Geochemical Investigations of King Island Well

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Motivation

- **Geochemistry of Reservoir Fluids**
  - Background geochemistry
  - Injection phase processes
    - Acidification and metal release
    - Short term rock-water-CO_2 interaction
    - Direct effects of CO_2 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**

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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**

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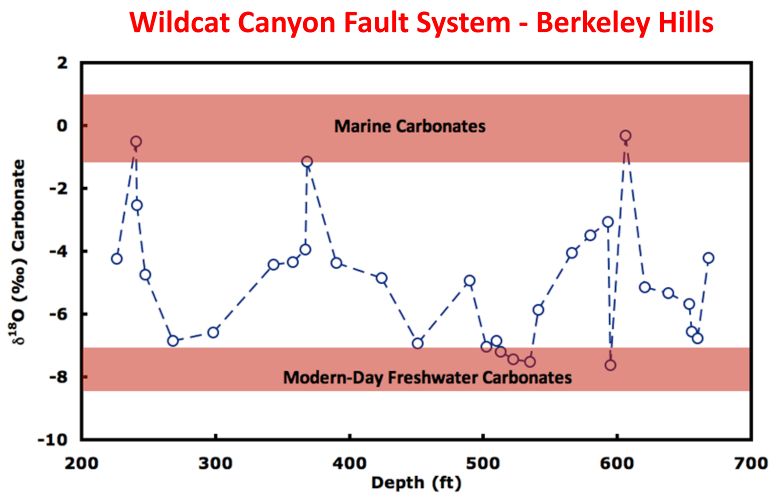
$\delta^{18}O$ of Carbonates for Identification of Active Flow Zones in Fractures



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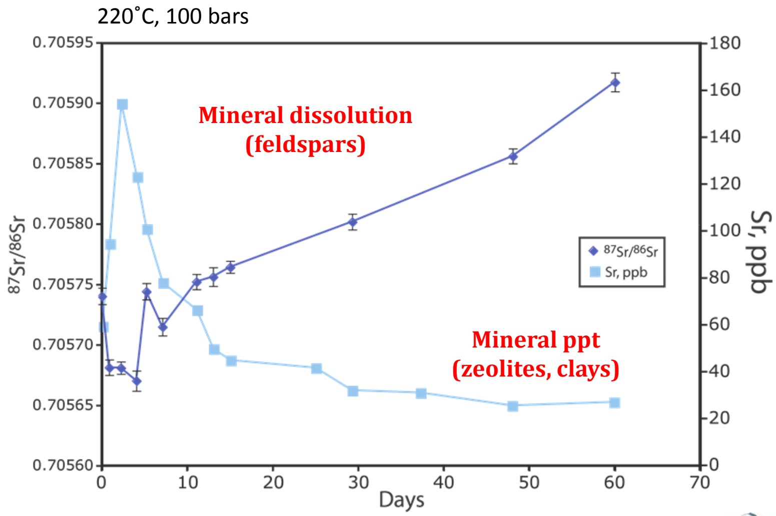
Sr Isotope Tracking of Mineral Reactions



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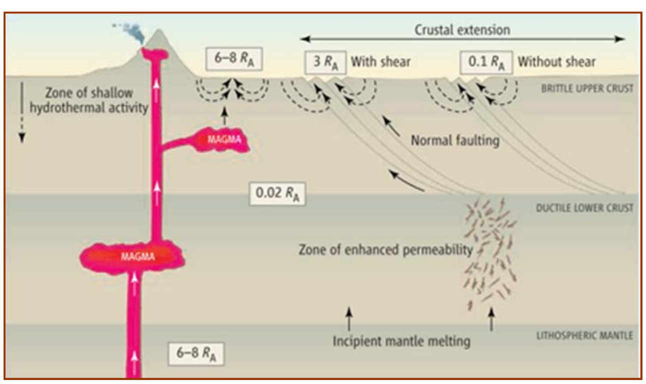
Helium Isotope Signatures

R = $^3He/^4He$; atmospheric $^3He/^4He$ (R_a =1.4x10^{-6})



