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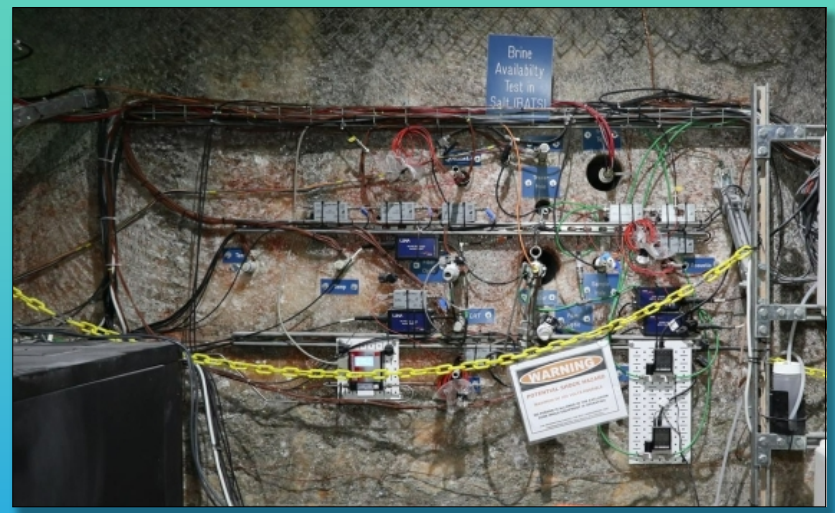

DECOVALEX-2023 Task E (BATS) Session Intro

DECOVALEX-2023 Task E (Wednesday Track 3)
Wednesday November 18, 2020

Kristopher L. Kuhlman
Sandia National Laboratories

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Task E Meeting Outline

- First step (Step 0) of Task E
  1. Small-Scale Brine Inflow Test (unheated brine migration)
  2. Brine Availability Test in Salt temperature response (heat conduction)
  3. Sensitivity analysis
  4. Uncertainty quantification
- Presentation of Step 0 Results

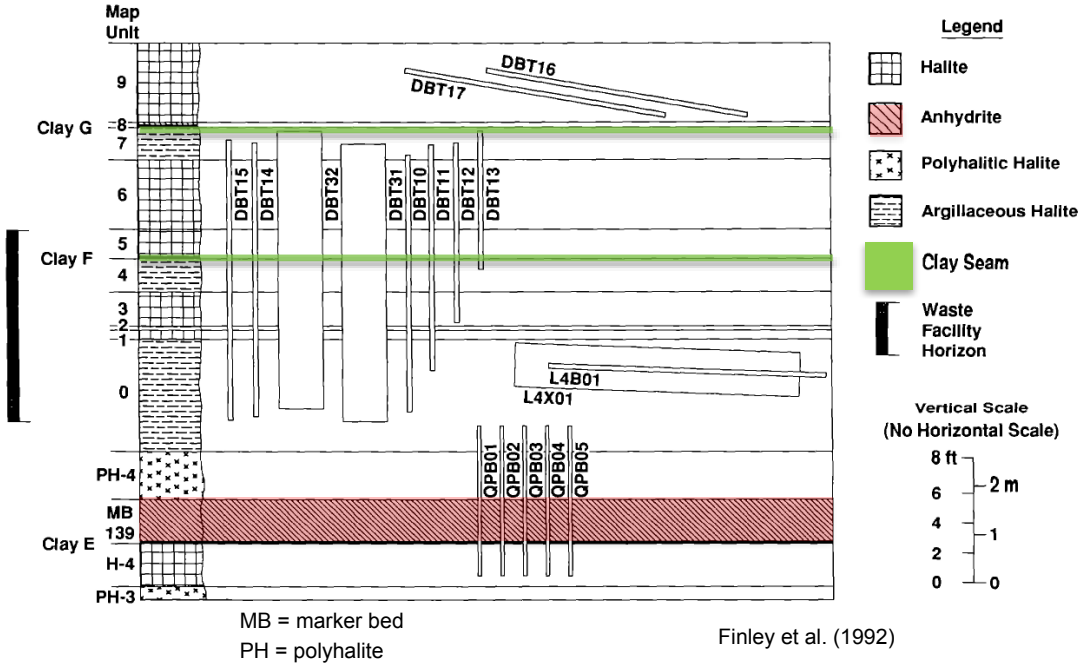
Time Zone	Standard Time (PST)			0
Chair	Kris Kuhlman			
Start	Finish	Duration	Topic	Speaker
05:00	05:10	*10*	Introduction	Kris Kuhlman
05:10	05:30	*20*	BGR	Hua Shao
05:30	05:50	*20*	COVRA	Jeroen Bartol
05:50	06:10	*20*	GRS	Kyra Jantschik
06:10	06:20	*10*	**Break**	
06:20	06:40	*20*	DOE – LANL/LBNL/SNL	Eric Guiltinan
06:40	07:00	*20*	RWM - Quintessa	Claire Watson / Steven Benbow
07:00	07:05	*5*	**Break**	
07:05	08:05	*60*	Discussion	Kris Kuhlman

