Safety aspects of long-term geological disposal of CO_2: Experience gained from radioactive waste disposal

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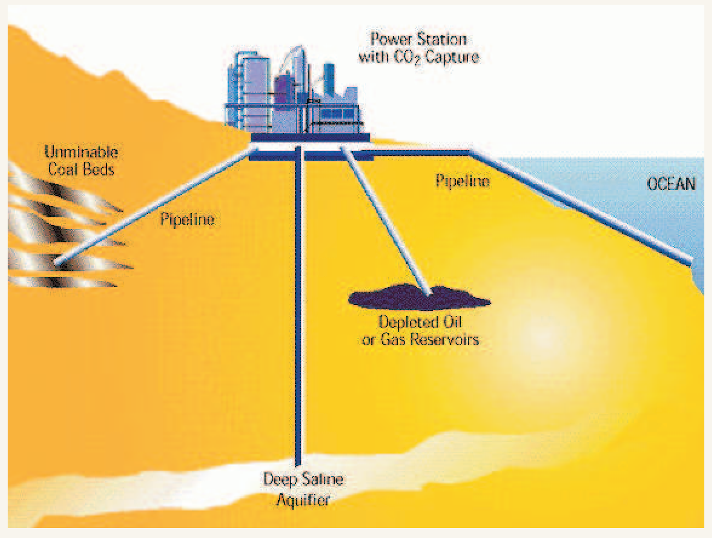
Introduction

Geological storage of CO_2 is one of the methods that have been proposed to reduce the amount of CO_2 released to the atmosphere. This technology is starting to be developed and tested in many commercial-scale projects worldwide. However, spreading out of such technology will depend on demonstration that disposal system is feasible to contain CO_2 for a sufficiently long period, that CO_2 disposal does not affect quality of ground water and that the technology gains acceptance from policy makers and the general public. Those aspects are consistent with RADIOACTIVE WASTE DEEP GEOLOGICAL DISPOSAL experience that has been developed for more than 30 years.

CO_2 deep geological disposal

MATERIAL DISPOSED:

- Gas CO_2 with different admixtures
- Liquid or supercritical state (50 – 80% of water density)



DISPOSAL CONCEPTS considered (Czech Republic)

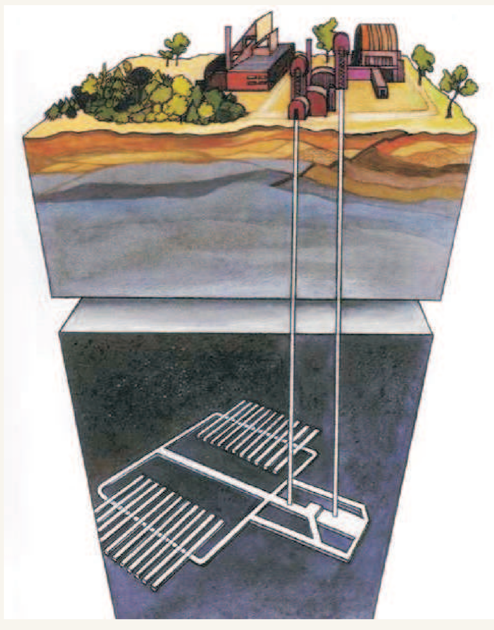
- Regional aquifers overlayed with impermeable caprock
- Local depleted oil and gas structures and/or aquifers
- Direct disposal of the CO_2, no other package

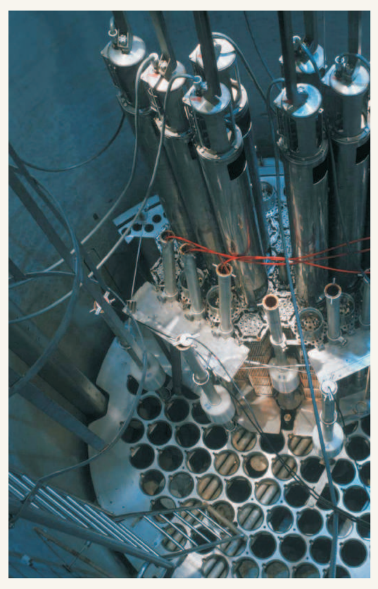
Depth: approx. 500 m
Time Life: 10^4 years

Radioactive waste deep geological disposal

MATERIAL DISPOSED :

- Spent nuclear fuel and high-level radioactive waste: solid material with high content of radioactive acitinides and fission products
- Different half-lives: from 10^2 years up to 10^9 years

