Shale Gas in Europe*

Brian Horsfield¹, Hans-Martin Schulz¹, Ingo Kapp¹

Search and Discovery Article #10380 (2012)
Posted January 9, 2012

*Adapted from oral presentation at AAPG International Conference and Exhibition, Milan, Italy, October 23-26, 2011. Please refer to similar article, Shale Gas for Europe, Search and Discovery article #70118 from AAPG European Region Newsletter, December, 2011.

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Abstract

Test drilling for shale gas (oil) is underway in Europe. While the geological setting is fundamentally different to that of the USA, complexity being the rule rather than the exception, opportunities appear abundant. In Poland it is mainly the Silurian, in England the Namurian and Wealden, in France the Jurassic, in Sweden the Cambrian and in Germany the Carboniferous, Jurassic and Wealden that are in focus. GASH is the first major research initiative in Europe that is focused on shale gas, and comprises two main elements: a European Black Shale Database (EBSD) and research on the factors governing shale gas formation and occurrence. The EBSD is being built by a team of geological surveys. Key well attributes stored in the database include depth, thickness, TOC, type of organic matter, maturity, gas shows and kicks, inorganic geochemical data, sedimentary facies, and so on. Well logs, core availability and seismic information are stored as meta-data. The research projects are focused on the two basic geological variables establishing viability, namely gas in place (GIP) and the delivery of gas to the wellbore. The Cambrian Alum Shale from Sweden and Denmark, the Lower Jurassic Posidonia Shale from Central Germany, and Carboniferous black shales from the UK in the west via the Netherlands to Germany in the east are the natural laboratories for the research programme.

There are additional hurdles to overcome when it comes to exploiting European shale gas. Costs per well are still higher than in the US, the rig count is dramatically lower, and mining regulations are certainly tighter. Of particular importance is the public’s perception of how drilling fluids may pose a threat to aquifers and surface ecosystems. Transparency in operations and staying in close touch with all stakeholders will be of paramount importance if technologically proven reserves are to be exploited. Environmental and social awareness issues are being pursued as part of the German government funded GeoEn project, as well as via ESOP (European Sustainable Operating Practices), a major joint initiative of the Gas Technology Institute, the University of Leoben and GFZ German Research Centre for Geosciences. This presentation will provide a pragmatic perspective to all of the above issues.
Reference

Shale Gas in Europe

Brian Horsfield, Hans-Martin Schulz, Ingo Kapp
GFZ German Research Centre for Geosciences,
14473 Potsdam, Germany
### European Black Shale Database

#### Examples include
- Maykop Shale
- Wealden
- Mikulov marl
- Liasic shales
- Meride Fm
- Dinantian
- Frasnian
- Graptolitic Shale
- Kukersite
- Alum Shale

#### Gas Shales in Europe

<table>
<thead>
<tr>
<th>Geologic Period</th>
<th>European Black Shale Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenozoic</td>
<td>Cenozoic</td>
</tr>
<tr>
<td>Neogene</td>
<td>Neogene</td>
</tr>
<tr>
<td>Paleogene</td>
<td>Paleogene</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Cretaceous</td>
</tr>
<tr>
<td>Jurassic</td>
<td>Jurassic</td>
</tr>
<tr>
<td>Triassic</td>
<td>Triassic</td>
</tr>
<tr>
<td>Permian</td>
<td>Permian</td>
</tr>
<tr>
<td>Triassic</td>
<td>Triassic</td>
</tr>
<tr>
<td>Carboniferous</td>
<td>Carboniferous</td>
</tr>
<tr>
<td>Devonian</td>
<td>Devonian</td>
</tr>
<tr>
<td>Silurian</td>
<td>Silurian</td>
</tr>
<tr>
<td>Ordovician</td>
<td>Ordovician</td>
</tr>
<tr>
<td>Cambrian</td>
<td>Cambrian</td>
</tr>
</tbody>
</table>

#### European Black Shale Data

<table>
<thead>
<tr>
<th>TCM Gas</th>
<th>Gas Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.6</td>
<td>Coalbed Methane</td>
</tr>
<tr>
<td>12.2</td>
<td>Shale Gas</td>
</tr>
<tr>
<td>35.6</td>
<td>Tight Gas Sands</td>
</tr>
<tr>
<td>85.5</td>
<td>Total</td>
</tr>
</tbody>
</table>

