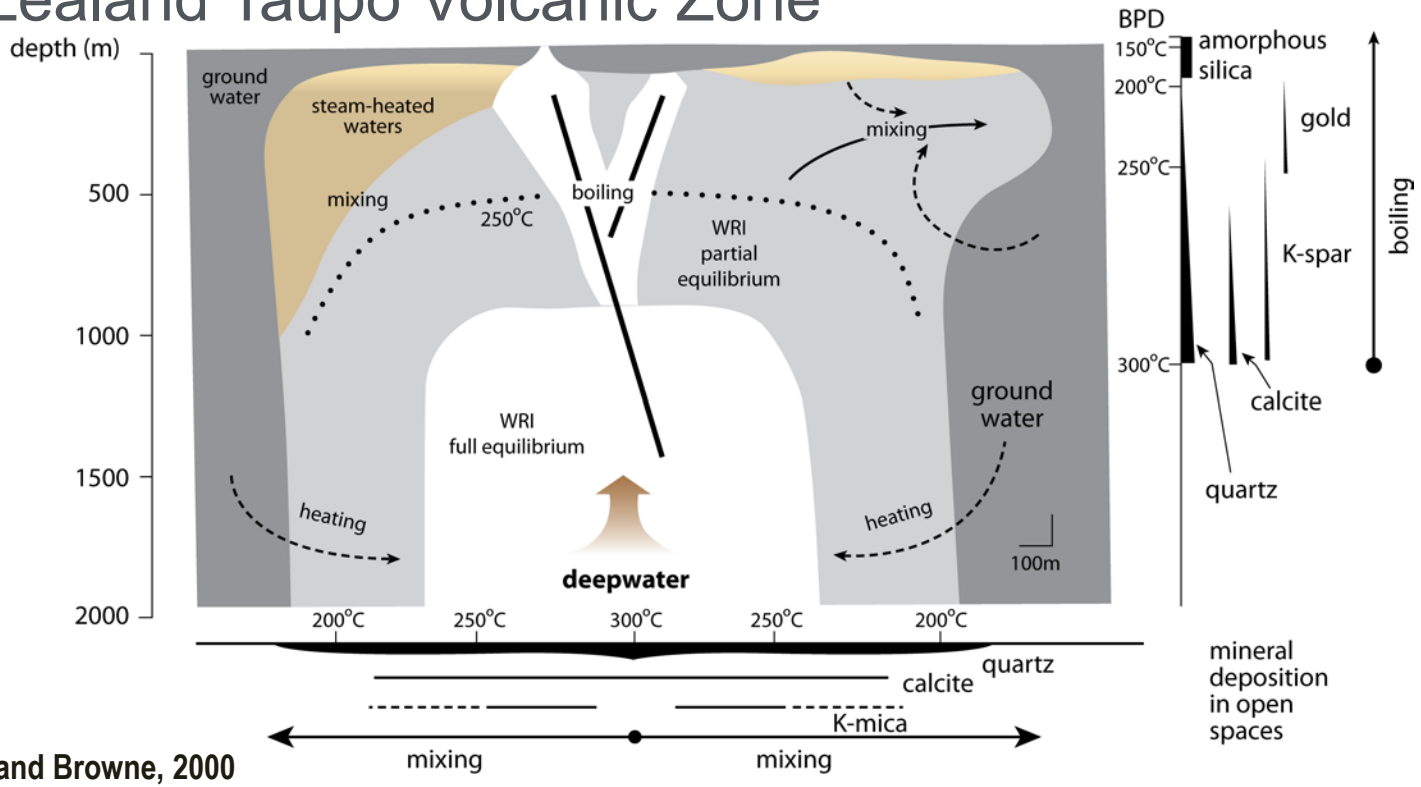
New Zealand Taupo Volcanic Zone



Simmons and Browne, 2000

Chemical Impact of Elevated CO_2 on Geothermal Energy Production

May 18-20, 2010

Principal Investigator
Susan Carroll
Lawrence Livermore National Lab

Track Name

Mandatory Overview Slide

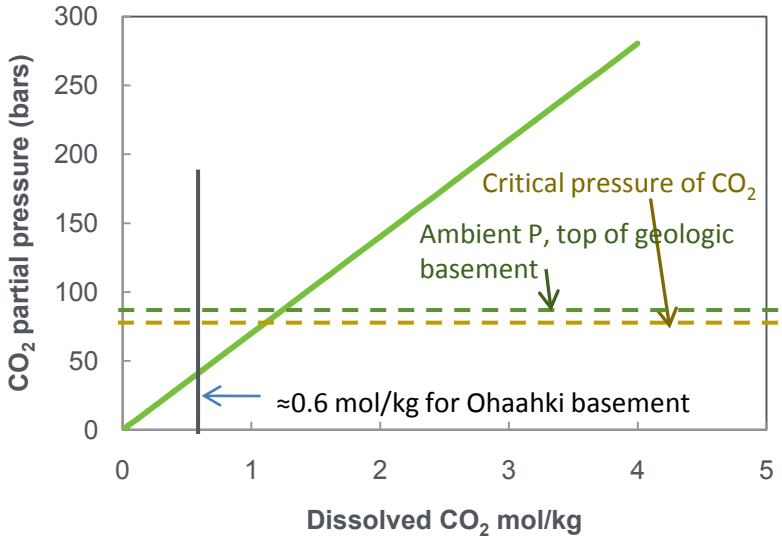
- Timeline
  - Start Date October 1, 2009
  - End Date June 30, 2012
    - No cost extension beyond FY11 requested for new postdoc
  - 10%
- Budget
  - Total project and received funding $1024,800
  - DOE share $1024,800
  - In kind services for Dr. Ed Mroczek, GNS Science, New Zealand
- Barriers
  - Difficult field experiments (boiling, gas phase separation)
- Partners
  - Dr. Ed Mroczek, GNS Science, New Zealand

