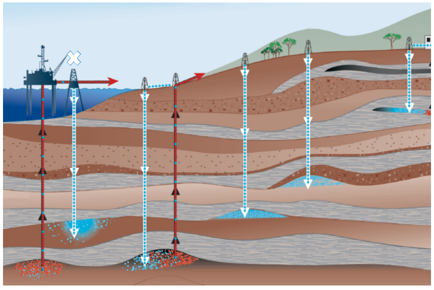
# Tracers for monitoring marine $CO_2$ storage

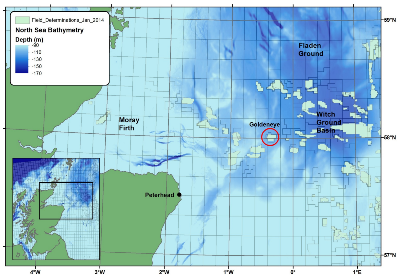
*Anita Flohr, Juerg M. Matter and Rachael H. James*

*Ocean and Earth Science, University of Southampton, National Oceanography Centre Southampton*
*A.Flohr@Southampton.ac.uk.*

## Introduction

Carbon capture and storage (CCS) is a key technology to timely, feasibly and substantially reduce $CO_2$ emissions from industrial processes[1]. Robust strategies for leak detection and management are crucial to make CCS a safe and effective strategy for the long-term mitigation of atmospheric $CO_2$ concentrations. STEMM-CCS is an EU-funded project, which addresses the lack of robust monitoring strategies for the offshore, sub-seabed storage of $CO_2$. To mimic a $CO_2$ leak across the sediment-water interface, a controlled $CO_2$ release experiment will be performed in the central North Sea. During this large-scale experiment, the utility of natural and artificial tracers to detect and quantify $CO_2$ leakages at the seafloor will be tested.





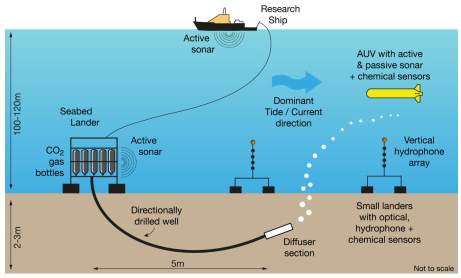




Fig. 1: Geological storage options for $CO_2$. STEMM-CCS addresses the offshore storage of $CO_2$ in depeleted oil/gas fields and saline aquifers (image © CO2CRC)[1]; Fig. 2: Location of Goldeneye platform (image © V. Huvenne); Fig. 3: Schematic of planned $CO_2$ release experiment close to the Goldeneye platform during which various techniques will be tested for their applicability to detect and quantify $CO_2$ leaks (image © K. Davis)

## The controlled sub-seabed $CO_2$ release experiment

**Why?** Mimicking a $CO_2$ leak across the sediment-water interface to test and calibrate various techniques for detecting and quantifying $CO_2$.

**When?** May/June 2019

**Where?** Goldeneye demonstration site, British sector of central North Sea, block 14/29, water depth 100-120 m

**What?** ~3 tons of $CO_2$ gas will be released to the shallow sediment (3m bsf) over a period of 14 days. Tracer gases will be mixed into the $CO_2$ gas stream. We will perform (a) gas bubble, (b) water column and (c) pore water sampling.

## The tracers

- The main requirements to qualify as a tracer are: chemical stability, non-toxicity, low background level, gases (Table 1).
- All the tracers have been widely used in CCS demonstration projects[2,3], except for the gaseous PFC tracer Octafluoropropane ($C_3F_8$).

| Purpose | Tracer properties | Tracers | Indicator for |
|---|---|---|---|
| **Leakage detection** | | | |
| | Low or significantly different background level | $C_3F_8$, $SF_5CF_3$, $SF_6$, Kr, Xe, $\delta^{13}C$ | Significantly different concentrations in gas and water samples compared to the background level indicate the influence of released $CO_2$ |
| **Differentiation and quantification** | | | |
| **a) Location** | | | |
| Water column & sediment | Non-soluble | $C_3F_8$ | $\Delta CO_2:C_3F_8$ in gas bubble samples to quantify how much $CO_2$ remained in the sediment |
| **b) Processes** | | | |
| Physical | Increasing solubility | $SF_5CF_3 < SF_6 < Kr < Xe$ | Tracks mixing, transport and arrival time of $CO_2$ |
| | Inherent, transported like $CO_2$ | $\delta^{13}C_{\_CO2}$ | Tracks the dissolution, mixing and transport of $CO_2$ |
| Biogeochemical | Inherent, reactive like $CO_2$ | $\delta^{13}C$ fractionation | Differentiation between chemical and biological processes |
| | Reactants, products | $Ca^{2+}$:salinity ratio | $CaCO_3$ dissolution or precipitation |
| | Reactants, products | $\Delta DIC:O_2$ | Respiration |

Table 1: Summary of the tracers that will be tested during STEMM-CCS and their purpose. Dissolved inorganic carbon (DIC), Octafluoropropane ($C_3F_8$), Sulfurhexafluoride ($SF_6$),Trifluoromethylsulfurpentafluoride ($SF_5CF_3$), Krypton (Kr), Xenon (Xe).

## The challenges

- **Reactivity of $CO_2$ vs. non-reactivity of artificial tracers**
- **Dissolution behaviour of artificial tracers under in situ conditions at trace gas concentrations**

**→ Risk of false positives**

## The solution

- **We plan to test the solubility and transport of the tracers at trace gas concentrations relative to the solubility and transport of $CO_2$, $\delta^{13}C_{CO2}$ and $\delta^{13}C_{DIC}$ under simulated in situ conditions.**
- **The findings will be a helpful input for the coupled and nested models.**

**References** [1] IPCC (2005), [2] Flude et al., 2016, [3] Myers et al., 2013

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