

# Geochemical Investigations of King Island Well

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## Motivation

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- **Geochemistry of Reservoir Fluids**
  - Background geochemistry
  - Injection phase processes
    - Acidification and metal release
    - Short term rock-water-CO<sub>2</sub> interaction
    - Direct effects of CO<sub>2</sub> 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

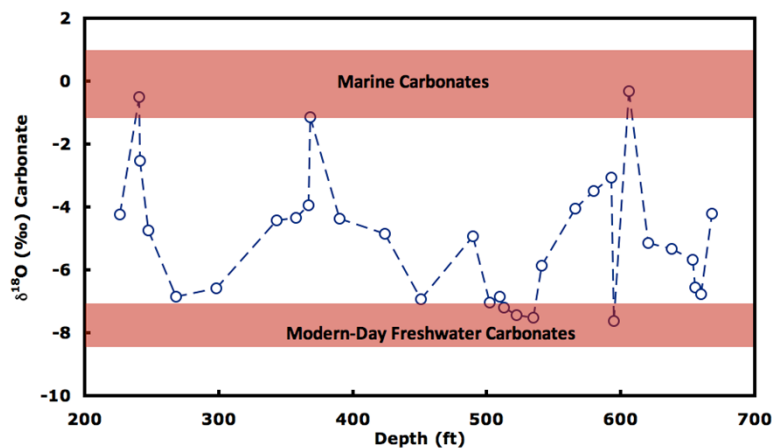
- **Chemical and Isotopic Characterization**
  - Chemical, mineralogic and isotopic studies of reservoir and cap rocks
  - Chemical and isotopic analyses of reservoir fluids
- **Laboratory Studies**
- **Reactive Transport Modeling**

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

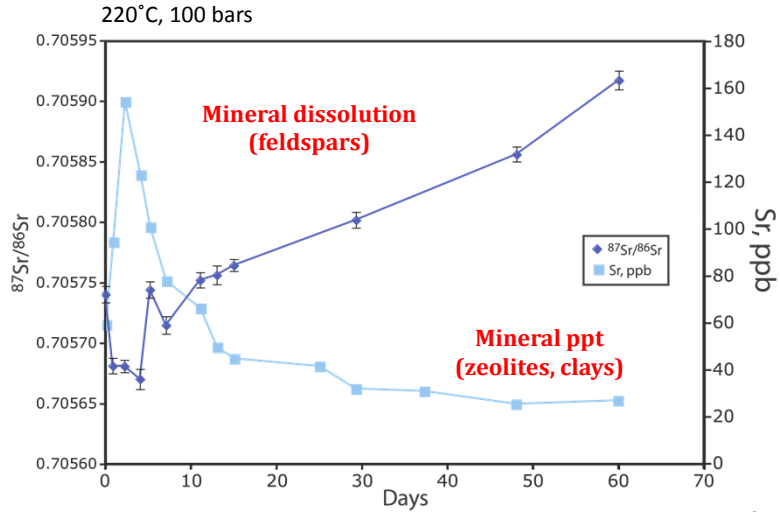
### Wildcat Canyon Fault System - Berkeley Hills



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## Sr Isotope Tracking of Mineral Reactions

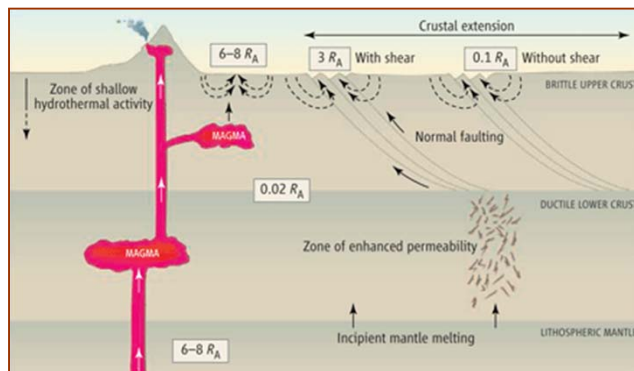


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## Helium Isotope Signatures

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



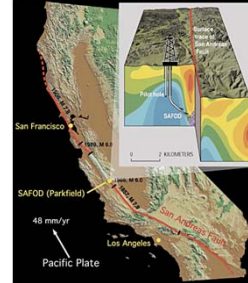
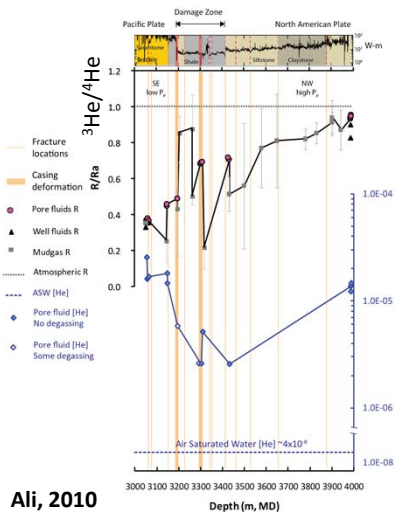
Mantle He: 6-8  $R_a$   
Atmospheric He: 1  $R_a$   
Crustal He: 0.02  $R_a$

