Shale Gas in Europe*

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Search and Discovery Article #10380 (2012)
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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

Ziegler, P.A., 1990, Collision related intra-plate compression deformations in Western and Central Europe, *in* N.A. Logatchev, and H.J. Zwart (eds.), Proceedings of the symposium; Intracontinental mountainous terranes; geological and geophysical aspects: Journal of Geodynamics, v. 11/4, p. 357-388.

Shale Gas in Europe

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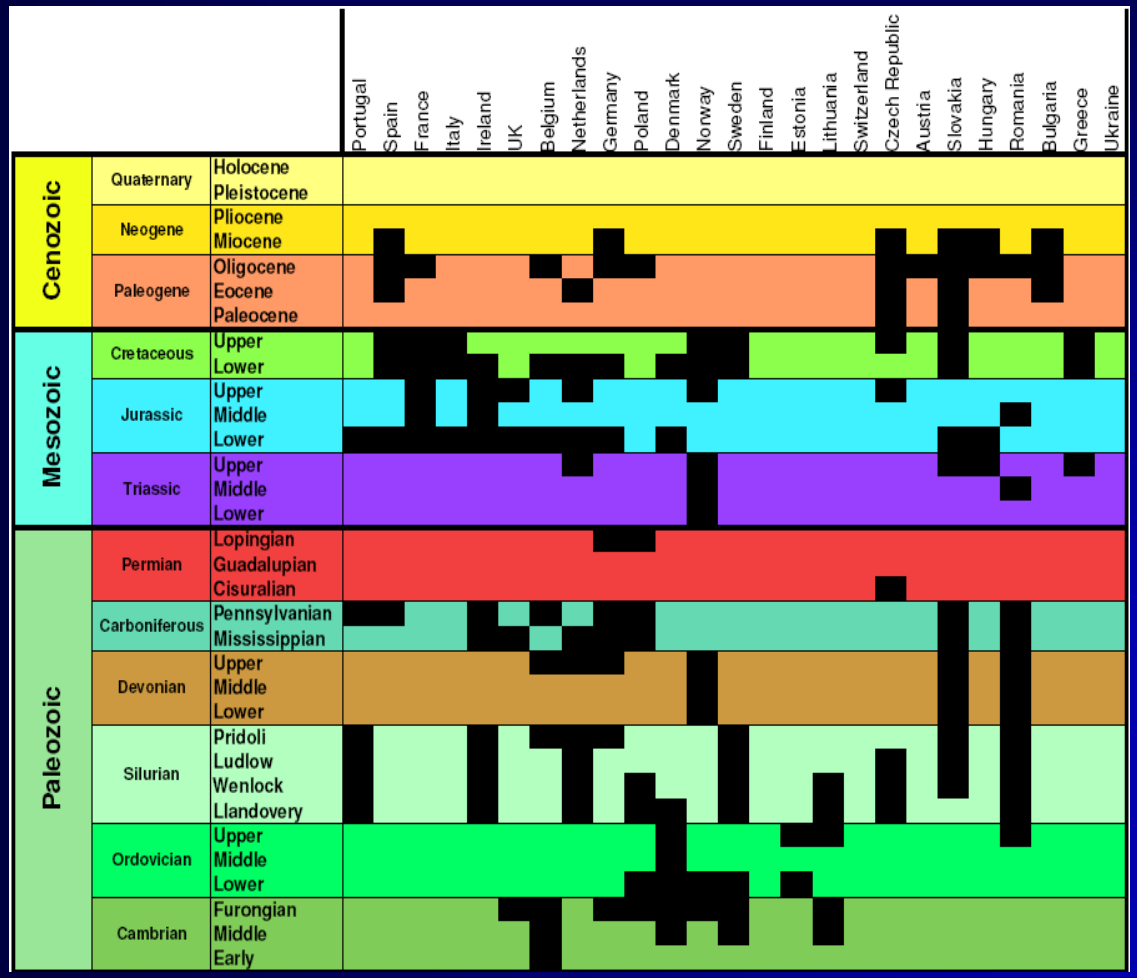
European Black Shale Database



