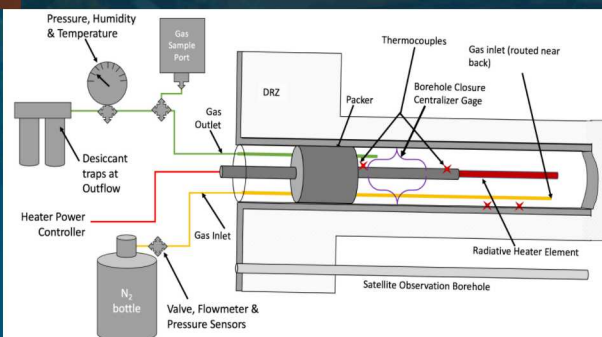


# Brine Availability Heater Test at WIPP



PRESENTED BY

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- Salt is a viable geologic media for the disposal of radioactive waste
  - Low connected porosity (0.1 vol-%) and permeability ( $\leq 10^{-22} \text{ m}^2$ )
  - High thermal conductivity ( $\sim 5 \text{ W}/(\text{m} \cdot \text{K})$ )
  - No flowing groundwater ( $\leq 5 \text{ wt-\% water}$ )
  - Hypersaline brine is biologically simple, has less-stable colloids
  - Cl ( $\sim 190 \text{ g/L}$ ) and B ( $\sim 1 \text{ g/L}$ ) in brine reduce criticality concerns
  - Excavations, DRZ, and fractures will creep closed
  - Mined salt reconsolidates and heals to intact salt properties
- However, disposing of heat generating waste still requires further research for long-term safety case predictions





# Brine Availability Test in Salt (BATS) at WIPP

- Borehole heater test currently being conducted at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, under DOE-Nuclear Energy
- Monitoring brine distribution, inflow, and chemistry from heated salt using geophysical methods and direct liquid & gas sampling.



# WIPP Salt Field Test Team

## Sandia National Laboratories

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## Los Alamos National Laboratory

Phil Stauffer, Hakim Boukhalfa, Eric Gultinan, Doug Ware, Thom Rahn

## WIPP Test Coordination Office (LANL)

Doug Weaver, Brian Dozier, Shawn Otto

## Lawrence Berkeley National Laboratory

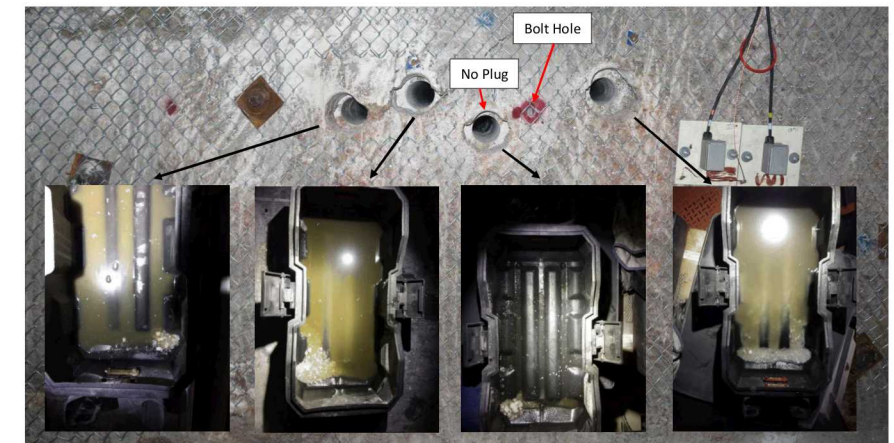
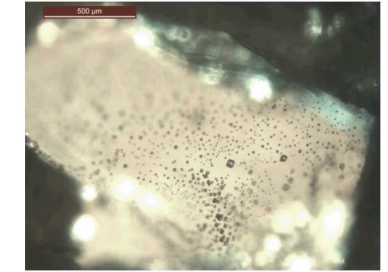
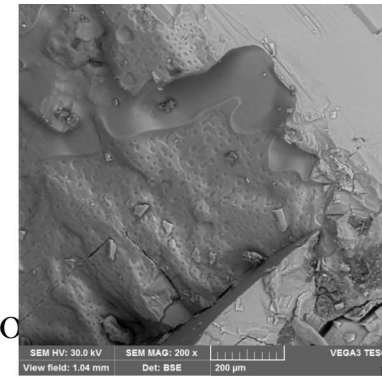
Yuxin Wu, Jonny Rutqvist, Jonathan Ajo-Franklin, Mengsu Hu





