Remediation of CO2 leakage from deep saline aquifer storage based on reservoir and pollution engineering techniques

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Géosciences pour une Terre durable

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Remediation of CO_2 Leakage from Deep Saline Aquifer Storage Based on Reservoir and Pollution Engineering Techniques

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CONTEXT

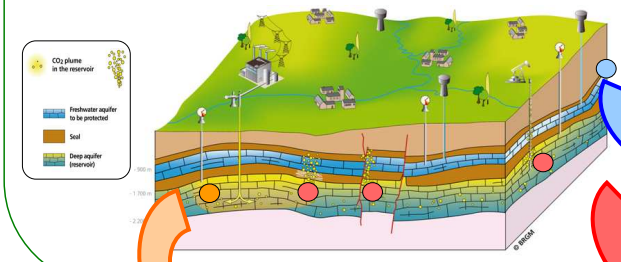
European Directive 2009/31/EC on the geological storage of CO_2 states:

Article 16, **Measures in case of leakages or significant irregularities**
« Member States shall ensure that in the event of leakages or significant irregularities, the operator immediately notifies the competent authority, and takes the necessary corrective measures ».
« significant irregularity » *means any irregularity in the injection or storage operations or in the condition of the storage complex itself, which implies the risk of a leakage or risk to the environment or human health;*
« corrective measures » *means any measures taken to correct significant irregularities or to close leakages in order to prevent or stop the release of CO_2 from the storage complex.*

➢Available remediation measures mainly stem from the field of **reservoir and pollution engineering** (e.g. IEA GHG, 2007);

➢But due to the **uniqueness of CO2 geological storage activities** (time and spatial scale): the extent to which such measures can be used, if not **adapted**, for CO_2 storage in deep saline aquifers should be investigated;

➢We adopt the global framework of the "**source** – **transfer** – **target**" approach **in case of the monitoring plan has detected an accidental CO_2 leakage from the reservoir** (either through faults or through abandoned wells).



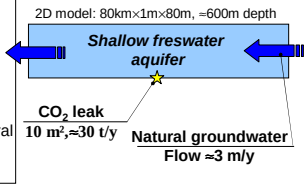
TARGET

➢**Objective:** remediate the **geochemical impact of a CO_2 intrusion** (release of Al, Ba, Cd, Cu, Fe, Mn, P, Pb and Zn);

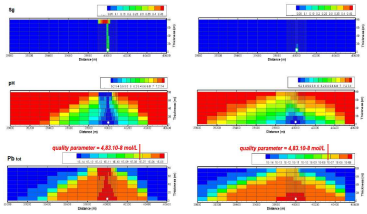
➢**Remediation technique: monitored natural attenuation MNA**;

➢**2D Reactive transport simulation:** TOUGHREACT (Xu et al., 2004);

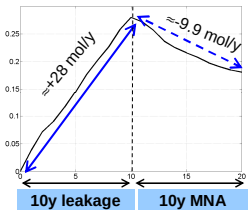
➢**Properties based on the glauconitic sandstone Albian aquifer** (France) with mineral precipitation/dissolution reactions as being the main processes, (Vong et al., 2009).



a) After 10y of CO_2 leakage | **b) Leakage stops and 10y of MNA**



Trace element over time: *example of Pb^{2+}*



Provided that the leakage is stopped, we show:

1. **Rapid decrease** of the free mobile accumulated gas in the aquifer;
2. **Natural attenuation of trace element release may be a long process**; in this case, the re- precipitation of the released Pb^{2+} requires almost 30y;
3. **More active intervention** procedures should be envisaged (*e.g.* pump and treats techniques).

SOURCE

➢ **Objective, in case of abnormal behaviour,** control the injection-induced overpressure within the reservoir;

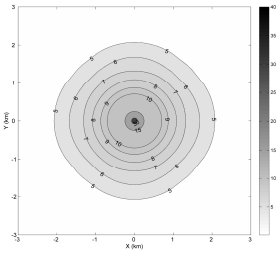
➢ **Remediation technique:**

1. **Pressure natural recovery;**
2. **Extract the injected CO_2;**
3. **Extract brine.**

➢ **Multiphase flow transport simulation:** TOUGH2/ECO2n (Pruess et al., 2005);

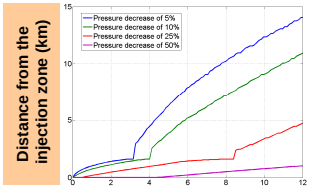
➢ **Application case:** 2D model of the Dogger aquifer in the Paris basin (Le Guenan et al., 2009).

Over-pressure after 10y of CO2 injection



	Benefits = Pressure decrease		Cost
	in the injection zone	*at 3km from the injection zone*	
1.	65%	30%	1Mt CO_2
2.	80%	45%	1.5Mt CO_2
3.	70%	35%	1Mt CO_2+1 well+0.5 Mt brine

Natural pressure recovery



TIME required for Pressure decrease (months)

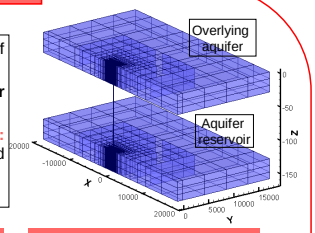
TRANSFER

➢**Objective:** control the upwards migration of the CO_2 leak;

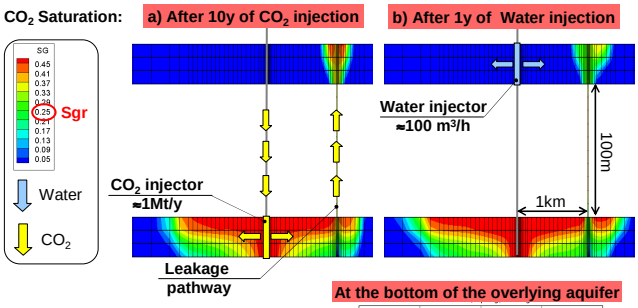
➢**Remediation technique: hydraulic barrier** through water injection in the overlying aquifer;

➢**Multiphase flow transport simulation:** TOUGH2/ECO2n (Pruess, 2005) and Local grid refinement (e.g. Audigane et al., 2009);

➢**Typical properties** of sedimentary aquifers.



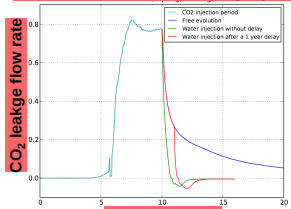
CO_2 Saturation: | **a) After 10y of CO_2 injection** | **b) After 1y of Water injection**



Hydraulic barrier has a twofold effect:

1. The CO_2 **leakage flow rate** at the bottom of the overlying aquifer is **stopped**;
2. The **trapping** (dissolution and residual) of the accumulated CO_2 is **enhanced**.

At the bottom of the overlying aquifer



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