

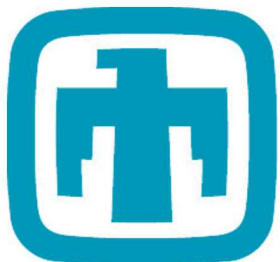
# Release of geogenic gases as a signal of deformation in rock

Stephen Bauer, Scott Broome

Sandia National Laboratories, Albuquerque, NM, USA,

Payton Gardner

University of Montana, Missoula, Montana, USA



**Sandia  
National  
Laboratories**



The authors acknowledge the support of the National Nuclear Security Administration Office of Defense Nuclear Nonproliferation Research and Development for funding this work. This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government. Sandia National Laboratories is a multitechnology laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.



**U.S. DEPARTMENT OF  
ENERGY**



# **Noble Gas Release as a Deformation Signal**

## *Hypothesis:*

- **Noble gas release may be related to deformation state of rock**
- **Natural gases may be used to signal deformation**

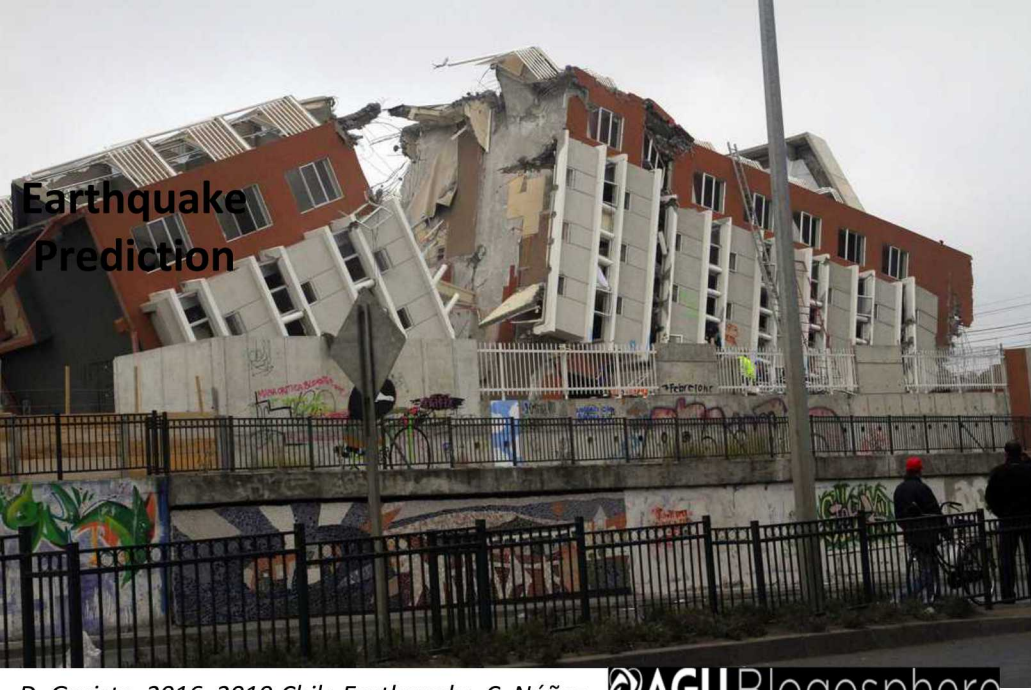
## *Objectives:*

- **Discovery of *real-time* gas emission during rock fracture and relate to deformation**
- **Demonstrate new tool in experimental rock deformation**  
(Bauer et al 2016)
- **Evaluate tool to signal deformation**
- **Develop inverse models used to infer fracture characteristics** (Gardner et al 2017)


# Given:

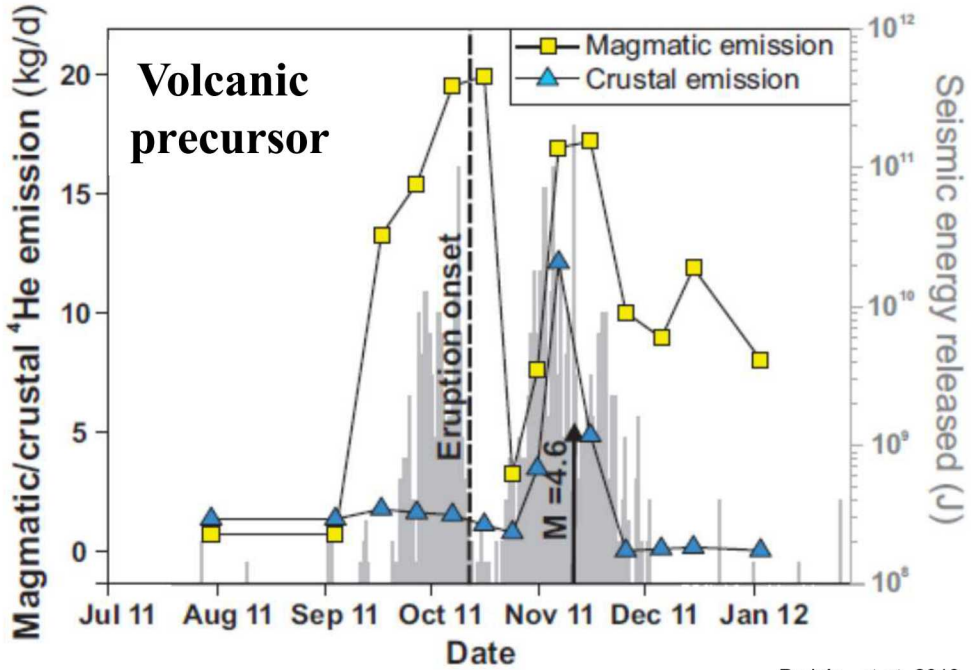
The geogenic noble gas composition and amount present depends on lithology, geologic history, age of the rock, and fluids present.

Release depends on initial gas content, pore structure and its evolution during deformation, deformation amount, and deformation dependent permeability and conditions of fracture versus intracrystalline flow.



