WASTE MANAGEMENT 2020

BRINE AVAILABILITY TEST IN SALT: THMC SIMULATIONS OF A HEATED BOREHOLE IN SALT - 20239

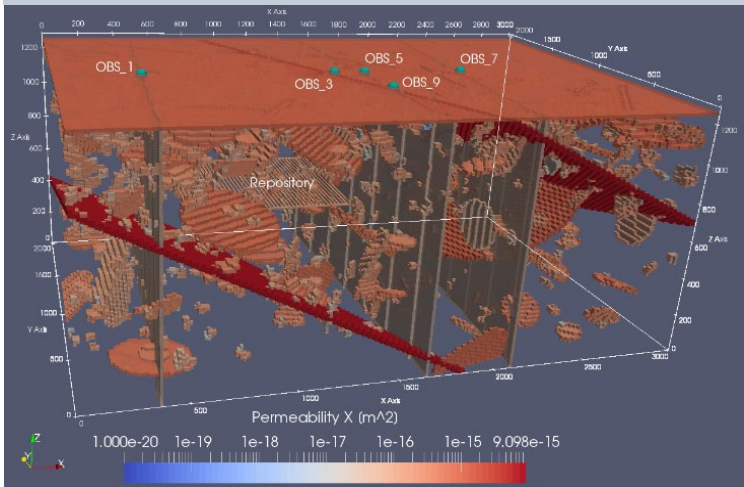
LA-UR-20-21948

SFWD

SPENT FUEL & WASTE DISPOSITION

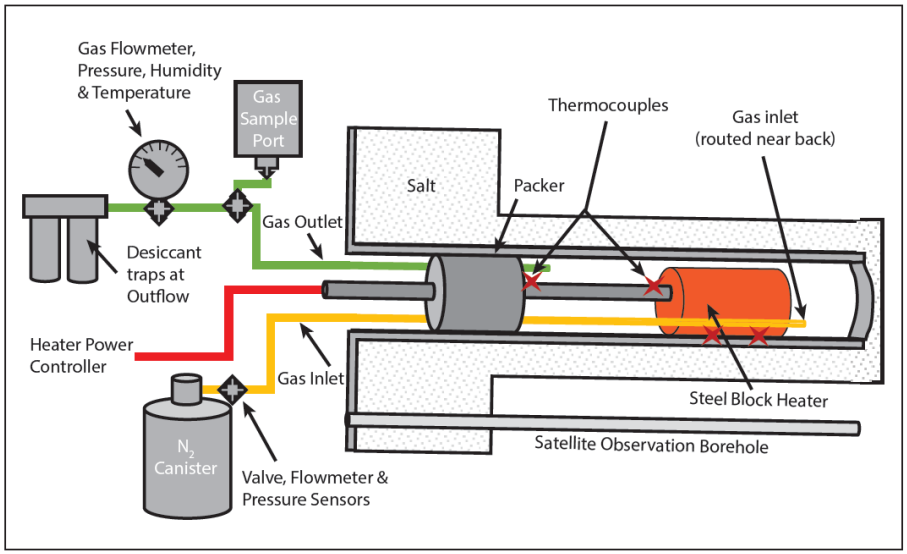
Eric Guiltinan[1], Terry Miller[1], Kris Kuhlman[2], Jonny Rutqvist[3], and Philip Stauffer[1]

1 Computational Earth Science Group, Los Alamos National Lab
2 Sandia National Laboratories
3 Lawrence Berkeley National Laboratory



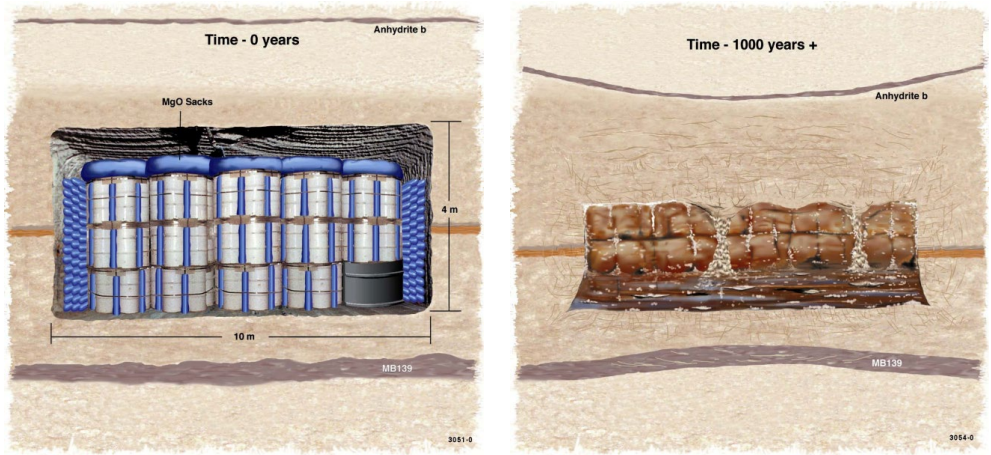
Brine Availability Tests in Salt (BATS)

Storing heat generating nuclear waste in salt is being investigated at WIPP

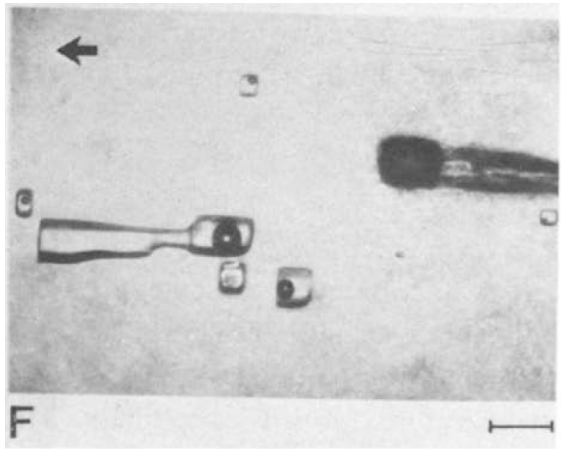


Is A Salt Repository the Answer?

- Salt is an attractive geological medium due to its extremely low permeability, self-sealing ability, and high thermal conductivity.
- However, questions remain regarding brine origin, availability, and chemistry during the heating of salt



Erickson and Dials, RadWaste Solutions, Jan.-Apr., 24-34, 2011.



Fluid inclusions migrating under a thermal gradient - Carter and Hansen, Technophysics, 93, 1983.

