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UKCCS RESEARCH CENTRE

Storage Research Projects:
Contribution of the British Geological Survey

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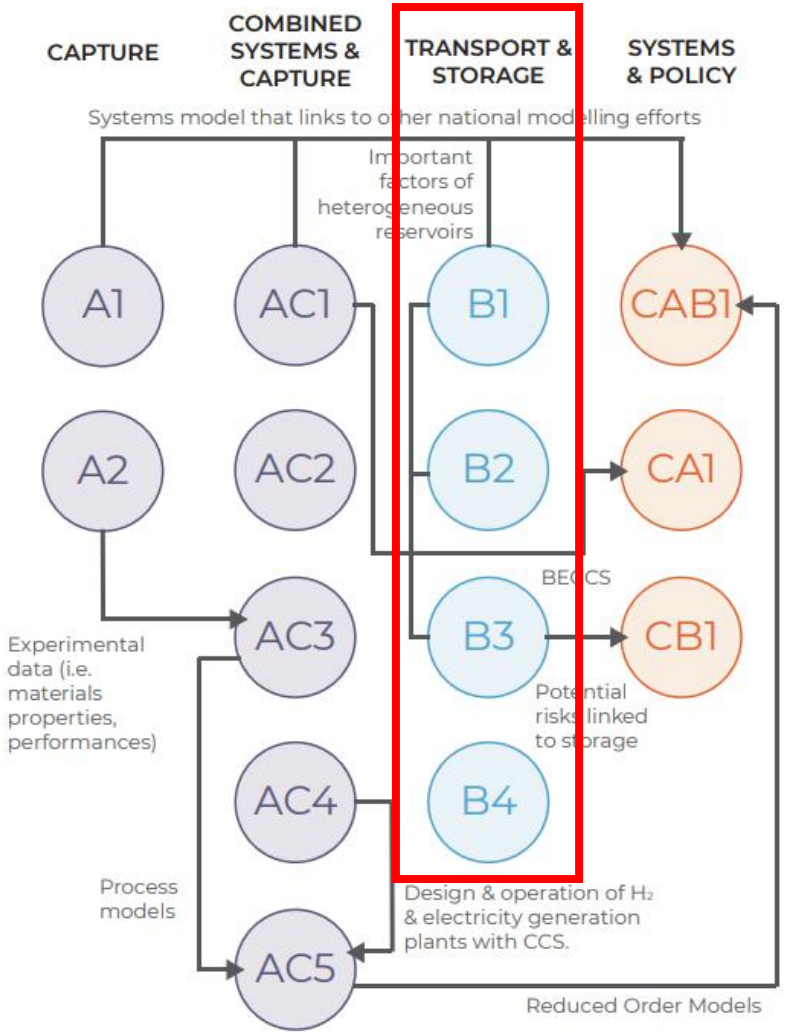
Outline of presentation