#### Comparison:
- Groningen 85 Tcf
- Leman 11 Tcf

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Horsfield et al.
AAPG International Conference and Exhibition, Milan, 26. October, 2011
Estimated global shale gas technically recoverable resources (tcf)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1. North America  *</td>
<td>3.842</td>
<td>7.140</td>
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<tr>
<td>2. South America</td>
<td>2.117</td>
<td>4.569</td>
</tr>
<tr>
<td>3. Europa</td>
<td>549</td>
<td>2.587</td>
</tr>
<tr>
<td>4. Africa **</td>
<td>1.548</td>
<td>3.962</td>
</tr>
<tr>
<td>5. Asia</td>
<td>3.528</td>
<td>5.661</td>
</tr>
<tr>
<td>6. Australia</td>
<td>2.313</td>
<td>1.381</td>
</tr>
<tr>
<td>7. Other ***</td>
<td>2.215</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16.112</strong></td>
<td><strong>25.300</strong></td>
</tr>
</tbody>
</table>
Horsfield et al.
AAPG International Conference and Exhibition, Milan, 26. October, 2011

Shale Gas Activity in Europe 2011

LEGEND
1: Sweden
Alum Shale (Cambrian)
2: Denmark
Alum Shale (Cambrian)
3: Poland
Paleozoic Shales
4: N. Germany
Mesozoic Shales, Lower Saxony Basin
5: Central Germany
Namurian Shales,
6: S. Germany
Permocarboniferous Shales, Bodensee-Trough
7: S. England
Weald Basin
8: N. England
Namurian Shales, W-Lancashire Sub-Basin
9: France
Mesozoic Shales, Southeast Basin
10: Switzerland
Lower Jurassic Shales, Fribourg, Vaud
11: Austria
Upper Jurassic Shales, Vienna Basin
12: Hungary
Cenozoic Shales, Mako Trough
13: Bulgaria
Mesozoic Shales, NE Bulgaria
14: Ukraine
Lower Carboniferous Shales, Dnepr Donets Basin
15: Turkey
Silurian Shales, Dadas Fm., SE Turkey
16: Spain
Lower Jurassic Shales, Basque-Cantabrian Basin

Map modified after: www.mygeo.info
### The Talk Today.....

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explore</td>
<td>tests!</td>
</tr>
<tr>
<td>Produce</td>
<td>optimise, sweet spots</td>
</tr>
<tr>
<td>Supply</td>
<td>infrastructure</td>
</tr>
<tr>
<td>Combustion</td>
<td>power generation</td>
</tr>
<tr>
<td>Safeguard</td>
<td>environment</td>
</tr>
<tr>
<td>Inform</td>
<td>general public</td>
</tr>
</tbody>
</table>

Horsfield et al.
AAPG International Conference and Exhibition, Milan, 26. October, 2011
Primary Energy Consumption in Germany 2009

Germany orders safety review at nuclear plants
By Quentin Peel in Berlin
Published: March 13 2011 15:19 | Last updated: March 13 2011 15:19

Horsfield et al.
AAPG International Conference and Exhibition, Milan, 26. October, 2011
**Shale Gas Formation in Time and Space**

- 12 research projects covering regional and reservoir scale
- European Black Shale Database

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**Sciences**

**Surveys**

**Sponsors**

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Regional scale research

Tectonic models
J.-D. van Wees, S. Cloetingh, O. Abbink (TNO-VU), F. Roure, F. Lorant (IFP), R. Sachsenhofer (Leoben University), M. Scheck-Wenderoth (GFZ-Potsdam)

Migration and Retention Processes in Shale Gas: Basin Modeling and Sensitivity Analysis
F. Lorant, C. Sulzer (IFP), B. Horsfield (GFZ-Potsdam)

Natural fracturing and pressure modeling in gas shales: reconstruction of geopressures and specific fracturation ratio law calibration
J-M. Daniel (IFP)

3D petroleum system modeling of shale-gas plays
V. Neumann, R. di Primio, B. Horsfield (GFZ-Potsdam)

Feasibility study for gas shales with bacterial gas - Microbiology and carbon mass balances of bacterial gas formation in gas shales and potential gas shale targets
H.-M. Schulz (GFZ-Potsdam), M. Krüger (BGR Hannover), W. van Berk (Techn. University of Clausthal)

Characterizing the electrical conductivity structure of black shale horizons
O. Ritter, M. Becken, U. Weckmann (GFZ-Potsdam), Ulrich Mann (FZ-Jülich)
Reservoir scale research

Multi-Scale Petrophysical Characterisation of Gas Shales
A.P. Aplin (Newcastle University), B.M. Krooss (RWTH Aachen), B. Horsfield (GFZ Potsdam), F. Stallmach (Leipzig University)

The organic matter component of gas shales: evolving source and reservoir properties
B. Horsfield (GFZ-Potsdam), A.P. Aplin (Newcastle University), B.M. Krooss, R. Littke (RWTH Aachen), B. Cramer (BGR, Hannover), F. Lorant and F. Béhar (IFP)