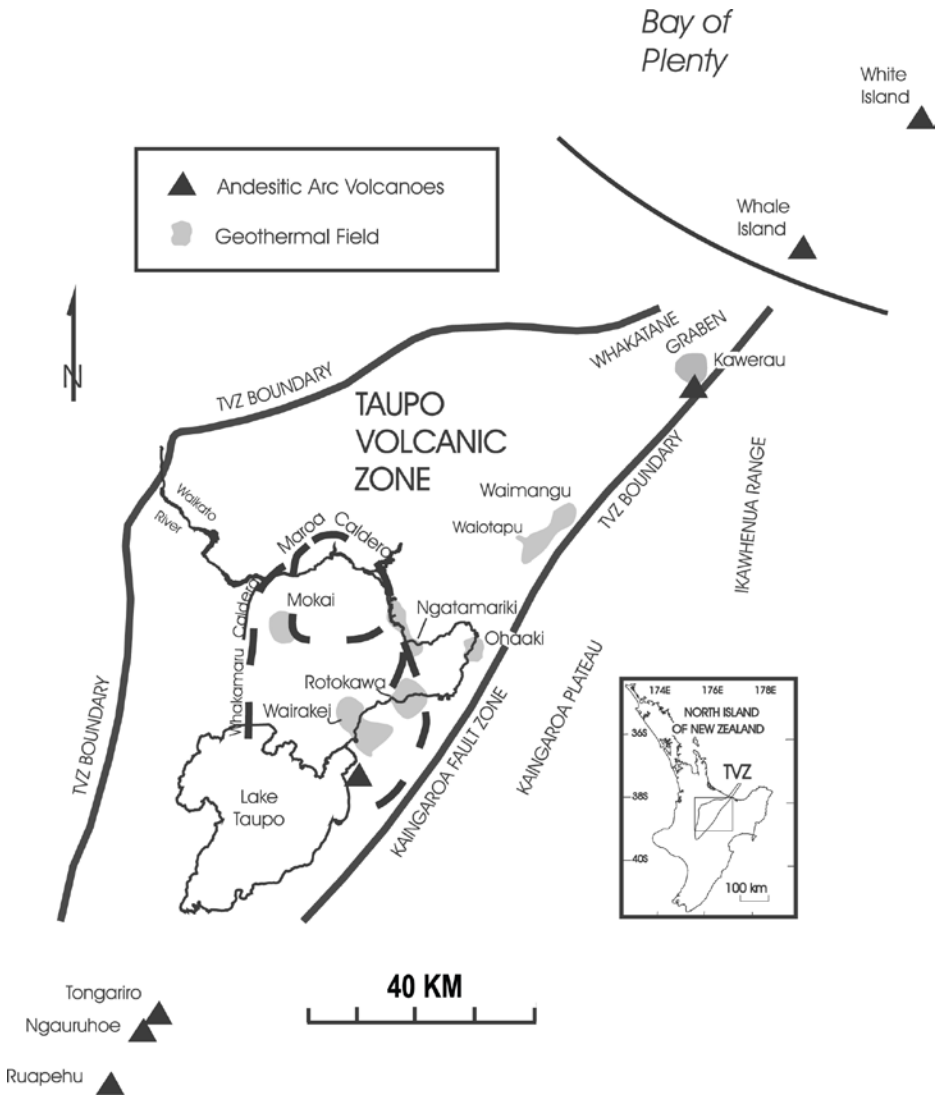
Relevance/Impact of Research

- *Hypothesis:* The use of supercritical CO_2 for enhanced production of geothermal energy will not be compromised by mineral dissolution and precipitation reactions.
- *Proposed Work:* We propose a two phase project to assess the geochemical impact of CO_2 on geothermal energy production by
  - analyzing the geochemistry of existing geothermal fields with elevated natural CO_2
