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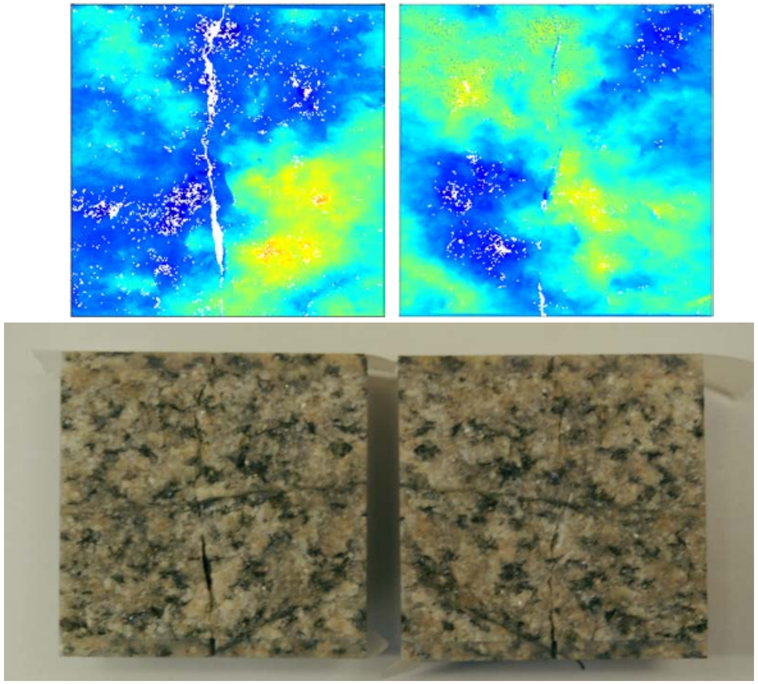

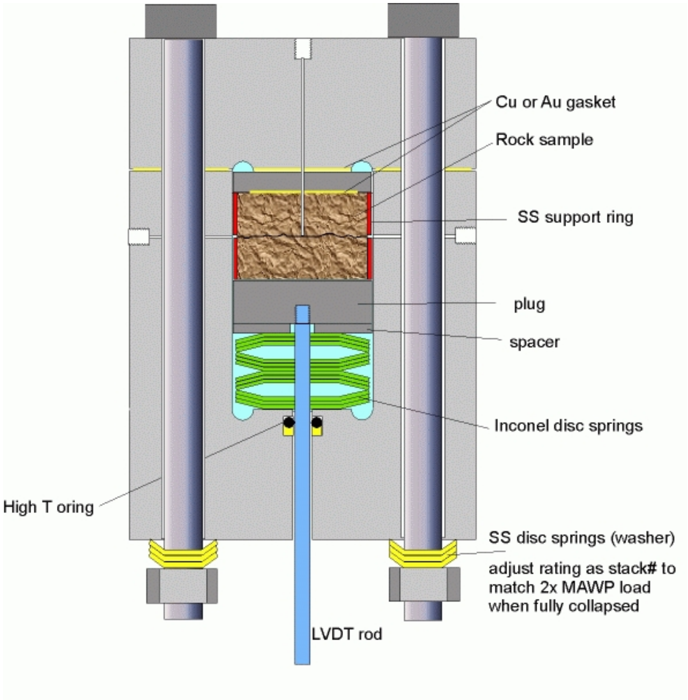


# Sustainability of Shear-Induced Permeability for EGS Reservoirs – A Laboratory Study

Project Officer: William Vandermeer

Total Project Funding: $330K FY 13

April 23, 2013

**Tim Kneafsey**

**Lawrence Berkeley National Laboratory**

Characterizing Fractures

# Relevance/Impact of Research



Objective - Quantify the sustainability of fractures under relevant conditions (up to 300C)

- Long-term permeability in fractures resulting from slip-shear depends on the lifetime of self-propping asperities.
- Asperity lifetime is a function of stress, mineral dissolution and precipitation, and/or mechanical deformation.
- Knowledge of fracture sustainability (and need for refracturing) will inform reservoir exploitation strategies allowing more economic heat extraction (lower levelized cost of electricity).
- Fracture sustainability of a number of rock types will be determined in laboratory tests under relevant conditions.

