

GERC

Geo**Energy** Research Centre

Research, CCS and a new Test Bed

Derek M. Taylor and *all the members of GERC*
Geo-Energy Research Centre

University of Nottingham



A Unique Partnership

- Largest UK GeoEnergy centre
- 136 staff involved across BGS and UoN
- £42M reservoir modelling suite

Schlumberger

Key facts:

Total value of centre ~£14 M

- £3 M strategic development funding (UoN and BGS)
- >£5 M funding portfolio (EU, EPSRC, NERC, ETI, Industry)
- £3.5 M Geo-energy test bed (GTB) facility
- £2.5 M G-ERA capital funding for GTB

British Geological Survey (BGS): Founded in 1835, the world's oldest national geological survey

- Delivers UK 'national capability'
- Hosts national databases and archives
- Measurement and observation of underground processes

University of Nottingham (UoN): One of top 1% of global Universities; Top 5 UK in Engineering and Science

- Departments related to GERC include Physics, Chemistry, Mathematics, Engineering and Geospatial



Co-located

Mission Statement

- A **co-investment partnership** between UoN and BGS
- Significantly enhances combined science capabilities, research income, and research outputs
- Operates as a **co-operative**
- Strategically focuses research and training activities on the subject of **rock-fluid interactions**

Multi-Scale Approach

GERC offers:

- Co-location of world class capabilities in **GeoEnergy**
- Critical mass that is effective
- Economic scale & competitive research costs



Science Directorates:

Geophys. & Envir. Modelling ●●
 Energy & Marine Geoscience ●●
 Engineering Geology ●
 Groundwater ●
 Minerals & Waste ●●●



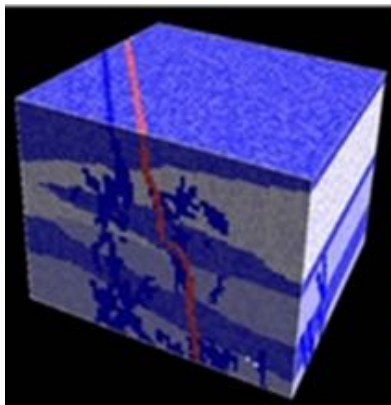
Faculty of Engineering:

Materials ●●
 Geospatial ●
 Civil ●●
 Chemical & Envir. ●●
 Mechanical ●●



Faculty of Science:

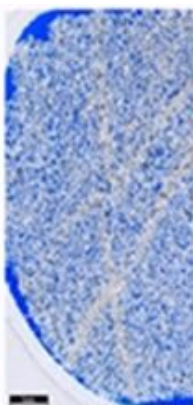
Chemistry ●
 Mathematics ●●●
 Physics ●●



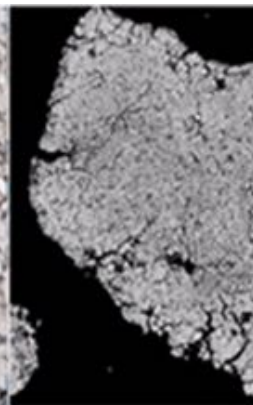
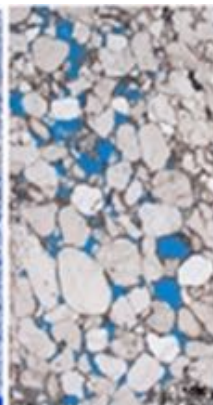
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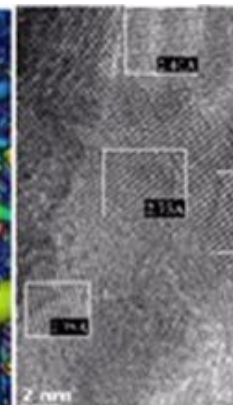
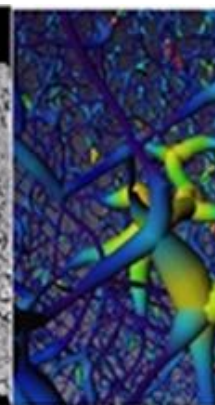
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mm



