British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Introduction to CCS work at BGS

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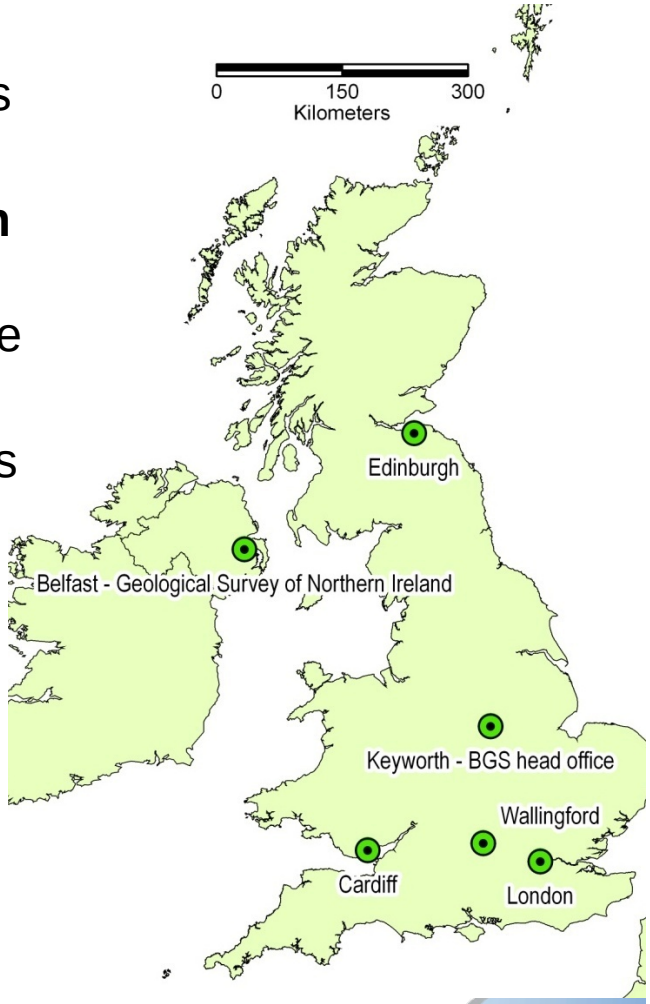
The British Geological Survey

- Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey
- The BGS is part of **the Natural Environment Research Council** (NERC), which is the UK's main agency for funding and managing research, training, and knowledge exchange in the environmental sciences.
- BGS carries out research in strategically important areas including energy and natural resources, vulnerability to environmental change and hazards, and Earth System Science, often in collaboration with the national and international scientific academic community.
- **The BGS CO_2 team is active worldwide in CCS with over 20 geoscientists working on CO_2 storage research**



The BGS CO_2 team

- The BGS CO_2 team is active worldwide in CCS with over 20 geoscientists working on CO_2 storage research and an annual budget of around UK£1million (approx $1.4m). CCS at BGS started early 1990's with Joule project
- Research topics at BGS include:
  - deep and shallow monitoring of storage sites,
  - storage capacity mapping in the UK and overseas;
  - storage capacity modelling via flow simulations;
  - experiments and modelling on geochemical and biological effects of storage;
  - experimental work on flow of supercritical CO_2 in low permeability media.

The British Geological Survey and the University of Nottingham have also initiated a collaborative institution for CCS research

Selected CCS Team Activities 2009 -2011

Plus advice to **Department of Environment and Climate Change for the UK competition**, support for the Otway Review (Australia), Gorgon Review, (Australia), Aalburg Review (Denmark), Altmark Review (Germany) and a number of commercial in confidence projects

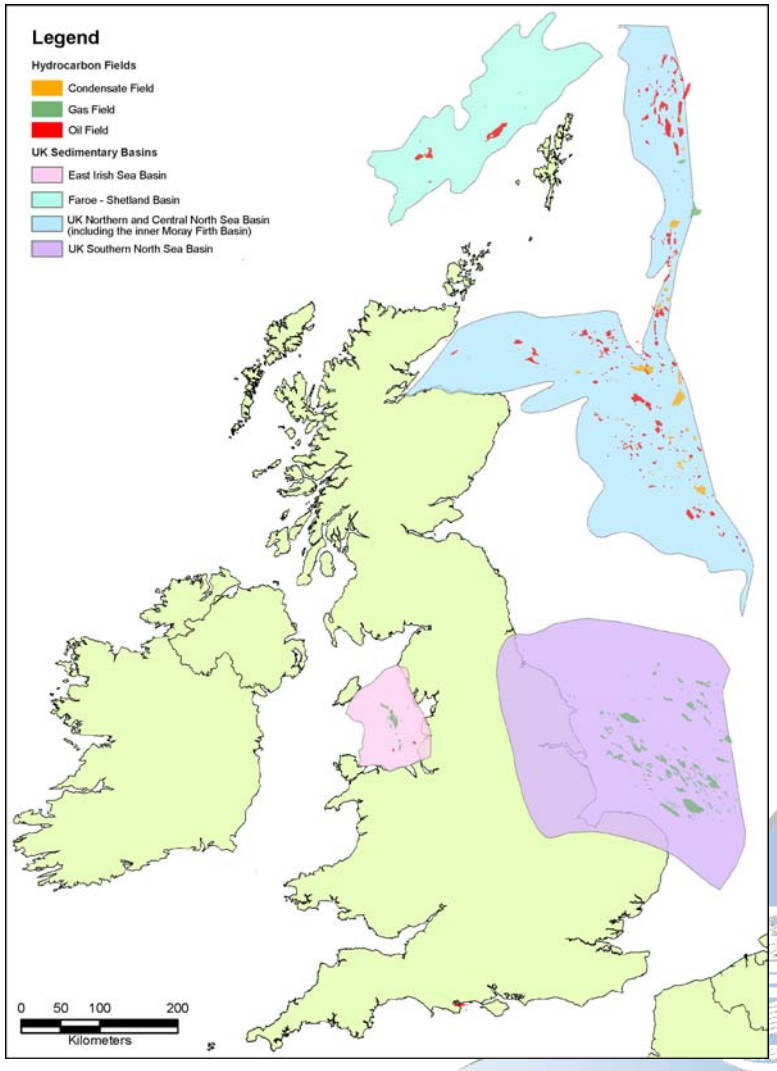
BGS involvement in CO_2 storage capacity estimation

