Unconventional Hydrocarbons
Town Hall Meeting
4 October 2017

Welcome

Ned Garnett, Associate Director, Research, NERC
Welcome and aims of the day

• Unconventional Hydrocarbons is an £8m programme co-funded by NERC and ESRC with the overarching objective to significantly improve the scientific evidence base on shale gas as a potential energy resource for the UK.

• Aims of the Town Hall meeting:
  • To provide a forum for discussion of the science challenges and possible approaches to undertaking the research.
  • To provide an opportunity to broker potential collaborations and partnerships.
Agenda

10.00 Welcome and introduction
10.10 Announcement of Opportunity
10.20 Relevant NERC/BGS projects
10.50 Brokerage session (coffee at 11.30)
12.30 Open networking 1/Drop in sessions
13.00 Lunch
13.45 Open networking 2/Drop in sessions
14.45 Coffee
15.00 Q&A session with funders
15.45 Closing statements
16.00 Meeting close
NERC strategy

Our vision:
To place environmental science at the heart of responsible management of our planet
Meeting society’s needs

- Benefiting from natural resources
- Resilience to environmental hazards
- Managing environmental change
- Discovery science
Strategic research mechanisms

i. Strategic Programme Areas (SPA)
Large scale complex programmes that take time to develop and deliver. Typically range in size from £5m to £20m depending on their scope and partnership funding.

ii. Highlight Topics (HT)
Focus strategic research on defined topic areas. Can be worth up to £4m and last up to four years.

iii. Joint Strategic Response (JSR)
Provides a timely response to opportunities for NERC to partner with other research funders. Size and scope will vary according to the opportunity.
SPA process

For strategic programme areas:

• Community (academic and user) generate and submit ideas
• Ideas are discussed and prioritised by the Strategic Programme Advisory Group (SPAG)
• These are developed by Working Groups into more advanced cases
• Science Board makes a recommendation to Council

NERC Council approved funding for Unconventional Hydrocarbons Strategic Programme Area
Unconventional Hydrocarbons Programme

• Following funding decision ESRC agreed to co-fund and the programme has been co-designed

• This call represents a unique opportunity for the environmental and social science communities to work together to provide an updated independent scientific evidence base to understand potential environmental and socio-economic impacts of unconventional hydrocarbon development in the UK
Unconventional hydrocarbons in the UK energy system: environmental and socio-economic impacts and processes

Announcement of Opportunity

Sophie Martin, ESRC
Blanche Wynn-Jones, NERC
Overview

- **Unconventional Hydrocarbons** is an £8m programme co-funded by NERC and ESRC
- Overarching objective is to **significantly improve and update the scientific evidence base** on shale gas as a potential energy resource for the UK
- Programme has **five science challenges**:
  - Challenge 1: The evolving shale gas landscape
  - Challenge 2: Shale resource potential, distribution, composition, mechanical and flow properties
  - Challenge 3: Coupled processes from reservoir to surface
  - Challenge 4: Contaminant pathways and receptor impacts
  - Challenge 5: Socio-economic impacts
This programme will support the following applications (each up to 4 years in duration):

- **Cross-cutting consortium**
  - Challenge 1
  - £1m at 80%FEC

- **Environmental science consortia**
  - Challenges: 2, 3 & 4
  - £1.7m at 80%FEC

- **Social science projects/ consortia**
  - Challenge 5
  - Total £1.5m at 80%FEC

Applicants may wish to make use of other relevant projects for example UK Geoenergy Observatories and the environmental monitoring in Lancashire and the Vale of Pickering.

- Environmental science consortia may apply for up to 3 associated studentships per consortium.
Challenge 1: The Evolving Shale Gas Landscape

Proposals submitted to this challenge should bring together the environmental and social sciences to:

- Provide evidence on the current status of the shale gas landscape
- Monitor how the shale gas landscape changes and evolves through the programme
- Conduct cross programme coordination and synthesis activities

The successful consortium must work with projects under the other Challenge areas throughout the duration of the awards.

£1m (80% FEC) available to fund 1 consortium project for 4 years
Challenge 5

Challenge 5: Socio-economic impacts

Proposals submitted to this challenge should focus on socio-economic factors in relation to the role of shale gas.