Achievements to date and ongoing progress

B1: Pressure Propagation & Control

Evaluating impact of deformation bands

B2: CO_2 Migration & Storage

Forensic analysis of 3D seismic data

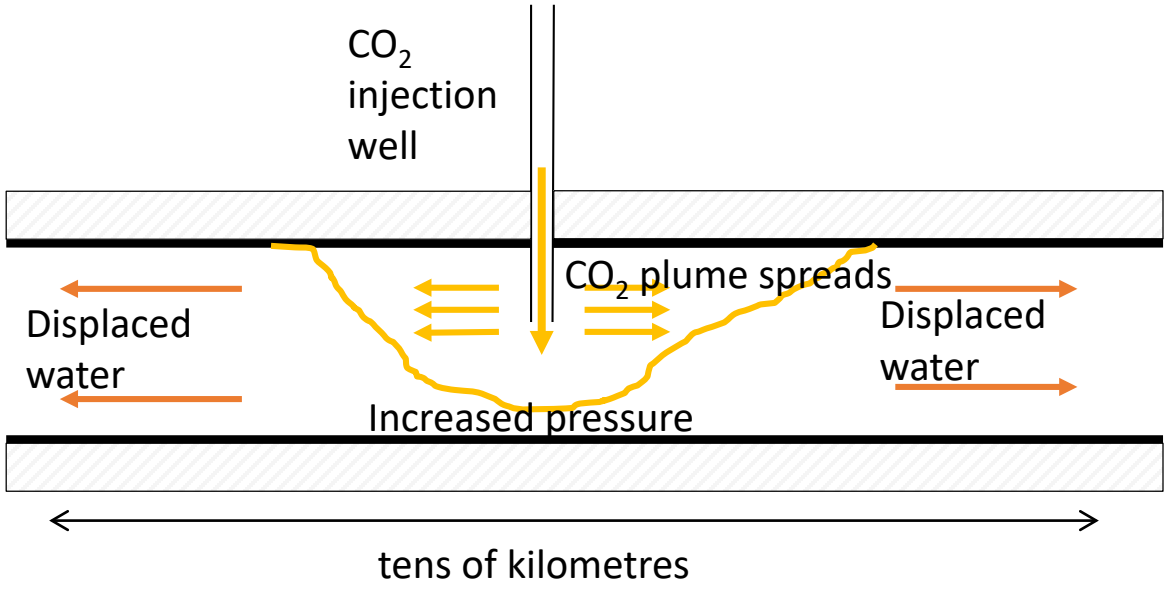
B3: CO_2 Modelling Software Assessment

Impact of parameter uncertainty in Multiphase flow models

B4: Scoping/Development of a Proposed CO_2GeoLab

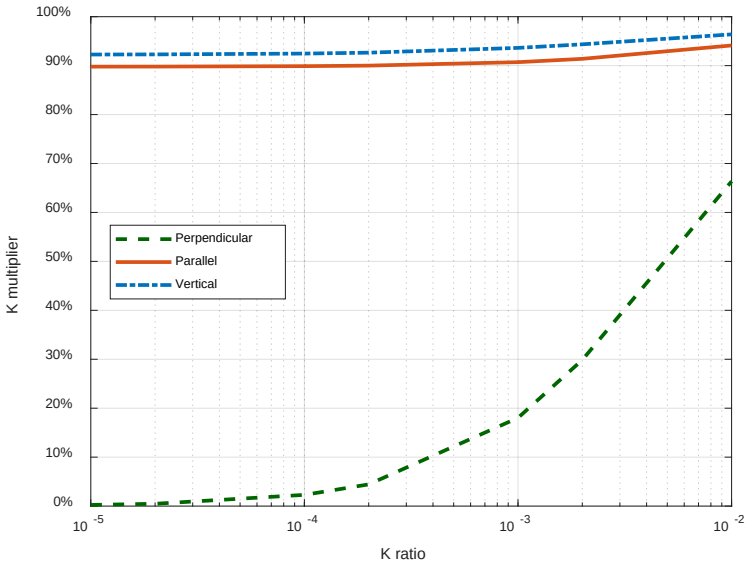
B1: Impact of deformation Bands

- Developed an analytical and numerical upscaling approach to assess the impact of deformation bands on bulk reservoir permeability
- Thick reservoirs such as Permo-Triassic saline aquifer
- Focus on fault damage zones and reservoir rocks *between* the faults *not the faults themselves*



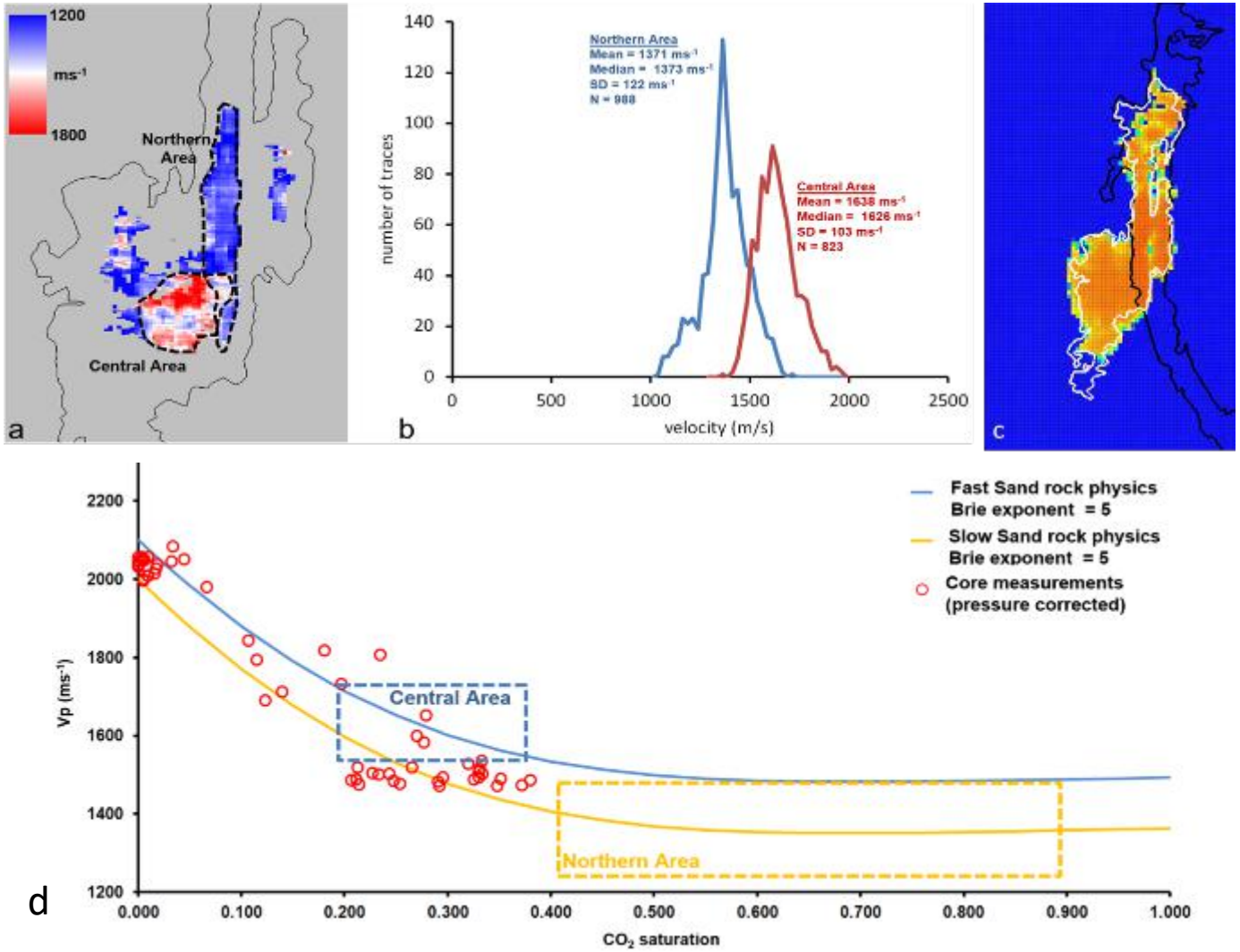
B1: Impact of deformation bands

- Three-sequential modelling stages based on field data acquisition and 3D seismic analysis
- Derived a Permeability (K) multiplier to account for pervasive deformation bands
- Calculated in three orthogonal directions
- Deformation bands can reduce average bulk permeability by up to 3 orders of magnitude
- Data-driven upscaling methodology can inform CO_2 storage capacity estimates



