This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

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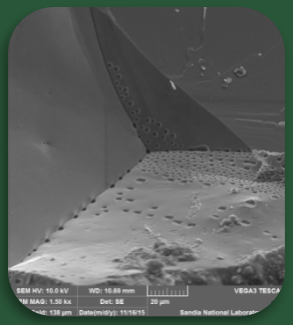

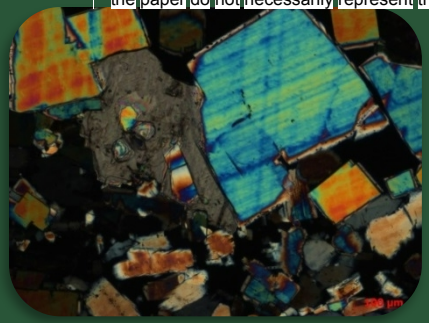

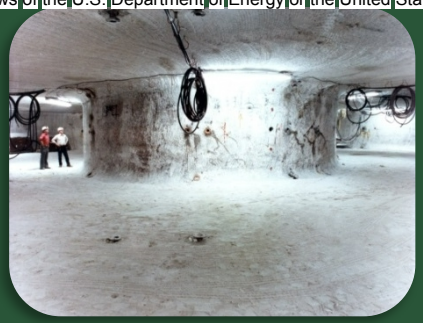

3D Numerical Study of BATS Field Test – Meshing and Modeling Complex Geometry

Richard Jayne
Sandia National Laboratories

Part 4 of the online workshop
September 9th, 2021

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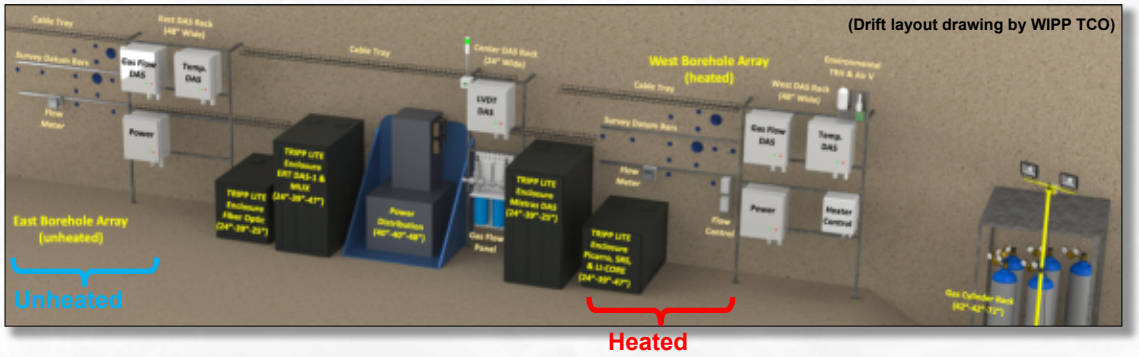
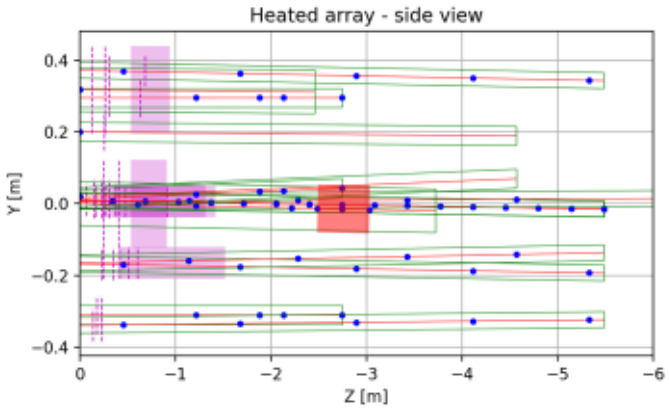
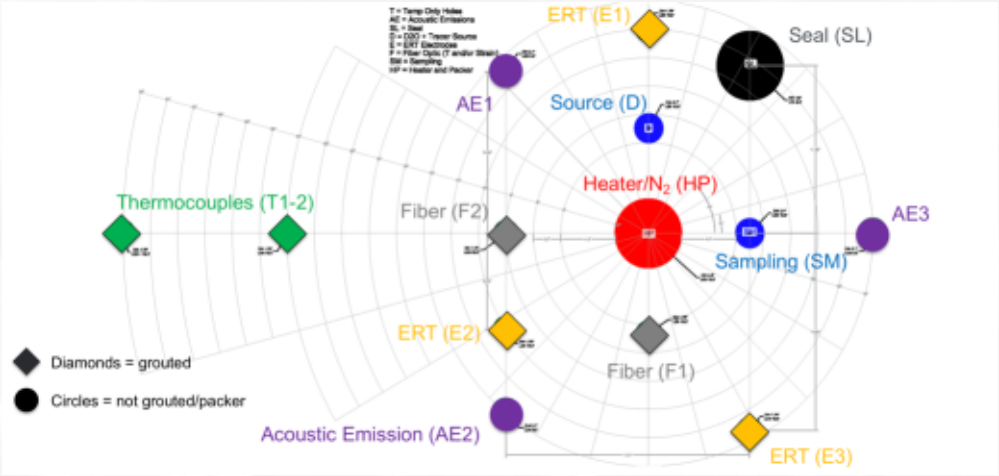
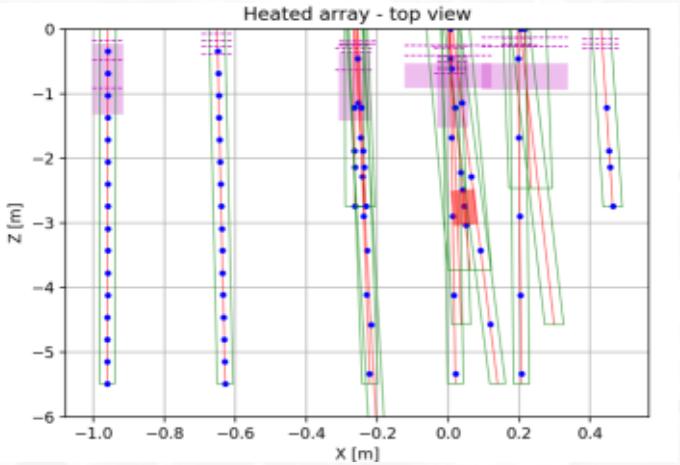
BATS EXPERIMENTAL SETUP