The following areas have been identified as key areas for research, however proposals are not limited to these:

• Public perceptions/community understanding
• Policy
• Economic impact

Proposals should take into account a range of scales, from local to regional and national, as well as the role of communication and engagement, which is relevant to all three areas. Proposals should also take into account the current socio-economic context, eg Brexit

£1.5m (80% FEC) available to fund 3-6 proposals for up to 4 years
Challenge 2: Shale resource potential, distribution, composition, mechanical and flow properties

Proposals submitted to this challenge should focus on improving our understanding of the geology of UK shales including resource potential and distribution.

The following gives some examples (but not an exhaustive list) which could be explored under challenge 2:

- Baseline monitoring studies of rock properties and structure to allow interpretation of observations during and after hydraulic fracturing.
- Understanding the controls on flow behaviour, including questions around porosity, permeability and geomechanics of shales, as well as the sorption and desorption properties of mineral and organic matter.
- The sensitivity of larger-scale geophysical properties of shales to micro-scale properties.

£1.7m (80% FEC) available to fund one project for up to 4 years
Challenge 3: Coupled processes from reservoir to surface

Proposals submitted to this challenge should focus on informing the development of a scientifically robust approach to risk assessment of leakage and induced seismicity in future exploration targets.

The following gives some examples (but not an exhaustive list) which could be explored under challenge 3:

- Measurements of the rates of geochemical reactions between potentially leaking fluids and minerals.
- Integration of laboratory and field studies to develop predictive models of the key risk factors by which the overburden may be compromised.
- Understanding the impacts of confining pressure, pore stress and strain on microbial communities, and on fluid flow and mineral-fluid reactions.
- Understanding the potential impact of hydraulic fracturing on the microbial communities that exist at depth.

£1.7m (80% FEC) available to fund one project for up to 4 years
Challenge 4: Contaminant pathways and receptor impacts

Proposals submitted to challenge 4 should focus on improving understanding of the source-pathway-receptor linkage in relation to shale gas.

The following gives some examples (but not an exhaustive list) which could be explored under challenge 4:

- Top-down quantification of contaminant flux and emissions from shale gas operational activity.
- Assessment of the relative contributions of different fugitive source pathways.
- Characterisation of the baseline atmospheric and near-surface environments prior to any shale gas activity.
- Characterisation of hydrogeological properties of subsurface media through which transmission of contaminants may occur.
- Evaluation of the sensitivity of environmental and human receptors.

£1.7m (80% FEC) available to fund one project for up to 4 years
Eligible for funding

- Individuals and organisations eligible for research grant funding from NERC, i.e. applicants in UK Higher Education Institutions (HEIs), RC-supported Research and Collaborative Centres and Independent Research Organisations
- Consortium proposals must include researchers from at least two eligible institutions
- Individuals may be named on a maximum of two proposals submitted to this call, but may be named as a lead PI on only one
Assessment

- Full proposals will be peer reviewed and funding recommendations made by a moderating panel of independent experts

- Assessment criteria:

  **Research Excellence**

  Relates to the originality and quality of the proposed research and the importance of the questions being addressed

  **Fit to Programme Requirements**

  Relates to the degree to which the proposed research addresses the objectives of the programme
Timeframe

• AO published – 4 September 2017
• Town Meeting – 4 October 2017
• Notification of Intent closes – 3 November 2017
• Full proposals close – 30 November 2017
• Panel – March 2018
• Grants start – Summer 2018*
• Kick off meeting – Autumn 2018

* Exceptionally, the start date of grants using the UK Geoenergy Observatories infrastructure may be delayed by more than three months (due to any delays in the UK Geoenergy Observatories timeline).
Rest of day…

- More talks to follow
- Structured brokerage and networking sessions
- Drop in sessions with funders at 12:30 and 13:45 – don’t forget to sign up
- Q&A session with funders at 15:00

Email: UH@nerc.ac.uk
UK Geoenergy Observatories
Mike Stephenson

Link to more information:
http://www.bgs.ac.uk/ukgeoenergyobs/home.html
Contents

• Why do we need UK Geoenergy Observatories?
• How did we design the facilities?
• Details of the facilities
Why do we need UK Geoenergy Observatories?