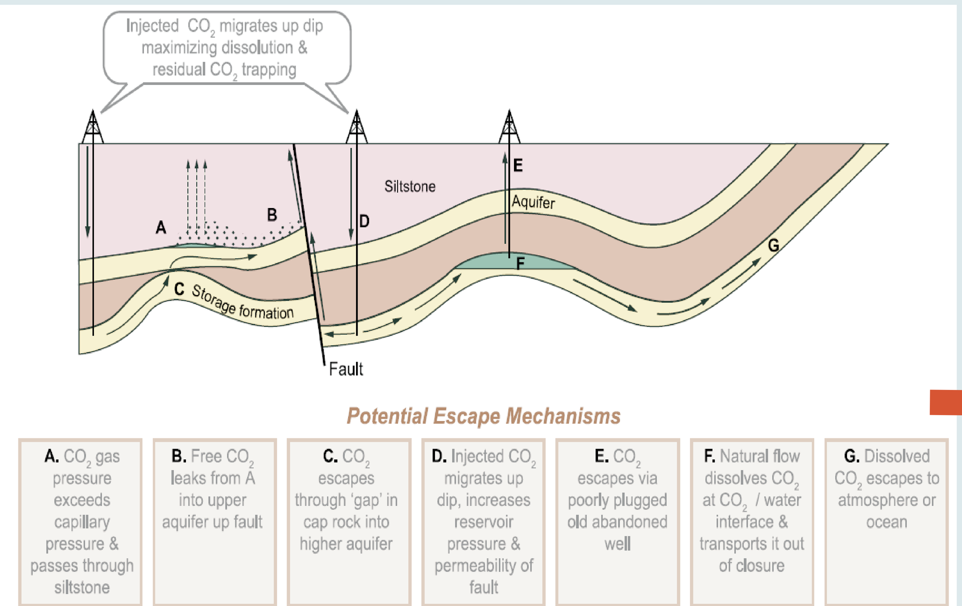




DISPOSAL CONCEPTS considered (Czech Republic)

- Crystalline host rock massive (granite)
- Multibarier system:
  Near field: fuel – canister – buffer and backfill
  Far field: host rock

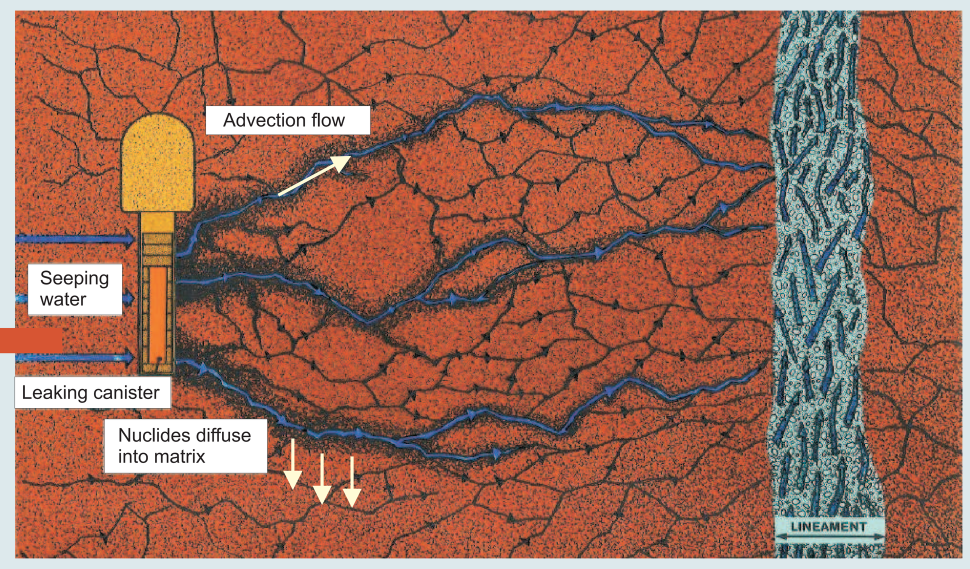
Depth: approx. 500 m
Time Life: 10^6 years



Some potential escape routes for CO_2 from storage formation (Metz et al., 2005: Carbon Dioxide and Storage. Cambridge University Press, New York).

Basic points of performance assessment

SYSTEM UNDERSTANDING
↓
SCENARIO DEVELOPMENT
↓
MODEL DEVELOPMENT
↓
TESTING METHOD DEVELOPMENT
↓
DATA ACQUISITION AND EVALUATION

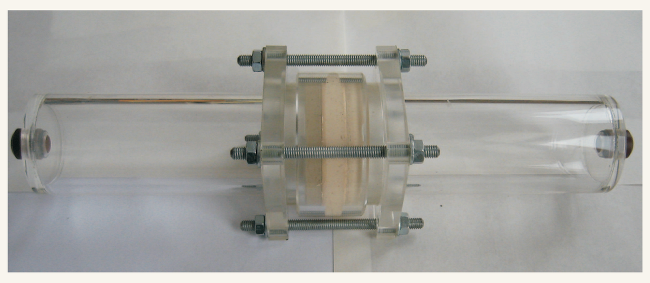


Radionuclide transport processes from deep geological repository.

