CO_2 Storage R&D Current and Future Developments

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IEA Greenhouse Gas R&D Programme

CTS Workshop, IEA, Paris

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Storage Developments

- Monitoring
- Modelling
- Risk Assessments and Management
- Future Developments

IEA Greenhouse Gas R&D Programme (IEAGHG)

- A collaborative international research programme founded in 1991
- Aim: To provide information on the role that technology can play in reducing greenhouse gas emissions from use of fossil fuels.
- Focus is on Carbon Dioxide Capture and Storage (CCS)
- Producing information that is:
  - ✓ Objective, trustworthy, independent
  - ✓ Policy relevant but NOT policy prescriptive
  - ✓ Reviewed by external Expert Reviewers

Southern Company

Chevron

TOTAL

CIAB

ExxonMobil

Masdar INSTITUTE

J-POWER

ieaghg

EPRI

JÜLICH FORSCHUNGSZENTRUM

DOOSAN Doosan Babcock

Statoil

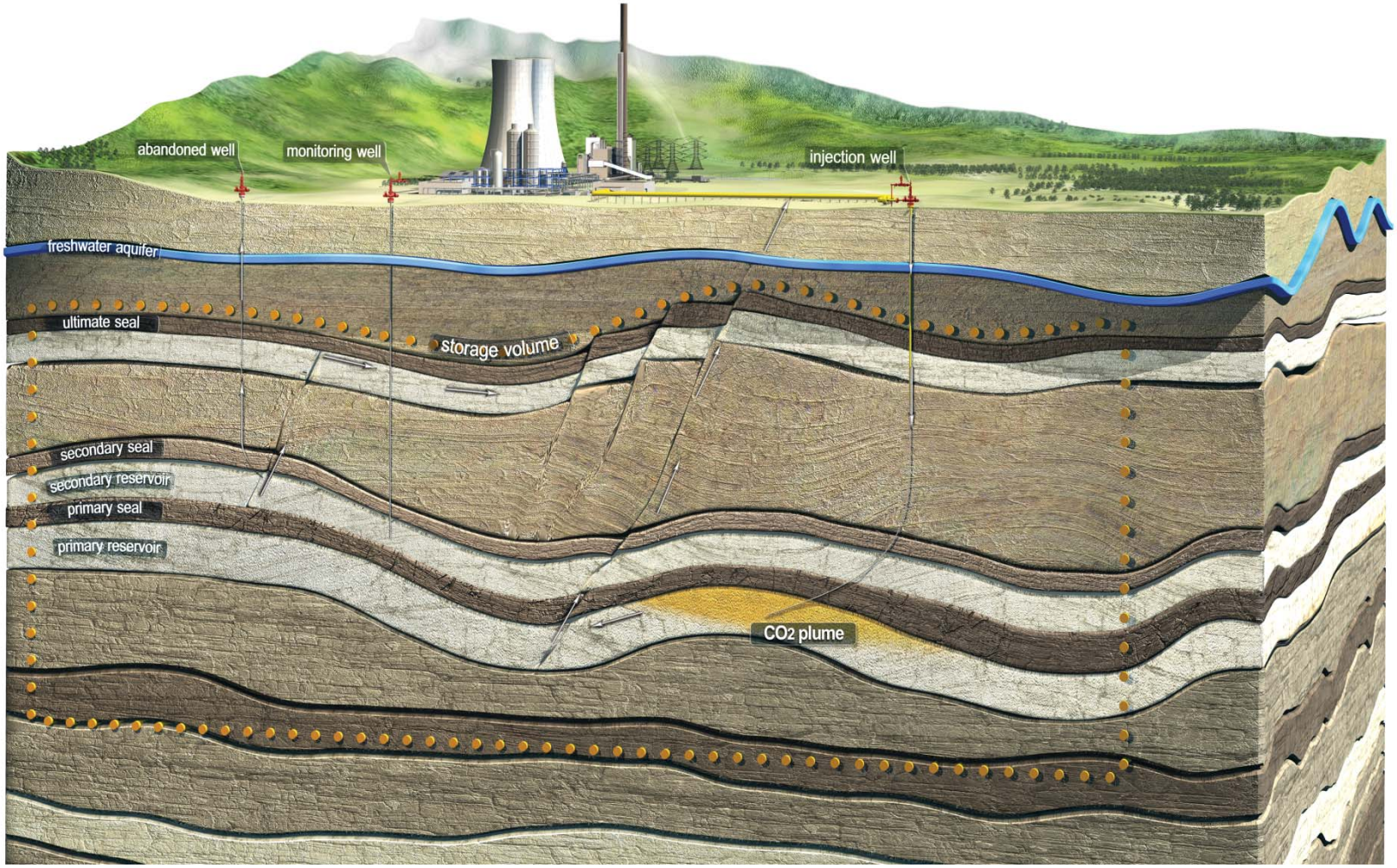
PETROBRAS

INSTITUTO DE INVESTIGACIONES ELECTRICAS

JGC

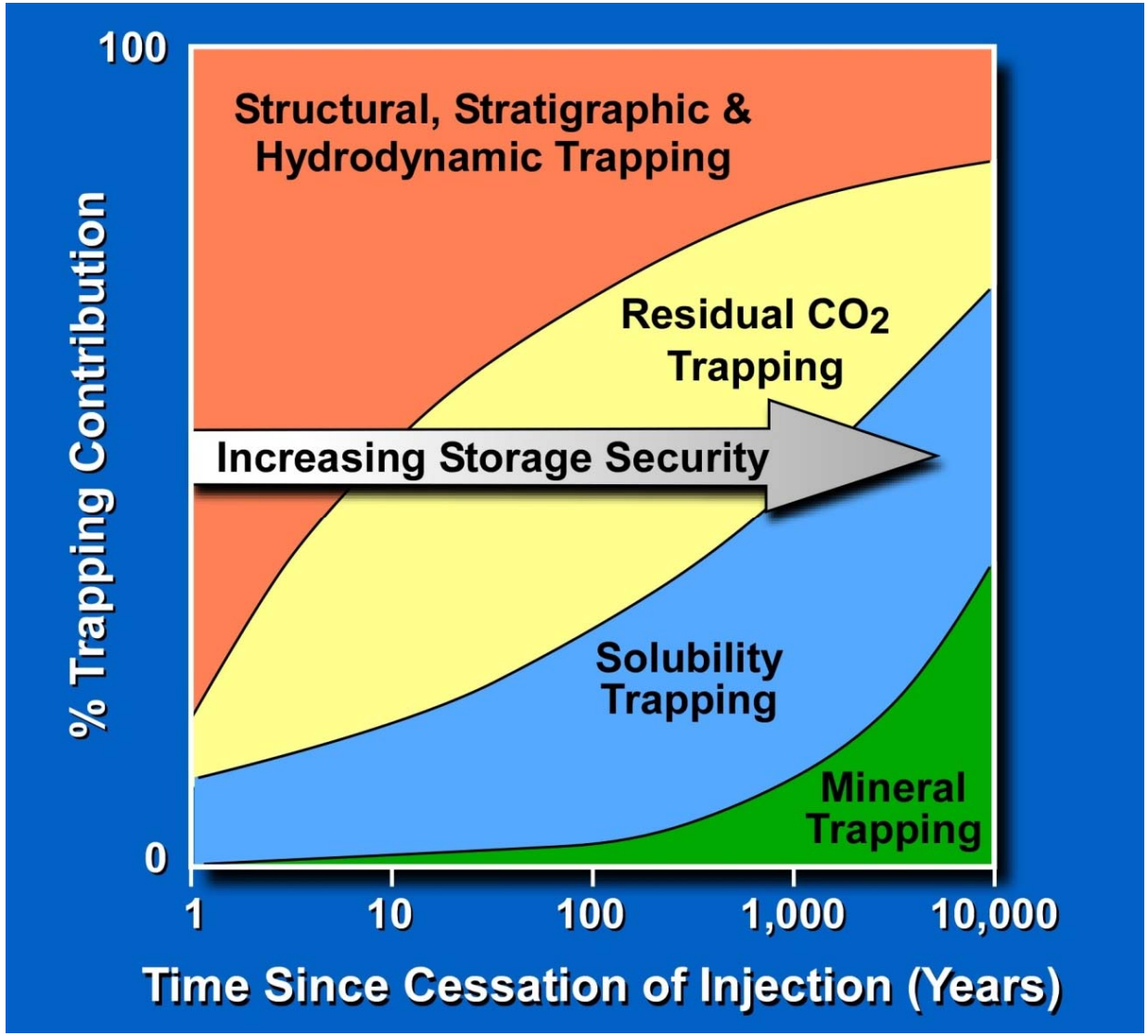
RWE The energy to lead

Modelling and Monitoring



Source: DNV

CO_2 Storage Trapping Mechanisms



From IPCC SR CCS, 2005

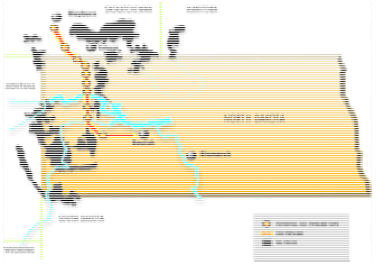
Demonstration of Storage at Large-scale