  - measuring realistic rock-water rates for geothermal systems using laboratory and field-based experiments to simulate production scale impacts (if any)
- The project will enable the effective deployment of EGS-CO_2
- Innovative aspects include combination of lab and field experiments with simulation.

Scientific/Technical Approach

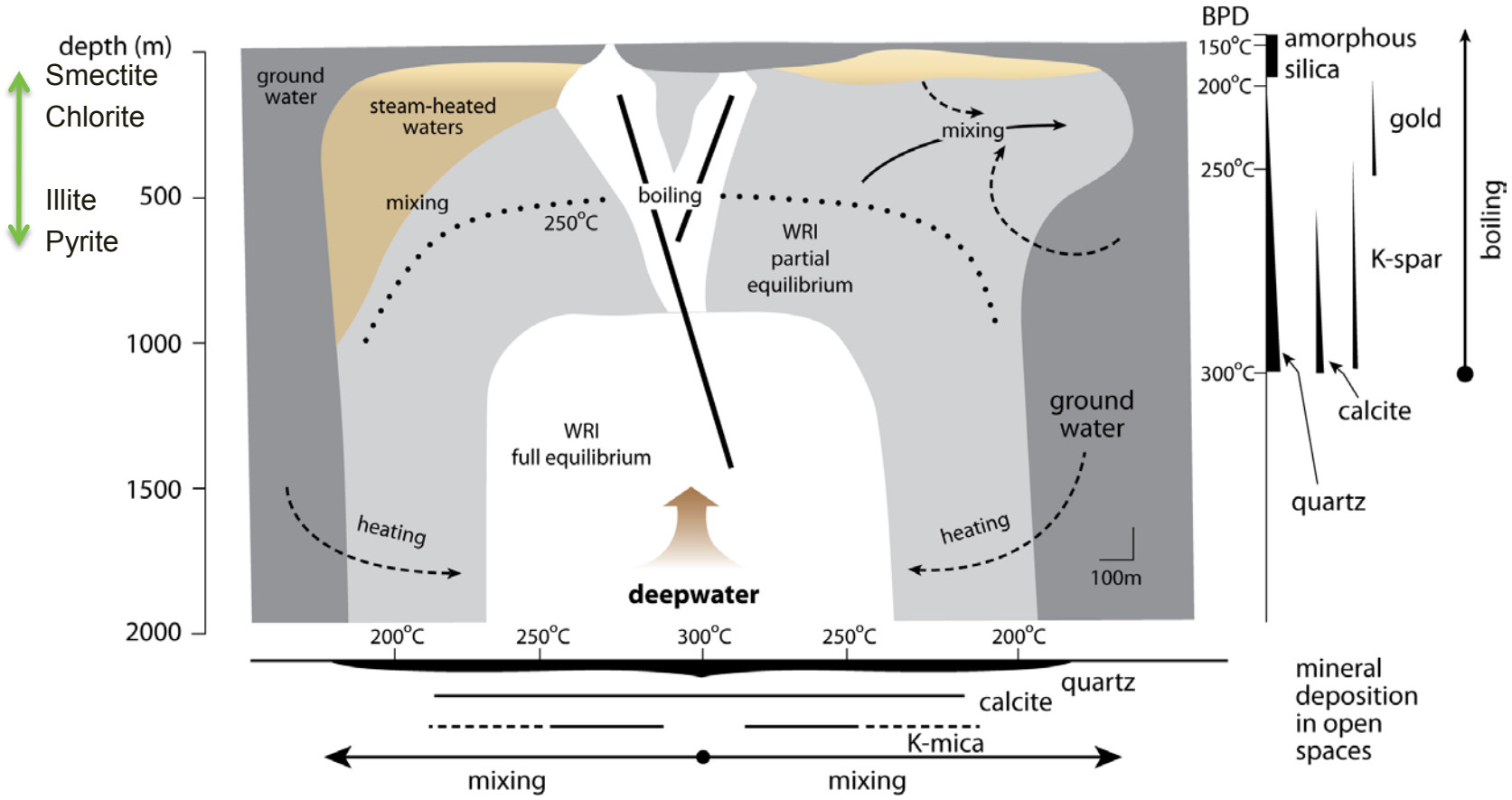
- Geothermal Field Site: Broadlands-Ohaaki Geothermal Field
- Temperature to 300° C
- Aqueous CO_2 ≈ 0.6 molal in deep fluid
- Partners with GNS