Single- and multiphase (gas-water) flow in gas shales and tight-gas systems
B.M. Krooss (RWTH Aachen)

Seismic characterization of shale gas reservoirs
C. Haberland, M. Stiller, K. Bauer, M.H. Weber (GFZ-Potsdam), U. Mann (FZ-Jülich)

Development of rock-physics modelling and microseismic interpretation for geophysical characterization of shale-gas reservoirs
S.A. Shapiro (FU Berlin), S. Stanchits, G. Dresen (GFZ-Potsdam)

Mechanical and Hydraulic Properties of Shales and Healing of Induced Fractures
G. Dresen, A. Reinicke, E. Rybacki (GFZ-Potsdam), M. Rouainia, A.C. Aplin (Newcastle University)
Namurian Holywell Shale:
- the source rock for oil and gas fields offshore in the East Irish Sea, and onshore UK, and
- Shale Resource: up to 1.95 Tcf unrisked GIIP

Wintershall concession

Ziegler (1990)
Surface topography to base Carboniferous. Fully balanced model of salt movement. Well data from >50 wells.
• Deep gas in focus
• T>200°C
• Coking systems
• Non-coking systems
• Kinetics
## Applying classical shale gas evaluation concepts to Germany—Part II: Carboniferous in Northeast Germany

Alexander Hartwig*, Sven Koenitzer, Bettina Boucekin, Brian Horsfield, Hans-Martin Schulz

Gerichtshauptmannschaft GZB, Postfach 4 2, 41640 Lingen, Germany

<table>
<thead>
<tr>
<th></th>
<th>Tournaisian/low visean</th>
<th>Middle visean</th>
<th>Upper visean</th>
<th>Westphalian A/B</th>
<th>Westphalian C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOC wt%</strong></td>
<td>0.2–0.9</td>
<td>0.5–1.1</td>
<td>0.6–1.2</td>
<td>0.6–1.7</td>
<td>0.25–0.5</td>
</tr>
<tr>
<td><strong>% R&lt;sub&gt;t&lt;/sub&gt;</strong></td>
<td>3.2–4.1</td>
<td>0.3–0.5</td>
<td>0.4–0.6</td>
<td>1.6–2.2</td>
<td>1.3–1.8</td>
</tr>
<tr>
<td><strong>Gas type</strong></td>
<td>Dry thermogenic</td>
<td>Wet thermogenic</td>
<td>Dry thermogenic</td>
<td>Dry thermogenic</td>
<td>Dry thermogenic</td>
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<tr>
<td><strong>Hydrocarbon shows</strong></td>
<td>Gas</td>
<td>Oil</td>
<td>Oil</td>
<td>Gas</td>
<td>Gas</td>
</tr>
<tr>
<td><strong>Hydrogen index</strong></td>
<td>4–28</td>
<td>29–91</td>
<td>7–57</td>
<td>8–25</td>
<td>14–40</td>
</tr>
<tr>
<td><strong>HI [mg HC/g rock]</strong></td>
<td>83</td>
<td>58</td>
<td>76</td>
<td>87</td>
<td>75</td>
</tr>
<tr>
<td><strong>TR&lt;sub&gt;II&lt;/sub&gt;%</strong></td>
<td>n-C&lt;sub&gt;15&lt;/sub&gt; HC up to C&lt;sub&gt;28&lt;/sub&gt;, no UCM hump</td>
<td>n-C&lt;sub&gt;25&lt;/sub&gt;+, almost absent, no UCM hump</td>
<td>n-C&lt;sub&gt;17&lt;/sub&gt; HC up to C&lt;sub&gt;26&lt;/sub&gt;, no UCM hump</td>
<td>n-C&lt;sub&gt;26&lt;/sub&gt;+, almost absent, no UCM hump</td>
<td>n-C&lt;sub&gt;26&lt;/sub&gt;+, almost absent, no UCM hump</td>
</tr>
<tr>
<td><strong>Residual hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mineralogy</strong></td>
<td>20–80% clay minerals, 5–80% calcite, 10–20% quartz, feldspar and pyrite</td>
<td>Predominantly calcite (50–90%), clay minerals, kaolinite, pyrite</td>
<td>Calcite up to 90%, siderite, clay minerals, up to 20% quartz, pyrite</td>
<td>20–80% quartz, 40–80% clay, some carbonate</td>
<td>20–40% quartz, 60–80% clay, some carbonate</td>
</tr>
<tr>
<td><strong>Thickness (m)</strong></td>
<td>400–1100</td>
<td>600–800</td>
<td>&gt; 400</td>
<td>100–600</td>
<td>425–600</td>
</tr>
<tr>
<td><strong>Depth (m)</strong></td>
<td>2500–5500</td>
<td>1500–4500</td>
<td>1000–4000</td>
<td>3200–6100</td>
<td>2500–5400</td>
</tr>
<tr>
<td><strong>Temperature (°C)</strong></td>
<td>~120</td>
<td>n.a.</td>
<td>&lt; 55</td>
<td>80–150</td>
<td>70–140</td>
</tr>
</tbody>
</table>
Nearly Out
Risk and Perceived Risk

