# Managing a leaky abandoned well: detection and advanced mitigation options (hydraulic barrier)

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Geoscience for a sustainable Earth

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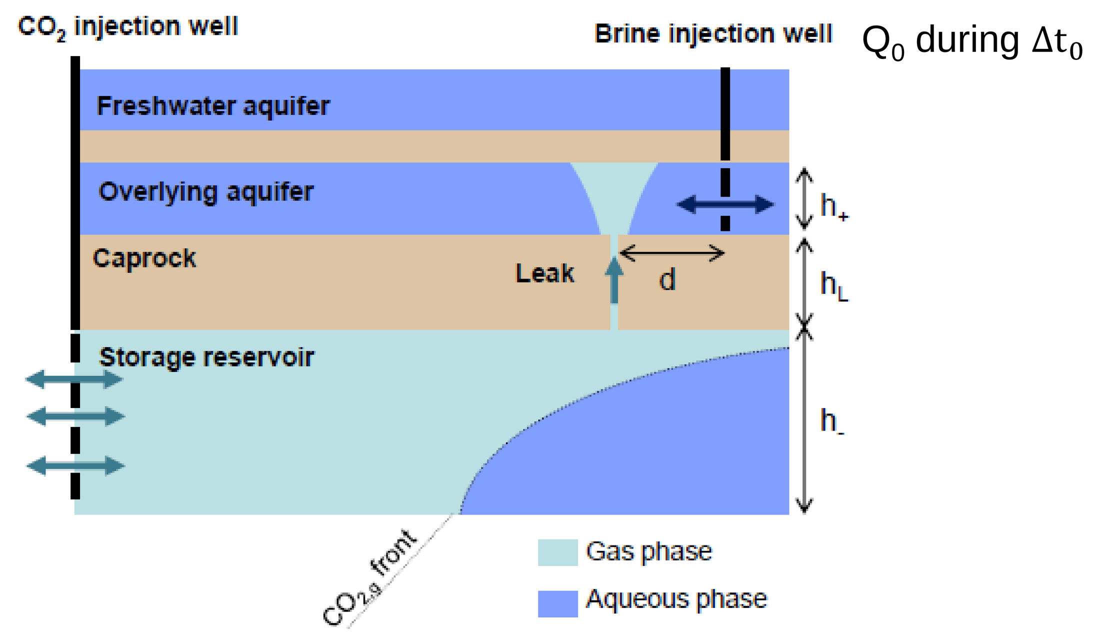
# Hydraulic barrier design and applicability for managing the risk of $CO_2$ leakage from deep saline aquifers

## Objectives

> In the case of leakage of $CO_2$ into an overlying aquifer through man-made (e.g. abandoned well) or natural (e.g. permeable fault) pathways, directly modifying the leak hydraulic properties may not be possible.

→ Used as a corrective measure, the "hydraulic barrier" relies on brine injection in the top aquifer in order to counter the driving forces of the migration ($CO_2$ buoyancy and injection-induced over-pressure)




## Operational issues

> Brine availability, surface piping and equipment

> Possibility of re-using an existing well

> Time delays of drilling a new well

> Permitting and regulatory issues

> Applicable once the secondary accumulation is detected (~ 1000/10000 tons of $CO_2$ at 1km depth) and characterized

> Detection and characterization time

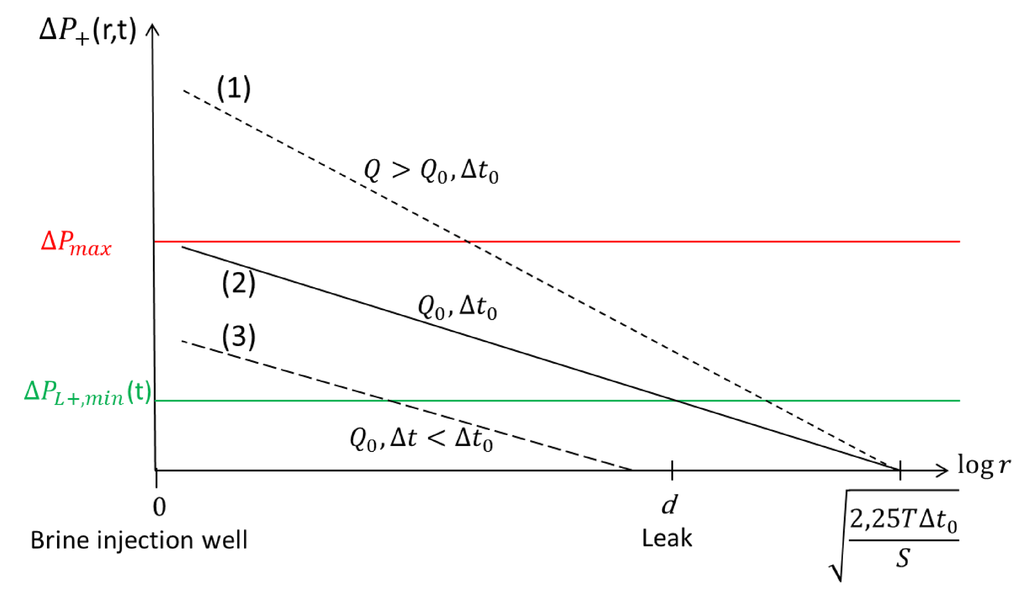
## Hydraulic barrier design: $Q_0$ & $\Delta t_0$ estimates