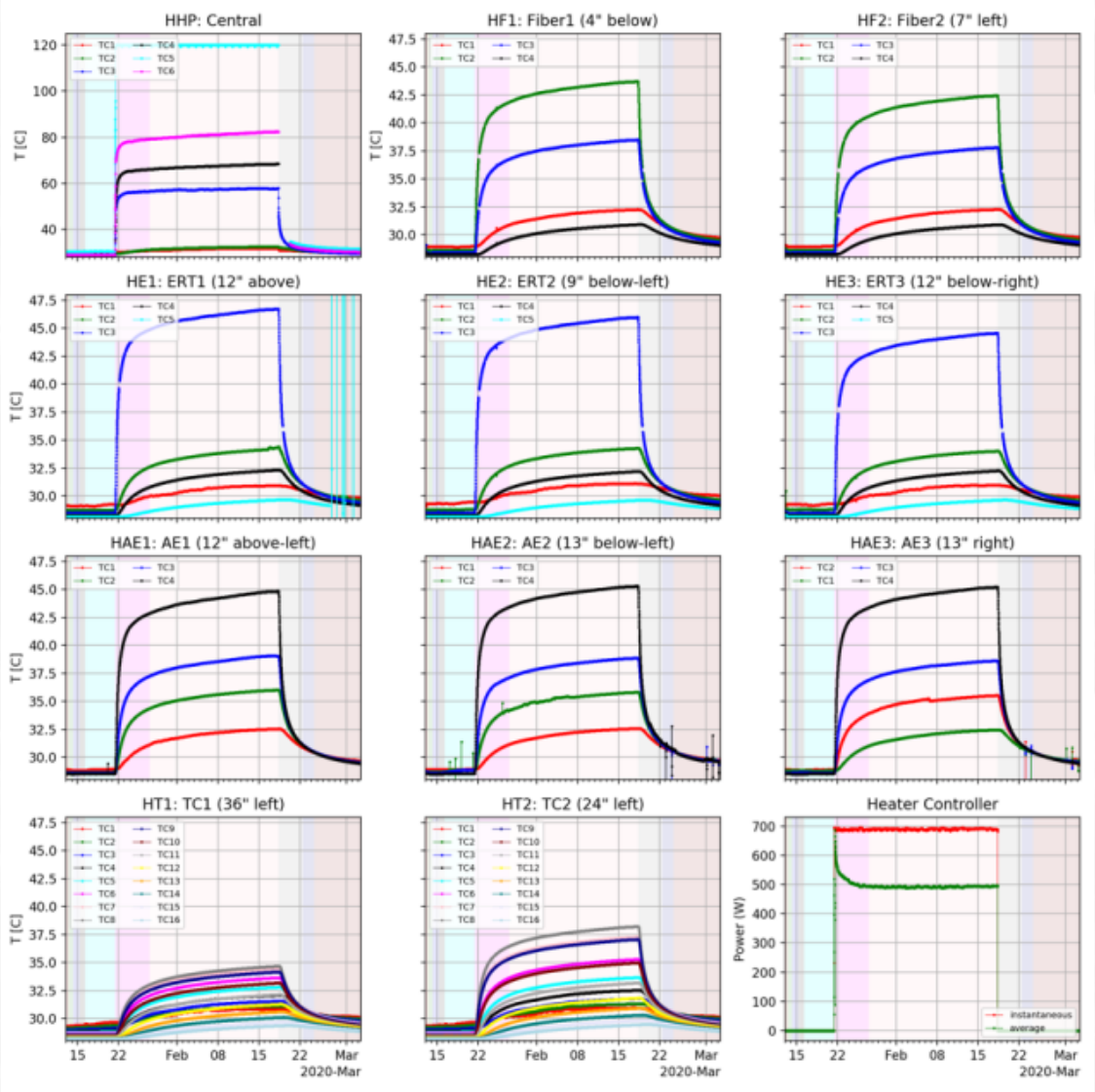






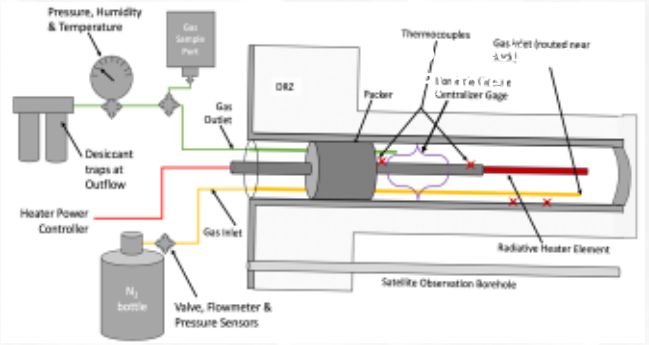


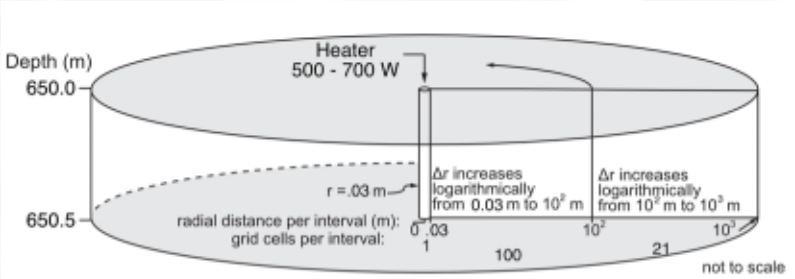
JANUARY - MARCH 2020 BATS TEST DATA



Previously Utilized 1-D Models to Match Field Test

- 1D radially symmetric
  - 121 grid cells
  - 1 km total model domain (0.03 – 150 m)
  - DRZ 0.03 – 1.75 m
- Heater in contact with salt
  - air causes issues with matching field data (radiative heating)
- Simulate 29 days of heating and 13 of cooling
  - On/off cycling in early test
  - Decreasing power input
- Matched temperatures measured at thermocouples