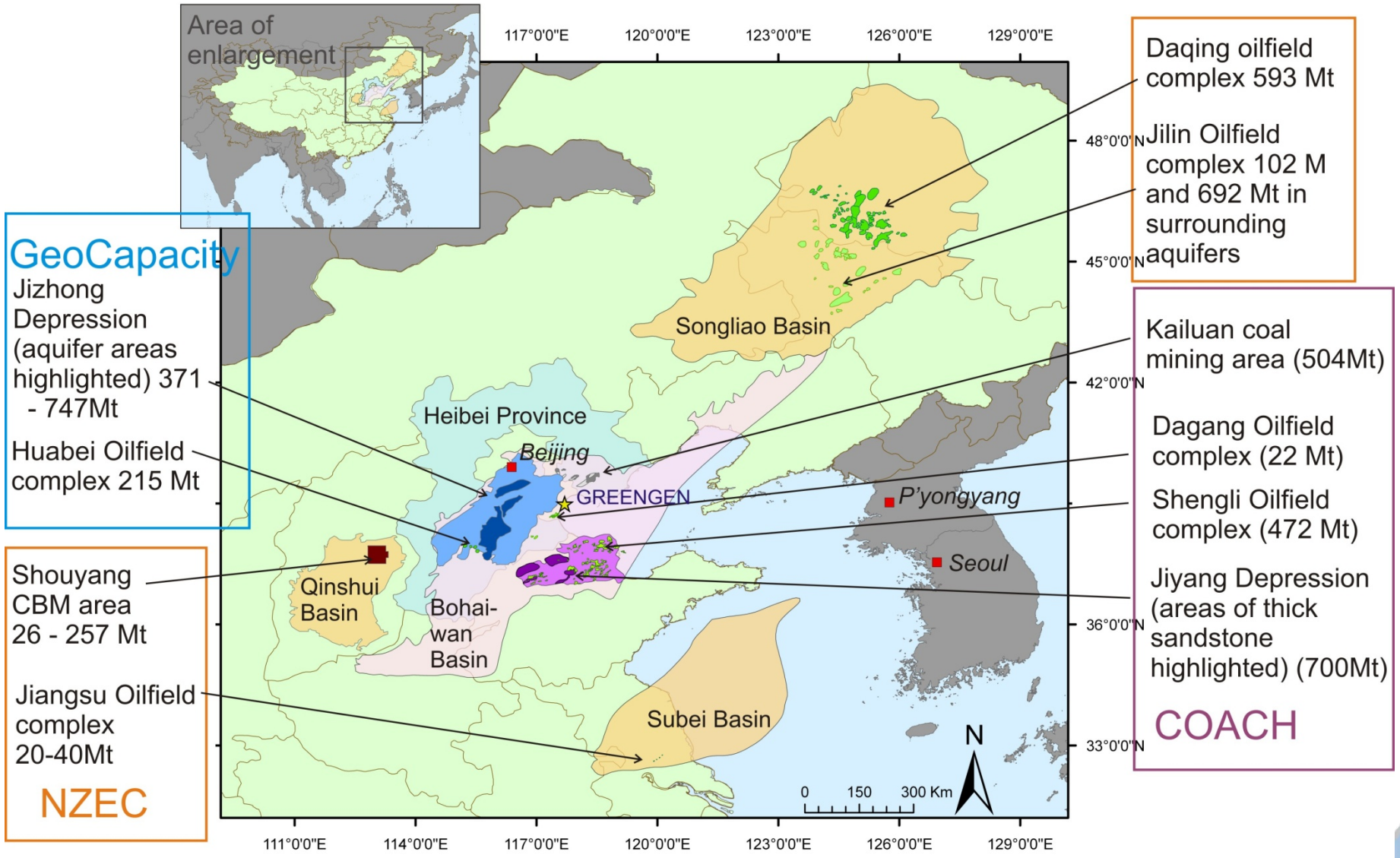
- Past:
  - Conducted resource estimates of the potential on the UK Continental Shelf for our Department of Energy and Climate Change
  - Involved in devising the CSLF methodology (http://www.cslforum.org/)
  - India (for IEAGHG), Ireland, China (COACH, NZEC and GeoCapacity)
- Present:
  - Involved in the current reassessment of UK storage potential funded by the Energy Technologies Institute
    - Database and calculation engine that includes attributes of those such as probabilistic estimate of storage capacity
  - **Involved in an emerging IEA initiative to produce a roadmap for CO_2 storage capacity estimation**
    - IEA want a to produce a roadmap that people can follow to derive a capacity number for their jurisdiction that is more realistic, e.g. How much capacity can be relied on at a certain cost?

Industrial carbon dioxide emissions and carbon dioxide storage potential in the UK

- Report COAL R308 DTI/Pub URN 06/2027 (October 2006)

Category	**Location**	**Estimated CO_2 storage capacity (million tonnes)**
Oil fields	Offshore	1171
	Onshore	4
Gas fields	Offshore	5138
	Onshore	5
Saline aquifers	Southern North Sea Basin	Up to 14250
	East Irish Sea Basin	Up to 630
	Northern and Central North Sea Basin and other offshore basins	Not quantified but potentially large
	Onshore	Not quantified but potential small
TOTAL QUANTIFIED CO_2 STORAGE CAPACITY		Up to **22414**