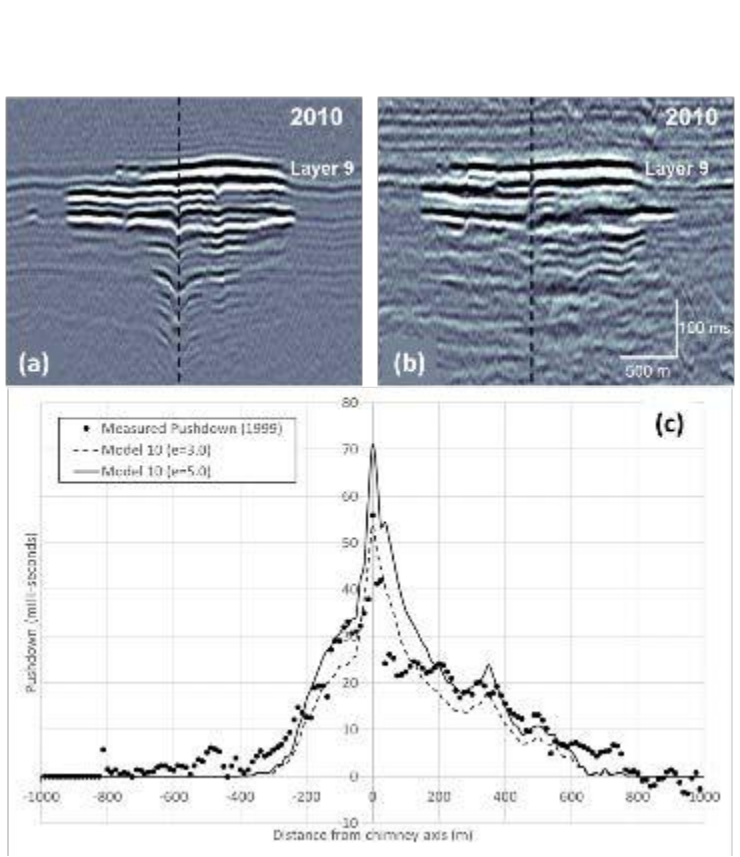
Fine-scale (2 m) → Outcrop model (~100 m) → Reservoir model (10 km)

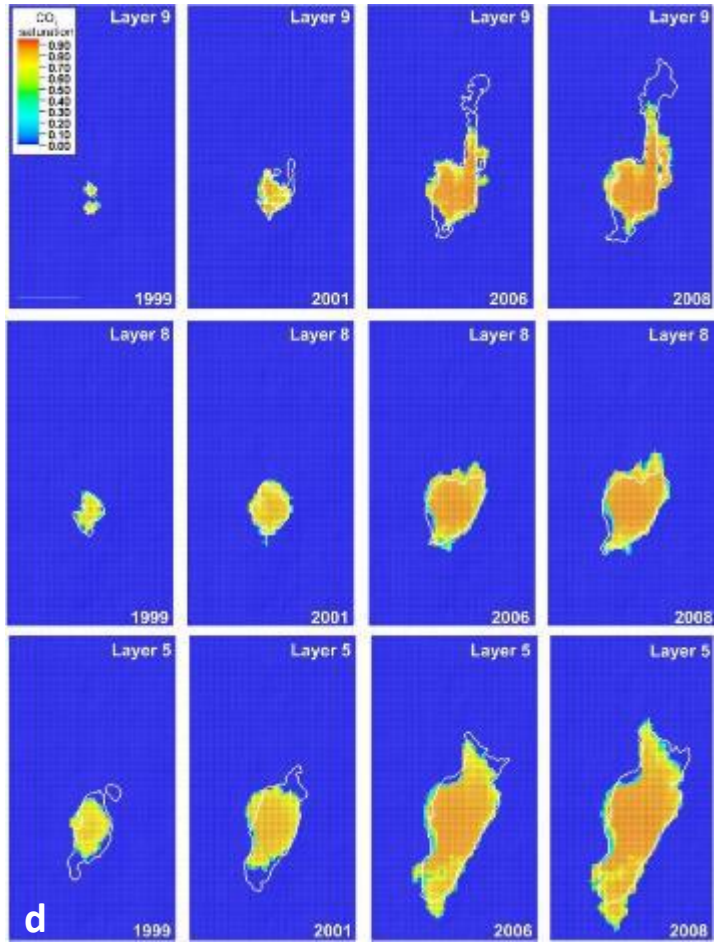
B2: Seismic velocity heterogeneity at Sleipner



- Layer velocities calculated from high-resolution seismic
- Two spatially distinct velocity regions (a northern area and central area with higher velocities)
- A channel feature interpreted correlates with low velocity sands of the northern area
- Incorporating the channel in reservoir models greatly improves understanding of CO_2 migration processes and improves predictive capabilities