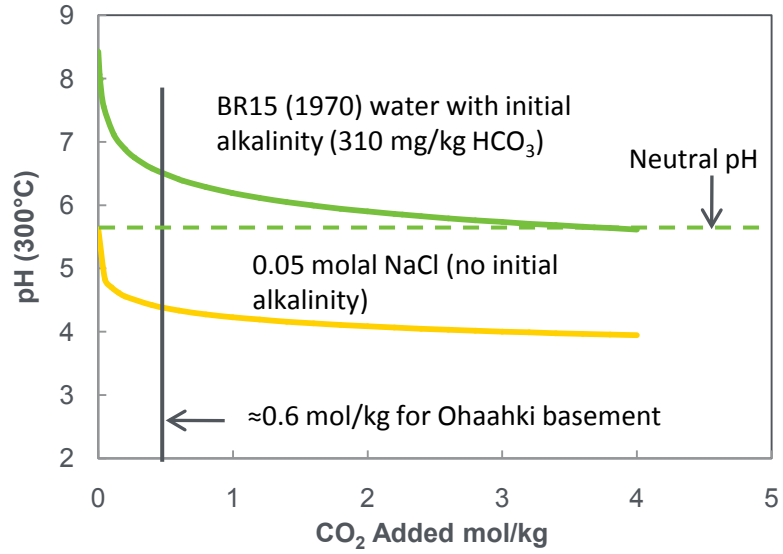


Scientific/Technical Approach

- Broadlands-Ohaaki Geothermal Field (Christensen et al., 2002; Simmons and Browne, 2000; Hedenquist, 1990)