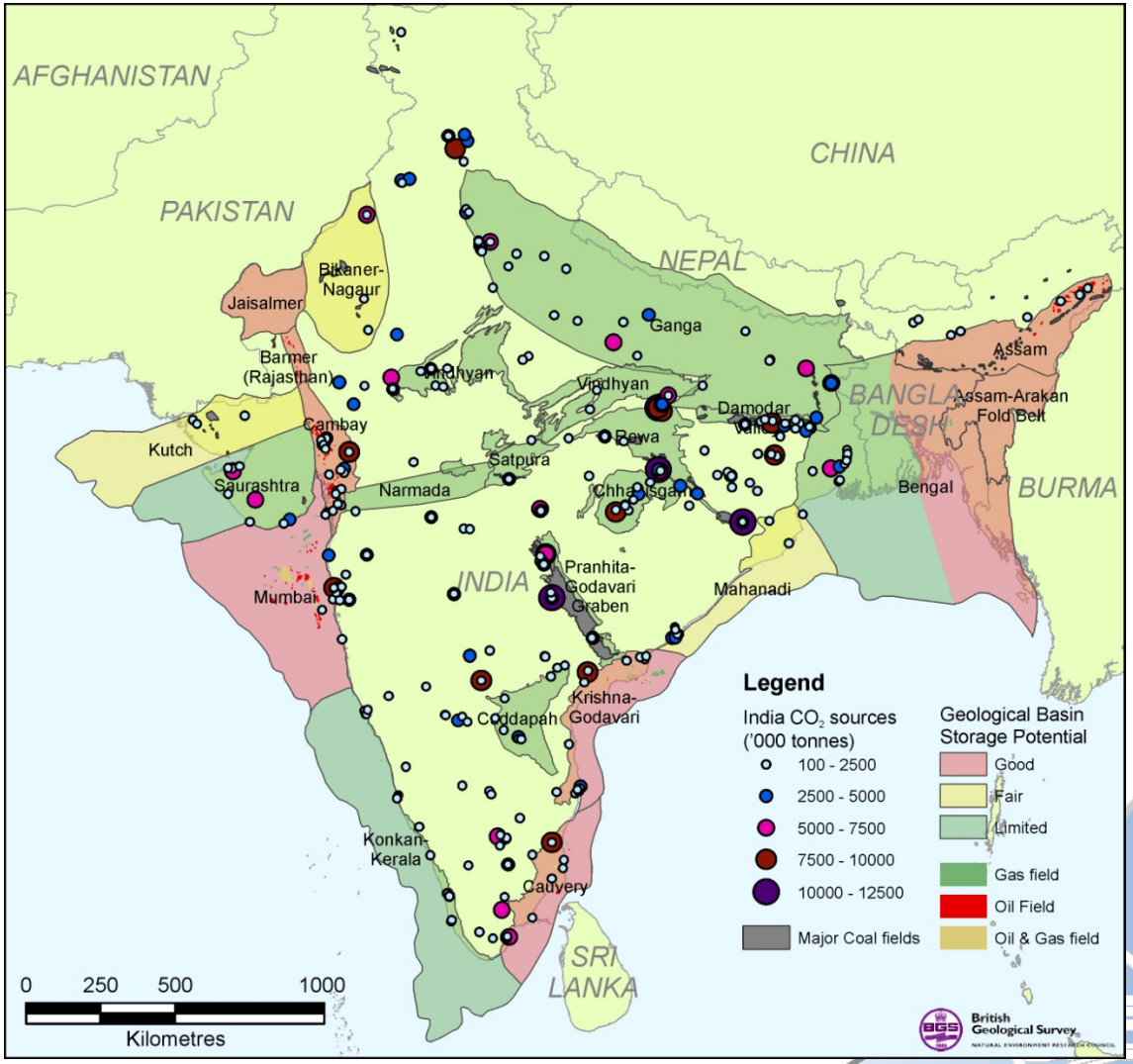


Basemap data taken from the Digital Chart of the World (1:1 million data), State province and basin outline (with the exception of Qinshui) reproduced with the kind permission of the USGS.

NZEC: http://www.NZEC.info, COACH: http://www.co2-coach.com/, GeoCapacity: http://www.geology.cz/geocapacity

A regional assessment of the storage potential of the Indian sub-continent

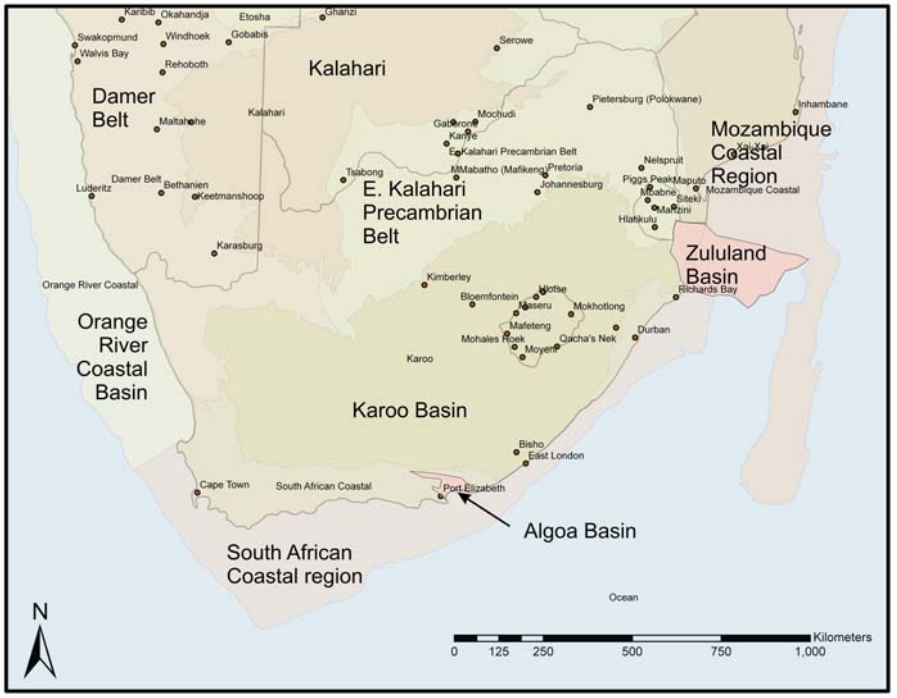
- IEAGHG report 2008/2
- India, Pakistan, Bangladesh, Sri Lanka
- BGS and local partners
- Indian CO_2 emissions in 2000 were 956 Mt (IEAGHG)
- Estimated storage capacity in oil and gas fields in the Assam, Barmer, Cambay, Mumbai and Gujarat fields 835 Mt
- Estimated Indian storage capacity of deep coals 345 Mt



South Africa – Europe Cooperation on Carbon Capture and Storage (SAfECCS)

Main aims:

1. Capacity building
2. Prepare for test injection:
   - Geological assessment of ‘Test Injection’ site
   - Assess how test injection could take place under current regulations
   - Assessment of financial opportunities for CCS in South Africa.