Mantle He: 6-8 R_a
Atmospheric He: 1R_a
Crustal He: 0.02 R_a

Hilton DR, Science 2007

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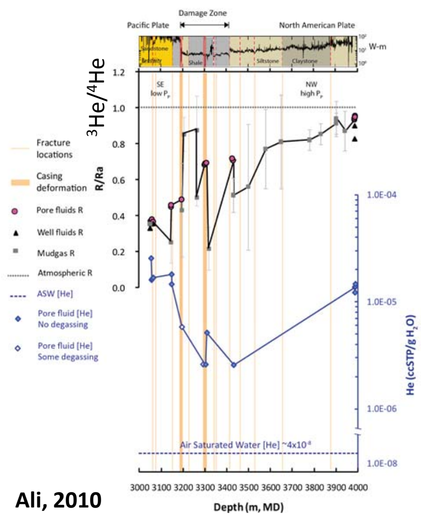
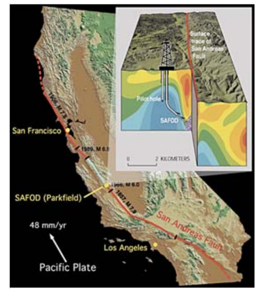
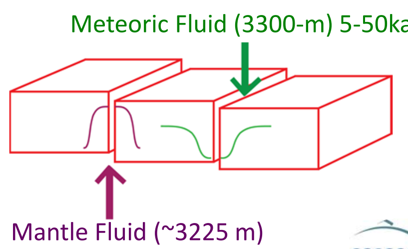
Zones of fluid flow across the San Andreas Fault

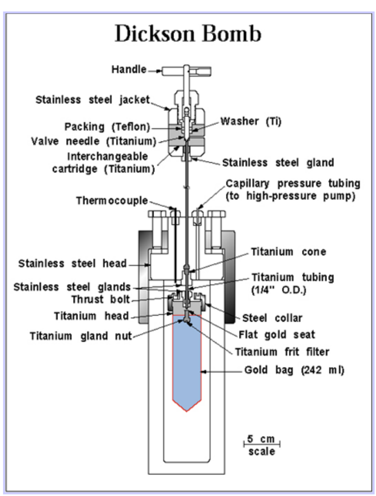


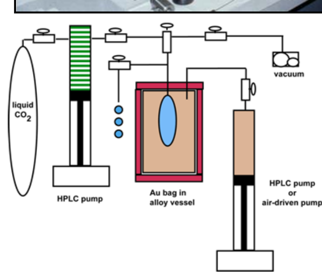
Ali, 2010





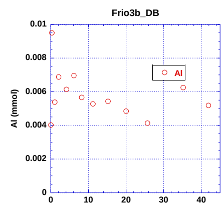
Hydrothermal Experiments

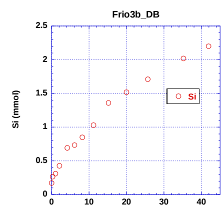




Long-Term Experiments (Frio)

- Conditions ~field (T, P, CO_2)
- Westcarb core and NaCl brine
- Equilibrate with 100 bar CO_2, 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





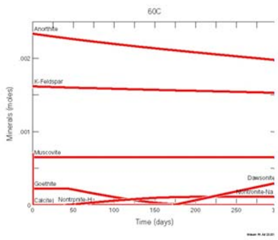


Fig 1. Model minerals at 60°

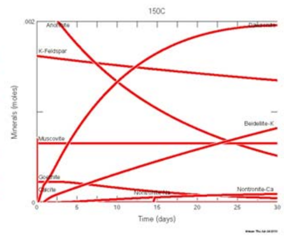


Fig. 2 Model minerals at 150°C

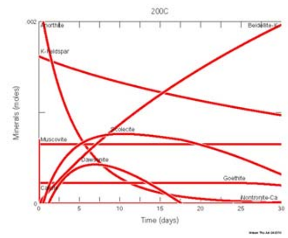


Fig. 3 Model minerals at 200°C

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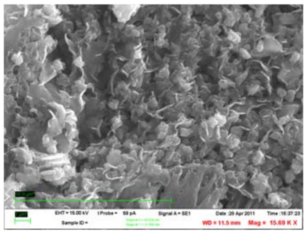
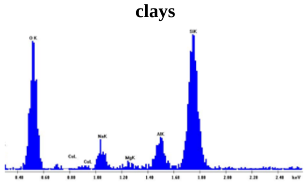
Beneficial Reaction Products

- **Au-bag Batch Reactor Experiments**
  - **SEM used to identify run products**

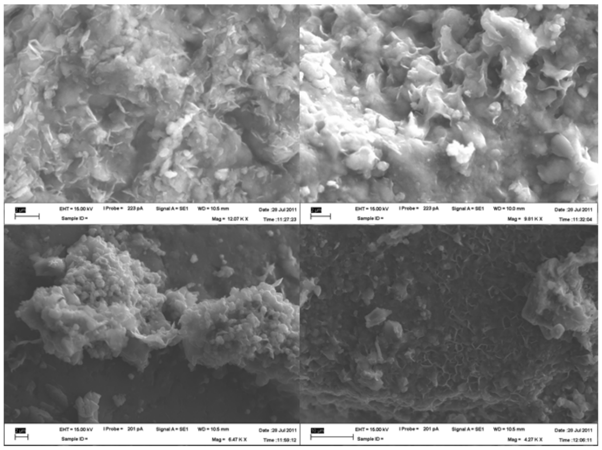
Frio C Sand, F4 experiment (neutralization)



clays



Frio Blue sand, F6 experiment (accelerated)



Clays and zeolites?

