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Photo of presenter:

Bio of presenter:

Title: Thermal Fracturing Behavior in Well Stimulations of Enhanced Geothermal Systems -

and major fractures. The profiles of borehole pressure decay obtained before and after each stage of stimulation show that thermal flows increase the permeability of treated specimens. Multiple treatments

SMU Geothermal Conference
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Laboratory thermal fracturing of wellbores - Implications in enhanced geothermal systems and unconventional reservoir stimulations

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Enhanced Geothermal System – Hot dry rock

- **Deep (~3-8km) hot dry rock with little natural permeability**
- **A borehole drilled to the desired depth and reservoir is created by hydraulic fracturing.**
- **Water is injected and hot water is collected from another borehole.**

Motivations

- Inherent thermal effects expected due to large temperature between injected fluid and hot rock

- Geophysical indications shows significant thermal effects during EGS hydraulic fracturing (e.g. delayed induced seismicity)

- Downhole thermal effects not well understand; in particular thermally induced fracturing in downhole environment needs further understanding.

Thermal Fracturing - Basic Concept

- Hydraulic frac uses high fluid pressure to fracture rocks.
- Thermal fracturing uses large temperature difference to induce local thermal stress and contraction to overcome tensile strength & initiate fractures.
- Pressure may be applied to borehole/reservoir to further propagate fractures.
- Water is used for fracturing and it is also carrying heat energy.

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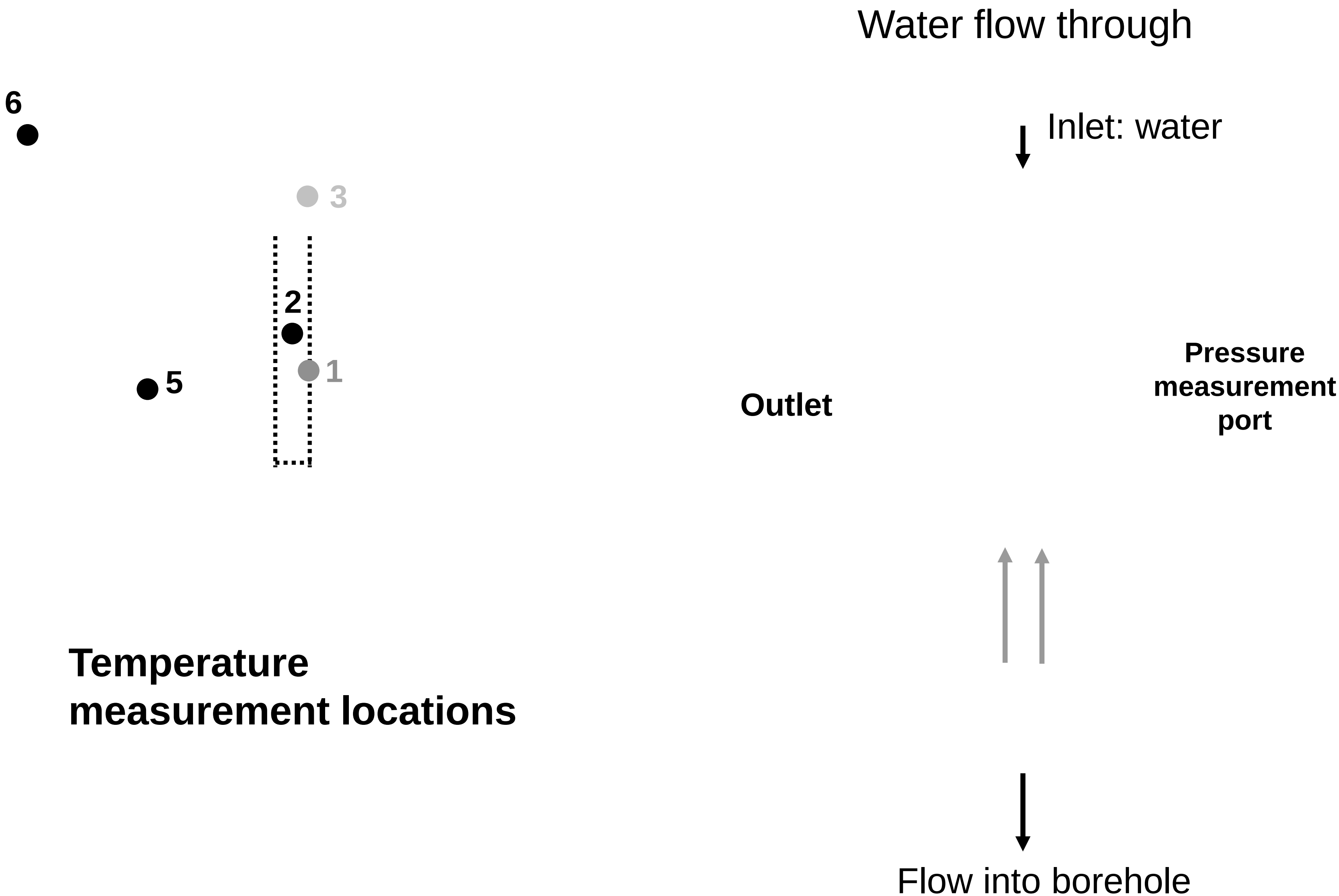
Thermal fracturing laboratory

