SAND2022-6110C

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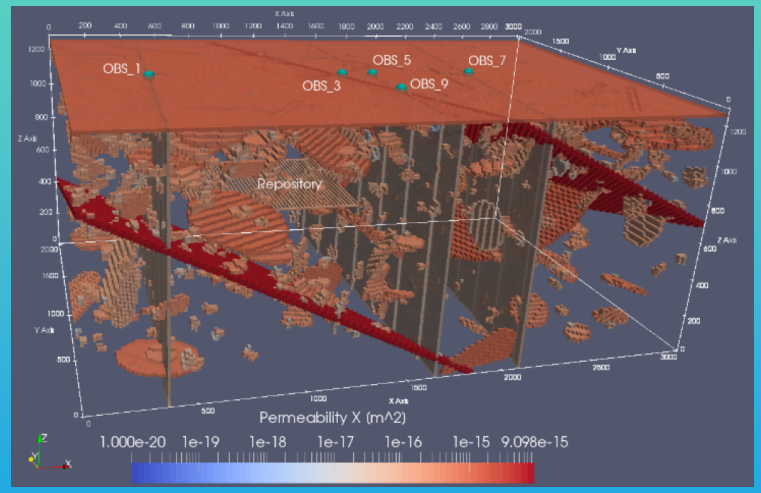
Spent Fuel and Waste Science and Technology (SFWST)



Task F: Salt PA in a Generic Salt Dome

SFWST 2023
May 9 – 13, 2022
Virtual Workshop

Rick Jayne
Sandia National Laboratories

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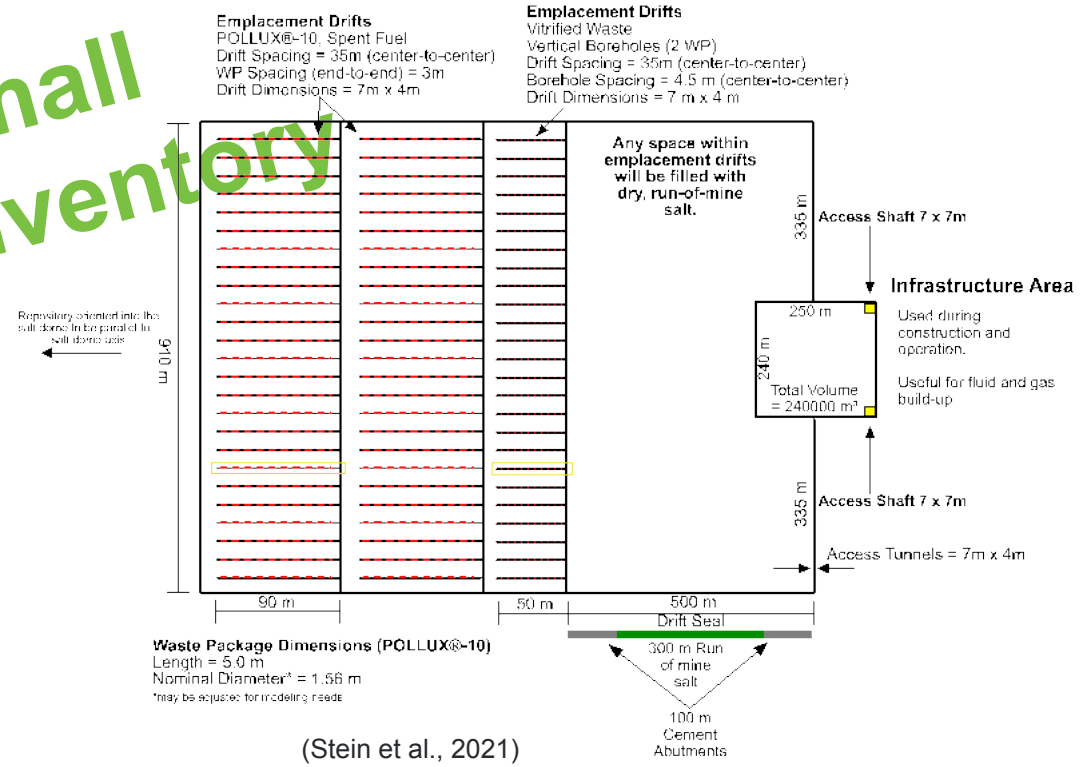
Overview

- DECOVALEX Task F Reference Case
  - Generic salt dome
- Model Development
- Stepped process – building complexity
- Modeling Approach
  - PFLOTRAN
- Meshing Scheme
  - VOROCRUST
- Results/Current Progress
- Next Steps

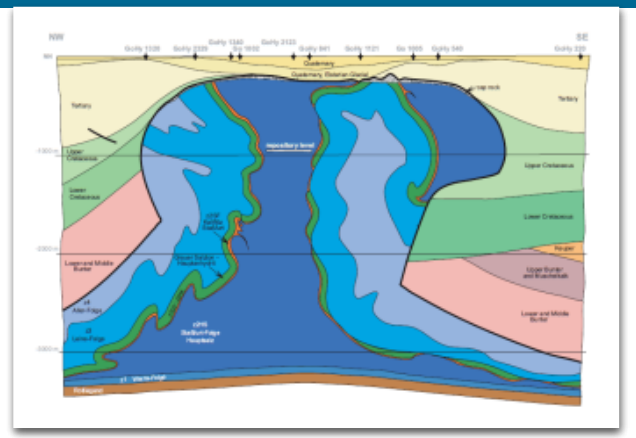
Salt Reference Case – Natural and Engineered Barrier System

- Salt dome
  - No flowing groundwater (~0.1 vol-% brine)
  - Openings creep closed (> $10^0 - 10^2$ yr)

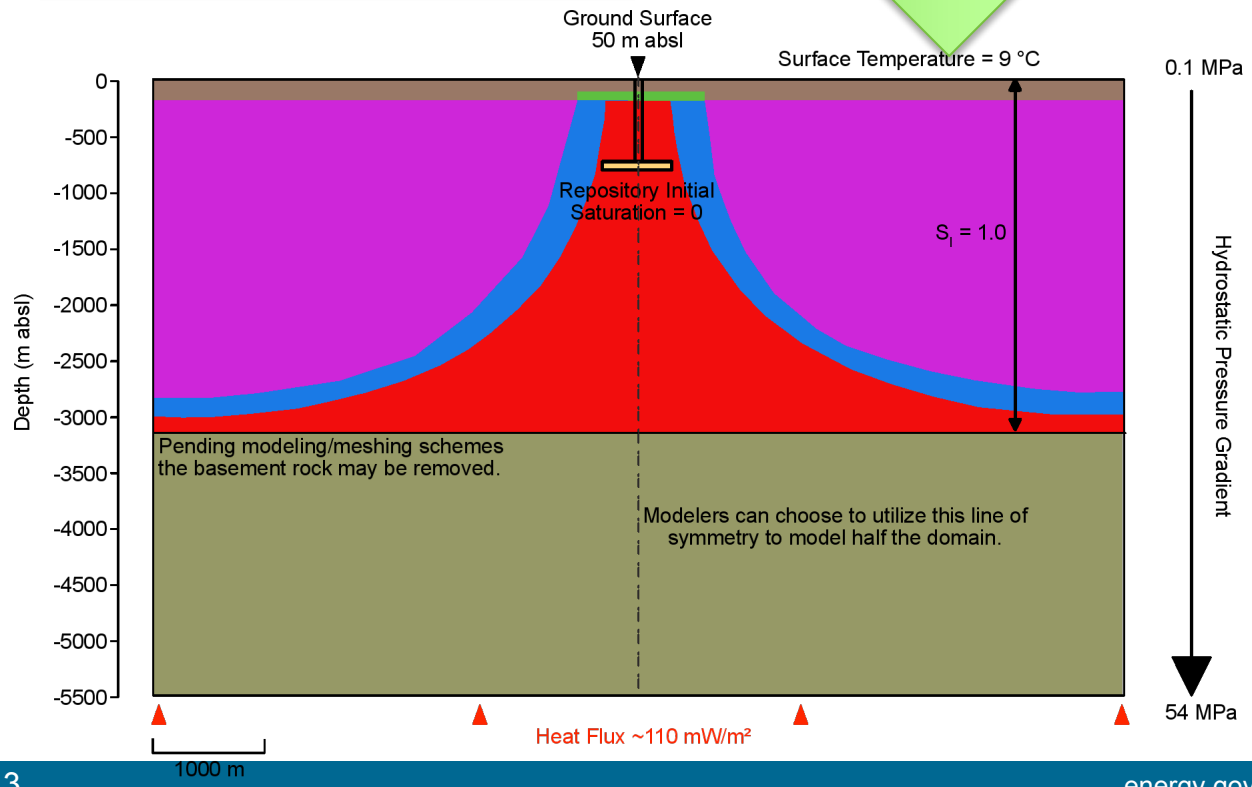
Small inventory



(Stein et al., 2021)



Simplified geome



Model Development

- Disturbed scenario: shaft seals fail at 1000 y
  - Bulk permeability increases from 5×10^{-17} m^2 to 5×10^{-15} m^2
- Staged model development
  1. Flow + radionuclide transport
  2. + multiphase flow
  3. + drift convergence
  4. + heat flow and temperature-dependence of drift convergence
  5. + model uncertainty in backfill consolidation model
  6. (+ gas generation)

Modeling Approach - PFLOTRAN

General Mode

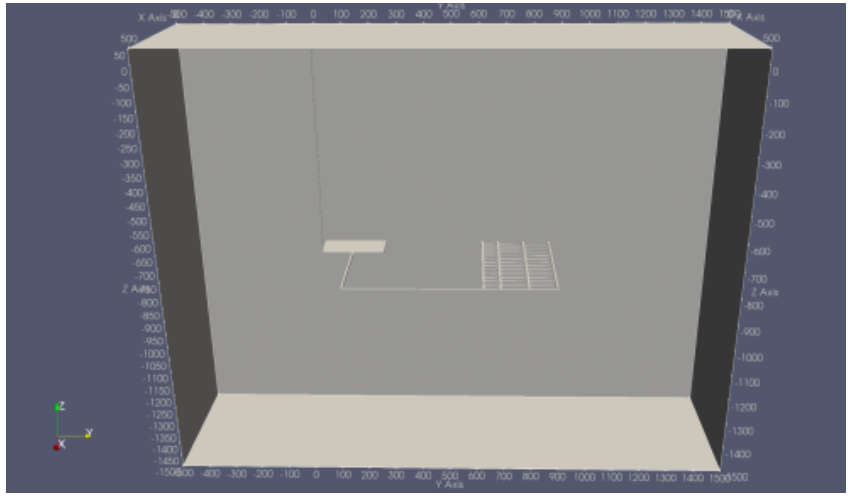
- Multiphase Flow
  - Computationally difficult
- Issues with convergence
  - Made all relative permeability models the same
    - VG
  - All drifts and seals are have same flow properties
  - Starting liquid saturation = 20%
- Simulation time ~30 hours