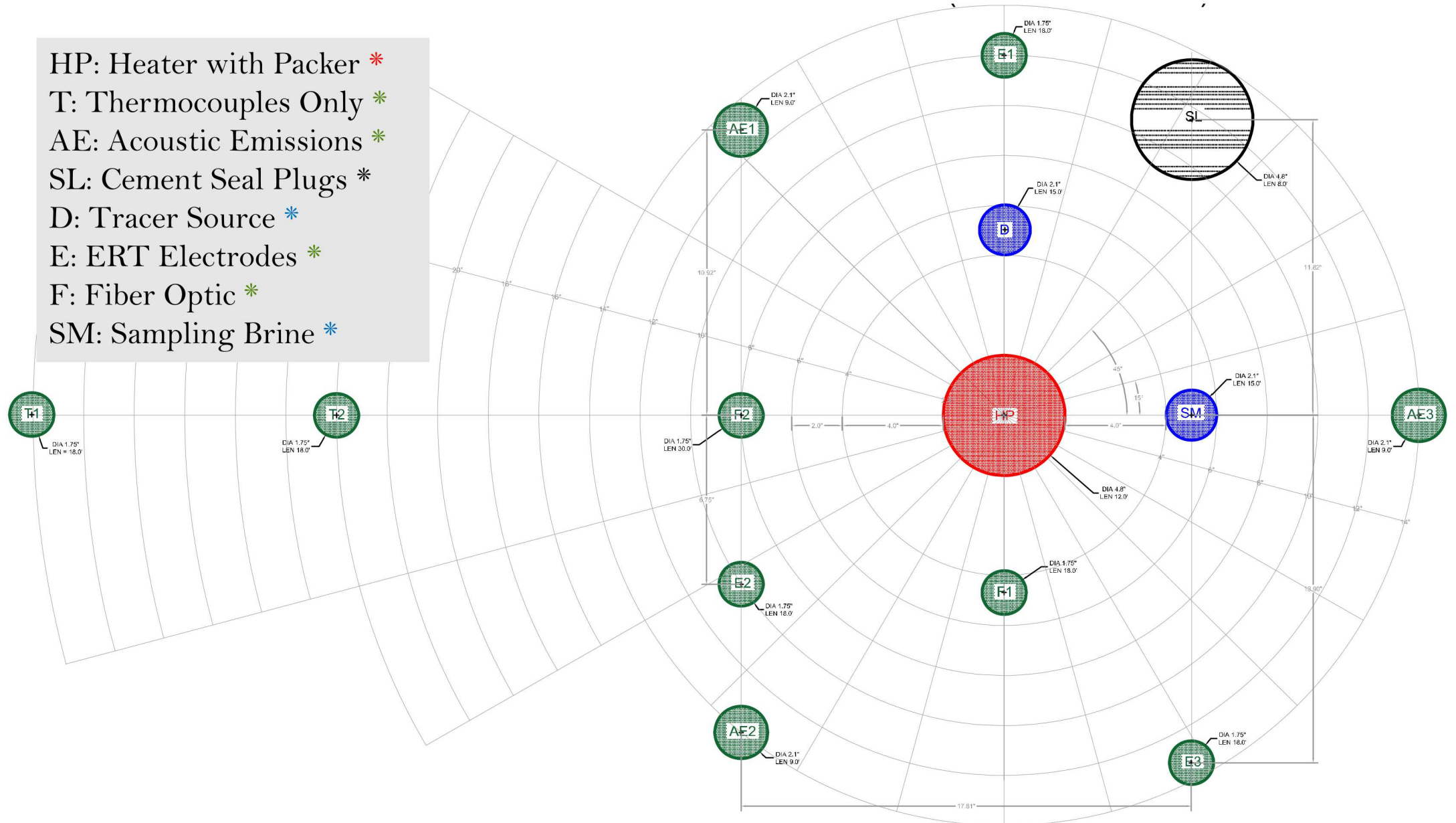
# Connection to Brine

- Bedded salt (specifically WIPP) can have a fair amount of brine in the formation from different sources that each respond differently to heat
  - Intergranular water (between grains)
  - Intragranular water (fluid inclusions inside grains)
  - Hydrated minerals
  
