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Shale gas in Europe

The need for a balanced perspective…

In the short space of five years shale gas has transformed the global energy outlook completely. This new natural gas resource accounts for about 10% of gas production in the USA, and by 2035 that number is expected to reach 35%. Estimates of global shale gas resources have recently been revised upwards to 25,300 trillion cubic feet (EIA, 2011)[1] from the earlier figure of 16,100 Tcf (Rogner, 1997)[2], significantly outstripping conventional resource estimates. No shale gas has been produced in Europe yet but the land grab has most certainly happened, and a great many companies are conducting extensive tests in Sweden, Germany, Poland, the UK and elsewhere to assess flow characteristics. Whether or not this activity signals a bonanza will undoubtedly be established over the next 10 years. And while scientific and technological innovations will play key roles in defining that path, it is environmental issues, both perceived and real, and the level of acceptance by the general public that will make or break shale gas in Europe in the near-term. Of the many players involved, the role of research organisations is yet to become clear: isolated ivory towers, or enablers? Here we lay out the shale gas playing field and the game that is afoot, and conclude, not unsurprisingly, that research organisations such as ours (GFZ German Research Centre for Geosciences) will play an active and defining role in sustainable shale gas exploitation.

Energy demand – the big picture

In its New Policy Scenario the Energy Information Administration has stated that world primary energy demand will increase by 36% between 2008 and 2035, from around 12,300 million tonnes of oil equivalent (Mtoe) to over 16,700Mtoe, or 1.2% per year on average.

The European Commission, in its strategic energy review of 2007, stated that ''a diverse portfolio of clean, efficient and low-emission energy technologies'' is needed to shield Europe from potential external energy crises, and to achieve supply security and environmental sustainability in the long term. While replacing fossil energy resources entirely by renewable energies is the goal, technical and economical arguments dictate that a diverse energy mix will remain in force for the foreseeable future. Total primary energy demand in the European Union remains stagnant, but the share of low-carbon fuels like natural gas is predicted to rise from 23% today to 37% in 2035.

Natural gas currently features prominently in practically all national energy portfolios and – because of its low carbon footprint and flexible availability – is widely regarded as the most important bridge to a renewable energy future. There is no doubt that gas is here to stay, at least for the foreseeable future. And as far as natural gas is concerned, while conventional deposits continue to feed the world's pipelines and LNG terminals, there is a 'new kid on the block', one that has already proved to be a game changer, namely shale gas.

What is shale gas?

Shale gas refers to natural gas that was generated, and is still confined, within fine grained dark grey-black sedimentary rocks called shales. This gas is disseminated within myriads of tiny (nm sized) pores or adsorbed on mineral and organic particle surfaces within the rock, and can only be released by the controlled fracturing of the rock by specialists. To date, shale gas has only been extensively exploited within the continental USA. Experience from the major shale gas players (including the Barnett, Haynesville, Fayetteville, Marcellus, Antrim, Ohio and Woodford) has revealed that the most prolific shales contain large concentrations of gas and are readily fractured due to the circumstances of their geological history.

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New technologies and concepts

One might conclude that it should simply be a matter of importing US know-how into Europe. After all, fracturing technology has been perfected thanks to lessons learned over the last 35 years from 2.5 million wells drilled mainly in conventional petroleum systems (Montgomery and Smith, 2010)[3], and especially in the last 10 years from the more than 40,000 wells drilled specifically into shale targets using 'slickwater' and 'hybrid' drilling fluids and deploying proppants. In reality, technology has to be tailored to the geology, and the geology is very difficult to predict. No two shales are the same, either laterally (tens of kilometres) or vertically (tens of metres) and this means that neither rock properties nor gas content can be predicted with any degree of accuracy. Experience gained from shale gas exploitation in the USA has shown that natural gas occurs in different types of

Here is a familiar view of shales, in this case the Kimmeridge Clay exposed along the Dorset coast, England. The 30 metre profile clearly shows how heterogeneous the shales are, with coarse and fine laminations evident at the metre to centimetre scale

shales (different mineralogy, organic content, etc.), not just in one type. Additionally the shales come in packages with other sedimentary rocks, making the potentially productive gross shale gas interval rather heterogeneous. Productivity depends on the degree to which heterogeneities can be delineated using seismics, logging and coring, and the positioning of the artificially stimulated fractures within those packages. There are therefore great opportunities for major scientific and technological breakthroughs to be made concerning the formation and exploitability of shale gas.