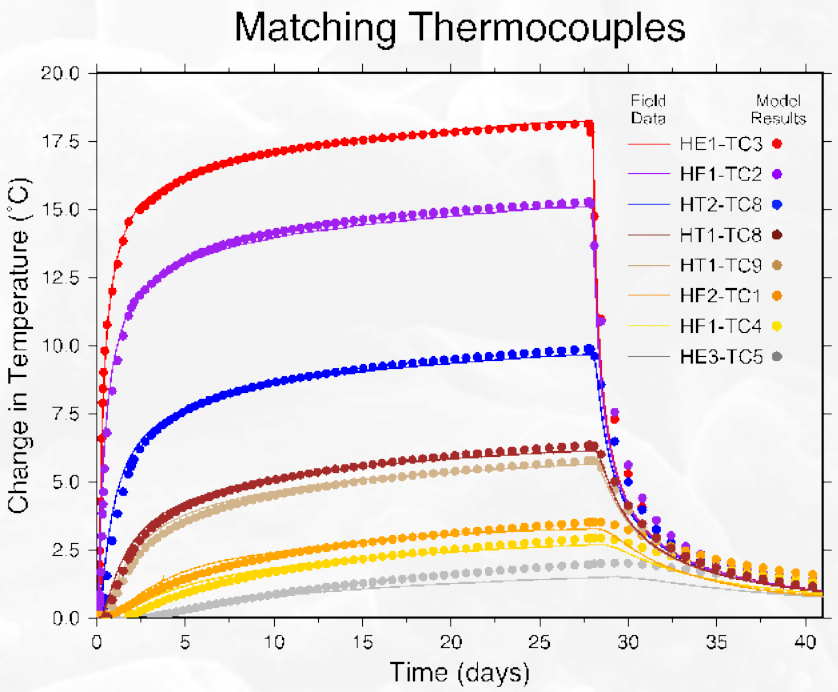


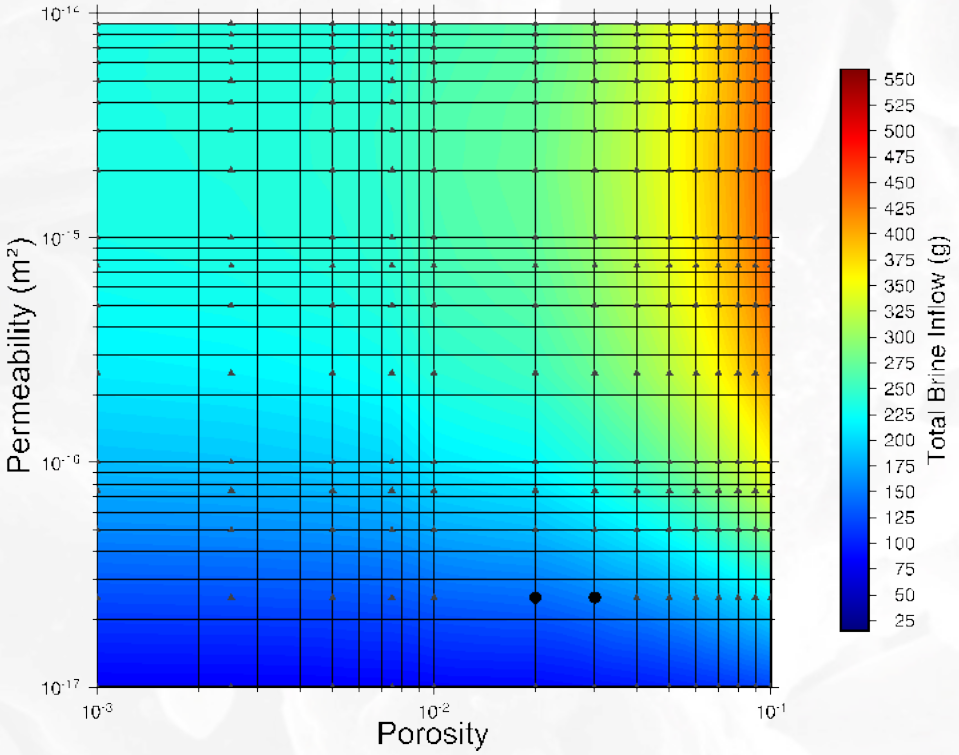
Reservoir Parameters

	Relative Permeability	Capillary Pressure
P_i = 0.1 - 12.4 MPa	λ = 0.412	λ = 0.412
T = 29.5 °C	S_{lr} = 0.2	S_{lr} = 0.2
k = 10^{-17} - 10^{-22} m²	S_{ls} = 1.0	α (Pa^{-1}) = 6.5 x 10^{-5}
φ = 0.001 - 0.01	S_{gr} = 0.2	S_{ls} = 0.999
K = 2.0 - 7.0 W/m °C		
c = 366 - 1000 J/kg °C		

(Jayne and Kuhlman, 2020)

1-D Models Were Effective Matching BATS Field Data

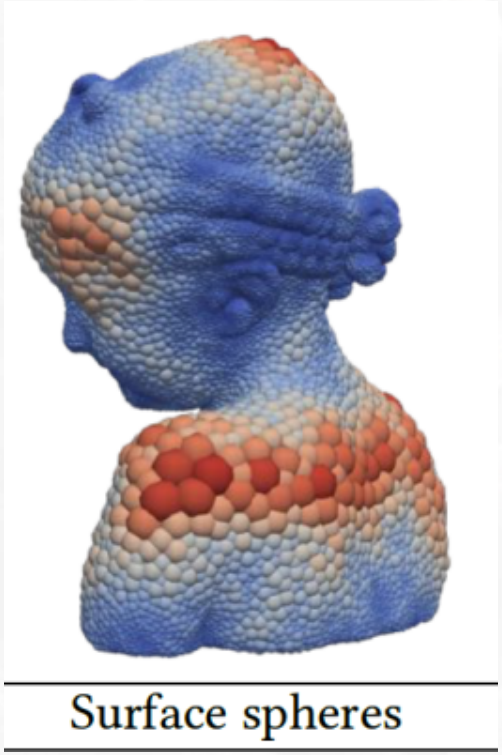




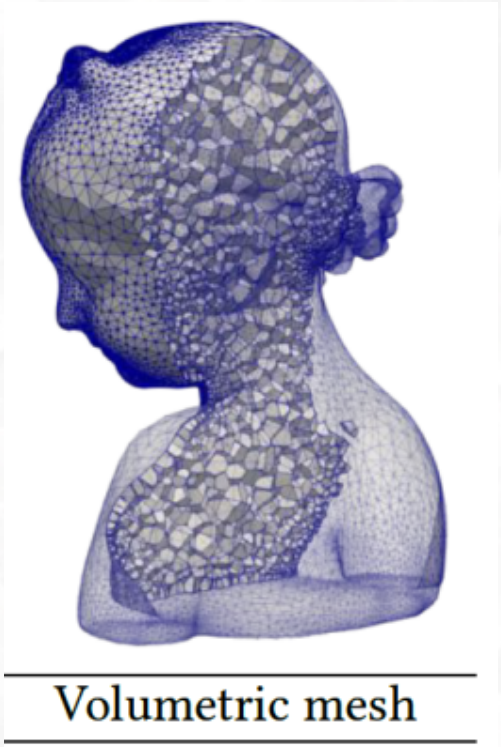
(Jayne and Kuhlman, 2020)