Water Sources in Salt

- Water sources in bedded salt:
  - **Intracrystalline** (brine inclusions)
  - **Intercrystalline** (e.g., mobile "pore fluid")
  - Water associated with **clay minerals** and polyhalite
- Water may be liberated from brine inclusion migration and clay dehydration (above 65°C)

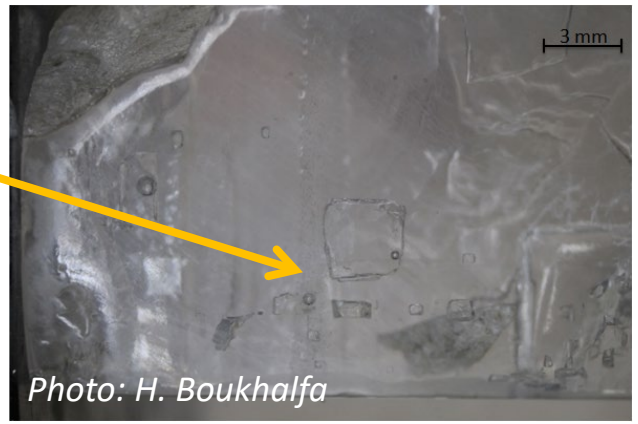
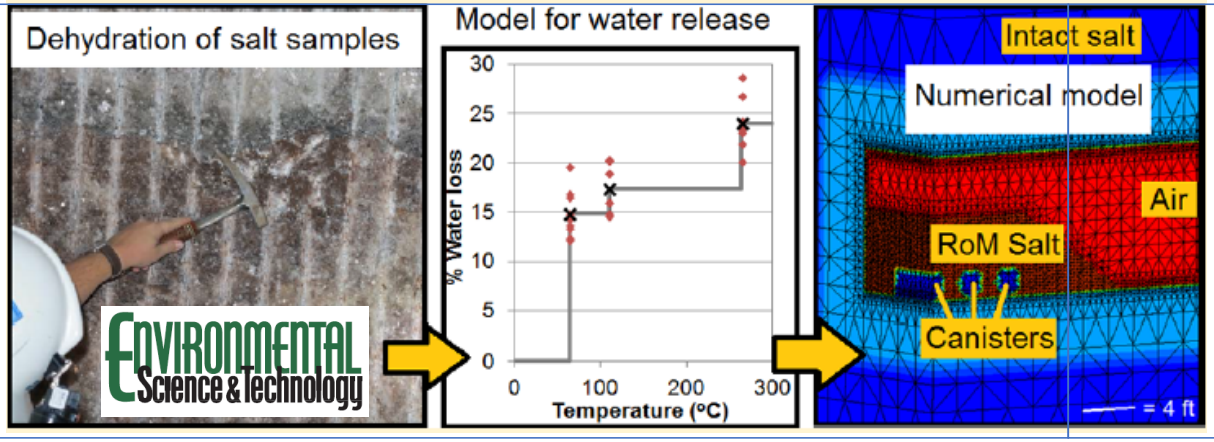


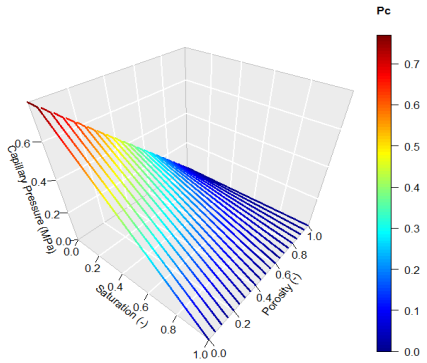
Photo: H. Boukhalfa

Photo: D. Weaver

Salt THMC Couplings

- *Deformation* ***F****(temperature, stress, time, saturation)*
- *Vapor pressure lowering* ***F****(capillary pressure, salinity)*
- *Porosity* ***F****(dissolution, precipitation, stress, strain)*
- *Thermal conductivity* ***F****(temperature, porosity, saturation)*
- *Permeability* ***F****(porosity, saturation)*
- *Capillary pressure* ***F****(porosity, saturation, temperature)*
- *Water vapor diffusion* ***F****(porosity, saturation, temperature)*
- *Clay dehydration* ***F****(temperature)*

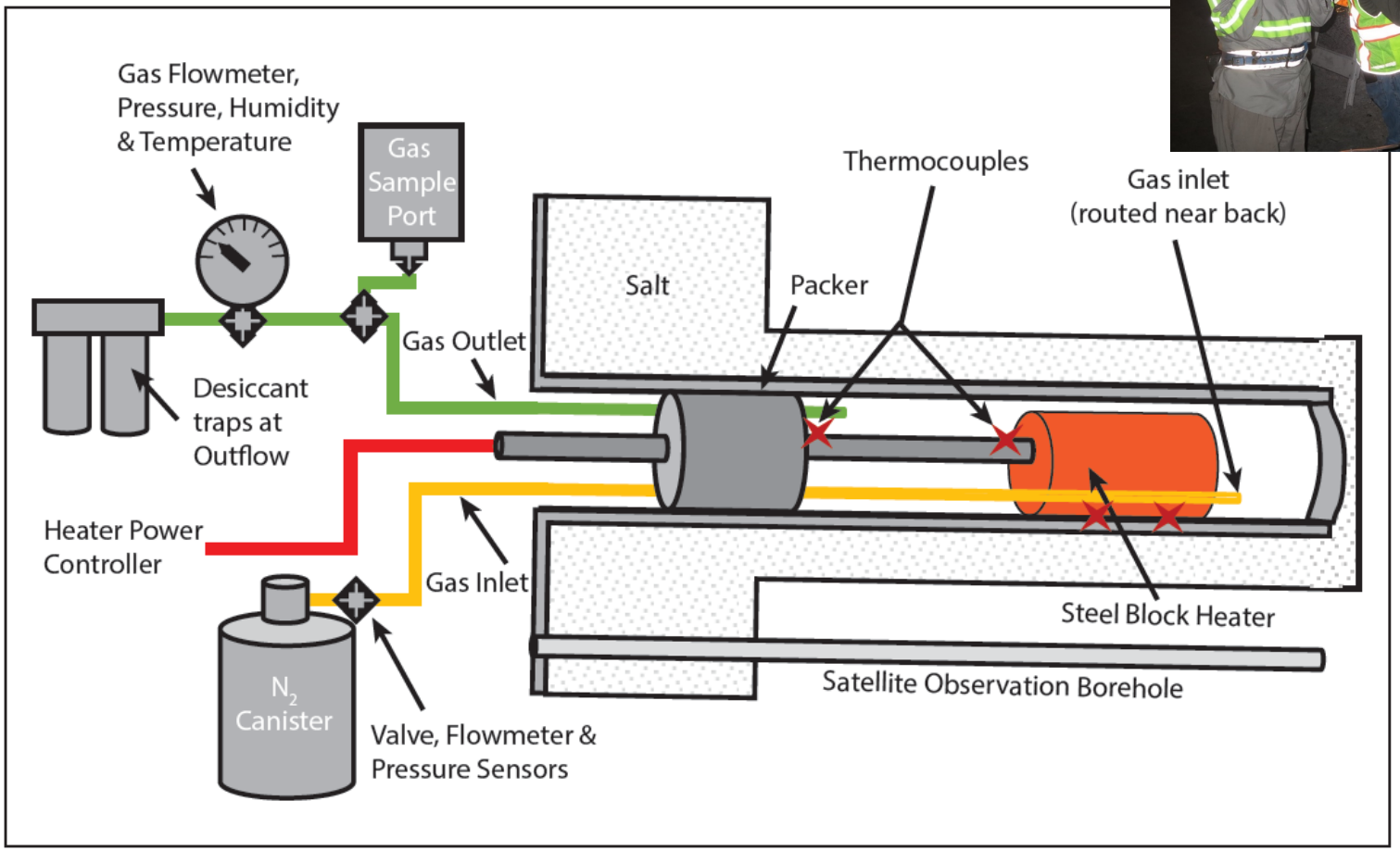




Capillary pressure / porosity function

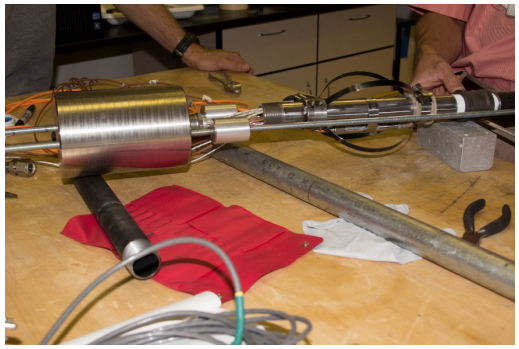
BATS: Phase 1s (Shakedown)