Gas shales in Europe

GASH – Gas Shales in Europe (www.gas-shales.org) – is the first interdisciplinary shale gas research initiative in Europe. Its goals are to understand how and where gas is formed and located within European shales, and what types of rocks are best suited for producing gas. There are two basic parts; one is research (how shale gas is formed), the other a database (where is shale gas most likely to occur). Pooling European expertise has been vital: GFZ's research partners include the leading academic institutions in geosciences from across Europe (Institut Français du Pétrole, France; TNO, The Netherlands; Universities of Aachen, Germany and Newcastle, GB; GEUS, Denmark and others). North American expertise has been a prerequisite, too, of course, with Geomark Research and Worldwide Geochemistry Inc involved from the start. GASH focuses on the potential gas shales of Europe, and especially on the Alum Shale of Denmark and Sweden, and the Posidonia and Carboniferous shales of Germany, which have been designated as 'natural laboratories'. Importantly, GASH also integrates proven US gas shales (eg. Barnett Shale) for calibration of key variables.

As far as the 'where?' is concerned, European geology is more complex than that seen in US gas shale basins. But we enjoy the advantage that the geology is well documented. Every country has its national survey and some also have state surveys. Collating this information is the challenge. A GIS-based European Black Shale Database (EBSD) is being compiled in collaboration with geological surveys from across Europe (18 to date) within GASH, using generalised recognition criteria based on thickness, organic matter content and so on.

The link with industry

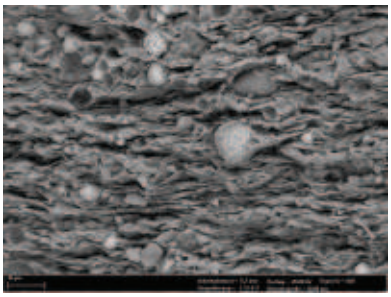
GASH relies strongly upon industry – firstly, its sponsorship provides the funds enabling young scientists (PhDs and postdocs) to begin and pursue their careers in research by conducting the research projects. Secondly, industry provides valuable data and samples, and thirdly it shares its experience. GASH is sponsored by ExxonMobil, Marathon, Statoil, Total, Schlumberger, Repsol, Vermilion, Bayerngas, Gaz de France Suez and Wintershall. Notably, the results from

the projects are published in the open scientific literature according to a schedule mutually agreed upon by sponsors and scientists. The results are, of course, also utilised as each company sees fit in its own shale gas portfolio. In short, the cooperation is based on independent scientific investigation that brings mutual benefits to the academic and industrial partners.

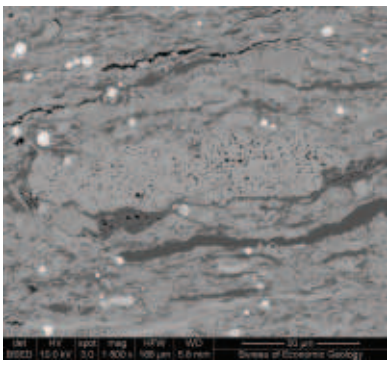
The operating environment

Europe has a high population density, and is largely unaccustomed to having potential new energy resources beneath its feet, albeit at two to three kilometre depth in the case of shale gas. It is already clear at this early stage of its development that shale gas exploitation in Europe will only be possible if risk mitigation is part and parcel of exploitation operations. Just being part is probably not enough. Instead, risk mitigation must be demonstrated to be an integral part, utilising technical and safety procedures stemming from national, European and self-determined industry regulation. Both technological and organisational innovations will be required. In the US, improved technological developments are already under way. New low-impact technologies that reduce the footprint of drilling activities, light weight drilling rigs with reduced emission engine packages, on-site waste water management, improvements in site access, and systems to fit the needs of specific development sites and at the same time providing stewardship of the environment are all in development. Cluster drilling, improved fracturing methods and fluids and enhanced monitoring and controlling concepts are also part and parcel of shale gas' future.

As far as Europe is concerned, there are many operational, regulatory and commercial challenges to developing unconventional gas resources. Hydrocarbon mining laws in Europe have been drafted for conventional activities. As a result, a large number of definitions and permitting approaches taken by these laws are unsuited to the nature of unconventional gas deposits and operations, creating legal uncertainty and operational challenges that will likely generate project delays. The EU simply requires that equal opportunities exist for exploration across Europe but leaves implementation of regulations to individual nations. Another constraint is related to the legal protection of many areas based on environmental regulations. The EU has issued numerous directives concerning environment, habitat, and water quality but enforcement is a national prerogative.