μm



nm

GERC

GeoEnergy Research Centre



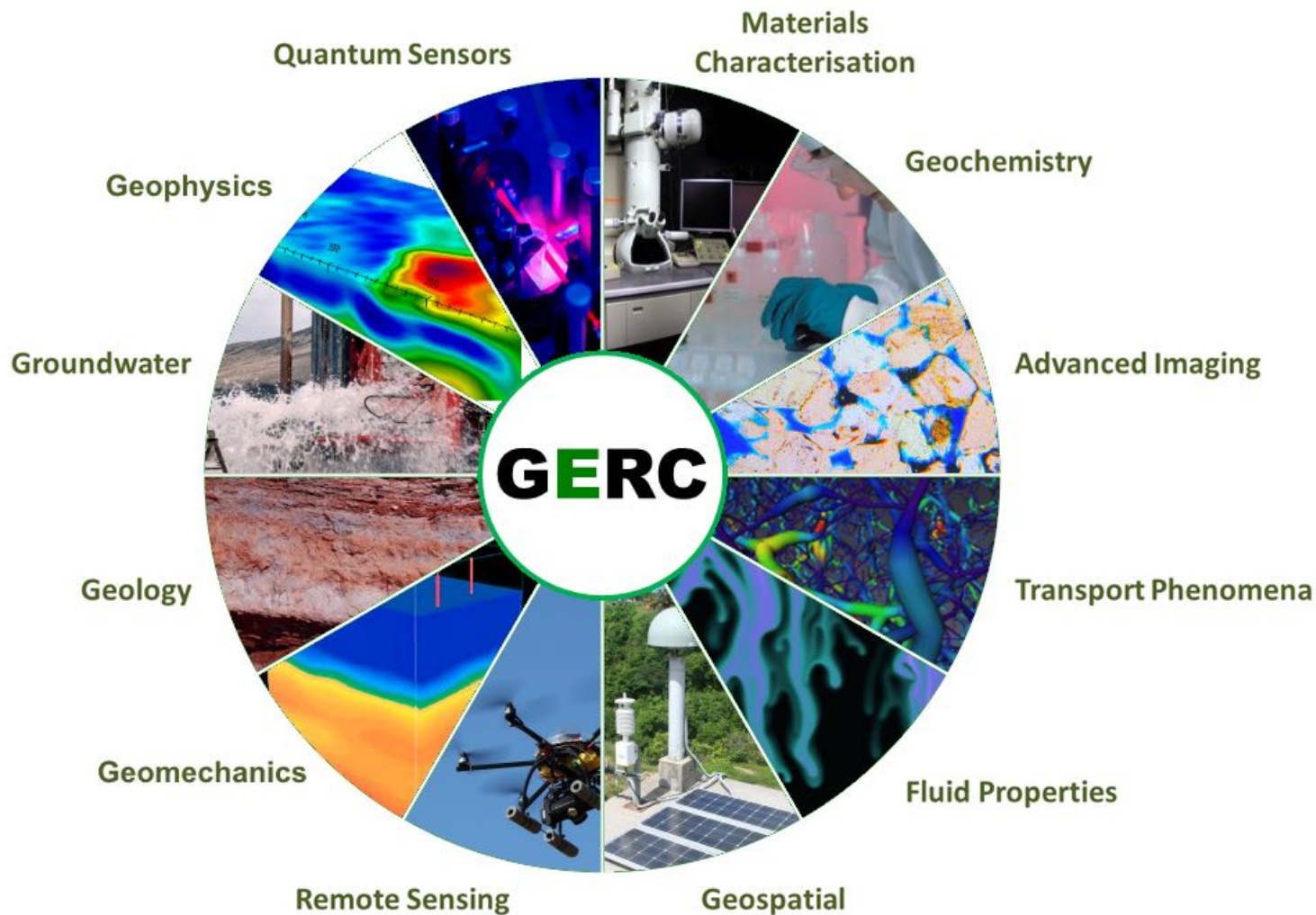
British
Geological Survey



The University of
Nottingham

UNITED KINGDOM • CHINA • MALAYSIA

Capabilities



Appointments

Director

Dr Matthew Hall

Research & Business Development Manager

Dr Max Bardwell

Deputy Director

Mr Jonathan Pearce

Centre Administrator

Miss Lindsay Holowka

GERC Research Fellows

Dr Lee Stevens

Dr Chunyu Jin

TBA Gas Adsorption Analysis

GERC Academic Staff Appointments

Dr Veerle Vandeginste, Assistant Prof. in Geochemistry

Dr Donald Brown, Assistant Prof. in Applied Mathematics

Dr Stephen Grebby, Assistant Prof. in Remote Sensing

Dr Bahareh Nojabaei & Miss Ellen Gilliland, Assistant Prof. in
Geoenergy Engineering (VT - US)

TBA Associate Prof. in Geoenergy (UoN - UK)

TBA Assistant Prof. in Fluid Dynamics

Affiliated Staff 136

Doctoral Centre

15 PhD studentships

GERC Honorary Staff Appointments (UoN-BGS dual affiliated)

Dr Sean Rigby

- GERC Doctoral Centre

Dr Chris Rochelle

- Early Career Researcher Incubator

Prof Ed Lester

- Industrial Liaison & Collaborations

Ms Ceri Vincent

- Science lead for the GeoEnergy Test Bed

Expert Advisory Board

Name	Organisation	Description
Allan Jones (Chair)	UoN	Honorary Professor and Energy Advisor to UoN
Derek Taylor	UoN	Honorary Professor at UoN and former EU Energy Advisor
Tony Espie	BP	Advisor on Oil and gas; CCS technology
Robin Irons	E.ON	Technical Head of Zero Emission Power Plant
Chris Banks	Schlumberger	Senior Geoscience Workflow Consultant
Blanche Wynn-Jones	NERC	Senior Science Programmes Officer - Energy
Celia Yeung	EPSRC	Portfolio Manager - Energy
Karl Bindemann	EPRI	Technical Executive – Power Generation
Andrew Green	ETI	Business and Programme Manager for CCS
Judith Shapiro	CCSA	Policy and Communications Manager
Andrew Long	UoN	PVC, Faculty of Engineering
Kate Royse	BGS	Science Director – Environmental Modelling

Research Interests

Our current portfolio includes research into:

- Fluid-rock processes in the shallow subsurface for CO₂ storage
- CO₂-enhanced shale and coal bed methane recovery