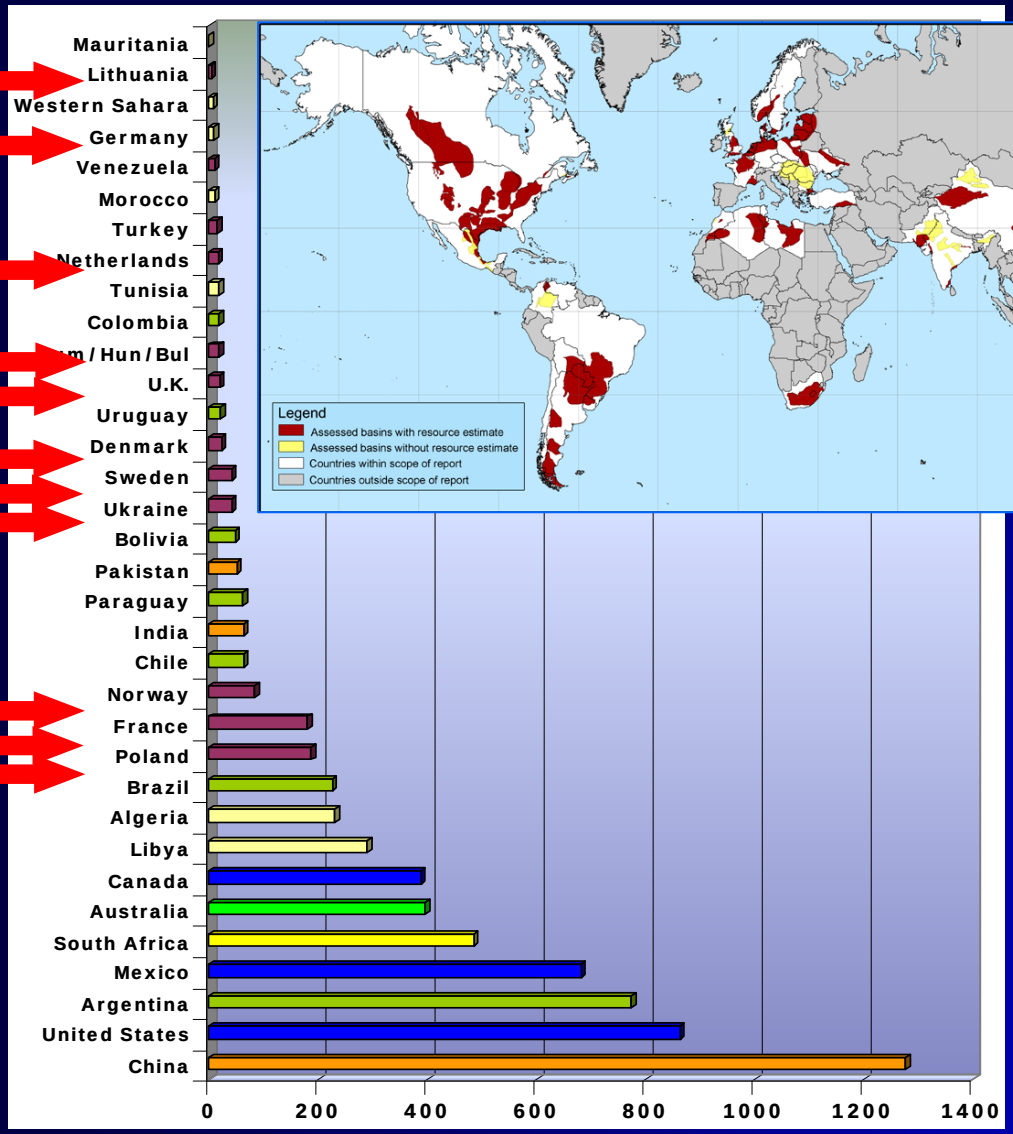
Examples include

Cenozoic
- Maykop Shale

Mesozoic
- Wealden
- Mikulov marl
- Liassic shales
- Meride Fm

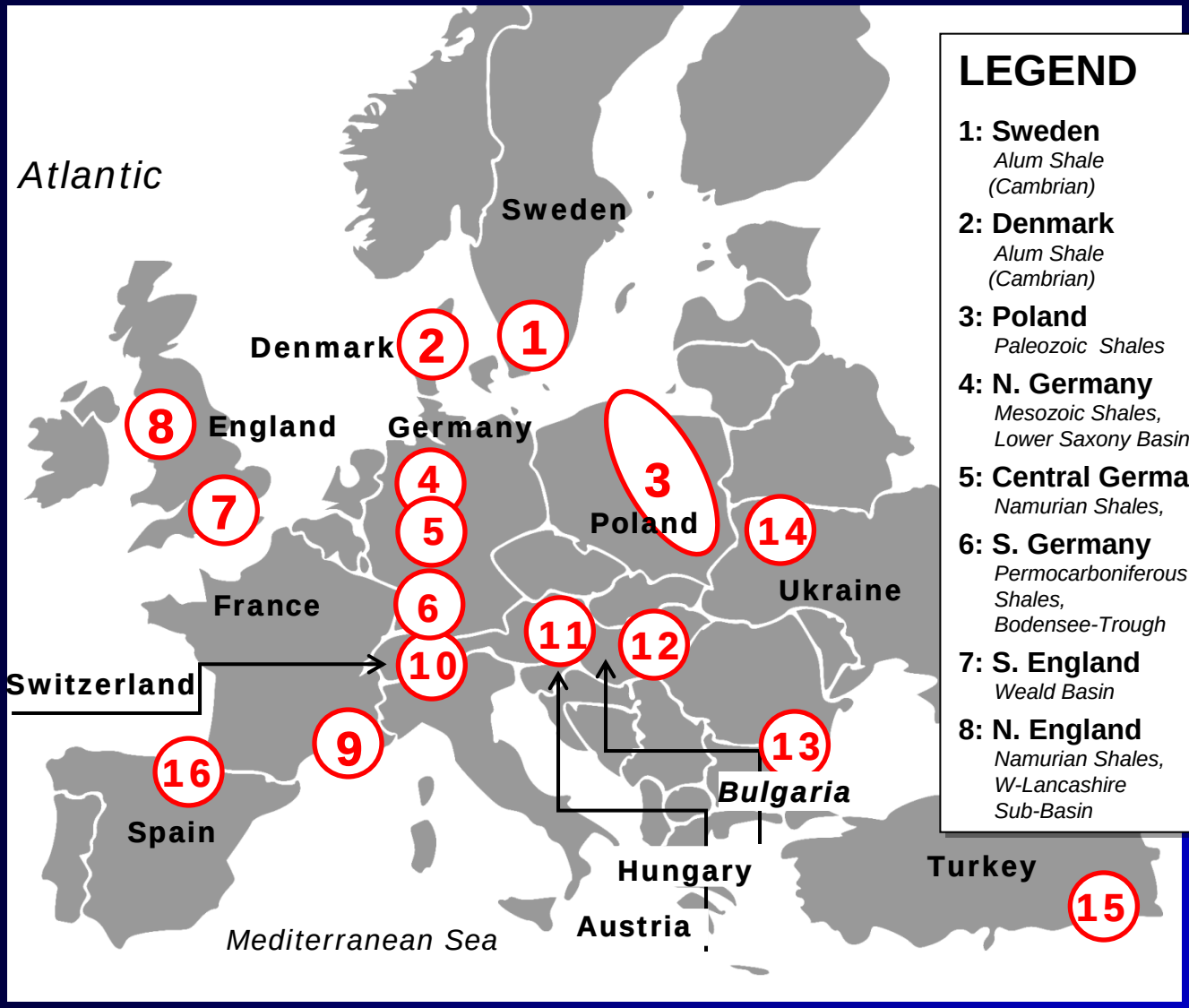
Palaeozoic
- Dinantian
- Frasnian
- Graptolitic Shale
- Kukersite
- Alum Shale

Estimated global shale gas technically recoverable resources (tcf)



Continent	H-H Rogner (1997) (Tcf)	EIA/ARI (2011) (Tcf)
1. North America *	3.842	7.140
2. South America	2.117	4.569
3. Europa	549	2.587
4. Africa **	1.548	3.962
5. Asia	3.528	5.661
6. Australia	2.313	1.381
7. Other ***	2.215	n/a
Total	**16.112**	**25.300**

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

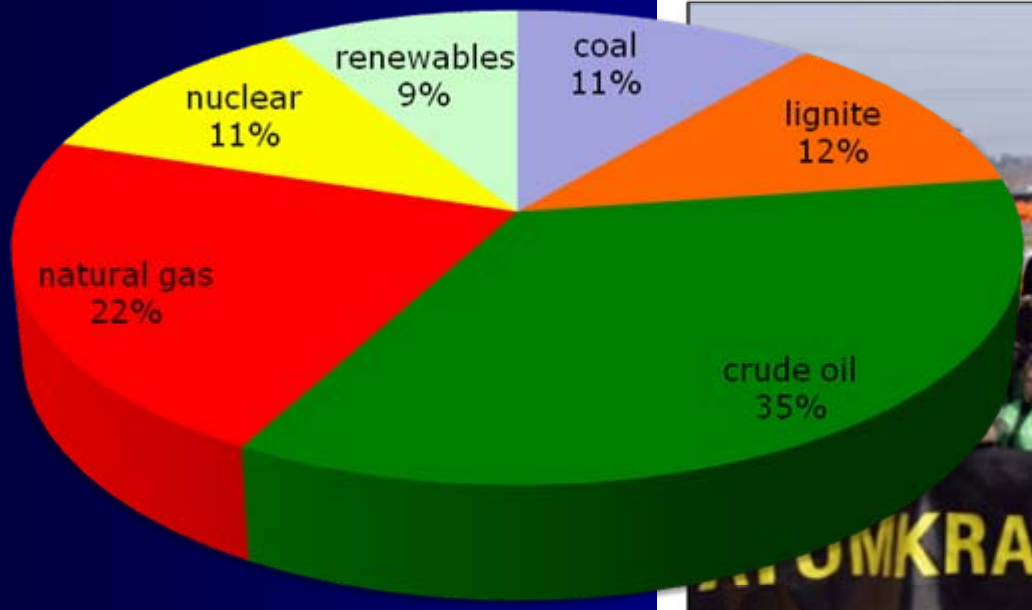
Map modified after: www.mygeo.info

The Talk Today…..

