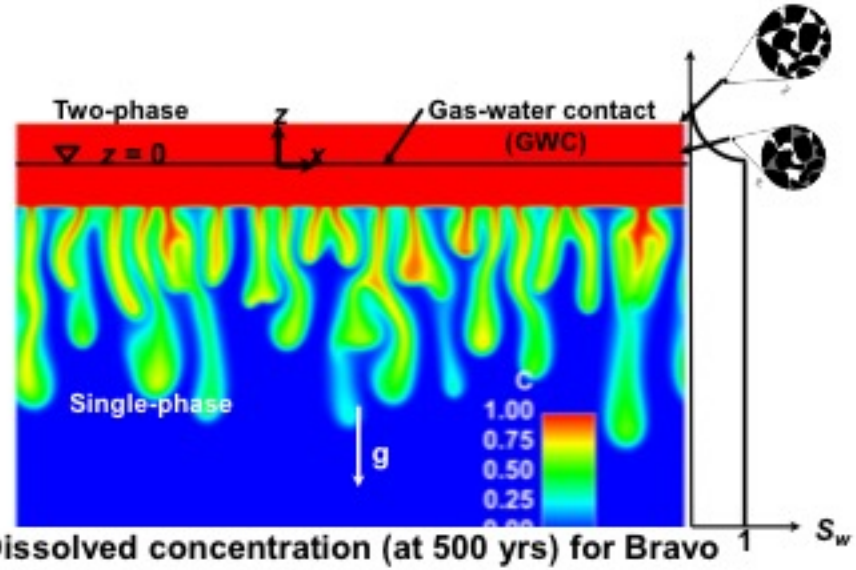
Estimating solubility trapping rates in GCS

Mario Martinez & Marc Hesse



Dissolved concentration (at 500 yrs) for Bravo Dome properties with 50 kPa entry pressure.

Figure shows sinking plumes of dense CO_2-saturated brine in the brine-saturated region below the gas-water contact. The upper (red) region is the two-phase capillary transition zone occupied by a brine and separate-phase CO_2.

Martinez, M. J., and M. A. Hesse (2016), Two-phase convective CO2 dissolution in saline aquifers, Water Resour. Res., 52, doi:10.1002/2015WR017085.

Work was performed at Sandia National Labs.

Scientific Achievement

Developed an advanced model for buoyantly driven convective dissolution of CO_2 into brine.

Significance and Impact

- Buoyantly driven convective dissolution enhances the rate of dissolution, but is difficult to quantify in the field
- Our two-phase model demonstrates an new correlation between entry pressure and dissolution rate, enhancing dissolution flux more than 3 times previous estimates.

Research Details

- Models have heretofore ignored the two-phase region above the gas-water contact where dissolution actually takes place
- The dissolution rate increases with capillary wicking potential (entry pressure) via convective current loops penetrating above the gas-water contact.
- An upper bound may be 5x based on a mixing model analog