# Scientific/Technical Approach

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- Design and build a test chamber to apply a normal force on a slightly mismatched fracture at elevated temperature and pressure, while flowing controlled-composition water through the aperture.
- Coordinate sample selection with industry and LLNL to incorporate reaction kinetics.
- Test sequence:
  - Core, cut, and fracture rock.
  - Characterize mineralogy and measure surface profiles of both halves.
  - Mismatch halves by specified rotation, install in chamber, and apply normal force.
  - Heat system and flow controlled-composition water through the aperture.
  - Collect effluent and quantify chemistry and isotope geochemistry.
  - Perform intermittent permeability measurements.
  - Recharacterize both halves upon test completion.

# Scientific/Technical Approach

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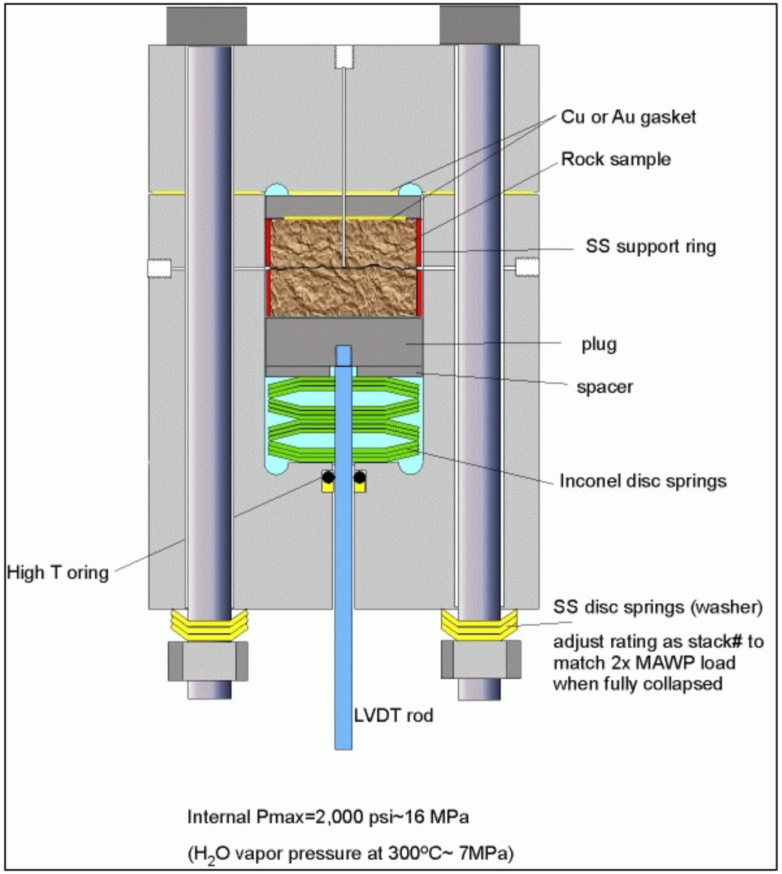
## Challenges

- Test chamber design/construction:
  - Inert wetted parts under applied conditions
  - Up to 2 inch (5 cm) diameter samples
  - Able to apply 2000 psi (13.8 MPa) fluid pressure and constant 3000 psi (21 MPa) or more normal stress
  - Quantify rock/fracture deformation
  - Minimize flow to dead spaces
- Test system design
  - Maintain constant temperature, pressure and continuous flow
  - Ability to collect appropriate samples
- Rock preparation
  - Selecting/creating appropriate fracture