B2: Chimneys and channels at Sleipner

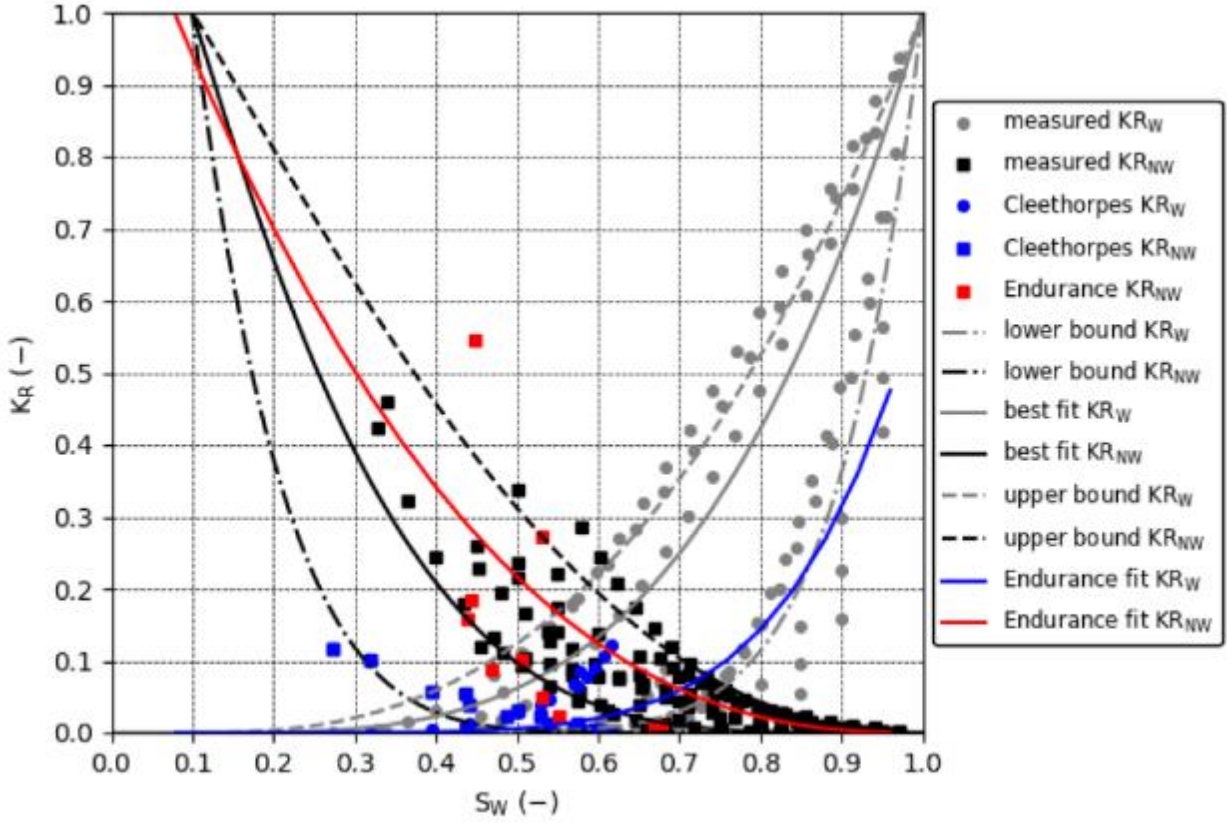




- Seismic observations on reservoir structure and heterogeneity used to develop improved reservoir models that capture CO_2 migration and storage processes
- Simulations using new reservoir models show markedly improved history-matches for key CO_2 layers
- Synthetic seismograms calibrated by laboratory rock physics data provide strikingly good matches to observed seismic monitoring datasets both in terms of reflectivity and time-shifts

B3: Review of key model parameters

- How sensitive are current simulation models to multiphase flow-parameter uncertainty in Bunter Sandstone Formation?
- Review of petrophysical model parameters and CO_2-brine relative permeability measurements
- Ongoing work with Imperial College to characterise transport and multiphase flow in Bunter Sandstone
- Update current models to improve confidence in storage capacity estimates



B4: Scoping for a UK storage pilot

Why?

To provide a research facility which contributes to enabling large-scale offshore CO_2 storage on the UKCS

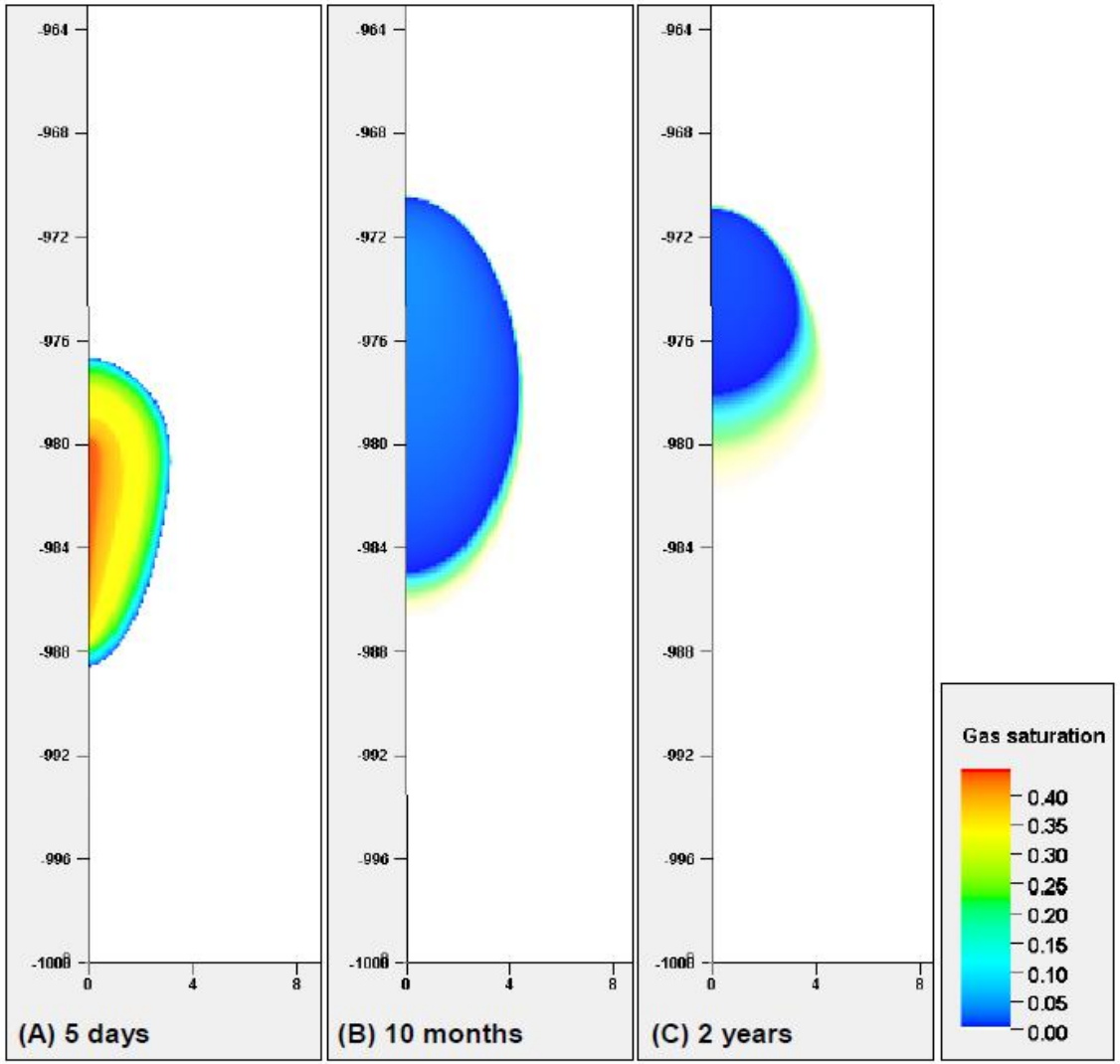
- Enable the UK to take a lead through developing flagship CO_2 storage research infrastructure
- Demonstrate that CO_2 injection in the UKCS is a viable proposition – prove injectivity and storage capacity
- Support policy by providing test for site abandonment and long-term liability issues
- A facility where we can undertake high-value activities which might be deemed too high risk to full-scale first-of-a-kind projects