Tests Began in July 2018 and were complete in May 2019

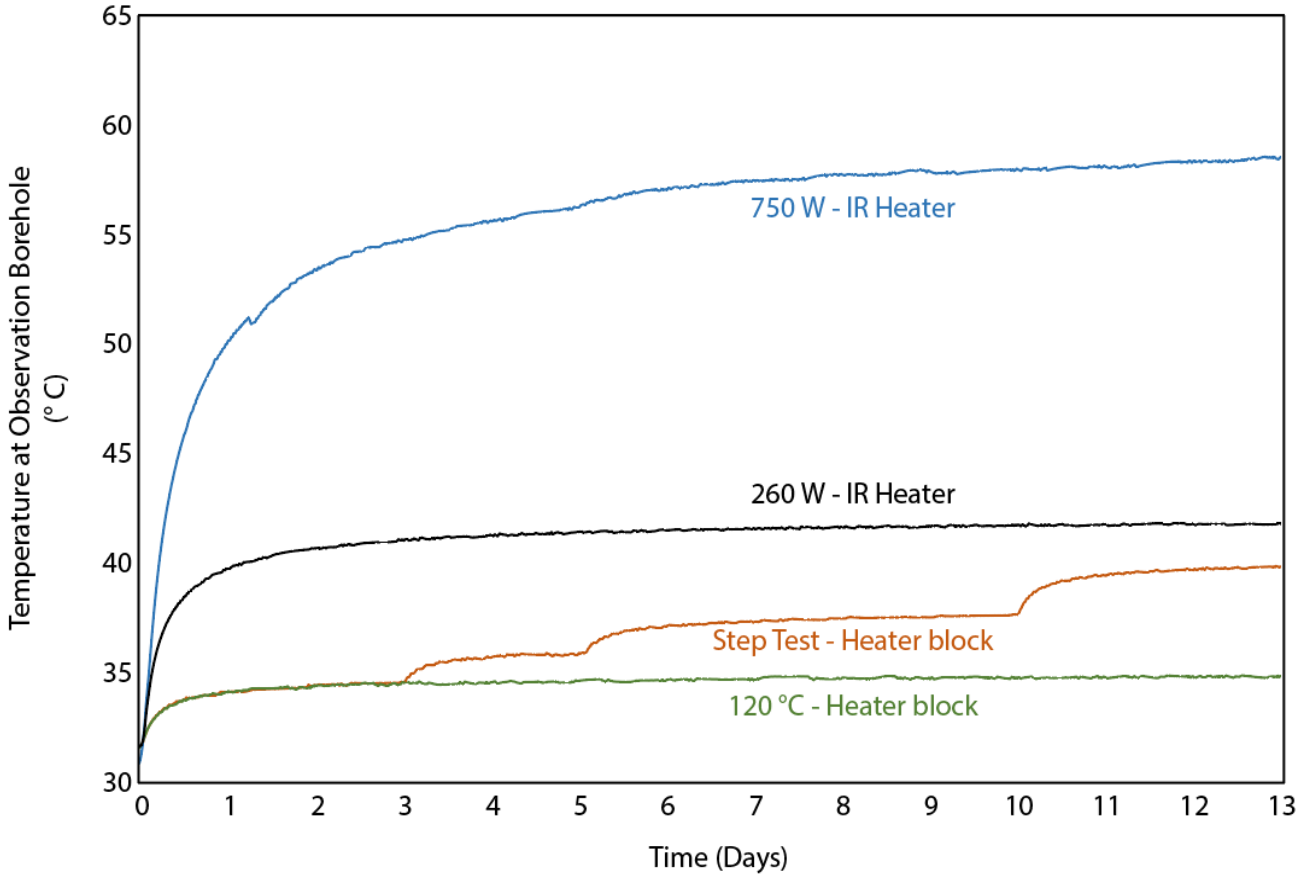


Phase 1s: Temperature Results

Heater Block



IR Heater



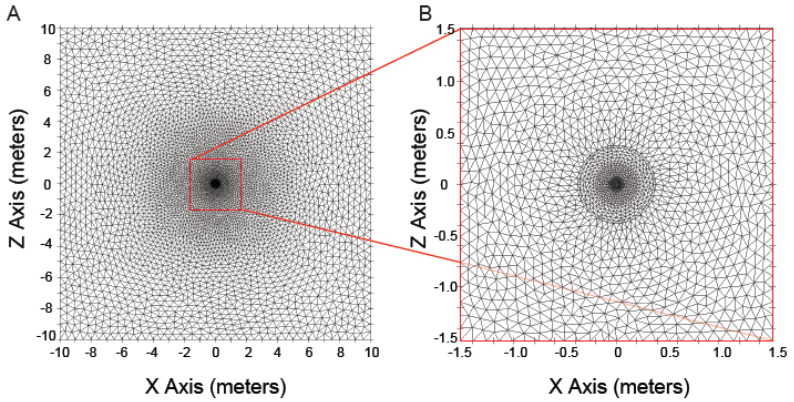
PHASE 1S: FEHM MODEL

Highly refined 3D Mesh

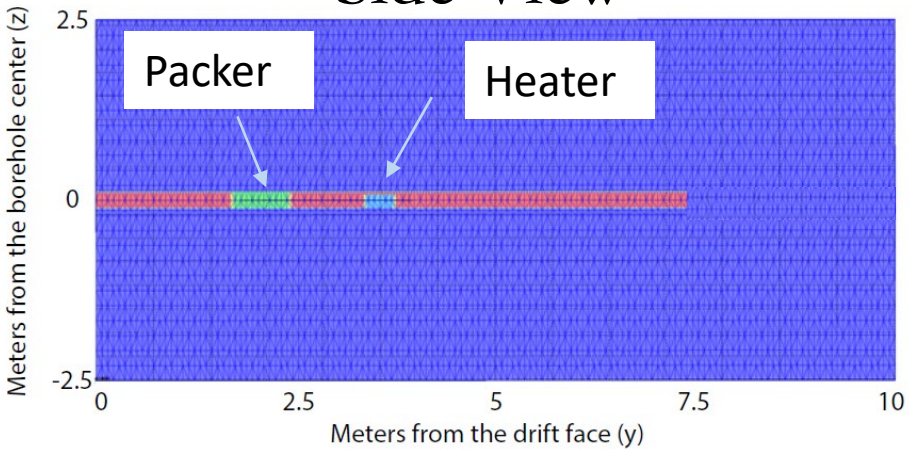
20m x 20m x 10m

1,003,995 total elements

Drift View