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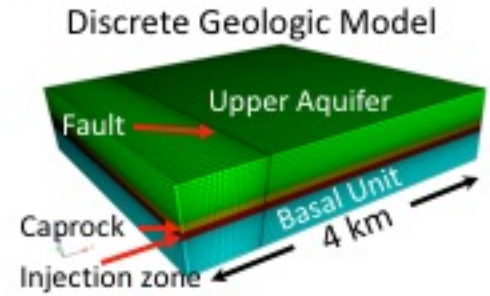
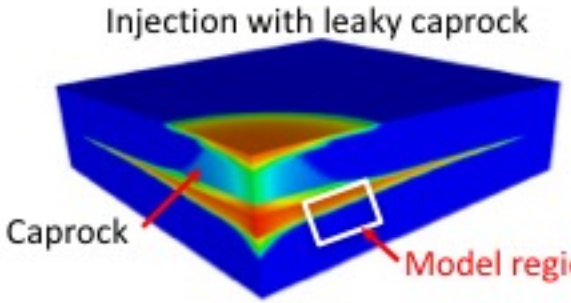
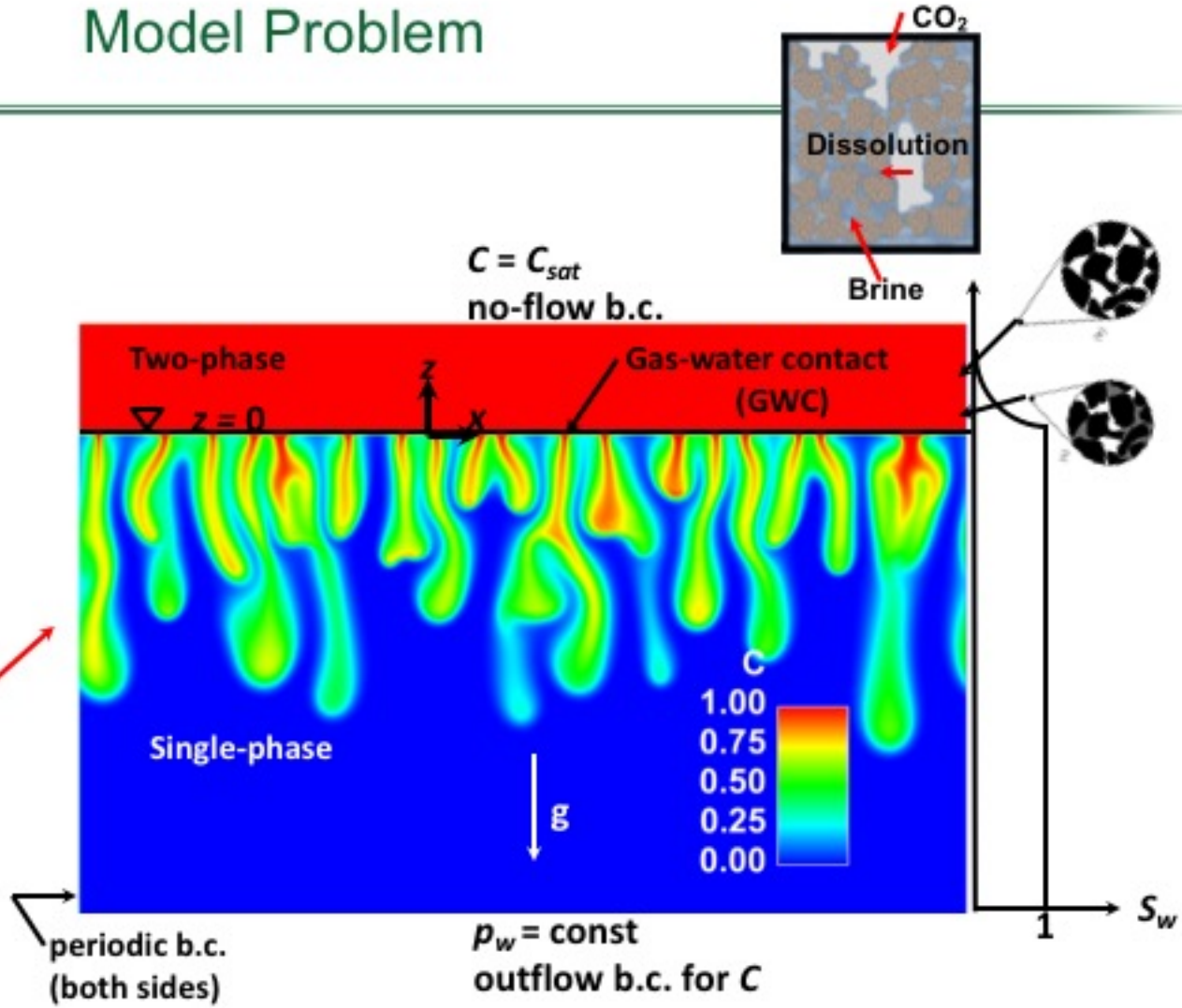
Model Problem