MESHING THE COMPLEX GEOMETRY OF BATS

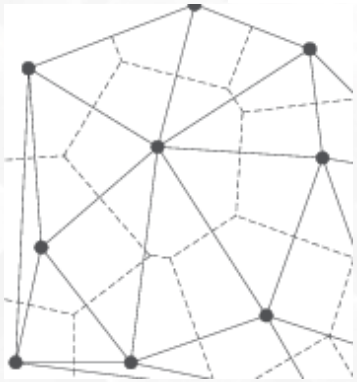
- Create surfaces
  - Using LaGrit
- Input for Vorocrust = .obj
- Few required parameters
- Complex geometry with orthogonal discretization



Surface spheres

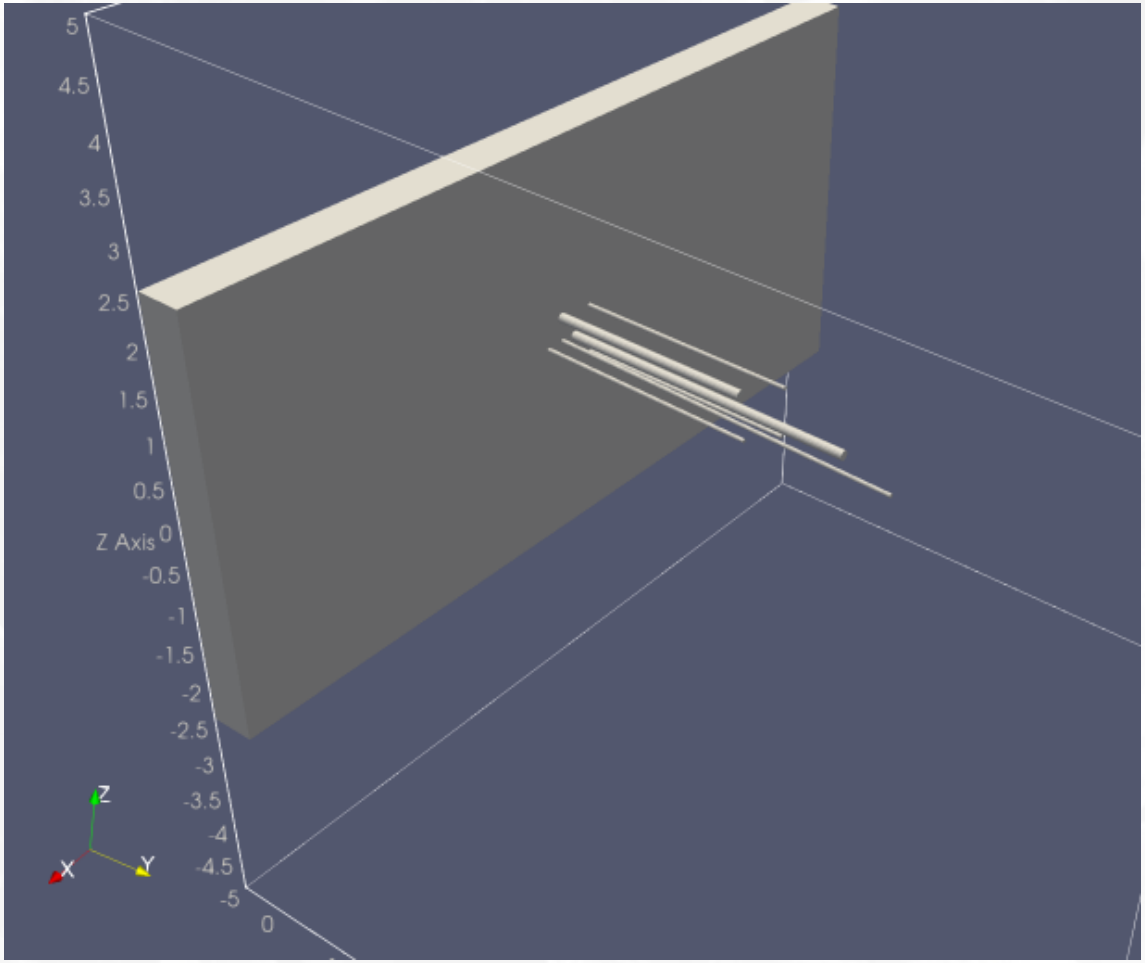


Volumetric mesh

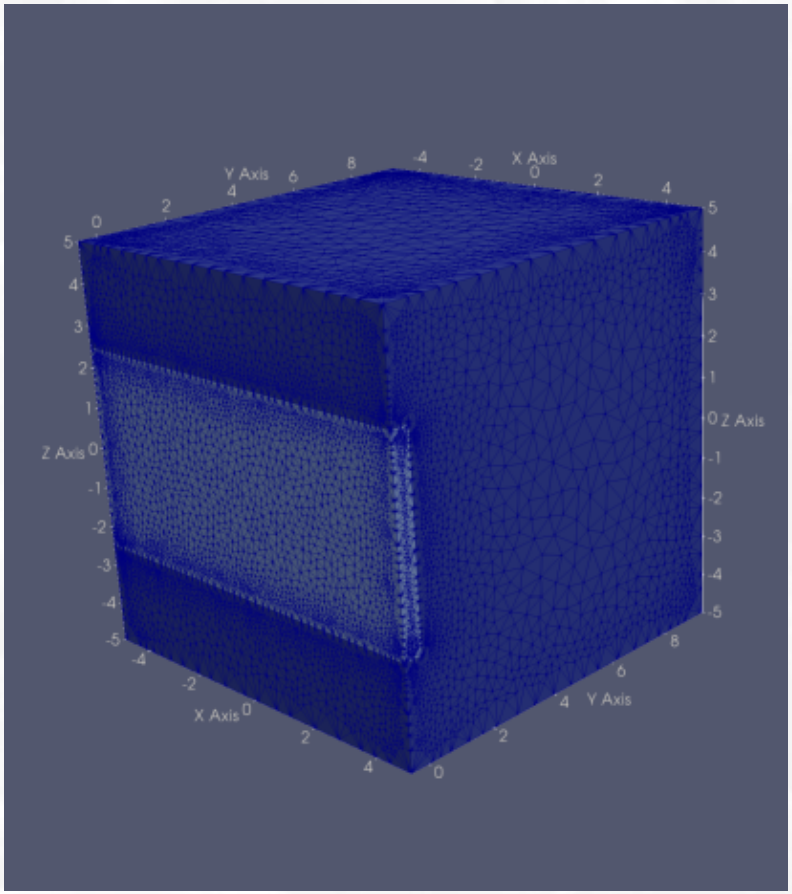


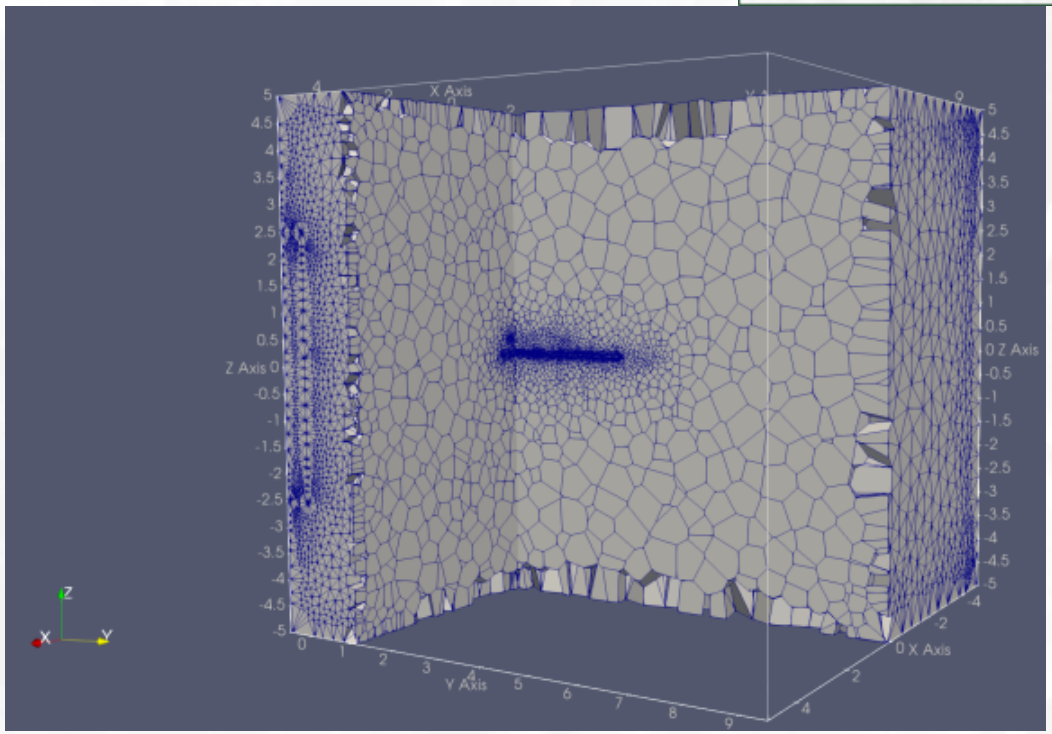
MESHING THE COMPLEX GEOMETRY OF BATS

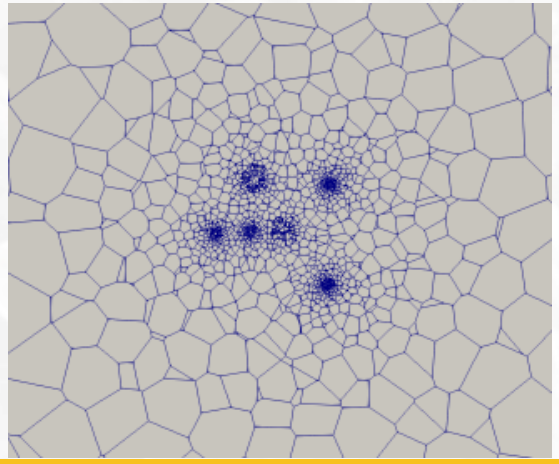
- Create surfaces
  - E.g. LaGrit
- Input for Vorocrust = .obj
- Few required parameters
- Complex geometry with orthogonal discretization