- Sensor development for geoenergy applications

We will explore opportunities to apply our expertise and facilities in the following sectors:

- Underground coal gasification
- Enhanced oil recovery / Heavy oil recovery
- Geothermal
- Groundwater security
- Gas hydrates
- Underground gas storage
- Radioactive waste storage
- Shale gas

Current Funded Projects

Over £7.5M of current externally funded projects:

- **EPSRC** (EP/M000567/1) (2014 – 2017). Gas Adsorption Analysis Suite (GAAS) – Strategic Equipment Grant, **£522k** (Hall, Schröder, Tendler, Mokaya, Walker, Rigby, Yang)
- **Royal Academy of Engineering** (2014 – 2019). Senior Research Fellowship ‘Rock-Fluid Interactions in Carbon Capture and Storage and Alternative Hydrocarbons’ sponsored by the British Geological Survey, **£415k** (Hall)
- **EPSRC** EP/K035878/1 (2013-2016) DiSECCS: Diagnostic Seismic toolbox for the Efficient Control of CO₂ Storage **£609k** (Chadwick, Gough, Noy, Angus, Williams, Best, Mander, Chapman)
- **EPSRC** (EP/K036025/1) CONTAIN: The impact of hydrocarbon depletion on the Treatment of cAprocks within performance assessment for CO₂ Injection schemes **£925k** (Harrington, Whitmarsh, Zimmerman, Paluszny Rodriguez, Graham)
- **EPSRC** (2012-2016) UK CCS Research Centre **£344k** (BGS CO₂ Storage team members)
- **NERC** (2012-2015). *CO₂ injection borehole cement evolution* **£57k** (Hall, Rigby, Milodowski, Rochelle)
- **NERC** (2013-2016) Fault Seal Controls on Storage Capacity **£188k** (Williams J, Williams G, Evans Chadwick)
- **NERC** (2013-2017) CO₂ Injection Storage **£149k** (Quinn, Vincent, Williams J)
- **NERC** (2015-2016) Multiscale CO₂ Storage **£80k** (Williams G)
- **EC** (2012-2015). ULTimateCO₂: Understanding the long-term fate of CO₂ **£444k** (Pearce, Bateman, Graham)
- **EC** (2011-2015): ECO₂: Sub-seabed CO₂ Storage: Impact on Marine Ecosystems **£348k** (White, Williams, Chadwick)
- **BIG CCS**. International CCS research Centre **£757k** (Chadwick, White, Williams)
- **BGS** (ongoing) CO₂Research **£240k** excludes some investments included above (CO₂ storage team lead by Pearce)