Initial storage pilot concept

- CO_2 injection well designed for the UK Geoenergy Observatories (UKGEOS) site in Cheshire
  - £31M capital infrastructure project
- A network of 50 boreholes designed to study how the underground environment changes with time
- The CCS concept comprised a single 800–900 m well with injection (push-pull) experiment in the Collyhurst Sandstone
- Fluid-flow simulation undertaken to review vertical CO_2 migration (10 T CO_2 injected)
- Designs reviewed and costed, but the CCS component *was not* taken forward to planning stage

- No plans for CO_2 injection as part of the recently awarded planning application!

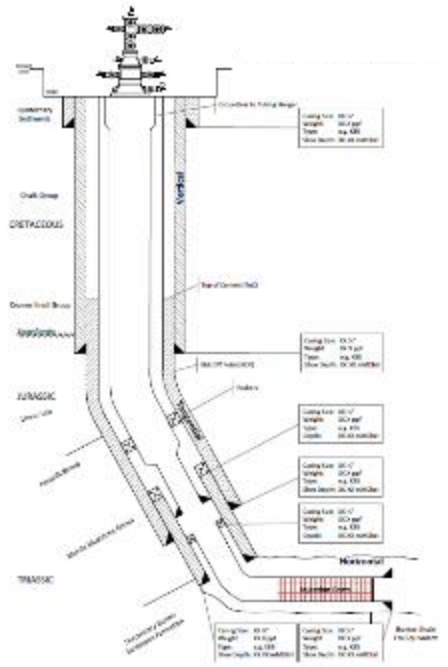
- (https://www.ukgeos.ac.uk/observatories/Cheshire)

