SAND2020-1782C

Geogenic Gas and Gas Transport

Lab measurements of noble gas capture from water saturated non welded tuff

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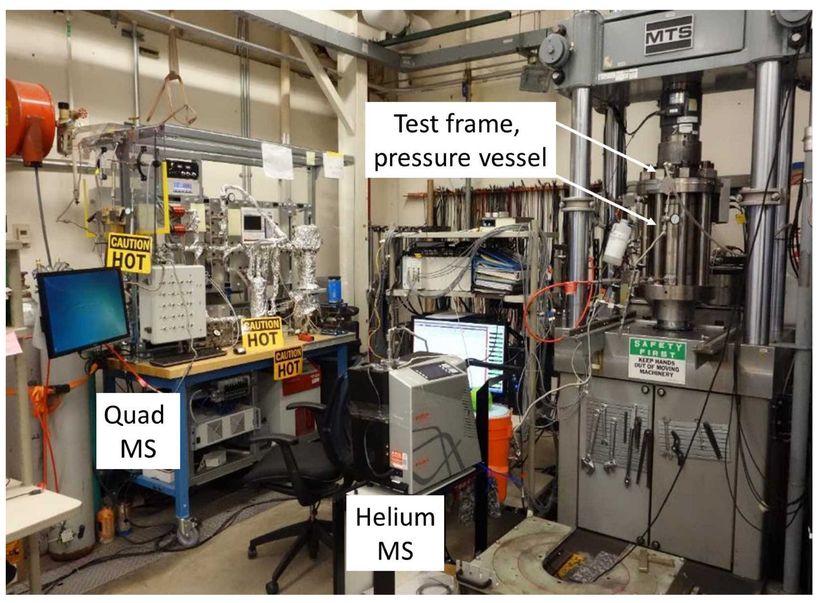
Goals and Objectives

- Our objective is to contribute to identifying potential new signals of underground explosions.
- Geogenic noble gases are probably contained in all crustal rocks. These gases represent a unique signal source, their release may be related to deformation state of rock; sensing this signal will inform us of deformation.
- We are evaluating this signal as a means to improve Nuclear Explosion Monitoring
- ***New work reports on noble gas capture from water-saturated PE-1 nonwelded tuff***

Introduction

The concept of noble gas release as deformation sensor is new, first developed through independent research. We are measuring the geogenic noble gas release signature for relevant lithologies; this release may represent a sensible signal of subsurface deformation in the absence of radionuclide release.



Test System

Methods

The residual gas analysis portion of the test system utilizes mass spectrometry (MS). The helium leak detector or QMS is capable of scanning the total abundance of gas over a broad mass range continuously during deformation.

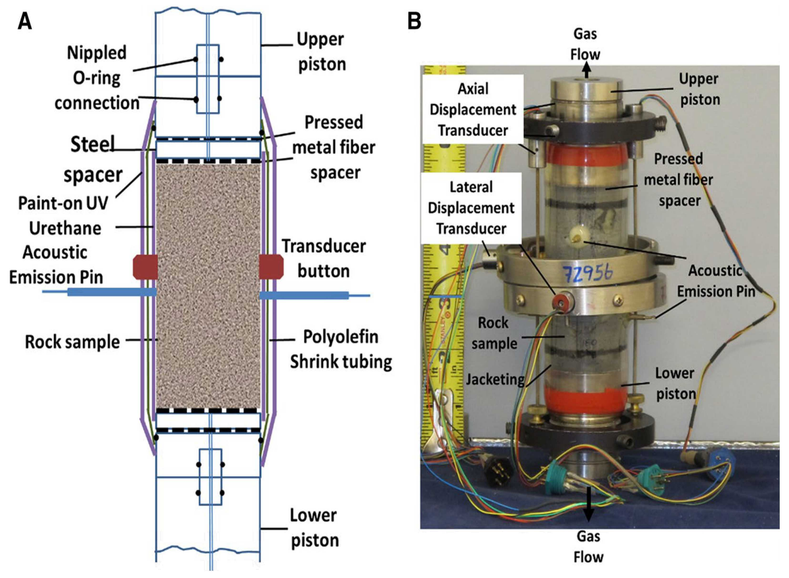
The mechanical portion of the test system consists of a triaxial cell(s), with the following capability:

- Sample diameter 2.5 cm to 10 cm
- Sample length 5 cm to 25 cm
- Confining pressure up to 400 MPa
- Axial force sufficient to fracture sample in compression and extension
- Pore fluid flow through capability used with high pressure (simulate pore pressure at depth) and low pressure (application of high vacuum).

