

A multi-tiered approach for carbon sequestration Area of Review delineation

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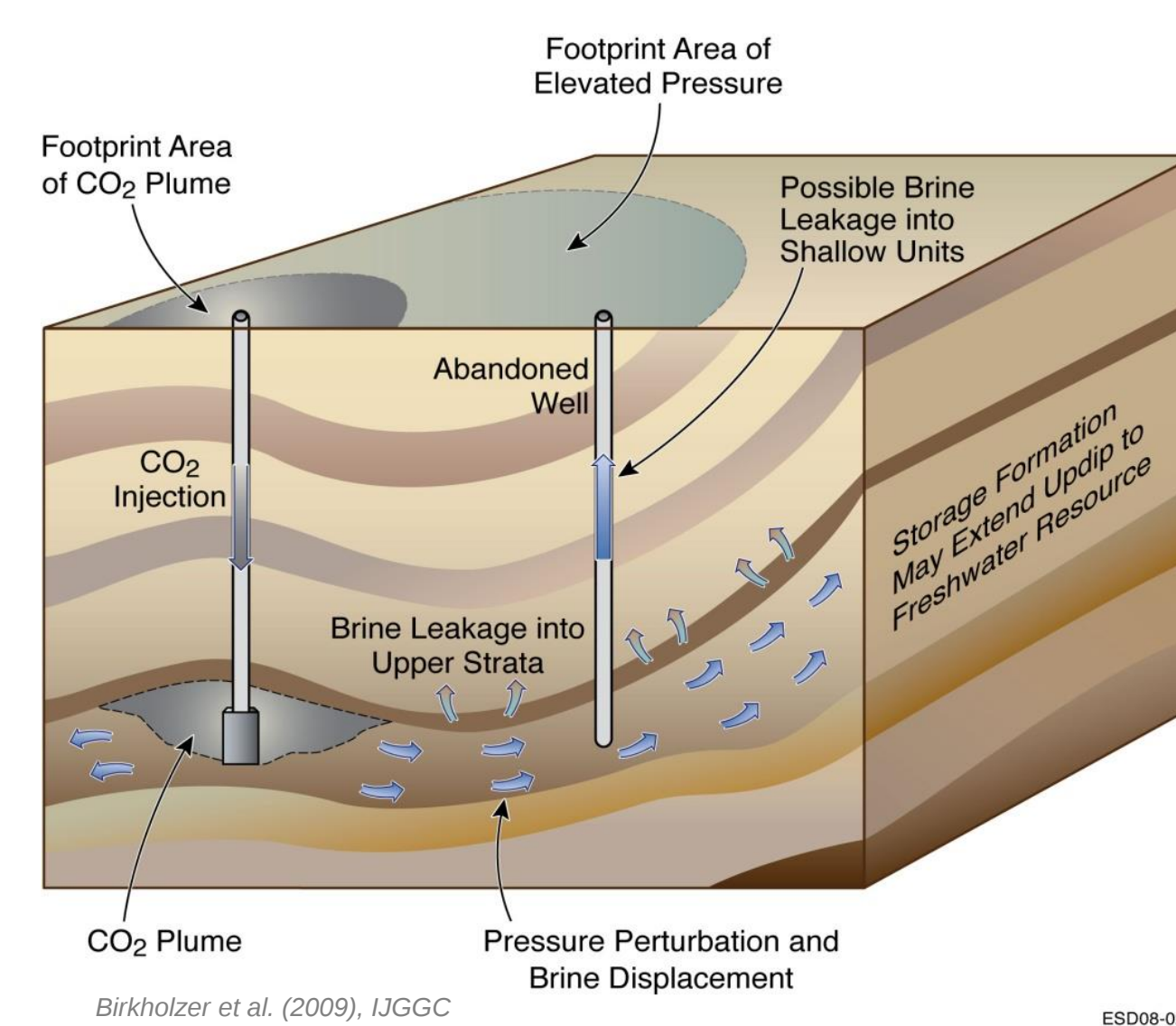
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Abstract

Geologic carbon sequestration through carbon dioxide (CO_2) injection is one option for climate change mitigation. The injection-induced migration of both CO_2 and resident formation fluids (brine) may pose a risk to overlying underground sources of drinking water (USDW). The Area of Review (AoR) is defined as the portion of a USDW that is susceptible to degradation from brine and/or CO_2 leakage. A sequestration operator needs to conduct site characterization, monitoring, and corrective action within the AoR. The open-conduit assumption gives un-necessary conservatism and can lead to very large AoRs. In this presentation we discuss a risk-based alternative AoR approach where the AoR is divided into three tiers. As each of the three tiers would have a different level of regulatory requirements, the cost of compliancy should be reduced when compared to the current AoR delineation, although the overall size of the AoR does not change.

