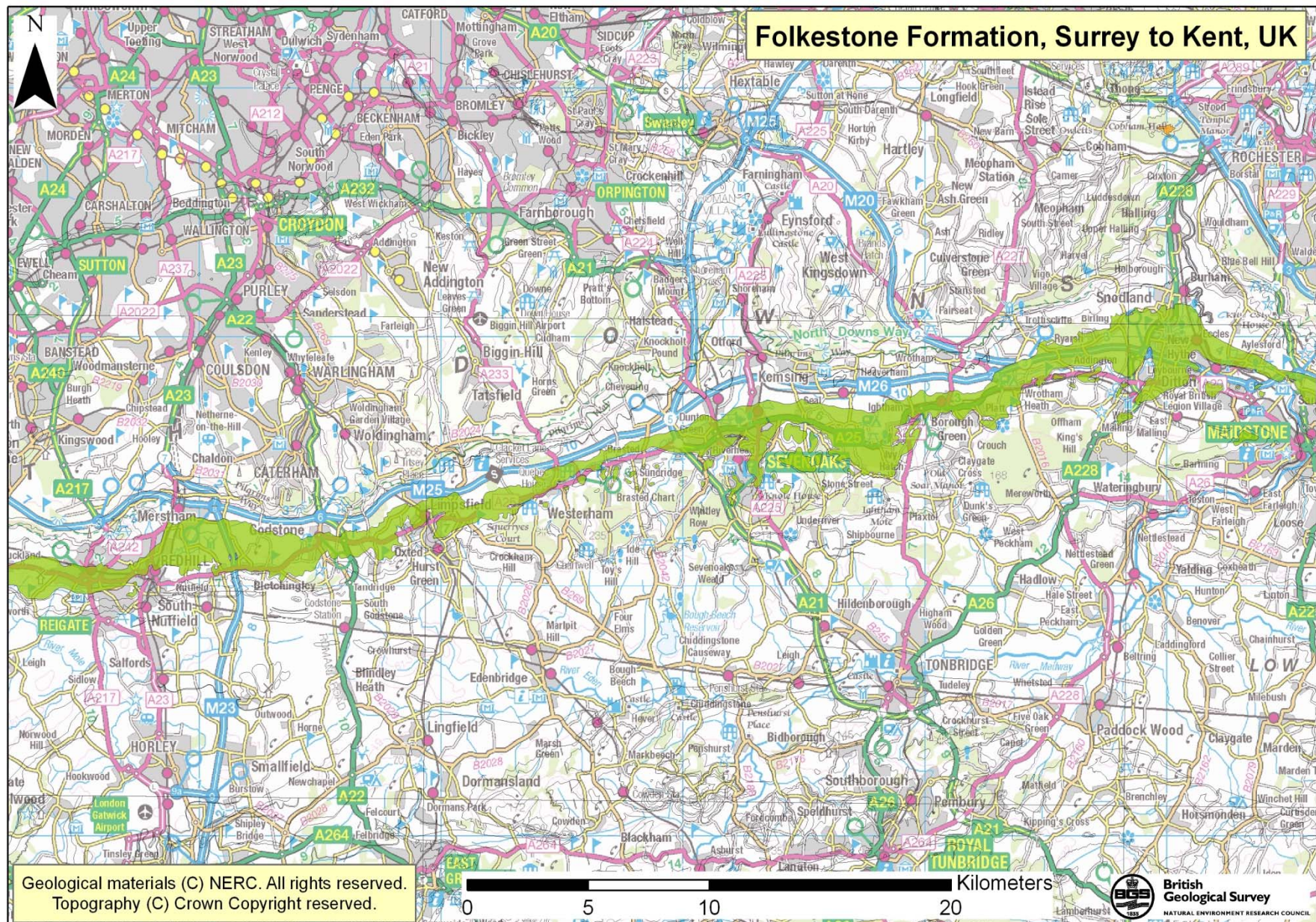
Woburn Sand Formation

2 mm



Woburn Sand Formation

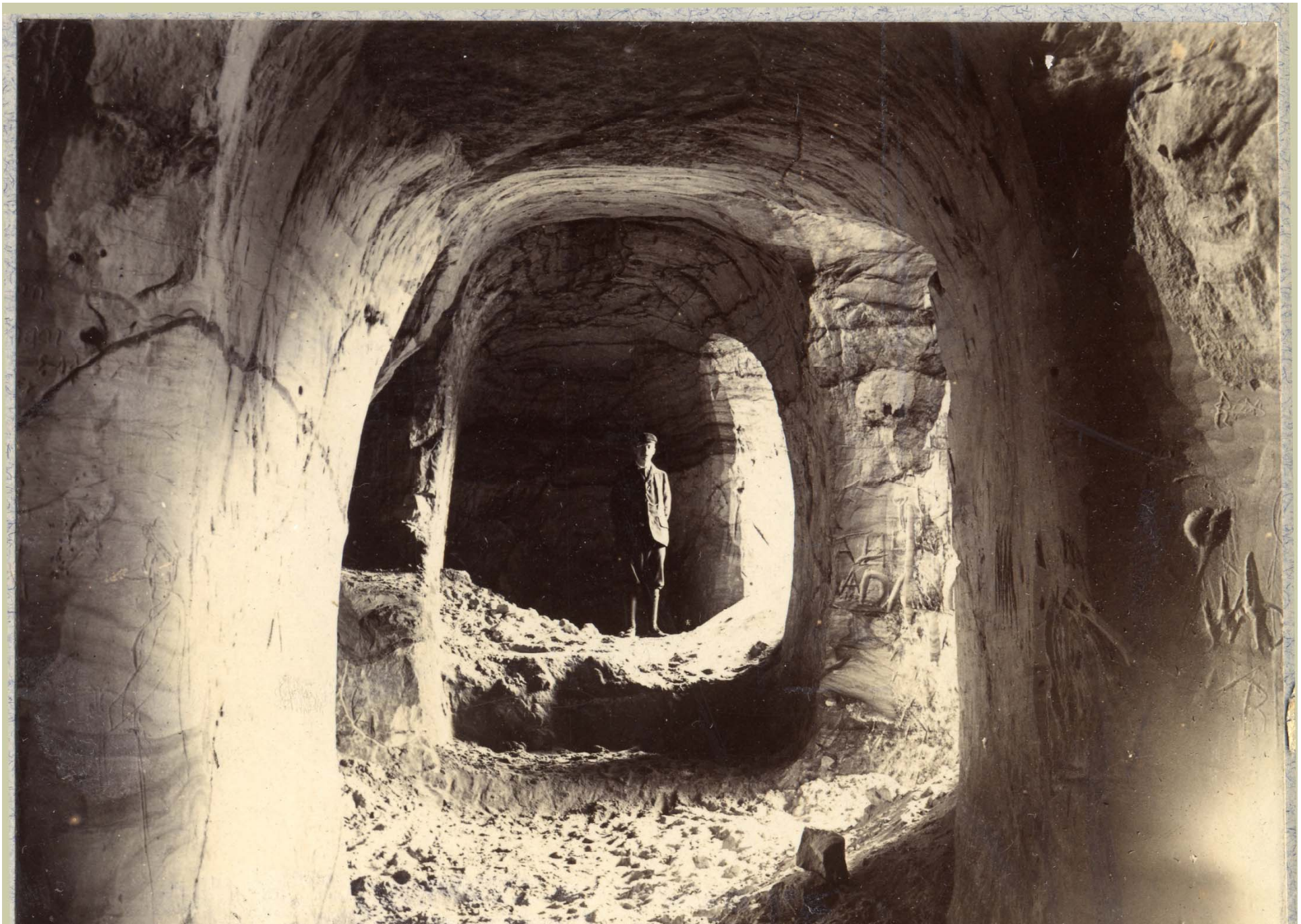
200 μm





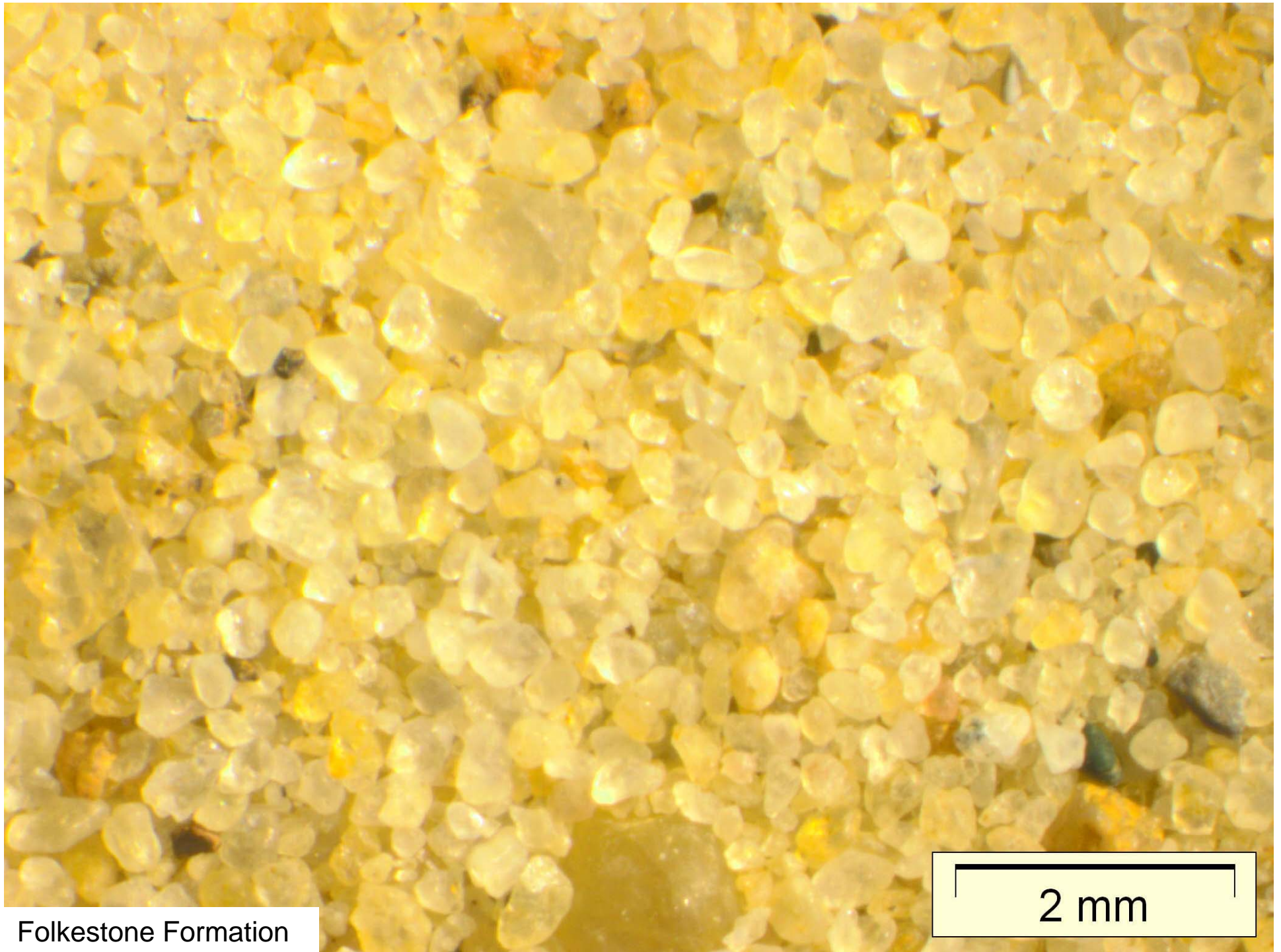
Mining of Folkestone Formation, Godstone, Surrey, UK (circa 1900)

<http://geoscenic.bgs.ac.uk/>



Mining of Folkestone Formation, Godstone, Surrey, UK (circa 1900)