The triaxial testing for this study is run in constant mean stress (CMS) loading, in an undrained mode. Pore pressure is monitored and "allowed" to fluctuate during the test. Modifications for this new test setup were made to collect noble gas from the sample after the triaxial testing by pumping gas from the water-saturated sample though a series of cold traps.

New Work

This new effort is focused on making measurements of water-saturated rock, which includes some of the challenges and reality of the natural underground conditions.



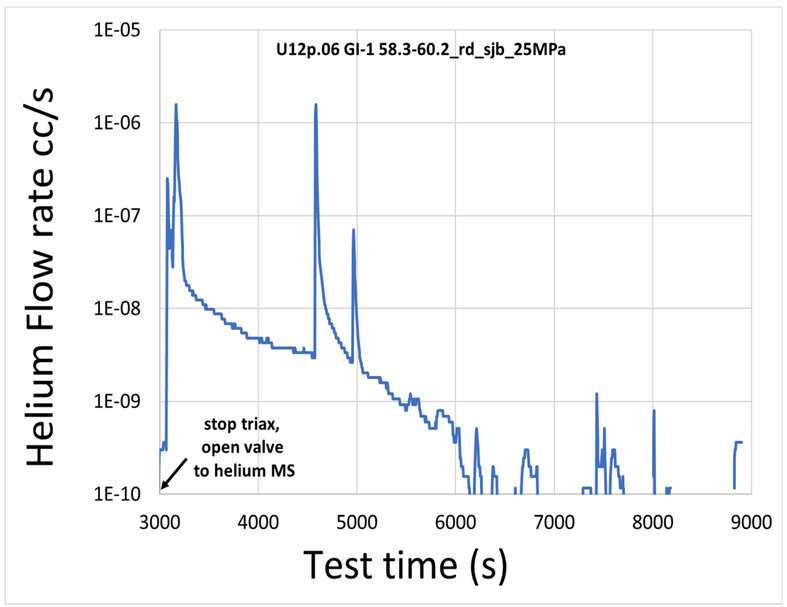
Sample assembly

Early results

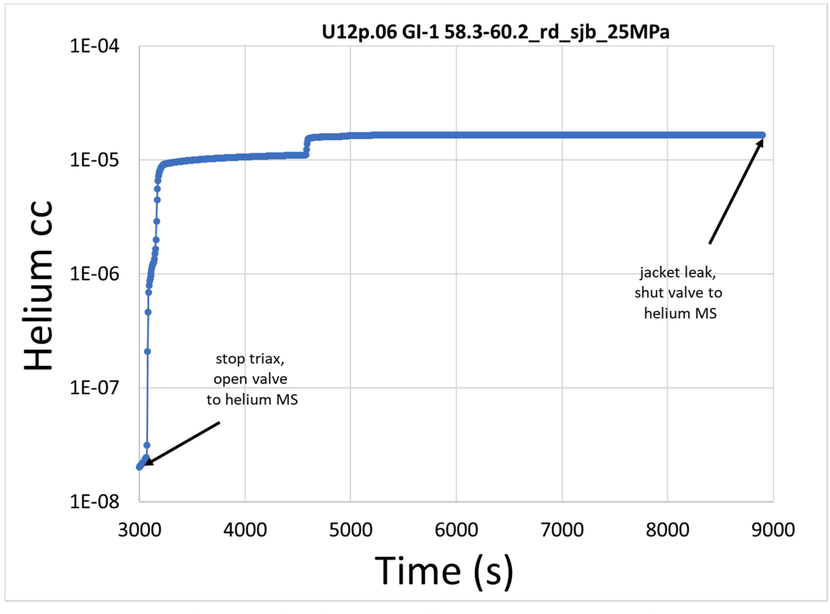
Four undrained water saturated triaxial CMS tests of nonwelded tuff are complete. Post test measurements of helium represent gas apparently released during the deformation. Helium was successfully captured from all samples.

Observations:

- A burst of helium upon exposing the sample to the gas analysis system
- One or more additional bursts of helium as time passes and the sample is drained of helium



Helium flow rate versus time



Cumulative helium collected versus time

Impact

Our results show:

1- Mechanical deformation of water saturated nonwelded PE-1 tuff releases noble gases.

