Estimating solubility trapping rates in GCS
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Scientific Achievement
Developed an advanced model for buoyantly driven convective dissolution of CO₂ 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 a 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

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

Figure shows sinking plumes of dense CO₂-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 CO₂.


Work was performed at Sandia National Labs.
Model Problem

Two reservoirs are modeled

<table>
<thead>
<tr>
<th>Property</th>
<th>Sleipner Utsira</th>
<th>Bravo Dome</th>
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</thead>
<tbody>
<tr>
<td>porosity</td>
<td>0.37</td>
<td>0.15</td>
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<tr>
<td>perm. (mD)</td>
<td>2000</td>
<td>50</td>
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Problem definition and dissolved concentration (at 500 yrs) for Bravo Dome properties with 50 kPa entry pressure.
Long-term quasi-steady dissolution flux

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

**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).