<http://geoscenic.bgs.ac.uk>



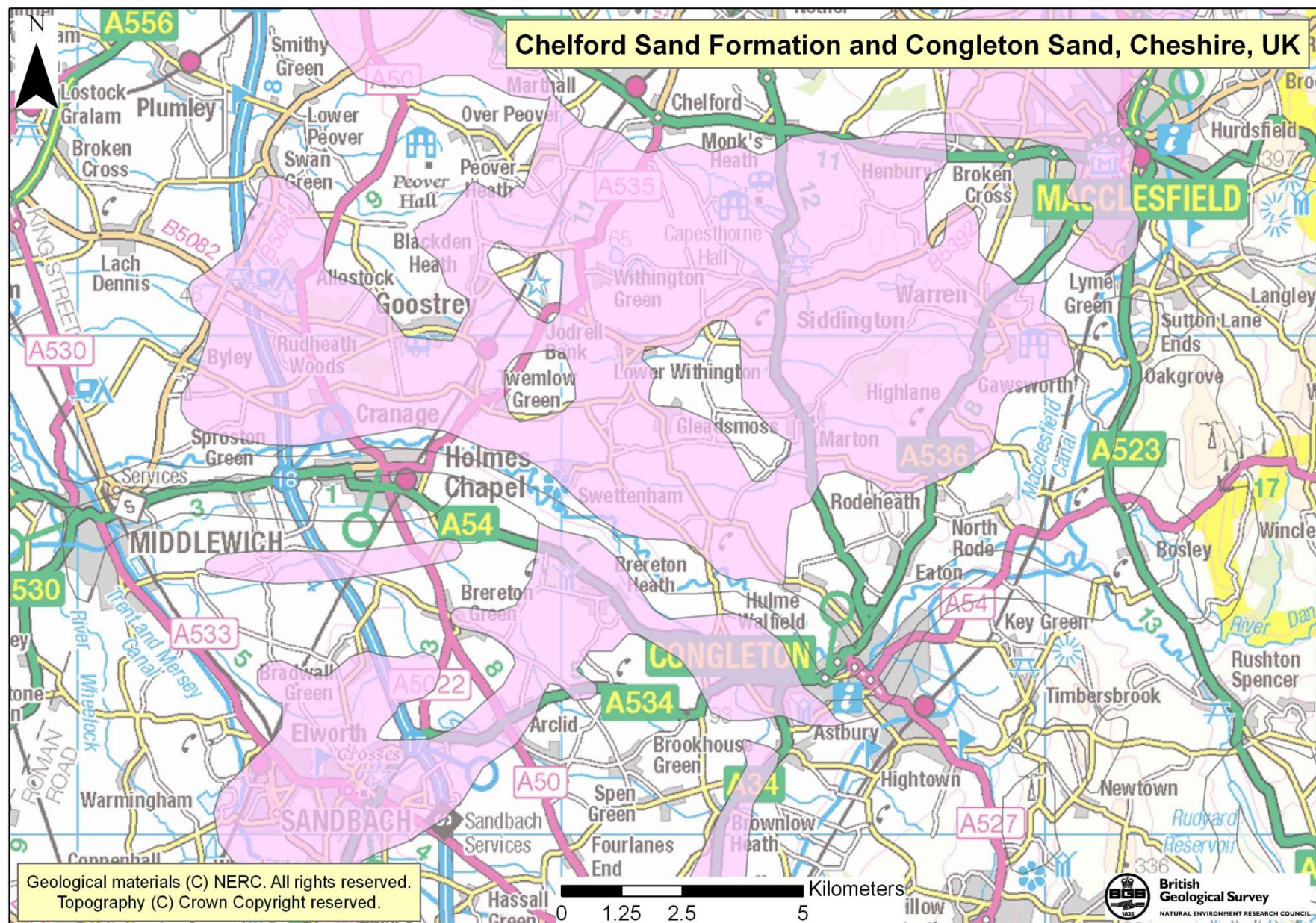
Folkestone Formation

2 mm



