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CO2 GeoNet

BGR Bundesanstalt für Geowissenschaften und Rohstoffe

IEA Greenhouse Gas R&D Programme

Natural Releases of CO_2: Building Knowledge for CO_2 Storage Environmental Impact Assessments

Hosts : CO2GeoNet and BGR

Sponsor : IPAC – CO_2

Maria Laach, Germany, 2-4 November 2010

IPAC CO2 International Performance Assessment Centre For Geologic Storage of CO2

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Natural Releases Workshop Agenda

0. Welcomes and Introductions

1. Setting the Scene

2. Releases Magnitudes and Impacts – Marine; Terrestrial

3. Mobilisation of Brine and Metals

4. Near surface vs Deep Subsurface Mechanisms

5. Monitoring Challenges

6. Conclusions and Key Outcomes

Field Trip

Summary session 1: Setting the Scene

Rob Arts

Summary

- Regulatory requirements (EU) by Tim Dixon
  - Main issues:
    - Risk assessment
    - EIA
    - Monitoring
  - Existing regulations had to be adapted to make CCS possible (London Protocol & OSPAR)
  - New regulations followed (EU storage directive and ETS-directive)
    - EU directive follows IPCC-GHG guidelines and OSPAR
    - Next (current) step: develop guidance docs (start with risk assessment)
    - ETS-directive -> Quantify leakage
    - Issue: Define “significant” adverse effects as stipulated in the directive(s)

Summary

- Regulatory requirements (US) by Travis McLing
  - No clear legislation in place, <u>different per state.</u>
  - There are draft requirements in place, e.g. US EPA draft rule.
  - Canada is ahead of the US for legislation
  - Main blockers are:
    - Who owns the porespace
    - Liability
    - Pipelines
  - Current regulations mostly covered by EPA for storage and IOGC for transport (based on long experience)
  - Unitization can force landowners to allow CCS in case >70% (of surface owners) is pro

Summary

- RISCS project by Dave Jones
  - Research into Impacts & Safety in CO2 Storage
  - Define critical risks
  - Originates from the 2008 IEA workshop
  - Work is focused on:
    - Natural analogues
    - Experimental injection sites
  - Outcome: Guide for impact appraisal (prepared in 3 stages, stage 1 is about ready)

Summary

- What can we learn from natural releases of CO2 by Jennifer Lewicki
  - Experiences at natural release sites have been gathered:
    - Volcanic regions
    - CO2 accumulations in sedimentary rocks
  - Release of CO2 seems related to faults
    - Faults can be laterally sealing, not necessarily vertically
  - Natural atmospheric releases are used to calibrate atmospheric modeling codes

Discussion

- Discussion on most suitable shallow technique to quantify leakage onshore:
  - Accumulation chamber, BUT in combination with other methods and when you know where the leak is (expected)
- What about remediation, has this been studied in relation to natural release sites ?
  - Not really
- Discussion on the global order of magnitude of natural releases:
  - At least two orders of magnitude lower than anthropogenic emissions, but natural fluxes are uncertain.
  - Public comm. aspects at site specific level

Session 2: Releases, magnitudes and impacts (Marine)

Jonathan Pearce

Key points

- Very useful knowledge transfer from ocean storage, ocean acidification and marine seepage research
- Analogues exist to study impacts mainly in volcanic areas
- Chemical processes
  - Decrease in pH by ~2pH units (extreme low pH due to hydrothermal fluid venting)
  - CO_2 in bubbles may dissolve so may not emit to atmosphere (note this would still be leakage under ETS and Storage Directive however)
  - Hydrate formation possible in deep cold environments

Key points

- Biological impacts
  - Decreases in biodiversity
  - Change in species – especially loss of calcareous organisms
  - However species may cope if sufficient energy provided from other sources
- Monitoring technologies
  - Sufficient to detect CO_2 bubble streams and monitor chemical effects (e.g. pH, pCO_2). Hydroacoustics
  - Technologies to assess impacts are being developed or applied e.g. Benthic chambers, ROVs etc
- Limitations
  - Response rates and recovery rates are difficult to establish from analogues
  - Analogues may be ‘steady-state’
  - Are scales (time, size, flux etc) realistic for storage?

Questions or gaps

- Are pockmarks indicative of leaking hydrocarbon fields or shallow gas?
- Will current research in analogues allow predictions of impacts if pH/pCO2 and flux can be measured at a leaking site?
  - What should we measure?
- Are monitoring technologies sufficient to measure rates?
- Public acceptability: it is not really a question of whether the public prefer offshore or onshore storage. Countries have to use the pore space they have access to.

Recommendations – for discussion

- Compare analogue data to risk assessments for real storage sites.
    - o Are the fluxes comparable?
- Recognise limitations as well as benefits – keep the context
    - o Experimental programmes are needed to understand key processes - especially on responses to changing conditions (adaptation/recovery/thresholds...)
- Test measurement technologies at analogue sites
- Should we have an offshore equivalent to ZERT/ASGARD/CO2fieldlab?

Session 2 Terrestrial Environment (Hardy and Martin)

- mofettes can be mapped quite accurately (time integrated) by mapping of plant and soil-animal species
    - adaptability different for different species, animal species may respond more quickly but plants stress can be identified remotely

      concentration levels as well ?

new

- many morphettophilic and –phobic plants

  other storage relevant regions worldwide ?

