Capturing carbon dioxide from power-station flue gases and disposing of it underground is one way of reducing anthropogenic emissions of greenhouse gases. **Andy Chadwick** describes the research carried out at the BGS to develop the technique.

Carbon capture and storage

To stabilise atmospheric concentrations of carbon dioxide (CO_2) at reasonable levels, drastic cuts in anthropogenic emissions are required in the coming decades. Large industrial point sources, particularly power stations, account for some 30 per cent of anthropogenic CO_2. Capturing CO_2 from flue gases and disposing of it underground in depleted hydrocarbon fields or saline aquifers offers a way of significantly cutting this component of greenhouse gas emissions. UK annual emissions of CO_2 exceed 500 million tonnes. Capturing and storing CO_2 from just the twenty largest industrial sources would reduce total UK emissions by around 20 per cent.

Measuring surface gas fluxes at the CO_2 injection operation at In Salah in Algeria.

The BGS has a distinguished history of research in carbon capture and storage (CCS), and co-ordinated the ground-breaking Joule 2 project — the first comprehensive technical appraisal of CCS in the mid 1990s. Since then, we have developed a worldwide reputation, actively researching into key issues facing CCS such as storage capacity, storage integrity, site monitoring methodologies and developing appropriate regulatory regimes.

In terms of estimating storage capacity, we are building 3D geological models and running numerical reservoir flow simulations to assess CO_2 plume migration in the subsurface and to calculate the pressure increases for very large-scale injection scenarios lasting many decades and involving multiple power stations.

Chemical reactions of CO_2 in the subsurface can play an important role in determining storage site security. CO_2 will initially dissolve into the saline groundwater within the pore spaces in the rock, and subsequently will tend to precipitate as carbonate minerals such as calcite — processes that will help safely trap the CO_2. The BGS is involved in exciting collaborative research with partner universities to investigate the rates and magnitudes of such reactions with a view to improving predictive computer models of CO_2 storage. We have been studying rocks in Utah as an analogue of a CO_2 storage site. Here, natural CO_2-rich waters appear to have reacted with sandstones and mudstones, and we hope that detailed analysis of their composition can provide insights into likely future reactions within a deep geological CO_2 store.

Sampling red sandstones that have been bleached to a pale buff colour by the possible former presence of CO_2-rich solutions.

In addition to the field studies, the hydrothermal laboratory at the BGS carries out long-term laboratory experiments to assess caprock sealing capacity and geochemical reactions in the reservoir. Some of our experiments


The hydrothermal laboratory at the BGS showing some of the CCS laboratory equipment.

on geological and wellbore materials from the Sleipner injection project have been running for more than five years at reservoir pressure and temperature (30°C, 80 bars). These are, we think, the longest-running CCS laboratory experiments in the world.

Storage-site monitoring is a key element in demonstrating storage integrity. The Sleipner project in the Norwegian North Sea is the world's longest-running CO_2 injection operation, and has now stored around 12 million tonnes of CO_2 in a saline aquifer some 900 metres beneath the seabed. Sleipner is being intensively monitored with a number of geophysical tools. Of these, 3D time-lapse seismic has provided dramatic images of the progressive development of the CO_2 plume in the storage aquifer. The BGS has played a central role in the interpretation of the time-lapse datasets, particularly quantitative analysis of the seismic data and history-matching the seismic images to reservoir flow simulations. From this research we are able to demonstrate that the injection project is proceeding according to plan, with no evidence of leakage from the storage formation. Ongoing CCS research at the BGS is focusing on developing suitable monitoring systems to address the recently developed regulatory requirements.

As well as the deep-focused monitoring tools which show how the CO_2 is behaving in the storage reservoir, it is also important to have effective shallow monitoring systems capable of detecting and measuring small amounts of CO_2 at the surface. Shallow monitoring helps greatly with public acceptance, and also, in the unlikely event that leakage did occur, would enable leaked CO_2 to be measured for emissions accounting purposes. The BGS is involved in surface monitoring at a number of injection sites throughout the world, and we have recently been developing a new mobile system for measuring variations in atmospheric CO_2 over wide areas above storage sites using a buggy-mounted infra-red laser.

Other BGS research activities in CCS include experimental work on the mechanisms of CO_2 flow through very low permeability rocks and field-based research into the potential impacts of CO_2 leakage on ecosystems. In summary, as CCS stands on the threshold of worldwide implementation, our current research portfolio spans the full spectrum of CO_2 storage activities, consolidating and enhancing our position as a world-leading centre for CCS.

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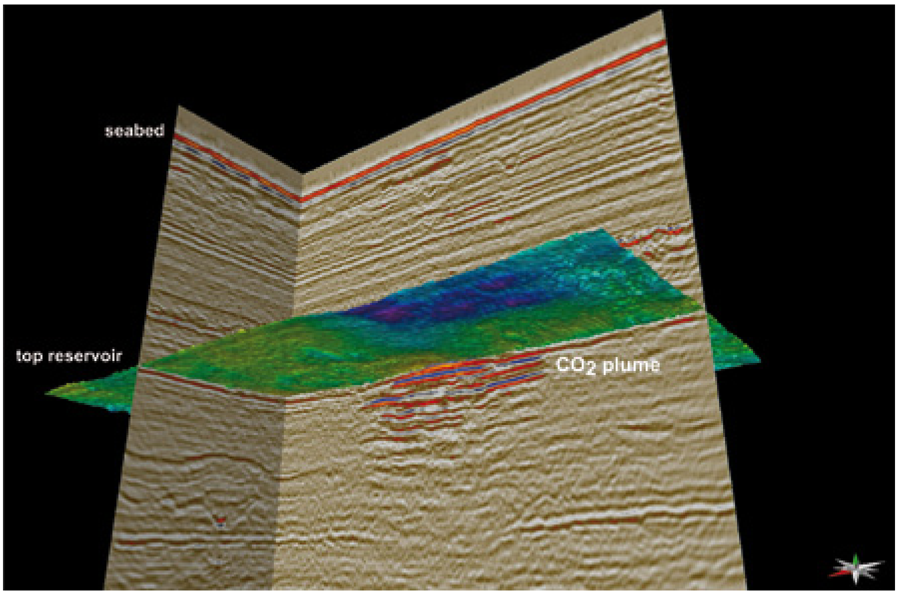

A 3D time-lapse seismic image at Sleipner from 2006, after ten years of injection. The image shows two intersecting vertical seismic sections, the mapped top reservoir surface viewed from below and very bright reflections corresponding to the CO_2 trapped within the reservoir.