Folkestone Formation

200 μm



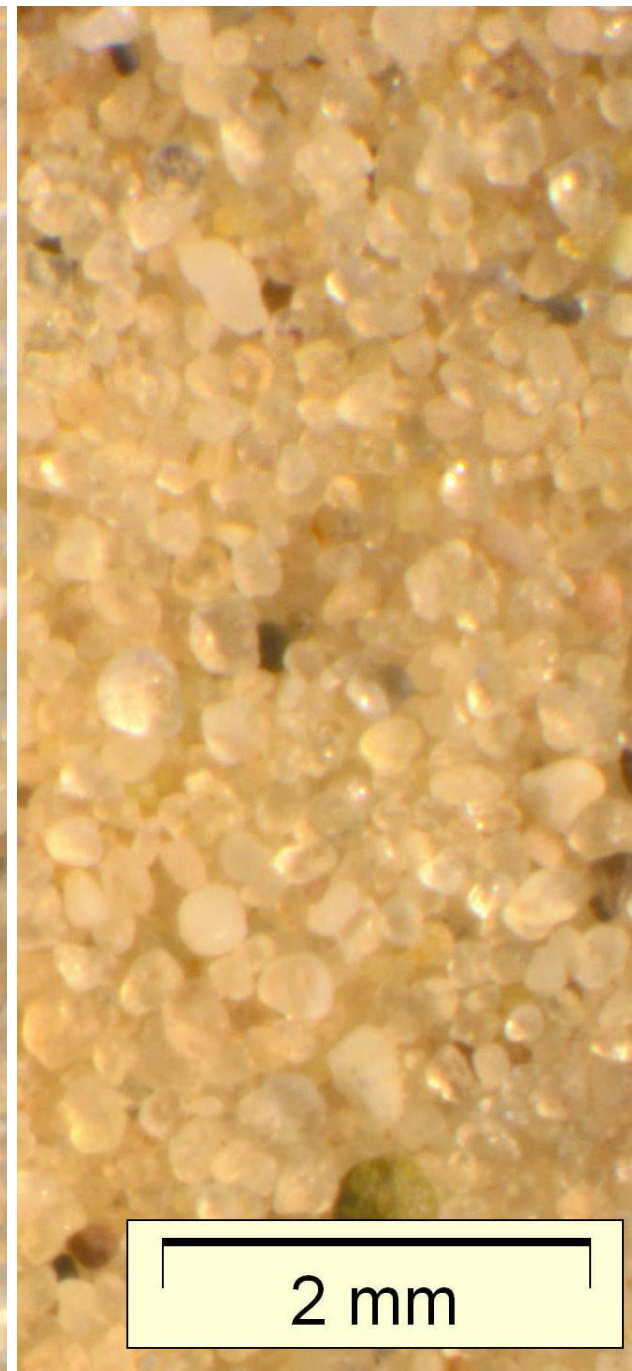
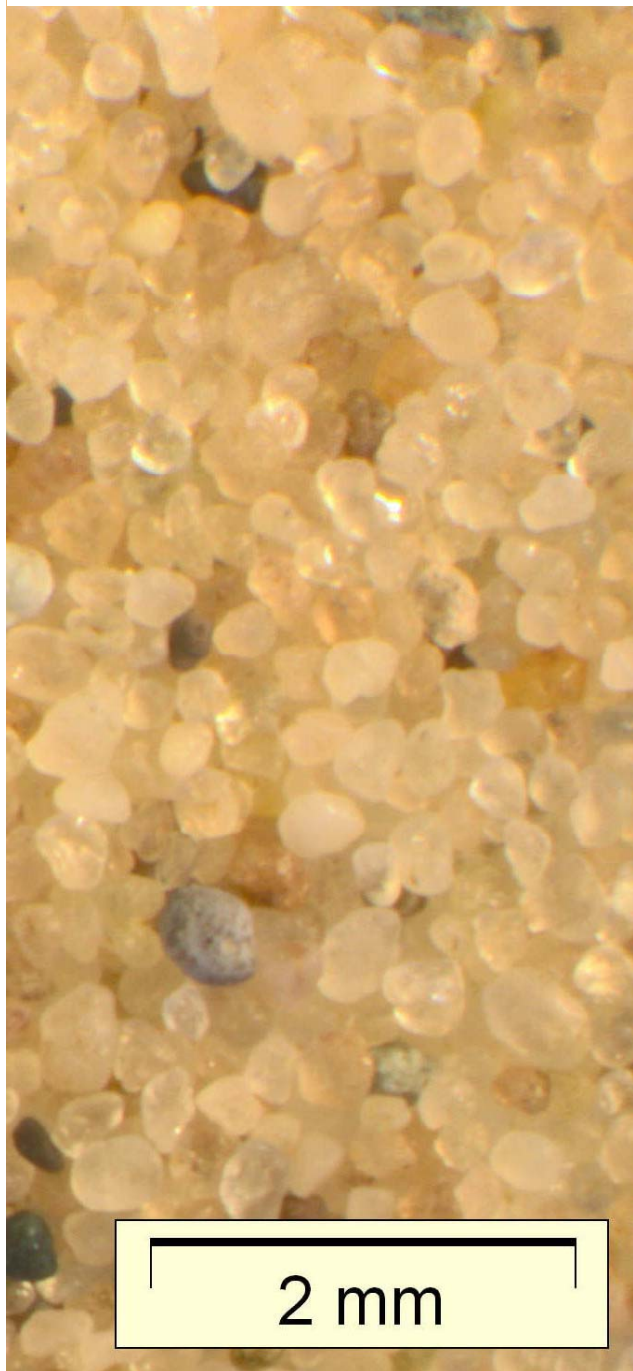