• Explore	tests!
• Produce	optimise, sweet spots
• Supply	infrastructure
• Combustion	power generation
• Safeguard	environment
• Inform	general public

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

Shale Gas Formation in Time and Space

GASH
Gas Shales in Europe

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

Sciences

Surveys

Sponsors

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: reconstuction 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)

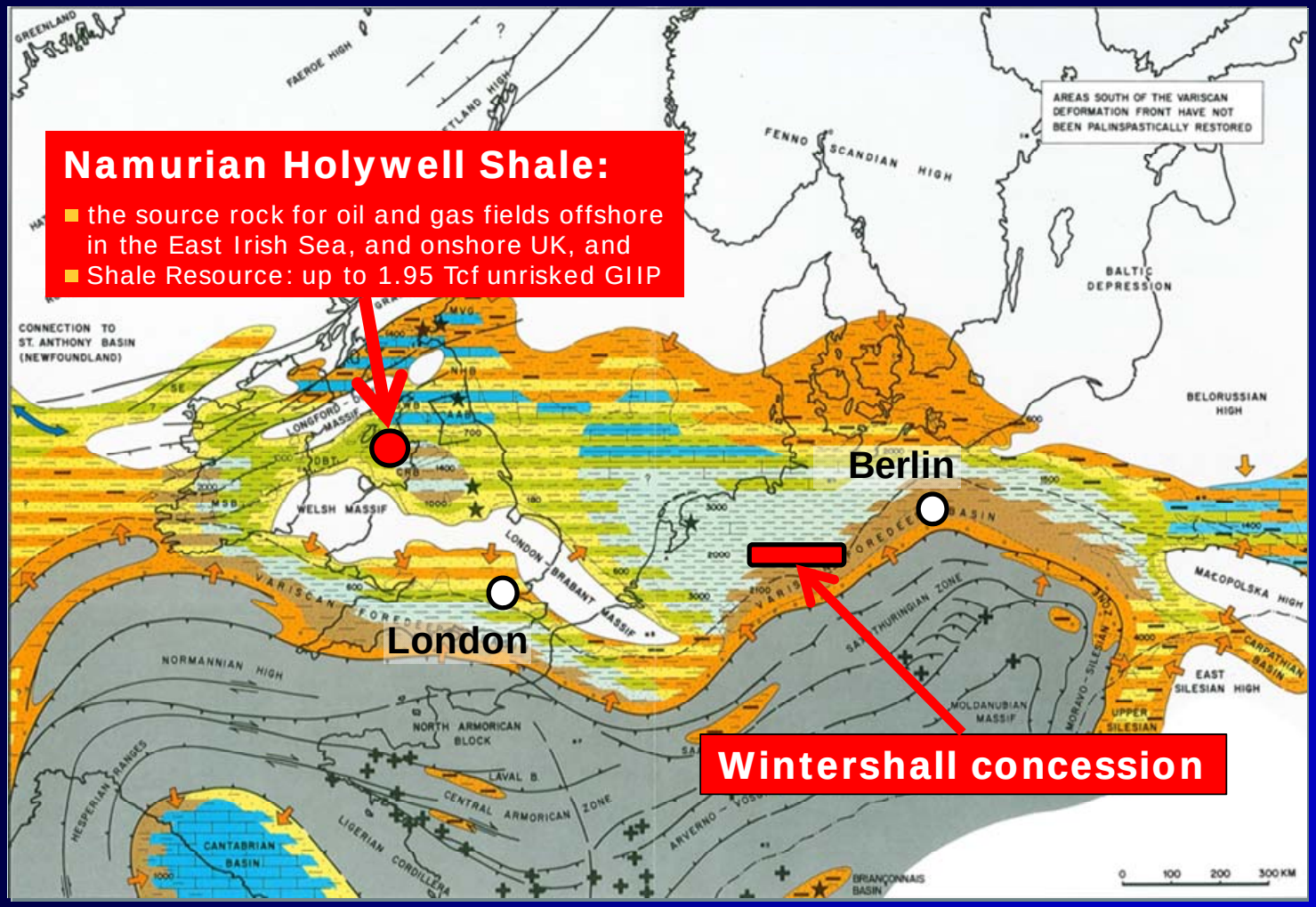
Seismic characterization of shale gas reservoirs
C. Haberland, M. Stiller, K. Bauer, M.H. Weber (GFZ-Potsdam), U. Mann (FZ-Jülich)

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)

Germany

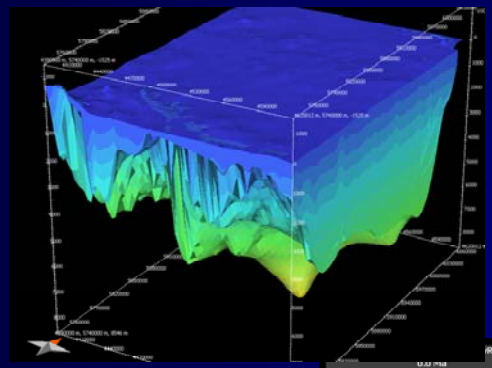
Upper Carboniferous



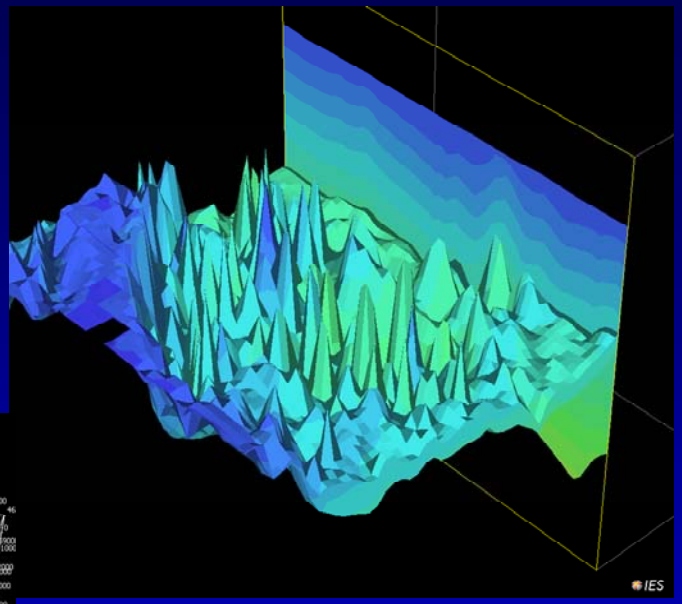
Ziegler (1990)

