Scientific Achievement

First estimate of solubility trapping, i.e. CO$_2$ dissolution, over millennial timescales.

Significance and Impact

We show that at Bravo Dome (NM) less than 20% of the 1.3 GtCO$_2$ naturally emplaced 10,000 years ago have dissolved. This indicates that solubility trapping in typical US storage formations is much slower than commonly assumed and that long-term storage security has to be ensured through other trapping processes.

Research Details

– Developed a large cross-disciplinary database for the Bravo Dome natural CO$_2$ field in New Mexico.
– Developed a purely data-based methodology to estimate the mass loss from the reservoir.
– We estimate that over 10,000 years 232 MtCO$_2$ have dissolved from a reservoir of 1.3 GtCO$_2$, approximately 10%.
– This is much slower than the only other field-based estimate that is available, but more representative of US.

Bravo Dome statistics:
1. Largest CO$_2$ field in the world.  
   22 TCF of natural gas, 99.9 % CO$_2$
2. Reservoir area is 2,200 km$^2$.
4. Gas is of volcanic origin.

Bravo Dome Data
1. 788 wells including 40 cored wells.
2. More than 40 2D seismic lines.
3. 3645 porosity & permeability data.
4. 18 noble gas and stable isotope analyses.

Best data set to study solubility trapping.
Calculation of dissolved CO$_2$

Due to the high data-density a purely data based estimate is possible.

Change in gas mass: 

$$M = M_i - M_f$$

Mass at final time:

$$M_f = \phi S (p) dV = m dA$$

$\phi$ = porosity, $S$ = gas saturation

$\rho$ = gas density, $p$ = pressure

$m$ = mass per unit area

But we cannot directly estimate the mass at initial time!
Geochemical estimates of local dissolution

Local mass fraction of gas dissolved:

\[ F = \frac{m_f}{m_i} \cdot \frac{\text{CO}_2/\text{He}_f}{\text{CO}_2/\text{He}_i} \]
Calculation of dissolved CO₂

\[ M \approx \iint m \, dA = \iint m_i \, m_f \, dA = \iint \left( \frac{1}{F} \right) m_f \, dA \]

Total mass of dissolved CO₂: 232 MtCO₂
Dissolution mechanism

NE portion of the reservoir with the highest dissolved fraction:

Dissolution may be controlled by density driven convection in brine.
Implications for CCS

232 MtCO$_2$ dissolved correspond to 64 years of coal-plant emissions.

IPCC-report suggest that most CO$_2$ is trapped in 10,000 years, but at Bravo Dome less than 20% of the emplaced CO$_2$ have dissolved!

Bravo Dome is representative for many US saline aquifers: Spatially extensive, 10’s-100’s m thick, and low-$k$ 10-100 mD.

Suggests that solubility trapping will take significantly longer in most US aquifer. Either we have to accept higher risk or long-term storage security has to be ensured by another trapping process.