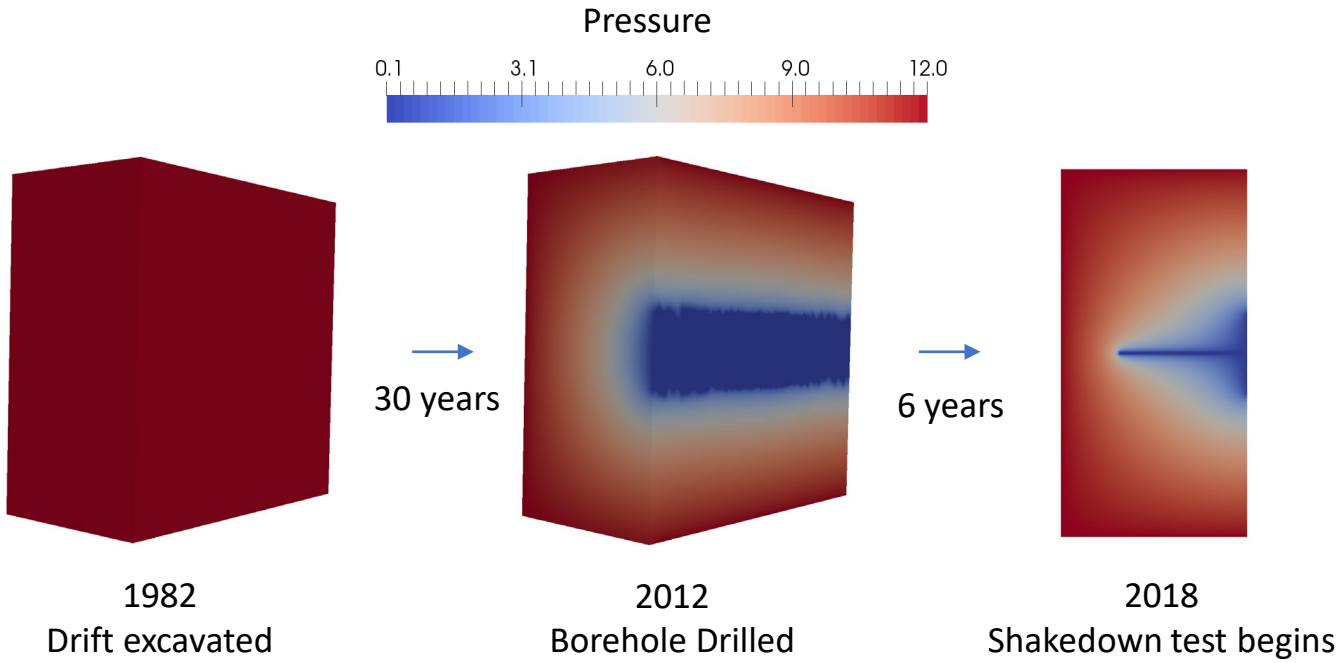


Side View



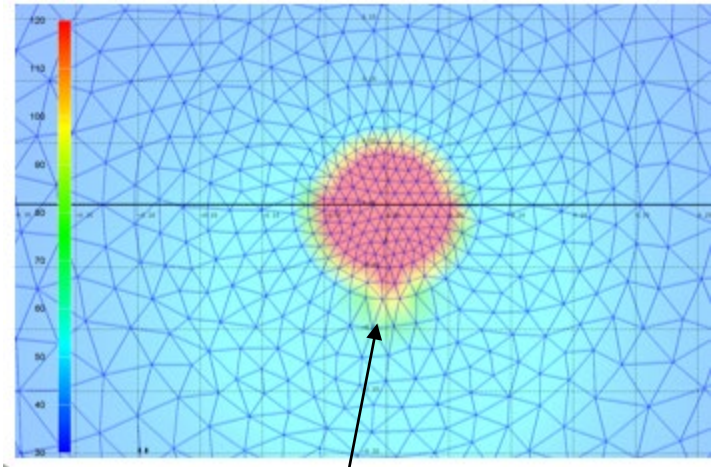
Phase 1s: Pressure Distribution

Long term simulations used to predict initial reservoir pressure

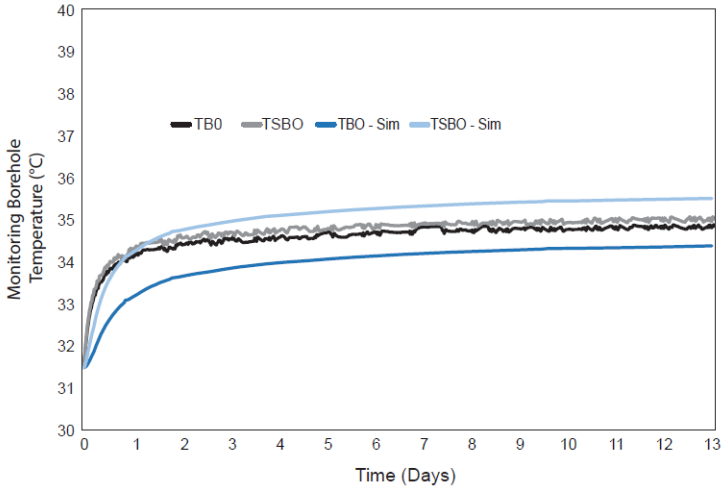


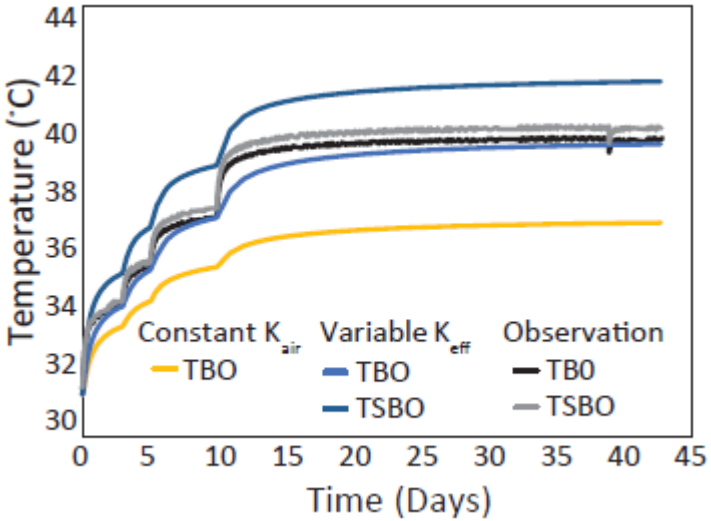
SHAKEDOWN: HEATER BLOCK

- Heater block makes minimal contact with salt and is buffered by air.