- Making power cleaner
- Storing energy better
- Achieving our commitments
- Dealing with intermittency
- Decarbonising heat

Low carbon transition

Climate Change Act 2008
The underground is vital for the ‘low carbon transition’

**Energy**
- Geothermal hot dry rock
- Geothermal district heating
- Geothermal minewater heating
- Shale gas

**Disposal**
- Carbon capture and storage

**Storage**
- Compressed air energy storage
- Hydrogen storage

- How much potential is there?
- Can these technologies be done sustainably?
- Both of these are science questions...So we need the facilities to answer these questions

The underground is vital for the ‘low carbon transition’
Extensive consultation with UK and international science community

How did we design the facilities? Lots of consultation....

Gathering of ideas

Formed a Science Advisory Group of independent and eminent scientists representing academia, industry and Government

The SAG produced a Science Plan which was then peer-reviewed

BGS designed the facilities to carry out the Science Plan
UK Geoenergy Observatories

- Monitoring and observing new and established technology
- Testing and innovating with new technology

Two sites

- Cheshire energy research field site - deep geology, carbon capture and storage, shale gas,
- Glasgow Geothermal energy research field site – shallower geology, mine water heat and geothermal
- Each site has special geological characteristics that make it suitable for research
Cheshire energy research field site

- Borehole arrays
- Geological characterisation
- Hydrogeology
- Informatics

http://www.bgs.ac.uk/ukgeoenergyobs/home.html
Borehole Arrays

• Designed to deliver the UK Geoenergy Observatories Science Plan.
• well-focused research infrastructure at a range of spatial scales and investigation depths
• To enable researchers to undertake experimentation and monitoring of subsurface processes
Borehole Arrays

- **Array 1** — baseline groundwater and surface-water monitoring array
  - Clusters of wells at 10 locations spread over an area of approximately 16 km$^2$. Each cluster includes three boreholes, drilled to depths of 25 m, 50 m and 100 m. Total number of boreholes is 30.

- **Array 2** — baseline seismic monitoring array
  - 20 seismic boreholes with average spacing 1 km, distributed across a 4 × 4 km area, centred on Ince Marshes.

- **Array 3** — deep well
  - A single deep well (~1200 m), TD in the Carboniferous Millstone Grit Formation, will be drilled and completed to allow multiple well entry for sensors and sampling.

- **Array 4** — multi-scale array
  - Over 20 boreholes (50 and 600 m), area of approximately 150 x 150 m - equipped with electrode networks for electrical resistivity tomography (ERT) and other sensor types (e.g. pressure transducers, fibre optic cable) attached to the outside of borehole casing.

- **Array 5** — multi-phase research well
  - Two wells – a multi-phase research well in the Permo-Triassic succession, and a second hydrogeological monitoring well.
Geological characterisation

- Northern margin of the Cheshire Basin
- Variable thickness of Made Ground and Devensian-aged Quaternary Deposits
- These rest on approximately 250 to in excess of 1000 m of faulted Permo-Triassic sandstone bedrock
- These rest on Carboniferous strata
- Deep boreholes proving sedimentary rocks of the Warwickshire Group, Coal Measures, Millstone Grit and Craven Group
Geological characterisation: Superficial geology

A schematic model (not to scale) showing the predicted natural superficial geology near Ince Marshes.

Download the Lithoframe viewer.
Geological characterisation: Bedrock Geology

General structure of the Ince Marshes area, based on interpretation of seismic reflection line SC-83-128V, illustrating the Ince Marshes horst structure defined by the Waverton Fault Zone to the west and Dungeon Banks Fault Zone to the east. FZ = Fault Zone.

<table>
<thead>
<tr>
<th>Stratigraphy</th>
<th>Bedrock geology: horst (as proved by the Ince Marshes 1 borehole); depths quoted in m to base of unit.</th>
<th>Bedrock geology: eastern graben (as proved by the Kemira 1 borehole); depths quoted in m to base of unit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permo-Triassic</td>
<td>272</td>
<td>1042</td>
</tr>
<tr>
<td>Carboniferous</td>
<td>331</td>
<td>1221</td>
</tr>
<tr>
<td>Warwickshire Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboniferous</td>
<td>945</td>
<td>Terminal depth at 1438</td>
</tr>
<tr>
<td>Pennine Coal Measures Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboniferous</td>
<td>Terminal depth at 1577</td>
<td>Not proved</td>
</tr>
<tr>
<td>Millstone Grit Group</td>
<td></td>
<td></td>
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</tbody>
</table>
Hydrogeology

Little natural groundwater flow probably occurs within the superficial deposits, with the exception of buried channels. Buried channels typically tens of metres deep and hundreds of metres wide, infilled with glacial deposits. Depending on the composition of the infill, these may influence groundwater flow in the area.