A new opportunity:
• security of supply
• plentiful
• affordable
• bridge to renewables

Concerns:
• Induced seismic activity
• Contamination
• Disposal
• Leakage

http://www.flickr.com/photos/energy_pictures/3686146477/
The Operating Environment

- High population density
- No mineral rights for landowners
- Water from surface and aquifers
- Service industries not developed
- Rig count is low
DREINSTENFURT Als „interessante Option“ bezeichnet Prof. Dr. Dietrich Borchardt ein Probe-Fracking um festzustellen, welche Risiken und Möglichkeiten diese unkonventionelle Methode der Erdgasförderung birgt. Borchardt leitet den siebenköpfigen wissenschaftlichen Expertenkreis, der sich am Freitag in Münsters Speicherstadt traf, um mit Betroffenen über die Sicherheit und Umweltverträglichkeit der Fracking-Technologie zu debattieren. Im Forum saß auch Drensteinfurts Bürgermeister Paul Befago, der in Stewwert könnte ebenfalls nach Erdgas gebohrt werden.

Ob die Expertenrunde nicht „ein Fegenblatt von Exxon“ sei, musste sich Borchardt im Verlauf der Veranstaltung vorangestellten Pressekonferenz fragen lassen. Der Expertenkreis wird nämlich „nach Bedarf“ von Ruth Hammermecher, die zusammen mit Dr. Christoph Ewe die Fachkonferenz moderierte, von Exxon finanziert Gegenwart stünden 1 Million Euro für die Untersuchung der Fachleute bereit. „Was ist die Alternative?“ fragte Borchardt zurück und verwies darauf, die Gesellschaft müsse eine Entscheidung „auf breiter rationalen Grundlagen finden“ und eben diese Grundlagen liefern der Expertenkreis.

„Unabhängiger Prozess“

Hammermecher betonte zudem, dass die Experten neutral seien und es keine inhaltliche Prüfung der Untersuchungsergebnisse durch Exxon geben werde. Im März 2012 würden diese ins Internet gestellt, ob sie dem Energie-Müll nun gefallen oder nicht. Sie hoffe hingegen, dass durch die Fachleute ein „unabhängiger Prozess“ ins Leben gerufen werden sollte.


• Neutral
• Addressing ALL issues:
  * Economic and societal benefits
  * Health and environment
• Transparency
• Best practices
German National Lab for Geosciences

- Helmholtz
  - 3.0 Mrd. €
  - 17 research centres
  - 30,000 staff, of which 9,000 scientists
  - 4,400 Ph.D students
  - 1,700 Apprentices

- Leibniz
  - 1.6 Mrd. €

- Max-Planck
  - 1.25 Mrd. €

- Fraunhofer
  - 1.0 Mrd. €

Single Discipline

Interdisciplinary

- GFZ
  - Helmholtz Centre Potsdam

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The Polish Exploration and Production Industry Organization (15 companies)

Sobieski Institute
Greg Pytel

Tischner European University
Jaroslaw Gowin

Kosciuszki Institute
Izabela Albrycht

GFZ
GTI
EFD
Core group
• Induced seismicity
• Water contamination
Implement Monitoring Programme

• Implement monitoring program in support of transparent exchange
• Establish baseline environmental quality (land, air, water) before field activities
• Monitor quality during execution of field activities and ongoing production
• Establish industry-provided “field laboratory” for demonstration of operating practices
• Utilize seismic imaging technology to model and measure reach of induced fractures
Funding Strategy

• PHASE 1:
Single industry partner provides free site access before, during and after fracking
Funding comes from non-industry sources

• PHASE 2:
Single industry partner provides free site access before, during and after fracking
Funding comes from mixed sources
The Debate

Security of supply, affordability, sustainability, safety

Frozen in the Headlights of Rhetoric

Poland

Security of supply, affordability, sustainability, safety

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Frozen in the Headlights of Rhetoric

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Wrap Up

• Technology vital as ever
• Process understanding will improve success ratio, reduce costs, reduce well spacing and is therefore key to exploiting European shale gas
• Environmental issues and acceptance will make or break in the short-term
• Europe is largely frozen in the headlights of rhetoric – we deserve better
• E-SOP is an important step forward to test the shale gas potential of Europe using best practices