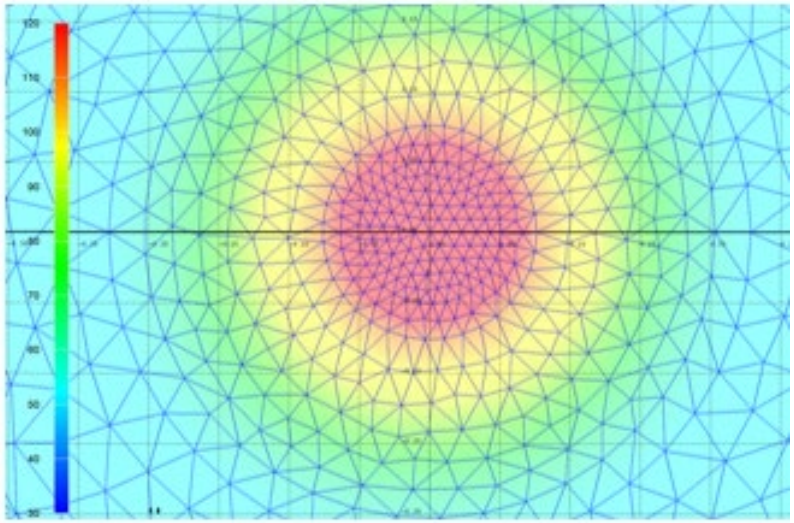
Contact with salt





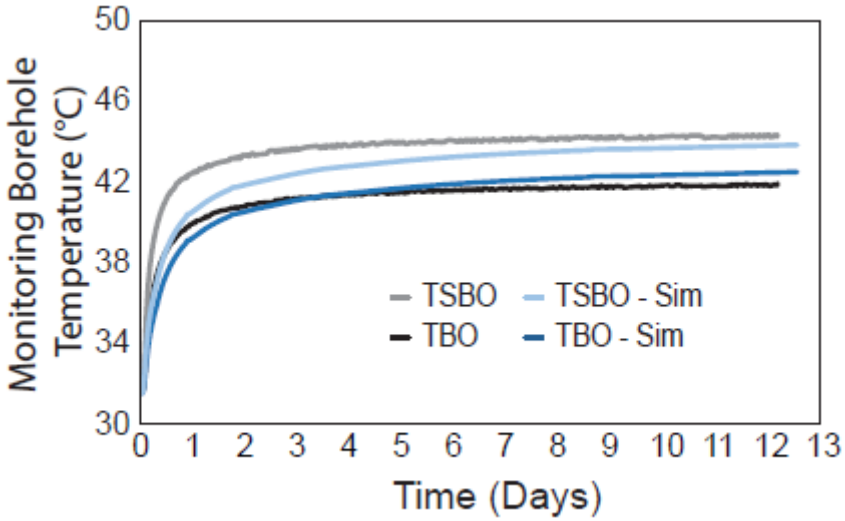
SHAKEDOWN: IR HEATER

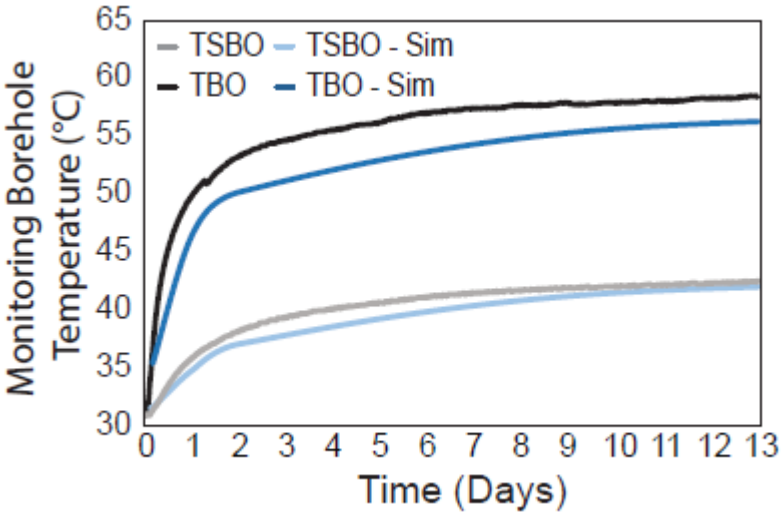
IR heater is fully coupled to salt



750W IR Heater

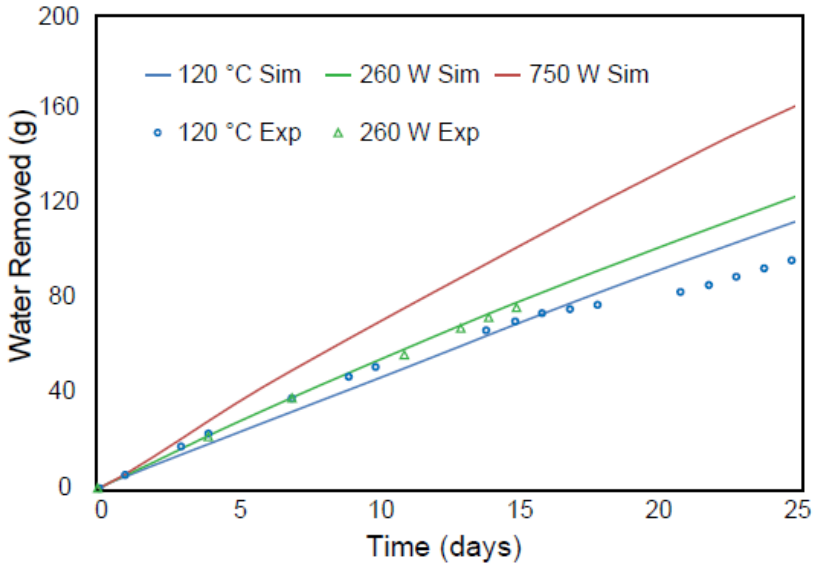
260W IR Heater





Water Production

- Dry nitrogen carries out water vapor
- Water mass measured by Drierite mass change