Sleipner
1Mt/y CO_2

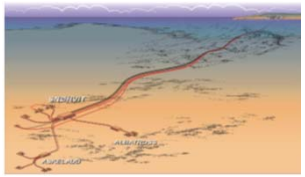
Weyburn
2.5 Mt/y CO_2

In-Salah
1.2 Mt/y CO_2

Snohvit
0.7Mt/y CO_2



350km overland pipeline

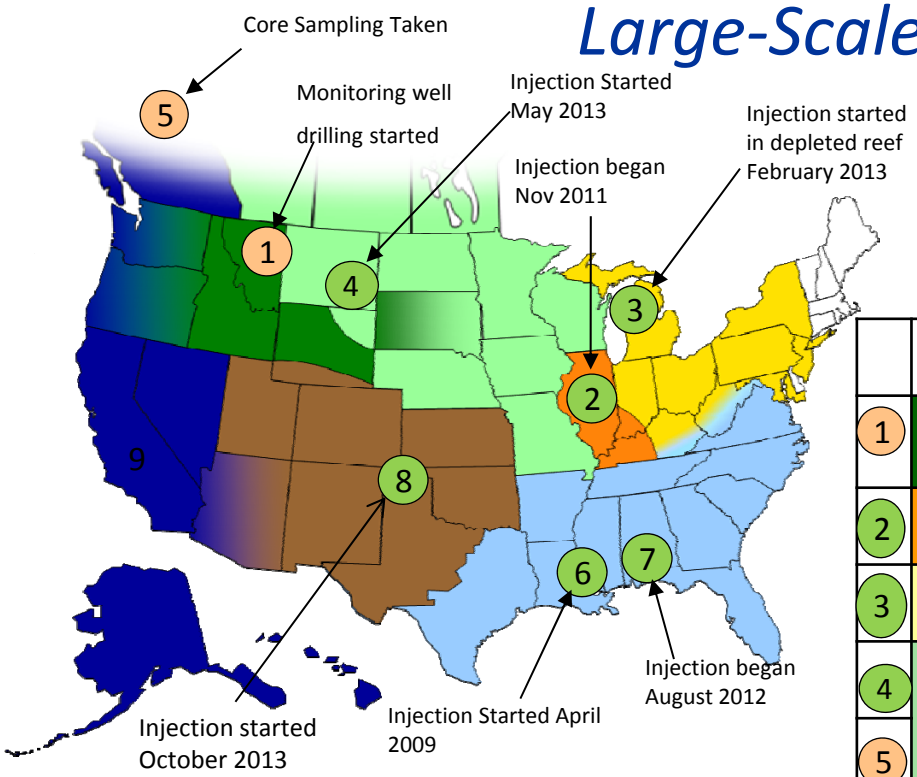


160km sub sea pipeline

1996 1998 **2000** 2002 **2004** 2006 **2008** 2010 2012 2014 2016 2018

RCSP Phase III: Development Phase

Large-Scale Geologic Tests



Injection Ongoing

Injection Scheduled 2013-2015

Note: Some locations presented on map may differ from final injection location

- ✓ *Large-volume tests*
- ✓ *Four Partnerships currently injecting CO_2*
- ✓ *Remaining injections scheduled 2013-2015*