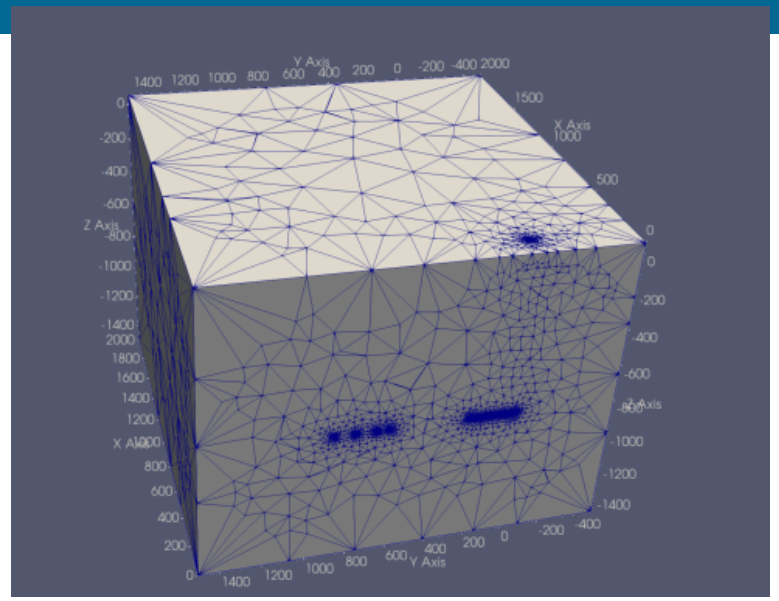
Richards Mode

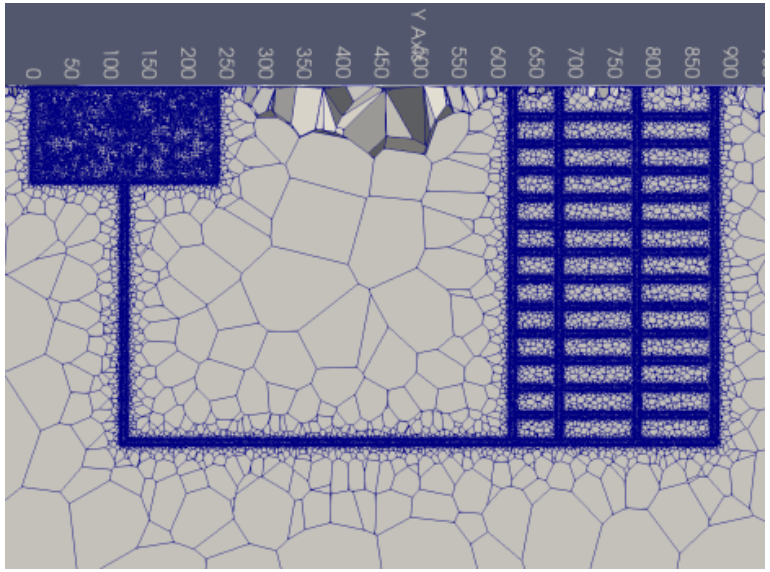
- Single phase unsaturated flow
- Some compromises for matching initial conditions
  - Changed initial pressure in repository to -1.7e^{6} Pa to increase gas saturation
    - Negative pressure is needed to impose ~20% liquid saturation
  - Simulation time ~24 hours
- How important is early time behavior of repository wetting up?

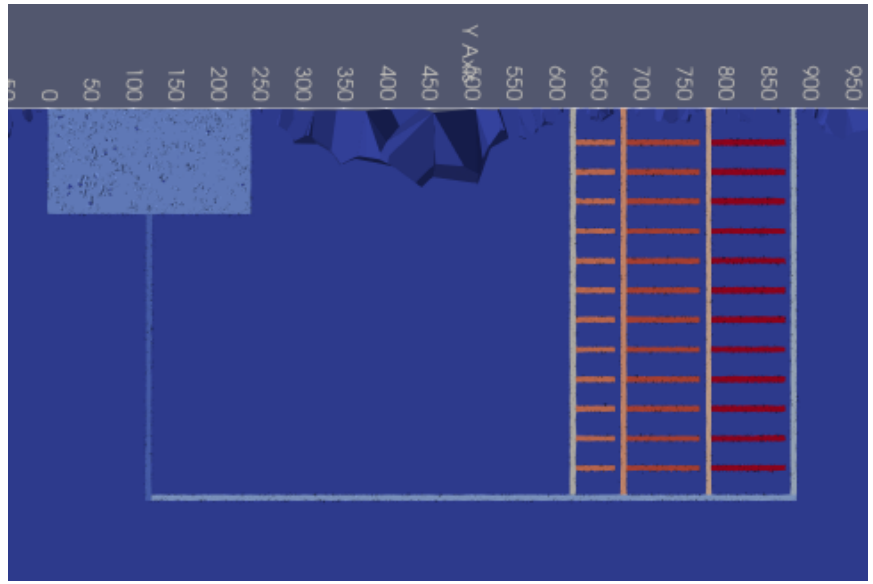
Meshing Scheme - Vorocrust

- Create surfaces
  - e.g. LaGrit
- Vorocrust needs .obj format
- Few required parameters
- Complex geometry with orthogonal discretization





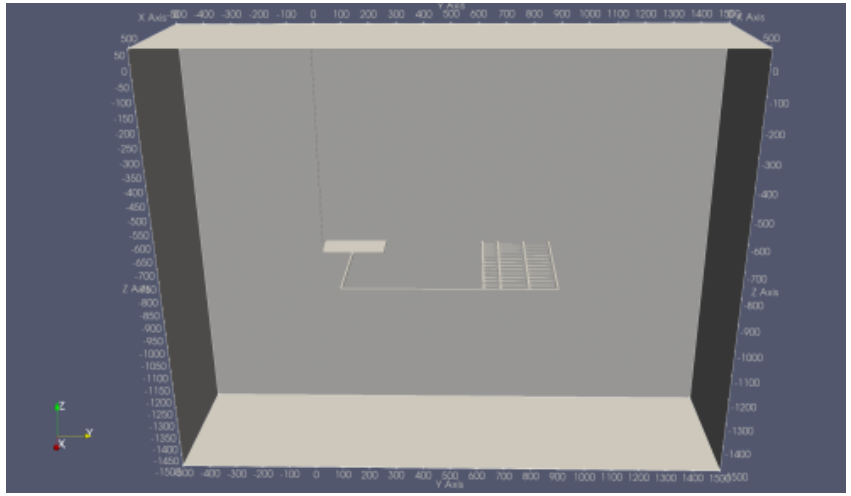


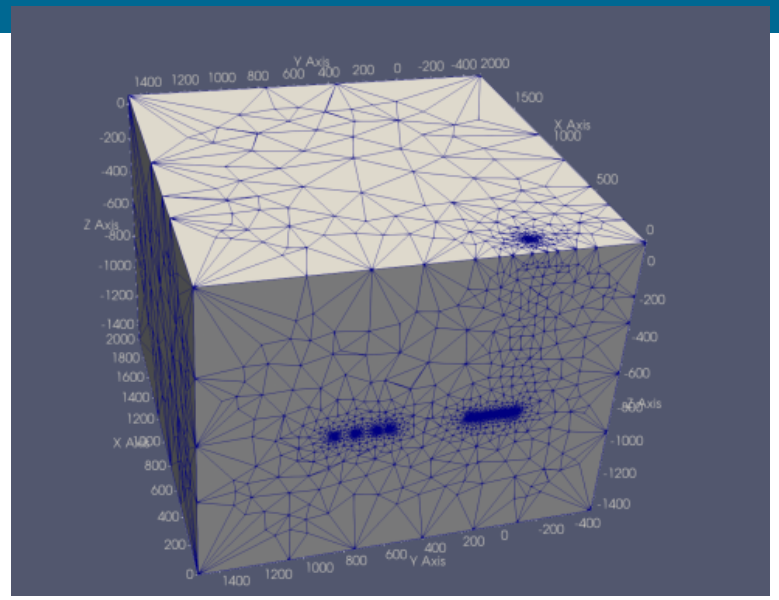


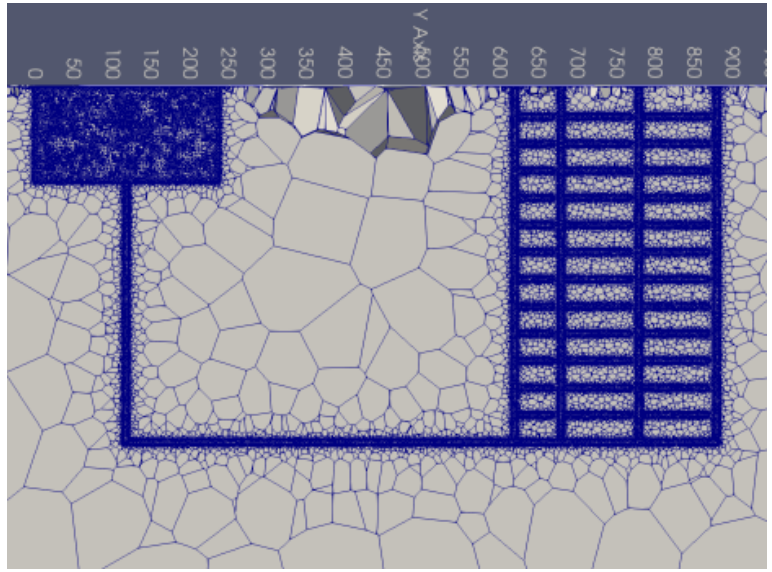
Meshing Scheme - Vorocrust

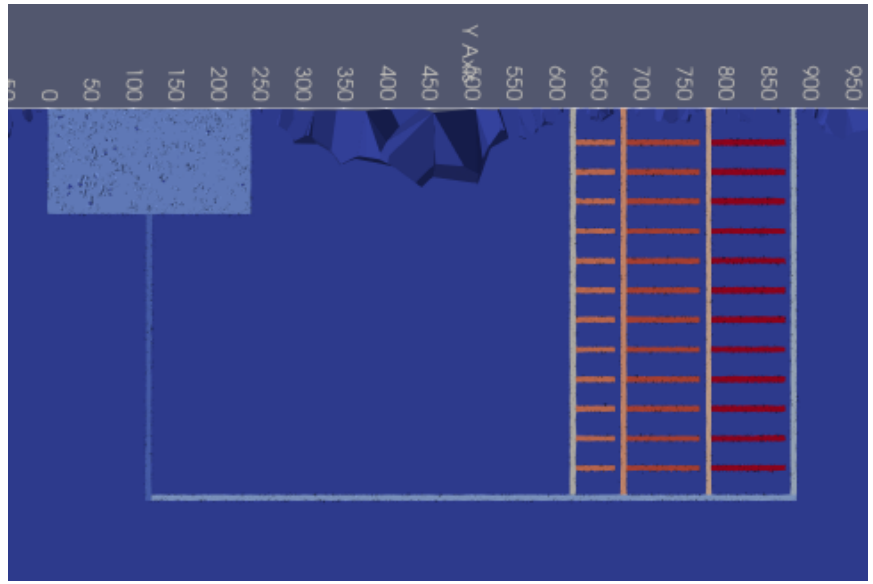
Current Mesh

- One geologic formation
  - Domal salt
- 2000 m x 2000 m x 1550 m
- ~431,000 elements