Drierite

Intact Salt permeability:1e-21 m^2

DRZ permeability: 1e-18 m^2

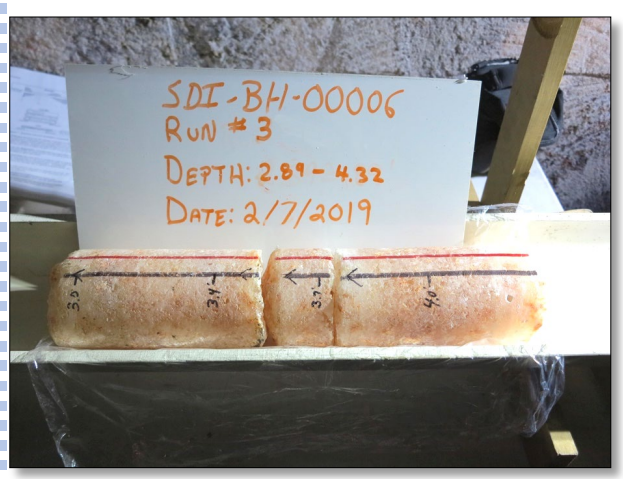
Background Pressure: 12 Mpa

BATS: Phase 1

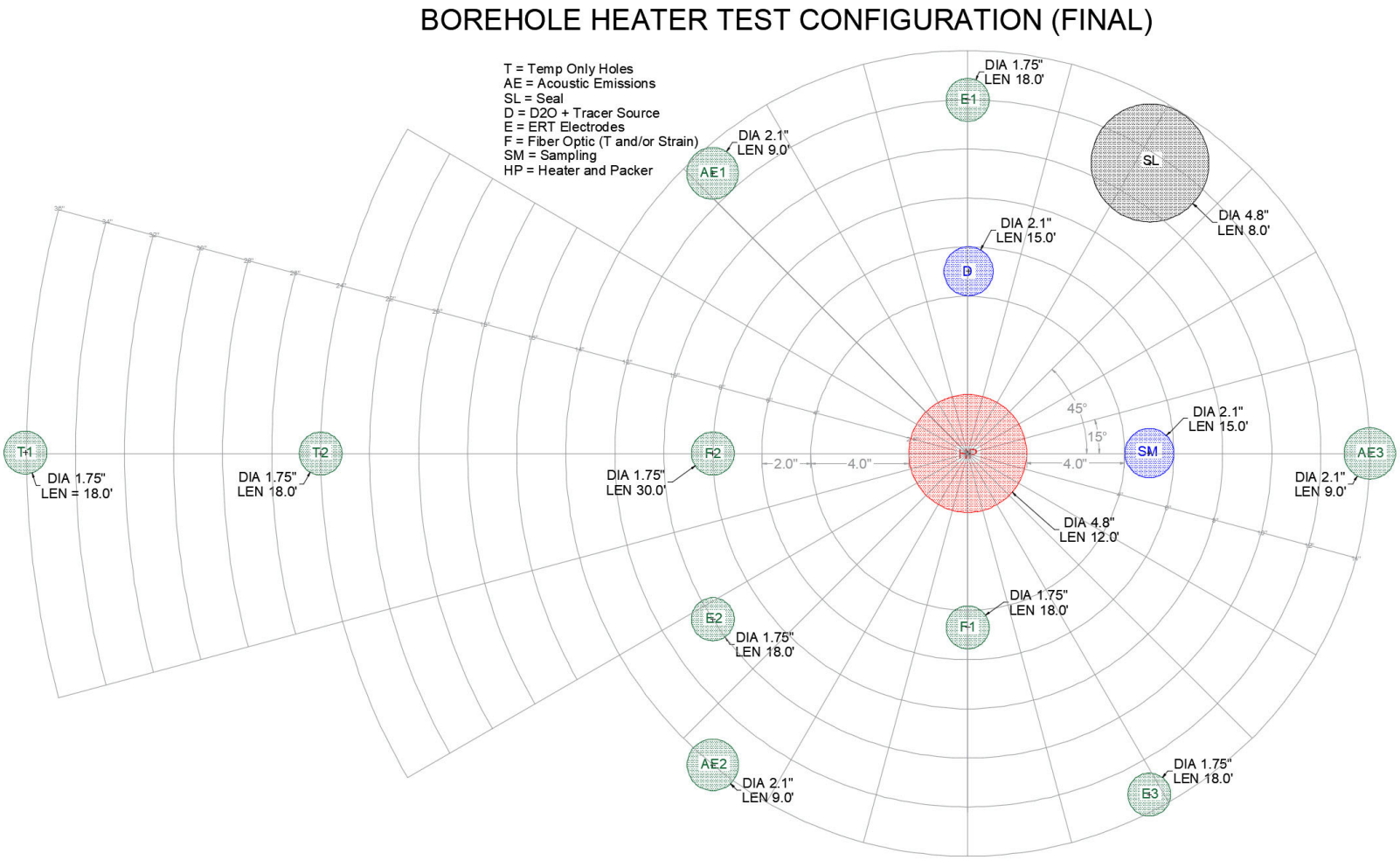
Brine Availability Test in Salt at WIPP (BATS) Phase 1

Monitoring brine distribution, inflow, and chemistry from heated salt using geophysical methods and direct liquid & gas sampling.