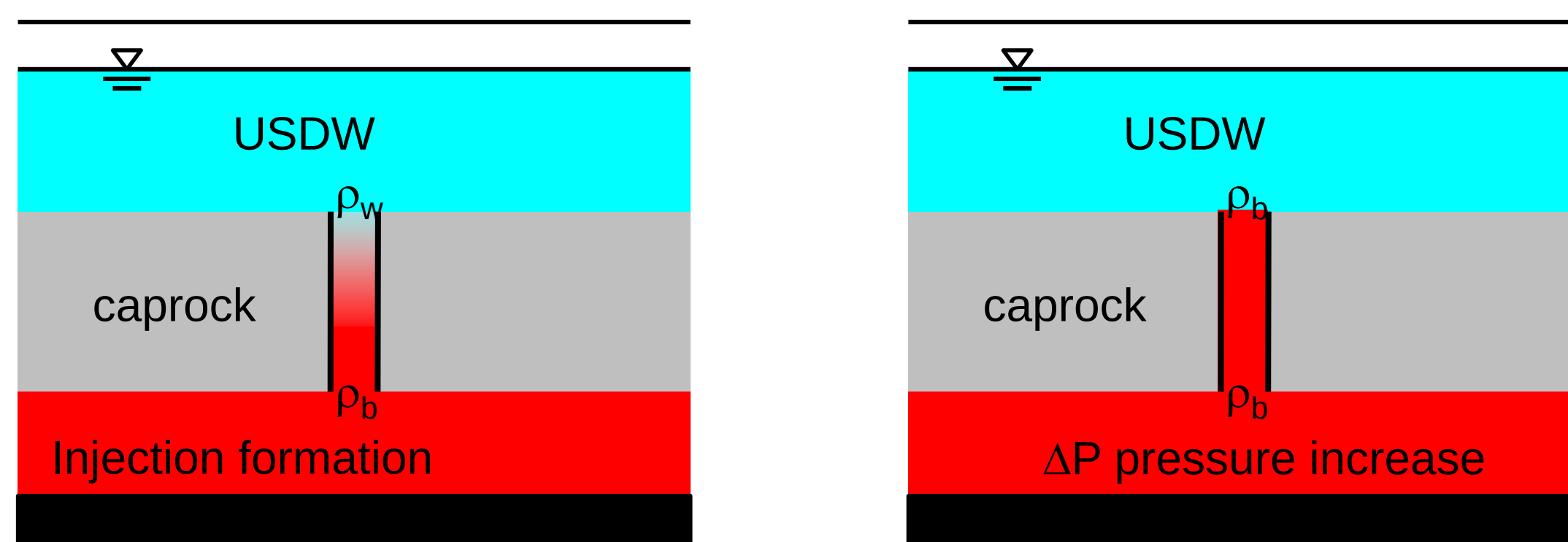
1. Geologic Carbon Sequestration

- CO_2 from stationary sources is injected deep underground
- CO_2 is buoyant, but held in place by caprock
- Existing brine is displaced
- Abandoned wells and faults are potential leakage pathways



2. Threshold pressure

- Threshold pressure is the pressure increase in the injection formation necessary to lift brine from the injection formation to an USDW.