Earthquake Prediction

D. Garisto, 2016, 2010 Chile Earthquake, C. Núñez  American Geophysical Union

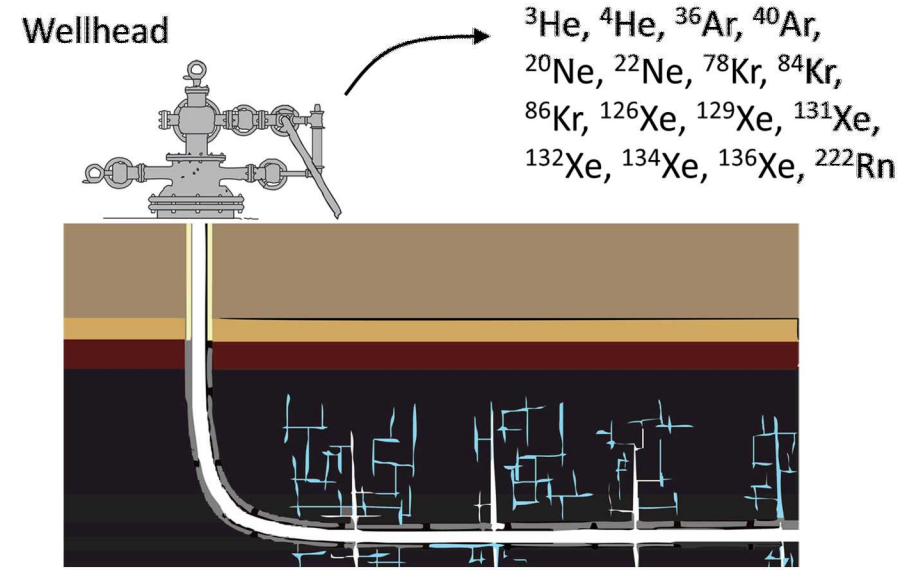


Padrón, et al, 2013

# Potential Applications



Underground Canary



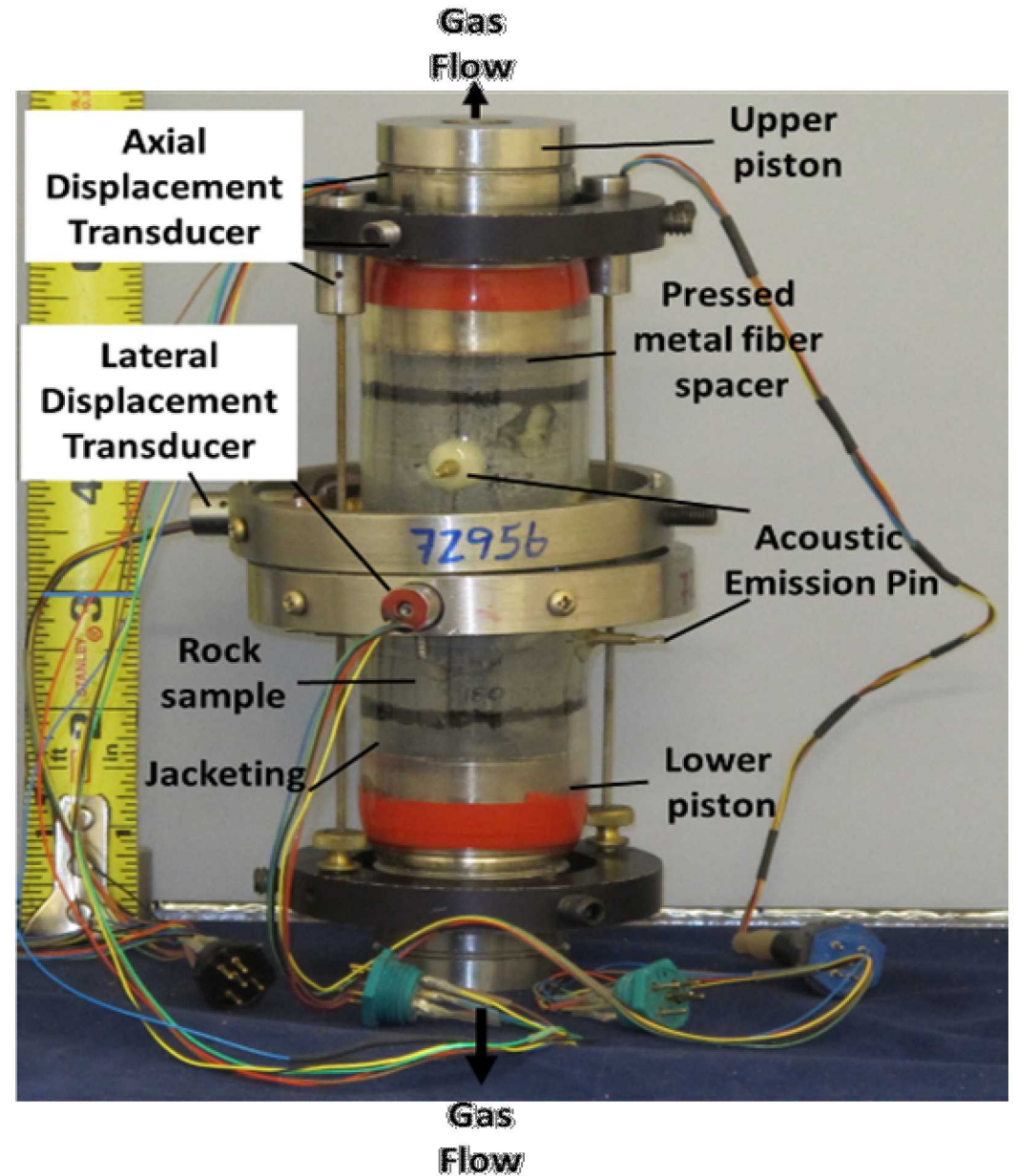
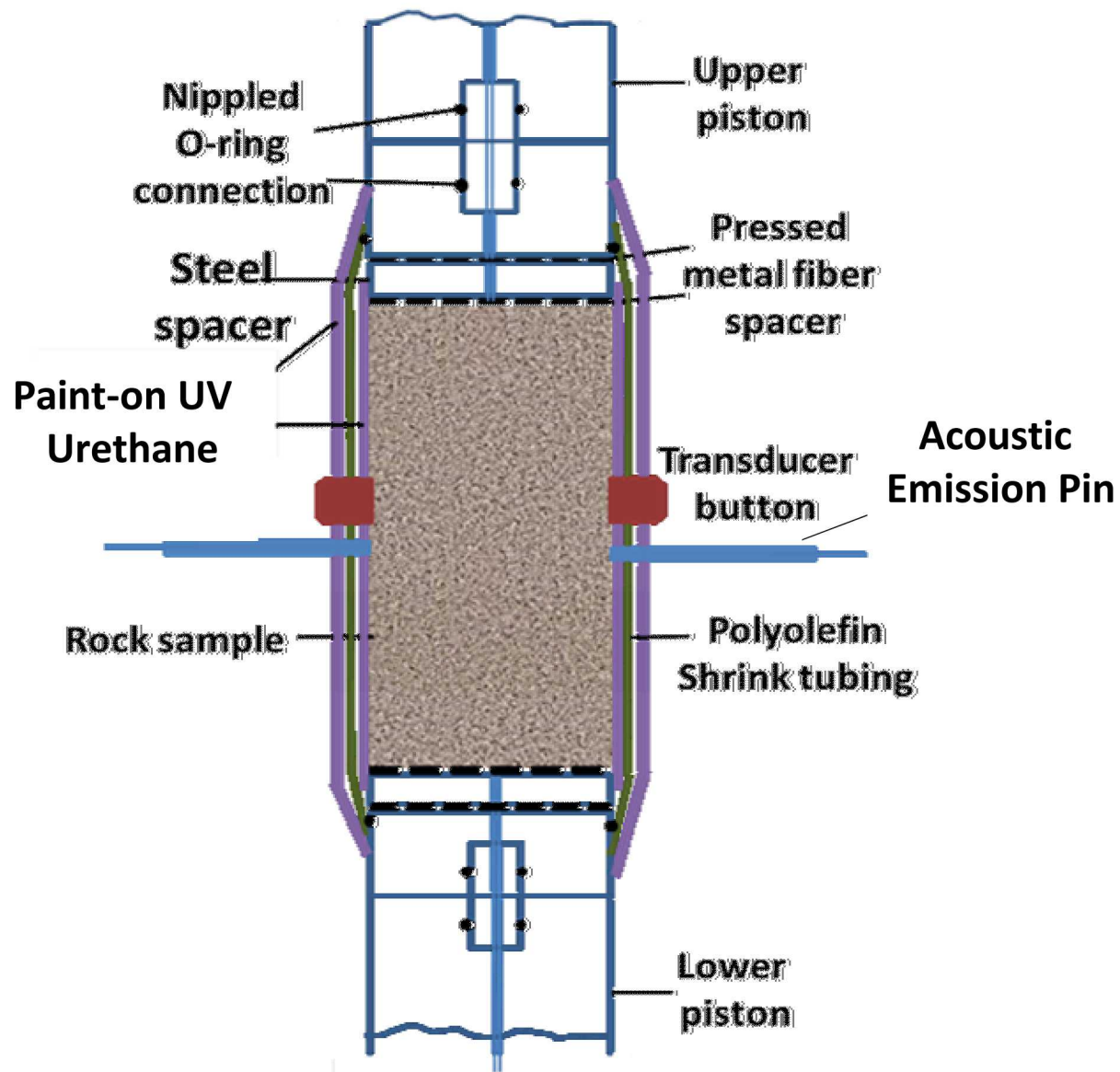
Resource Assessment (modified from King, 2010)