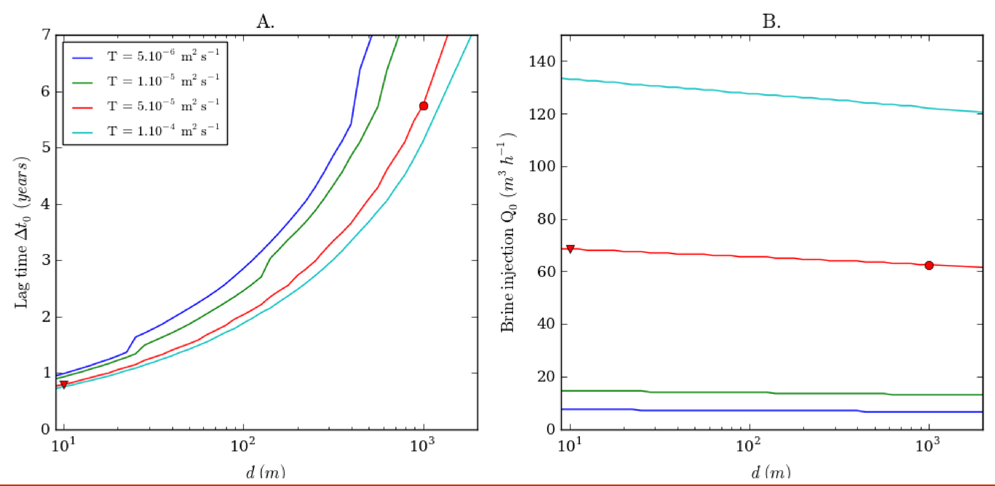
The brine injection rate $Q_0$ and duration $\Delta t_0$ are chosen in order to fulfill the following requirements :

> Rapidity: The duration necessary for stopping the leak should be as short as possible.

> Integrity (mechanical): Simple conservative analytical model of the tensile failure in the caprock in order to determine the maximum overpressure $\Delta P_{max}$

> Efficiency: $\Delta P_{L+,min}(t) \leq \Delta P_{L+}(t)$, where $\Delta P_{L+,min}$ is the pressure build-up over the leak necessary for preventing the leakage due to the pressurized storage aquifer and to the $CO_2$ buoyancy (determined for the considered leakage scenario). $\Delta P_{L+}$ is the overpressure induced by the brine injection over the leak, estimated using the analytical Theis solution.




## Numerical model

> Large scale multiphase flow transport simulation using TOUGH2 code

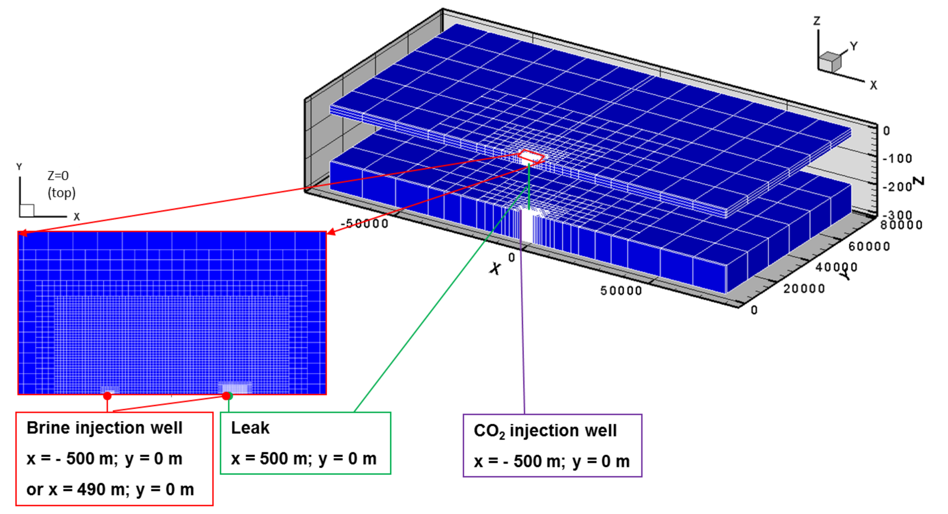
> two horizontal and homogeneous 78 × 78 km aquifer layers are connected by a 170 m high vertical conduit