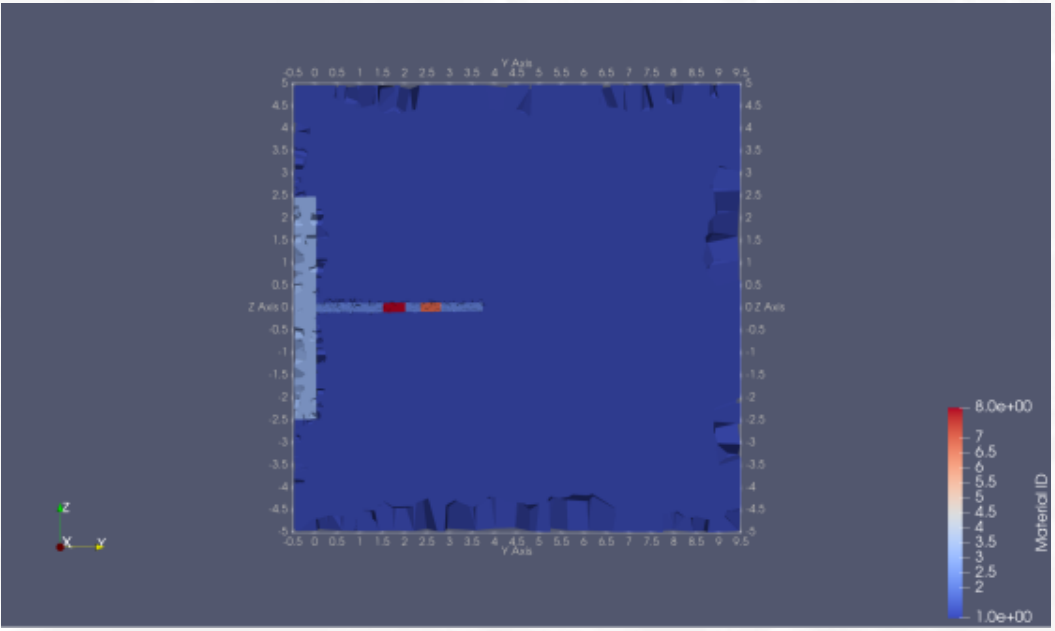
MESHING THE COMPLEX GEOMETRY OF BATS

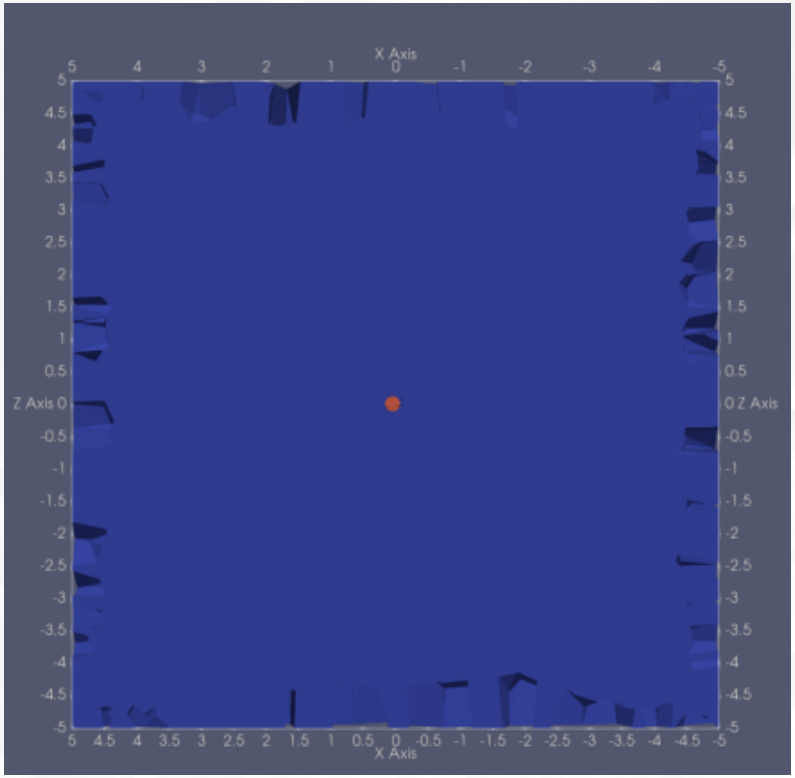


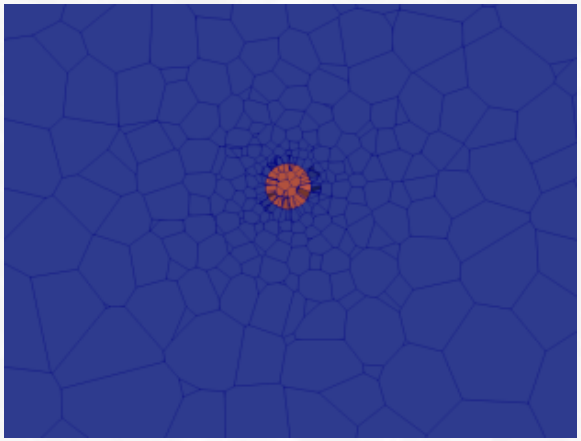




Starting with Only the Heater Borehole

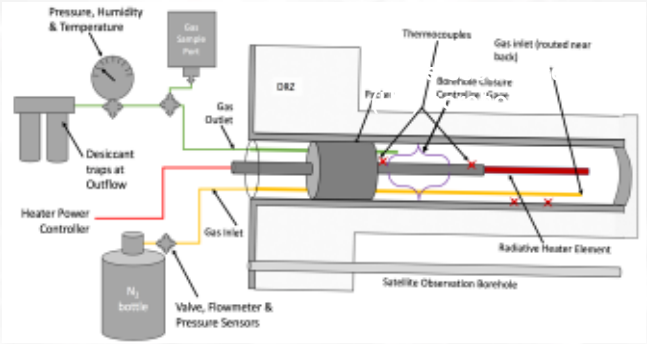


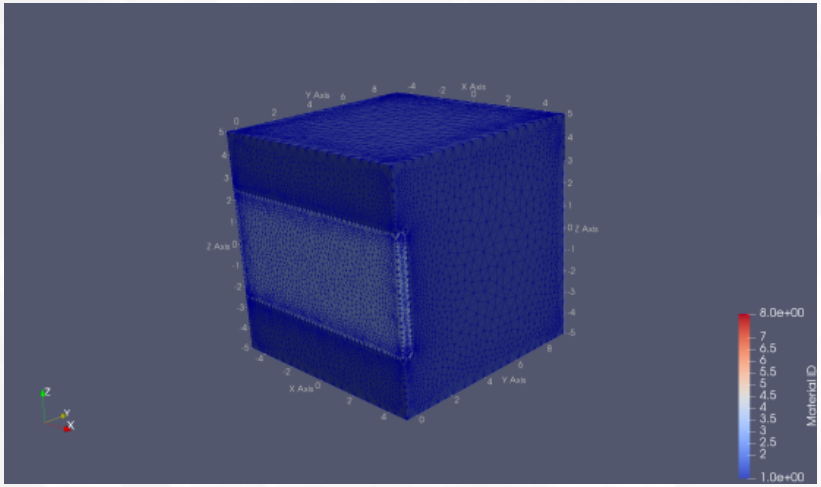




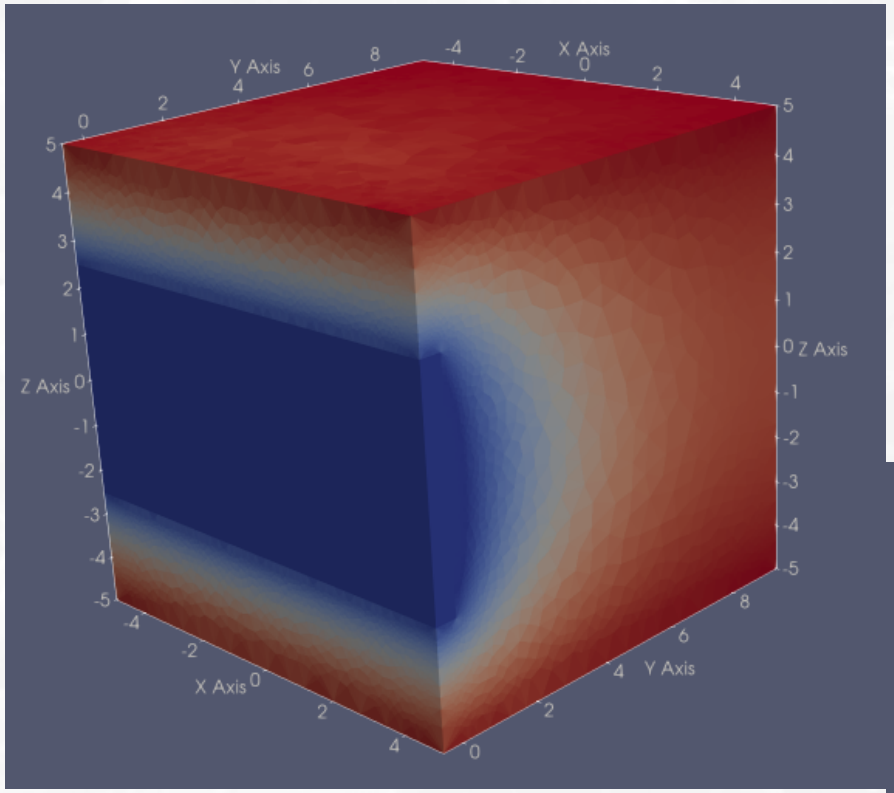
Building Complexity - Utilizing 3-D Models to Match Field Test