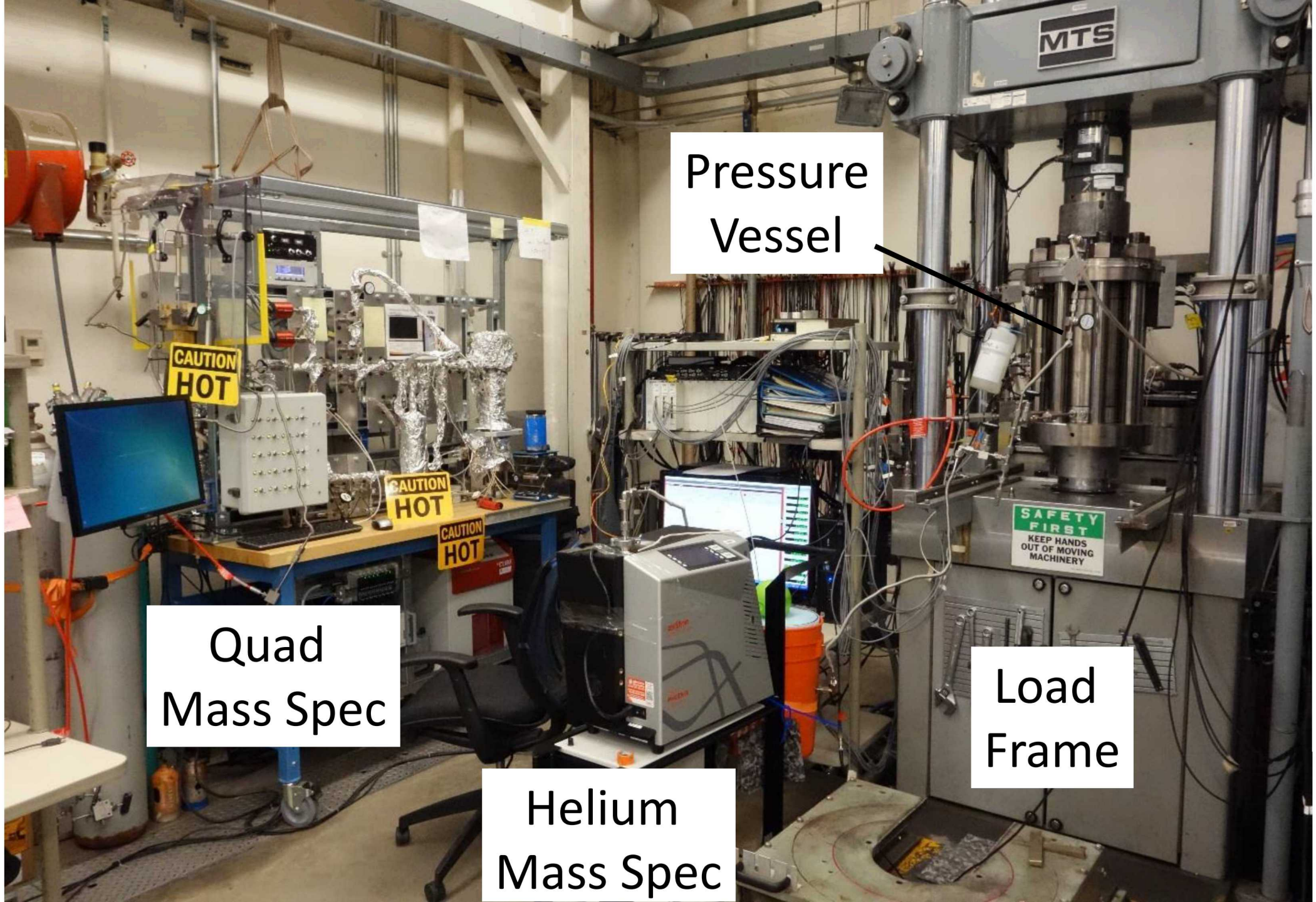
# Today

- Data to support a field test planned for later this summer.
- Test system combines triaxial rock deformation and mass spectrometry to measure noble gas flow before, during, and after rock fracture.
- Results/relationships of specimen strain, microstructural evolution, acoustic emissions, and noble gas release for a range of conditions in a rhyolite