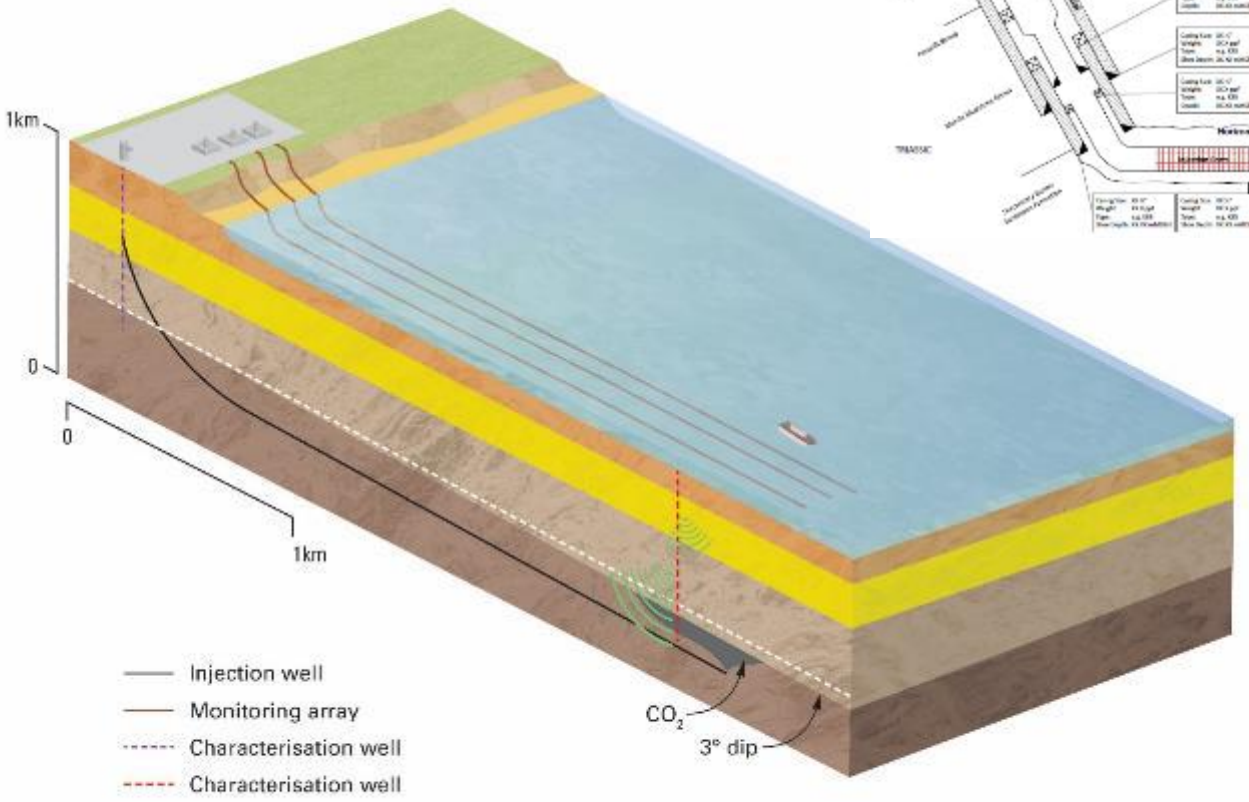


East Coast Pilot Project Concept

- Support Southern North Sea storage in the Bunter Sandstone
- Injection from on-to-offshore
  - remove technical obstacles whilst maximising scientific gain
- Near shore site with continuous monitoring
- Injection of ~15,000 T staged over 2 or 3 injection periods

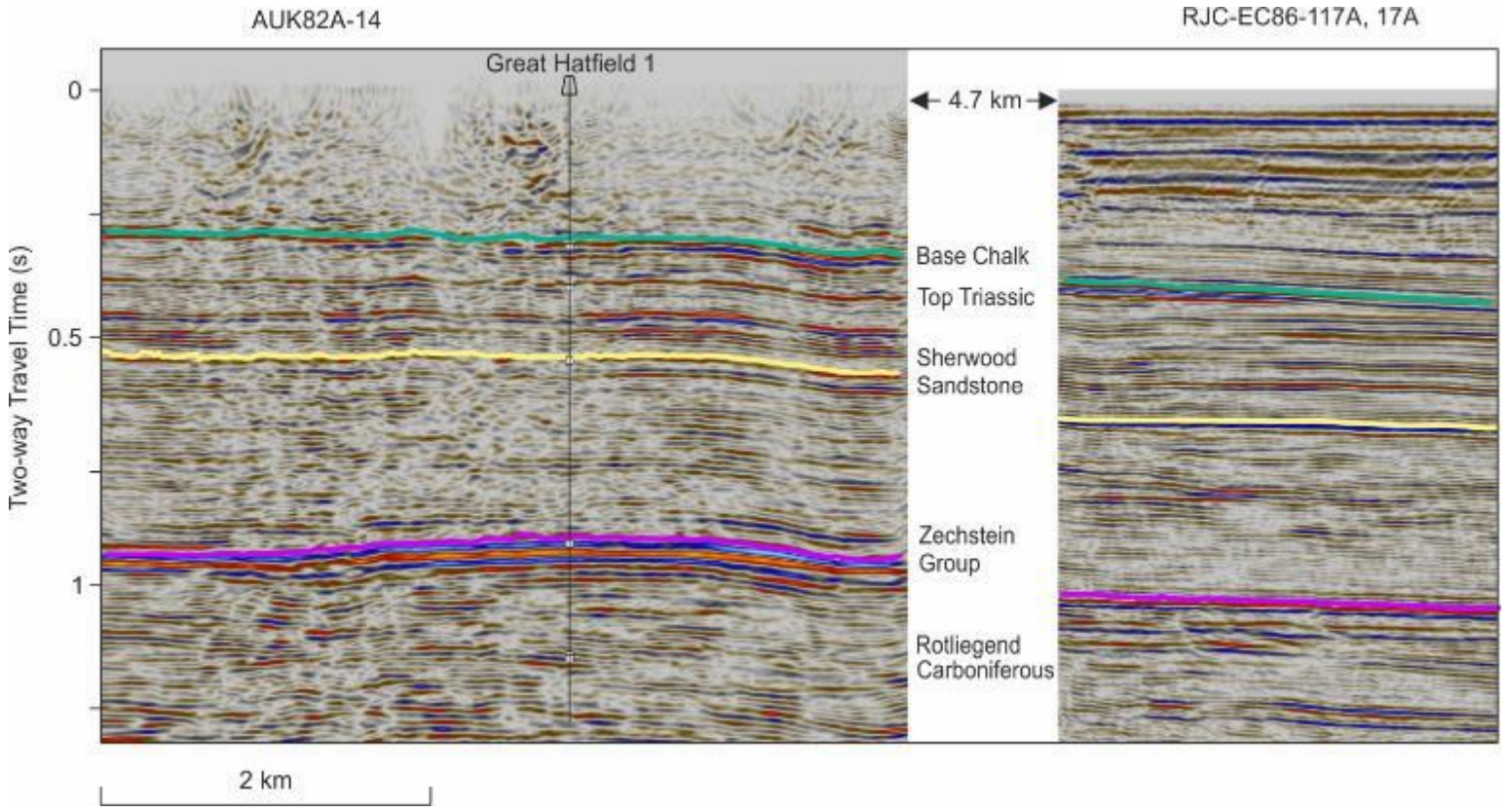
- Sites on the east coast offer potential for storage of dense phase CO_2
- Gently dipping seal allows migrating CO_2 to be tracked