CO2GeoNet

- Coordinated by BGS
- CO_2GeoNet is *the* European scientific authority on CO_2 geological storage. As an independent and multidisciplinary scientific body, CO_2GeoNet has the key role of building trust in CO_2 geological storage and supporting wide scale CCS implementation
- Over 150 CO_2GeoNet researchers from 13 European institutes
- Four domains of activity
  - Research
  - Scientific advice
  - Training and capacity building
  - Information and communication

CO2GeoNet researchers working jointly at Latera

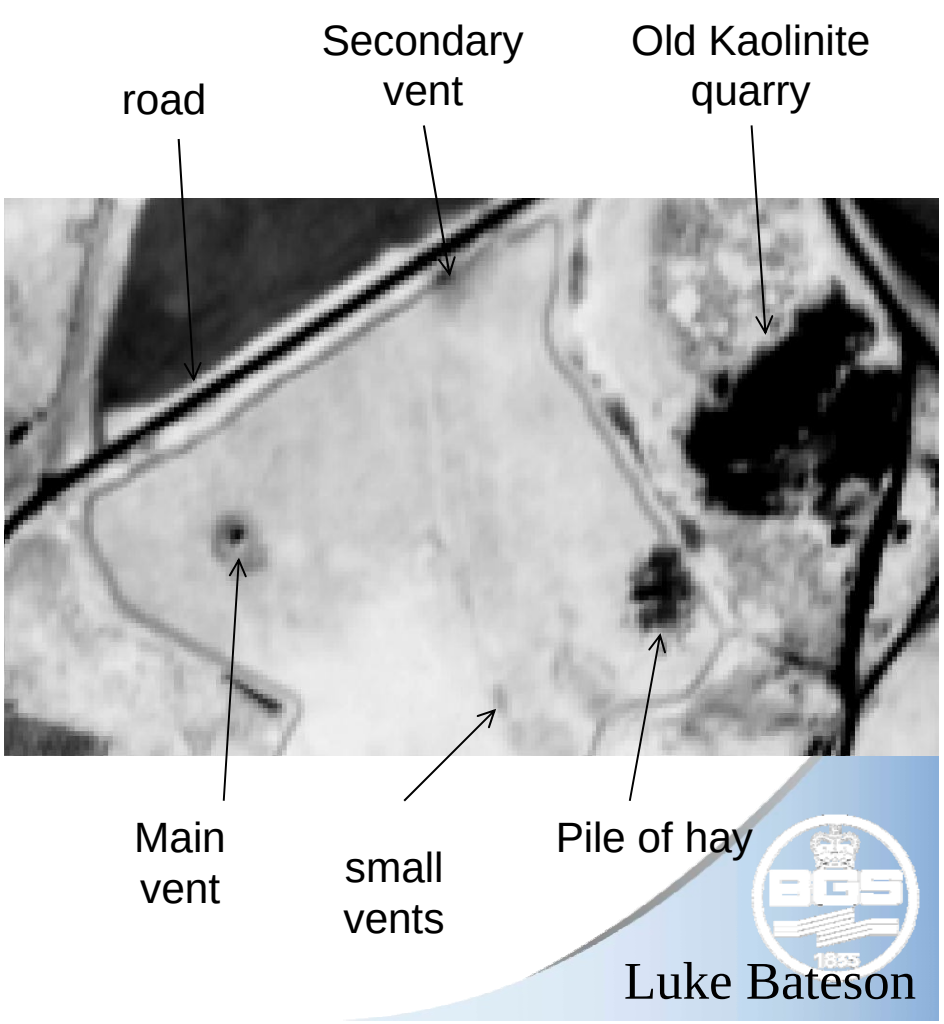
Latera Study Site

- NERC ARSF data flown in Italy in September 2007
- Ground-truthing data also collected.
  - Field spectrometer readings (ASD)
  - Soil gas flux to atmosphere
  - Soil gas compositions
  - Atmospheric monitoring
    - Weather station
    - Eddy covariance