# Sample assembly





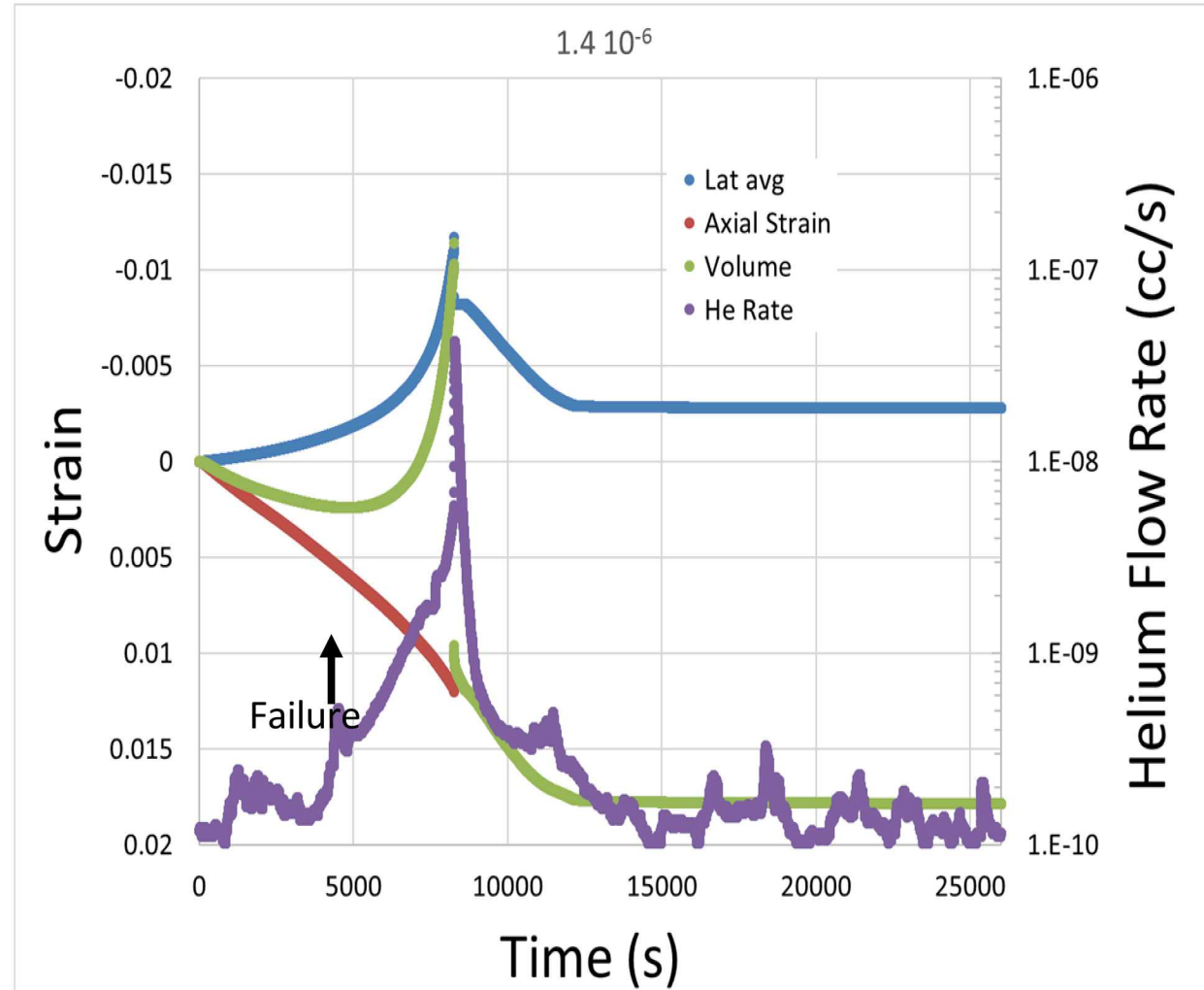
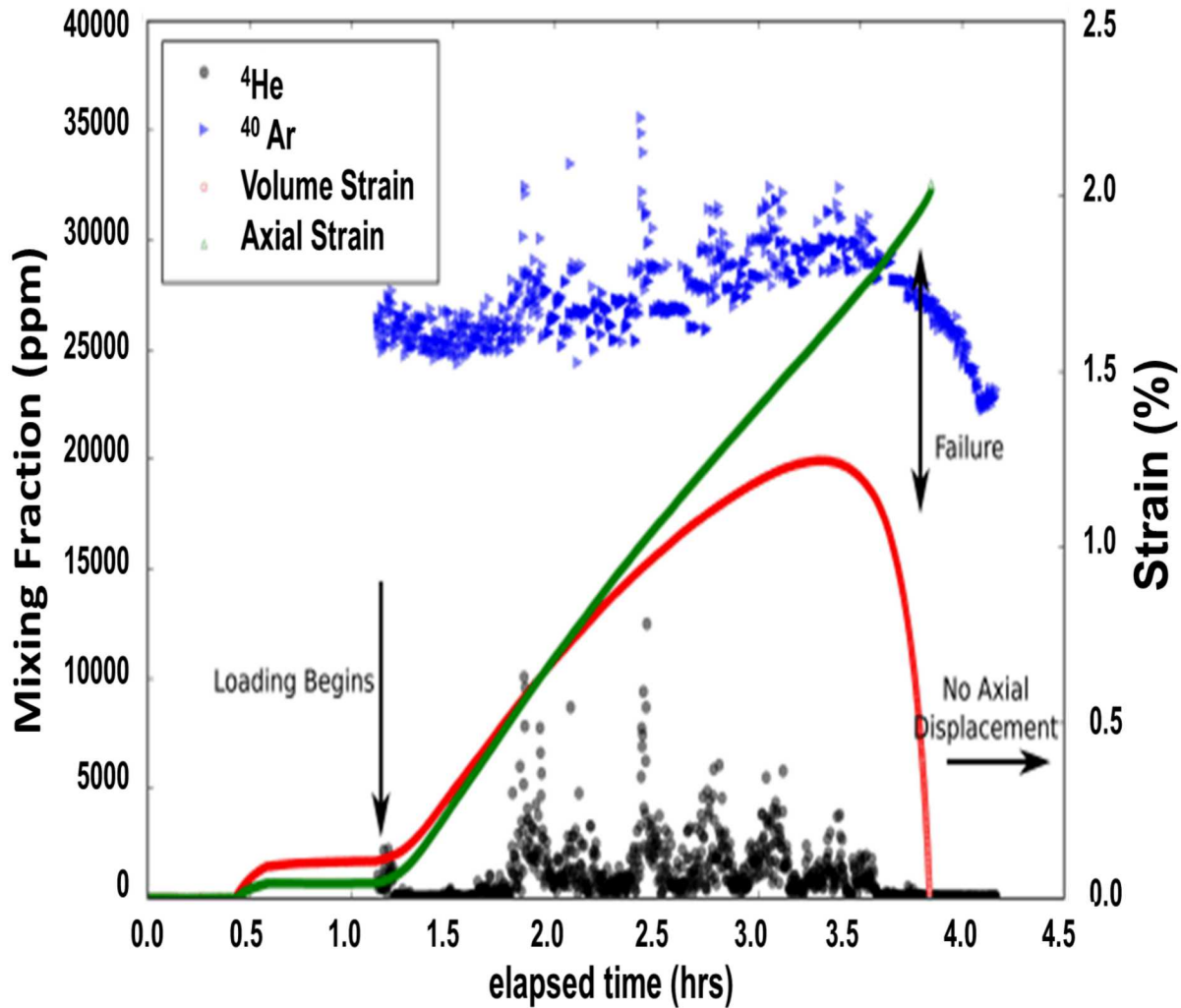
Pressure  
Vessel

