Geochemical Investigations of King Island Well

Mark Conrad, Shahla Ali, John Christensen, Kevin Knauss and Nic Spycher

Earth Sciences Division
Lawrence Berkeley National Laboratory
Berkeley, CA

Motivation

- **Geochemistry of Reservoir Fluids**
  - Background geochemistry
  - Injection phase processes
    - Acidification and metal release
    - Short term rock-water-CO₂ interaction
    - Direct effects of CO₂ vs. pH
  - Long term rock-water interaction
    - Formation of beneficial alteration products (carbonates, clays)

- **Reactivity of Rocks**
  - Maintaining permeability/porosity of reservoir rocks
  - Integrity of cap rocks

- **Input Data for Reactive Transport Modeling**
Planned Research

- Chemical and Isotopic Characterization
  - Chemical, mineralogic and isotopic studies of reservoir and cap rocks
  - Chemical and isotopic analyses of reservoir fluids

- Laboratory Studies

- Reactive Transport Modeling

\( \delta^{18}O \) of Carbonates for Identification of Active Flow Zones in Fractures

Wildcat Canyon Fault System - Berkeley Hills

Earth Sciences Division
Sr Isotope Tracking of Mineral Reactions

220°C, 100 bars

Mineral dissolution (feldspars)

Mineral ppt (zeolites, clays)

Helium Isotope Signatures

\[ R = \frac{^{3}\text{He}}{^{4}\text{He}}; \text{ atmospheric } ^{3}\text{He}/^{4}\text{He} \ (R_a = 1.4 \times 10^{-6}) \]

Mantle He: 6-8 \( R_a \)
Atmospheric He: 1\( R_a \)
Crustal He: 0.02 \( R_a \)

Hilton DR, Science 2007
Zones of fluid flow across the San Andreas Fault

Meteoric Fluid (3300-m) 5-50ka
Mantle Fluid (~3225 m)

Ali, 2010

Hydrothermal Experiments

Dickson Bomb

Earth Sciences Division
Long-Term Experiments (Frio)

- Conditions ~field (T, P, CO₂)
- Westcarb core and NaCl brine
- Equilibrate with 100 bar CO₂, run at high T to accelerate reaction progress
- Geochemical Modeling used to confirm mineral stability fields – set T limit
- SEM used to identify run products
- Example = Frio C Sand at 150°C

![Fig 1. Model minerals at 60°C](image1)
![Fig 2 Model minerals at 150°C](image2)
![Fig 3 Model minerals at 200°C](image3)

Beneficial Reaction Products

- Au-bag Batch Reactor Experiments
  - SEM used to identify run products
  - Frio C Sand, F4 experiment (neutralization)
  - Frio Blue sand, F6 experiment (accelerated)

![Clays and zeolites?](image4)

Earth Sciences Division
Reactive Transport Modeling - Conceptual Model

Earth Sciences Division

Processes to Consider

- Multiphase fluid flow (CO$_2$/H$_2$O)
- Mutual CO$_2$/H$_2$O solubility
- Aqueous- and gas-phase transport
- Multicomponent reactions
  - Mineral precipitation/dissolution
  - Aqueous complexation
  - Surface complexation (as needed)
  - Gas dissolution/exsolution
- Porosity-permeability coupling
Example of Radial RT Model


Example Simulation – Injectivity (TOUGHREACT)

Silica scaling in geothermal injection well

\[ \frac{k}{k_0} = \left( \frac{\phi - \phi_c}{\phi_0 - \phi_c} \right)^n \]

Verma & Praess (1988)

Several other options to couple K and \( \Phi \)

Xu et al., 2004, Geothermics, 33, 477-491