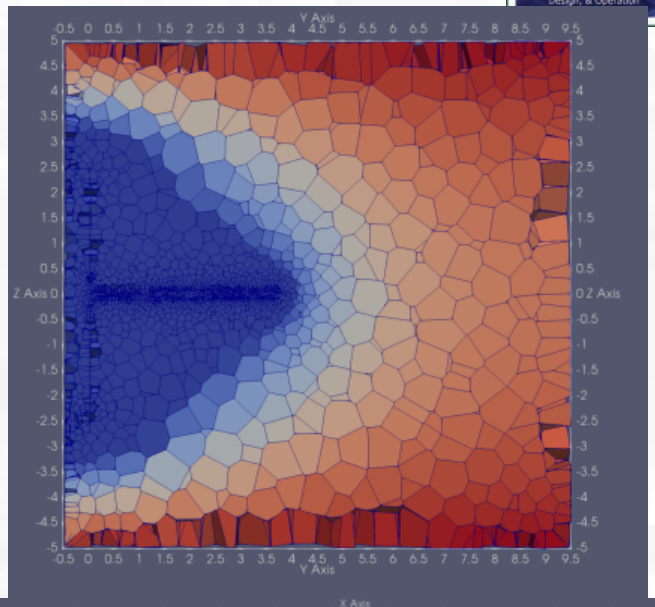
- 3D Model Domain
  - ~ 65,000 grid cells
  - 10 m × 10 m × 10 m
- Heater in contact with salt
  - air causes issues with matching field data (radiative heating)
- Simulate 29 days of heating and 13
  - Incorporates the on/off cycles in early time and gradual lowering of energy input
- Match temperatures measured at 3 thermocouples in-plane with heater
  - HE1 – TC3 – 0.4 m
  - HF1 – TC2 – 0.5 m
  - HT2 – TC1 – 1.68 m