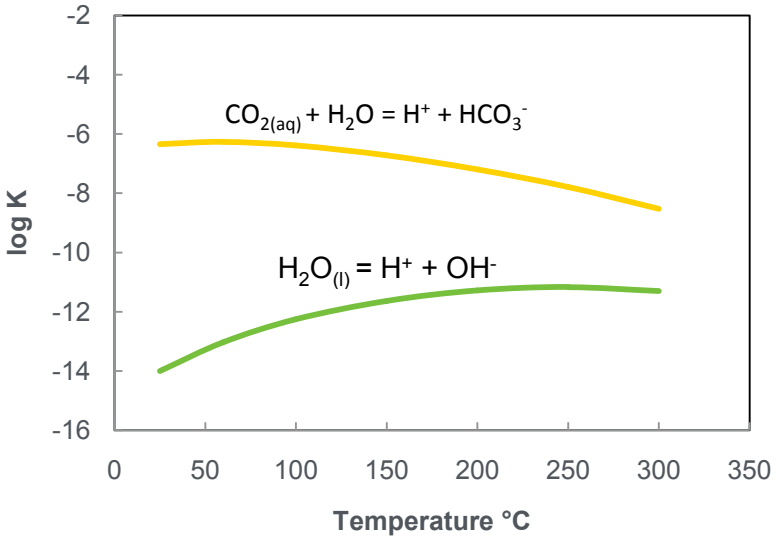


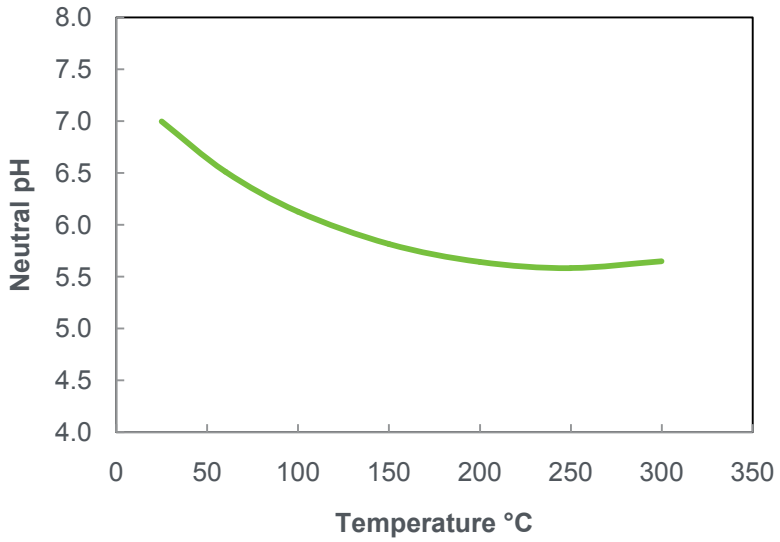
Scientific/Technical Approach



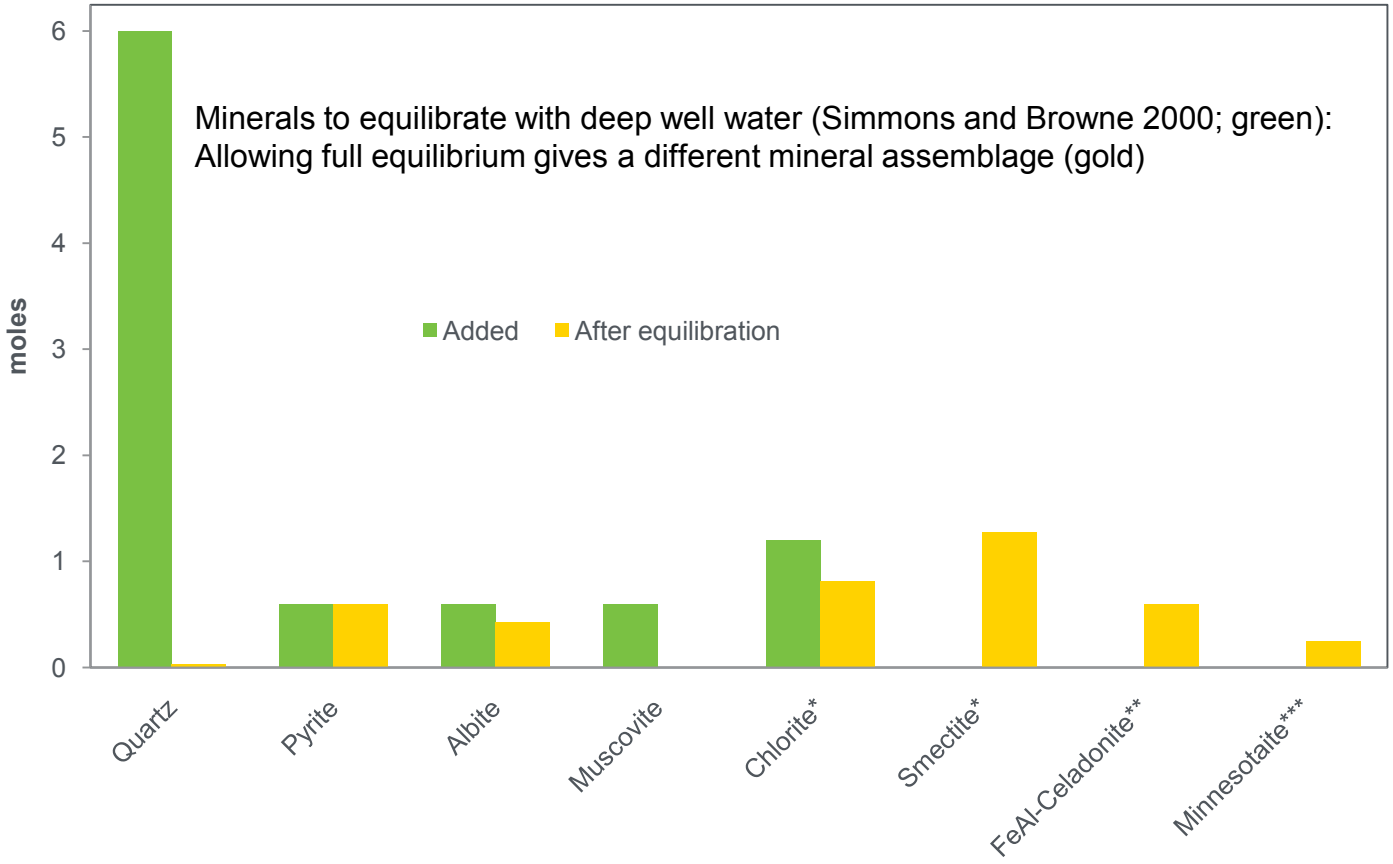
Geochemical Model

