Monitoring challenges for CO$_2$ storage

Opportunities to work together

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Introduction to carbon capture and storage (CCS)

At BGS we research the ways in which CO₂ can be stored in rocks under the ground.

Carbon capture and storage (CCS) is one of the ways that Britain and the world can maintain electricity supplies and economic growth while not changing the atmosphere and the climate.

CCS involves capturing carbon dioxide (CO₂) from large emission sources and then transporting and storing or burying it in a suitable deep geological formation. CCS can also mean the removal or scrubbing of CO₂ from the open atmosphere followed by storage in a deep geological formation.

Why do we need to store carbon dioxide?

Learn about the causes of climate change and the greenhouse effect, and how mankind is accelerating the process as a result of a rapid rise in world population and the need for energy to power our homes, for transport, and industry.

- What is climate change?
- How does the greenhouse effect work?
- Human influence on climate change
- How do power stations capture CO₂?

See also
- Carbon capture and storage (CCS) research
- Advanced seismic techniques
- CO₂ storage Sleipner
- UK CO₂
- Clean coal and renewables
- Reservoir geoscience in oil and gas

Video
- OICB 2007 CCS Interview Dr Sam Holloway (BGS)
- BBC CCS Interview Dr Miko Stephenson (BGS)

Magazine articles
- Clearer skies for China
Monitoring aims

• Site performance: current and future (EC Directive)
  • Image/measure CO2 in the reservoir
  • Monitor containment risks
  • Performance monitoring
  • Constrain predictions of long term site behaviour

• Enable site closure
Monitoring technology

see: IEA selection tool
http://www.co2captureandstorage.info/co2monitoringtool/index.php
CO₂ injection commenced 1996
~ 1 Mt CO₂ injected per annum
> 11 Mt currently *in situ*

**Timelapse (4D) seismic monitoring programme**

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
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<tbody>
<tr>
<td>1994</td>
<td>3D baseline</td>
</tr>
<tr>
<td>1999</td>
<td>3D</td>
</tr>
<tr>
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</tr>
<tr>
<td>2004</td>
<td>3D</td>
</tr>
<tr>
<td>2006</td>
<td>3D (+ hi-res 2D)</td>
</tr>
<tr>
<td>2008</td>
<td>3D</td>
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Image/measure CO2 in the reservoir: Sleipner 2

vertical sections (2D)

3D view

Plume in 2001

Top reservoir

Base reservoir
Image/measure CO2 in the reservoir: Sleipner 3
Containment risks: geological seal 1
Early warning of subsequent leakage

Sleipner 1996 – 2006 no detected migration of CO₂ from the reservoir
Containment risks 2: man made infrastructure

Courtesy CO2Geonet and S Bachu

Integrity monitoring CASTOR Criteria Report
Performance monitoring 1: well logs and cross hole seismic

• ALSO downhole methods at K12B

http://www.beg.utexas.edu/gccc/bookshelf/Final%20Papers/05-03-Final%20(AGU%20Papers)/05-03c-Final.pdf
Performance monitoring 2: remote sensing

- Uplift at In Salah

http://www.treuropa.com/HomeTRE/NewsEvents/Newsletter/tabid/195/newsid972/92/Default.aspx#num1
Performance monitoring 3: sea bed survey

(Hoveland, 2007)
Performance monitoring 4: sea bed survey

- Open path laser gas analysers:
  - Purpose: Rapid surveying
  - Detection limit/sensitivity
    - 5-10 ppm CO₂
    - 0.1-1 ppm CH₄
  - Readings every 1 sec
  - Linked to GPS position

Monitoring can detect CO₂ at very high sensitivities
Long term site behaviour

- Simulation of how injected CO2 disperses and gradually dissolves within a reservoir.
- Red zone illustrates free CO2 gas.
- Green zone shows dissolved CO2.
- When the gas is injected into the bottom of a reservoir it will rise to the cap rock and spread out like a bubble with a diameter of several kilometres. It will gradually dissolve in the underlying water column, and the images show how this CO2 solution eventually removes all the CO2 from underneath the rock seal and stores it like carbonated mineral water at the bottom of the formation. In this simulation it would take about 5000 years for all the CO2 to dissolve.

Courtesy Erik Lindeberg: http://www.ntnu.no/gemini/2005-01e/basicallygood.htm
Conclusions

• Need to monitor, measure and predict in line with regulatory requirements
• Monitoring tools provide different and complementary information
• Key challenge: develop site specific, cost effective monitoring strategy using correct blend
Opportunities to work together

• GCCSI
  • Just announced Aus $ 50 m/yr
    • Address generic barriers to global CCS
    • Assist projects to operation

• UK-US FCO funded colaboration
  • 1-2 week visits UK/US CCS experts
  • Deadline 13 Dec

• 2011 FP7 Cooperation Programme Theme 6
  • International research colaboration US, China, India, Russia, Latin America
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