- Discussion

BATS heated array

1. WIPP Small-Scale Brine Inflow Test (1987-1992)

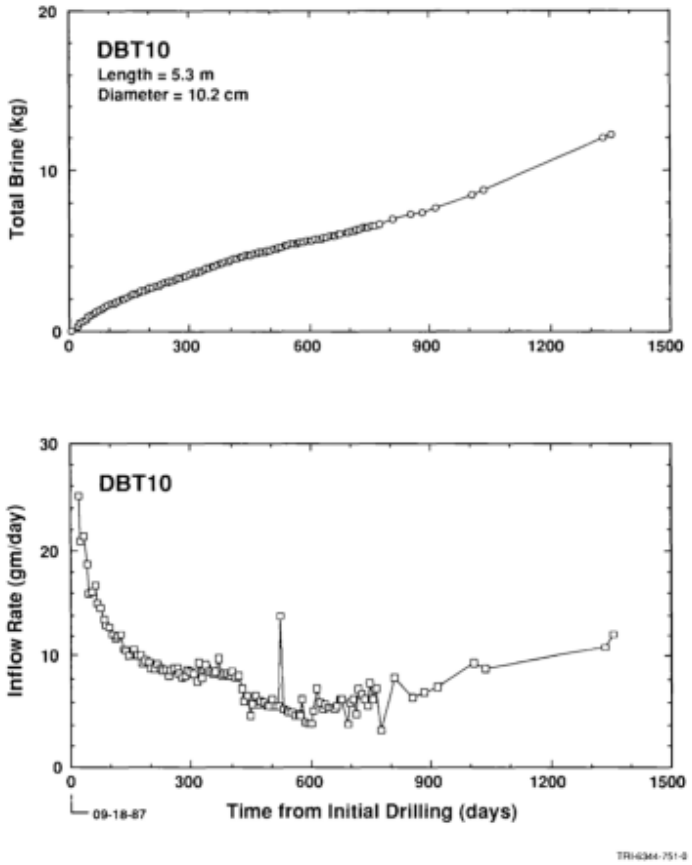
- Monitored brine inflow to 17 unheated boreholes
- Relatively new drifts
- Weekly brine inflow mass
- Effects of stratigraphy



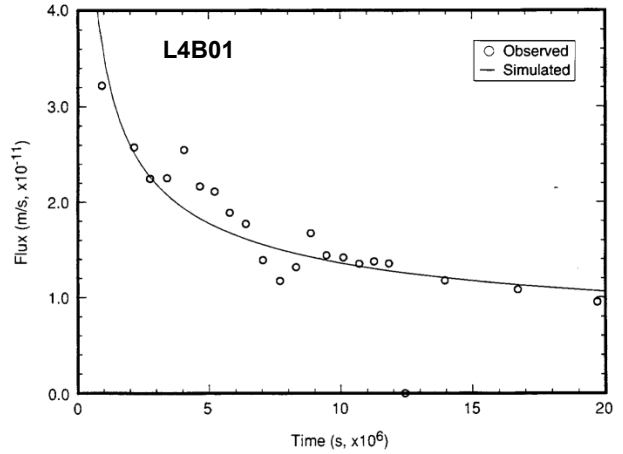
MB = marker bed
PH = polyhalite

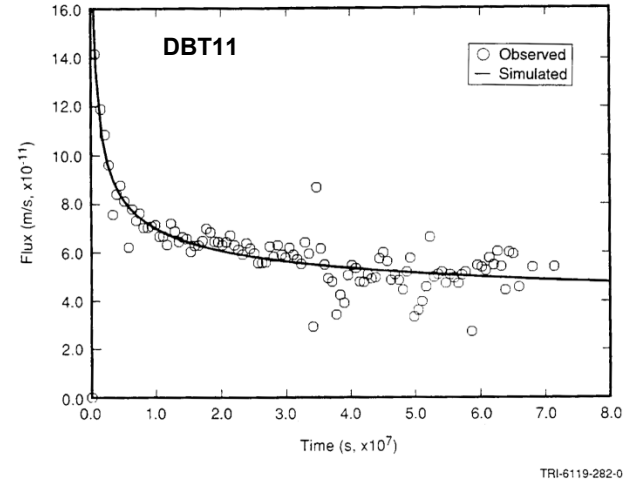
Finley et al. (1992)

