Both experimental study and numerical modelling of the effect of temperature gradient on CO2 injection

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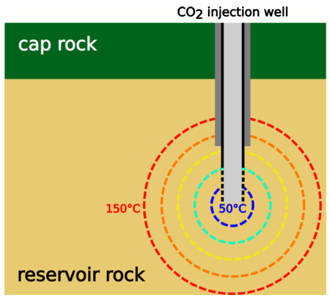
PGT Pôle Géochimie Transport – Reactive Transport Group

CONTEXT

CO_2 injection and underground storage obviously requires dealing with **temperature differences** between the **injection well** and the **reservoir**. For example, in Rousse-Lacq (french capture and storage project led by TOTAL) CO_2 is injected at 50°C in a gas depleted reservoir whose temperature is 150°C.

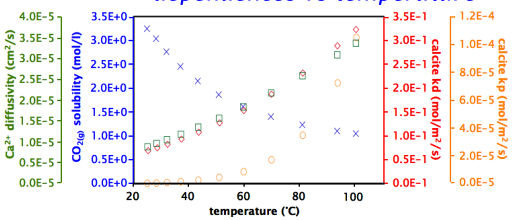


CO_2 injection scheme

To assess this issue, an experimental set-up, COTAGES, has been designed and numerical simulations with the reaction/transport code HYTEC has also been performed to reproduce the observed behavior.

NUMERICAL MODELLING USING HYTEC

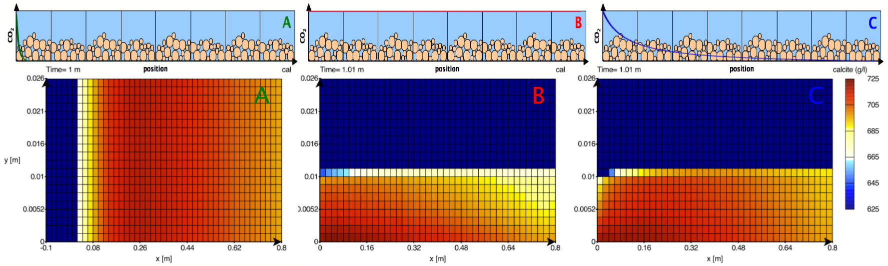
Temperature enhances both **species transport** and **reactions kinetics**, while **CO_2 solubility** also greatly **decreases**.

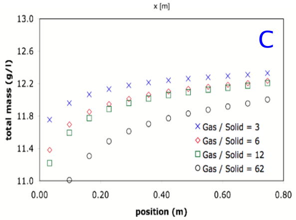


involved phenomena dependences vs temperature

2D numerical simulations have been run with the following assumptions:

- **purely diffusive transport** (Oelkers & Helgeson 1988),
- **kinetically controlled precipitation/dissolution** (Kovac et al. 2006),
- **aqueous reactions controlled by thermodynamics** (www.ctdp.org).





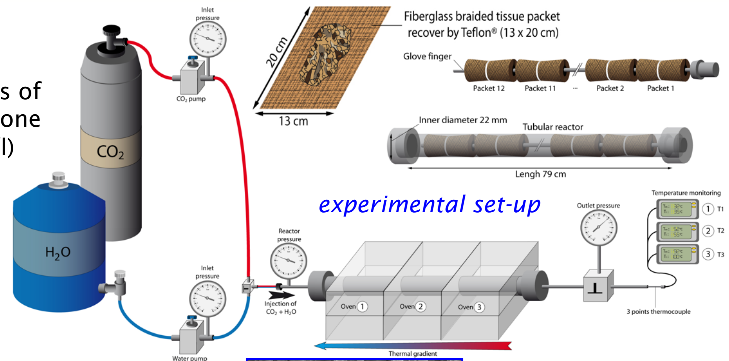
testing injection scenarios
(CO_2 initial location and quantity)

- **dissolution/transport competition is qualitatively reproduced.**
- **precipitation kinetics seems underestimated.**
- efforts has still to be done on transport (porosity effect, advection…).

COTAGES EXPERIMENT

PROTOCOL

- Loading the reactor with 12 packets of 12.5 g each containing oolitic limestone
- Injecting solution (H_2O + NaCl 4 g/l)
- Heating up zone 3 up to 100°C
- Reaching steady-state (zone 2 ≈ 55°C - zone 1 ≈ 30°C)
- Injecting CO_2 in the cold zone

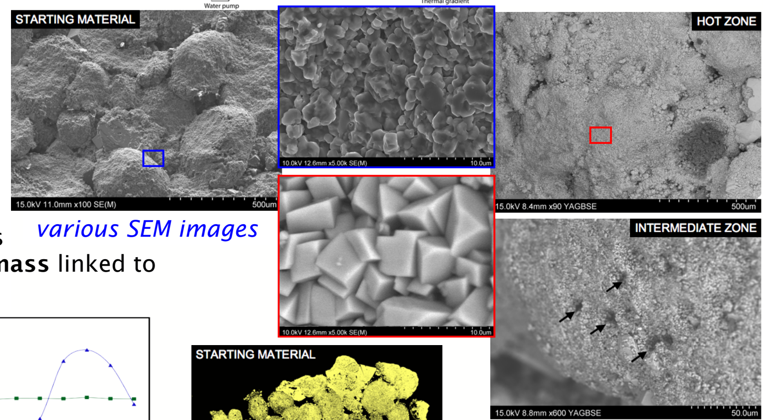


experimental set-up

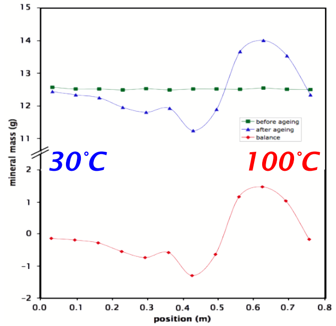
AFTER 30 DAYS OF EXPOSURE

Mass transfer between the **intermediate zone** (2) and the **hot zone** (3)

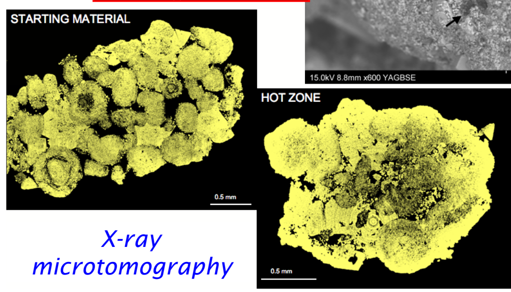
- HOT ZONE (3) : **carbonates precipitation** on the surface of grains and formation of **aggregates**
- INTERMEDIATE ZONE (2) : **dissolution** around grains and **etch pits** on the surface of oolites
- COLD ZONE (1) : **weak loss of mass** linked to **moderate dissolution**



various SEM images



mass balance vs temperature



X-ray microtomography

CONCLUSION & PERSPECTIVES

This problem is crucial as **injectivity shall be maintained during** the whole **CO_2 injection** and the combined approaches appear promising in this purpose.
The developed **experimental set-up** will now be used to **test various assemblages** (cement, reservoir rocks, cap rocks, water composition, gas composition…). Greater analyses will help **improve** our **numerical model** and its ability to **reproduce quantitatively experimental results** and possibly **allow upscaled predictions**.