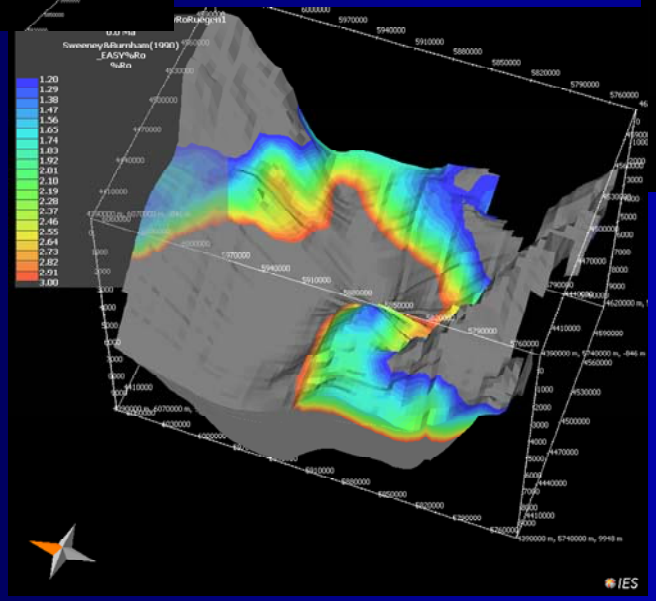
Germany

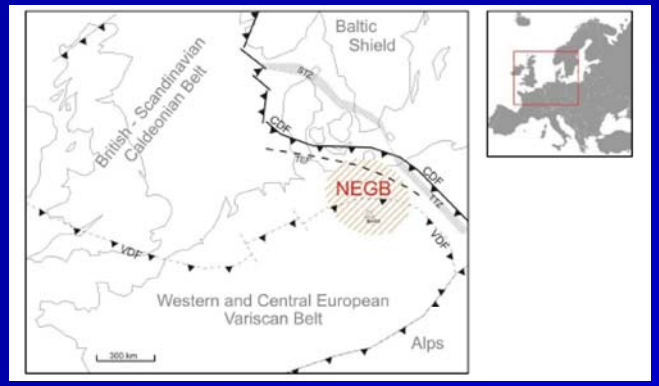
Upper Carboniferous



Surface topography to base Carboniferous.
Fully balanced model of salt movement
Well data from >50 wells



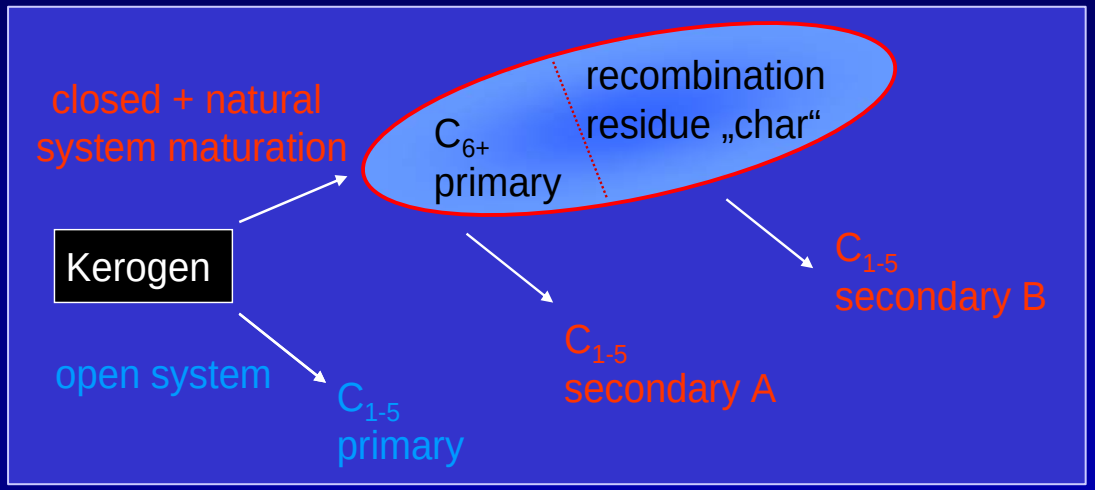




HiTMe *High temperature methane*

GFZ Helmholtz Centre Potsdam

- *Deep gas in focus*
- *T>200°C*
- *Coking systems*
- *Non-coking systems*
- *Kinetics*



Mahlstadt and Horsfield, 2011 – AAPG International Conference & Exhibition

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Contents lists available at ScienceDirect

Chemie der Erde

journal homepage: www.elsevier.de/chemer

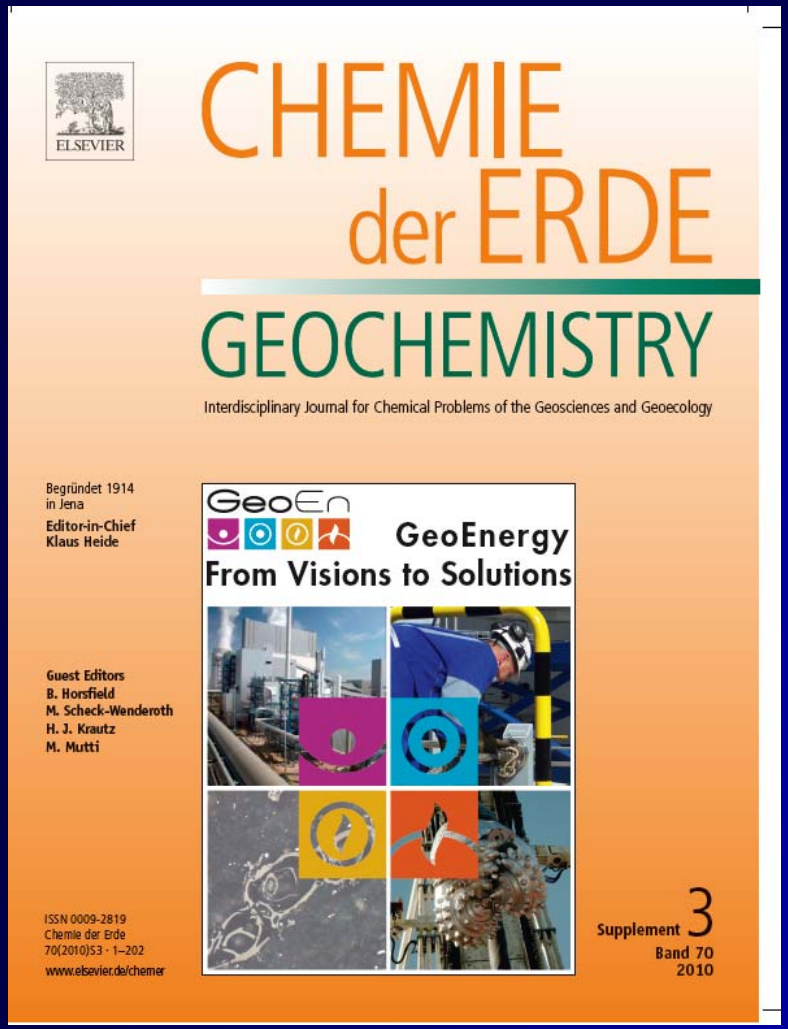
Applying classical shale gas evaluation concepts to Germany—Part II: Carboniferous in Northeast Germany