- Add CO_2 back into degassed well water
- CO_2 is a weaker acid at temperatures above 100° C





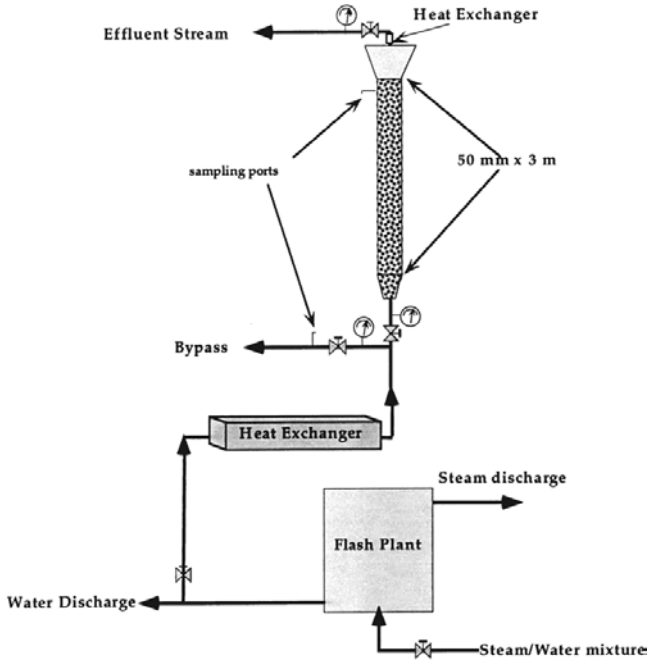
Assessment of basement fluid and mineral geochemistry