Congleton Sand: Silica sand quarry, Cheshire, UK

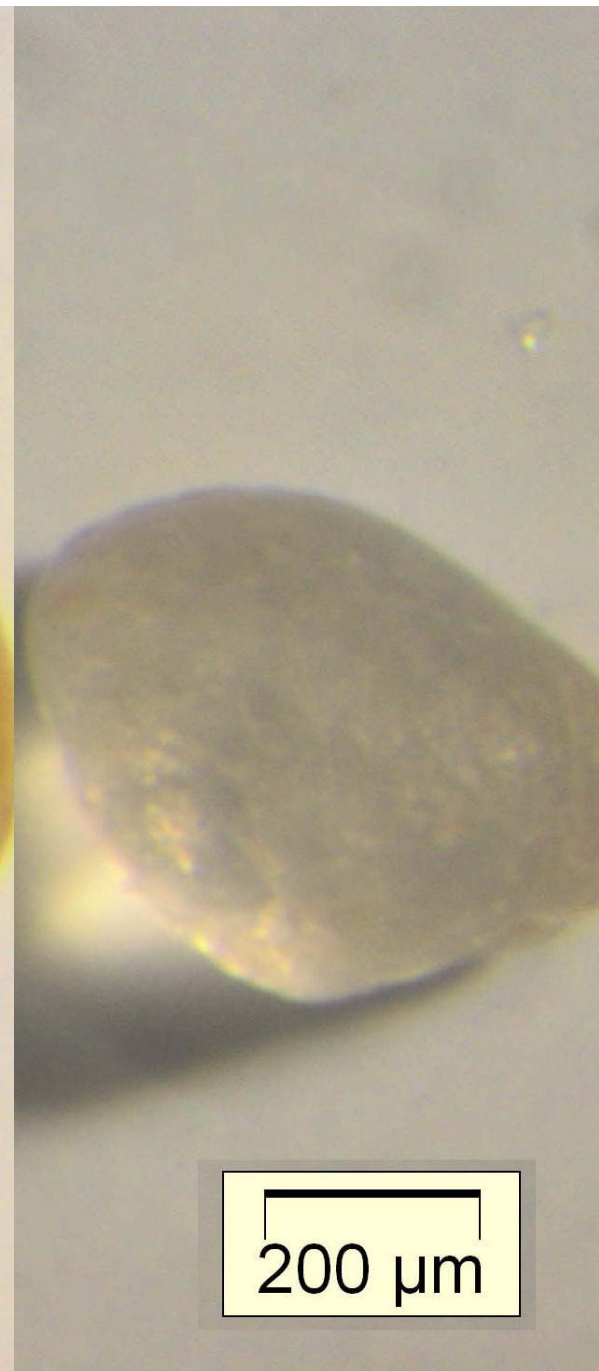


Congleton Sand: Silica sand quarry, Cheshire, UK

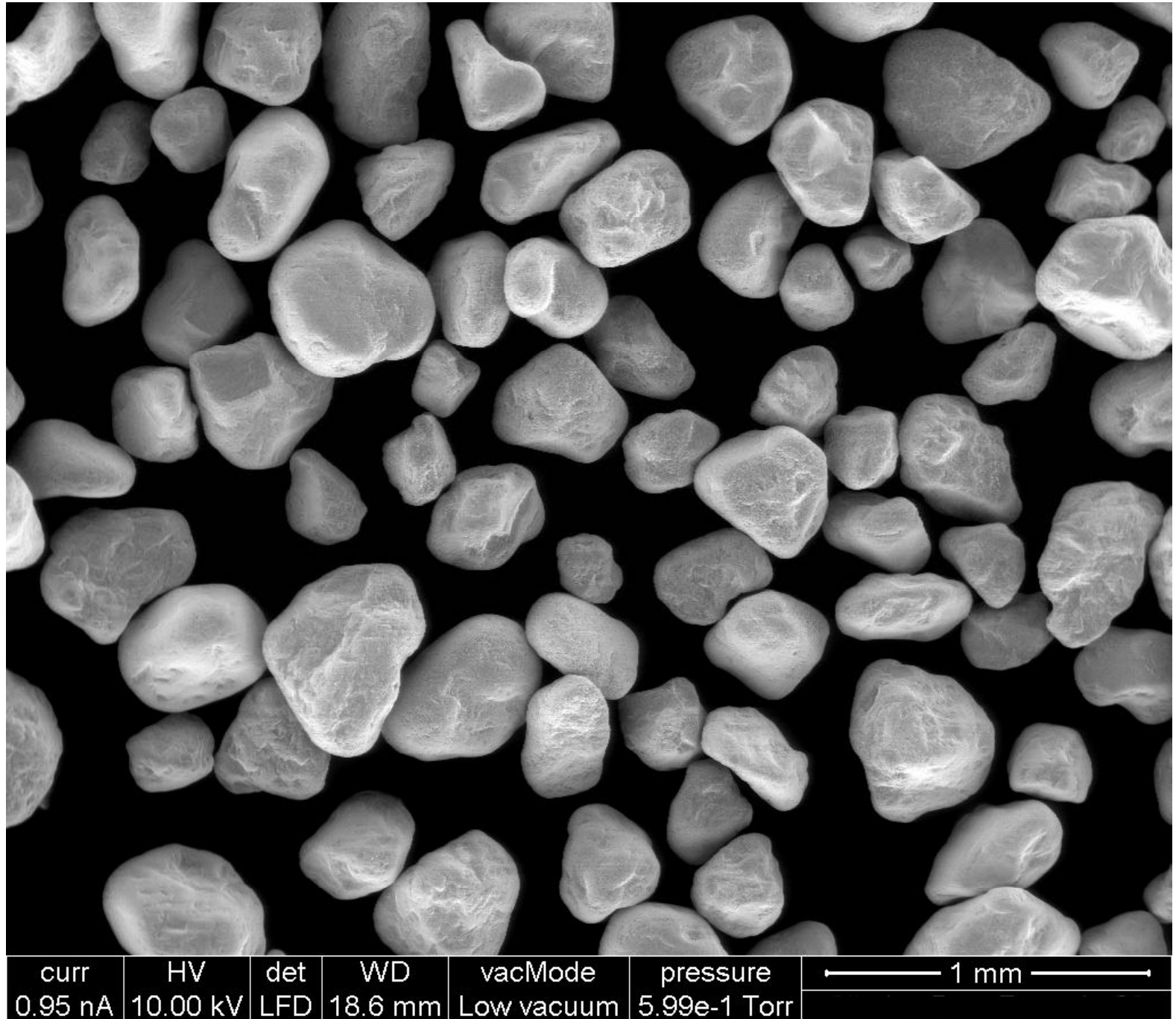
Congleton Sand



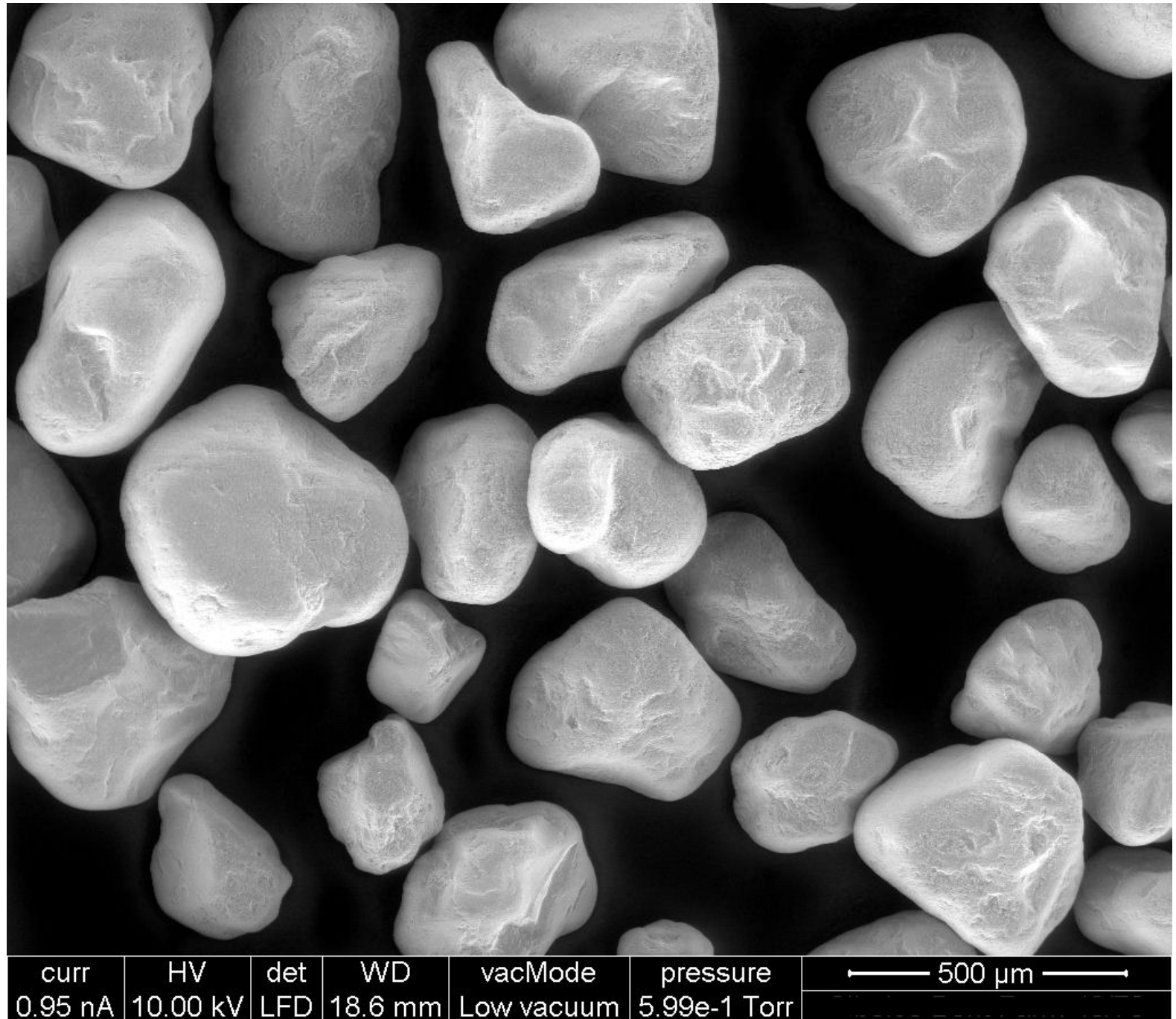
Congleton Sand



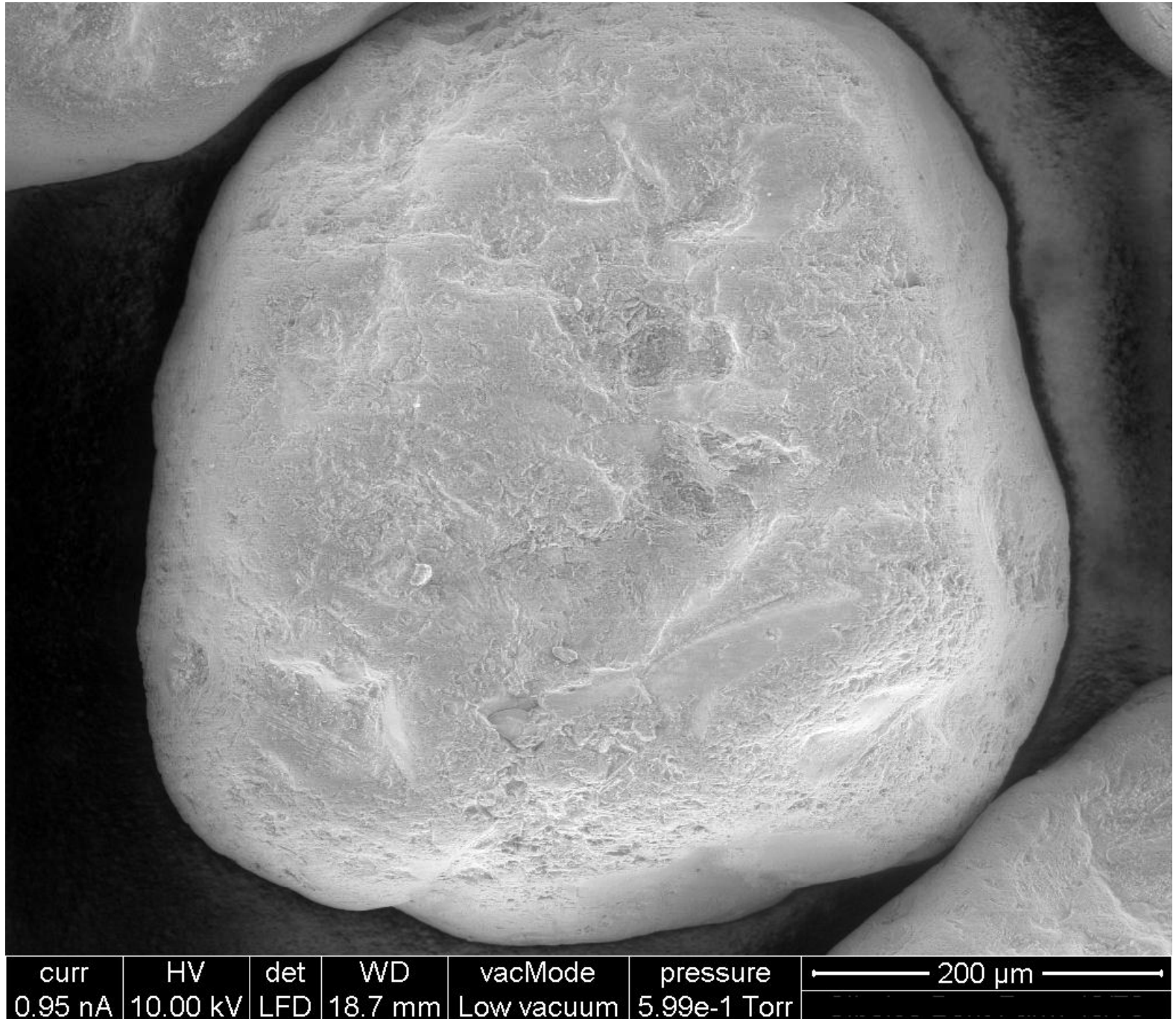
Congleton Sand



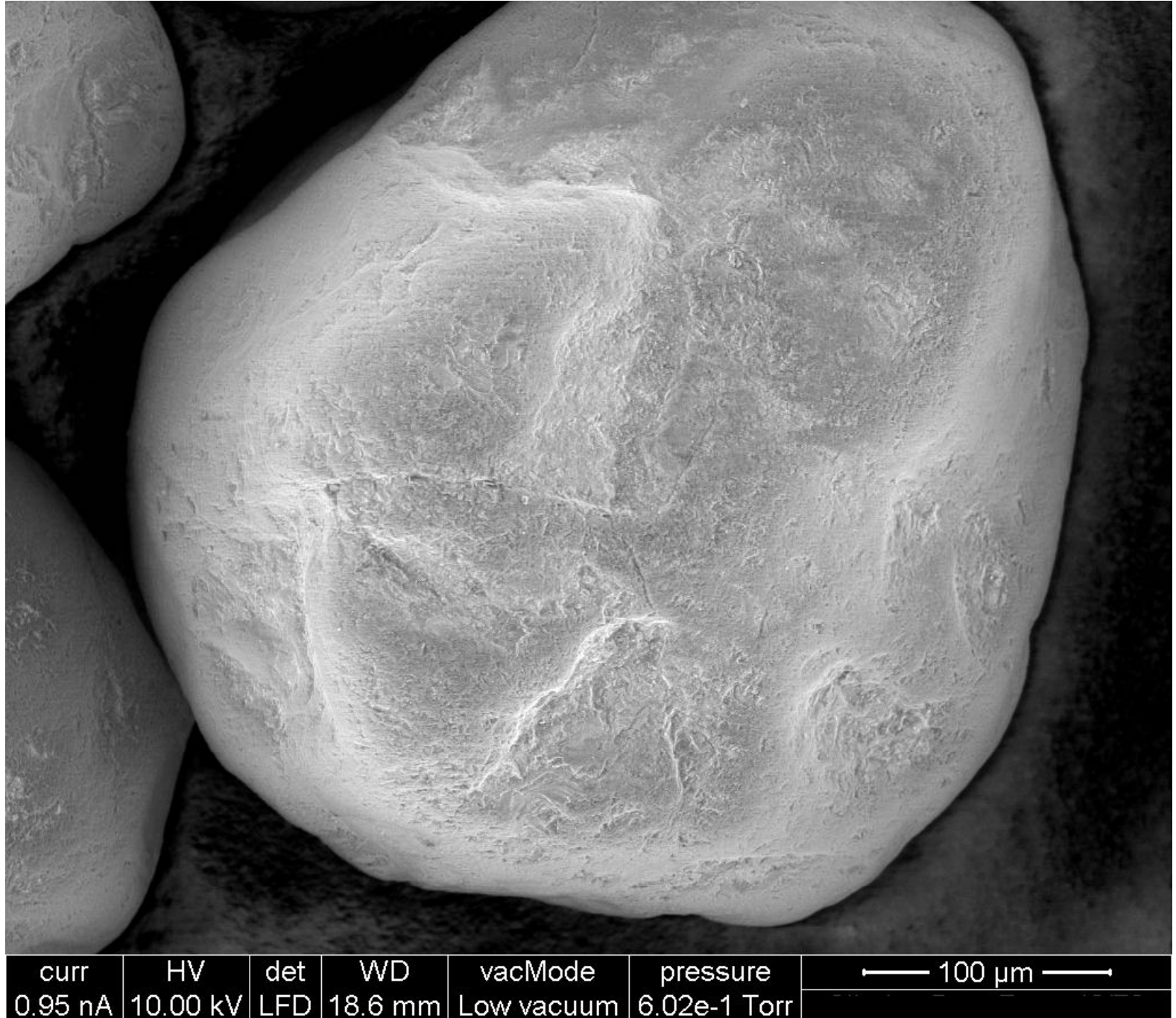