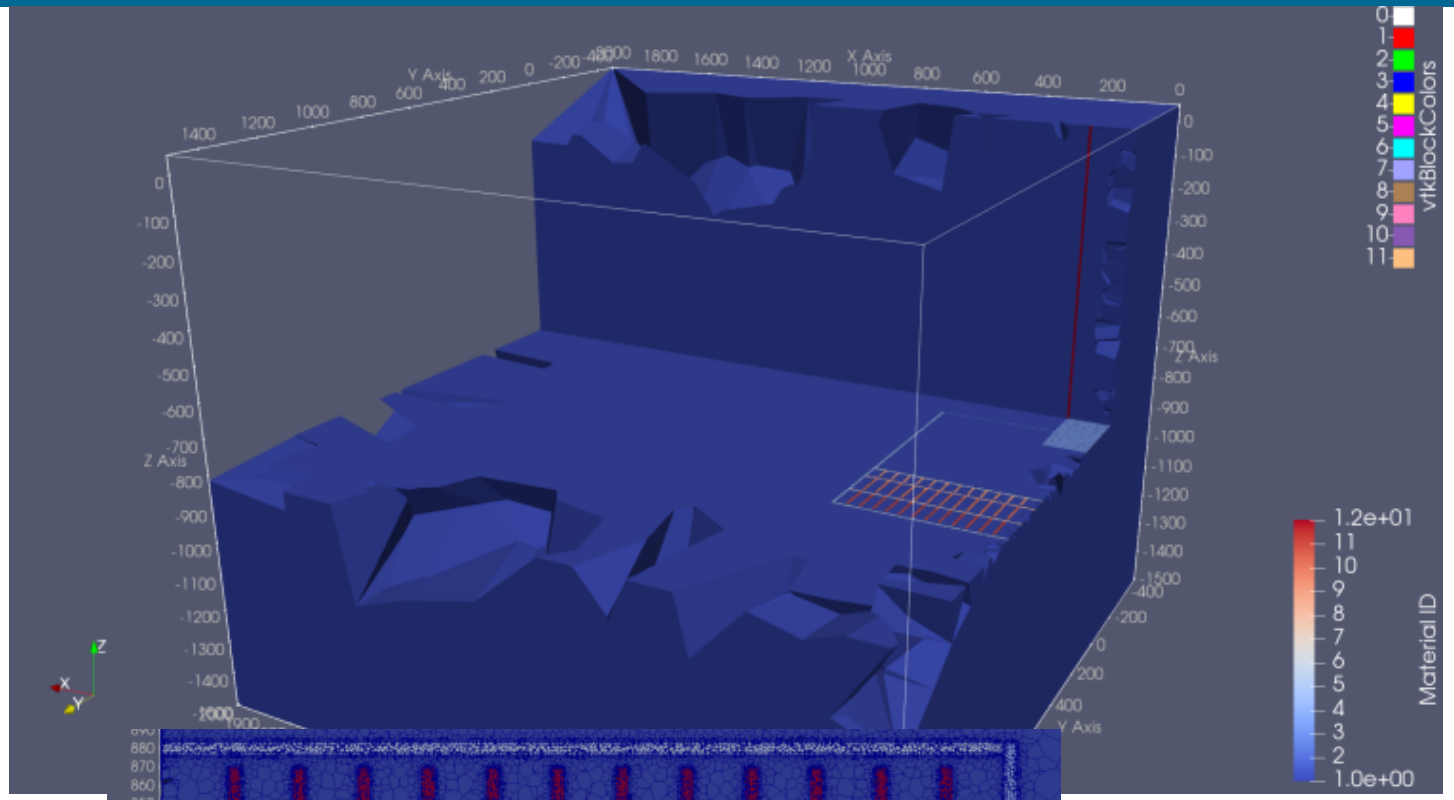


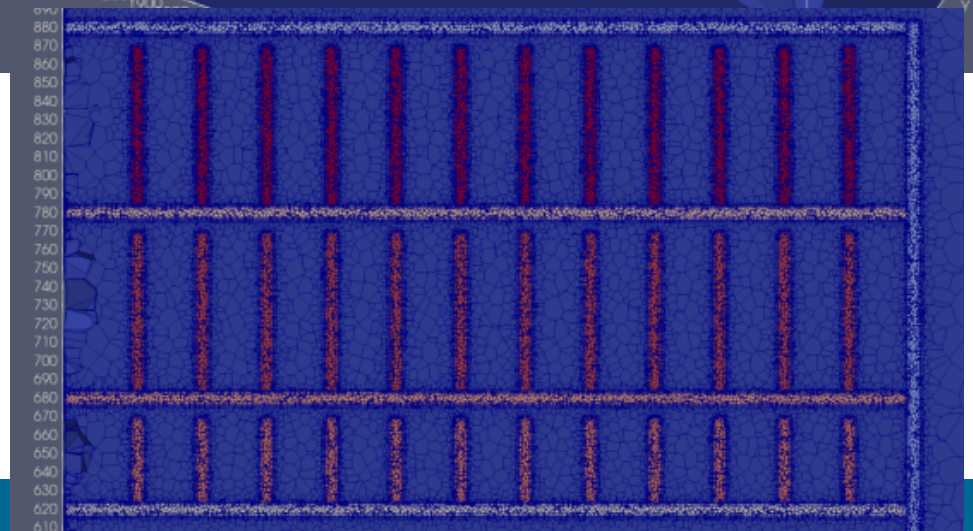


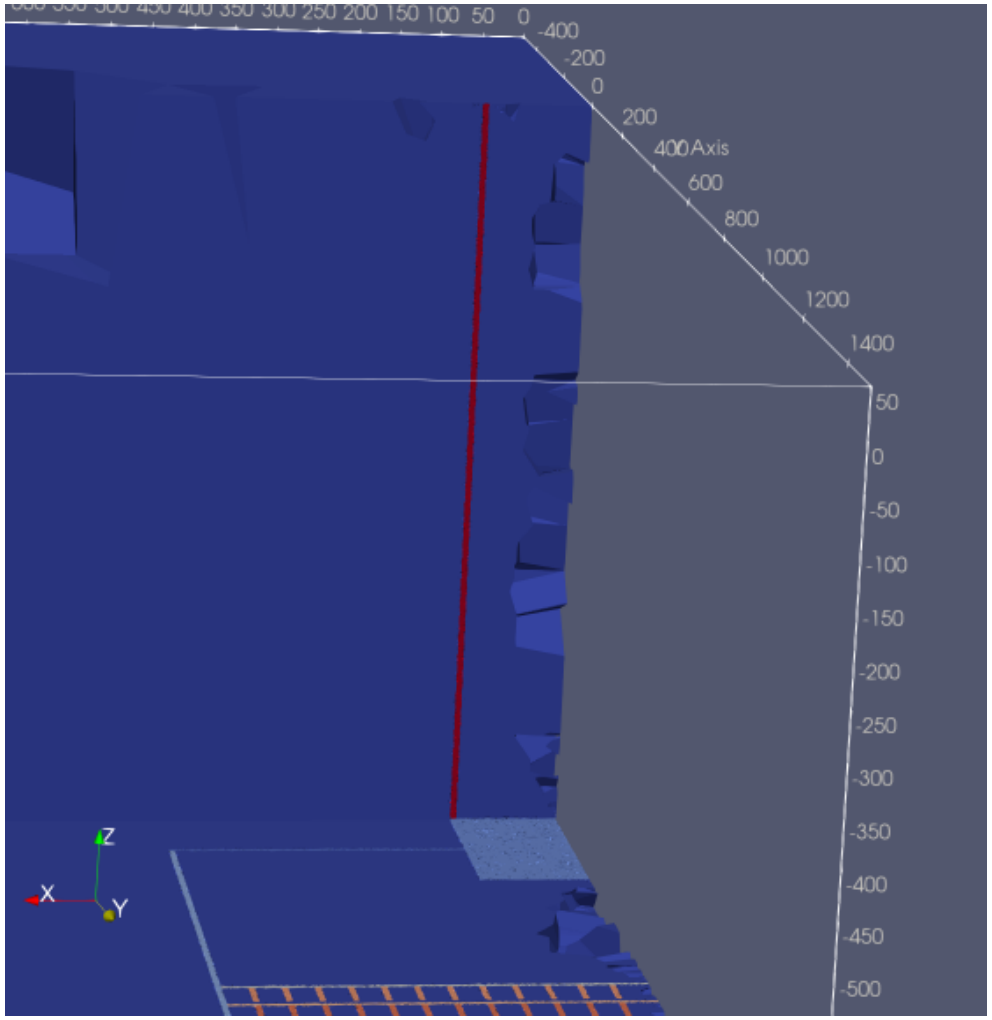




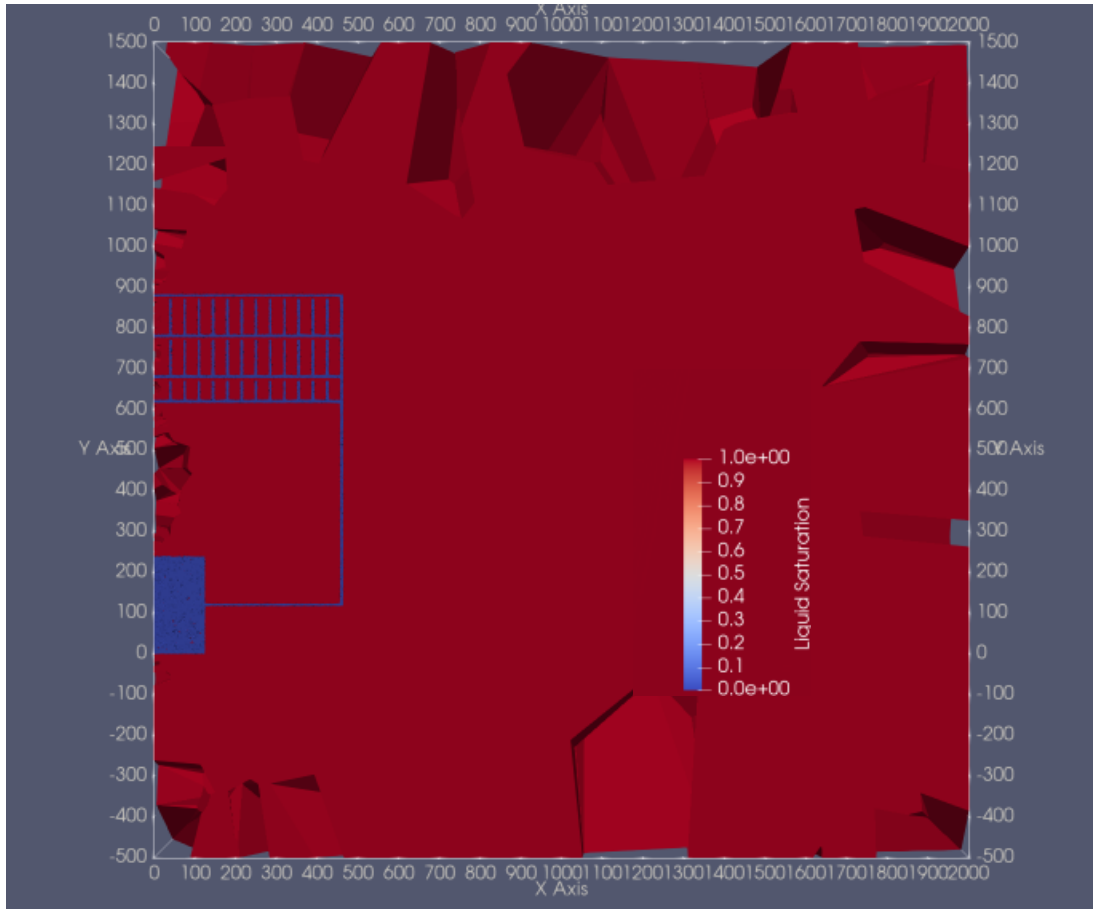
MESHING SCHEME - VOROCRUST

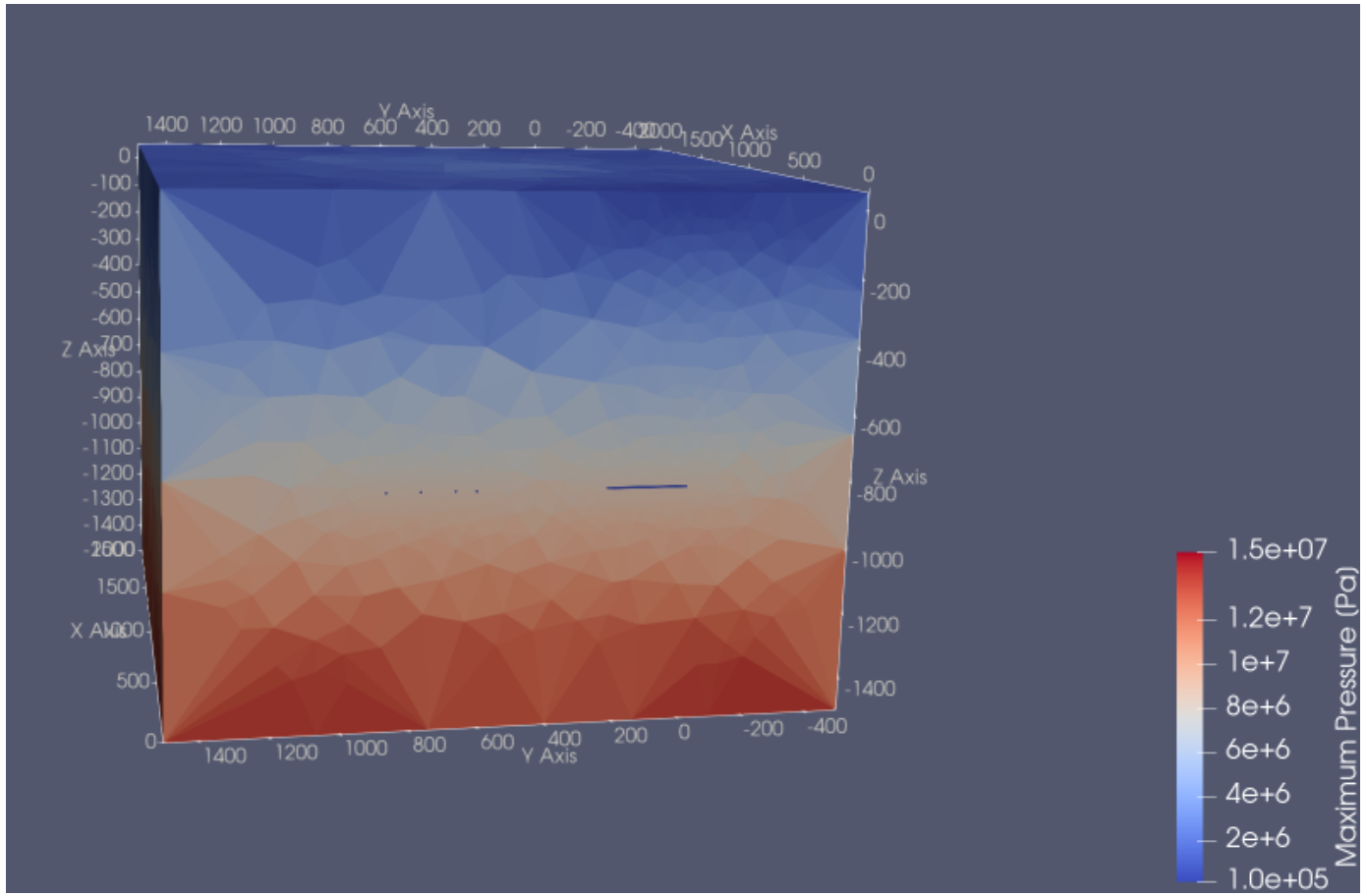




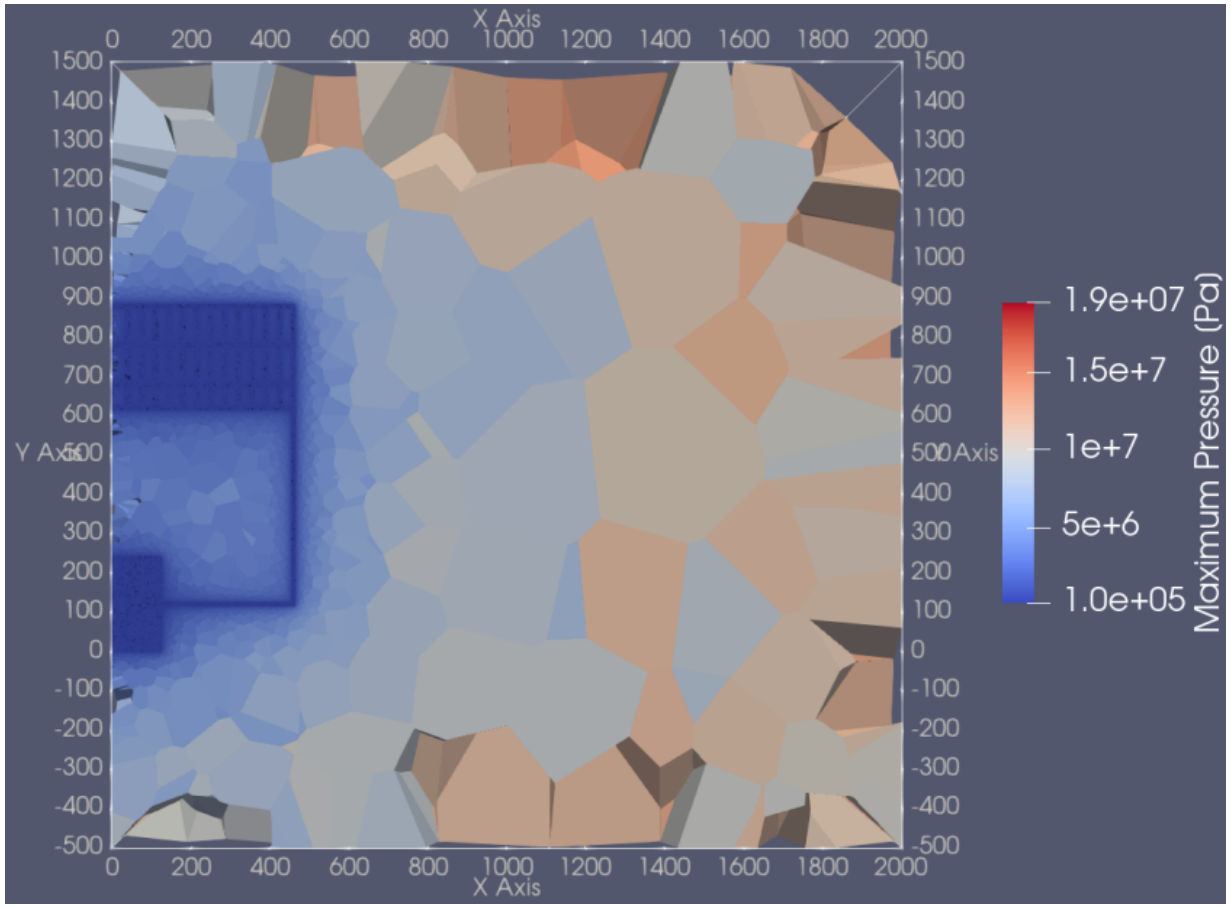