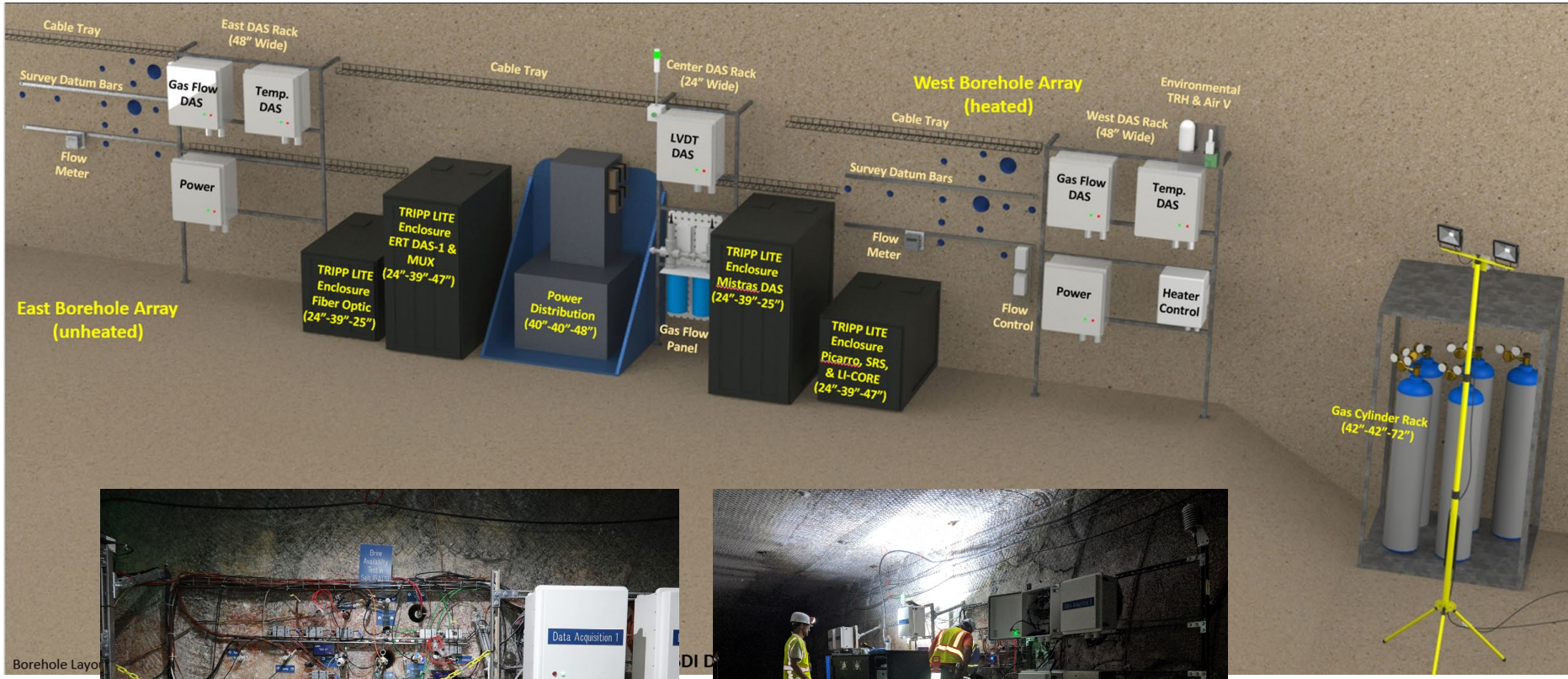
Heater turned on January 2020



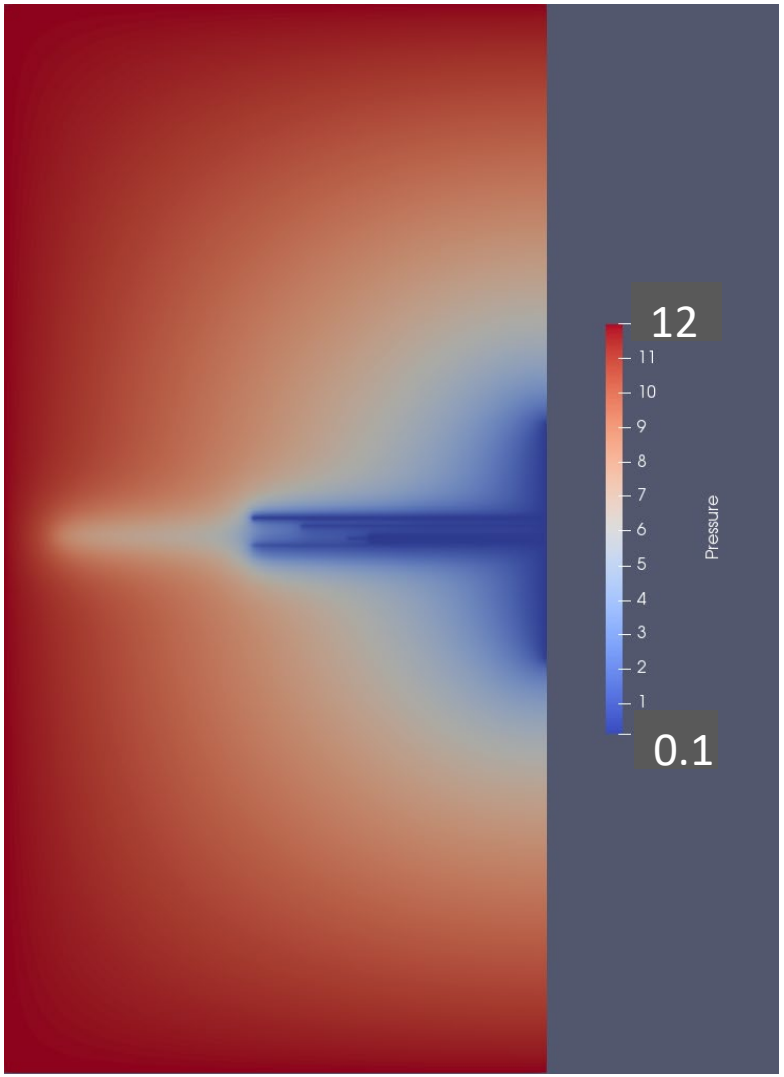
BATS: Phase 1 Borehole Pattern



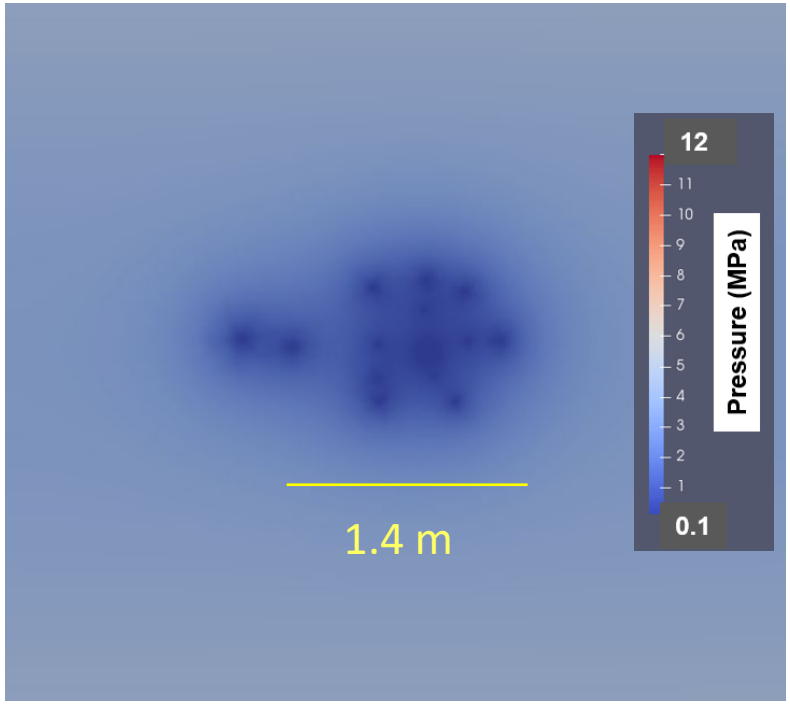
BATS: Phase 1 Layout



Phase 1: Pressure Distribution



- 7 years of open drift
- 5 days of open boreholes



Slice 2 m into the drift face

Phase 1: Temperature Prediction

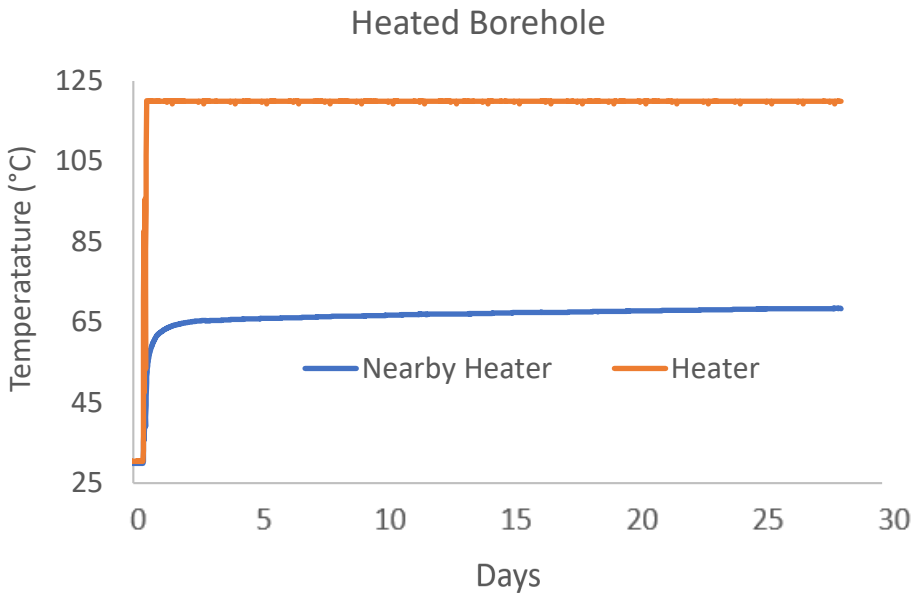
$$K_T(T) = K_{T\cdot 300}\left(\frac{300}{T}\right)^{1.14}$$