- Gas Adsorption Analysis Suite (GAAS)
 - Advanced imaging is one of the University of Nottingham's core strengths and a strategic priority area for growth. This equipment would significantly enhance the existing capabilities.
 - An Xradia Versa XRM 520 has sub-micron resolution with a minimum achievable voxel size of 70 nm.
 - A Dual Scan Contrast Visualizer (DSCoVer) which enables compositional probing for features normally indistinguishable in a single scan
 - Diffraction Contrast Tomography (DCT) which provides non-destructive 3D information about grain orientations and morphologies in crystalline solids to enable crystallographic mapping without having to wait for limited time at a synchrotron.

- Rock-Fluid Interactions in Carbon Capture and Storage and Alternative Hydrocarbons (*Senior Research Fellowships*)
 - Developing a suite of novel capabilities
 - o Advanced 3D imaging techniques
 - o Advanced numerical modelling of transport phenomena
 - Primary research themes
 - o CO₂ storage
 - o Multi-phase fluid transport
 - Secondary research themes
 - o Shale gas
 - o Gas hydrate

- DiSECCS
 - will develop monitoring tools and methodologies to identify and characterise injection-induced pressure build-up in storage reservoirs, to predict the onset of mechanical instability, and to improve in situ quantification and understanding of processes
 - Industrial partners, BP and Statoil, have provided unique access to monitoring datasets from the three global large-scale CO₂ storage operations: Sleipner, In Salah and Snøhvit.

- CONTAIN:
 - Focussed on providing a better understanding of the impact of depletion and re-inflation on reservoir and caprock material
 - It will involve a combined approach, using both laboratory experiments and computer simulation, to improve our understanding of this aspect of storage site behaviour
 - The project will generate a much needed and unique dataset, new modelling tools and a fuller understanding of the processes involved
 - The findings will inform regulators and aid operators in reducing the financial and environmental risks of CCS for depleted storage sites.

Fault Seal Controls

- FAULT SEAL CONTROLS ON STORAGE CAPACITY
 - Investigate the roles and properties of faults in their capacity to retain CO₂
 - Natural and engineered accumulations of hydrocarbon and CO₂-hydrocarbon mixtures will be examined across a wide self-similar province (to minimize geological variability) to develop a knowledge base of fault flow properties
 - Fault geometries, orientations, seismic attributes, proven vertical trapping and lateral pressure retention values and column-heights will be documented. High-quality data-rich examples will be selected for analysis with established software tools to predict and calibrate CO₂ column height and pressure retention
 - The fault properties knowledge-base and the newly calibrated tools will be applied to selected key reservoirs from the ETI UK Storage Assessment Project (UKSAP). This will provide improved and evidence-based assessment of storage in regional UK North Sea aquifers such as the Bunter Sandstone, Forties, Tay and Captain.

