Material and Gas Transport Properties of Test Bed Core

SAND2019-2328R

Project Tweet: ***Measurement of noble gas diffusivity in partially saturated and tight lithologies***

Background/State of the Art

Noble gas radionuclides are considered one of the primary indicators of an underground nuclear explosion.

Transport from detonation point to the surface is a complex process relying on barometric pumping, thermal buoyancy, etc.

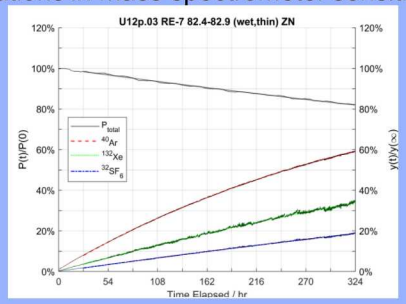
Diffusion to the surrounding rock matrix alters both the arrival time and magnitude of the radionuclide signature.

Contemporary techniques to measure diffusivity date back 70+ years:

- Wicke-Kallenbach (1941)
- Ney-Armistead (1947)

Innovation

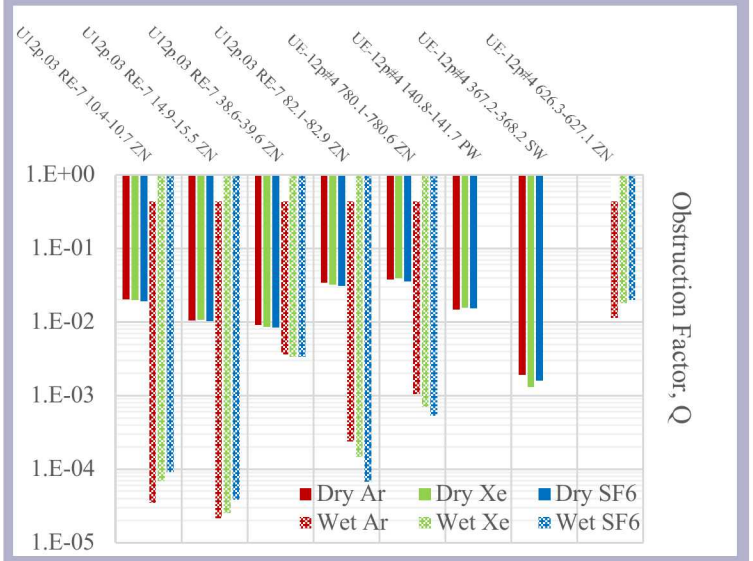
- The Ney-Armistead method has been altered for continuous mass spectrometry
- The advective flow rate (<0.05 sccm) is quantified using the pressure decay curve
- Mole fractions are utilized to accurately compensate for decompression and variations in mass spectrometer sensitivity



Approach, Metrics and Outcomes

MAIN ACHIEVEMENT

- Obstruction to tracer diffusivity in partially saturated media has been reliably measured in wide range of core samples:



HOW IT WORKS

- By an engineered design, tracer and carrier molar balances are well-approximated by linear differential equations.
- The system of differential equations can be solved simultaneously, allowing recorded data (total pressure and ion current ratios) to be fit to an analytical solution.
- This technology was built upon previous iterations that required the recorded data to be fit to numerical simulations.

ASSUMPTIONS AND LIMITATIONS

- Waxed core sample moisture content is assumed to be representative of the field conditions.
- Through diffusivity is not necessarily equal to the uptake diffusivity due to cul-de-sac pores and sorption.

Impact

- Measurements of the matrix diffusivity are necessary to:
  - Ensure gas transport models are using appropriate material properties
  - Provide informed parameters for radionuclide predictions where models have not been tuned
- Technology to measure matrix diffusivity is not limited to UNE monitoring applications

TRLs:

- **Start: 1** Basic principles observed
- **Finish: 5** Operational laboratory scale

Publications SAND2019-0786

Goals/Action Plan

Current FY

- Iterate on existing design to improve precision and increase throughput
- Acquire Hg porosimetry and relative gas permeability data

Future FY

- Correlate pore distributions and water saturation to effective gas permeability and diffusivity

Team

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