- Impacts of brine on performance of repository
  - Waste package corrosion effects
  - Limit closure of brine-filled cavities
  - Transport of radionuclides to the far field
  
- **Main goal is to improve the understanding of brine availability evolution of brine chemistry in bedded salt when heated**



# Overall Test Layout

HP: Heater with Packer \*  
T: Thermocouples Only \*  
AE: Acoustic Emissions \*  
SL: Cement Seal Plugs \*  
D: Tracer Source \*  
E: ERT Electrodes \*  
F: Fiber Optic \*  
SM: Sampling Brine \*



# Test Design: Heater Borehole

## Behind packer

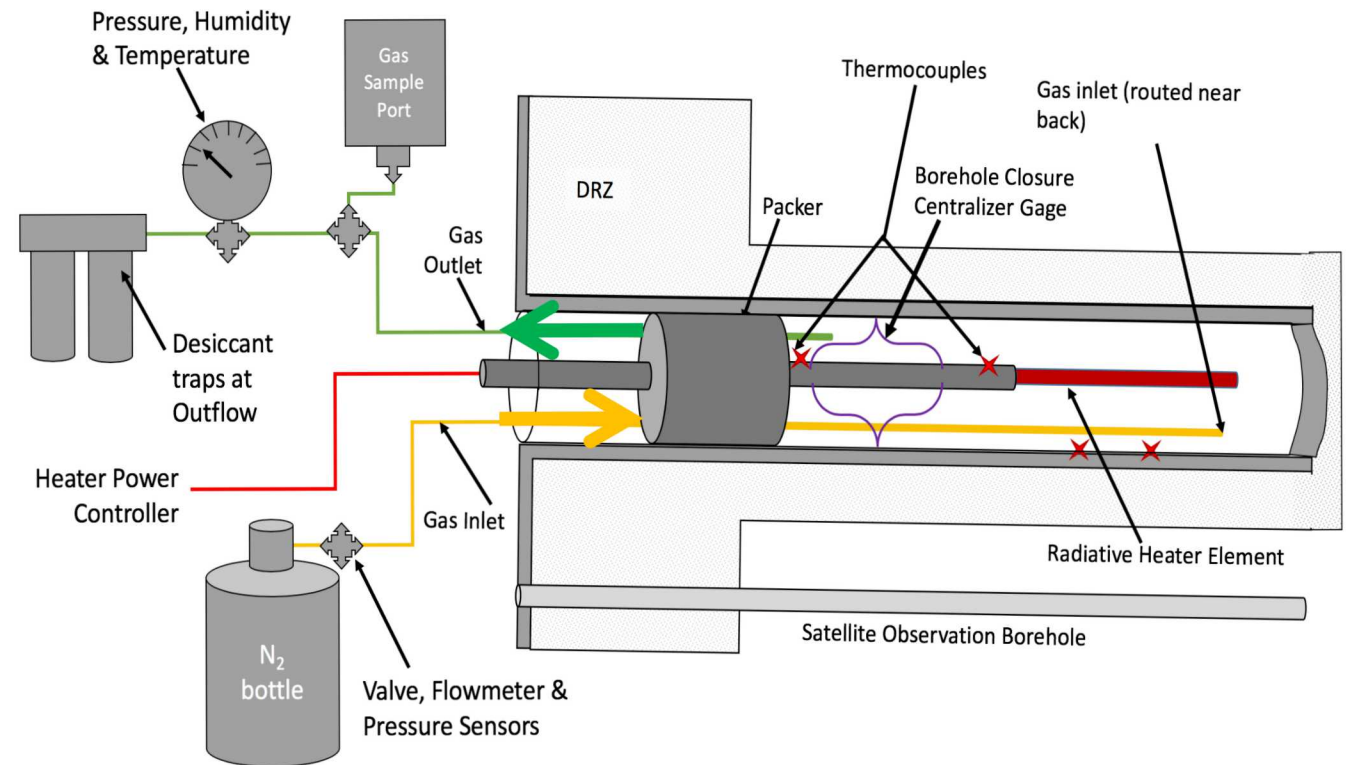
- Circulating dry  $N_2$
- Quartz lamp heater (750 W)
- Borehole closure gage (LVDT)
- Gas permeability before / after
- Thermocouples