	Partnership	Field Project – Geologic Formation	Metric Tons Injected to Date
1	Big Sky	Kevin Dome- Duperow Formation	0
2	MGSC	Illinois Basin Decatur- Mt. Simon Sandstone	> 850,000
3	MRCSP	Michigan Basin - Niagaran Reef	> 234,000
4	PCOR	Bell Creek - Muddy Sandstone	> 741,000
5		Fort Nelson - Sulfur Point Formation	0
6	SECARB	Early Test (Cranfield Field) - Tuscaloosa Formation	> 4,300,000
7		Anthropogenic Test (Citronelle Field) – Paluxy Formation	> 100,000
8	SWP	Farnsworth Unit - Morrow Formation	> 102,000
	WESTCARB	Regional Characterization	

Courtesy NETL 2014

Monitoring Network and Modelling Network - Combined Meeting

Hosts: BGS, SCCS

Sponsors: UKCCSRC, US DOE, MSG GSL

6th - 8th July 2016

Edinburgh, UK

www.ieaghg.org

Monitoring Network

Technical Sessions relating to Monitoring

- Monitoring Seismicity
- Novel and Distributed Techniques
- Reducing Monitoring Costs
- Near-surface Monitoring – Long-term Natural Variability
- EOR Monitoring, Reporting and Verification Plan - discussion
- Ongoing Injection Projects
- Closed and Post-injection Projects
- Use and Application of Pressure Measurements

Monitoring - Overall Key Messages & Conclusions

- Monitoring optimization to reduce costs – Quest MMV and EOR MRV
- Benefits being demonstrated by permanent installation of fibre-optic distributed acoustic sensors (DAS), and some limitations, and developments such as helical fibres.
- Temporal and spatial complexity of near-surface baselines and implications for monitoring.
- The need to close the monitoring-modelling loop
- What does conformance look like in practice?

Overall:

- **Good progress with learning from pilot and demonstration projects**
- **Good progress in reducing costs for large-scale projects**

Modelling Network

Technical Sessions relating to Modelling

- Upscaling from Core to Reservoir
- Wellbores – Legacy & Future
- Modelling Environmental Conditions in the near surface and atmosphere.
- Ongoing Projects.
- Closed and Post Injection Projects
- NRAP Tools
- Lessons from Other Industries
- Use and Application of Pressure Measurements
- Conformance in the Monitoring and Modelling Loop

Specific Key Messages

- Heterogeneity within reservoirs matters. It has a large influence on fluid flow and it effects trapping processes. If heterogeneity is ignored CO_2 migration can be overestimated.
- Upscaling is a highly complex problem. The multi-scale REV (representative elementary volume) concept should be applied at length-scales (5-10 rock functions). CO_2 storage is dominated by gravity and capillary forces away from the well.
- Two phase CO_2-brine flow modelling requires careful assessment of the gravity, viscous, and capillary forces used by numerical reservoir simulators.
- Modelling flow in an open wellbore is non-darcy and requires a different modelling approach.
- The coupling of reservoir to wellbore is important. Depressurization and associated effects can lead to phase changes during upward flow

Key Messages: Implications for Long-term

- Use of legacy 2D seismic to examine historic overburden leakage can provide useful background information.
- There is increasing technological maturity in understanding pressure gauge data in above zone intervals, including physical mechanisms for pressure transfer.
- There are now several sites demonstrating conformance in the modelling-monitoring loop with an increasing number of demonstration sites reaching a completion stage.

Future Developments

- CO_2 well-control technology and procedures, along with modelling of well blowouts and well-kill approaches, needs to be improved.
- The existing knowledge and experience gained from CO_2 injection wells needs to be expanded.
- Training and demonstration of well incident management is required.
- More case studies on what conformance looks like in practice would be beneficial.
- More work on models of dissolution processes.