Two reservoirs are modeled

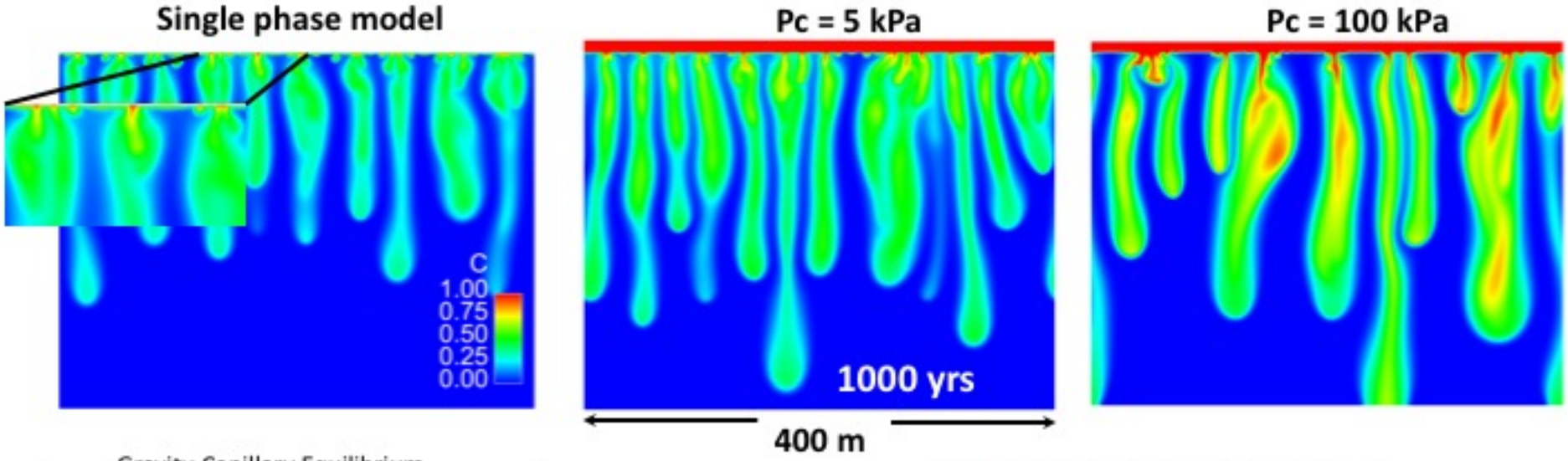
Property	Sleipner Utsira	Bravo Dome
porosity	0.37	0.15
perm. (mD)	2000	50