Large abstractions in the Permo-Triassic Sandstones e.g. for public water supply near the recharge area, and for industrial use in the Ellesmere Port and Stanlow areas.

The Permo-Triassic Sandstone aquifer is confined by low permeability superficial deposits and the piezometric surface is above the top of the sandstone, but not above ground level in the area.

The hydraulic gradient in the area is very low, and thus groundwater flow is expected to be very slow. There is very little known about the hydrogeology of the Carboniferous strata beneath the Permo-Triassic.
Informatics

- Allow data (real-time or otherwise) collected in the field to be streamed back to scientists and/or web portals
- Store scientific data in bespoke databases
- Facilitate re-use and sharing of scientific data between scientists
- Allow for expansion as demand requires (e.g. allowing data from new experiments to be streamed to the portal)
- Be supported long-term by BGS data and system management
- Provide access to new NERC facilities such as a suite of state of the art core scanners.
Data and science available to everyone

Groundwater quality

For the public:
To see what’s happening

For scientists:
For research and innovation

For industry:
For new products, jobs and investment

...often in real time....
Glasgow Geothermal energy research field site

What science will we do and what will it look like?

Example – mine water heat

- How much heat is there? Enough for houses and businesses?
- What’s the most efficient way of getting the heat out?
- How fast does the heat get replenished?
Conclusions

- UK Geoenergy Observatories is a major investment in UK science infrastructure
- Will address fundamental and applied science questions about energy in the subsurface for the low carbon transition
- Two sites will be developed to address science questions set out in the Science Plan
- Data and science open to everyone for science, innovation, investment, products and jobs
- Both field sites subject to gaining necessary planning/ regulatory approvals. Assuming that our plans gain the necessary approvals - we aim to begin drilling in summer 2018.

- More information: http://www.bgs.ac.uk/ukgeoenergyobs/home.html
Environmental (Baseline) Monitoring: Lancashire and Vale of Pickering

Rob Ward
Director of Groundwater Science
British Geological Survey

www.bgs.ac.uk/research/groundwater/shalegas

In collaboration with:
Rationale

- Extension to national baseline monitoring

- Independent integrated monitoring programme:
  - Water, air, seismicity, ground motion, soil gas and radon

- To provide high quality (spatial and temporal) data and information in shale gas development areas to:
  - Inform public, industry, regulators of environmental baselines, their natural variability and change
  - Assist in shaping regulatory monitoring and good practice
  - Improve understanding of sub-surface in the context of shale gas (avoid issues encountered in NA)
  - Test new monitoring technology/sensors and support future research
VoP Geology

(A) Bedrock
(B) Superficial

http://www.bgs.ac.uk/valeofpickering
Water monitoring sites

**Lancashire**

- Proposed Shale Gas Site
- Monitoring borehole
- Monitoring stream
- New BGS BH's

**Vale of Pickering**

- New water/seismic boreholes
- Settlements
- Towns

- Monitoring Sites
  - Monitored groundwater
  - Single sample groundwater
  - Monitored stream
  - Single sample stream

**Simplified Geology**

- Mercia Mudstone Group
- Sherwood Sandstone Group
- Bowland Shale Group
- Fault

**Unstable parameters** (pH*, EC*, dissolved O₂, T*, redox)

**Inorganic/organic chemistry**

**Dissolved gases** (incl. CH₄, CO₂, Rn, noble gases)

**Stable isotopes** (δ¹⁸O, δ²H, δ¹³C DIC/CH₄)

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Seismic array – Vale of Pickering

Array detection capability:
- $\geq 0.5$ across whole area
- $\geq 0.0$ centre of VoP
- $\leq 0.0$ around KM8

Quarry blast north of Pickering – 1.3ML

Seismic events detected by the Vale of Pickering stations and permanent BGS monitoring stations in the north east of England from 1/8/2016 to 31/10/2016. Diagonal crosses show earthquakes. Square crosses show events of a suspected explosive origin, e.g. quarry blasts.