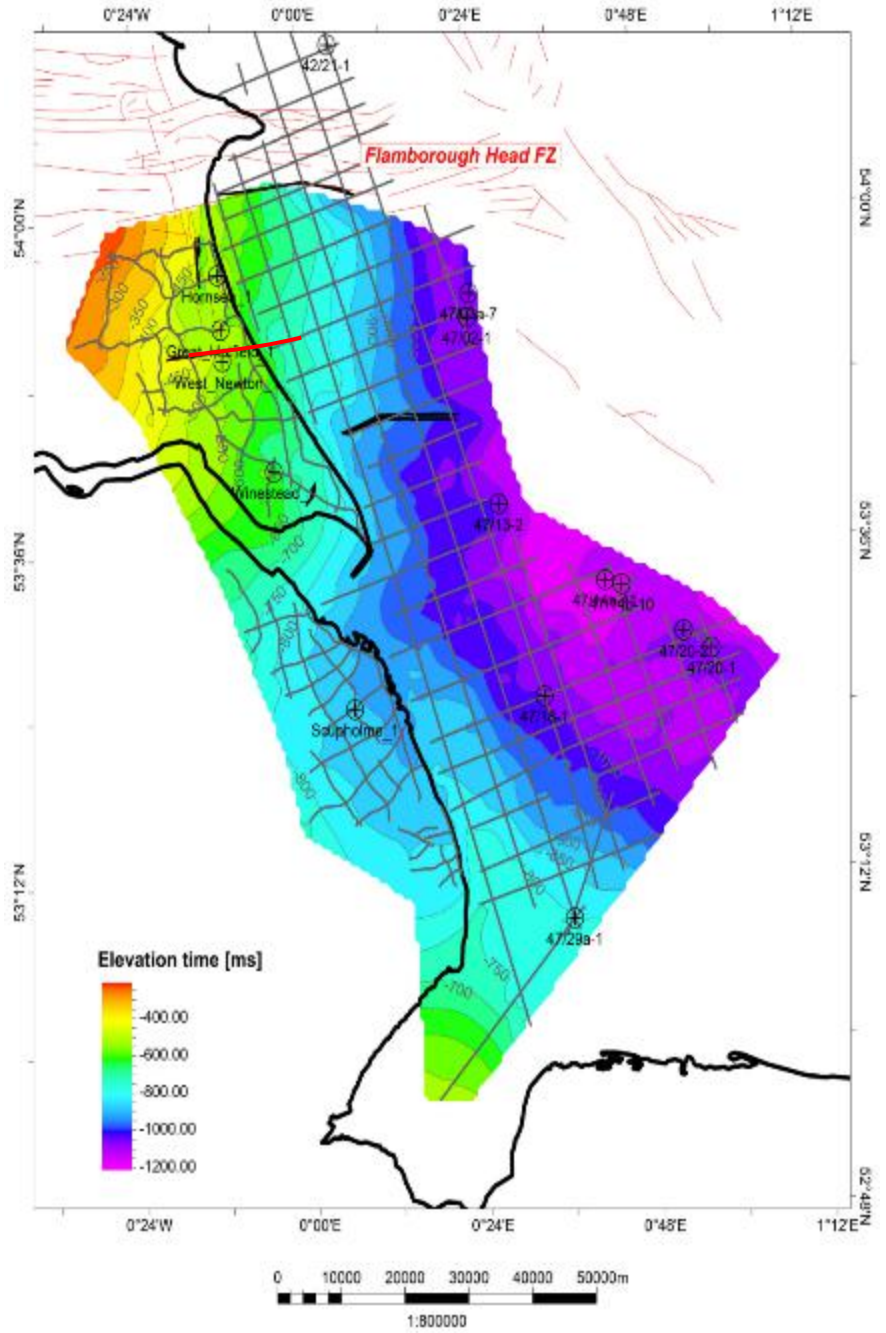




Geological considerations

- East Riding and Lincolnshire ideal
- Favourable depth and thickness of Sherwood Sandstone, limited structural complexity