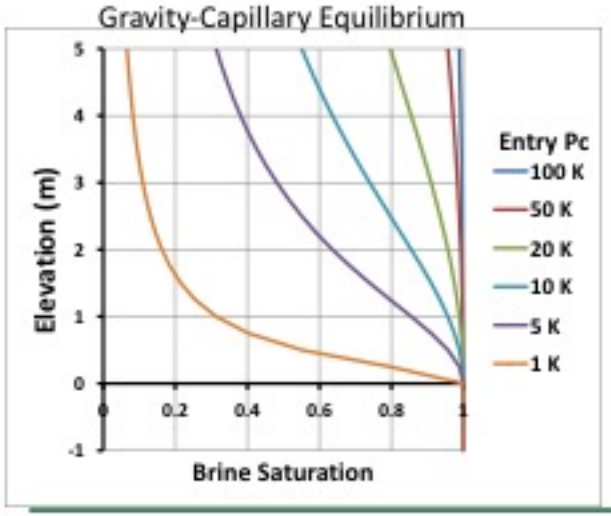


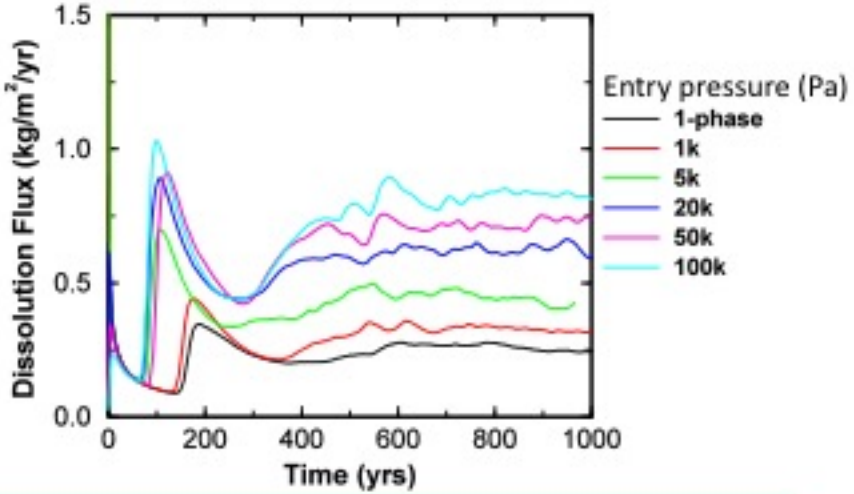
Problem definition and dissolved concentration (at 500 yrs) for Bravo Dome properties with 50 kPa entry pressure.

Impact of Capillary Transition Zone on CO_2 Dissolution Into Brine

Dissolved CO_2 in Bravo Dome (k= 50 mD poro = 0.15) reservoir







Long-term quasi-steady dissolution flux

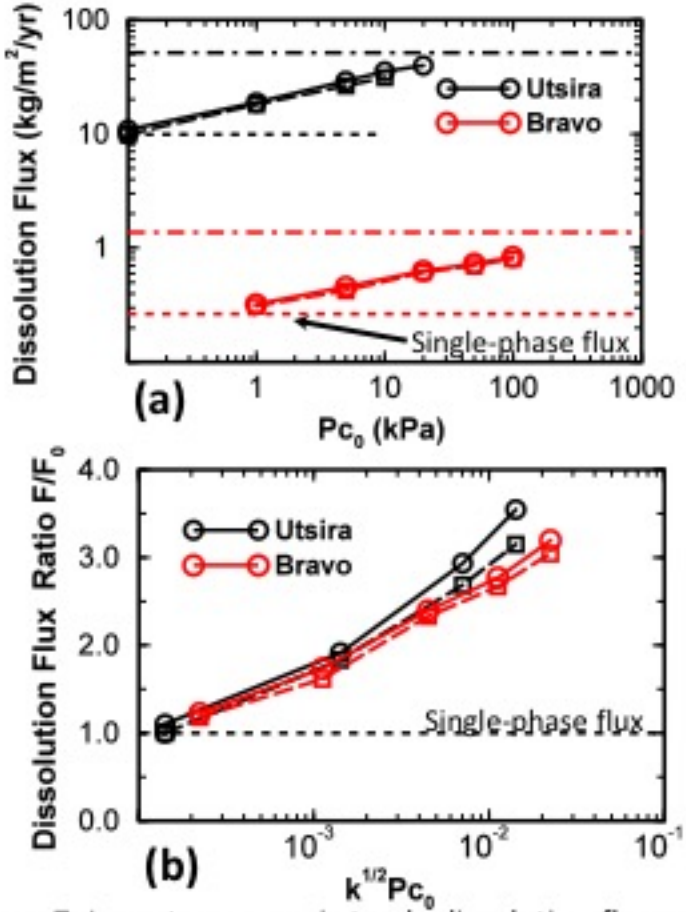


Figure 7. Long-term, quasi-steady dissolution flux as function of entry pressure and residual brine saturation (solid lines, $S_{wr} = 0$; dashed lines $S_{wr} = 0.3$) in (a) dimensional units and (b) with flux normalized by the single-phase, closed top dissolution flux (F_0) and entry pressure normalized with permeability (units of surface tension, N/m).

- $p_{c0} \rightarrow 0$ recovers the single-phase, closed top dissolution rate
- For "large" but feasible p_{c0}, Flux ~ 3.5x single-phase fluxes
- An upper bound on flux is ~5x single-phase value, based on a convective mixing analog

Mixing Problem