Energy Research Accelerator (ERA)



- Aims to deliver step change in energy research and development
- Facilities and demonstrators

Phase 1 funding awarded:

- £60M from UK Government
- £120M from private sector & Midlands Innovation universities

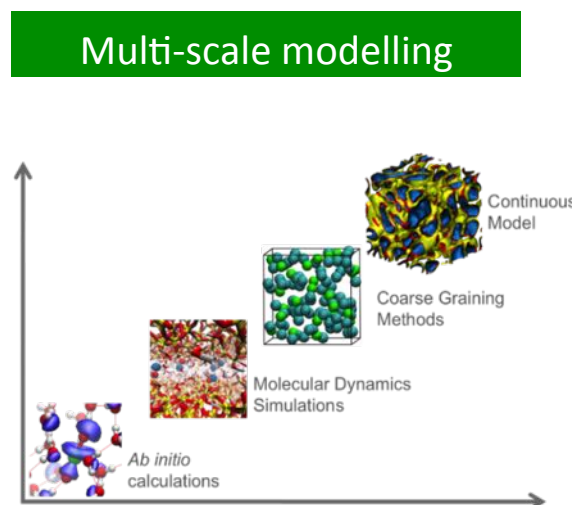
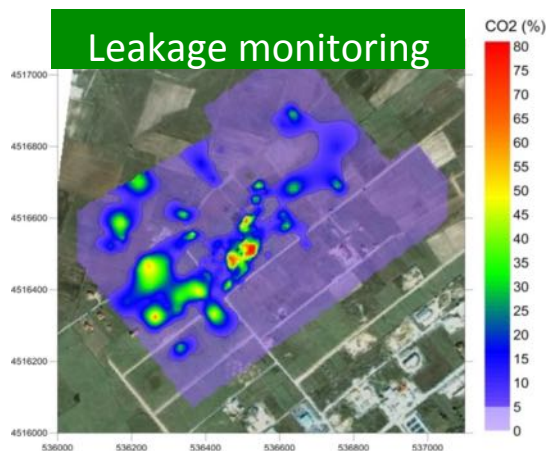
UoN leading the G-ERA theme:

- **Future fossil** *unconventional fossil, CCS, improved power plant efficiency, utilising biomass and waste*
- **Developing Energy Storage** *geothermal, microgrid storage, grid scale energy storage: CAES, hydrogen, electrochemical, thermal, solar fuels, and waste disposal: CO₂ and nuclear*
- **Energy Communities** *optimising smart microgrids, balancing distributed assets: generation, storage and demand, optimising energy use within urban centres*

GeoEnergy Test Bed (GTB)

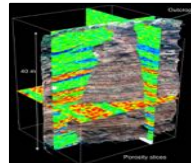
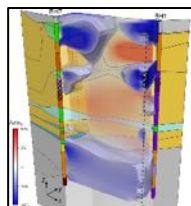
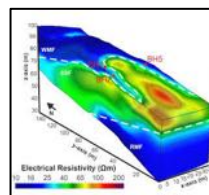
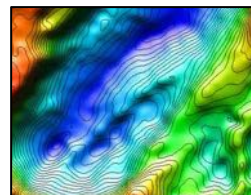
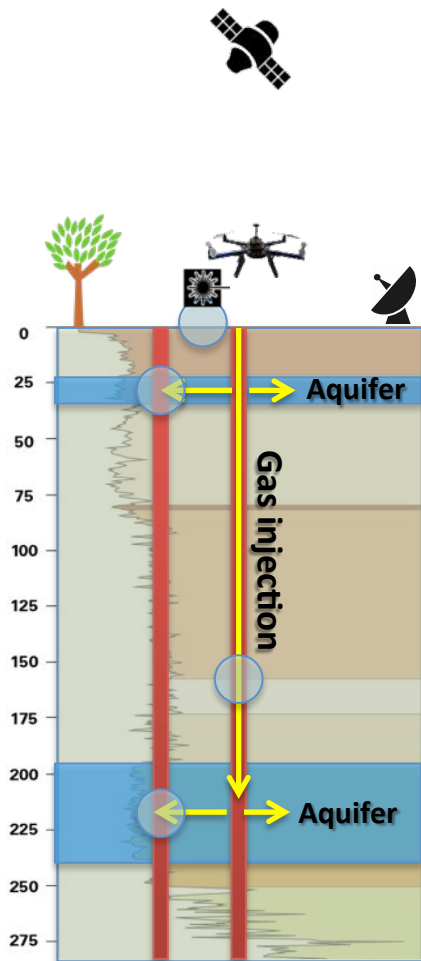
This is a **GERC facility** designed to:

- Catalyse external collaboration with UK and overseas institutions
- Leverage UK/ EU consortia funding
- Become a UK National Facility
- £3.5 M facility (including investment and in-kind value e.g. land, drilling, *etc.*)
- £2.5 M UK government-funding for developing research programme
- Designed to investigate leakage and sub-surface fluid transport
- Testing and developing prototypes for next generation sensor technologies
- Capacity for “ground-truthing” GERC experimental and modelling capabilities/ software



GeoEnergy Test Site

Highly Characterised site, hydrogeological testing, gravimetric surveys, electrical resistivity and 4D tomography, full rock core analysis



Gas monitoring migration, attenuation and remediation

Micro Seismic monitoring and satellite ground movement

Gas emission soil & atmosphere monitoring

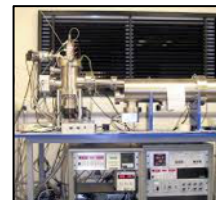
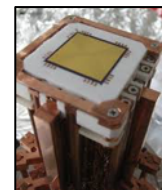
Advanced Sensor and Software Testing & Development

Real Time Big Data Handling & Distribution

Next Generation quantum gravity sensors

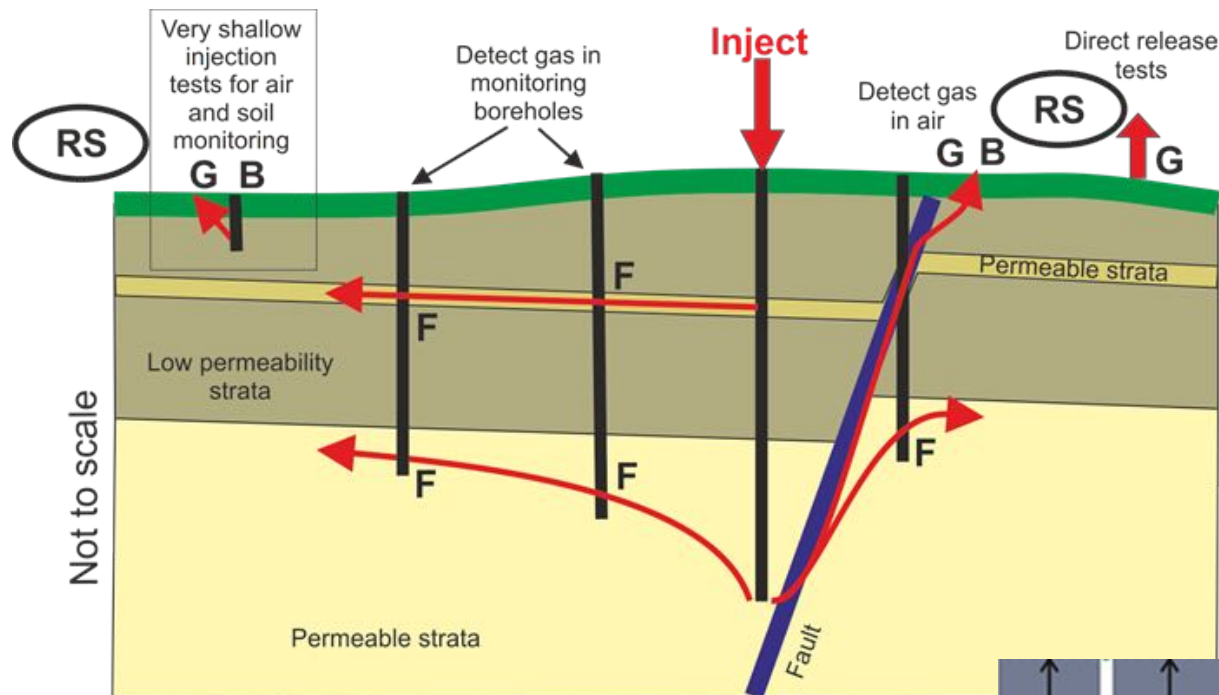
VOC downhole & surface gas monitoring
VOC fingerprinting