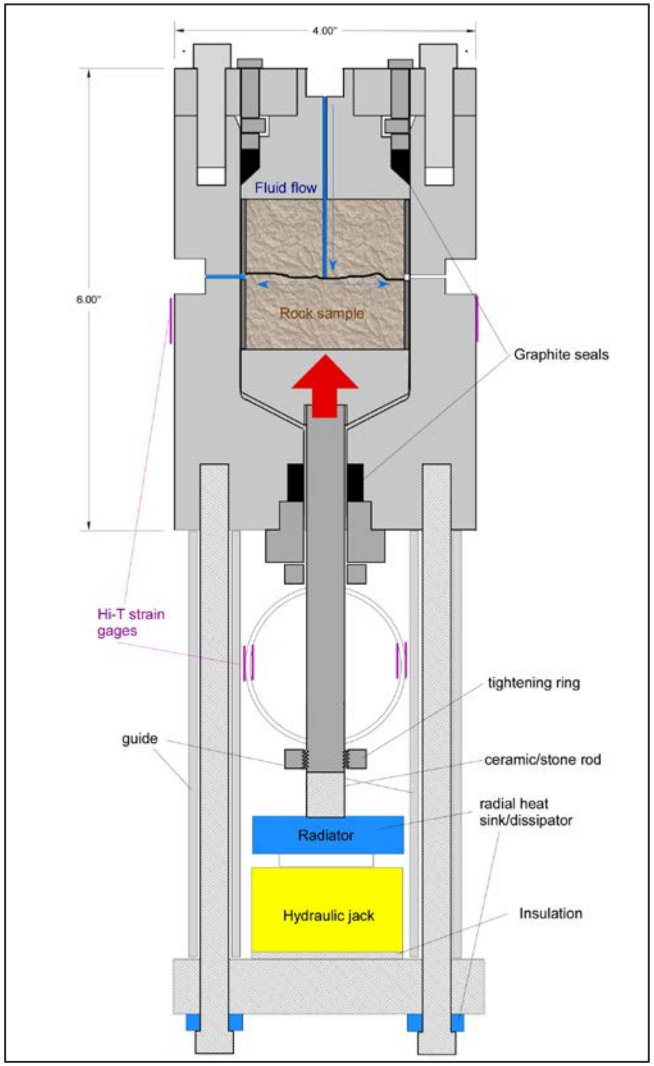



Initial Concept

Custom test chamber applies mechanical stress to open, flowing fracture. Changes in fracture aperture are indicated by change in pressure needed to flow water through cell.

Experiment design issues:

- Seals, seals, seals.
  - Design adjusted to use off-the-shelf graphite seals.
- Chemical compatibility
  - Titanium vessel (6AL-4V, appropriately passivated).
  - Gold-plated wetted parts (as needed).
- Vessel assembly
  - Internal spring system vs. external jack → external jack allows higher normal stress and a more flexible test series while reducing dead volume.




Build Design

# Accomplishments, Results and Progress

Progress to date:

- Novel pressure vessel design completed
  - Several iterations have been required to balance data needs, physical system constraints.
- Qualified detailed designer/manufacturer on board
- Sample collection initiated
- Collaboration/discussions with LLNL initiated (Susan Carroll and coworkers)

| Original Planned Milestone/ Technical Accomplishment | Actual Milestone/Technical Accomplishment | Date Completed |
|---|---|---|
| Complete vessel design | 12/1/12 | 1/31/13 |
| Complete vessel construction | 3/31/2013 | mid/late April |

# Future Directions

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- Complete system construction and assembly
  - Resolve remaining design issues
  - Complete any remaining procurements
- Shake down and perform preliminary test by 7/31/2013
- Continue discussions with LLNL

| Milestone or Go/No-Go | Status & Expected Completion Date |
|---|---|
| Preliminary test | 7/31/2013 |
| | |
| | |

# Summary Slide



- Understanding fracture sustainability can be used to inform siting target zones and locations of interest.
- We are building an experimental system to examine asperity (and permeability) lifetime under relevant conditions stress and temperature conditions.
- We are collaborating with LLNL to overlap our geomechanical (with chemistry) test with their mineral dissolution kinetic studies under similar conditions.
- Vessel construction and system construction are underway (as of 3/15/13), and a preliminary test should be complete by mid-summer.

# Project Management

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- FY2013 budget request $330K
- FY2013 funds received $300K (10/26/2013)

Timeline:

| Planned Start Date | Planned End Date | Actual Start Date | Current End Date |
|---|---|---|---|
| 10/1/2103 | End of FY15 | 10/26/2013 | End of FY15 |

Budget:

| Federal Share | Cost Share | Planned Expenses to Date | Actual Expenses to Date | Value of Work Completed to Date | Funding needed to Complete Work |
|---|---|---|---|---|---|
| $300K (FY13) | 0 | $65K | $22K | $35K | $278K |

- Perform preliminary vessel design in-house with detailed design and construction by others.
- Collaborate with LLNL to overlap LLNL dissolution kinetics studies.
- Initiate discussions with industrial partners to obtain important samples.
- Project is slightly behind schedule due to late start but no major adjustment needed at this point.

# Additional Information



Research Team

- Tim Kneafsey
- Seiji Nakagawa
- Pat Dobson
- Mack Kennedy

Collaborators at LLNL

- Susan Carroll
- Megan Smith