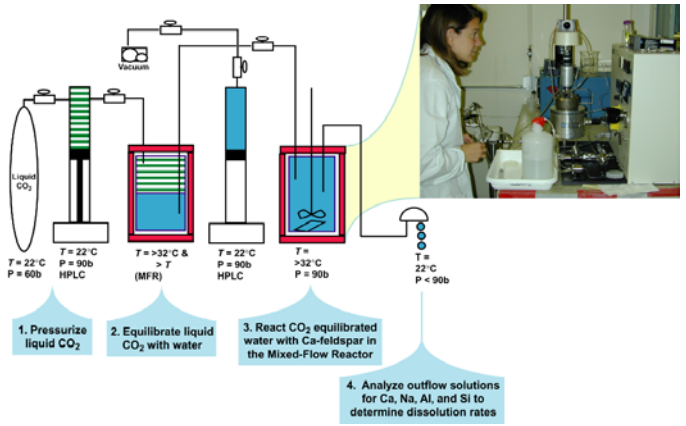


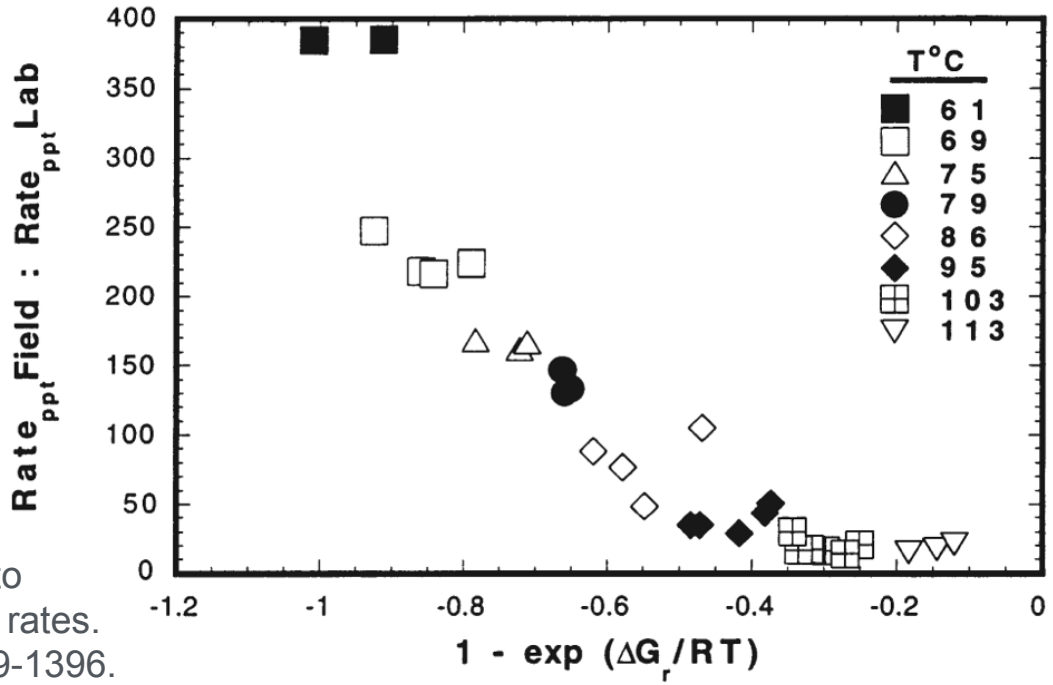
*Two chlorite compositions were added, a third one resulted
**Ferroaluminoceladonite ($KFeAlSi_4O_{10}(OH)_{2)}$), similar to illite
*** $Fe_3Si_4O_{10}(OH)_2$

Scientific/Technical Approach

- Field and Laboratory Studies







Carroll S. A., Mroczek E., Alai, M., Ebert M. (1998) Amorphous silica precipitation (60° to 120° C): Comparison of laboratory and field rates. *Geochimica et Cosmochimica Acta* **62**, 1379-1396.

- Overview projects:
  - Selected Ohaaki-Broadlands Geothermal Field as a natural analog for CO2-Rock-Water Interaction
  - Started simulations to bound experimental pressure, temperature, and pCO2 for lab and field studies
  - Collaborating with Dr. Ed Mroczek, geothermal geochemist, GNS Science, New Zealand
  - Hired Dr. Megan Smith, geochemist, June 1, 2010 start date.

Project Management/Coordination

Table 1. Timeline for Chemical Impact of Elevated CO_2 on Geothermal Energy Production

	Year 1	Year 2	Year 3
Evaluate geothermal systems	Task 1		
Select geothermal and volcanic sites for geochemical analysis			
Finish geochemical analysis			
Report on the role of CO_2 on geochemistry in geothermal environments			
Laboratory Measured Rates	Task 2		
Design experimental protocol based on field sites			
Conduct Laboratory experiments			
Field Measured Rates	Task 3		
Select low and high CO_2 geothermal sites			
Design and assemble field reactor			
Finish Field Experiments			
Derive rate law from Lab and Field experiments			
Report on the comparison of lab and field rates			
			Task 4
Final Report on geochemical impact of supercritical CO_2 on geothermal energy production			

Project Management/Coordination

- Spend Plan

Table 2. Revised spend plan in $K.

	FY10	Fy11	FY12
Oct	12.3	42.4	15.0
Nov	12.3	42.4	15.0
Dec	12.3	42.4	15.0
Jan	12.3	42.4	15.0
Feb	12.3	42.4	15.0
Mar	12.3	42.4	15.0
Apr	51.2	42.4	15.0
May	51.2	42.4	15.0
Jun	51.2	42.4	15.0
Jul	51.2	42.4	
Aug	51.2	42.4	
Sep	51.2	42.4	
FY Total	380.8	509.0	135.0
Project Total	$1024.8K		