Finley et al. (1992)



(Beauheim et al., 1997)





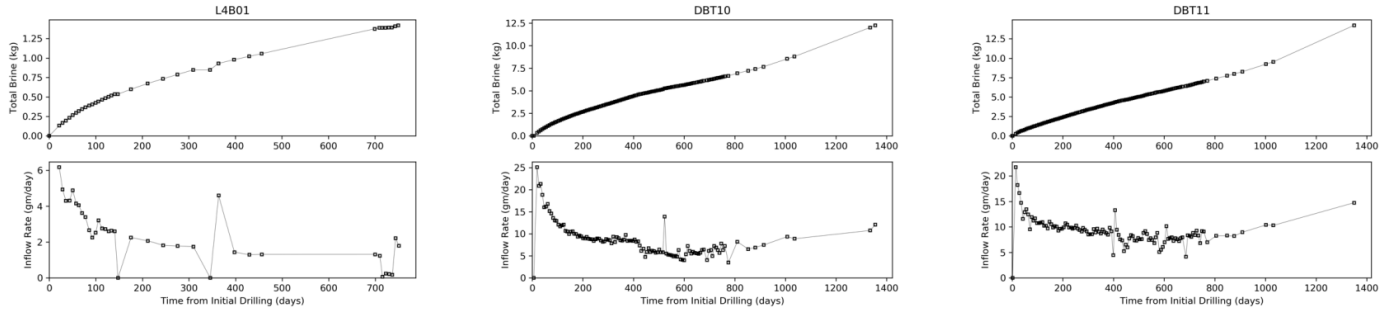
1. WIPP Small-Scale Brine Inflow Test (SSBIT)

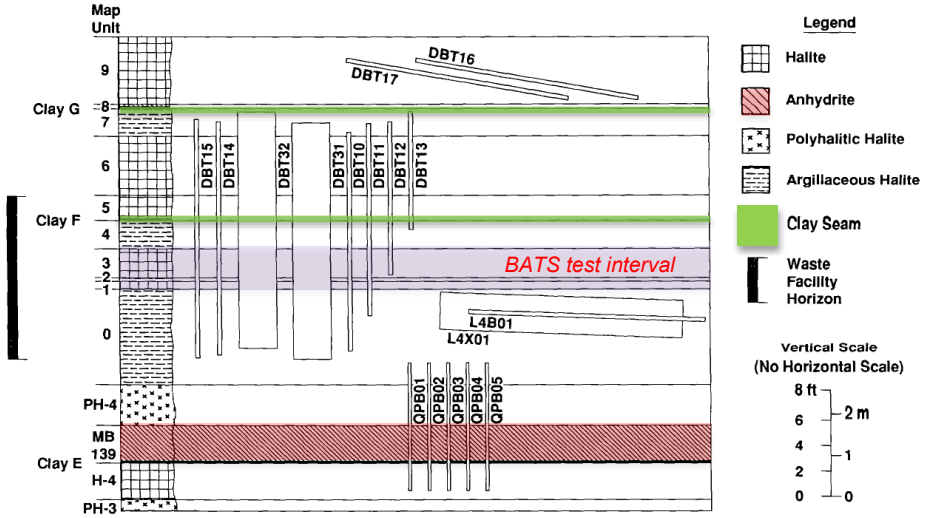
- <u>Comparison:</u> Simulate inflow rate to boreholes
  - *Only fit to monotonically decreasing brine production*
  - *Include boreholes L4B01, DBT10 & DBT11* (+ others if you want)

- Predictive H[1] models:
  - Simple or include geometrical (borehole extent + room DRZ) complexity
  - Uniform parameters or include geological complexity