2- These noble gases may be captured and represent a deformation signal.

3- The capturing is represented as an episodic phenomena. This implies that quantitative measurements of gas capture in fluid bearing rock should be near continuous, otherwise important information may be missed.

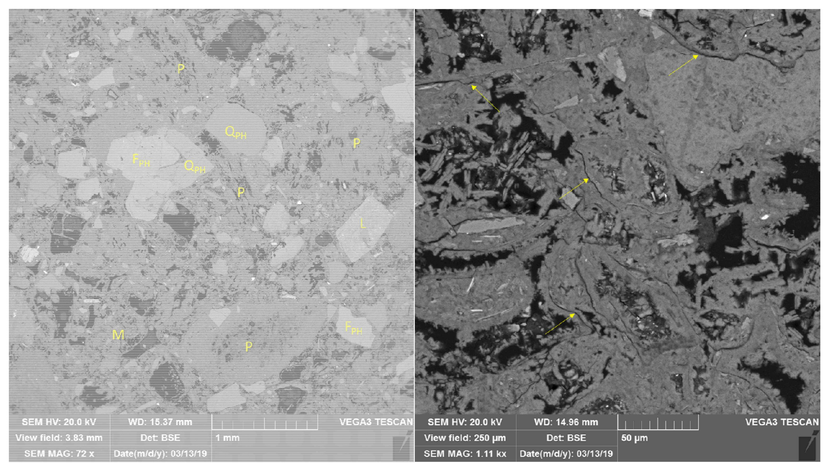
We propose using noble gas release to signal rock deformation caused by nuclear explosions. This signal will be present when rock is fractured, thus detection of this gas signal will be present in the absence of a RN signature.

Future Work

1- Analysis/publication of field measurements before during and after the Blue Canyon Dome shot#1 are underway.

2- Publication of this new method of capturing noble gases released during water-saturated triaxial deformation of tuff.

3- Field measurements are in planning for Blue Canyon Dome and elsewhere next half.



Potential noble gas storage sites

Left: U12p03-RE7-47A-SEM-tuff-components

BSE image of zeolitic nonwelded ash-flow tuff showing pore voids (black), phenocrysts of quartz (Q_{PH}) and feldspar (F_{PH}), zeolitized pumice (P), and lithic clasts (L) within a matrix (M) of smectite and zeolitized glass shards and ash.

Right U12p03-RE7-47A-SEM-tuff-matrix

BSE image of matrix from zeolitic nonwelded ash-flow tuff. Matrix is composed of relict glass shards (see dogbone shape at bottom right corner of image), pumice fragments, and ash-sized particles that have been altered to a combination of smectite and zeolite (clinoptilolite). Zeolite crystals grow outward from relict glass components in an acicular to tabular form into void spaces. Smectite forms as an alteration product of volcanic glass and is incorporated into zeolite crystallization (see upper right portion of image). Desiccation microcracks are common in this matrix material (arrows), and tend to follow relict shard and pumice boundaries.

Publications/Deliverables:

- Bauer, SJ, WP Gardner, H Lee (2016), Release of radiogenic noble gases as a new signal of rock deformation, Geop.Res.Lett, 43 ,10,688–10,694, doi:10.1002/2016GL070876.
- Bauer, SJ, WP Gardner, JE Heath (2016), Helium release during shale deformation: Experimental validation, Geochem. Geophys. Geosyst., 17, 2612–2622, doi:10.1002/2016GC006352.
- SJ Bauer, WP Gardner, W. Lee, 2017 Noble Gas Release and Flow Through a Granite and Basalt, Stanford Geothermal Conf., SAND2017-1552 C.
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- SJ Bauer, ST Broome, WP Gardner, (2018) Release of geogenic gases as a signal of deformation in rock, 52nd US Rock Mechanics / Geom. Symp., Seattle, Wash.
- Bauer, SJ (2018), Observation of the Kaiser Effect Using Noble Gas Release Signals, Rock Mech Rock Eng., DOI 10.1007/s00603-017-1324.
- SJ Bauer, WP Gardner, H. Lee (2019) Noble Gas Release from Bedded Rock Salt during Deformation, *Geofluids*,Art.ID2871840 https://doi.org/10.1155/2019/2871840

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