Hilton DR, Science 2007

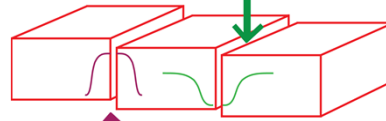
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## Zones of fluid flow across the San Andreas Fault



Meteoric Fluid (3300-m) 5-50ka

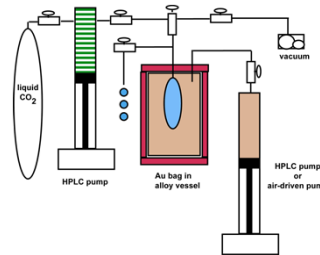
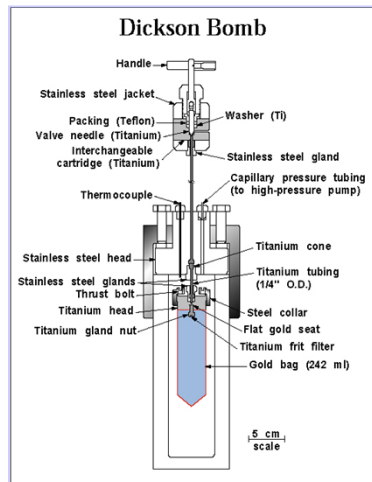


Mantle Fluid (~3225 m)

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## Hydrothermal Experiments



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## Long-Term Experiments (Frio)

- Conditions ~field (T, P, CO<sub>2</sub>)
- Westcarb core and NaCl brine
- Equilibrate with 100 bar CO<sub>2</sub>, 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

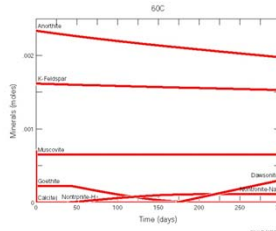
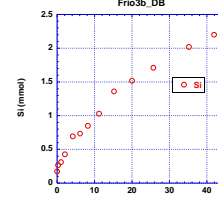
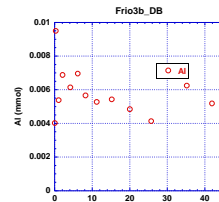


Fig. 1. Model minerals at 60°

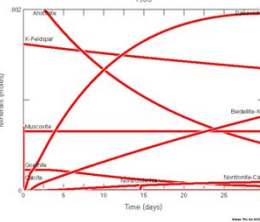


Fig. 2 Model minerals at 150°C

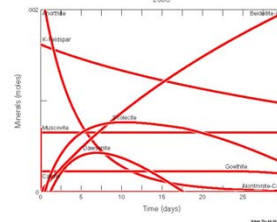


Fig. 3 Model minerals at 200°C

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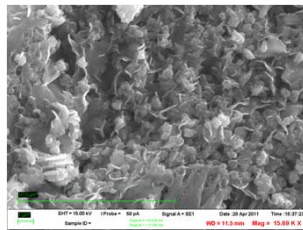


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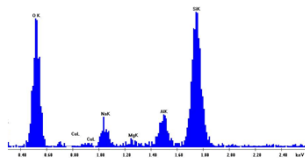
## Beneficial Reaction Products

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

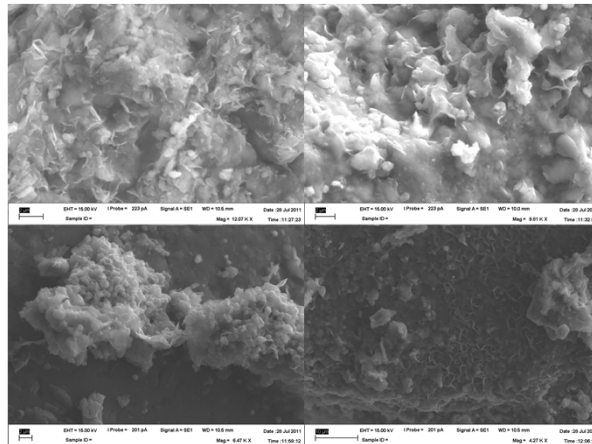
Frio C Sand, F4 experiment  
(neutralization)



clays



Frio Blue sand, F6 experiment  
(accelerated)