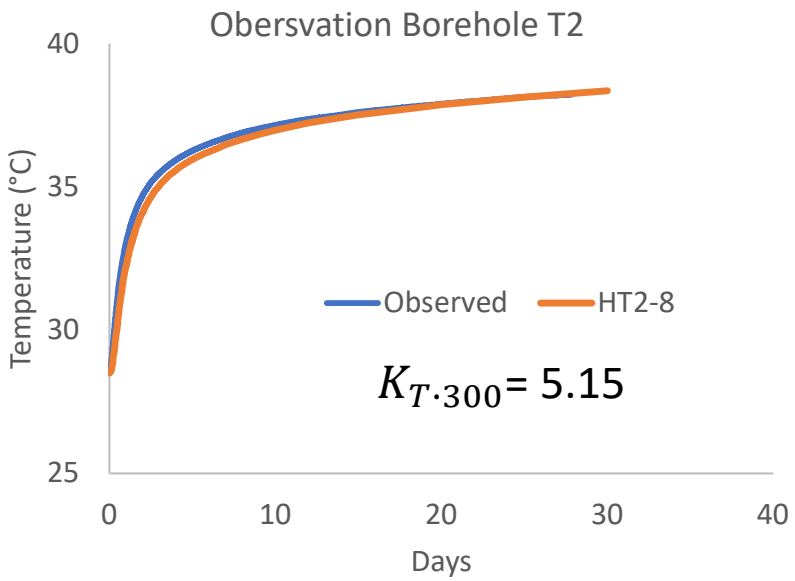
Halite

$K_{T\cdot 300} = 5.4\ \frac{W}{mK}$

Rock Salt

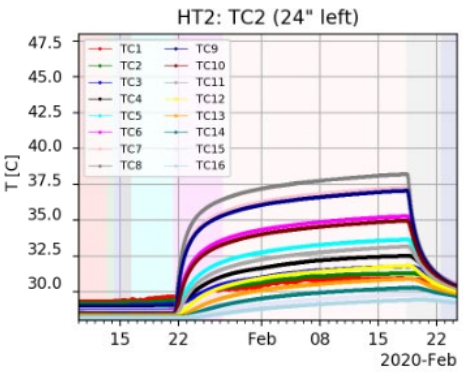
$K_{T\cdot 300} = 4.5 - 5.5?$



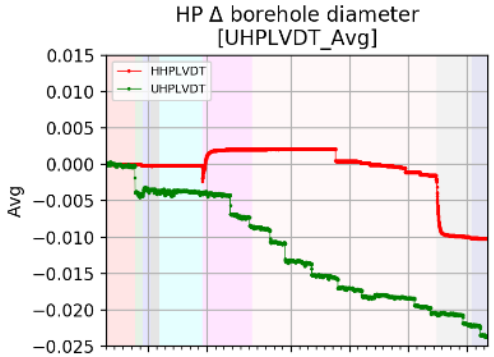


Phase 1: Other Observations

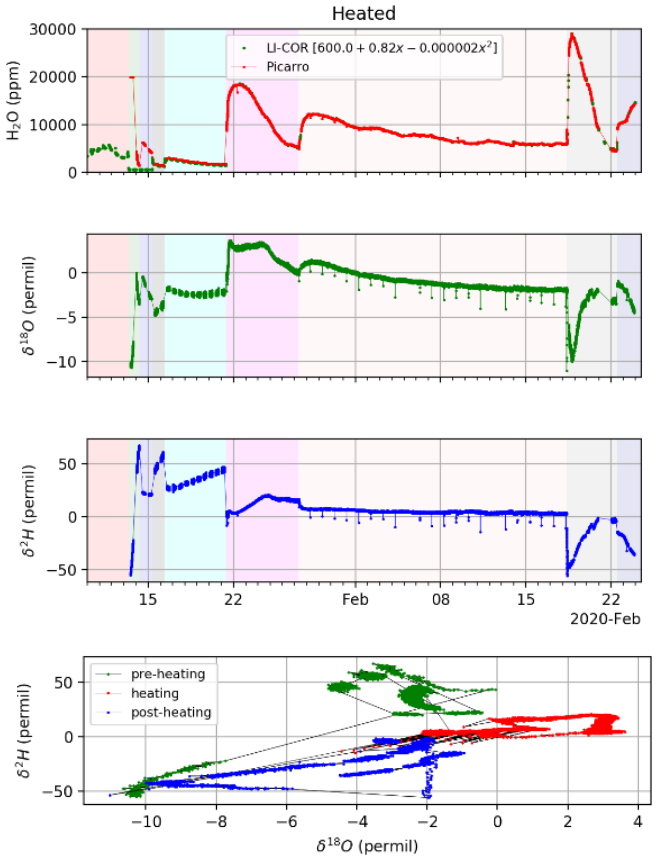
Temperature



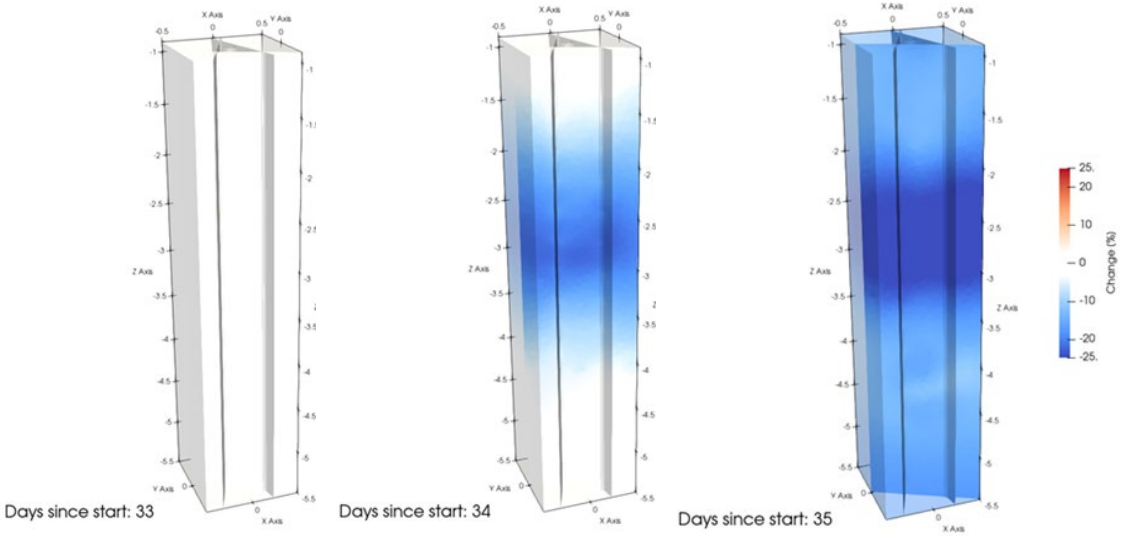
Strain



Isotopes



Electrical Resistivity



Questions?

https://sfwd.lanl.gov/

SFWD

Spent Fuel &
Waste Disposition