Bowland Shale Mapping and Resource Estimation (sorry not yet)

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BGS: Sue Stoker, Ian Andrews
The huge shale gas deposit around Blackpool is 50pc larger than previously thought, according to reports.

Blackpool shale gas deposit 50pc larger than first thought

Huge shale reserves may be worth over £1.5 trillion... but is it safe?

North Sea is sitting on gas goldmine

Britain is sitting on an estimated £1.5 trillion of shale gas reserves, a Government-commissioned report is expected to say.

Fracking: Whistlebllows cautious on shale gas revolution

Shale gas could redraw the economic map of Britain - but price of houses near wells could fall 24%
• 2010 DECC estimated potential production -
  • *The UK Carboniferous (Upper Bowland Shale) shale gas play, if equivalent to the Barnett Shale of Texas, could potentially yield up to 4.7 tcf shale gas.*

• 2011 Cuadrilla 200 tcf (5,664 BCM) estimate for Gas in Place

So Cuadrilla claim 200 tcf *gas in place* on their licence where DECC estimate 4.7 tcf could potentially be produced.

Both may be right.
Area of 2012 Study
UKOGL seismic and Bowland shale in wells
Depth to Top Bowland

Bowland Basin
Lancashire High
Cheshire Basin
Gainsborough Trough
Derbyshire High
Humber Basin
Thickness of Bowland-Hodder Unit
### North American Shale Gas Analogies

<table>
<thead>
<tr>
<th>Shale Gas</th>
<th>Age</th>
<th>Lithology</th>
<th>Depth (ft)</th>
<th>Thickness (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnett - Fort Worth Basin</td>
<td>Mississipian 340 MYA</td>
<td>Siliceous mudst</td>
<td>7,500</td>
<td>300</td>
</tr>
<tr>
<td>Eagle Ford – South Texas</td>
<td>Cretaceous 100 MYA</td>
<td>Bituminous shales</td>
<td>11,500</td>
<td>250</td>
</tr>
<tr>
<td>Haynesville – Texas/Louisiana</td>
<td>U Jurassic 170 MYA</td>
<td>Argill/Calcareous</td>
<td>12,000</td>
<td>225</td>
</tr>
<tr>
<td>Horn River – NE British Columbia</td>
<td>U. Devonian 370 MYA</td>
<td>Brittle Shale</td>
<td>8,800</td>
<td>450</td>
</tr>
<tr>
<td>Marcellus - Appalachia</td>
<td>M Devonian 385 MYA</td>
<td>Argill mudst</td>
<td>7,000</td>
<td>350</td>
</tr>
<tr>
<td>Bakken – Williston Basin</td>
<td>U Dev/L Mississ. 360 MYA</td>
<td>Sst/Siltst/Carbonate</td>
<td>10,000</td>
<td>150</td>
</tr>
</tbody>
</table>

(source: www.transformsw.com/papers-and-presentations/studies.html)
1 Northern Bowland Basin

2 Eastern Bowland Basin
5 Widmerpool Trough

SSW

Long Eaton

Widmerpool Trough

NNE

Strelley

2 km

Two-way time (seconds)

Base Permo-Trias
Top Millstone Grit
Top Bowland-Hodder
Base Bowland-Hodder
Base Carboniferous
The Bowland Shale does not look like North American producing plays

• Upper part is thin but widespread marine shale unit drowning most platform highs
• Lower part is very thick rift-basin fill shales with mass-flow carbonates and rare mass-flow sandstones, passing laterally to platform carbonates on highs
Bowland-Hodder Unit: (Widmerpool Trough)

Old Dalby
Widmerpool Trough

Upper Unit

Lower Unit

Intrusions

Rempstone
Widmerpool Trough

Upper Unit

TOC
2.66-7.37
HI_{pd} 170-463
Ro 0.6-0.7

Lower Unit

Basement
Depth cross-sections

Section A
NNW
Bowland Basin
Thistleton
Hesketh
Bowland Basin
Pendle Line
SSE

Section B
NW
Bowland Basin
Ribchester Syncline
Pendle Line
Holme High SE

Section C
W
Blacon East
Erbistock Basin
Permo-Triassic Cheshire Basin
Bosley Trough

Section D
SW
Widmerpool Trough
East Midlands Shelf
Gainsborough Trough
NE

Section E
SW
Derbyshire High
Edale Basin
NE

Depth (x1000 feet)

Depth (km)

Permo-Triassic
Coal Measures
Millstone Grit
Bowland-Hodder unit
basin shales
Bowland-Hodder unit
platform limestones

Bowl-and-Hodder unit not resolved on seismic data.

Cross-section thickness in meters (feet).