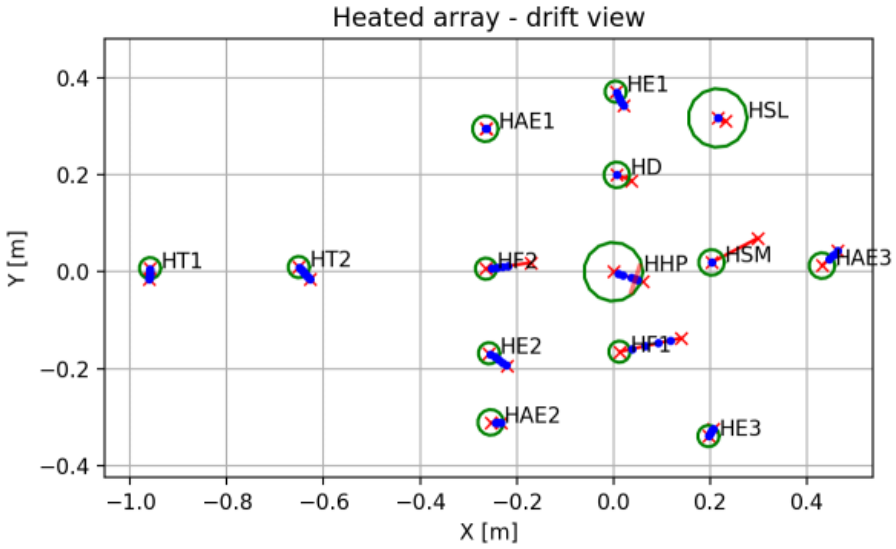
Horizontal borehole in Map Unit 0

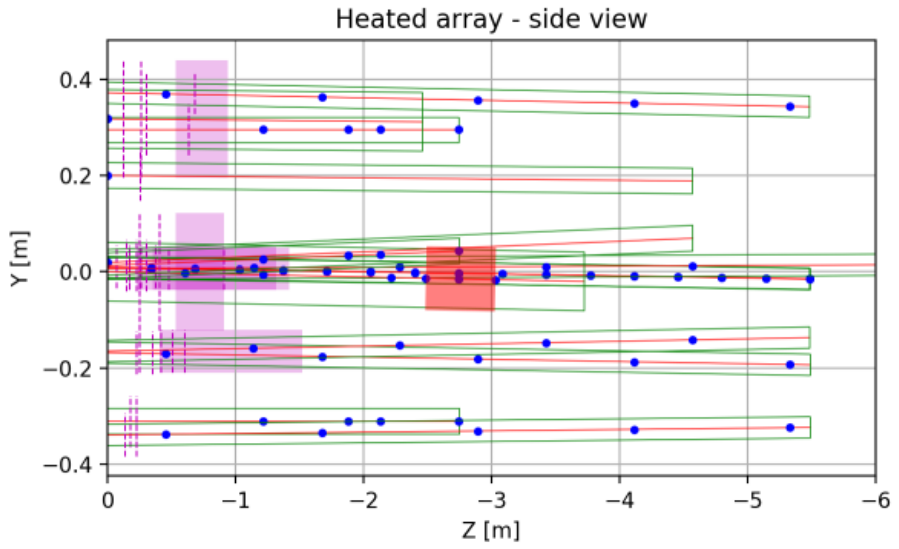
Vertical boreholes that cross Clay F