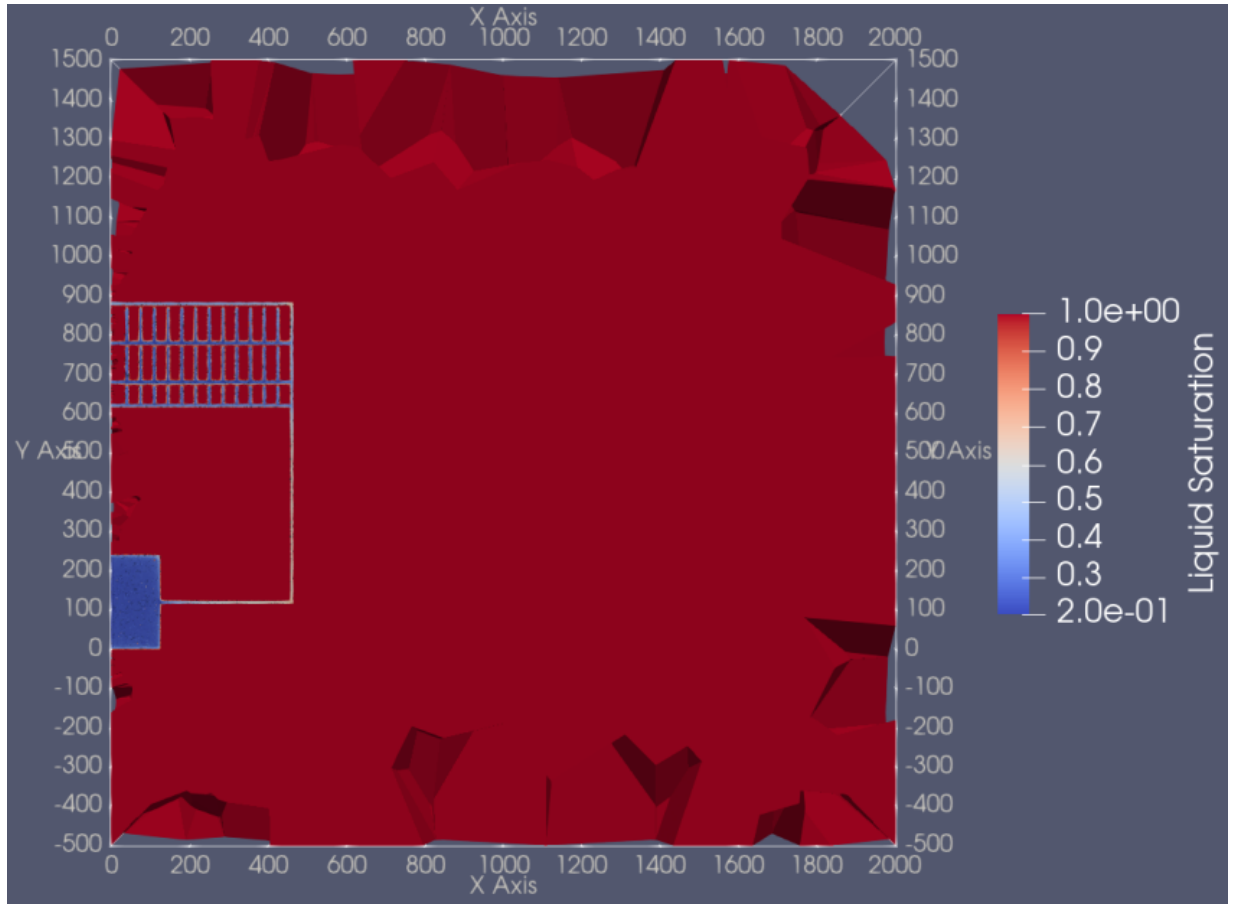
Initial Conditions



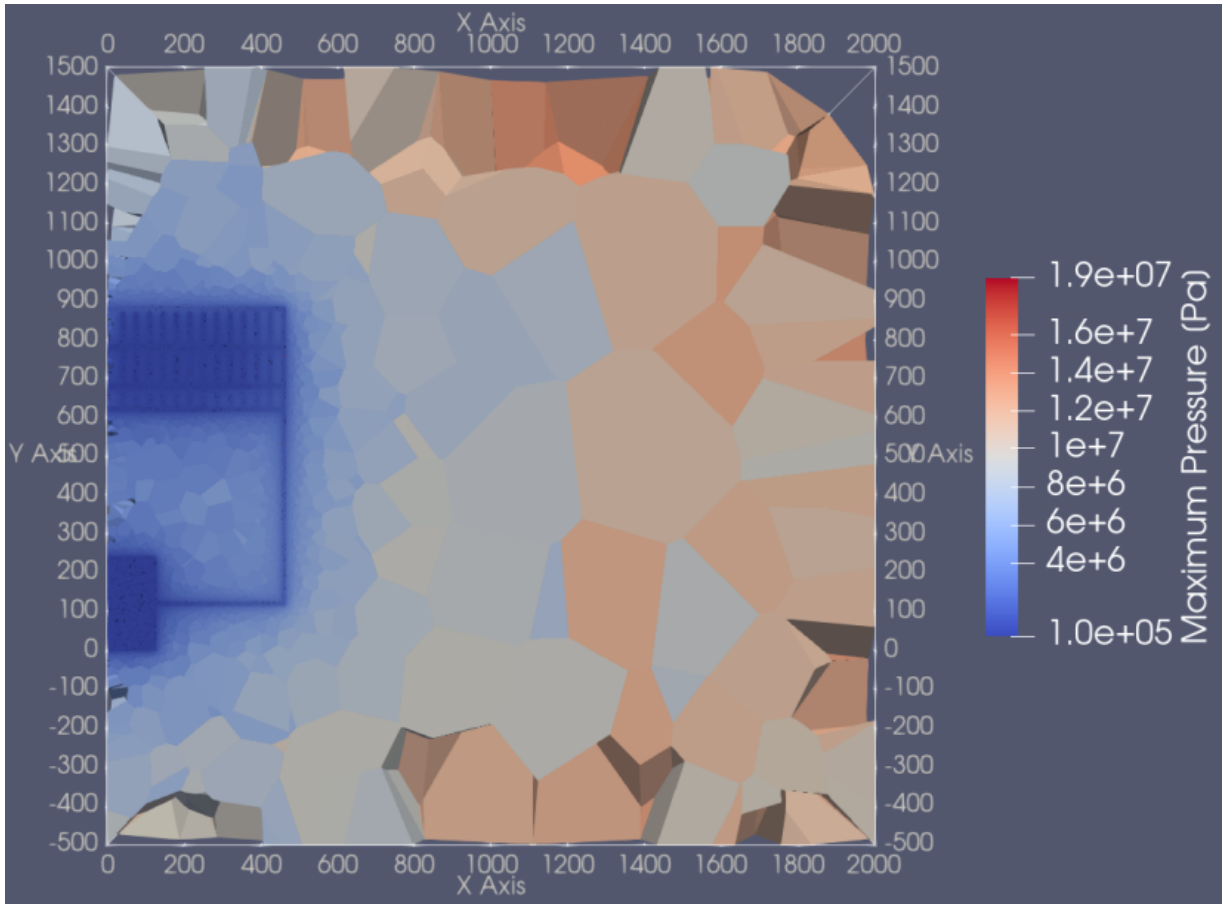


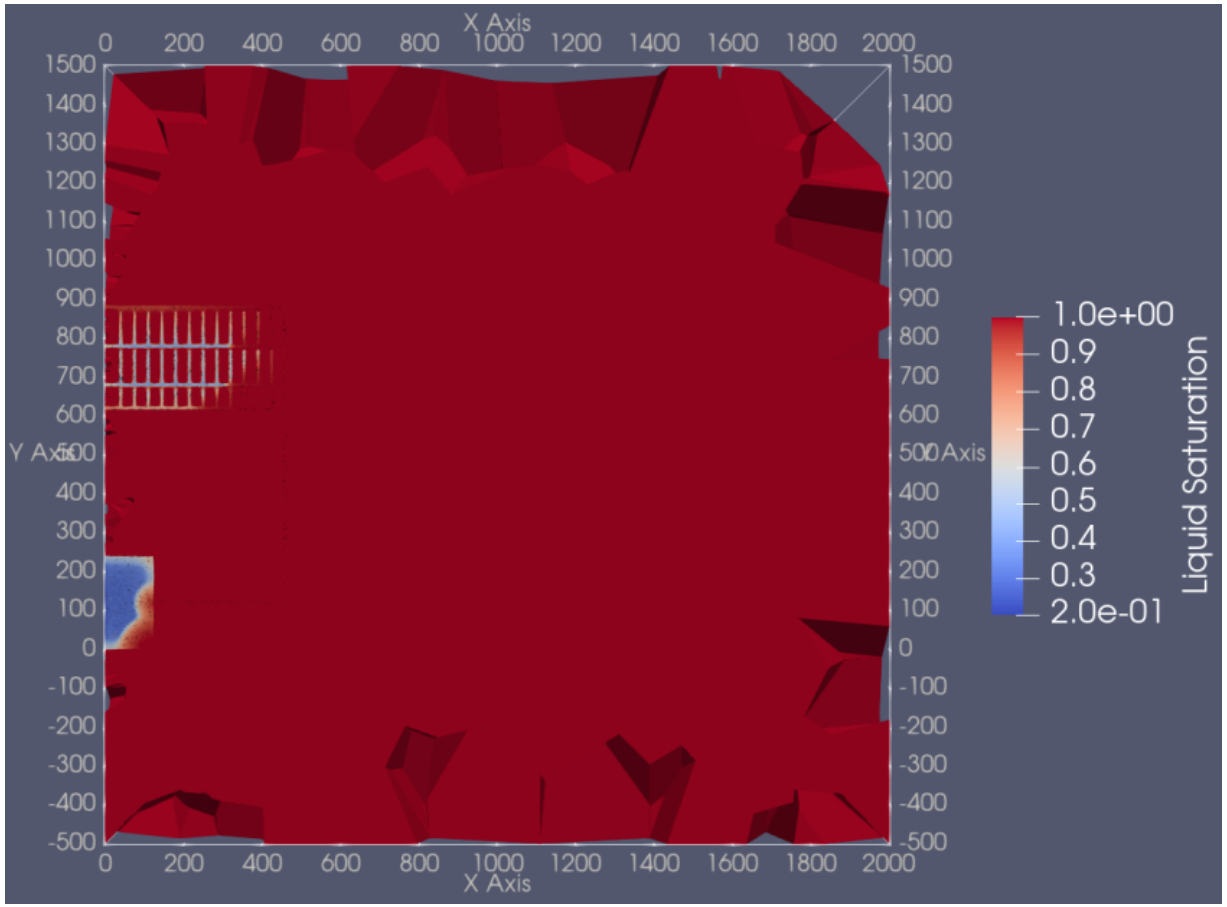
General Mode - 5,000 Years



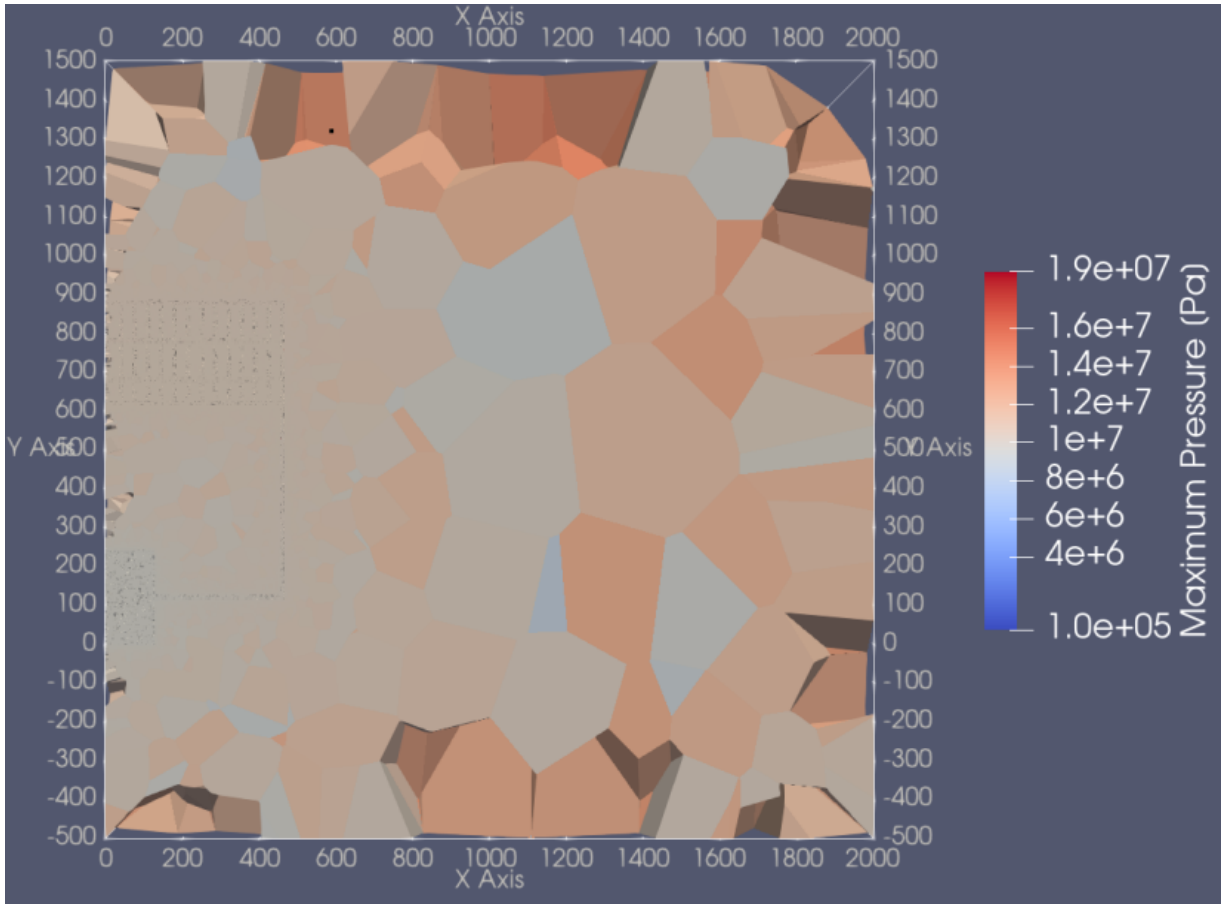


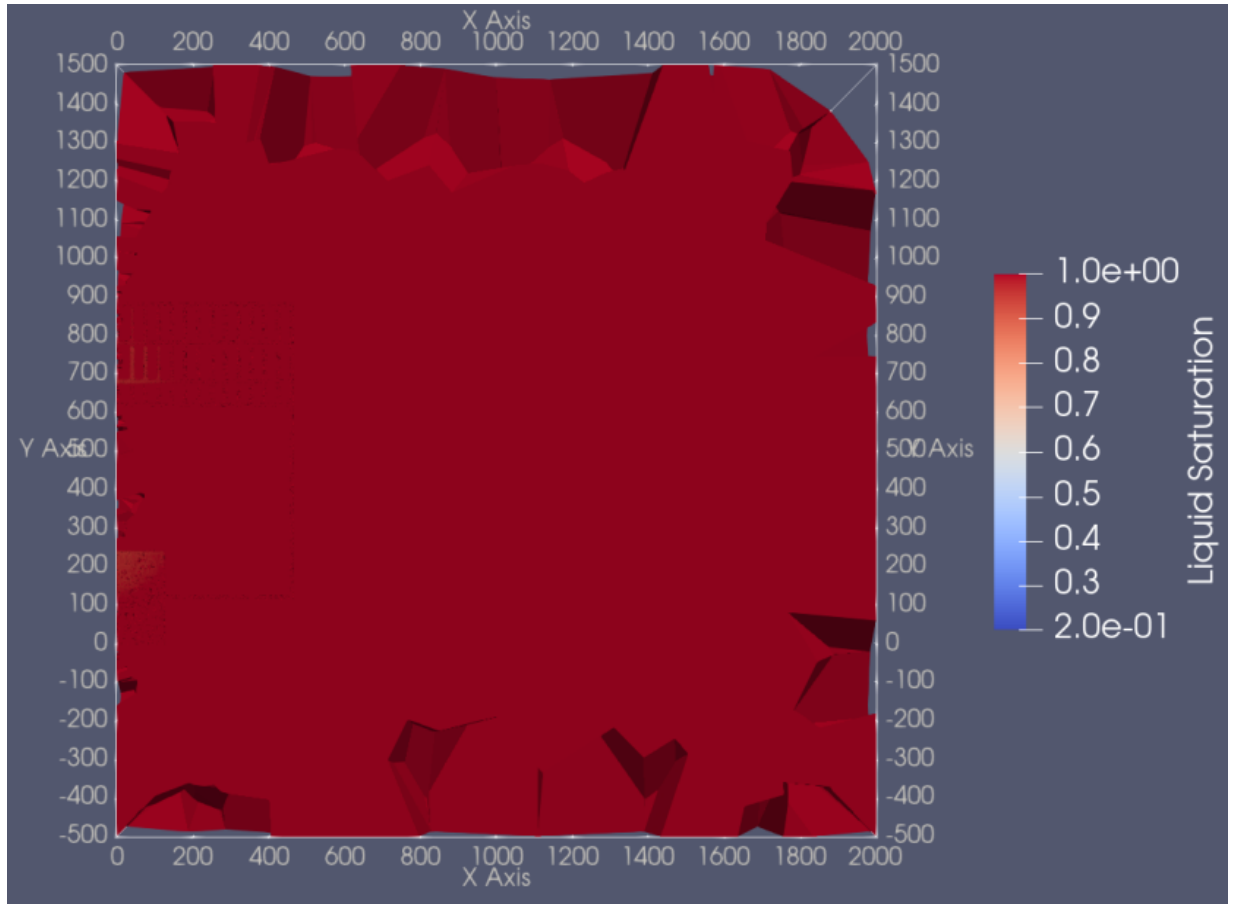