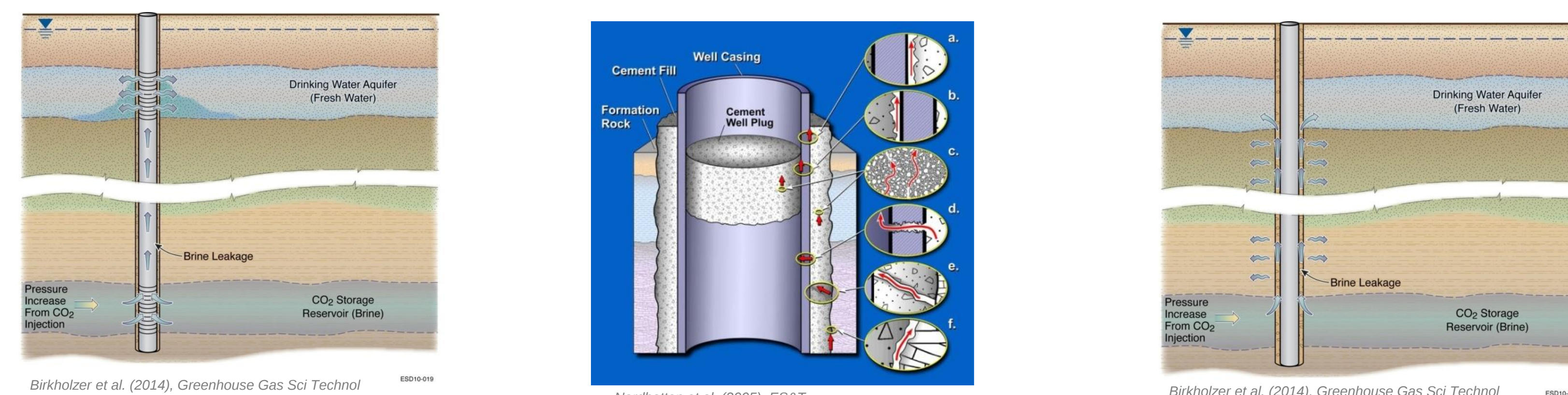


3. Area of review delineation

- CO_2 plume and pressure response are predicted using computer modeling
- Threshold pressure is predicted based on density difference, vertical distance from injection formation to USDW, and pre-injection pressure conditions
- AoR is the overlay of CO_2 footprint and the area where the threshold pressure is exceeded.



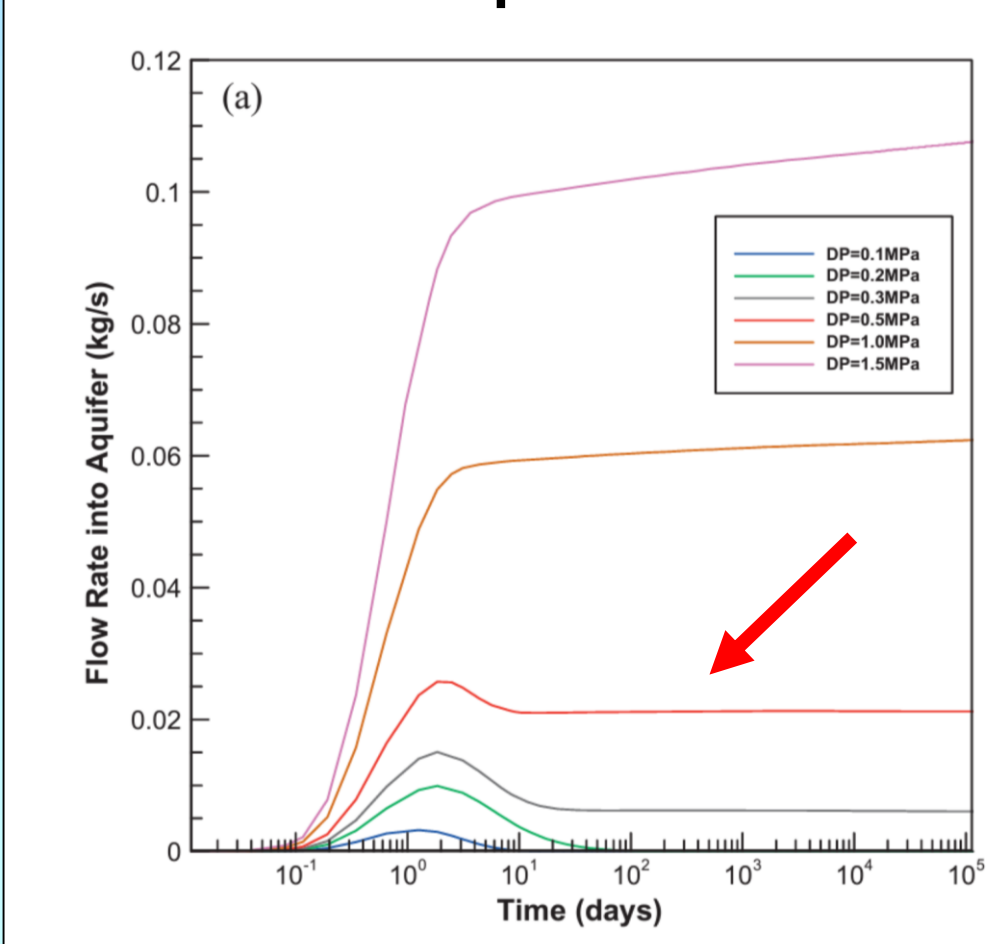
4. Leakage pathways



- Leakage can occur inside the well casing as well as along the outside of the casing through fractures in the well cement and host rock.
- Flow inside of the casing is usually blocked by cement plugs.
- Flow outside of the casing may interact with intermediate formations.