## Outside Packer (Gas Stream)

- Gas concentrations by SRS analyzer
- Isotopic makeup by Piccaro analyzer
- Humidity with Li-COR
- Additional water content by dessicant

## Samples

- Cores (X-Ray CT and X-Ray Fluorescence at NETL)





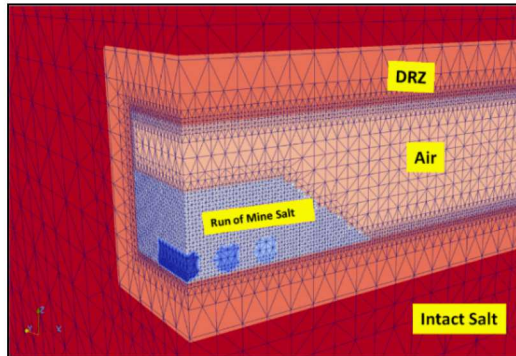
# Test Design: Additional Boreholes

- Thermocouples
  - Measuring temperature distribution and changes throughout the array over time
- Geophysics
  - Acoustic Emissions (AE) / ultrasonic wave velocity
    - “Listen” to damage in the salt due to heating, cooling, and brine migration
    - Image changes in saturation associated with dry-out to inform two-phase flow models
  - Electrical resistivity tomography (ERT)
    - Acquire resistivity changes that can be attributed to changes in porosity and brine saturation, and possibly image any dry-out
  - Fiber Optic distributed strain / temperature
    - Extent of deformation attributed to temperature along the length of the boreholes
- Cement Seal Plugs
  - Record strain and temperature within seals, as well as compositional analysis to examine interaction with salt
- Tracer Source
  - Analyze arrival and concentration changes after introduced above heater to determine gas and liquid flow/transport
- Sampling Brine
  - Periodic liquid brine samples analyzed for natural chemistry and natural / applied tracers



# THMC Process-Level Modeling

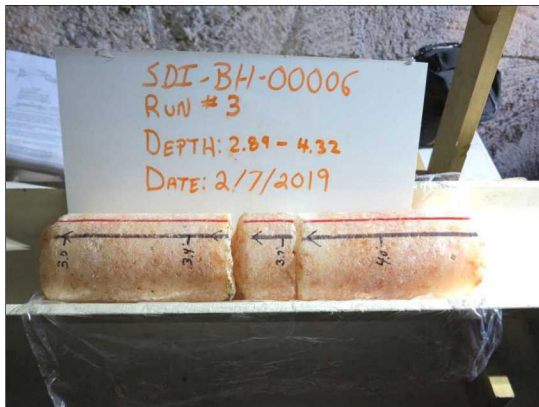
- Thermal-Hydrological-Mechanical-Chemical (THMC)
- TOUGH-FLAC simulates large-deformation THMC
- FEHM numerical model simulates small-deformation THMC
- Isolating specific processes allows more rapid validation
- Some processes are validated using TH, TM, THC, or THM



- WIPP heater test will provide in situ data for improving confidence in heat-driven salt convergence and brine release

# Current Status

- New boreholes currently being drilled and cored in WIPP underground, testing beginning Summer 2019, into FY20.
- Shakedown equipment tests ongoing.
- Pre-assembly and pressure testing of heater packer components
- Beginning brine analysis from newly drilled boreholes



# WIPP Test: Summary

- **FY19–20: Brine Availability Test in Salt at WIPP**
  - Monitoring brine sources, inflow, and composition in heated salt through geophysical methods and direct liquid & gas sampling
  - Characterize brine source and their response to temperature
  - Assess new methods to characterize salt DRZ
- THMC process–model developments to better design & interpret field tests
- International collaborations on field test and models to leverage expertise in Germany, Netherlands, UK



Improve safety case in salt for heat-generating waste





Questions?