> exponential grid refinements down to a 0,8m x 1,6 m grid block section for the leak

> 100 thick storage layer (gravity neglected); 3x10m thick overlying aquifer

> 3 Mt/y $CO_2$ injection

> Homogeneous petrophysical properties typical of deep sedimentary basin.

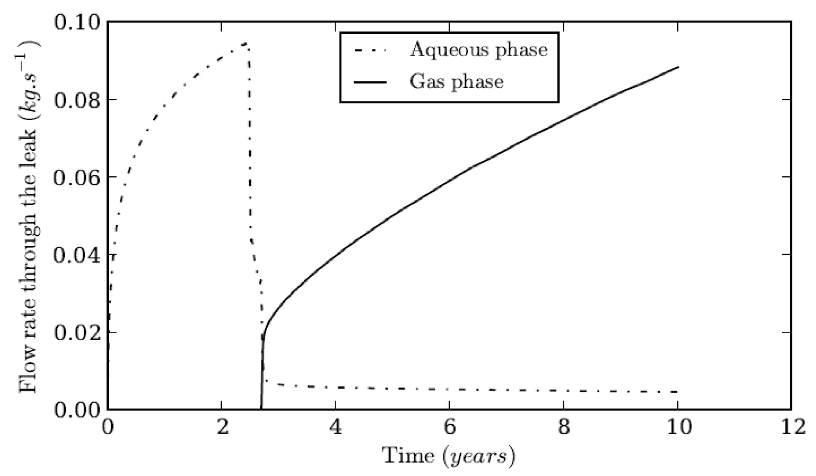


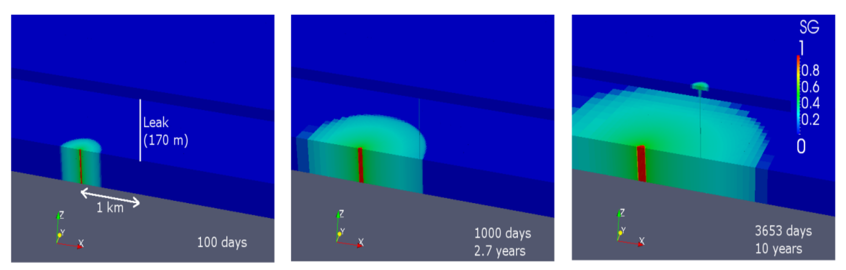

## Leakage modeling

> Leakage detection at 10 years

> $CO_2$ injection is stopped

> Secondary accumulation: 13.8 kt of $CO_2$ (detectable through seismic survey), 18% only is dissolved