Vegetation Health

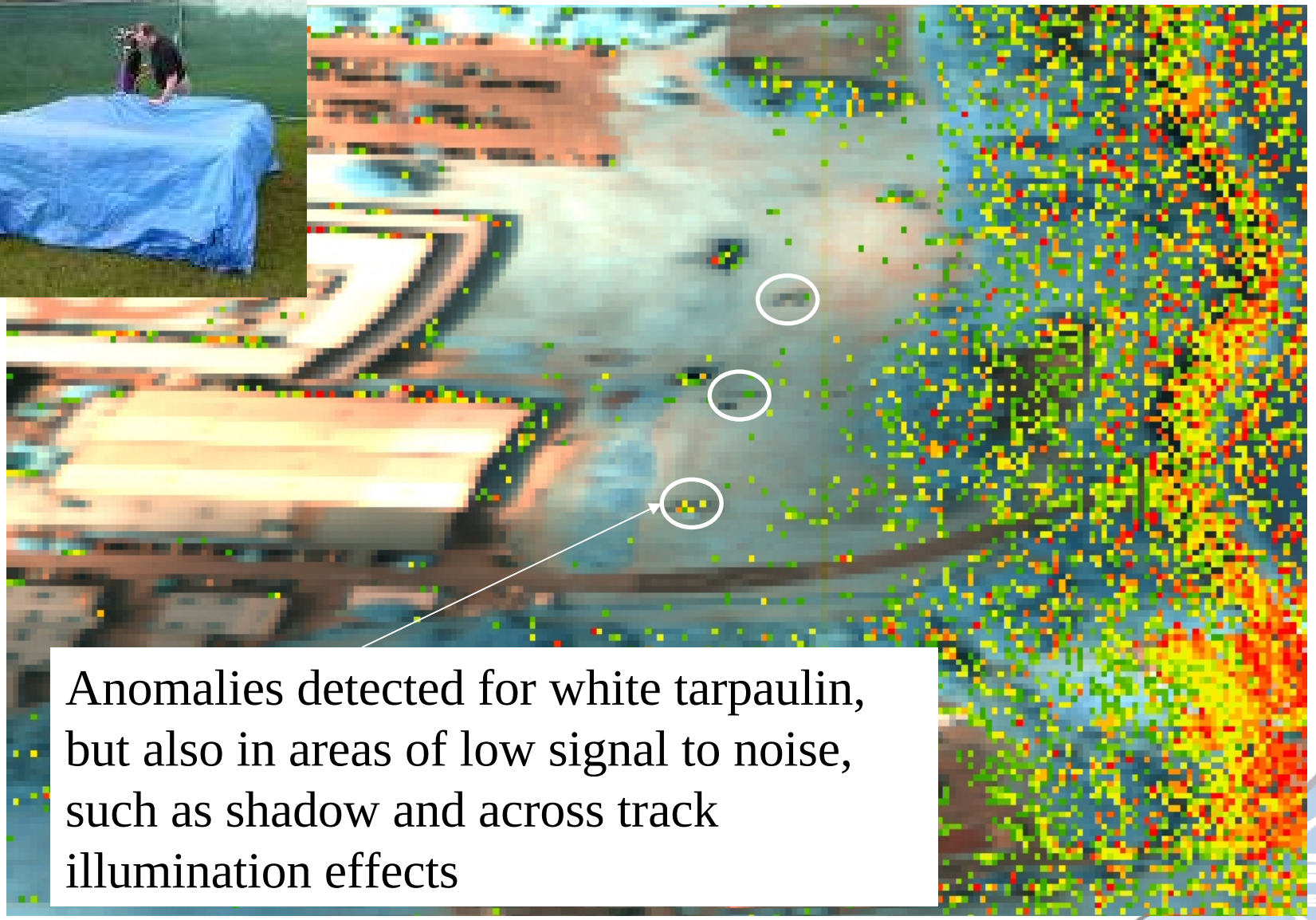
Dark areas = unhealthy vegetation

- NDVI greyscale for the main vent area



Luke Bateson

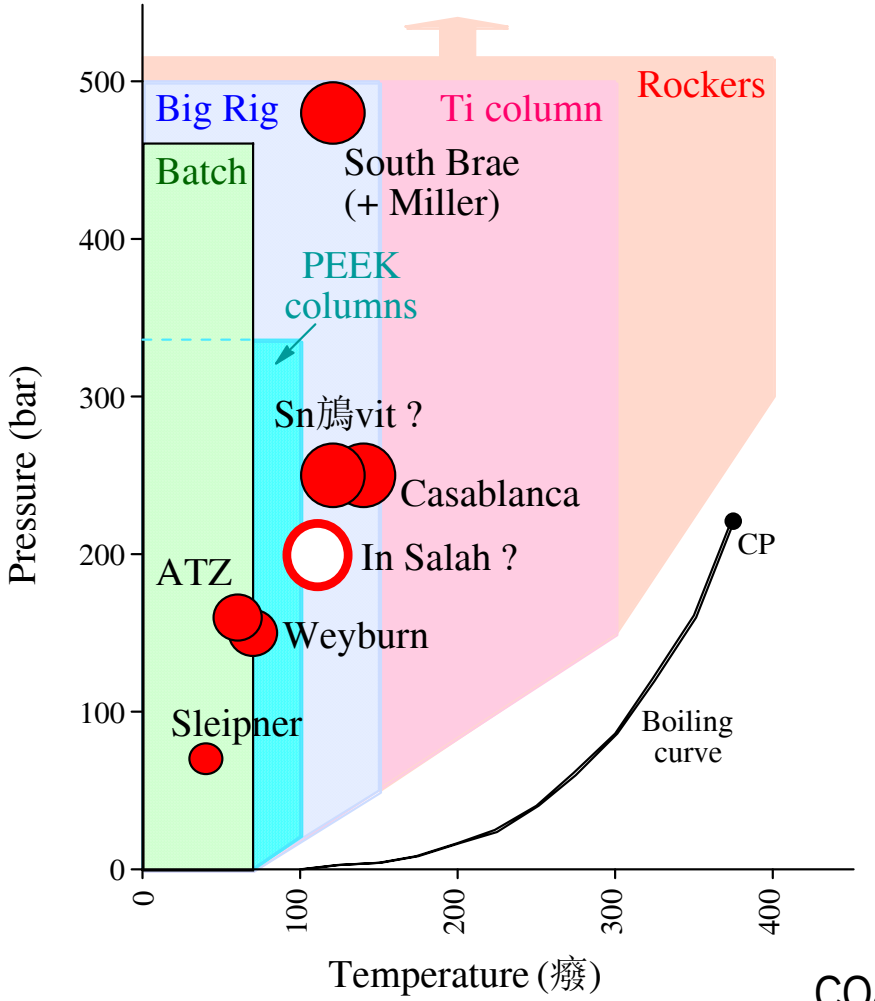
Test at BGS – **Continuum Interpolated Band Ratio** result

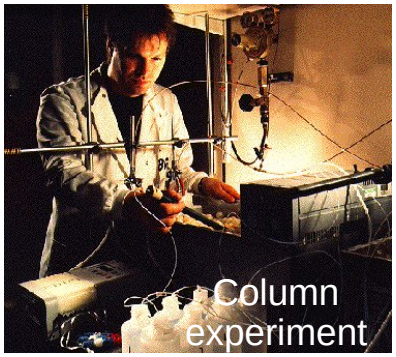


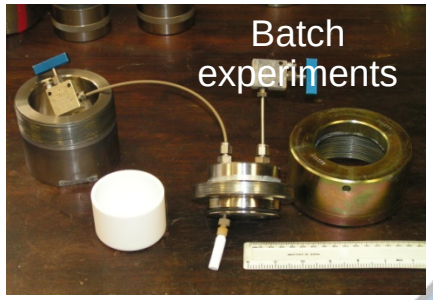
Anomalies detected for white tarpaulin, but also in areas of low signal to noise, such as shadow and across track illumination effects

BGS Hydrothermal Laboratory

CO_2-water-rock geochemistry







Site-specific studies using borehole core (e.g. Sleipner, Weyburn, Casablanca, ATZ-Austria, Snohvit).

CO_2 Storage reactions
Gas Hydrates
Geothermal systems

Cement/alkaline fluid reactions
Radioactive Waste disposal
Mineral dissolution kinetics