Thermal fracturing laboratory



Water flow through hot concrete borehole

Temperature - Heating

(Test #15; Specimen #7)

Temperature - Water flow

(Test #15; Specimen #7)

Fracture assessments: Bubble generation

(Face 1, Specimen #7)

Water flow through hot granite borehole

Temperature - Water flow

Granite block Specimen #2 (the first stimulation)

Fracture assessments: Pressure decay tests

Granite block Specimen #2 (the first stimulation)

Fracture assessments: Bubble generation

Comparison of bubble leakage before and after the first stimulation (Face 4, granite Specimen #2).

Fracture assessments: Bubble generation

Comparison of bubble leakage before and after the first stimulation
(Face 5, granite Specimen #2).

Fracture assessments: Acoustic velocity

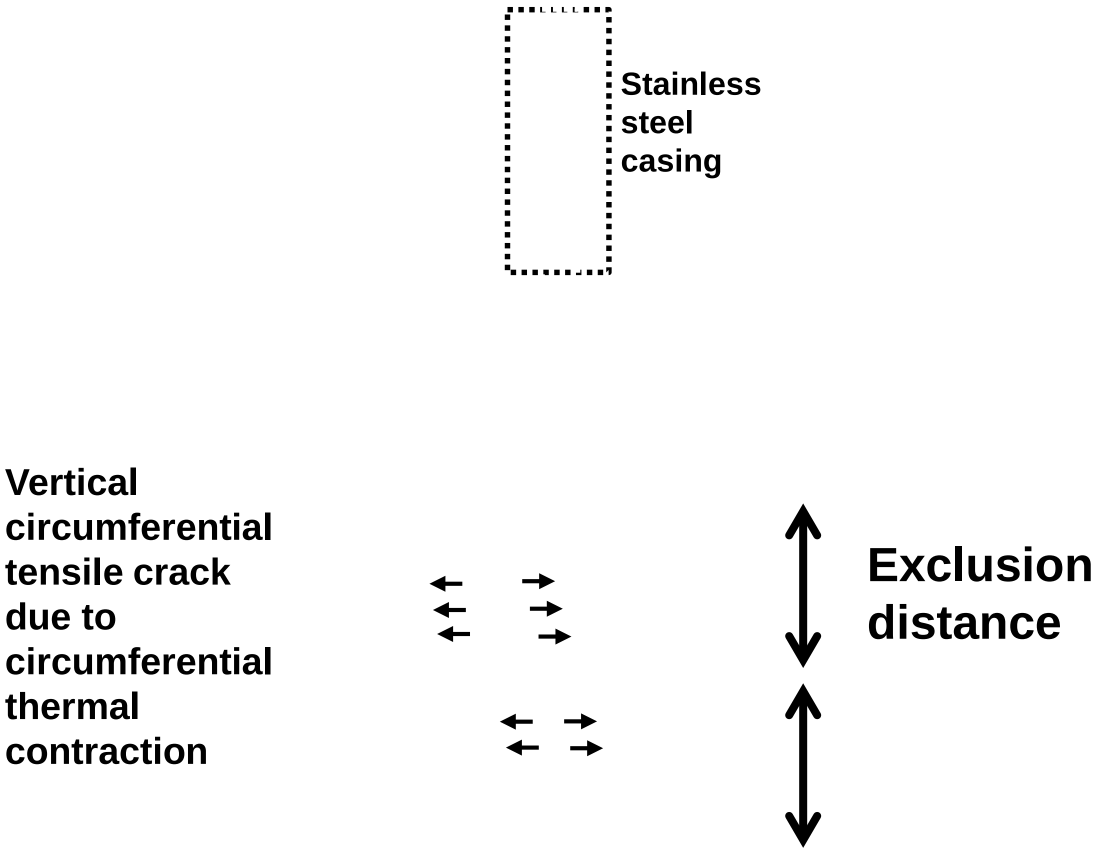
P-Wave velocity

Granite specimen #1

Liquid nitrogen on room-temperature borehole

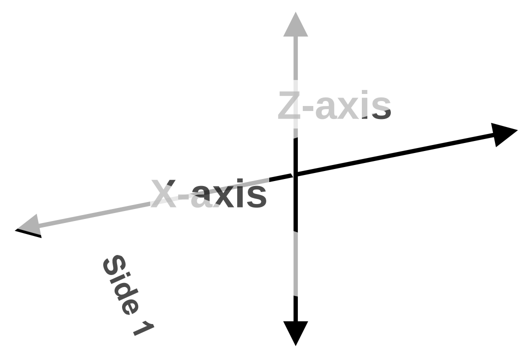
Thermal fracture propagation

Liquid nitrogen flow - acrylic specimen



Triaxial loading