General Mode - 20,000 Years



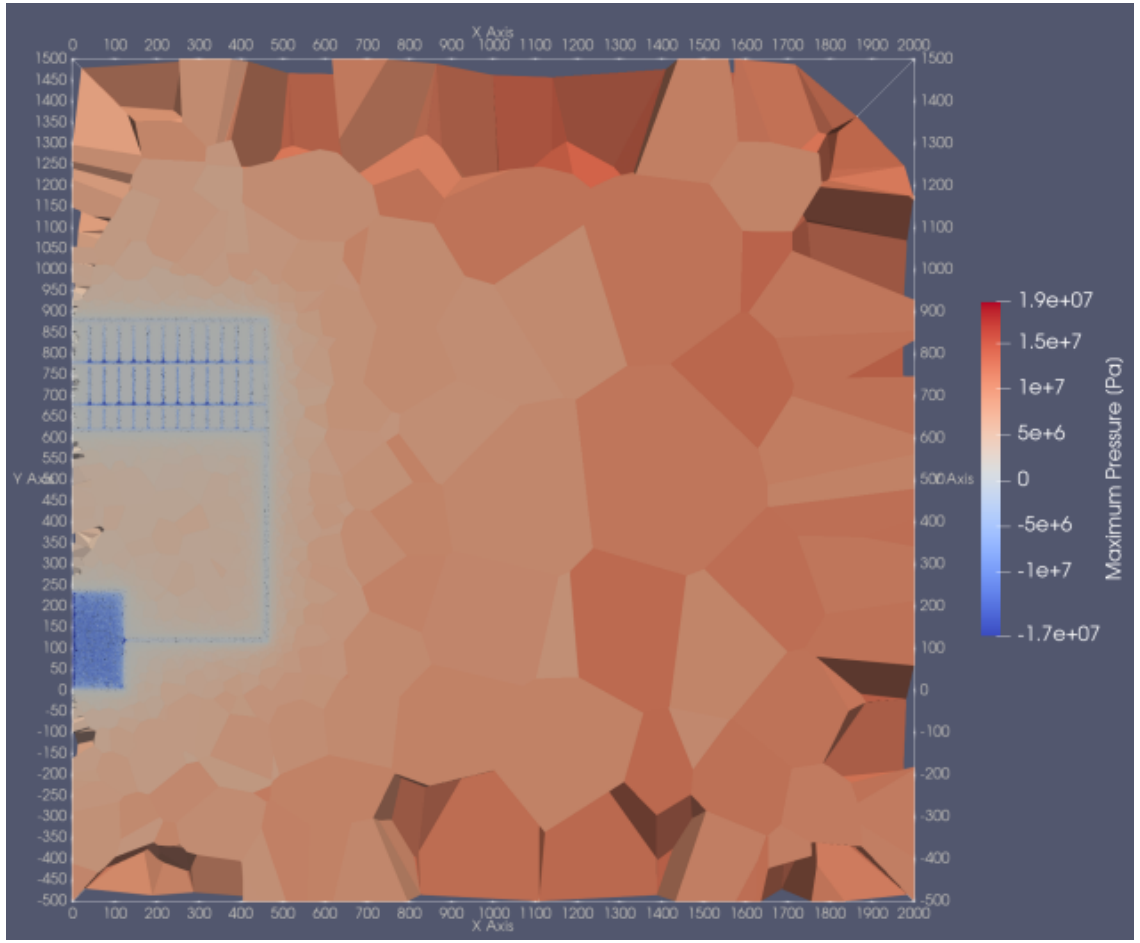


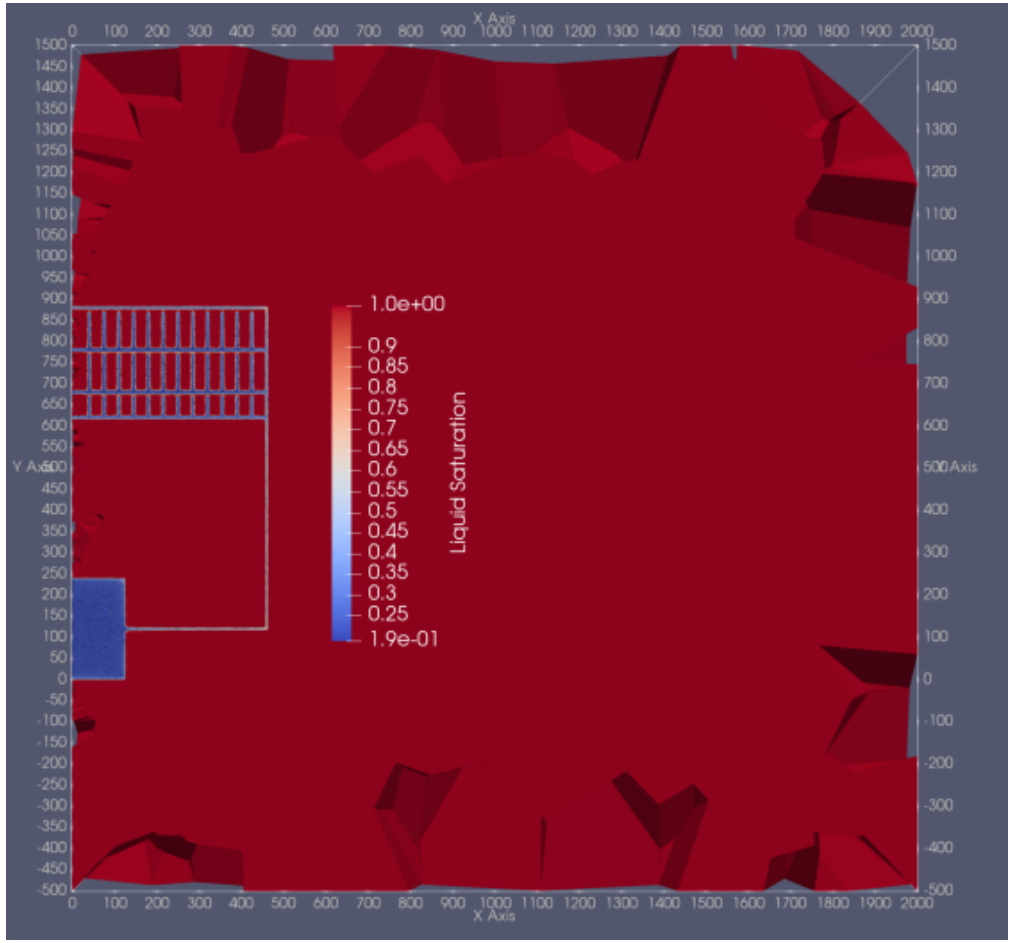
General Mode - 40,000 Years



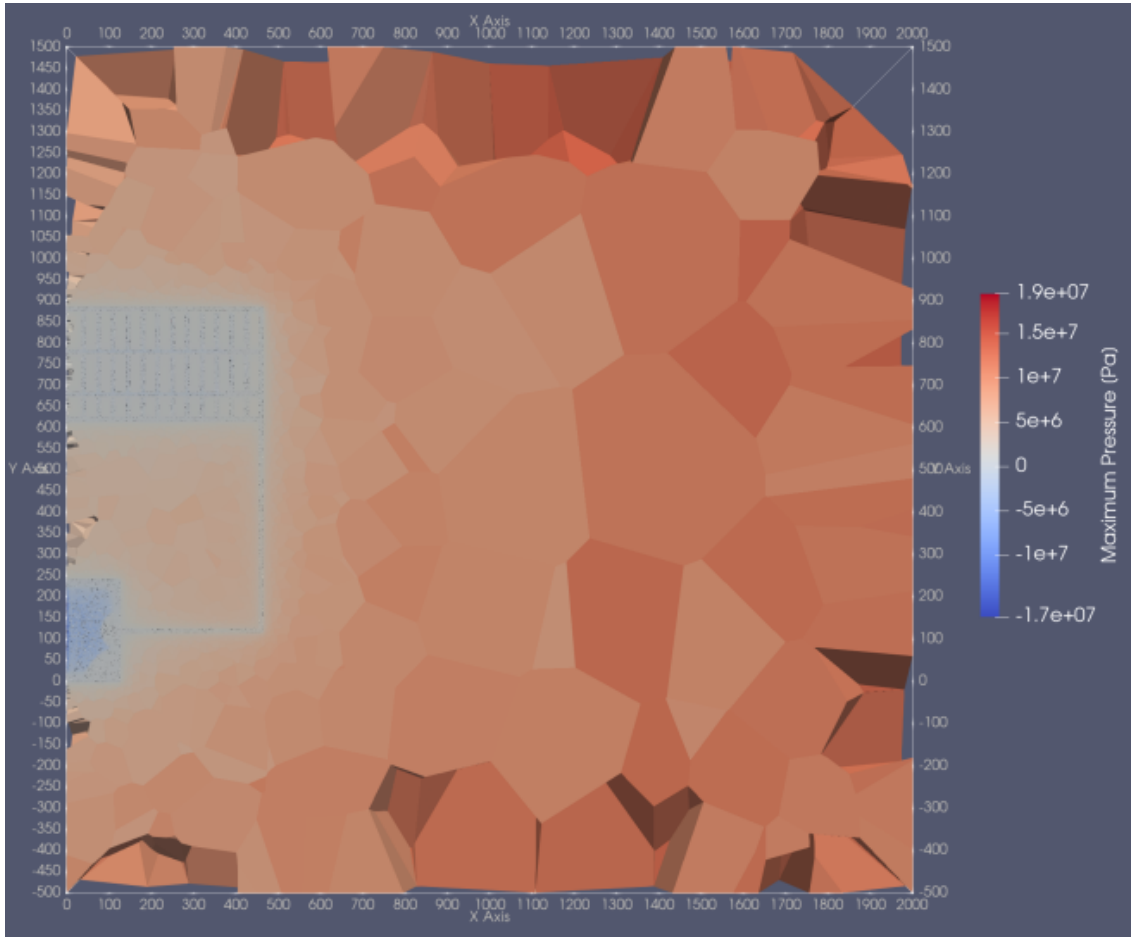


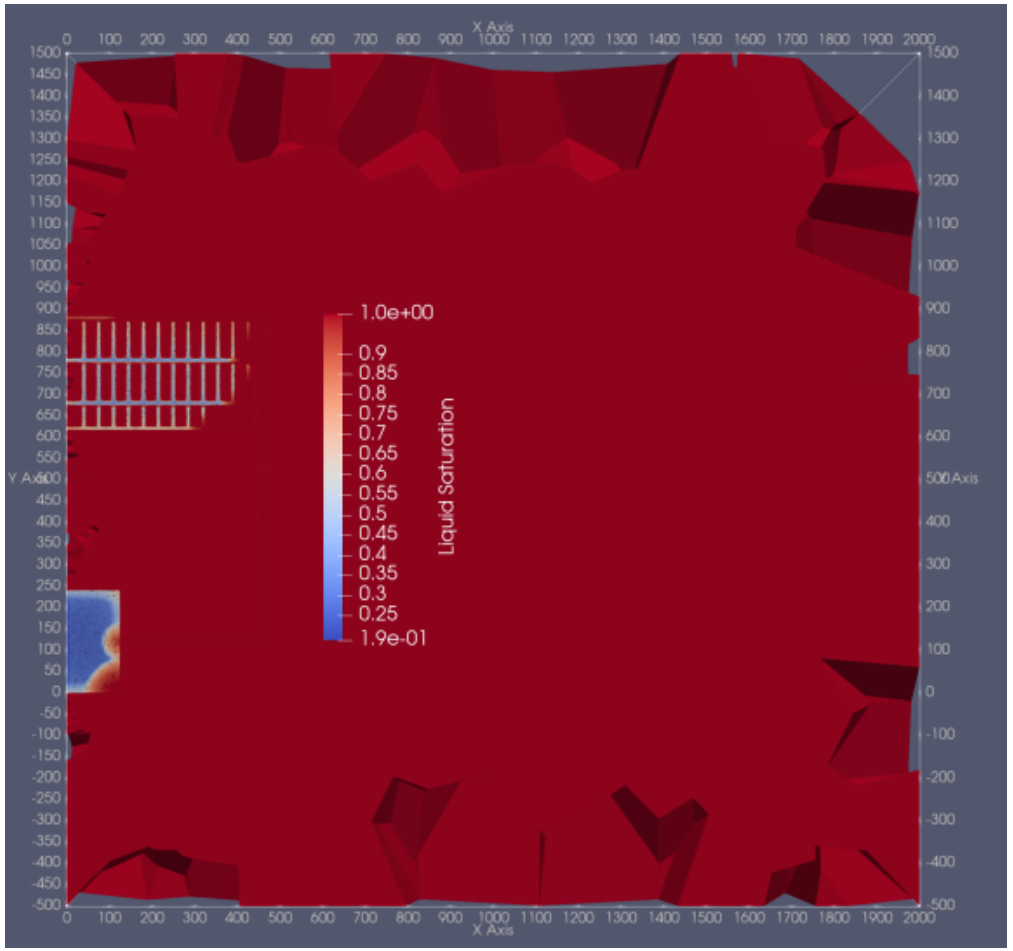
Richards Mode – 5,000 Years