OFFSHORE CO_2 STORAGE

International Workshop on Offshore Geologic CO_2 Storage

- Workshops organised by the Bureau of Economic Geology (BEG) at The University of Texas at Austin in collaboration with the South African Centre for CCS at SANEDI, IEAGHG and with support from CSLF and UNFCCC's CTCN

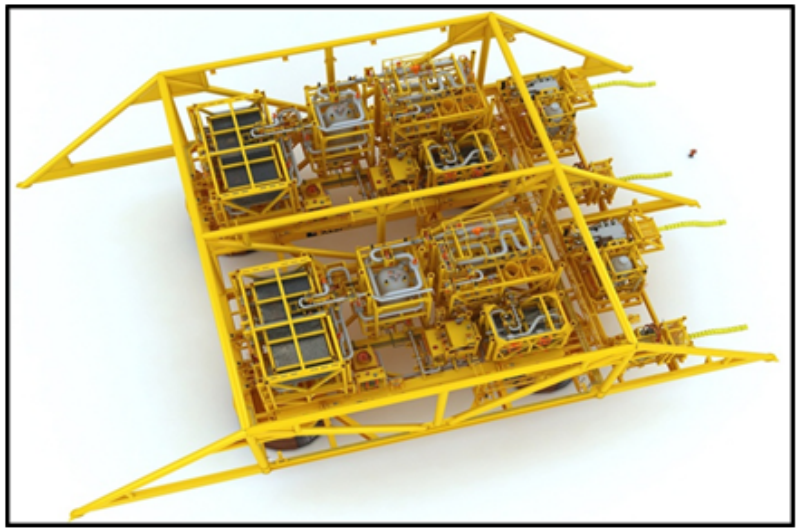
- To facilitate sharing of knowledge and experiences among those who are doing offshore storage and those who may be interested

- 19-21 April 2016, at the BEG, University of Texas, Austin
- 13 countries attended (7 developing countries)

- 2nd Offshore Workshop 19-20 June 2017. Beaumont, Texas

Two important subsea building blocks

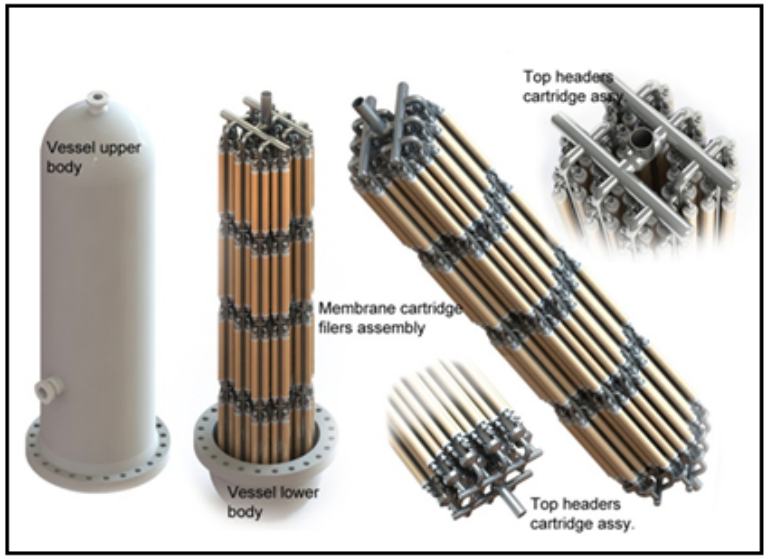
Compression System



2010 – 2015 Åsgard:

- 21 MSm^3/d flow rate
- 2 x 11.5 MW compressor power
- 300 m water depth
- 40 km step-out distance
- Topside Variable Speed Drives, Circuit breakers and UPS
- Delivered by Aker Solutions

Compact membrane packing



- Onshore stacking not feasible subsea
- Compact packing arrangement developed by AKSO

AkerSolutions™

Offshore Environmental Monitoring

STEMM-CCS Project

- EU Project to Advance Environmental Monitoring for Offshore CO_2 Storage Projects
- Building on QICS and ECO2 projects
- Led by UK National Oceanography Centre plus 13 partners
- IEAGHG perspective: optimisation and cost-reduction of monitoring for offshore CCS

Objectives of STEMM-CCS

- Develop **a robust environmental baseline assessment methodology** under "real life conditions".
- Develop and implement **methods for constraining the natural and anthropogenic induced CO_2 permeability of the overburden** in offshore CCS sites.
- Develop **a suite of cost effective tools to identify, detect and quantify CO_2 leakage** from a sub-seafloor CCS reservoir.
- Assess the applicability of **artificial and natural tracers for detection, quantification and attribution of leakage** of sequestered CO_2 in a marine environment.
- Model and assess **impacts of different reservoir leak morphologies** and provide **decision support tools for monitoring, mitigation and remediation action**.
- Document **best practice for selection and operation of offshore CCS sites** and complete **knowledge transfer to industrial and regulatory stakeholders.**
- Develop best practice for **knowledge sharing.**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 654462

Approach: Leakage detection, localisation and quantification

Aim: better understand fluid and gas flow in operational conditions, leading to efficient and economic monitoring strategies.