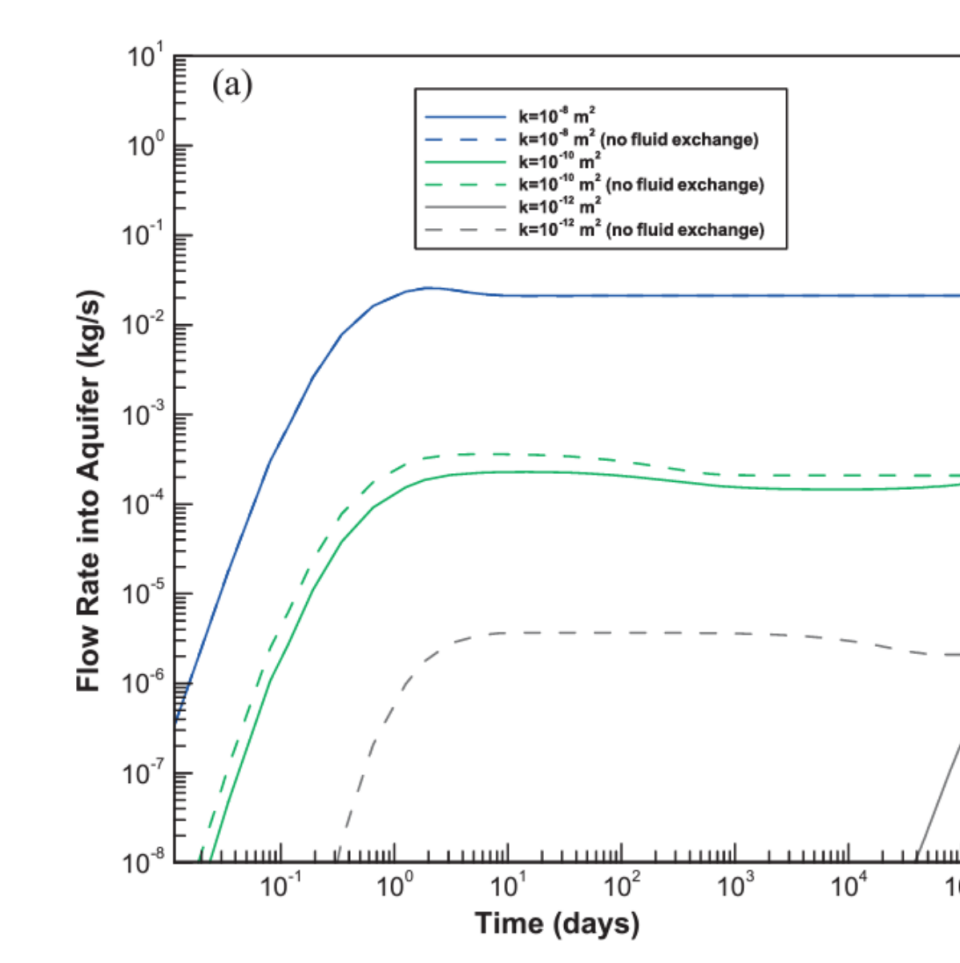
5. Brine Leakage

Flow in open conduit



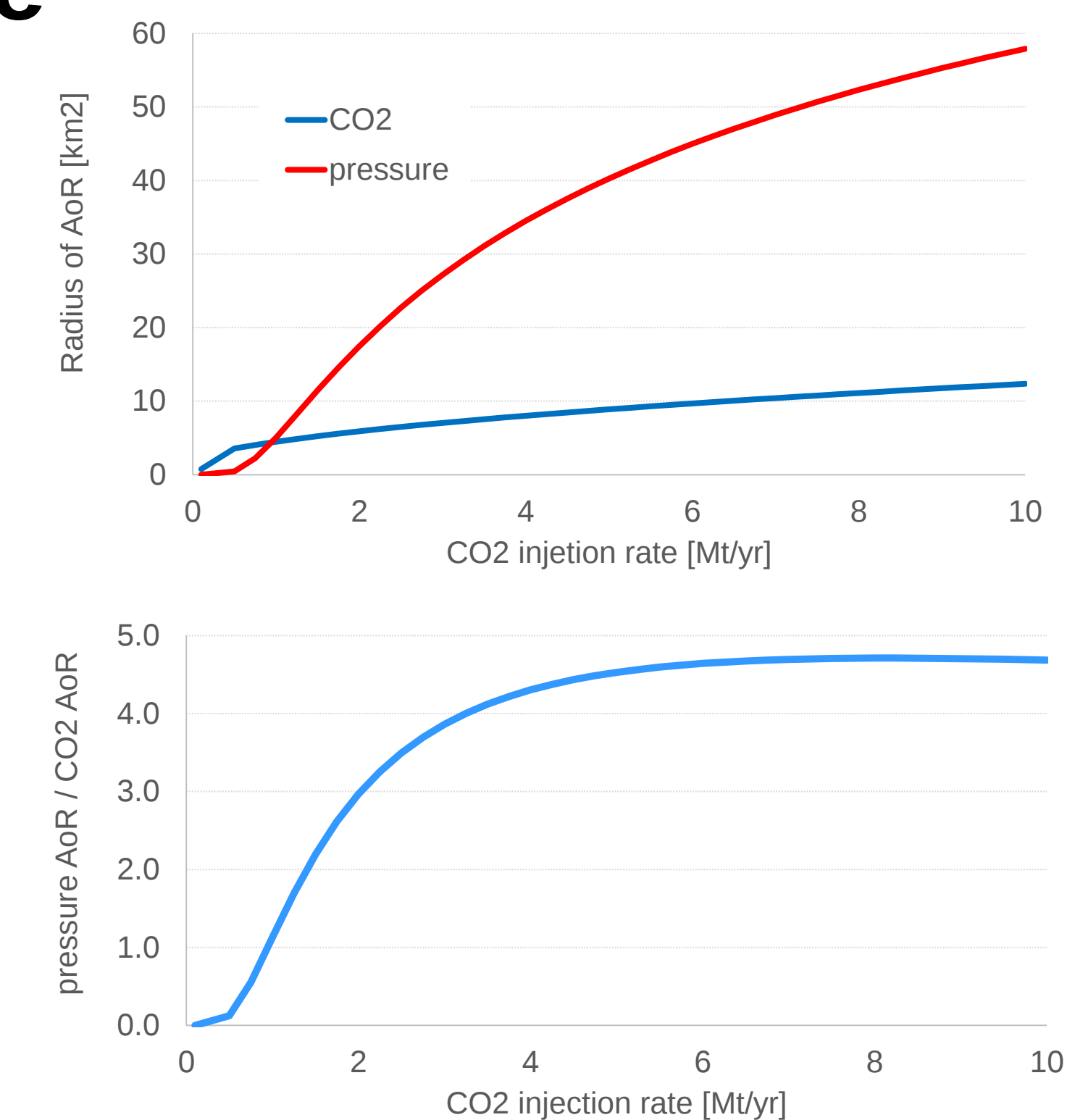
- In an open conduit, sustained flow occurs once the threshold pressure is exceeded.
- Fractures with lower permeability lead to significant reduction of flow.
- Leakage into intermediate formations can significantly reduce flow into USDW.

Flow in fractures



6. Area of Review size

- Simple case: homogeneous, horizontal, impermeable top and bottom
- Semi-analytic solutions for CO_2 plume radius and pressure response
- Permeability 250mD; threshold pressure 0.5 MPa
- AoR is pressure defined for most cases with industrial-scale injection rates



7. Three-tiered approach

- Goal: decrease regulatory burden on injection operations, while maintaining protection of drinking water resources
- Area of review is divided into three tiers:
 - Area of CO_2 footprint: most stringent rules for site characterization, remediation and monitoring
 - Area where pressure increase may cause significant brine flow along fractures in well cement and/or natural fractures: regulations as stringent as for area of CO_2 footprint
 - Area where pressure increase can lift brine to USDW through open bore hole: less stringent regulations, focused on detecting large leakage pathways
 - Area with potential for significant brine flow based on risk assessment and therefore site specific

8. Publication

More details can be found in J. Birkholzer, A. Cihan, K. Bandilla (2014). A tiered area-of-review framework for geologic carbon sequestration. *Greenhouse Gases: Science and Technology*, 4:20-35.

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