IMPACTS OF POSSIBLE SEEPAGE FROM CO2 SUB-SEABOTTOM STORAGE

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What if CO₂ SEEPAGE happens?

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Key elements in the development and testing of CCS in sub-seabed sites

**Long-term monitoring**

of potential migration or **leakage of CO₂** streams from sub-seabed geological formations, including substances mobilized by these streams, should be undertaken over a time-scale which will allow effective verification of predictive models,

**monitoring**

*the sea-floor and overlaying water* to detect leakage of the CO₂ stream, or substances mobilized as a result of the disposal of the CO₂ stream, into the marine environment. In this context, special attention should be given to abandoned wells and faults that intersect the sub-seabed geological formation or to any changes in the security of the cap rock during and after injection (faults, cracks, seismicity); and

**monitoring**

marine communities (*benthic and water column*) to detect effects of leaking CO₂ streams and **mobilized substances** on marine organism
Impact of high CO2 – low pH

- Biogeochemistry
  - Physiology
- Community structure / Biodiversity
  - Population
  - Ecosystem
- Socio economy
Most of focus so far to **CALCIFIED** organisms

**PELAGIC**
- Foraminifera
- Pteropods

**BENTHIC**
- Corals
- Molluscs
- Brachiopods
- Echinoderms
Challenging issues

A large number of organisms are waiting to be investigated such as bacteria, archaea, infaunal animals, fish and other species of commercial interest.

Physiological studies from extreme values (leakage conditions) to environmentally relevant CO₂ levels

Physiological and genetic adaptation

Bridge BioGeoChemistry and Physiology

Nutrients, trace / heavy metals

(SECONDARY EFFECTS)

The impacts of changes in the mobility and speciation of nutrients, trace metals as well as toxicity and bioavailability of pollutants such as heavy metals
Research tasks related to sub-seabed CO$_2$ storage:

How do we detect low flux or episodic seeps?, (increased CO$_2$ levels, geochemical or biological signatures, Up-stream /downstream comparisons)?

What chemical transformations occur in sediment and seawater?

What marine organisms are sensitive to excess CO$_2$ and the associated chemical transformations, and what are the effects?

How do we do an Environmental Impact Assessment?
Needed Action

• Determine full scope of **Biogeochemical** and **Ecosystem** impacts from CO2 seepage & acidification.

• Incorporate these impacts into the cost/benefit equations for CO2 mitigation.
Batch CO2 seepage experiments; not-realistic!

Schematic representation of the seepage chambers used in our previous study.
Ratios of metal fractions in the CO₂ chamber and the control chamber

\[ R = \frac{[\text{DGT-M}_{\text{CO₂}}]}{[\text{DGT-M}_{\text{control}}]} \]

Ardelan et al. 2009; Ardelan & Steinnes, 2010
\[ R_{DGT} = \frac{DGT-Te_{CO_2}}{DGT-Te_{control}} \]
More realistic, long-term experiments are needed to upscale experimental data to the ecosystem level.

e.g.

- flow-through mesocosms experiments under realistic pressure,
- Synergy /antagonism with other environmental parameters,
- Observation on Multi-generation
- focus on chronic effects rather than acute effects etc.
The high pressure Titanium tank is a UNIQUE possibility for controlled experiments at 30 atm pressure with continuously running seawater.

**Biology**

**Chemistry**

The Karl Erik TiTank makes it possible to perform experiments with low level of CO2 seepage in long-term and thereby predicts realistic effects of CO2 on aquatic communities. The outcome of the experiment may be used further for improvement of monitoring techniques.
SINTEF Sealab Deepwater Testing Facility
Karl Erik Titanium Tank (KE-TiTank)
Latest results from KE-TiTank experiments in 2011

\[ \Delta \text{Concentration} = C_{\text{downstream}} - C_{\text{upstream}} \]

\[ C_{\text{upstream}} \]

1 L min\(^{-1}\)

\[ \text{Pressure: } 10 \text{ bar} \]

\[ \text{pH}_{\text{NBS}}: 8.1 \]
\[ \text{TA: } 2330 \text{ meq kg}^{-1} \]
\[ \text{pCO}_2: 338 \text{ µatm} \]
\[ \text{DIC: } 2130 \text{ mmol kg}^{-1} \]

\[ C_{\text{downstream}} \]

\[ \text{pH}_{\text{NBS}}: 6.9 \]
\[ \text{TA: } 2330 \text{ meq kg}^{-1} \]
\[ \text{pCO}_2: 6600 \text{ µatm} \]
\[ \text{DIC: } 2635 \text{ mmol kg}^{-1} \]
KE-TiTank experiments 2011

Changes in concentration & forms of redox metals of Fe & Mn due to experimental CO₂ seepage

Pressure: 10 bar
pH reduction: from 8.1 to 6.9
pCO₂: from 338 to 6600 µatm
Weakened Fe & Mn Shuttle

$\text{Fe(OH)_2 (s)}$

$\text{Mn(IV)O}_2 (s)$

$\text{Fe}^{II}$

$\text{Mn}^{II}$

$\text{O}_2$

$\text{Fe}^{II}$

$\text{Mn}^{II}$

Desorption & dissolution of TM

Fe, Mn,.....
the bacterial communities in deeper sediment layers, meaning layers beneath (2-9 cm) of the top sediment, which was significantly changed due to experimental CO2 seepage
CONCLUSION

We have some biogeochemical signatures for low-flux CO2 seepage

To be able to say;

"Everything is under control"

Impact of CO2 on marine ecosystem

It is necessary to study the worst case scenario, although the chances of the leak are slim
Thank you!

For Collaboration
Please contact

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