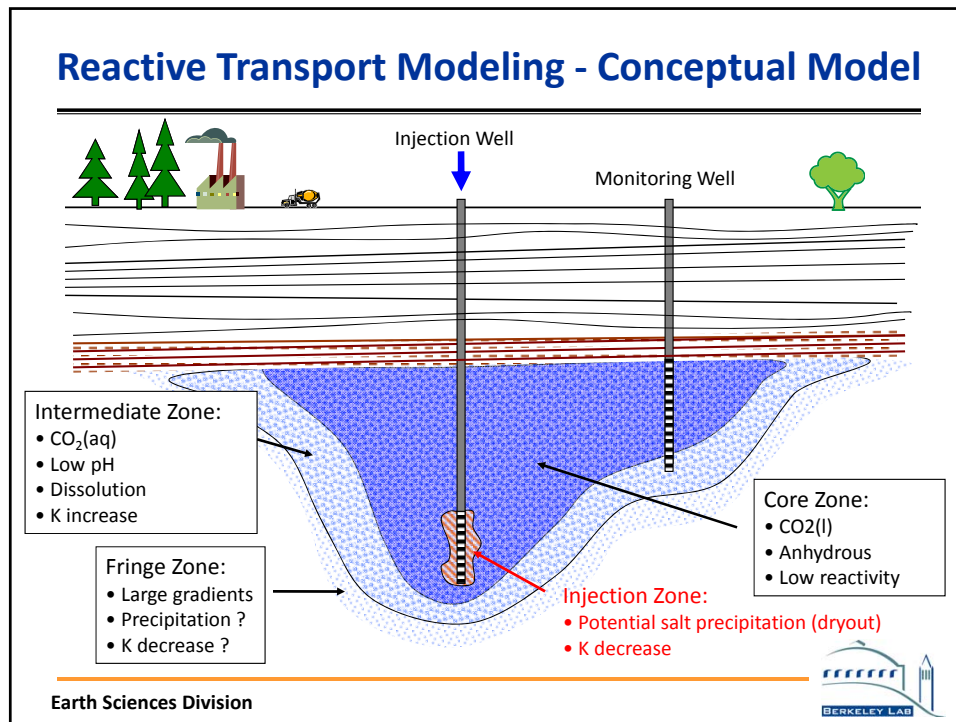


Clays and zeolites?

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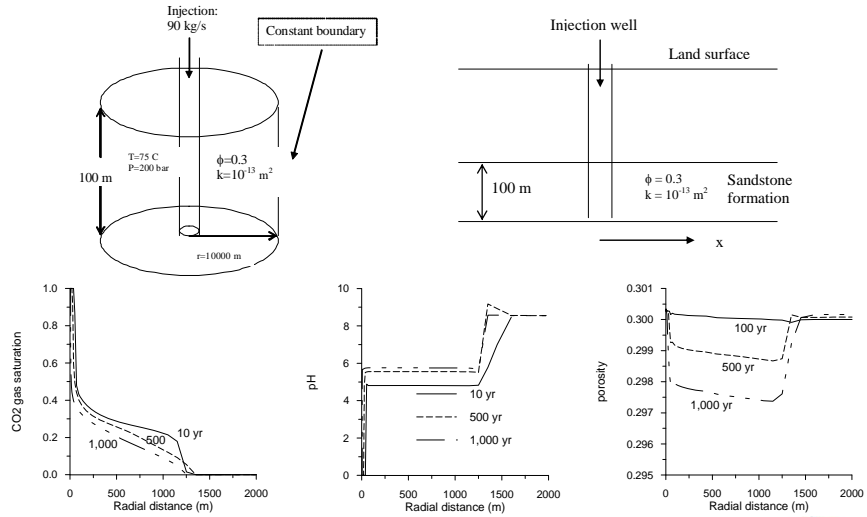


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- ### Processes to Consider
- **Multiphase fluid flow (CO<sub>2</sub>/H<sub>2</sub>O)**
  - **Mutual CO<sub>2</sub>/H<sub>2</sub>O solubility**
  - **Aqueous- and gas-phase transport**
  - **Multicomponent reactions**
    - Mineral precipitation/dissolution
    - Aqueous complexation
    - Surface complexation (as needed)
    - Gas dissolution/exsolution
  - **Porosity-permeability coupling**
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## Example of Radial RT Model



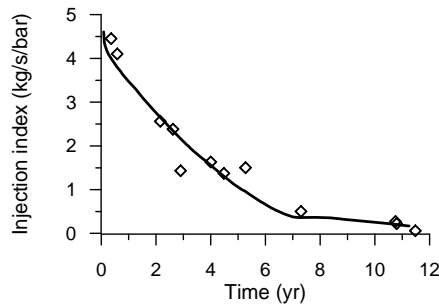
After Xu et al. (2003) JGR, 108 (B2), 2071-2084 and (2006) C&G, 32, 145-165

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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  $\Phi$

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

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