Data acquisition and evaluation

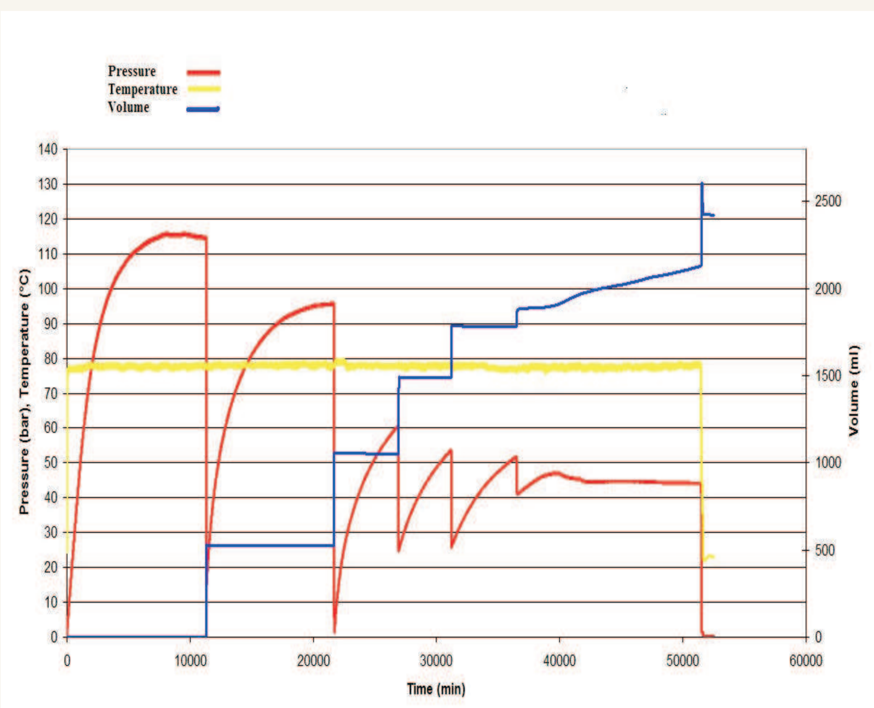
LABORATORY EXPERIMENTS (EXAMPLES)
Gas migration through and interaction with rock material

The cell for through-diffusion experiments (NRI Rez system) Potential for study of dissolved CO_2 migration through caprock.



Anaerobic box enabling to study processes without O_2 influcence (NRI Rez laboratory).

Result example of hydrogen gas release through compacted bentonite. NRI laboratory results (project FORGE).
Potential for study of gass CO_2 migration through caprock.



MODELLING

SAFETY ASSESSMENT

SCENARIO DEVELOPMENT
„…a hypothetical sequence of processes and events devised to illustrate a range of possible behaviours of a disposal system for a purposes of making or evaluation a safety case or for considering the long term fate of disposed substance…"

NORMAL vers INTRUSION scenarios

FEP

FEATURES	EVENTS	PROCESSES
SYSTEM CHARACTERISTICS	PROCESS IN SHORT TIME SCALE	INFLUENCE EVOLUTION OF SYSTEM

FEP catalogue

QUINTESSA CO_2 FEP DATABASE — NEA/OECD FEP DATABASE

FEP INTERACTION
INTERACTION MATRICES

TOTAL PERFORMANCE ASSESSMENT

CONFIDENCE BUILDING

PUBLIC ACCEPTANCE

Data acquisition and evaluation

EXPERIMENTS IN-SITU
Real scale and more realistic time scale experiments
Site specific for host rock

UNDERGROUND RESEARCH LABORATORIES
Underground facilities for real scale and more realistic time scale experiments (Mont Terri (Ch), Bure (F) in clays)

Potential for CO_2 experiments

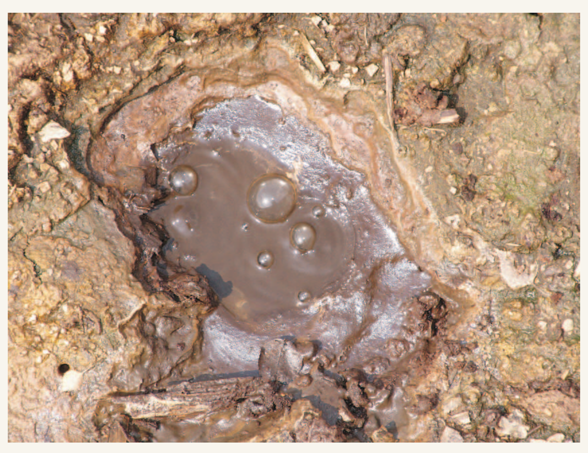
NATURAL ANALOGUES (www.natural-analogues.com)
Can complement the results from short-term laboratory experiments, since they allow studying natural systems that have evolved over geological time scales.

CO_2

- Geothermal fields
- Volcanic CO_2 transport in fractures
- CO_2 rich hydrothermal vents

Radioactive waste

- Natural U forms and their stability in different host rocks (Ruprechtov natural analogue, CZ)
- U transport in fractures
- U retention within natural barrier system
- (U deposit–clay hallo, Cigar lake, Can)



Mofetta CO_2, SOOS, Czech Republic

MODELLING

CONCLUSIONS:

The methodological and conceptual similarity of CO_2 and radioactive waste geological disposal enables to use the experience, know-how and laboratory equipment acquired during tens of years of research in radioactive waste disposal in order to be used in the field of carbod dioxide disposal.

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