Controlled release experiment: Injection of CO_2 into shallow sediments at Goldeneye – comprehensive monitoring programme based on chemical and acoustic methods for both detection and quantification.

Precursors: Chemical and isotopic characterisation of precursor fluids/gases in reservoir and overburden.

Artificial and natural tracers: Assessing the utility of a range of tracers as an aid to detection and monitoring.

Modelling: Very fine scale complex hydrodynamic – biogeochemical – bubble / dissolved leakage models coupled to sensor emulators. Multiple scenarios.

Derivation of monitoring strategies and aids to quantification

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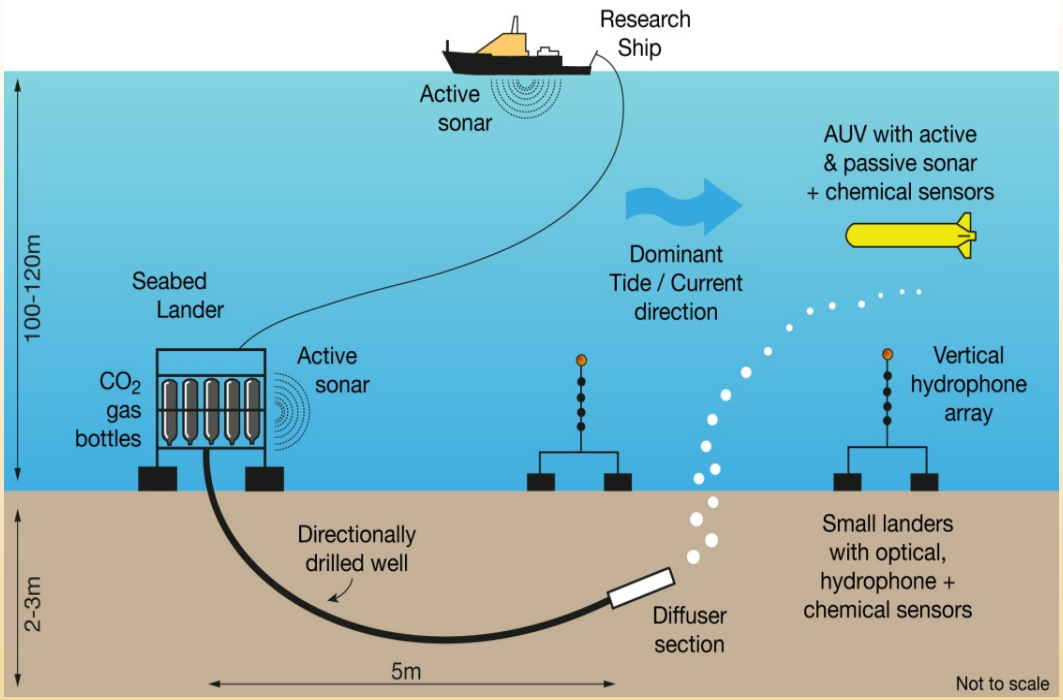
Main Experiment - 2019



Schematic of the shallow sub-surface release of CO_2 gas in sediments (< 5 m depth) near Peterhead (Goldeneye) CCS demonstration project. Note that this small-scale release in near-surface sediment does not affect the integrity of the CCS Storage Site.