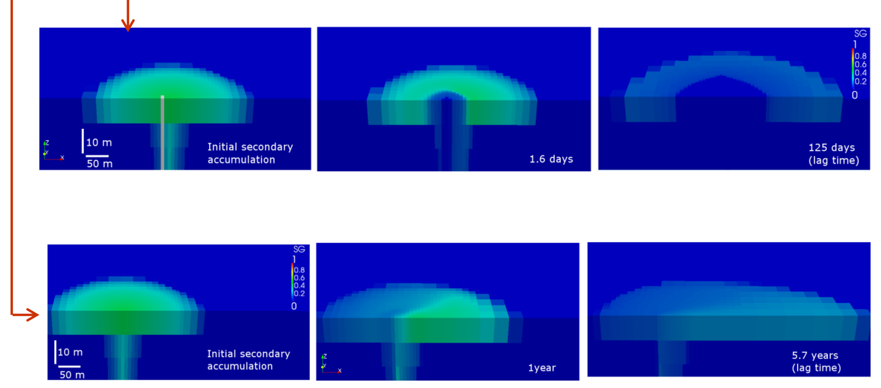


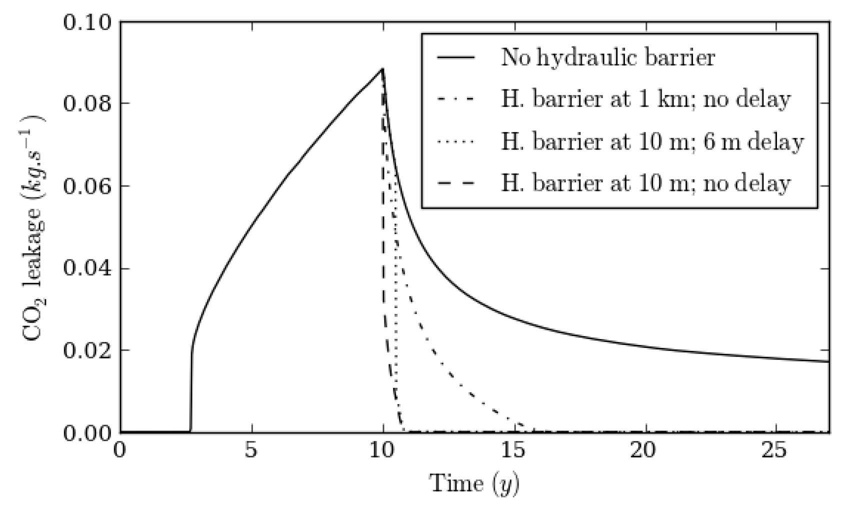

## Hydraulic barrier modeling and results

> Simulated hydraulic barriers cases and comparison of the duration necessary for stopping the leakage

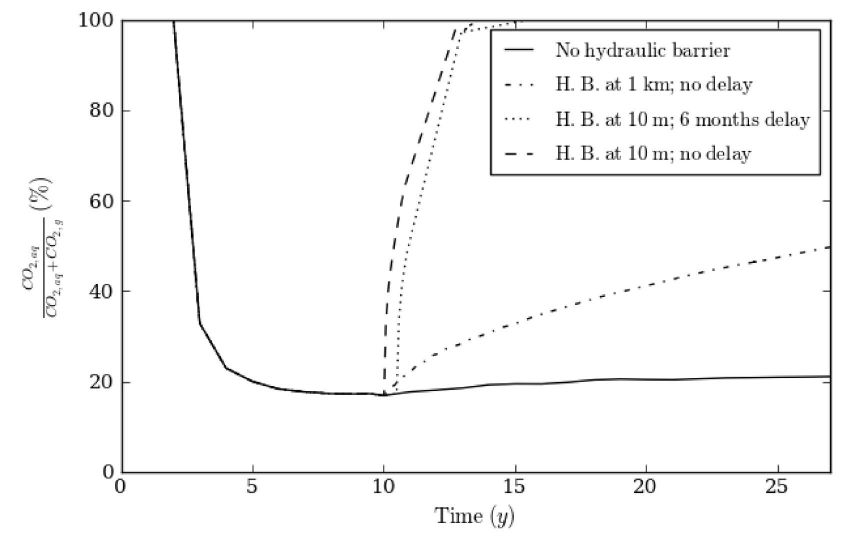
| Case | Parameters set using the design methodology | | Results from the 3D simulations | |
|---|---|---|---|---|
| | $Q_0$ | $\Delta t_0$ | $\Delta t_0^{3D\ sim.}$ | $(\Delta t_0^{3D\ sim} - \Delta t_0)/\Delta t_0$ |
| Well at 1 km, no delay | 62.5 m³/h | 5.7 years | 5.6 years | -3 % |
| Well at 10 m, no delay | 68.5 m³/h | 289 days | 287 days | -1 % |
| Well at 10 m, 6 months delay | 71.5 m³/h | 125 days | 105 days | -16 % |




> Leakage over time




> Secondary accumulation over time




## Conclusions

> This methodology proposes some clear criteria for setting the main parameters of the hydraulic barrier. This remediation option can then be balanced with other possible strategies.

> The time necessary for stopping the leakage are in good agreement with those obtained through 3D numerical simulation.

> From the analytical results:

A leakage into a high transmissivity aquifer increases the necessary brine injection rate

Brine must be injected in the vicinity of the secondary accumulation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Cf. details in Réveillère, A., Rohmer, J., Manceau, J.C., 2012. Hydraulic barrier design and applicability for managing the risk of CO2 leakage from deep saline aquifers. IJGGC Vol. 9, July 2012, pp. 62–71


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