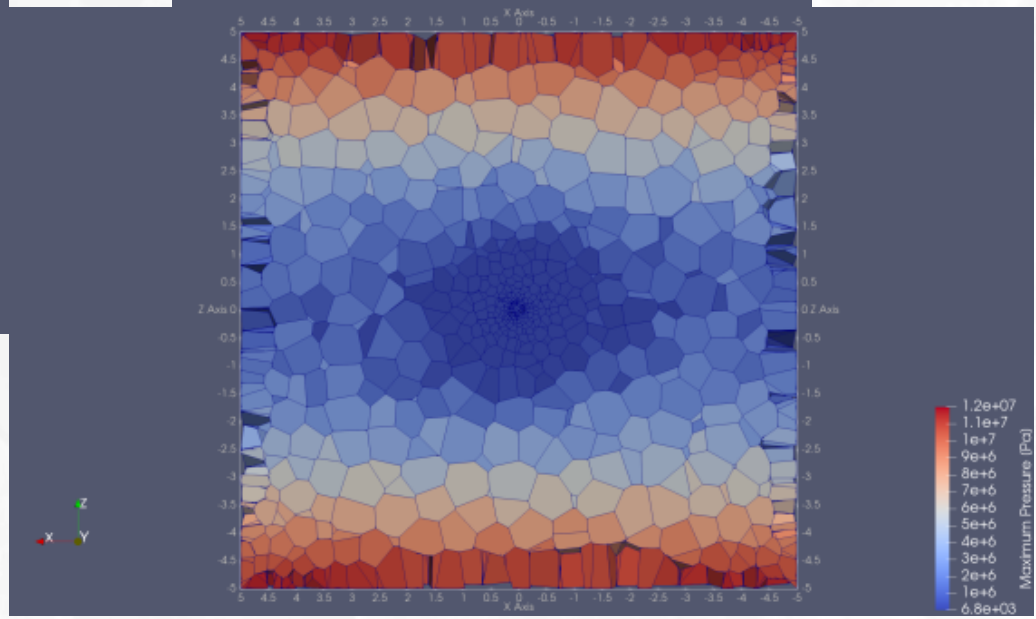




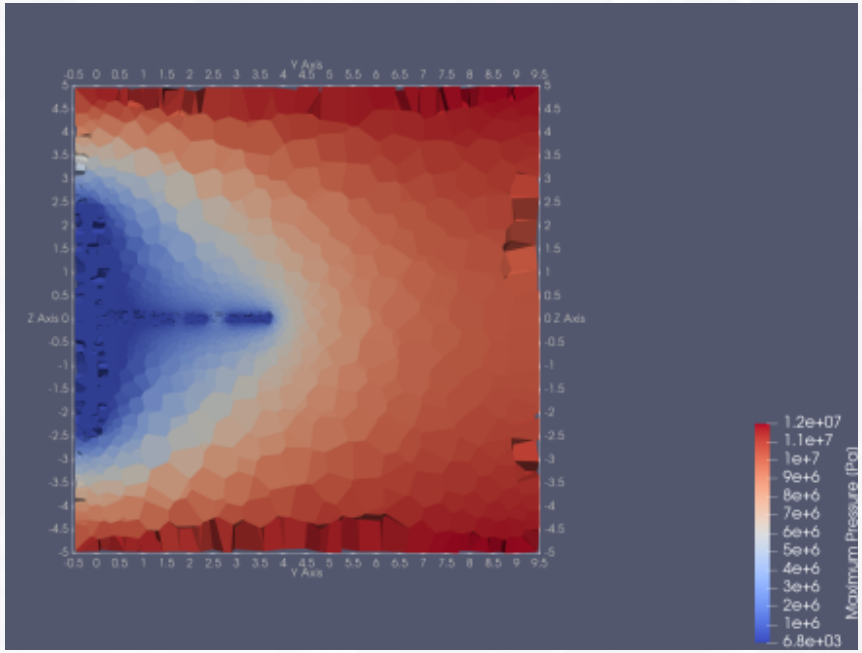
INITIAL CONDITIONS - FLUID PRESSURE

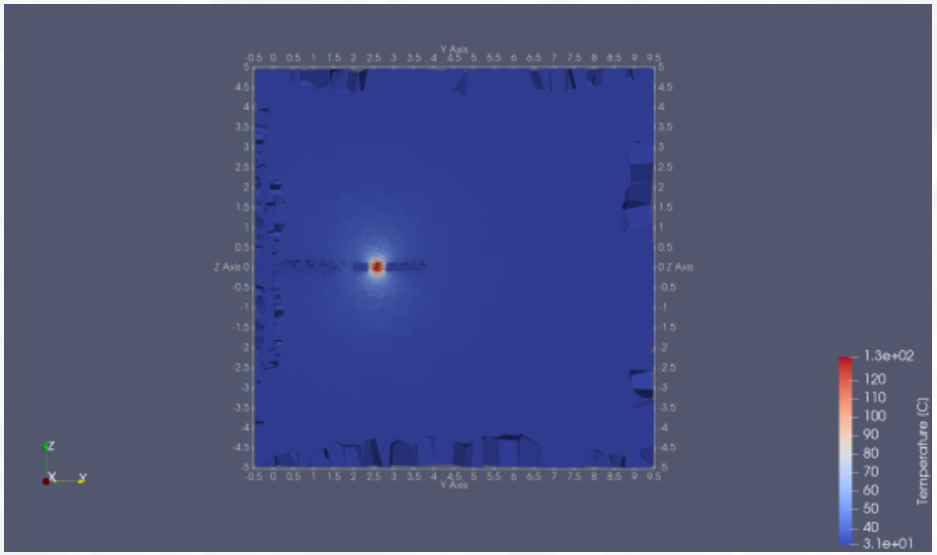


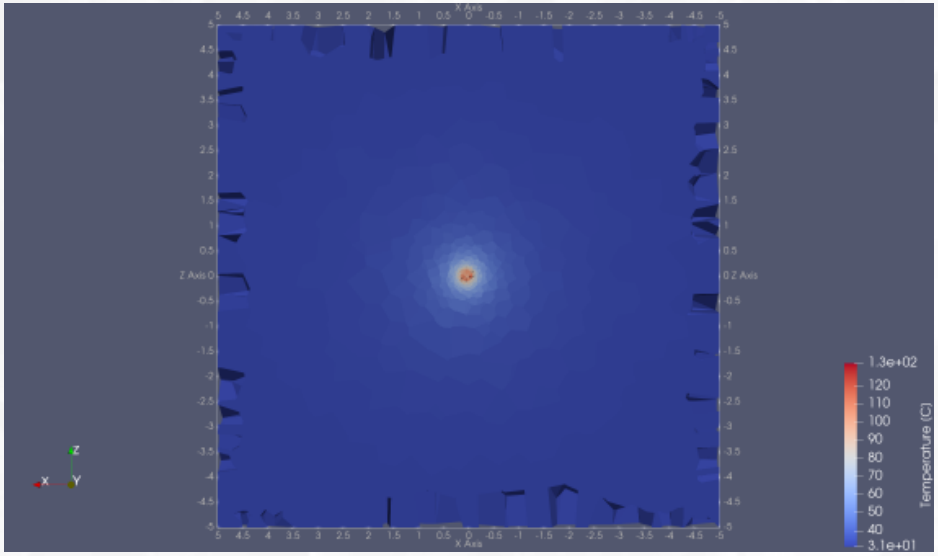




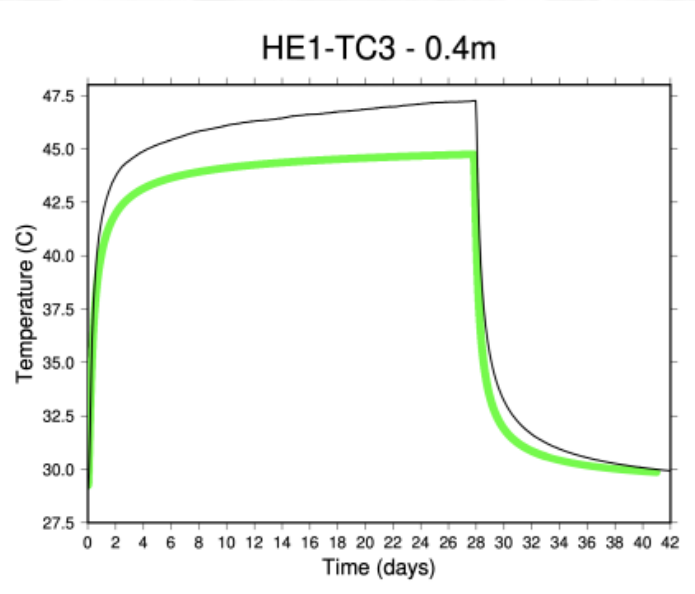
Temperature and Fluid Pressure at the End of Heating

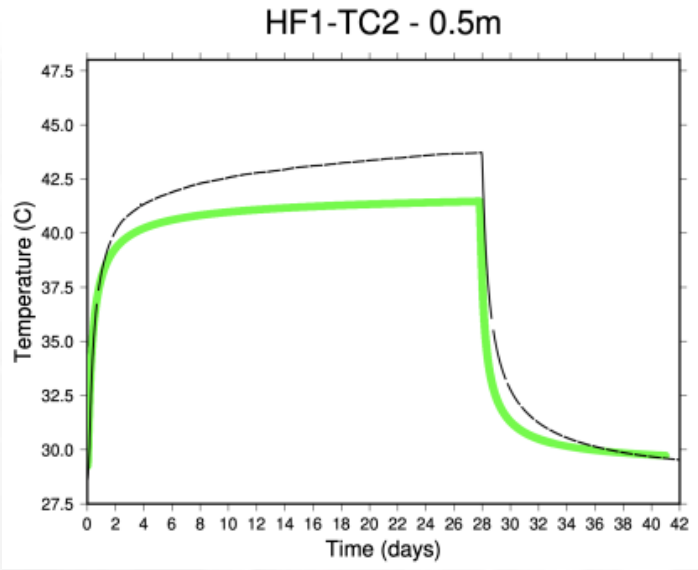