Keith Bateman and Chris Rochelle

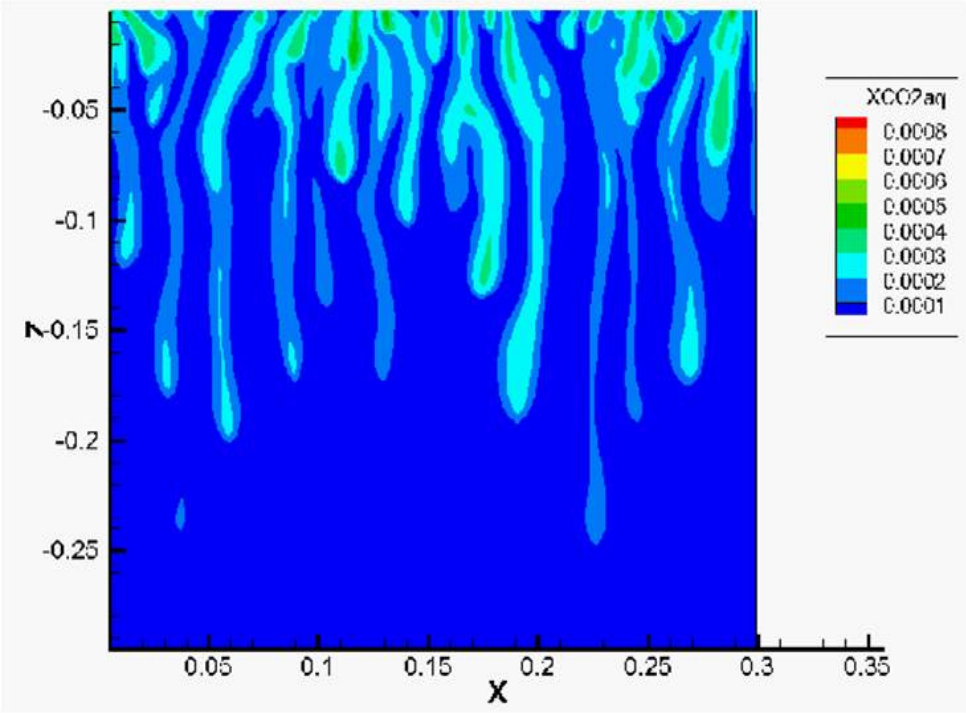
CO_2 dissolution into formation waters

Dissolution of free phase CO_2 into formation water at the base of the 'CO_2 bubble' is a key first step in the process of solubility and mineral trapping.

We need to understand how this occurs, and how to enhance the process.

Lab test timelapse sequence showing plumes of denser CO_2-rich water descending into CO_2 -poor water.

Cell = 30x30 cm, test duration = 2 hours.



TOUGH2 simulation showing very similar results to the lab experiment - increasing confidence in the ability of predictive codes to match reality.

Keith Bateman and Chris Rochelle

CO_2-cement reactions

- Previous cement studies:
  - Utilise equipment in the Hydrothermal Lab.
  - 15 years working with cements and alkaline fluids in experiments as part of UK and international radwaste programmes.
  - Long-term mineralogical changes in cements in the natural environment (analogue studies).

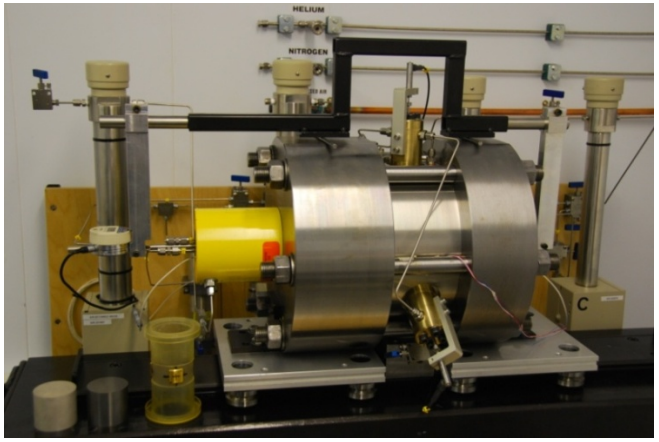
- CO_2-cement reactions:
  - Generic theoretical studies on volumetric changes.
  - Site-specific studies (e.g. Sleipner and Weyburn).
  - CO_2GeoNet project on CO_2-borehole infrastructure interactions.

Keith Bateman and Chris Rochelle

BGS Transport Properties Research Laboratory

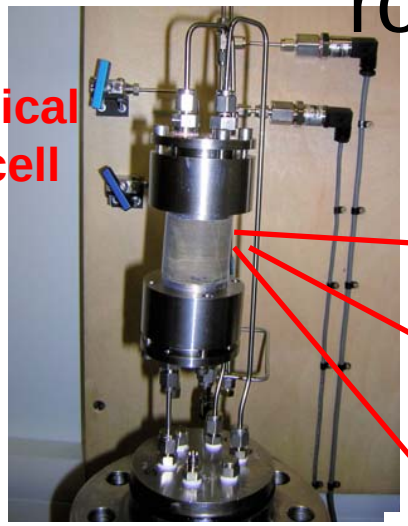
CO_2-caprock reactions:

- Generic and site-specific studies – multiphase flow in low permeability media
- Intact caprocks:
  - Fluid/gas transport parameters (such as capillary entry pressure)
- Enables assessment of seal capacity and long-term integrity
- Focus on understanding physical processes to inform models
- **Emphasis on long duration, high precision experiments**
- State of the art Super-critical CO_2 rig
- Allows testing of seal materials at a range of representative in-situ stresses and conditions
- Flow through faults, fractures and interfaces