Magnitude 1.7 ML earthquake, 4/5/2016

1/1/2016 to 31/12/2016
120 events detected
54 events located

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Ground motion - inSAR

- Synthetic Aperture Radar (SAR) imagery and Interferometric SAR (InSAR) processing
- Millimetric resolution – vertical and lateral movement
Atmospheric composition

Objectives:
• Understanding the local background as basis for any future change
• Facilitates future emissions quantification and research design/delivery

Measurements:
• LOD < ambient global average
• Traceability to international standards
• Dynamic range up to level of maximum expected concentrations

<table>
<thead>
<tr>
<th>Species</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Met Data</td>
<td>1 minute</td>
</tr>
<tr>
<td>(wind speed/direction, T, P, RH)</td>
<td></td>
</tr>
<tr>
<td>NO, NO₂, NOₓ</td>
<td>1 minute</td>
</tr>
<tr>
<td>O₃</td>
<td>1 minute</td>
</tr>
<tr>
<td>PM₁, PM₂.₅, PM₄, PM₁₀</td>
<td>1 minute</td>
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<tr>
<td>NMHCs</td>
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<tr>
<td>H₂S</td>
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<tr>
<td>CH₄</td>
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<tr>
<td>CH₄ δ¹³C</td>
<td>6-monthly</td>
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<tr>
<td>CO₂</td>
<td>1 minute</td>
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</tbody>
</table>
Atmospheric composition

CO₂/CH₄ Plumpton

Kirby Misperton

Little Plumpton Windrose

Ozone
Radon monitoring - VoP

Monitoring points in the Vale of Pickering
Environmental baseline monitoring in the Vale of Pickering - Real-time data and data summaries

**Groundwater quality**

- **Major ions**
  - Concentration (mg/L)
  - Box plots showing summary data for groundwater samples from the Quaternary superficial aquifer of the vale of Pickering.

- **Minor constituents**
  - Concentration (mg/L)
  - Box plots showing summary data for groundwater samples from the Quaternary superficial aquifer of the vale of Pickering.

**Seismic Monitoring**

The images show a day of seismic data for a single channel. Each horizontal line is 30 minutes long with the start time given on the left axis and each vertical line marking one minute. The times are in UTC (or GMT) and so are an hour behind local time in summer.

The colours are simply to make interpretation easier. Seismic activity is shown when a line goes from flat to moving up and down. This is most likely to be something local to the station - a passing tractor or large animal. Earthquakes are distinct because they cause activity on several stations at the same time.

13 seismic monitoring stations found within the area:

<table>
<thead>
<tr>
<th>Station Code</th>
<th>Station Name</th>
<th>Real-time Seisograms *</th>
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<tbody>
<tr>
<td>AU05</td>
<td>Laytham, Yorkshire</td>
<td>2017-01-26, 2017-01-25, 2017-01-24</td>
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<td>AU07</td>
<td>Birkdale, Yorkshire</td>
<td>2017-01-26, 2017-01-25, 2017-01-24</td>
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<td>AU08</td>
<td>Settrington, Yorkshire</td>
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<td>Barton-le-Street, Yorkshire</td>
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<td>AU10</td>
<td>Kirby Misperton 1, Yorkshire</td>
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<td>AU11</td>
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<td>AU13</td>
<td>Kirby Misperton 2, Yorkshire</td>
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</tbody>
</table>
Vulnerability and risk framework

• 3D-GWV and risk assessment framework (DRASTIC-based method)
• Identification of spatial relationships and vertical separations
• 25 aquifer-shale combinations

3D Mapping of shales and aquifers

www.bgs.ac.uk/research/groundwater/shaleGas/3dgwv
www.bgs.ac.uk/research/groundwater/shaleGas/aquifersAndShales
Thank you

More information at:

www.bgs.ac.uk/research/groundwater/shalegas
www.bgs.ac.uk/valeofpickering
www.bgs.ac.uk/lancashire

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