Quad  
Mass Spec

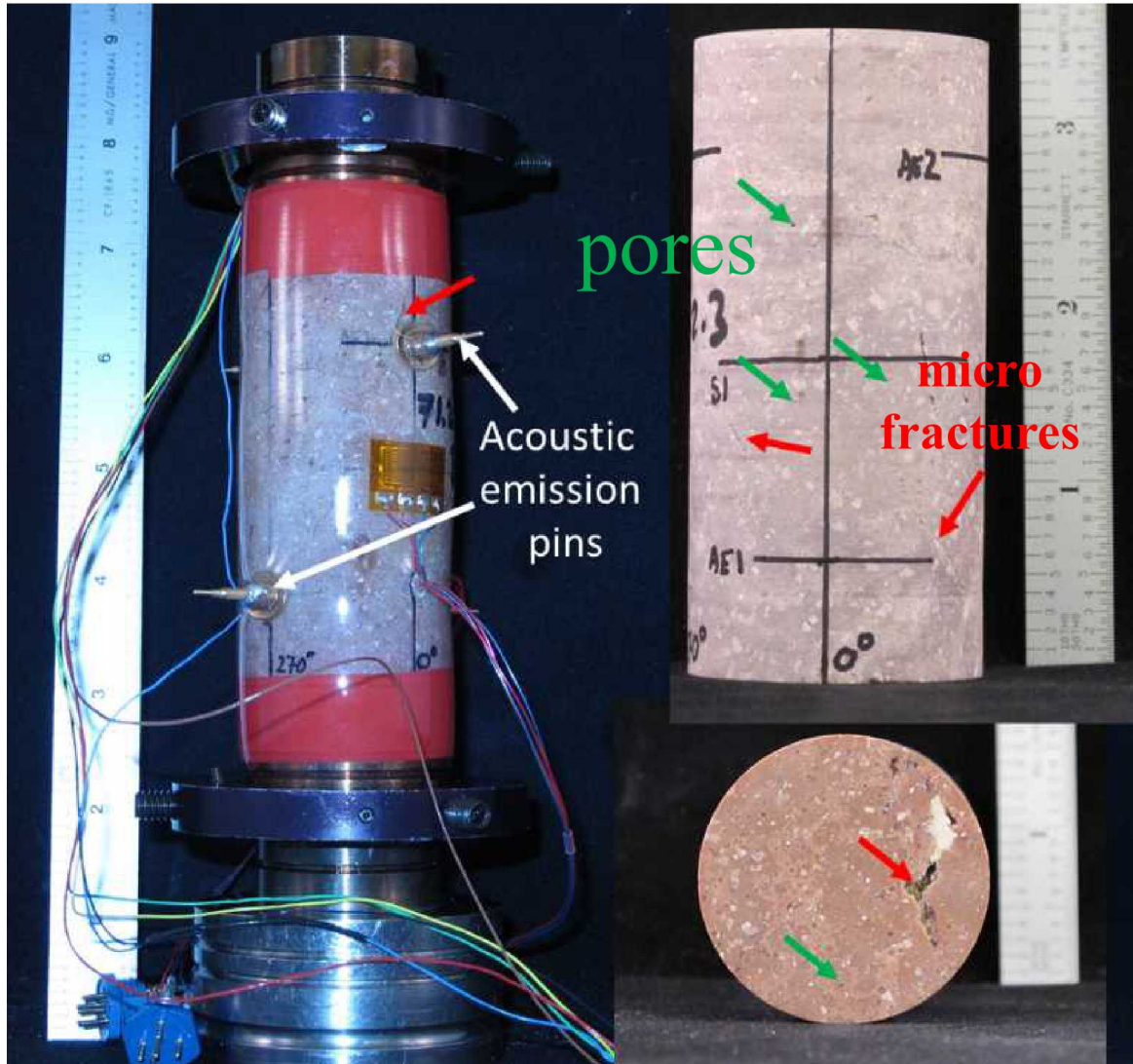
Helium  
Mass Spec

Load  
Frame

# Real-time Noble Gas Release Westerly granite



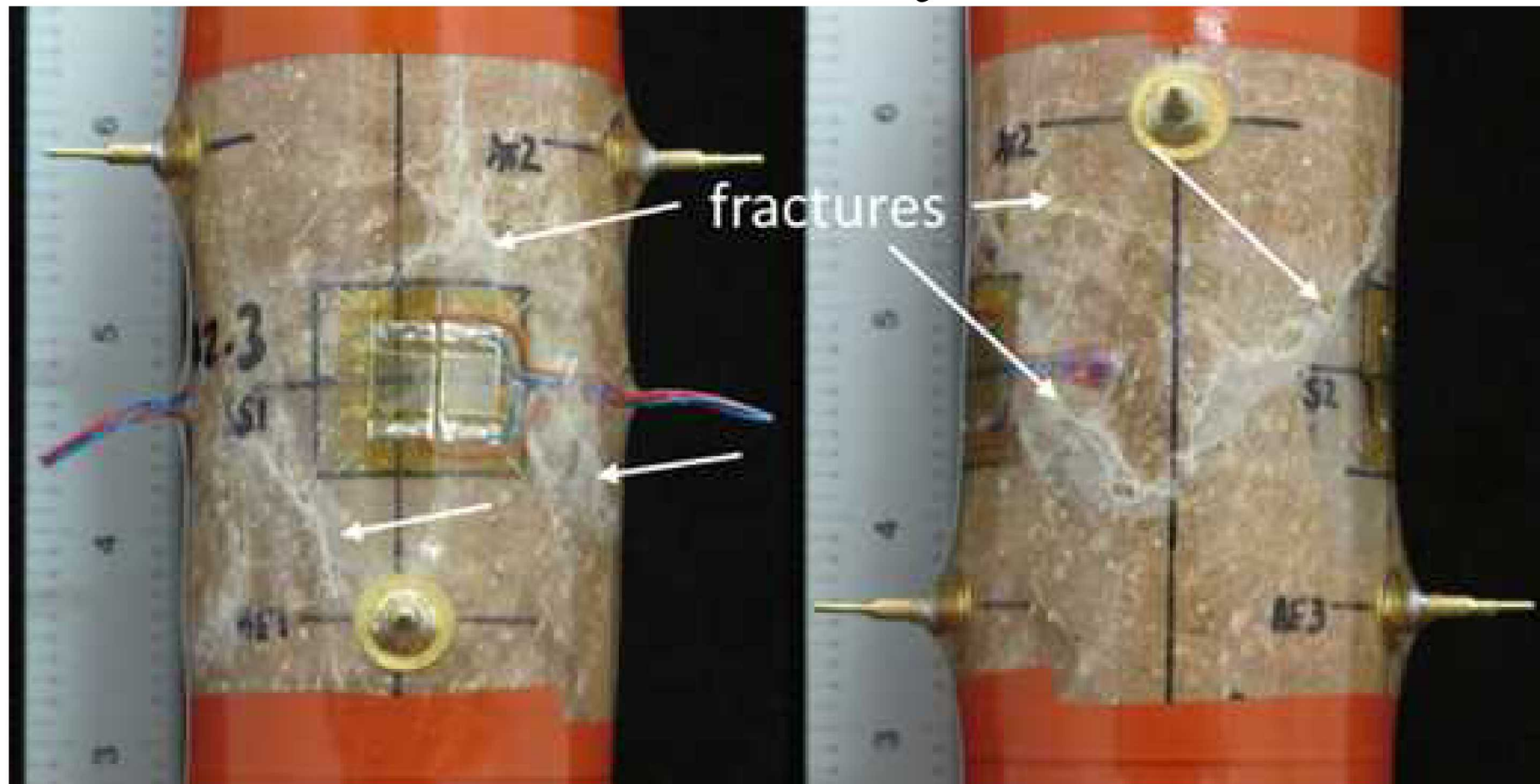