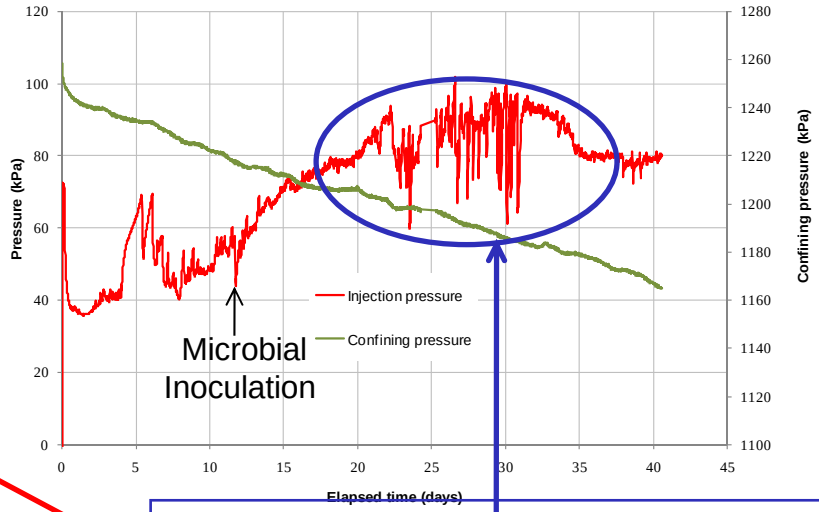


Approach for evaluating microbial impacts on rock **physical properties**

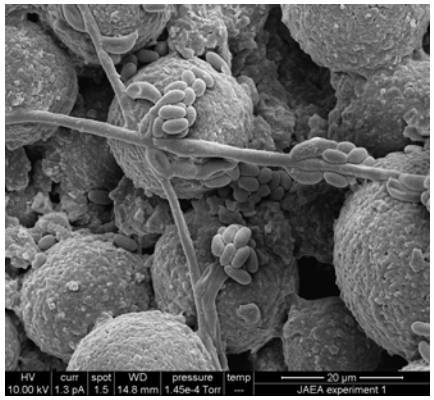
Biological flow cell



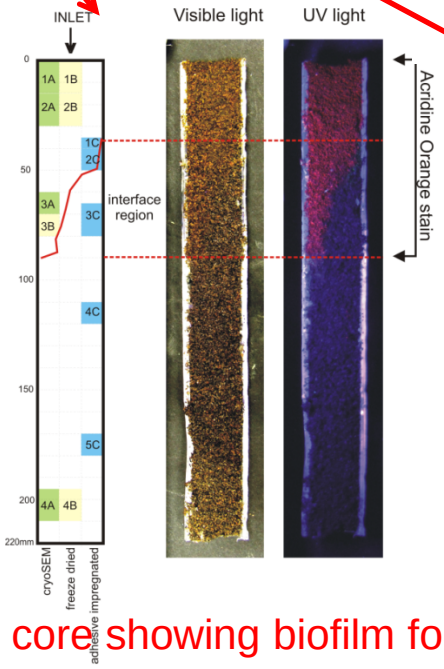
Injected with microbes



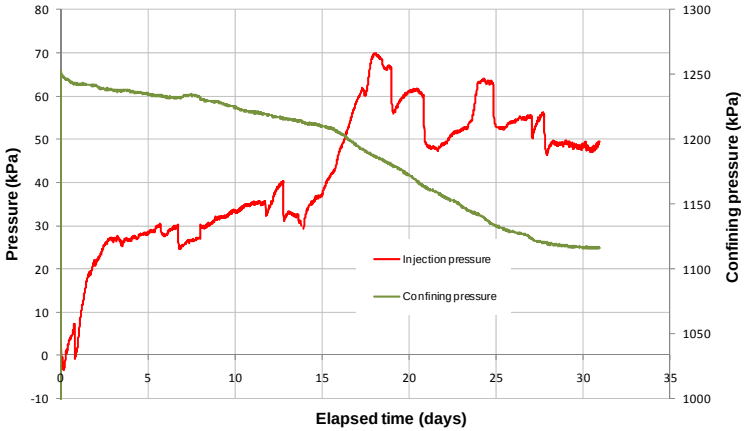
Change in flow due to cycling of biofilm formation/breakthrough of fluid



Microbes and biofilms on pyrite grains



Analysis of core showing biofilm formation



No injection of microbes

Julie West

RISCS Project

www.riscs-co2.eu

Damaged pasture from natural CO_2 seeps in northern Greece

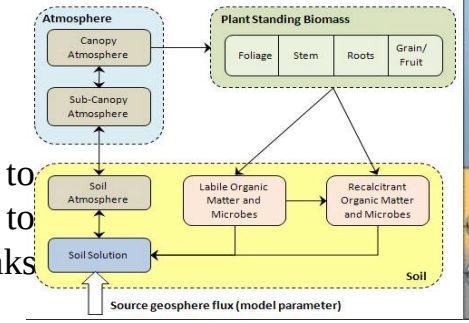
Natural CO_2 seeps near Sicilly used to investigate marine responses to CO2 leaks

Palaemon serratus, one of several marine species whose response to elevated CO_2 is being investigated

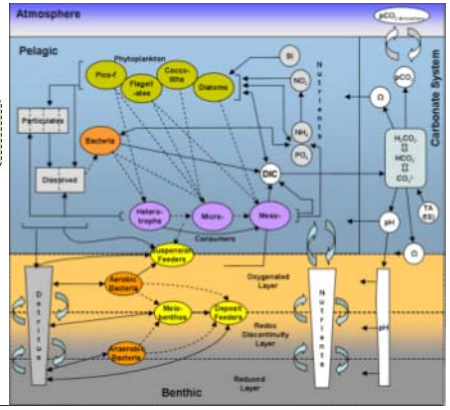
Monitoring CO_2 fluxes in experiments investigating impacts of CO_2 leaks on agricultural soils and crops

- Investigating impacts of potential leaks from storage sites to inform risk assessments

Mesocosm experiments investigating impacts of elevated CO_2 on benthic organisms. *Courtesy of Edwin Foekmar, IMARES*



Soil-plant model used to investigate plant responses to CO_2 leaks



Marine biogeochemical model for investigating marine responses to CO_2 leaks

Gas flux measurements and biological monitoring at ASGARD site (UK)

soil gas and flux monitoring techniques

Mobile open path laser tool development – In Salah, Weyburn

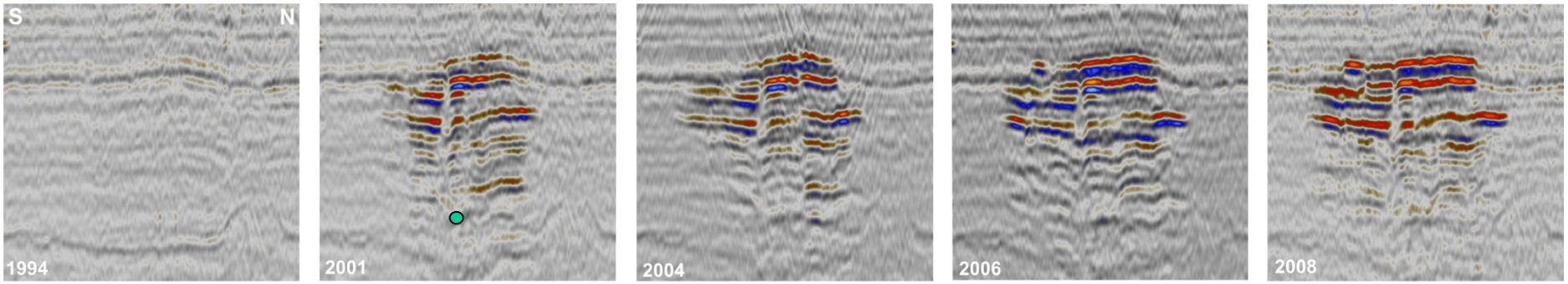
CO2 REMOVE
research monitoring verification