Scanning electron microscopy of finely laminated shale broken perpendicular to layering reveals that individual laminations are made up of clay minerals and organic matter, along with isolated quartz grains and aggregates of rounded pyrite bodies. Here we see particles that are tens of micrometres in size (1000 micrometres = 1 millimetre). This time the shale is from northern Germany



At the same scale, but this time with the surface finely milled, fine pores in both organic matter and between minerals are visible. Shale gas resides in pores like these, even down to nanometre size

More importantly, the spectre of environmental damage caused by cost-cutting in the USA has pervaded the press. Reports in the media correctly draw our attention to environmental concerns. Some of the headlines, however, are grossly exaggerated. Numerous phenomena have been attributed to shale gas fracturing. These include induced seismic activity, leakage of gas through casing into aquifers, escape of drilling fluids onto agricultural land, the potential toxicity of fluids used for fracturing and the disposal of fluids returning to the surface. All of these issues have to be addressed.

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The way forward

The production of unconventional gas in many countries, even at modest levels, could transform the supply mix in that country. Thus, unconventional gas production could have a significant effect on the gas import requirements of that country and on regional gas flows. But as things stand today, it is unclear how matters will develop in Europe. Assessments alternate between very optimistic prognoses concerning shale gas extraction and the absolute rejection of exploiting this resource under any circumstances.

Europe urgently needs to assess the benefits that shale gas offers future generations, and at the same time ascertain the kinds of regulatory framework required for ensuring the adoption of best practices for environmental security. Shale gas exploitation in Europe requires transparency, a fact already recognised by industry. Yet, industry-led consortia hoping to demonstrate the worthiness of their own operating practices are likely to be viewed with raised eyebrows by the general public, even if neutral and scientifically esteemed parties are enrolled as advisors.

We believe that academia must assume the leading role, namely one of 'honest broker'. And this is where the GFZ German Research Centre for

Geosciences and its partners Gas Technology Institute (GTI) and Environmentally Friendly Drilling (EFD) come in. The E-SOP Initiative (European Sustainable Operating Practices) has the intention of identifying, developing, demonstrating, and deploying sustainable field operating practices, technology solutions, safety standards, and environmental assurance. The specific stakeholder concerns that E-SOP will address include the impact on drinking water supplies and quality, air quality, noise, wastewater and solid wastes, greenhouse gas emissions, truck traffic, and surface disturbance. E-SOP will also address the need for comprehensive and transparent information for the general public and policymakers on the benefits and risks associated with developing unconventional oil and gas resources. Field demonstration programmes will identify, develop and document sustainable operating practices and business models as well as the processes required to implement them. Monitoring and modelling of shallow and surface environments at and around industry-provided well sites to demonstrate and test best practices are central to this strategy.

Closing remarks

The European Commission has recognised the potential of unconventional gas in its 'Energy 2020' strategy document, clearly recommending further examination: 'The potential for further development of EU indigenous fossil fuel resources, including unconventional gas, exists and the role they will play must be assessed in all objectivity.' Now is the time for the honest broker to step forward and ensure that demonstration programmes are conducted to the highest level of excellence and integrity: let's see how things develop!

1 http://www.eia.gov/analysis/studies/worldshalegas/

2 H-H. Rogner, 1997 An assessment of World Hydrocarbon Resources. Annu. Rev. Energy Environ. 22:217-62

3 Hydraulic Fracturing, History of an Enduring Technology, Carl T Montgomery and Michael B Smith, NSI Technologies, JPT · December 2010

E-SOP Partners of the GFZ

GTI is a leading independent research, development, and training organisation. For 70 years, GTI has solved important energy and environmental challenges by developing technology-based solutions that create value for consumers, government, and industry. For more than 20 years GTI has been collaborating with academia, government, and industry to identify, develop and deploy solutions for converting the potential of unconventional gas resources into reality.

EFD Europe was established to identify, fund and transfer cost-effective technologies and best practices to accelerate development of reserves in a safe and environmentally friendly manner. The Chair of Drilling and Completion Engineering at the Montanuniversität Leoben, Austria, hosts and leads EFD Europe, aiming at developing drilling and completion technologies with the highest safety standards and with the least possible environmental impact, as a platform for the different stakeholders.

The GFZ is the national research centre for Earth sciences in Germany, working in all the disciplines from geodesy to geoengineering. As a member of the Helmholtz Association of German Research Centres, GFZ studies System Earth and its characteristics, as well as the processes that occur on its surface and within its interior. The long-term aim of GFZ is to understand the highly complex, non-linear systems of planet Earth and its interactive natural subsystems to comprehend the extent of global change and its regional effects and to evaluate the influence of human activity on the Earth.

With 33,000 employees in 17 research centres and an annual budget of approximately €3.3bn, the Helmholtz Association is Germany's largest scientific organisation.

Brian Horsfield

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