Mapping in progress.
TOC in Bowland/Hodder
Vitrinite Reflectance vs. Depth

Baseline curve

All wells

Widmerpool 1 – minor uplift

Swinden 1 – major uplift
Depth to top gas window at VR = 1.1
Depth cross-section showing the effect of the sub-ground level and isomaturity cut-offs

- **Bowland-Hodder interval 0-2000 ft below ground level removed**
- **Bowland-Hodder interval within oil window removed (VR < 1.1%)**
- **Bowland-Hodder interval within gas window (VR > 1.1%) – used for volumetric estimation**
Location of DECC/BGS Rock-Eval samples
BGS Rock-Eval work: HI (pd) vs Tmax

Table 3. Minimum and Best Values for Determining Whether a Low-Porosity, Low-Permeability Shale Has High Thermal Maturity Using Both Visual and Chemical Maturity Parameters

<table>
<thead>
<tr>
<th></th>
<th>R_0 (%)</th>
<th>T_max (°C)</th>
<th>TR (%)</th>
<th>HI_{pd} (mg HC/g TOC)</th>
<th>Dry Gas (%)</th>
<th>C_{20+} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.00</td>
<td>455</td>
<td>80</td>
<td>76–100</td>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td>Better</td>
<td>1.20</td>
<td>465</td>
<td>90</td>
<td>50–75</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td>Best</td>
<td>1.40</td>
<td>475</td>
<td>95</td>
<td>&lt;50</td>
<td>95</td>
<td>1</td>
</tr>
</tbody>
</table>

Jarvie et al, 2007
Generation potential vs organic richness for DECC Bowland Shale samples

Blue line is Barnett Shale well maturation trend (Jarvie, 2008)
Jarvie et al, 2012 – Characteristics of best shale gas resource system

Wells in best-producing areas (in terms of initial production and ongoing production):

- Marine shales, commonly described as type II organic matter
- Organic rich source rocks; >1% TOC present day
- In gas window (>1.4% Ro)
- Have low oil saturations (<5% So)
- Have significant silica content (>30% with some carbonate)
- Have non-swelling clays (are brittle)
- Have <1000 nanoD permeability
- Have < 15% porosity, typically 4-7%
- Have GIP values of more than 100 bcf/section
- Have 150+ ft (45+m) of organic rich mudstone
- Are slightly to highly overpressured
- Have very high first year decline rates
- Have consistent or known principal stress fields
- Are drilled away from structures and faulting
- Are continuous mappable systems
## So, will the Bowland Shale produce shale gas?

<table>
<thead>
<tr>
<th>Positive factors</th>
<th>Negative factors</th>
<th>Unknown or poorly known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of &gt;2.5% TOC intervals</td>
<td>Variable organic content in lower unit isopach thick areas.</td>
<td>Limited well penetrations in lower unit isopach thick areas.</td>
</tr>
<tr>
<td>Some Type II kerogen</td>
<td>Some Type III kerogen</td>
<td>Gas yield</td>
</tr>
<tr>
<td>Brittle shale (interbedded w/brittle limestones)</td>
<td>Structural complexity and inversion</td>
<td>IP and decline rate</td>
</tr>
<tr>
<td>Thermal maturity &gt;1.1 R₀ &gt;3.5 R₀</td>
<td>Relatively low gamma response compared to North American analogues</td>
<td>Extent of over-pressuring</td>
</tr>
<tr>
<td>Evidence of gas in shale wells and producing fields sourced from Bowland Shale</td>
<td>Lower unit isopach thick areas have no North American shale gas analogues</td>
<td></td>
</tr>
</tbody>
</table>
Bowland/Hodder Shale Isopach

- Bowland Basin
- Edale Basin
- Erbistock Sub-Basin
- N Staffordshire Basin
- Gainsborough Trough
- Widmerpool Gulf
• BGS Mapping, geochemical analysis still underway

• Fault-bounded thickns do not look like North American analogies, but have few well penetrations

• Bowland /Hodder has condensed zones of high-TOC, laterally correlative high gamma, brittle shale

• Basins are mature for gas, but some for liquids, too
DECC will publish Bowland Tech report and GIP estimation early in 2013

Thanks to Sue Stoker, Ian Andrews, Mike Sankey at BGS!
NEW CONTROLS ON SEISMIC RISKS PERMIT A RESUMPTION OF SHALE GAS EXPLORATION

Hydraulic fracturing operations for shale gas in the UK have been suspended since May 2011, pending the investigation of two seismic tremors experienced near Preese Hall, Lancashire during fracking operations.

In the light of the recommendations of a panel of independent experts, of comments received in response to a public consultation, and of the recommendations of an authoritative review of the scientific and engineering evidence on shale gas extraction made by the UK’s science and engineering academies, the Royal Society and the Royal Academy of Engineering, the Secretary of State for Energy has announced the introduction of new regulatory requirements to ensure that seismic risks are effectively mitigated.

A copy of the Secretary of State’s statement to Parliament is available at the following link. [link].

Subject to these new requirements, DECC is prepared in principle to consider new applications for consent to such operations, and the suspension is therefore lifted. As before, final consent to any well or well operations is dependent on confirmation that all other necessary permits and consents have been obtained. A wide range of other issues were raised in the responses to the public consultation, and DECC together with other relevant bodies has prepared a full Q&A brief on these issues, which can be found at [Q&A link.....]

The full Government response to the recommendations made on the scientific and engineering evidence by the Royal Society and the Royal Academy of Engineering can be found via the following link [RS/RAE response]

Here is further background information on Shale Gas

- Environment Agency’ guidance note on exploratory shale gas operations