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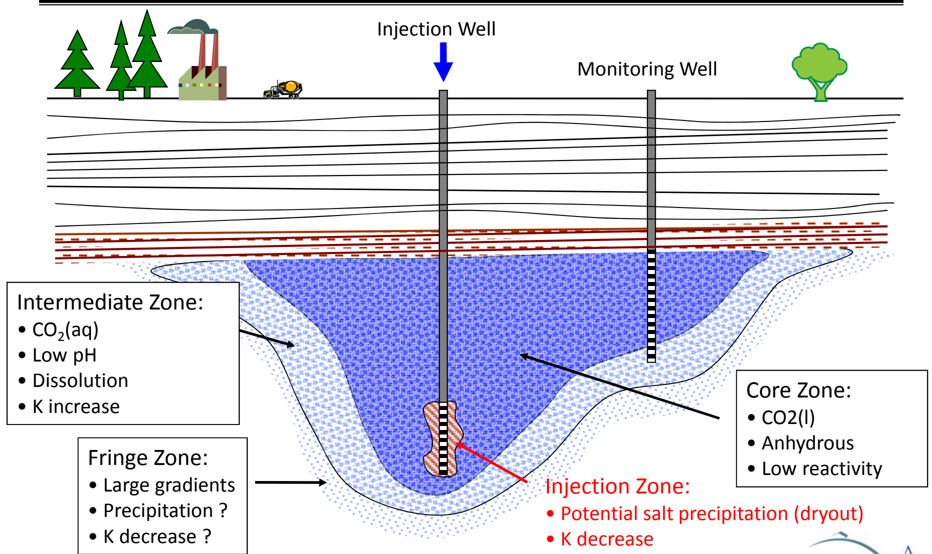
Reactive Transport Modeling - Conceptual Model



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Processes to Consider

- Multiphase fluid flow (CO_2/H_2O)
- Mutual CO_2/H_2O solubility
- Aqueous- and gas-phase transport
- Multicomponent reactions
  - Mineral precipitation/dissolution
  - Aqueous complexation
  - Surface complexation (as needed)
  - Gas dissolution/exsolution
- Porosity-permeability coupling

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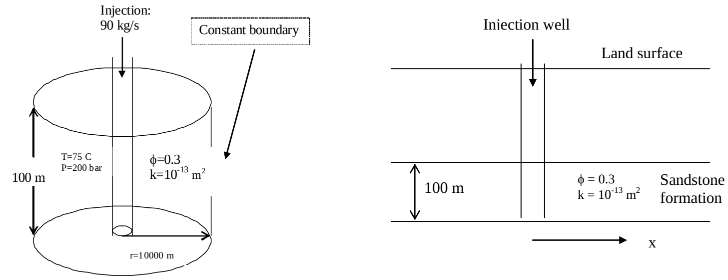
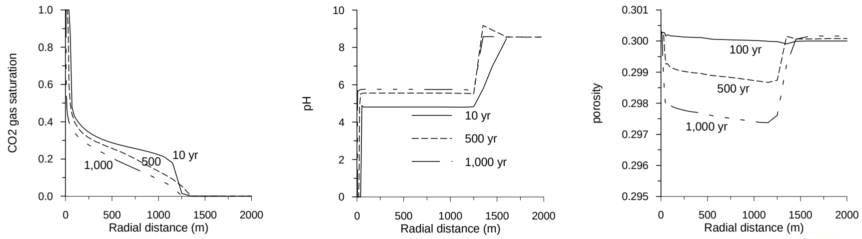
Example of Radial RT Model





After Xu et al. (2003) JGR, 108 (B2), 2071-2084 and (2006) C&G, 32, 145-165

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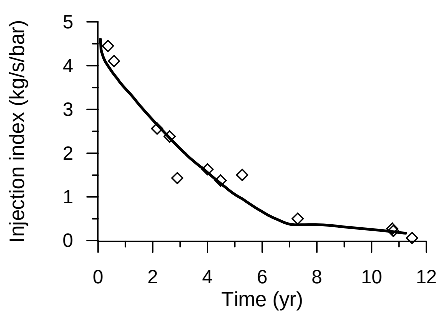
Example Simulation – Injectivity (TOUGHREACT)

Silica scaling in geothermal injection well



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

Verma & Pruess (1988)

Several other options to couple K and Φ

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

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