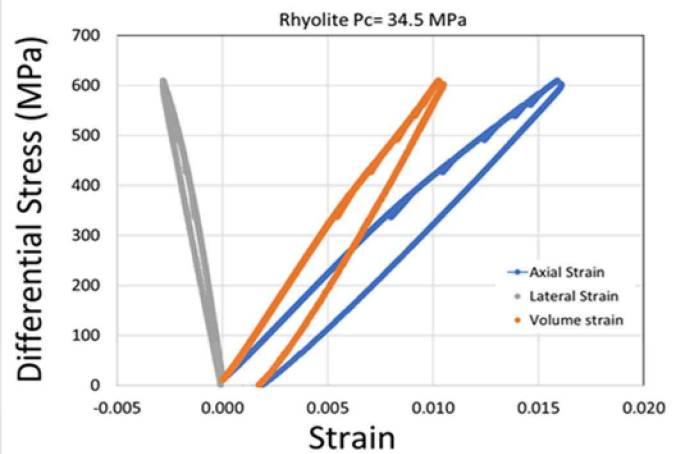
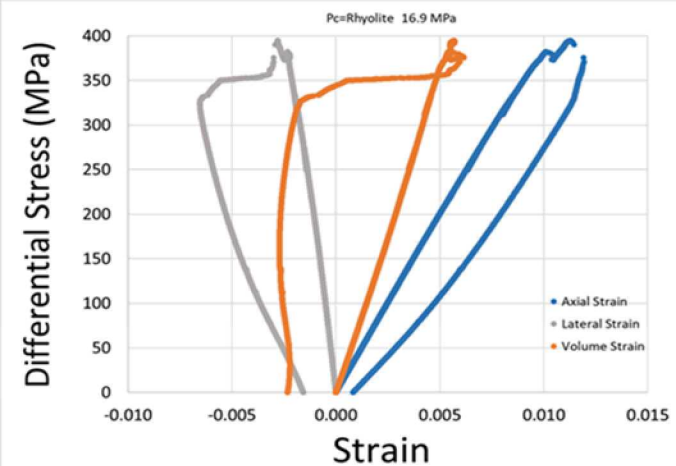
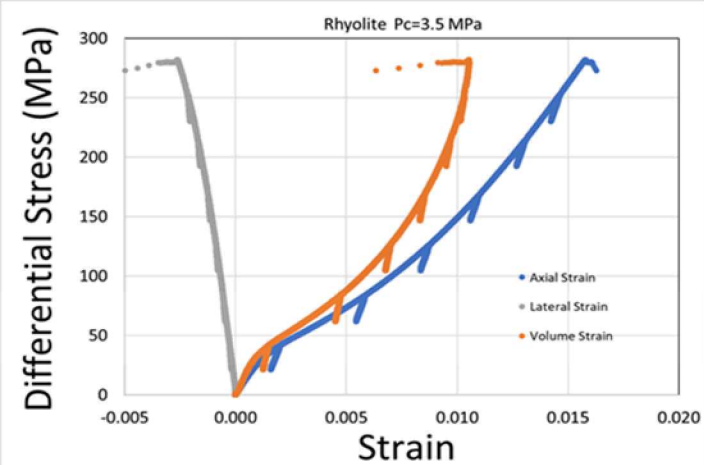
# Rhyolite from Blue Canyon Dome in Socorro, NM