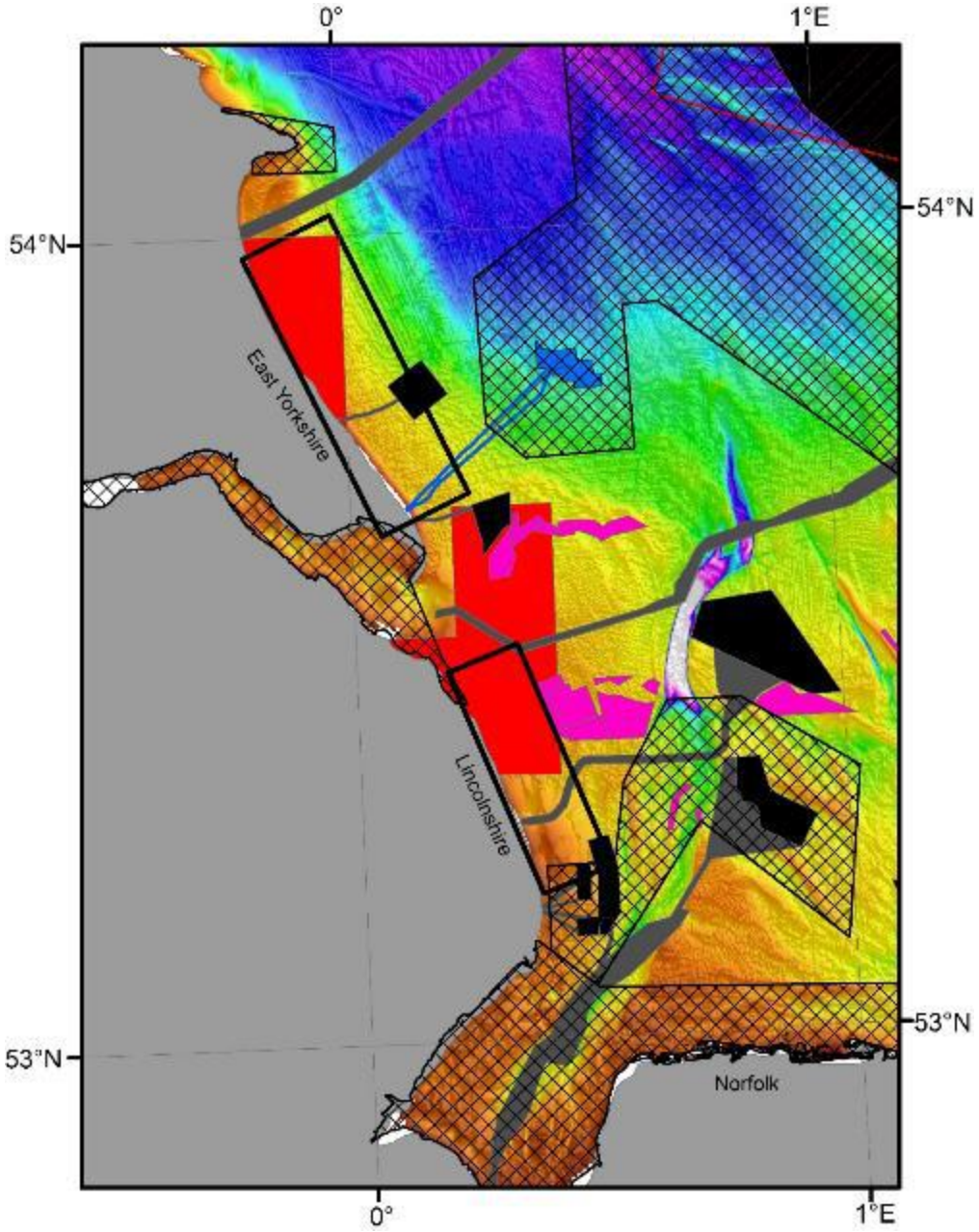


Scientific Objectives

- Downhole monitoring using seismic imaging and velocity tomography
- Sparse semi-permanent seabed monitoring systems
- New offshore monitoring concepts in shallow water
- Continuous, real-time monitoring methods to inform conformance schemes
- Machine learning and artificial intelligence tools for subsurface monitoring
- Reservoir processes and trapping mechanisms
- Long-term fate of carbon dioxide in the reservoir
- Community engagement – social research in the community

Scoping studies to inform location

- Regional geological screening and mapping
- Marine environment data and baseline desk study
  - Special areas of conservation, windfarms, extraction licences, MoD exclusion zones
- Location insight study: Political, social, economic and geographic considerations influencing the siting of a CO_2 storage pilot on the East Coast
  - East Lindsey District Council and East Riding of Yorkshire County Council
  - Identified potential areas in each council – slight leaning towards East Riding
  - Next steps include shortlisting and detailed PESTLE analysis



East Coast Storage Pilot – Next steps

- Exploration of opportunities for capital funding
  - Early discussions with NERC
  - UKGEOS is one funding model
  - Industrial Strategy Challenge Fund, Mission Innovation
- Engagement with UK CCS Community
  - Consolidate concept through feedback and discussion
  - Ensure that the pilot supports, and not competes with commercial deployment
  - An opportunity to develop research facility for the CO_2 storage community
- Development of detailed technical plans and supporting science case
- How might we cost-effectively obtain and transport 15Kt CO_2?

High-level objectives

- Reduce risks and demonstrate low-cost, safe injection to enable further offshore development
- Support Clean Growth Plan
- Implement part of CCUS Taskforce recommendations:
  - Separated T&S infrastructure
  - Test business model viability
- The Committee on Climate Change recommends that the first clusters are operational by 2026
- Storage pilot seen as a stepping stone to achieving 10 Mt CO_2 pa by 2030 (CCTF report, 2018)
- Not a replacement for full-scale deployment but important facility for developing storage potential

High-level benefits

- By developing its own storage site the UK can:
  - Increase confidence for specific geological formations that can be used for future CO_2 storage
  - Secure inward investment by offering opportunities for collaboration with the best R&D groups globally
  - Increase capability, knowledge and expertise for CO_2 storage site development
  - Contribute to implementation of the European Strategic Technology (SET) Plan
  - Support UK transport and storage infrastructure

Contact points for East Coast Storage Pilot

- John Williams (jdow@bgs.ac.uk)
- Jonathan Pearce (jmpe@bgs.ac.uk)
- Jim White (jame3@bgs.ac.uk)

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Peer-reviewed papers

Vosper, H., Chadwick, R.A., Williams, G.A. 2018. CO_2 plume migration in underground CO_2 storage: The effects of induced hydraulic gradients. *International Journal of Greenhouse Gas Control*, **74**, 271–281.

Chadwick, R.A., Williams, G.A., Falcon-Suarez, I. 2019. Forensic mapping of seismic velocity heterogeneity in a CO_2 layer at the Sleipner CO_2 storage operation, North Sea, using time-lapse seismics. *International Journal of Greenhouse Gas Control*, **90**, 102793.

Conference papers

Vosper, H. 2018. The impact of deformation bands in fault zones on permeability: an upscaling approach. *Handling fault seals, baffles, barriers and conduits, Geological Society, London, 15-17th November 2017*.

Chadwick, R.A., Williams, G.A. 2018. Forensic mapping of spatial velocity heterogeneity in a CO_2 layer at Sleipner using time-lapse 3D seismic monitoring. *EAGE Fifth CO_2 Geological Storage Workshop, Utrecht, 21-23rd November 2018*.

Williams, G.A., Chadwick, R.A. 2018. Chimneys and channels: History matching the growing CO_2 plume at the Sleipner storage site. *EAGE Fifth CO_2 Geological Storage Workshop, Utrecht, 21-23rd November 2018*.