Future Directions

FY10

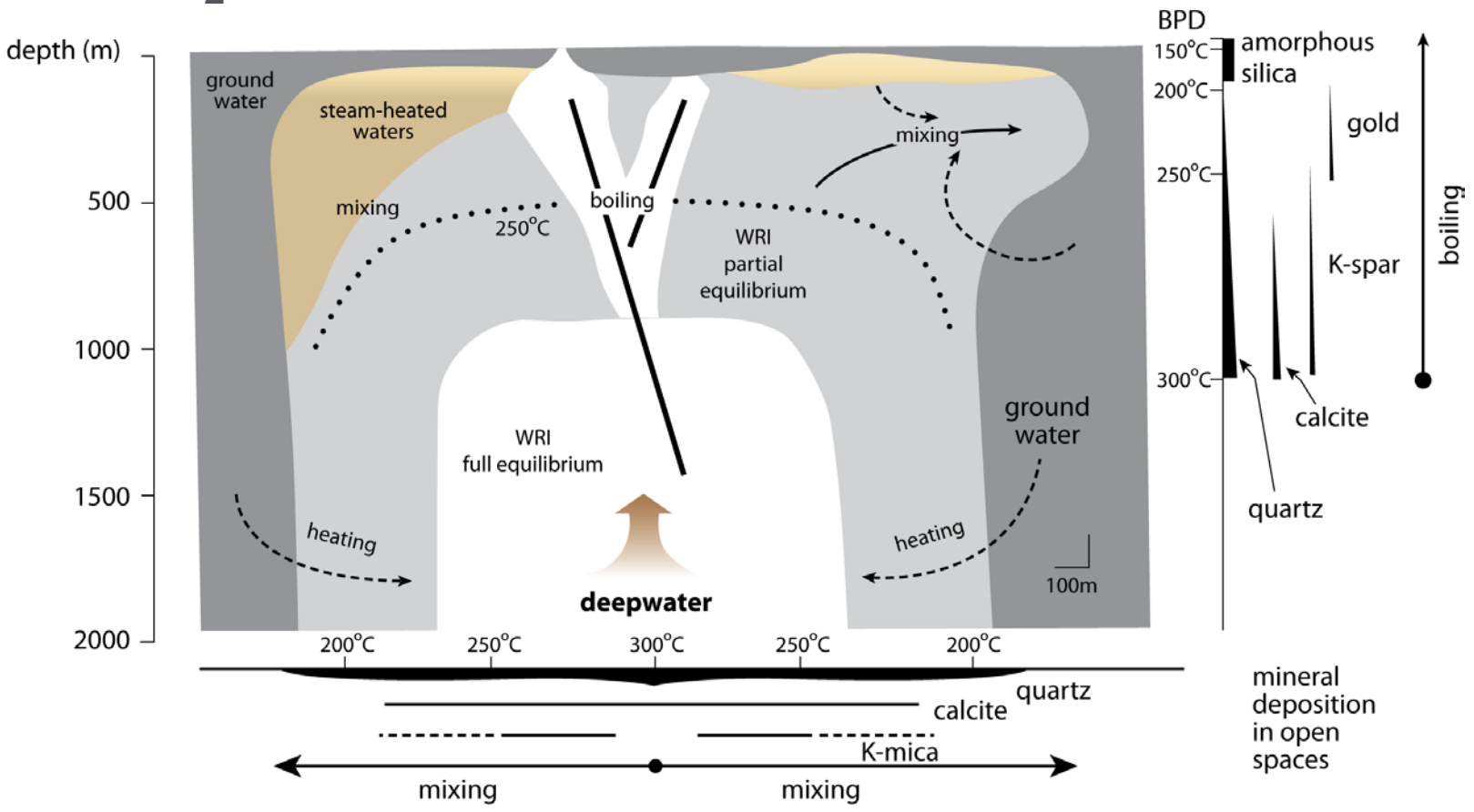
- Task 1: Finish Geochemical Analysis of the New Zealand Taupo Volcanic Zone
- Task 2: Design laboratory experiments based on field sites and conduct laboratory experiments
- Task 3: Design and fabricate the field reactor

- **FY11**
  - Task 2 and 3: September 30, 2011: Finish lab and field experiments
  - Derive rate laws from field and laboratory experiments
  - Report comparing field and laboratory rates
- **FY12**
  - Task 4: Final Report on the geochemical impact of CO_2 on EGSCO_2.

Mandatory Summary Slide

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- We are investigating the geochemical impact of CO_2 on EGSCO_2.



Supplemental Slides

Optional Slide

- Wolery, TJ and Carroll, SA (2010) **CO_2-Rock Interactions in EGSCO_2: New Zealand TVZ Geothermal Systems as Natural Analogs** GRC's 34th Annual Meeting, October 24-27, 2010, Sacramento

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