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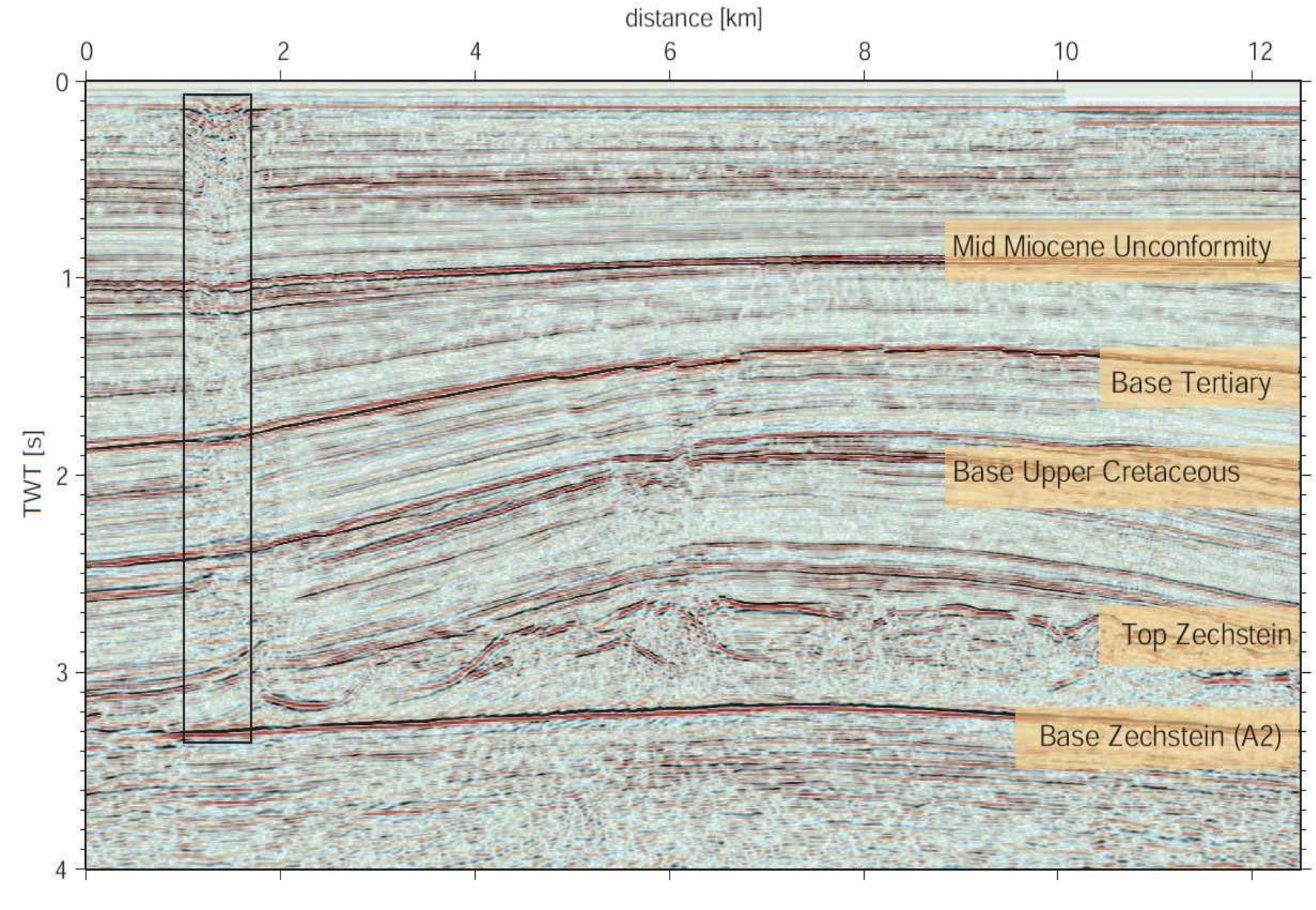

Seismic reflection section illustrating a chimney structure in the German sector of the North Sea (Schlesinger, 2006). The chimney (boxed) cross-cuts the top c. 3 seconds two way time (TWT) of the sedimentary overburden (c. 3 km).

UK ETI MMV System

- To develop and demonstrate a cost-effective integrated MMV system for CO_2 and environmental assessments in the marine environment.
- The project is led by Fugro in collaboration with Sonardyne, with input from the NOC, BGS, PML and the University of Southampton.
- Detect, locate, characterise and quantify sources of any leaks at depths and areas typical for offshore CO_2 storage sites, ie between 5m and 200m water depth and areal extents of 10-3000km^2.
- Two 'Landers' and the NOC Autosub Long Range AUV has been adapted to mount a range of sensors (chemical and physical) and data processing hubs.

Storage Developments

- Monitoring
- Modelling
- Risk Assessment and Management – techniques established, now industry BAU (eg Shell and NRAP tools)
- Future Developments

Thank You

Any questions?

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