Congleton Sand



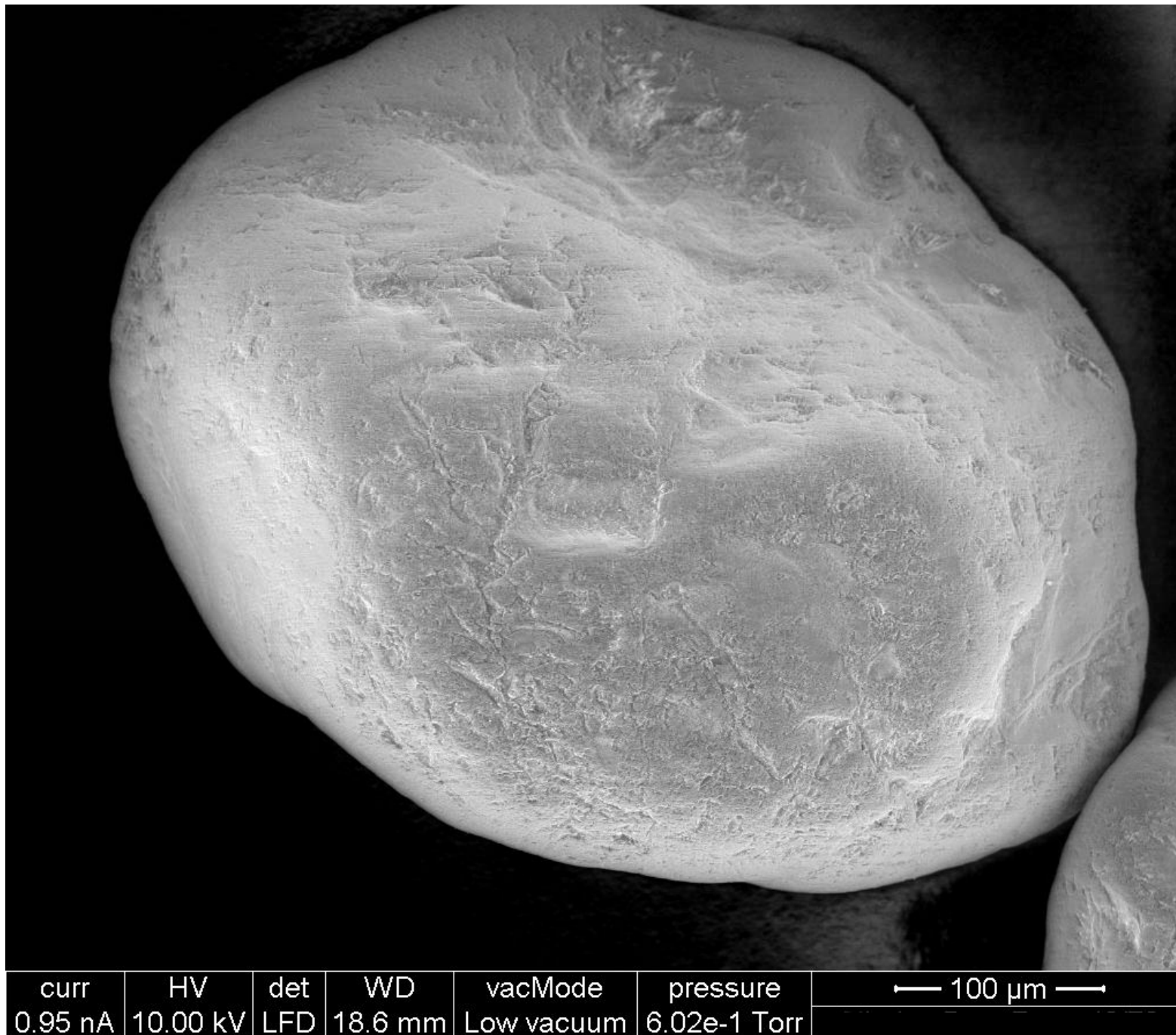
Congleton Sand



Congleton Sand



Congleton Sand



Wind blown (Aeolian) sand, North Lincolnshire, UK

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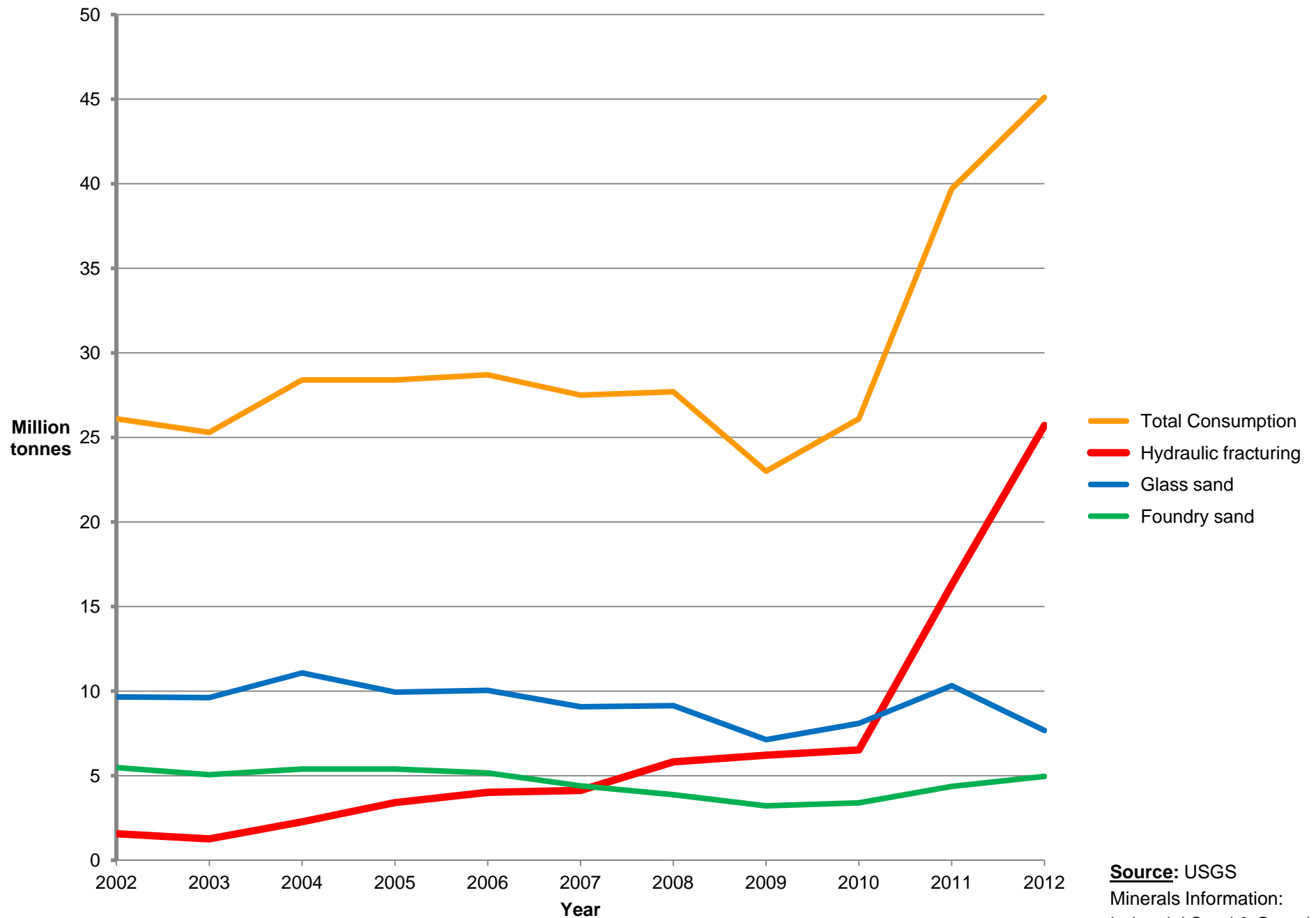
Future for frac sand?

- If a shale gas industry develops in the UK, Frac sand could become a major use of silica sand in the future
- In the USA, Frac sand was estimated to account for 5% (1.4 Mt) of the industrial sand market in 2002, this leapt to 57% (25.7Mt) in 2012*

* Sand and gravel (Industrial) U.S.G.S.
Mineral Commodity Summary 2013



US Silica Sand consumption 2002-2012



Source: USGS
Minerals Information:
Industrial Sand & Gravel



Conclusions

- Frac sand is one application amongst many for silica sand
- There are silica sand deposits in the UK that are suitable for use as frac sand
- There is plenty of silica sand for any future shale gas development in the UK



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Thank you for your attention!



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