Subsurface fluid monitoring by ERT



Links to international full-scale demo sites eg
ESIOS (UK), Otway (Aus), VCCER (US)

GTB site geology



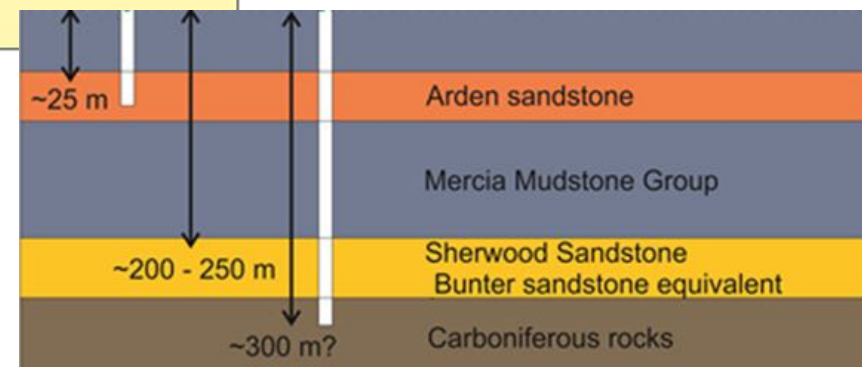
G = gas monitoring
F = fluid monitoring
RS = remote sensing
B = biological monitoring

A multi-borehole array test site

Fully instrumented with surface and down-hole sensors

Sensors will be recorded and operated by an on-site control centre

Actual site geology is ideal



Virginia Center for Coal and Energy Research (VCCER) www.energy.vt.edu

Creation of two new positions under the University of Nottingham and Virginia Tech joint initiative:

- First UK-USA university partnership to do this
- Associate Professor in Geoenergy (UK) in Dept. of Chemical & Environmental Engineering and GERC
- Associate Professor in Geoenergy Engineering (US) in Dept. of Mining & Minerals Engineering and VCCER
- Each position will hold Affiliated Associate Professor at the other centre (GERC/VCCER)

LARGE-SCALE TEST SITES:

CO₂ storage & enhanced coal bed methane (CBM): Injecting 20,000 tons of Carbon Dioxide into multiple unmineable thin coal seams in Buchanan County, Virginia; 305 – 670 m (1000-2200 ft) depth

- 3 injection wells with multiphase flow meters
- 3 multi-zone monitoring wells with surface and downhole pressure & temperature gauges
- 20 off-set producing wells monitoring water and gas quality and production
- \$15M multi-part project with the National Energy Technology Laboratory (NETL) of the US

Shale gas: Horizontal shale gas site (Chattanooga shale formation, Morgan County, Tennessee); 792 – 1036 m (2600-3400 ft) depth

- 1 injector well and 14 producing wells for methane extraction and monitoring



China University of Mining and Technology

111 Project: UoN-CUMT 5yr joint project
Staff exchange and collaborative research
Geomechanics and Underground Engineering

Two Key State Laboratories:

- Geomechanics & Deep Underground Engineering
- Coal Bed Methane Technology

LARGE-SCALE TEST SITES:

CO₂ storage: Shenghua's CCS demonstration, China's first pilot project for deep saline aquifer storage, 0.1 Mt CO₂/yr

CO₂ EOR: Yanchang oil field in Shanxi province and Shengli oilfield in Shandong province implementing CO₂ EOR pilot projects with emphasis on its large-scale industrialisation

Coal bed methane: Qinshui county and Zhangzi county both in Shanxi province

- Qinshui: 300 - 800m depth with 100+ producing wells
- Zhangzi: Coal seam at 900 – 1000 m depth with 3 injector wells and 12 monitoring & producing wells.

For more information...

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