Alexander Hartwig*, Sven Könitzer, Bettina Boucsein, Brian Horsfield, Hans-Martin Schulz

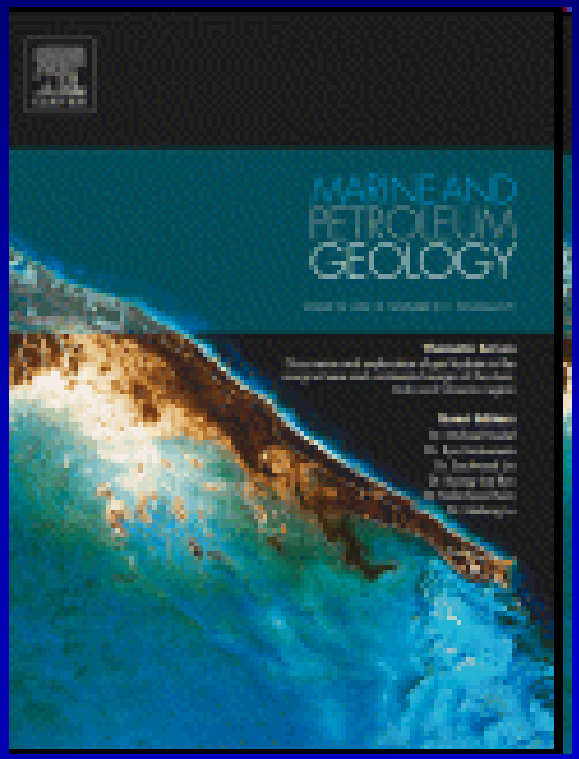
GeoForschungsZentrum GFZ Potsdam, Sec. 4.3 Organic Geochemistry, Telegrafenberg, D-14473 Potsdam, Germany

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

Out (2010)



Nearly Out



Risk and Perceived Risk

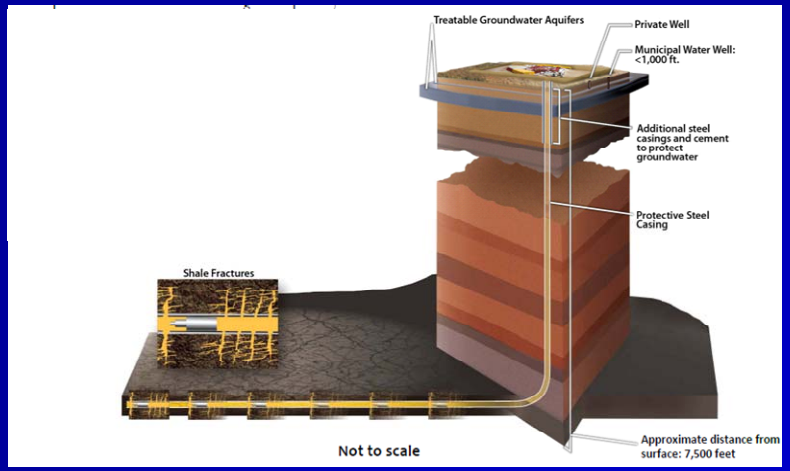
A new opportunity:

- security of supply
- plentiful
- affordable
- bridge to renewables

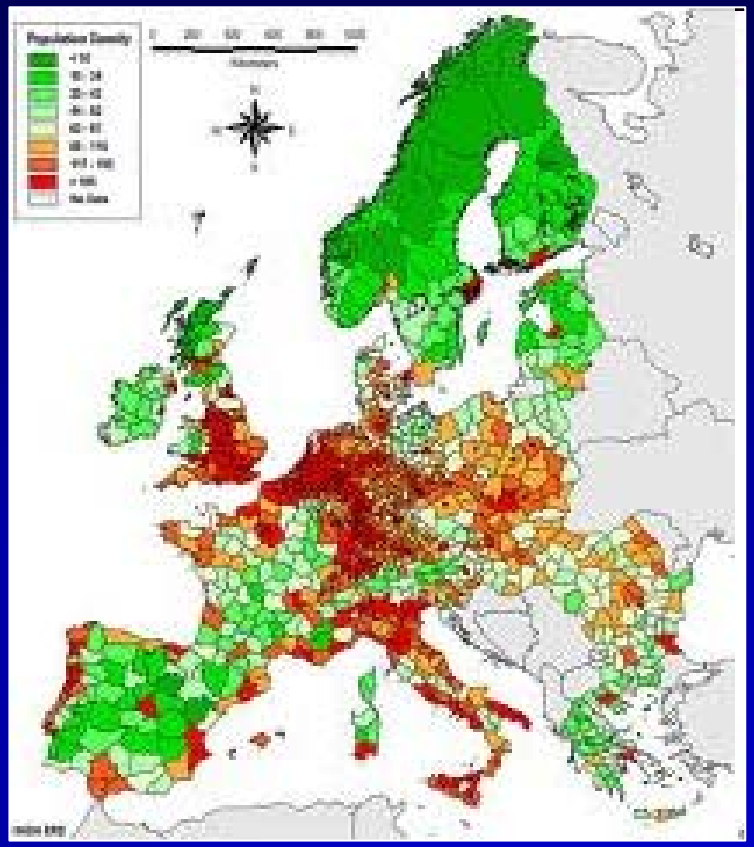
http://www.flickr.com/photos/energy_pictures/3686146477/

Concerns:

- Induced seismic activity
- Contamination
- Disposal
- Leakage



The Operating Environment



- High population density
- No mineral rights for landowners
- Water from surface and aquifers
- Service industries not developed
- Rig count is low

ExxonMobil

Neutral Expert Committee

Dreingau Zeitung

Donnerstag, 11. August 2011

Home | Tipps und Termine | Kleinanzeigen | Vertrieb | Archiv | Dreingau Zeitung | Preise und AGB | Kontakt

Expertenkreis diskutiert Probe-Fracking

Samstag, 28. Mai 2011

Der Expertenkreis gab gestern erste Arbeitsergebnisse bekannt. Foto Schneider

DRENSTEINFURT Als „interessante Option" bezeichnete 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 Berlage, denn in Stewwert könnte ebenfalls nach Erdgas gebohrt werden.