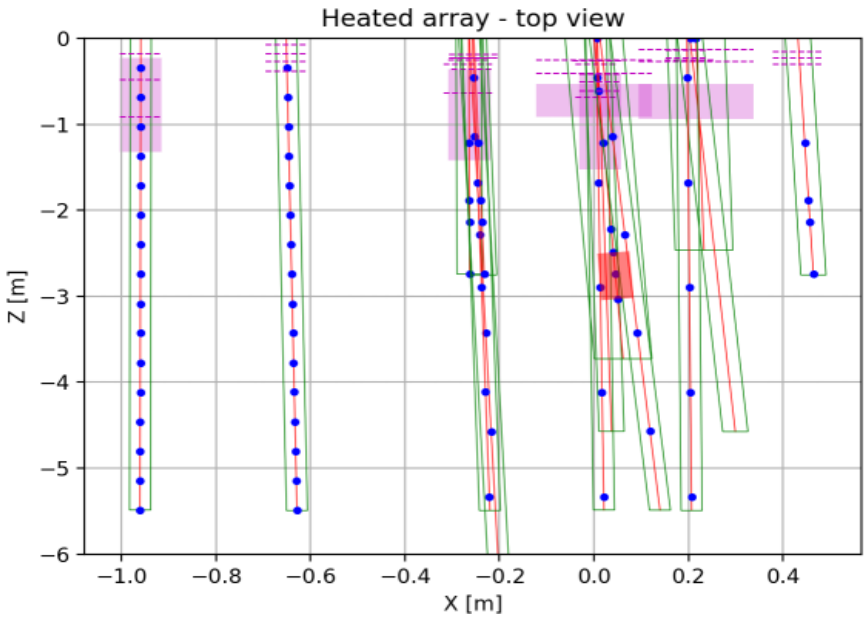




2. Brine Availability Test in Salt (BATS) As-Built



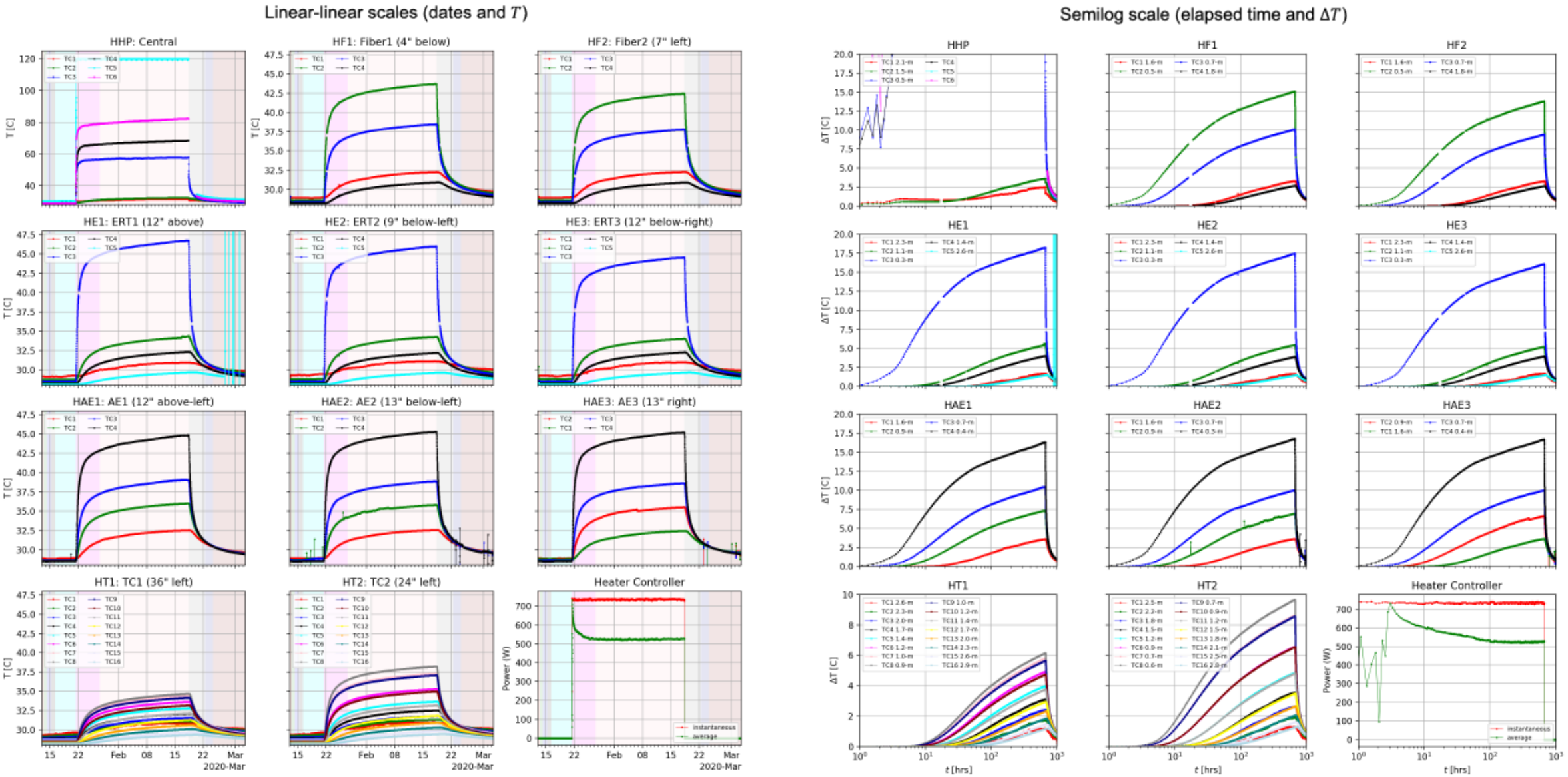




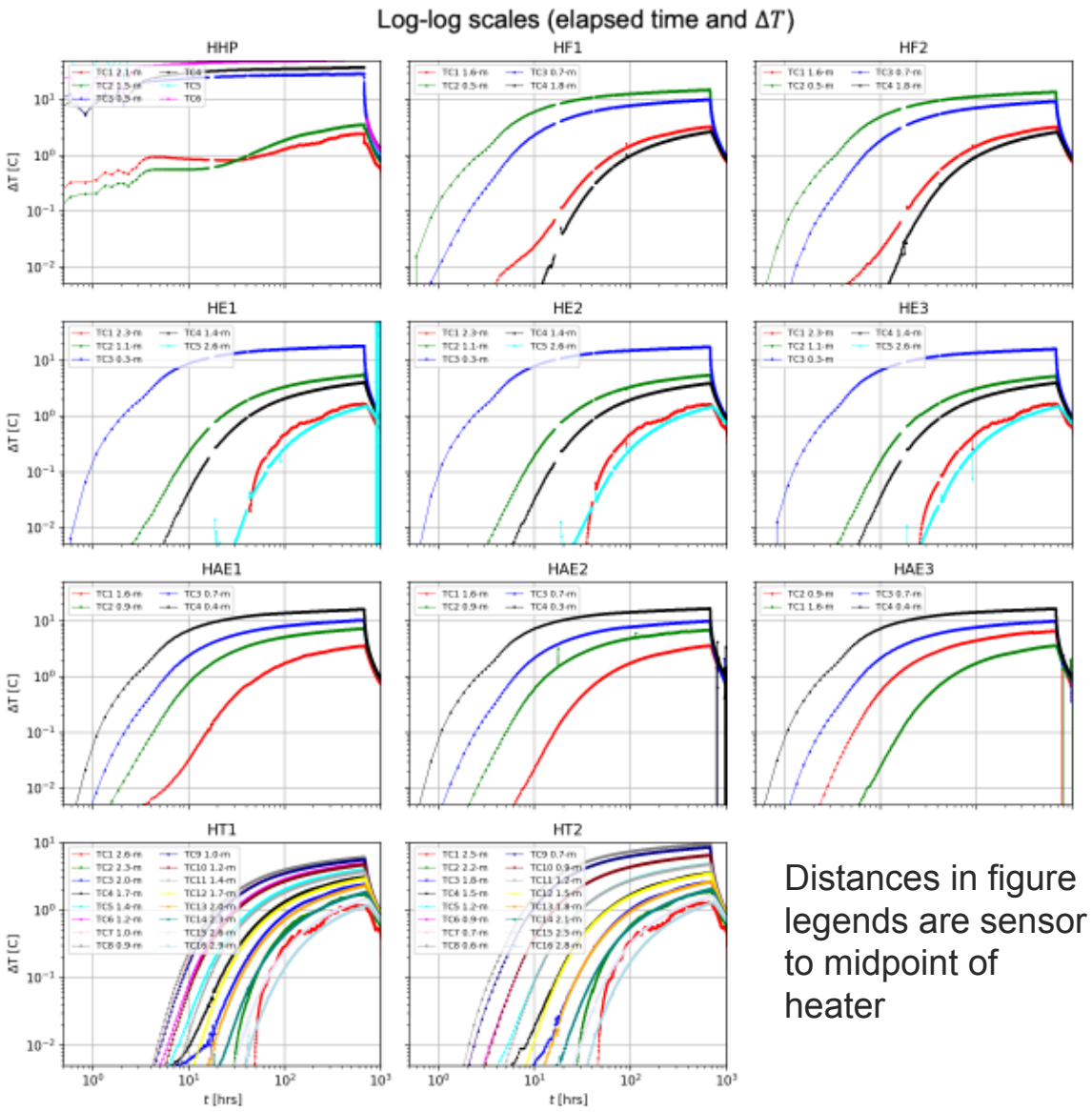
- Heated array as-built
- Drilled Feb-Apr 2019
- Side & top views show
  - Thermocouples (blue dots)
  - Heated interval (red box)
  - Fractures/damaged zone (purple)