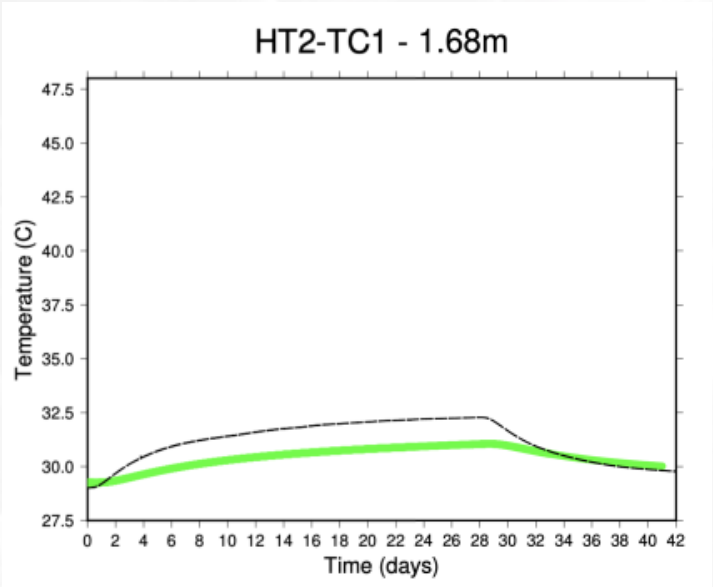




Modeled Temperature at Thermocouples







Conclusions and Future Work

- Preliminary 3D Modeling – LaGrit + Vorocrust leads to a much more accurate representation of the BATS field test vs. a hex mesh
- Continue to build complexity
  - Add more wells
  - Add heterogeneity
  - Add DRZ