Ob die Expertenrunde nicht „ein Feigenblatt von Exxon" sei, musste sich Borchardt in einer der Veranstaltung vorangestellten Pressekonferenz fragen lassen. Der Expertenkreis wird nämlich „nach Bedarf", so Ruth Hammermacher, die zusammen mit Dr. Christoph Ewen die Fachkonferenz moderierte, von Exxon finanziert. Gegenwärtig stünden 1 Million Euro für die Untersuchungen der Fachleute bereit. „Was ist die Alternative?", fragte Borchardt zurück und verwies darauf, die Gesellschaft müsse eine Entscheidung „auf besten rationalen Grundlagen finden". Und eben diese Grundlagen liefere der Expertenkreis.

„Unabhängiger Prozess"

Hammerbacher 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-Multi nun gefielen oder nicht. Sie hob hervor, dass durch die Fachleute ein „unabhängiger Prozess" ins Leben gerufen werden solle.

Zentrales Thema der Fachtagung, zu der Vertreter betroffener Gemeinden und Verbände ebenso eingeladen waren wie Kammervertreter, Anlieger und Vertreter von Initiativen, war der Trinkwasserschutz. Dietrich Borchardt stellte zunächst Arbeitsprogramm und Zeitplan des Expertenkreises vor. Prof. Dr. Martin Sauter klärte über Risiken im geologischen System auf. Auch er sprach sich für die Option eines Probe-Frackings unter kontrollierten Bedingungen aus. Konkrete Planungen gebe es in dieser Hinsicht aber noch nicht, so Hammermacher.

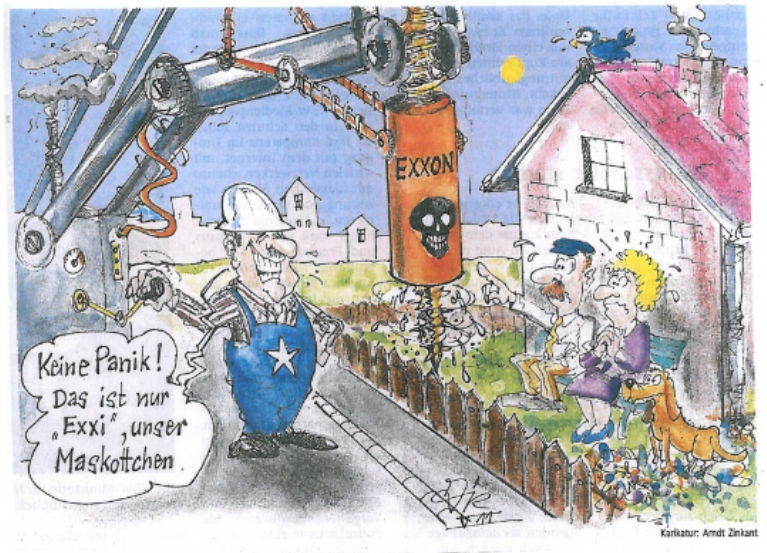
Über „Risiken im technischen System" und „Strategien zur toxischen Bewertungen von Inhaltsstoffen der Frac-Flüssigkeiten" sprachen Prof. Dr. Alexander Roßnagel und Dr. Hans-Joachim Uth sowie Dr. Mechthild Schmitt-Jansen. Ein Diskussionsplenum schloss sich an.

Exxon-Karikatur

1

15. Juni 2011 von Matthias Eschmann

Ein Bild sagt mehr aus als tausend Worte.