Discrete fractures in BATS near-drift EDZ

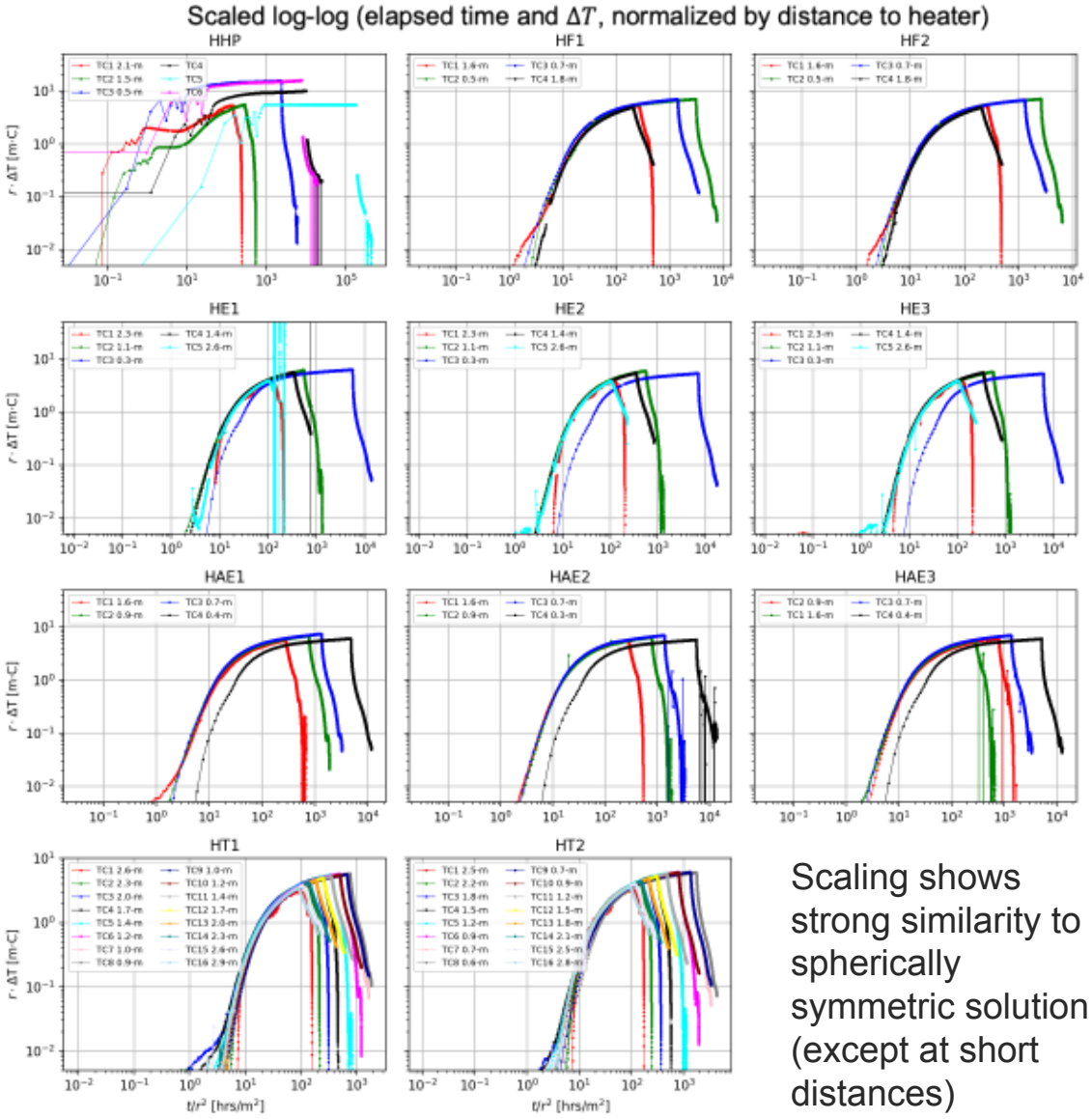
2. Jan-Mar 2020 BATS Temperature Response



2. Jan-Mar 2020 BATS Temperature Response



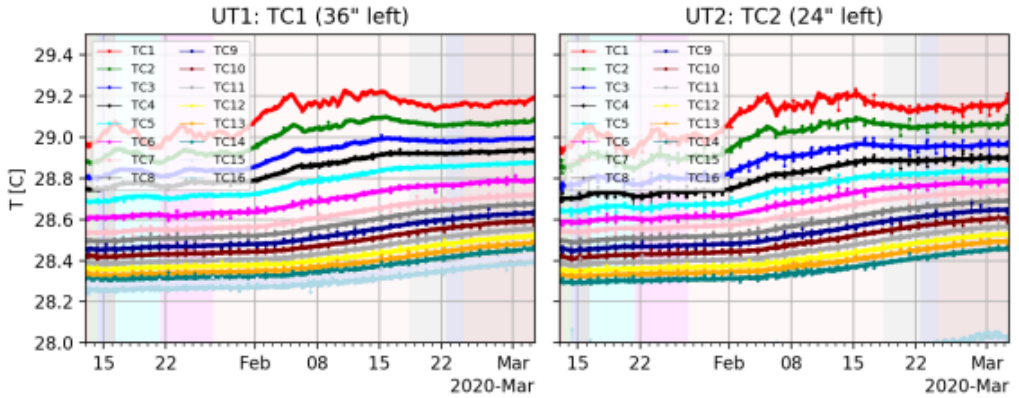
Distances in figure legends are sensor to midpoint of heater



Scaling shows strong similarity to spherically symmetric solution (except at short distances)