- portfolio of methods recommended for various scales (detection – quantification and system understanding)

Gap: groundwater impact by subsurface fluids +/- CO_2

Session 3: Mobilisation of Brine and Metals

- Different analytical tools are needed to determine the effects of CO_2 injection
- Monitoring tools needed to determine what is being mobilised:
  - Existing sensors need to be improved
  - New sensors need to be developed
  - New applications, particularly biological and geophysical modeling, need to emerge
- Additional research needs
  - Research needs to integrate laboratory, field and modelling studies: analogue and pilot projects
  - Absent additional research, risk assessments regarding the mobilization of metals may be inaccurate
  - One study focusing on an aquifer near Chimayó, New Mexico, USA, containing natural sources of CO_2 determined that the presence of trace elements was more closely associated with brackish water than in-situ mobilization of trace metals
    - Intrusion of brackish water displaced by co2 could be more important – more research needed.

Session 3: Mobilisation of Brine and Metals

- Contaminants injected with CO_2
  - Another pure modelling study examined the effect of the presence of impurities injected with CO_2, particularly SOx and Nox
    - These impurities increased the acidification of groundwater
    - This increased the dissolution of different substances with resulting Health Specific Impacts
    - The movement of these substances post-dissolution varied with the substance
  - Pipeline systems integrating multiple sources of CO_2 will likely contain multiple impurities
  - Contaminants may be used as tracers

Session 4: Near Surface vs. Deep Subsurface Mechanisms

David Bowen (Lee Spangler): Outcrops and Escape Mechanisms

- Great care in making direct links between all leak analogues and CCS implications
- Huge energy required for CO2 for the larger-scale breech seals
  - Not all leaks reach the surface
  - Outcrop studies impart important information to the study of natural analogues

Session 4: Near Surface vs. Deep Subsurface Mechanisms

Giovanni Chiodini: Volcanic and non-volcanic Releases

- Escaping CO_2 gas from the deep subsurface commonly is trapped in “reservoirs” at 500-1000m depth
- CO_2 leaking and accumulation has been associated with induced seismicity
- High CO_2 fluxes through aquifers is possible

Session 4: Near Surface vs. Deep Subsurface Mechanisms

Travis McLing: Near Surface Interactions: Soda Springs Idaho, a Case Study

- Water chemistry bears the signal of reactions during CO_2-water migration from depth
- It is possible to measure the magnitude of CO_2 charged fluids required to impact near surface fresh water system using natural analogues
    - Highly site specific
- Study of near surface mitigation of CO_2 leaks

Session 4: Near Surface vs. Deep Subsurface Mechanisms

Rob Arts: Tracking CO_2 movement

- Great advances have been made in monitoring CO_2 storage in the subsurface
- Migration of CO_2 at Sleipner
  - o CO_2 has moved upwards through discontinuous clay layers
  - o CO_2 has moved to the top of the Utsaria Formation
- Calibration of CO_2 transport models requires monitoring. Models are iterative and regulations require recalibration.
- Abandoned well control is a very challenging problem
- We need to understand the system

Session 4: Near Surface vs. Deep Subsurface Mechanisms

Janin Frerichs The Effects of High CO_2 Concentrations on Microbial Communities at Natural CO_2 Seeps an Depleted Natural Gas Reservoirs

- There is a systematic microbiology response to high CO_2 concentrations
- Understanding this response is critical to the implementation of CCS

Nutrients are important to the microbiology community

Session 5: Monitoring challenges in light of natural systems (Part 1)

Seepage is relatively easy to detect in a marine environment due to the differences in physical properties between CO2 and seawater. Hydro acoustical methods have been successful at detecting natural CO_2 seepage from the seabed

Finding a leak is difficult due to scale of storage projects

"needle in a haystack"

Session 5: Monitoring challenges in light of natural systems (Part 1)

A monitoring in and above reservoir should indicate a need to monitor at surface. Developing a shallow monitoring strategy should be an iterative process based on feedback from primary deep monitoring tools.

Controlled releases provide additional data that can compliment the study of natural analogues. More sites with different properties are starting to be investigated.

A monitoring portfolio that includes currently-available methods that detect, quantify and reduce uncertainly is recommended.

Session 5: Monitoring challenges in light of natural systems (Part 2)

Near surface (vadose zone) is dynamic, background variation is complex and important to understand

- Establishing good background data is extremely important

Processes and their variability are site specific

Other gases can provide valuable information e.g. Nitrogen and Oxygen

Monitoring should address multiple requirements

Poorly understood data sets may represent a political or public acceptance challenge

Recurring Learnings and Points

Integration of field, lab and modelling work

Integrate current research in various natural analogue studies: focussed program

There are a range of variables, so need to understand the system: what is common and what is different

Need to further understand the hydrogeochemistry/hydrogeology/hydrodynamics

Indicator species: draw together into database

Gaps

Focussed research program

CO_2 displaced waters

Understanding of physical processes of CO_2 flow in aquifers

Field studies in mobilisation of brine and metals

Lack data of natural background CO_2 in offshore environments

Long term impacts

Mechanisms in the deep subsurface from natural analogues (understanding of caprock and additional barriers)

Understanding of seismicity (Italy)

Recommendations

Follow up meeting

- o Perhaps additional dedicated session focussed on impacts at AGU?

Integrated natural analogue/controlled release program: international, cross-disciplinary

Integrate modelling, field and lab research.

Further research on long-term impacts in marine & terrestrial environments

Biologists and geologists – work together

- Expand community inc. experts from other areas of geological storage.

Next steps…

- ***PPTs will go onto website***
- ***Report of meeting will be produced***
- ***Next Environmental Impacts meeting tbc***

Steering Committee for Natural Releases Workshop

Tim Dixon – IEAGHG

Franz May – BGR (Host)

Lee Spangler – Montana State University

Travis McLing – Idaho National Laboratory

Jonathan Pearce – BGS

Katherine Romanak – BEG, University of Texas at Austin

Ameena Camps – IEAGHG

Salvatore Lombardi – 'La Sapienza' University of Rome

Also Heike Rutters, BGR, Julie West, BGS, Sam Neades, IEAGHG

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