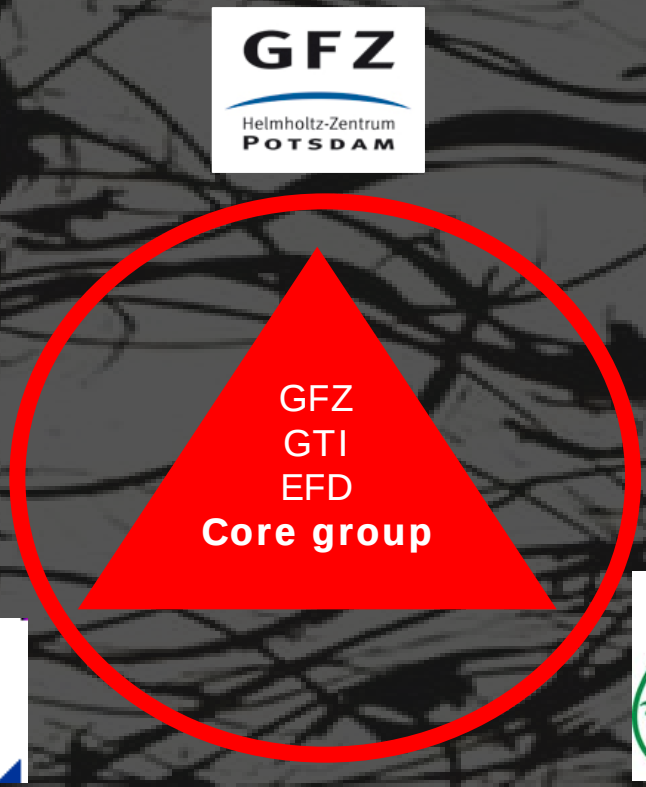


Karikatur: Arndt Zinkant

E-SOP

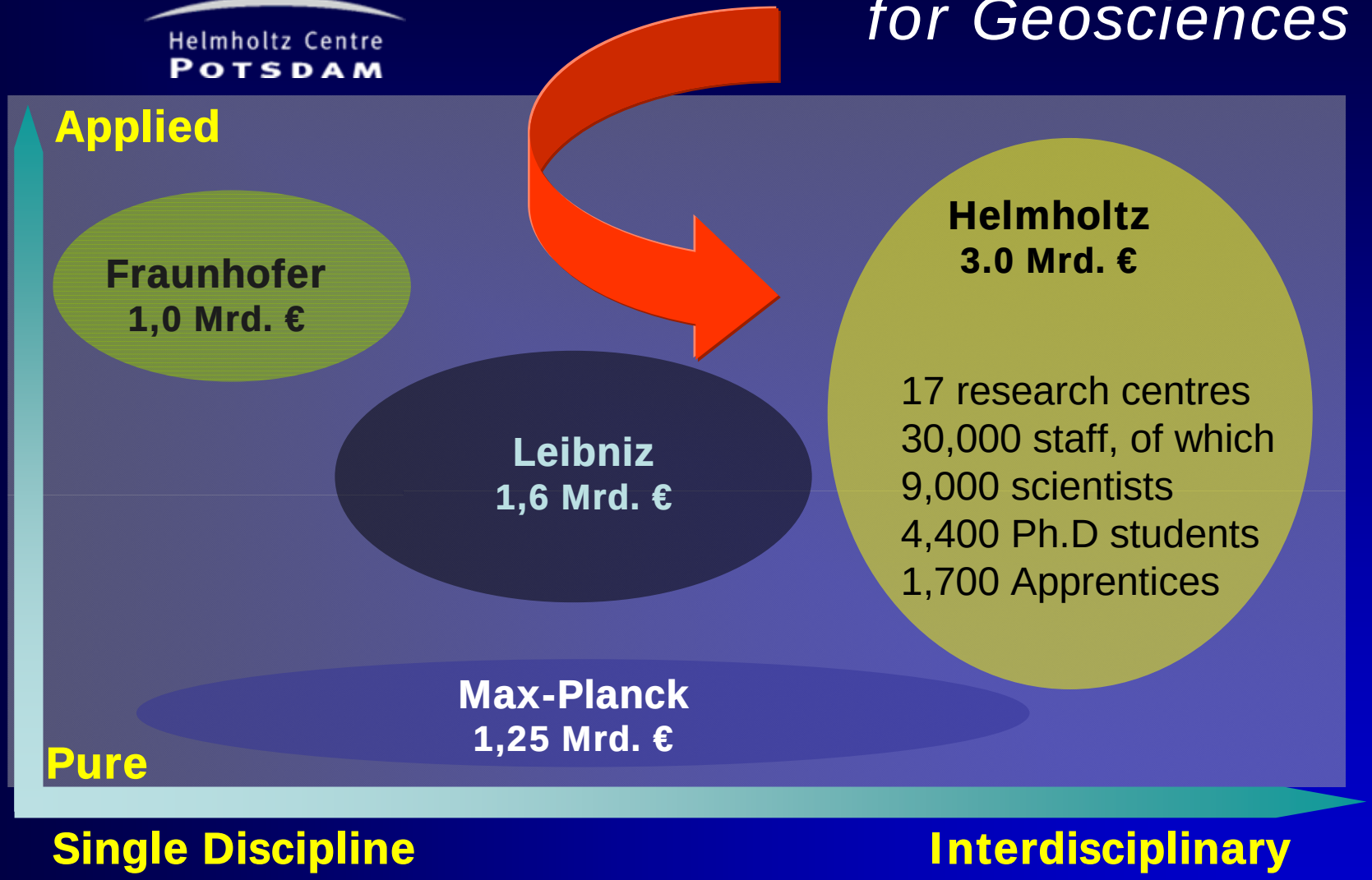
EUROPEAN SUSTAINABLE OPERATING PRACTICES INITIATIVE

- **Neutral**
- **Addressing ALL issues:**
  Economic and societal benefits
  Health and environment
- **Transparency**
- **Best practices**



GFZ
Helmholtz Centre
POTSDAM

German National Lab for Geosciences



E-SOP

EUROPEAN SUSTAINABLE OPERATING PRACTICES INITIATIVE

OPPPW

The Polish Exploration and Production Industry Organization (15 companies)

Sobieski Institute
Greg Pytel

TISCHNER EUROPEAN UNIVERSITY

Tischner European University
Jaroslaw Gowin

Kosciuszki Institute
Izabela Albrycht

GFZ Helmholtz-Zentrum Potsdam

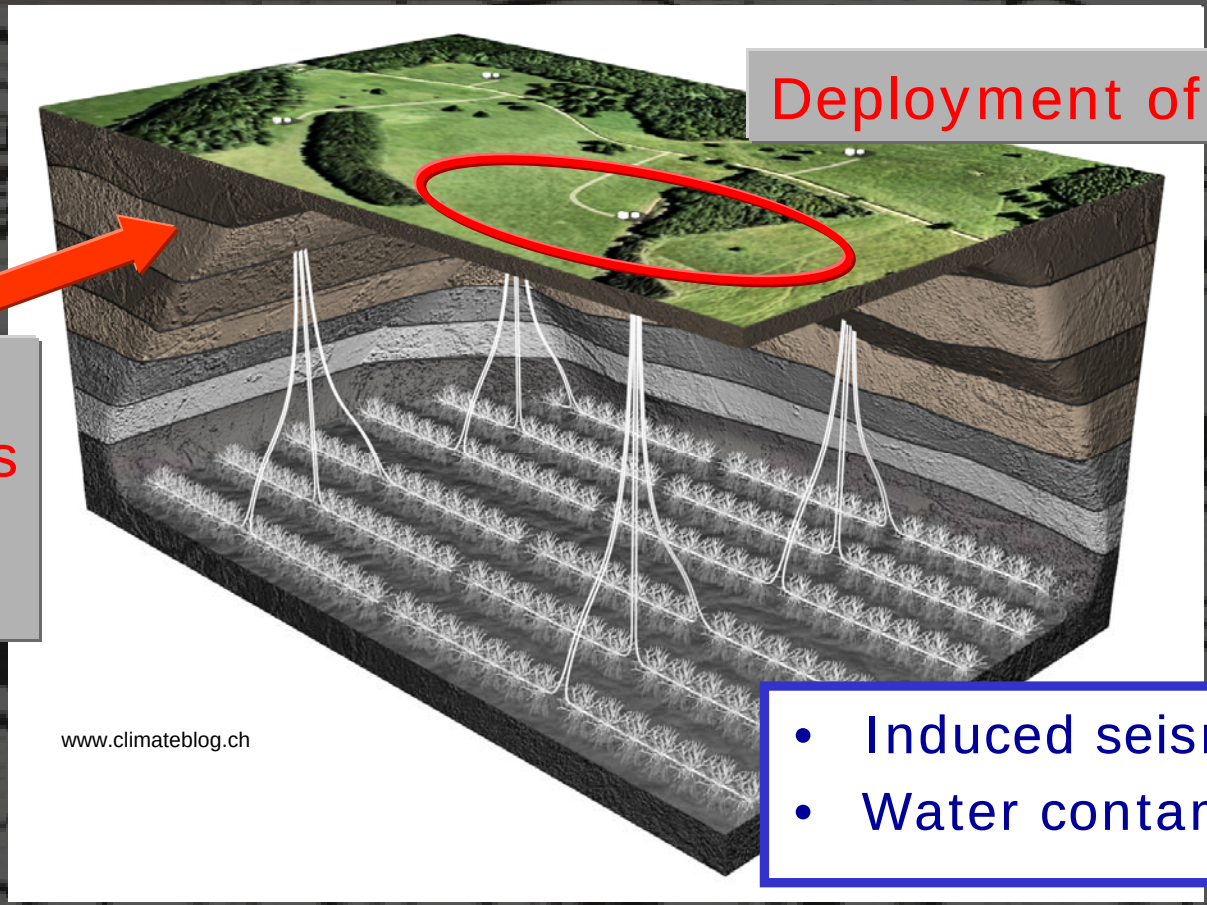
GFZ
GTI
EFD
Core group

gti.