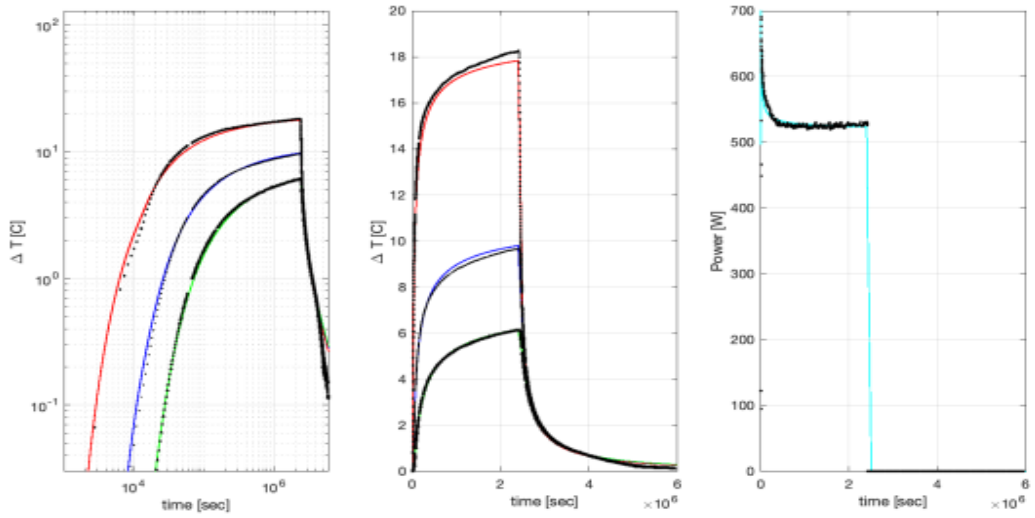
2. Jan-Mar 2020 BATS Temperature Response

- Data:
  - Measured temperature at ~62 locations through time (15-minute averages)
  - Estimated x, y, z locations of thermocouples [TC] (assuming on borehole axis)
  - Power delivered to heater (15-minute averages)
- Possible complications:
  - Ambient 0.8 ºC ΔT over 6 m (hotter drift)
  - Near-drift temperatures fluctuate ~0.1 ºC (ventilation)
  - Heater controller had issues in first ~2 hrs (on-off 3x)
  - ERT nightly: applied current → crazy TC readings (deleted)
  - Salt thermal conductivity is a function of temperature (Acton, 1977; Kuhlman et al. 2020)
  - Most TC are grouted into boreholes (grout properties being characterized)
  - Constant-temperature heater controller
    - setpoint = 120 ºC (HHP-TC5), but actual borehole wall temperature may be less (96 to 120 ºC)
    - Possibly due to effect of lamp shining directly on controller thermocouple
    - Possibly due to poor contact between controller TC and borehole wall



2. Jan-Mar 2020 BATS Temperature Response

- Comparison:
  - Change in temperature through time at least 5 locations (heating + recovery)
    - HT1-TC8, HT2-TC8, HE1-TC3 are ~same depth as the heater (0.3, 0.6, 0.9 m radially from heater)
    - HF2-TC4, ~~TC1~~HT1-TC16 are deeper into the salt (1.8, 2.8 m radially from heater)
  - Power and temperature at HHP borehole wall through time (one is specified)
- Early-time recovery data don't have on-off issues in early-time heating data
- BATS data no longer preliminary
  - Kuhlman et al. (2020)
- Predictive T (conduction) models:
  - Include material properties variability? (DRZ, grout)
  - Include effects of drift and air-filled boreholes?
  - Include temp-dependent thermal conductivity?



Kuhlman, K.L., M.M. Mills, R. Jayne, E. Matteo, C. Herrick, M. Nemer, J. Heath, Y. Xiong, C. Choens, P. Stauffer, H. Boukhalfa, E. Guiltinan, T. Rahn, D. Weaver, B. Dozier, S. Otto, J. Rutqvist, Y. Wu, M. Hu, S. Uhlemann & J. Wang, (2020). *FY20 Update on Brine Availability Test in Salt*. SAND2020-9034R. Sandia National Laboratories.

Proposed Task E Steps

Step 0: Single-process H^1 and T benchmarks

Step 1: TH^1 benchmark & H^2M/H^2 unheated brine inflow test case

Step 2: TH^2M heated brine inflow test case

Step 3: Alternatives (ERT/AE joint inversion, seals, TH^2MC, creep)

Table 3. Proposed detailed Task E schedule of steps.

	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.
	2020		2021		2022		2023	
Step 0								
Step 1								
		Midterm Report → (Nov 2021)						
Step 2								
Step 3								
					Papers and Final Report → (Nov 2023)			

Infrared heater in BATS HP borehole

H^1= single-phase; H^2 = two-phase