- Simulating in-situ stress
- Loading 20cm cube up to 35 MPa in x & y axes, and 45MPa in z axis,
- Independently control loadings in the three axes.



Liquid nitrogen flow – temperature in borehole

The higher the flow rate,
the quicker the temperature drop.

Breakdown pressure – Comparison

Borehole pressure at fracture = 1200 psi

Untreated

Confining stress x:y:z=500:750:1000 psi

Fracture pressure 680 psi

After LN flow

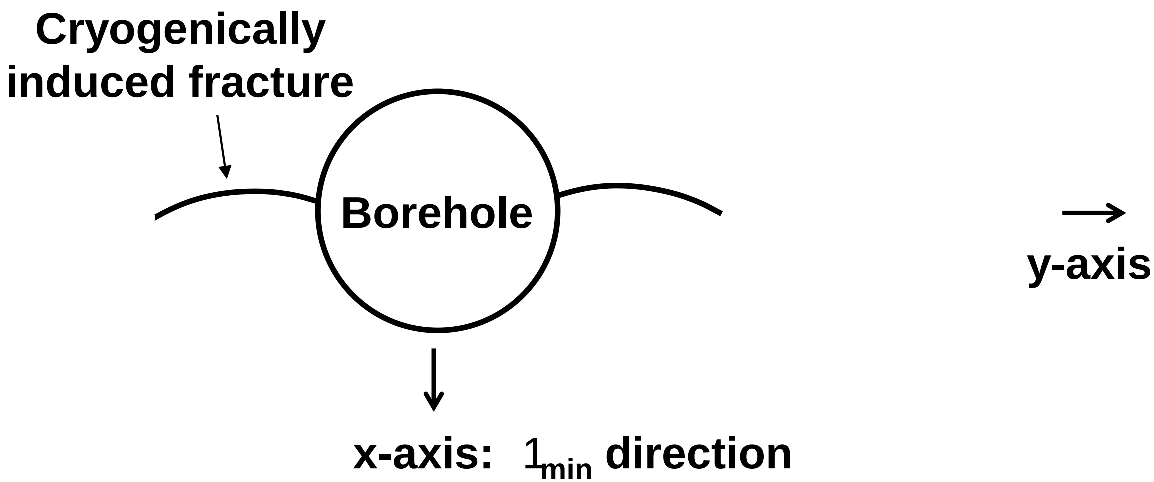
Audible gas leaking started
- internal fractures

Thermally induced fractures as “seed fractures” for pressure-induced fracturing

Confining pressure   z:y:z = 1000:3000:4000 psi

Cha et al. 2017

Depiction of fractures



Slightly curved nature of thermally induced fractures and straighter fractures extended by gas pressure

Hydraulically induced fractures

(Gas pressure)

Shale specimen

Conclusions and implications

- Thermal shock and thermal fracturing is maximized by
  - Continuous fluid flow through wellbore (Stagnant fluid become

Acknowledgements