EFD

E-SOP

EUROPEAN SUSTAINABLE OPERATING PRACTICES INITIATIVE



- Induced seismicity
- Water contamination

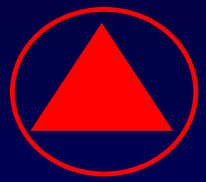
E-SOP

EUROPEAN SUSTAINABLE OPERATING PRACTICES INITIATIVE

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

Sedimentary Basins:
Baltic Depression, Danish Polish Marginal Trough, Warsaw Trough, Lublin Trough, Foresudetic Monocline, Carpathian Foredeep

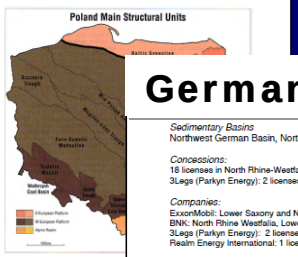
Concessions
>70 licenses total (October 2010) in the Lublin, Mazowsze, Pomeranian and Lower Silesian regions.

Companies:
PGNiG S.A.; LOTOS Petrobaltic S.A.; RWE Dea AG oddział w Polsce S.A.; Celtique Energie Poland Sp. z o.o.; ExxonMobil Exploration and Production Poland Sp. z o.o.; DPV Service Sp. z o.o.; Mirisk Energy Resources Sp. z o.o./ Gora Energy Resources Sp. z o.o.; CalEnergy Resources Poland Sp. z o.o.; Saponis Investments Sp. z o.o./Indiana Investments Sp. z o.o. (BNK Petroleum Inc.); PL Energia S.A.; Orlen Upstream Sp. z o.o. (PNK Orlen S.A.); FX Energy Polska Sp. z o.o.; Energia - Zachód, Cybinka, Torzym, Kaliszanin Wschodnie - Sp. z o.o. Sp. kom; GAS PLUS International Sp. Sp. z o.o./Lane Resources Poland Sp. z o.o.; Liesa Ebergy Sp. z Vabush Energy Sp. z o.o. (San Leon Energy Plc); Marathon Oil Po Area D, Area E, Area F, Area G, Area H, Area I Sp. z o.o.; Strzelec Polska Exploration and Production Sp. z o.o./Chevron Polska E Maryani Investments Sp. z o.o./Joyce Investments Sp. z o.o./H (Relam Energy International Co.); Composite Energy (Poland) Sp. z

Drilling activities (shale gas):
Lane Energy: 1st vertical well, #1LE Lebień in the Lebork concessio 2nd vertical, Legowo LE1 well in the Cedry Wielkie concession was Talisman Energy: 3 wells, one in each concession, starting in August

Shale targets:
Silurian graptolitic shale and Upper Ordovician shales in the Depression) and the Danish-Polish marginal Trough.
Silurian shales in the Warsaw and Lublin Troughs
Carboniferous (Visean Kulm facies) in the Foresudetic Monocline

Unconventionals:
The first reliable estimates of northern Poland-located shale gas Spring 2011, while for the entire country's resources – at the end of Preliminary estimates (depending on references): 1.4–3 Bm³



Germany

Sedimentary Basins
Northwest German Basin, Northeast German

Concessions:
18 licenses in North Rhine-Westfalia
3Legs (Parkyn Energy): 2 licenses in the Baden-W

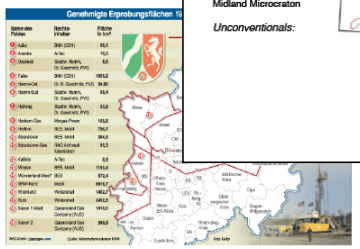
Companies:
ExxonMobil: Lower Saxony and North Rhine-West
BNK: North Rhine Westfalia, Lower Saxony, Thurin
3Legs (Parkyn Energy): 2 licenses in the Baden-W
Realm Energy International: 1 license 160km west

Companies in North Rhine-Westfalia:
BNK Petroleum; A-TEC Anlagentechnik GmbH;
GeoEnergien, PVG mbH; Mingas-Power GmbH;
Erdöl GmbH; RAG Anthrazit Ibbenbürgen GmbH
Company Ltd.

Drilling activities:
ExxonMobil: 4 wells completed and 2 more
Niedernwöhren 1 and Schlahe 1 spudded in 2009.

Shale targets:
Carboniferous Lower and Upper Alum Shales,
Jurassic Posidonia shale,
Lower Cretaceous Wealden Shale (Lower Saxony
The Upper Devonian Kellwasser shale (northern G
Lacustrine shales of Permian age (Bodensee Trou

Unconventionals:



U.K.

Sedimentary Basins:
Pennine Basin, Weald and Wessex Basin, Midland Valley Basin, East Midlands Province, East Irish Sea Basin, Cheshire Basin, West Lancashire Basin, South Wales Variscan foreland Basin, South Wales-Bristol Basin

Concessions:
Cuadrilla Resources

Companies:
Cuadrilla Resources; Eurenergy Resource Corp.

Drilling activities:
Cuadrilla Resources: one well in the Bowland shale near Blackpool, Lancashire Basin, plans wells in the Weald Basin
Eurenergy plans to drill a well in the Weald Basin

Shale targets:
Three Jurassic shales in the Weald and Wessex Basins (Kimmeridge Clay, Lias clays, Oxford Clay).
Carboniferous shales: Tournaisian Lower Limestone Shale (now Avon Group), Topmost Dinantian Upper Limestone Shales (Oystermouth Formation) to Early Namurian Marros Group, Lower (Dinantian) and Upper (Namurian) Bowland Shales
Cambrian shales on the Midland Microcraton

Unconventionals:

France

Sedimentary Basins:
Languedoc Pousaillon (Lodève Basin), Cevennes mountain region, Savoie area, Paris Basin

Concessions:
25 in total:
http://www.eco-sapiens.com/gaz-de-schiste.php
Total E&P and Devon Energy Corp.: 1 license (Montelimar Permit, 4,327 km²)
Schuepbach Energy LLC, Dale Gas Partners LP, and Franco-Belgian GDF Suez: 2 licenses (Villeneuve-de-Berg Permit 931km²; Nant Permit 4,414 km²)
Edgon Resources, Eagle Energy Ltd., and YCI Energy Ltd.: 1 license (Navacelle Permit 216 km²)
Mouvoil SA: 1 license (Bassin d'Alès Permit)
Bridgeoil Ltd. and Diamoco Energy: 1 license (Plaine d'Alès Permit 503 km²)
Eurenergy Resource Corp.: 1 license (Moselle Permit near Lorraine 5,280 km²)

Companies:
Total E&P, Devon Energy Corp., Schuepbach Energy LLC, Dale Gas Partners LP, Franco-Belgian GDF Suez, Edgon R Energy Ltd., Mouvoil SA, Bridgeoil Ltd., Diamoco Energy, Eurer Resource Corp., Royal Dutch Schell, BP plc, Statoil ASA,

Drilling activities:
Toreador: planned 3 wells in the Paris Basin, first to be spudded i

Shale targets:
bituminous Autunian (Lower Permian) shale in Permo-Carboni (Stephanian-Autunian Lodève Basin)
Lower Jurassic (Liassic) in the Paris Basin (fractured oil shale)

Unconventionals:

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