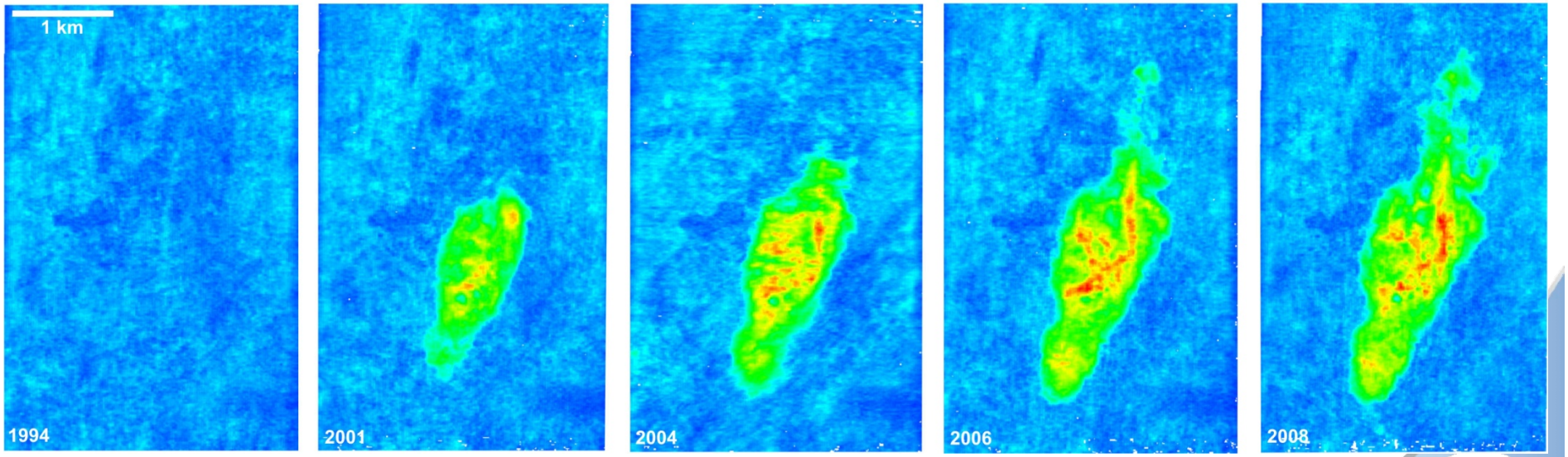
- Tool comparison and development of generic monitoring strategies
- Interpretation, modelling and assessment of site monitoring datasets at Sleipner (including 3D seismic), Weyburn and InSalah

Dave Jones

Sleipner: Imaging CO_2 in the reservoir

vertical section





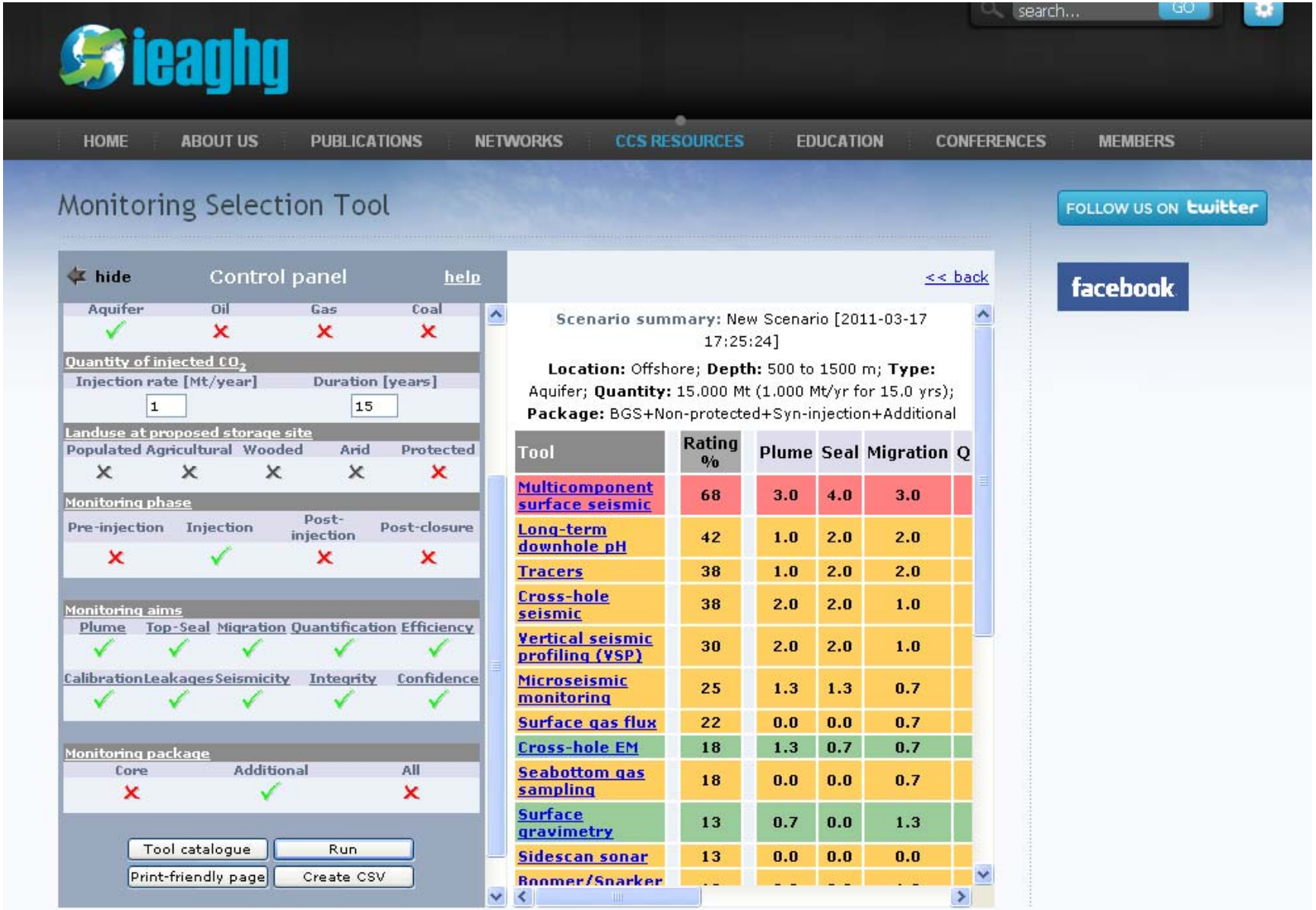
plan view

Seismic courtesy Statoil

Fieldwork

- Concentrated on sampling bleaching contacts, further ground-truthing and trying to understand what field relationships tell us

Jonathan Pearce and Gary Kirby



http://www.co2captureandstorage.info/co2monitoringtool

John Rowley and Sarah Hannis

Thank you

Useful links

- http://www.bgs.ac.uk/research/energy_co2.html
- www.co2remove.eu
- www.nzec.info
- http://www.sintef.no/projectweb/bigccs/
- http://www.sintef.no/co2fieldlab
- http://www.energytechnologies.co.uk/Home/Technology-Programmes/carbon-capture.aspx
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