Minerals at the BGS

- 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.

Clive at a silica sand quarry in Hampshire

http://www.bgs.ac.uk/staff/profiles/1159.html
What is Frac Sand?

- Silica sand used in hydraulic fracturing treatments to ‘prop’ open fractures in oil & gas reservoirs to enhance recovery
- Also known as ‘Proppant’ sand
- Silica sand is composed of high-purity quartz (SiO$_2$) sand
- Alternatives – resin coated sand and ceramics (made from calcined kaolin or bauxite)
Petroleum and natural gas industries — Completion fluids and materials —

Part 2: Measurement of properties of proppants used in hydraulic fracturing and gravel-packing operations

BS EN ISO 13503-2:2006 + A1:2009 This standard covers measurement of the properties of proppants and also the specifications for proppants (it is related to API RP-56:1995)
# Frac sand properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong></td>
<td>&gt;99% Silica, SiO₂ (Quartz or resin coated quartz) or 100% ceramic</td>
</tr>
<tr>
<td><strong>Particle-size</strong></td>
<td>Narrow size-distribution - 90% within specified size ranges e.g.</td>
</tr>
<tr>
<td></td>
<td>12 / 20 # (1700 – 850 microns)  20 / 40 # (850 – 425 microns)</td>
</tr>
<tr>
<td></td>
<td>40 / 70 # (425 – 212 microns)  70 / 140 # (212 – 106 microns)</td>
</tr>
<tr>
<td><strong>Particle-shape</strong></td>
<td>Well-rounded, spherical grains (&gt;0.6 for quartz sand and &gt;0.7 for</td>
</tr>
<tr>
<td></td>
<td>resin coated sand and ceramic proppants)</td>
</tr>
<tr>
<td><strong>Crush resistance</strong></td>
<td>Withstand compressive stress 4000 - 6000 psi (28 - 42 MPa),</td>
</tr>
<tr>
<td></td>
<td>determined at 10% crush material</td>
</tr>
<tr>
<td><strong>Acid solubility</strong></td>
<td>Limits on acid soluble material (&lt;2% ≥30/50, &lt;3% &lt;30/50, &lt;7% for</td>
</tr>
<tr>
<td></td>
<td>resin coated sand or ceramic proppants)</td>
</tr>
<tr>
<td><strong>Turbidity</strong></td>
<td>Limits on clay (&lt;2 microns) and silt (2 - 63 microns) content,</td>
</tr>
<tr>
<td></td>
<td>maximum turbidity 250 FTU (Formazin Turbidity Unit)</td>
</tr>
</tbody>
</table>

Frac sand sporting analogy

**Football**s = $20/40$
$(850 – 425 \text{ microns})$

**Tennis balls** = $40/70$
$(425 – 212 \text{ microns})$

**Golf balls** = $70/140$
$(212 – 106 \text{ microns})$

**NB** Ratios are roughly equivalent between the diameters of the balls and those of the sand grains.
Roundness & Sphericity

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

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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
UK frac sand resources?

- Where will the frac sand come from?
- Foundry sand is a close equivalent - requires high quartz content (98%), round grains with good sphericity, narrow size distribution and free of clay
- 20 quarries produce foundry sand in UK
- For this presentation I’ll focus on three potential sources:
  - Chelford & Congleton Sands (Cheshire)
  - Woburn Sand Formation (Bedfordshire)
  - Folkestone Formation (Hampshire, Surrey & Kent)
<table>
<thead>
<tr>
<th>curr</th>
<th>HV</th>
<th>det</th>
<th>WD</th>
<th>vacMode</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95 nA</td>
<td>10.00 kV</td>
<td>LFD</td>
<td>18.6 mm</td>
<td>Low vacuum</td>
<td>5.99e-1 Torr</td>
</tr>
</tbody>
</table>

**Congleton Sand**

Scale: 500 μm
Woburn Sand Formation: Silica sand quarry, Bedfordshire, UK
Woburn Sand

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>0.49 nA</td>
<td>10.00 kV</td>
<td>LFD</td>
<td>23.6 mm</td>
<td>Low vacuum</td>
<td>8.98e-1 Torr</td>
</tr>
</tbody>
</table>

MPLT615

200 µm
Folkestone Sand Formation: Silica sand quarry, Hampshire, UK
Folkestone Sand Formation: Silica sand quarry, Hampshire, UK
Folkestone Sand

curr | HV  | det | WD  | vacMode | pressure
-----|-----|-----|-----|---------|---------
0.49 nA | 10.00 kV | LFD | 24.0 mm | Low vacuum | 9.02e-1 Torr

1 mm
Folkestone Sand
Future for frac sand?

• Depending on well length/ number of hydraulic fracturing treatments, 2000 to 10,000 tonnes of frac sand per well

• If shale gas is developed in the UK and assuming 10 wells pa, this equals 20,000 to 100,000 tonnes of silica sand (equiv. to 0.5 - 2.5% increase in consumption)

• In the USA, frac sand accounted for 5% (1.4 Mt) of the industrial sand market in 2000, this leapt to 62% (29.9Mt) in 2013*

* Sand and gravel (Industrial) U.S.G.S. Mineral Commodity Summary 2014
Conclusions

• Frac sand is a potential new application for silica sand in the UK
• There are silica sand deposits in the UK that are potentially suitable for use as frac sand
• Watch this space!
Thank you for your attention!

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