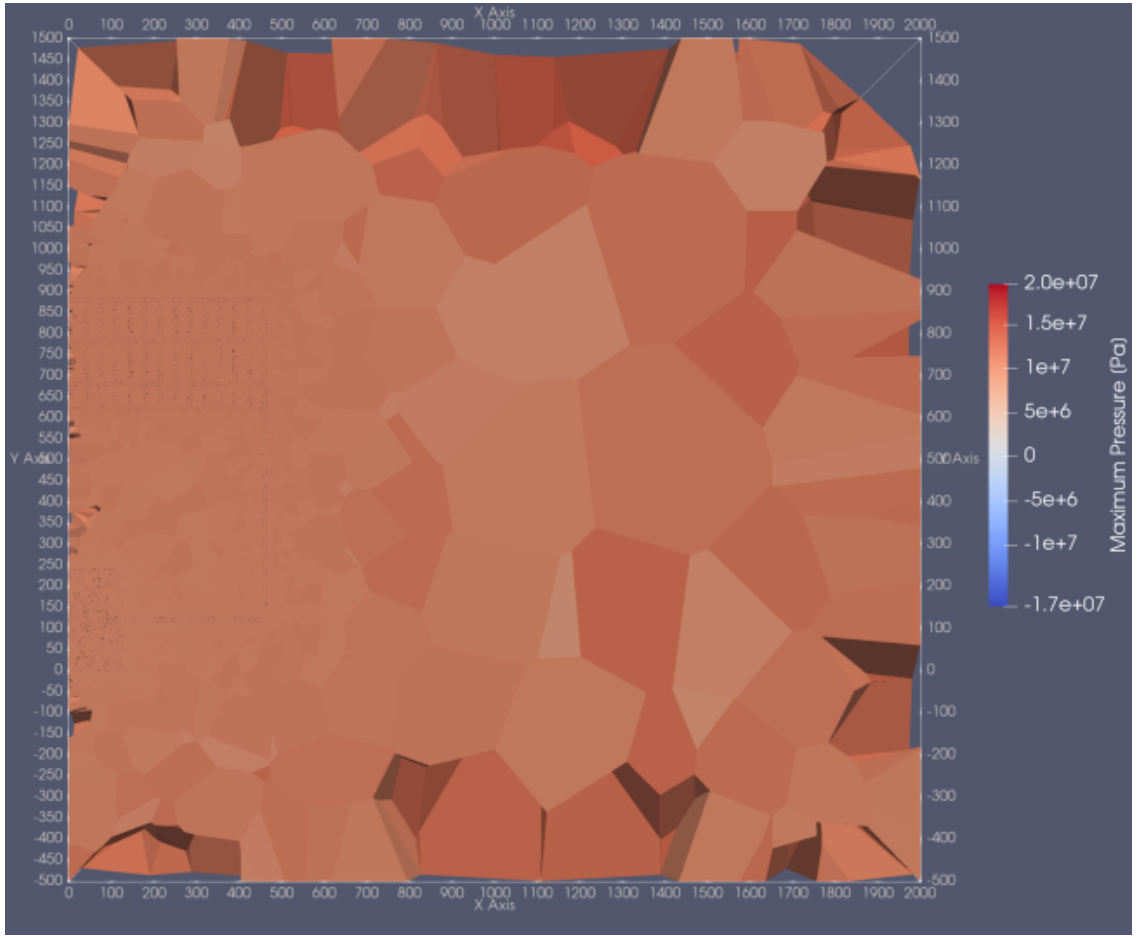


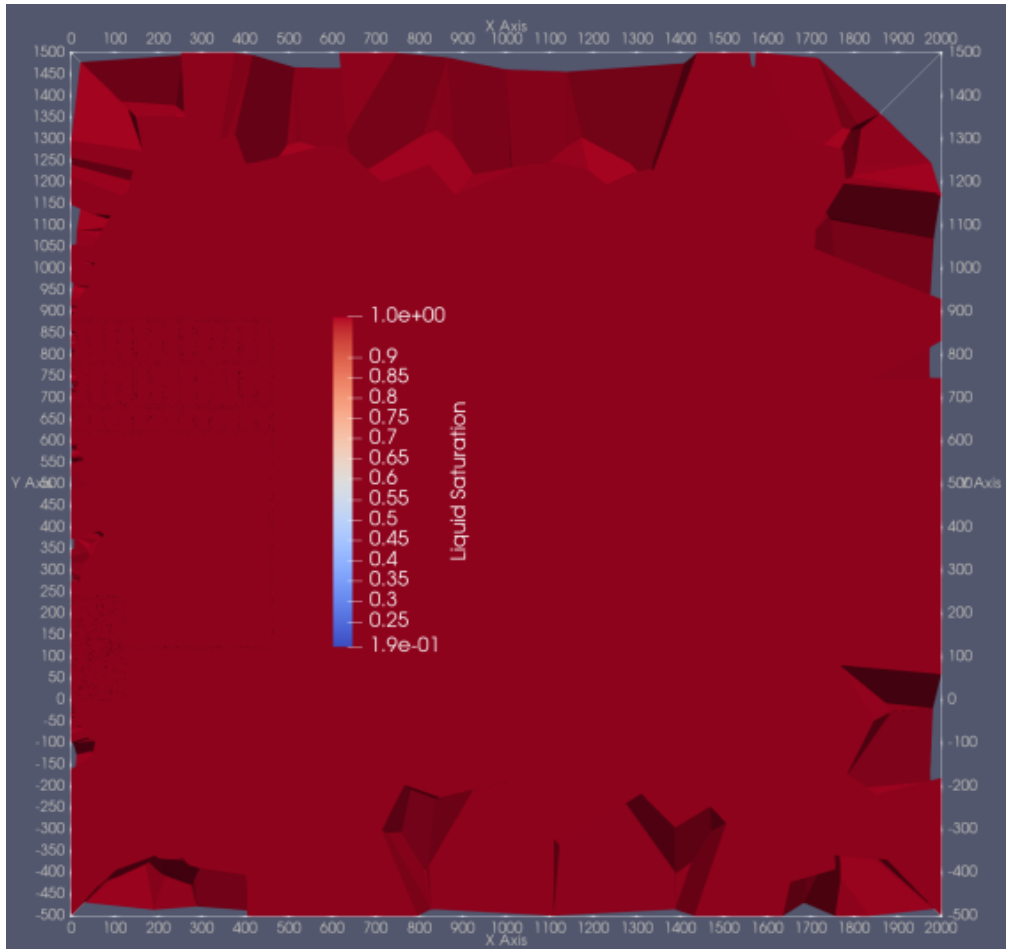
Richards Mode – 20,000 Years



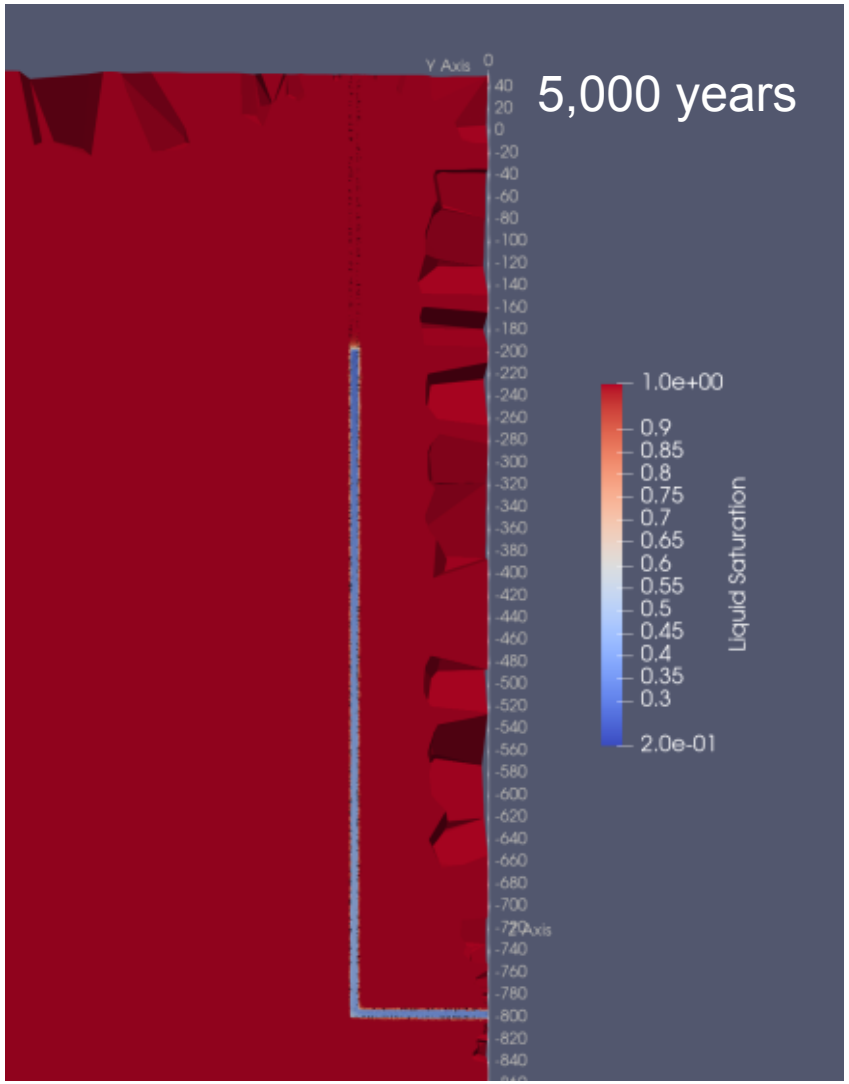


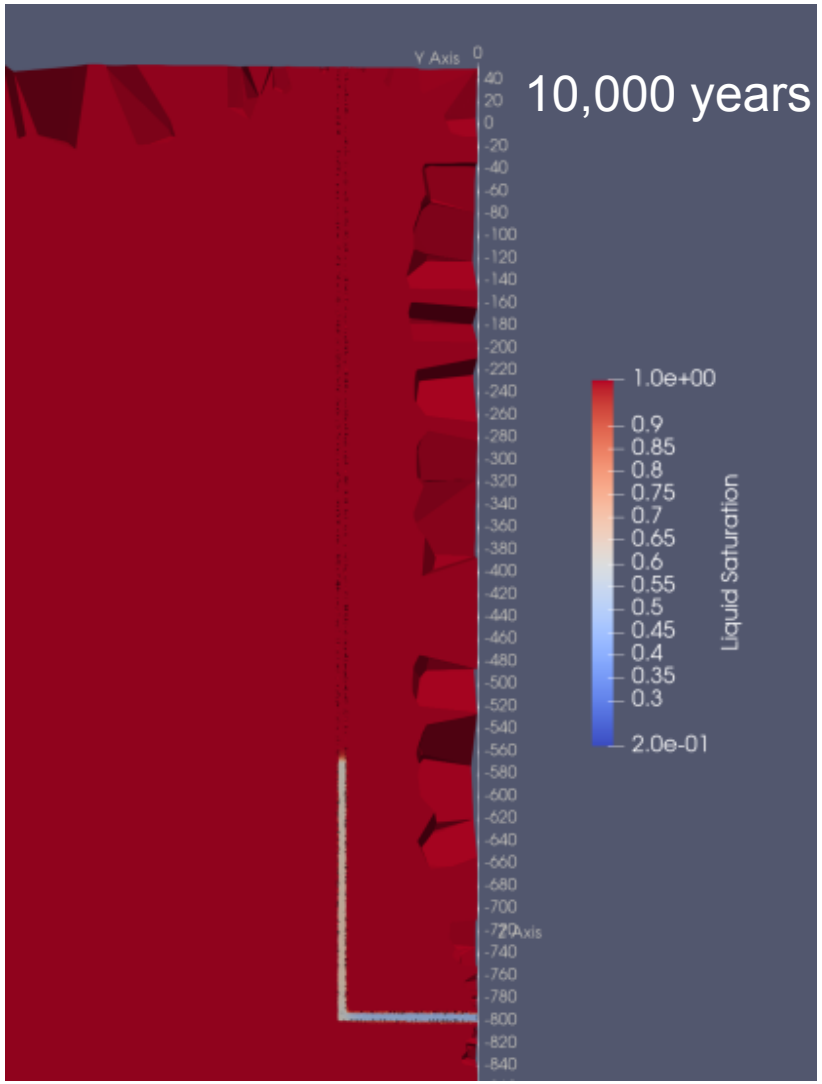
Richards Mode – 50,000 Years

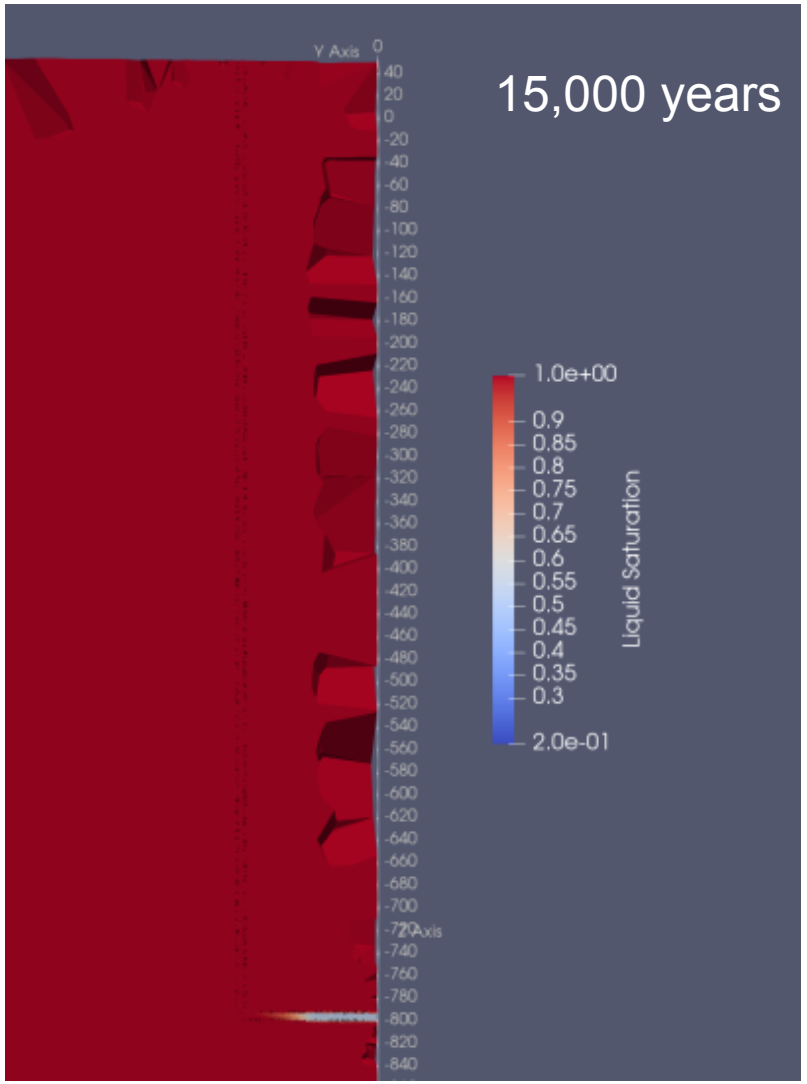




Shaft Saturation Results







Next Steps

- Continue working with both General and Richard's mode
- Add transport – starting with tracers
- Update material properties
  - Different permeability and porosity between salt and seals, backfill, etc.
- Simulate shaft seal failure
  - Potentially discretize shaft seal (may have issues with convergence due to how small some grid cells may be)
- Geologic layers
  - At minimum add high permeability overburden
- Implement creep closer
  - Stepped permeability?
- Regional pressure gradient needs to be added