Densely welded tuff, ~30Ma  
aphanitic  
quartz (55 %),  
sanidine (45 %)  
[high temperature K feldspar  $K(AlSi_3O_8)$ ]

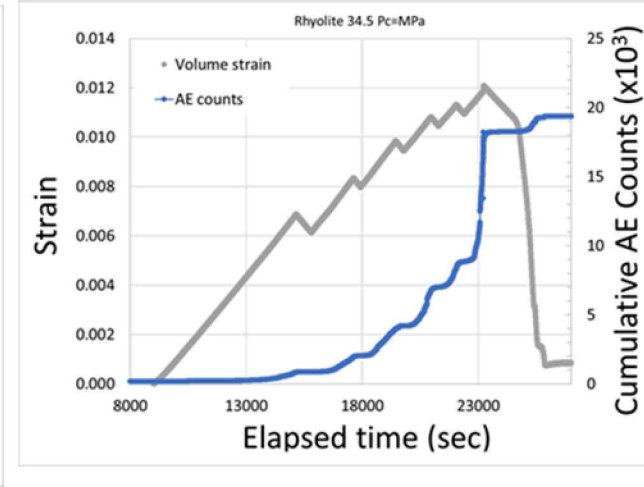
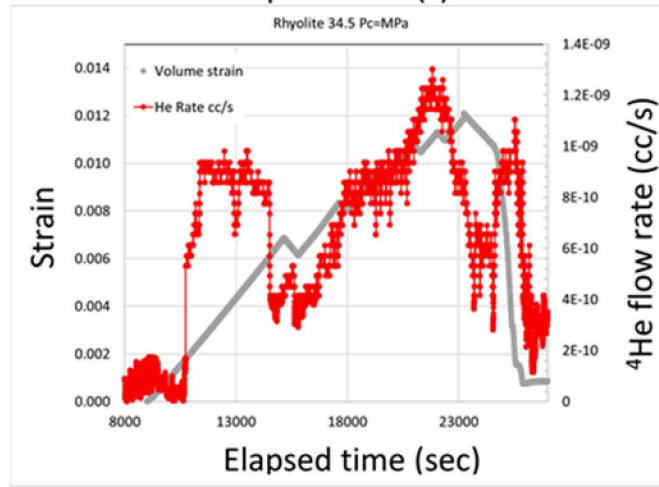
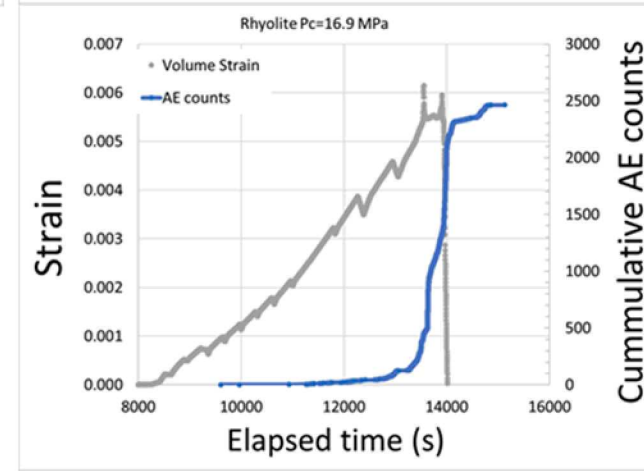
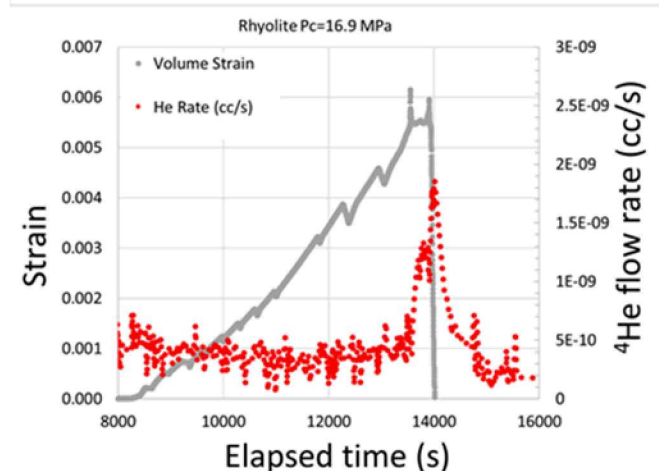
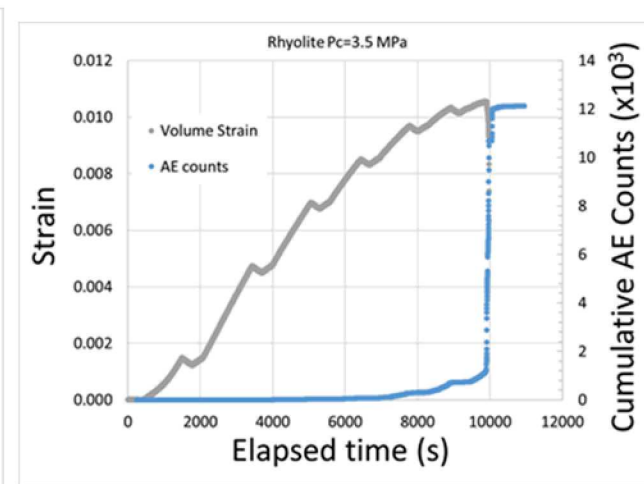
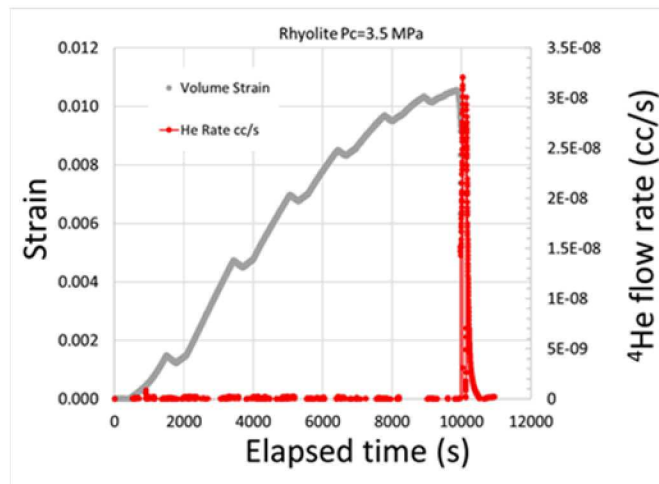
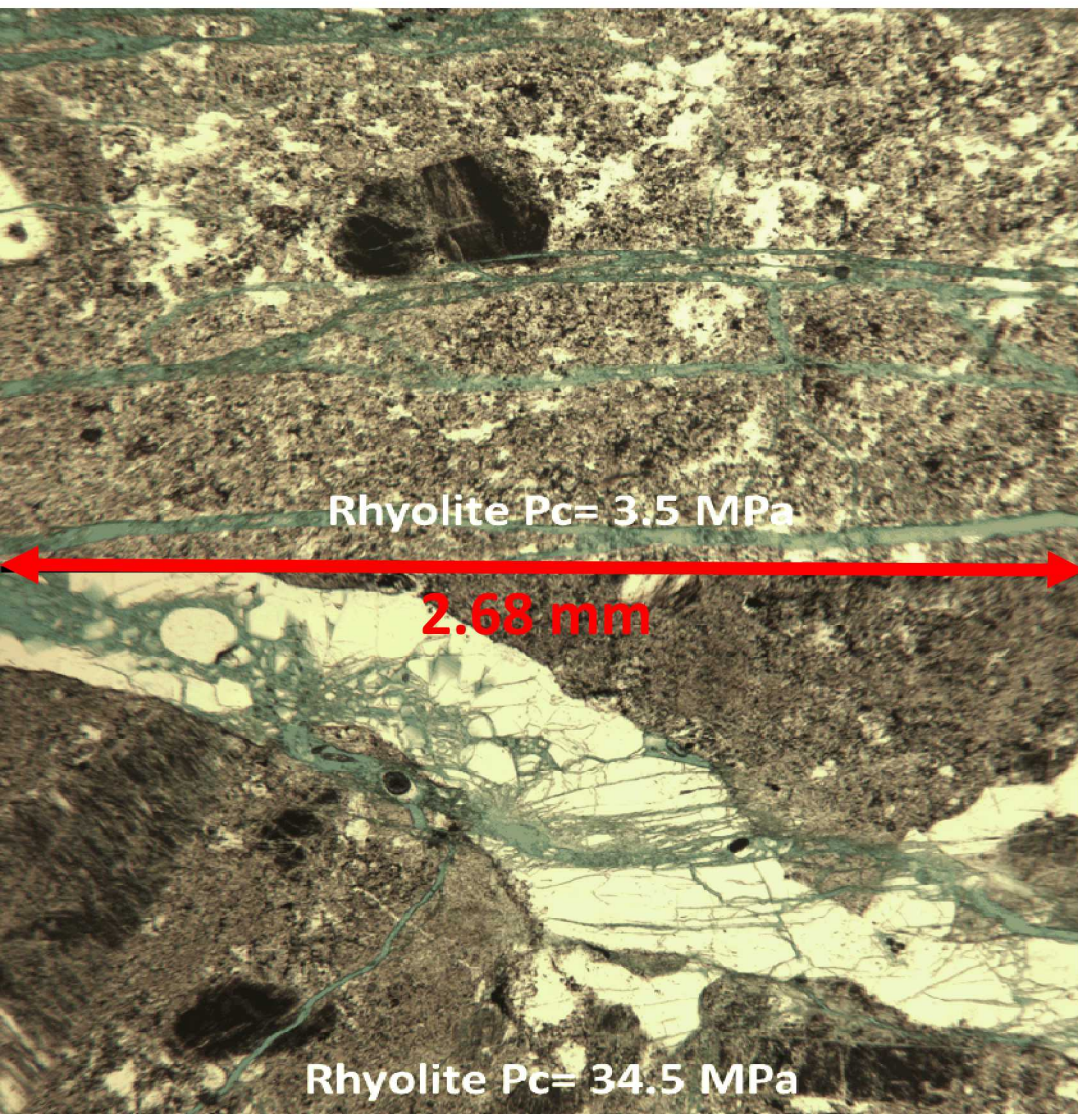
**Many microfracture, some filled with quartz**  
**Many sub millimeter pores**

# Fractured Rhyolite

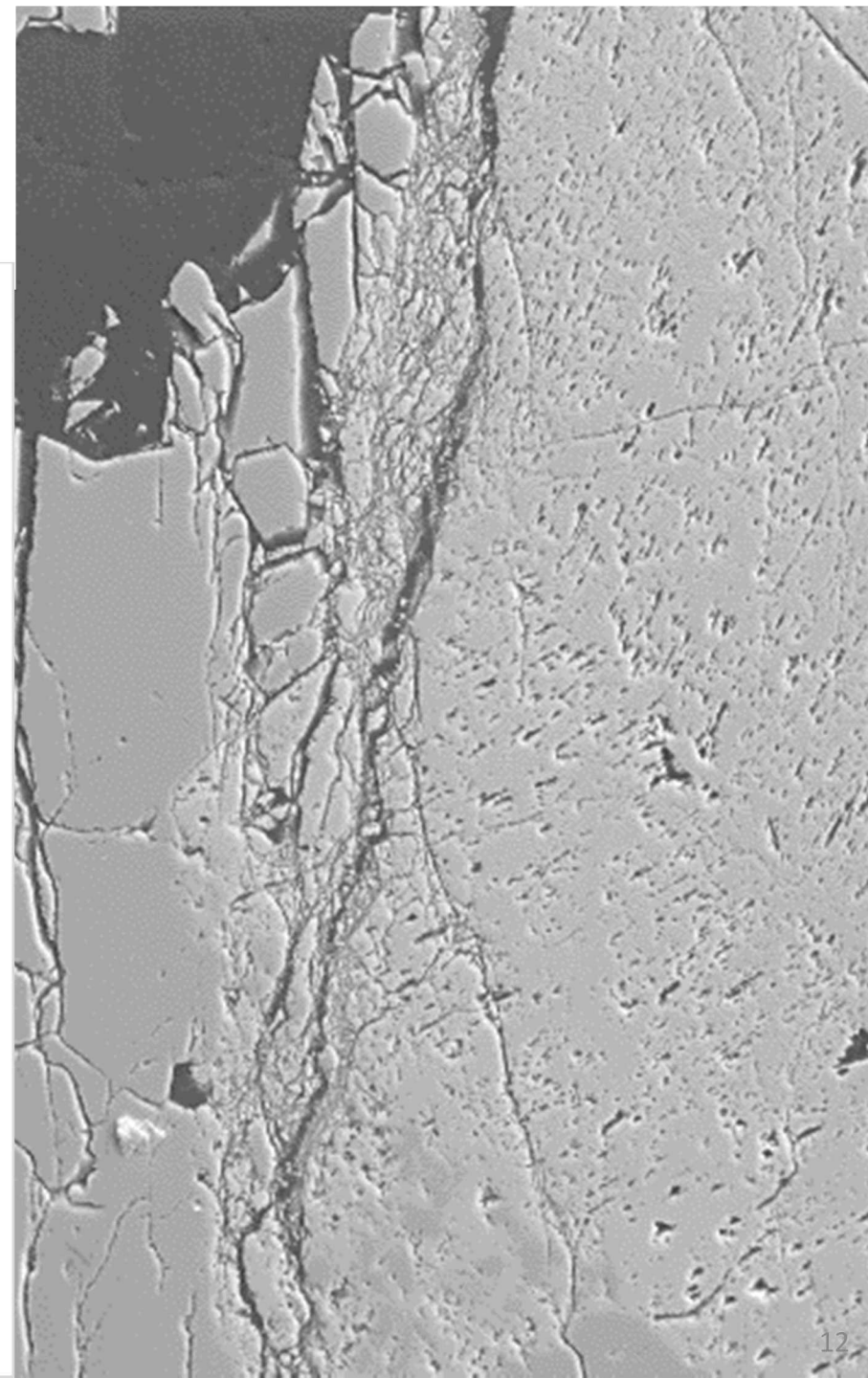
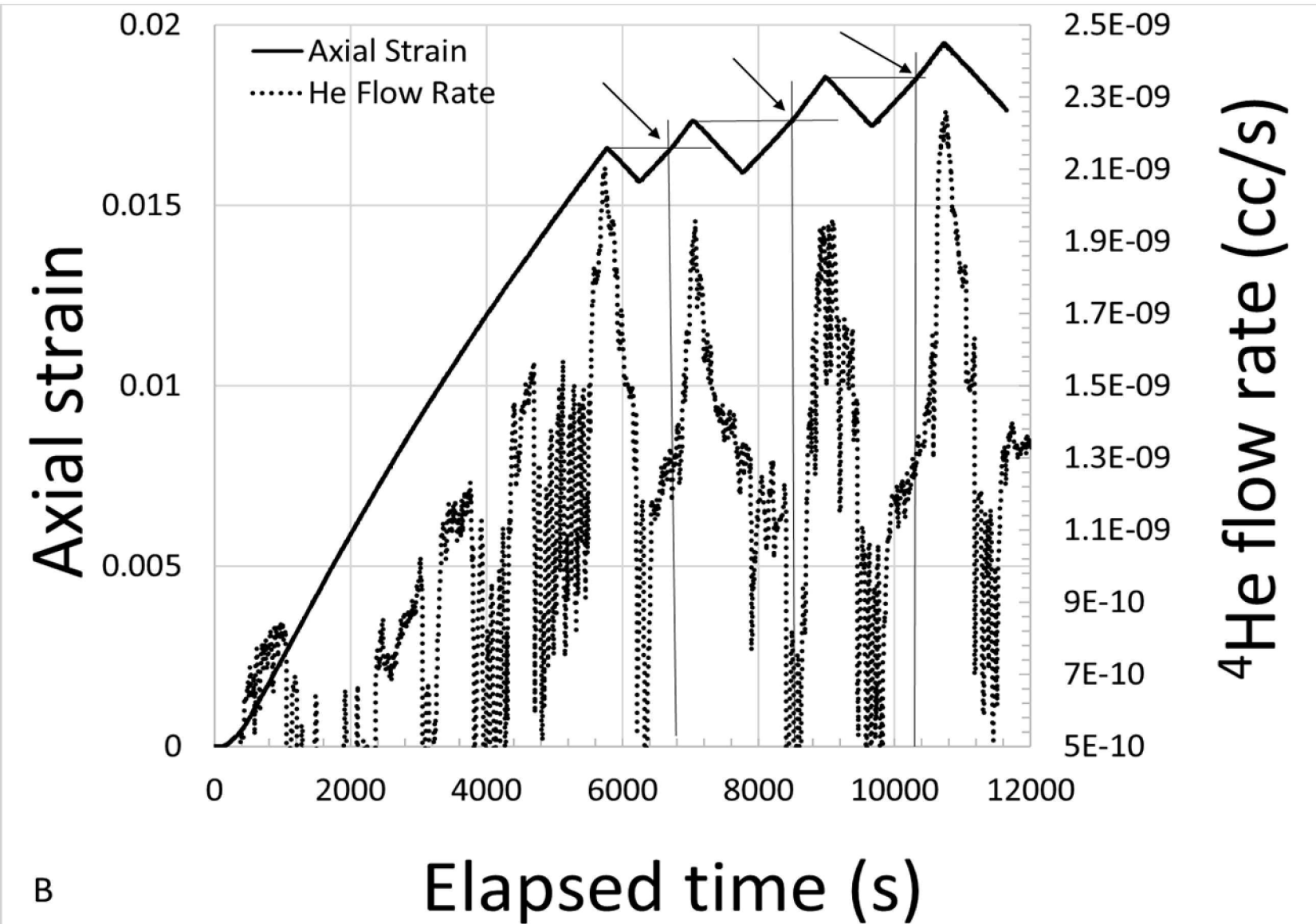


Stress/strain relationships with changing confining pressure

# Helium release, Acoustic emissions



# History dependence



# Results

- (1) Rhyolite characterized for field test, helium present
- (2) Noble gases are released and measured real time during deformation
- (3) Gases are released from intracrystalline sites.
- (4) The noble gas release signal is *sometimes* precursive to macrofracture
- (5) Gas released depends on initial gas content, pore structure and its evolution during deformation, deformation amount, and permeability

*Thanks!*

● *Questions?*



