SAND2019-14726PE

ATA / Org. 1558 Interchange: WIPP Geomechanics

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Org. 1558, Computational Material Mechanics

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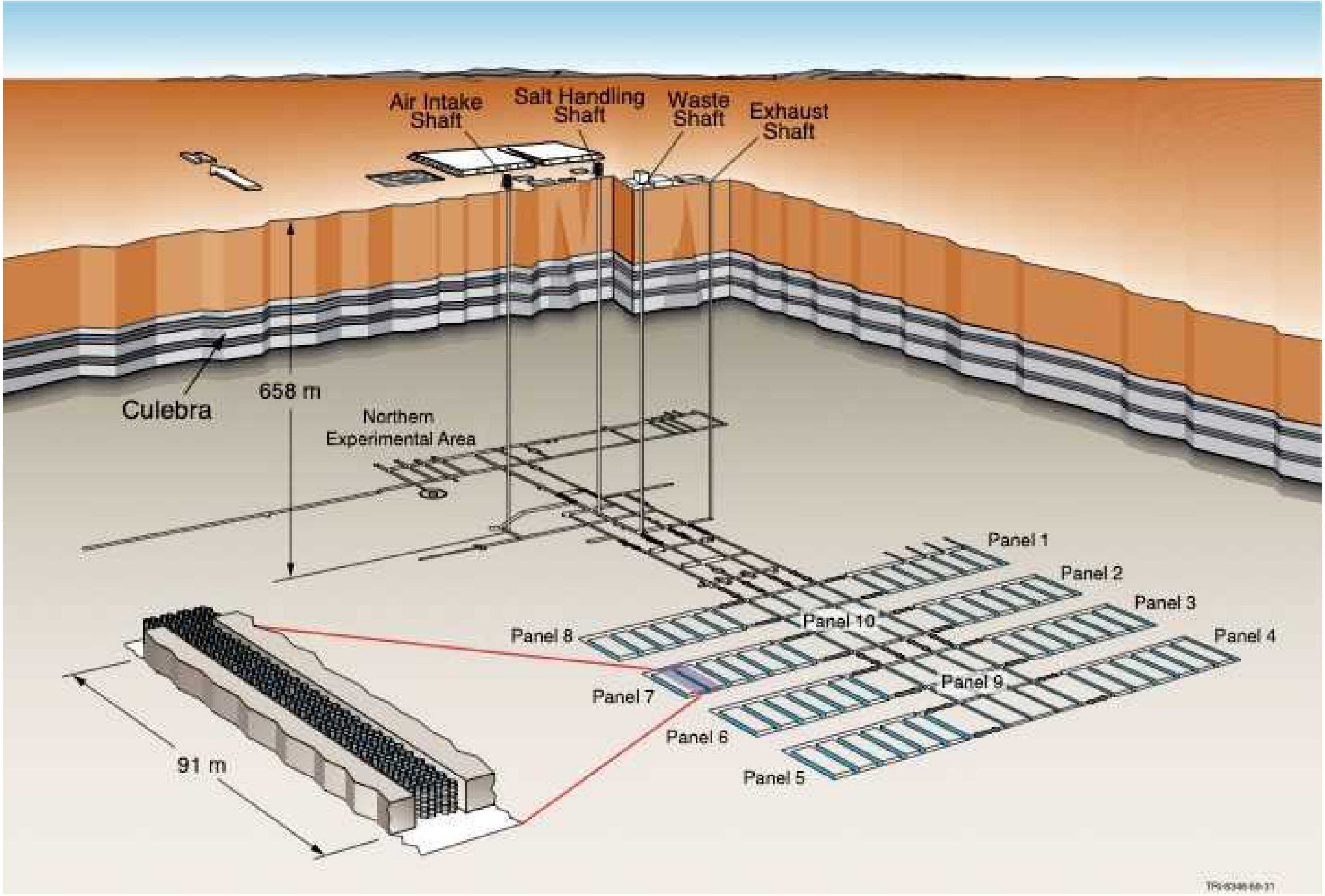
Background

Salt's Advantages for Nuclear Waste Isolation

1. Intact salt, without cracks, is virtually impermeable to fluid flow.
2. Cracks heal with sufficient confining pressure and time.
3. Salt viscoplastically flows in the presence of shear stress.
4. Salt is a good thermal conductor.

WIPP Location

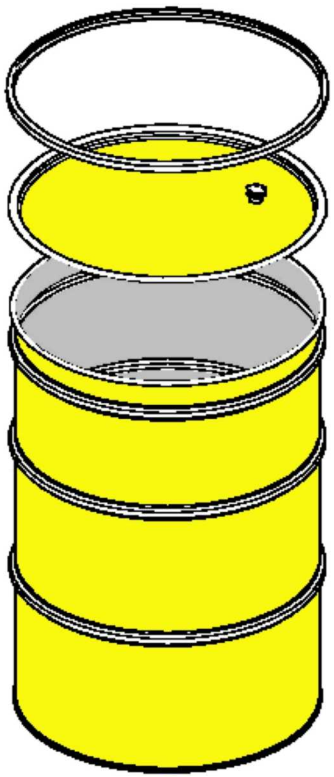
WIPP Layout


Air Intake Shaft
Salt Handling Shaft
Waste Shaft
Exhaust Shaft
Culebra
658 m
Northern Experimental Area
Panel 1
Panel 2
Panel 3
Panel 4
Panel 10
Panel 8
Panel 9
Panel 7
Panel 6
Panel 5
91 m

Waste Compaction

Standard Waste Containers

Schematic

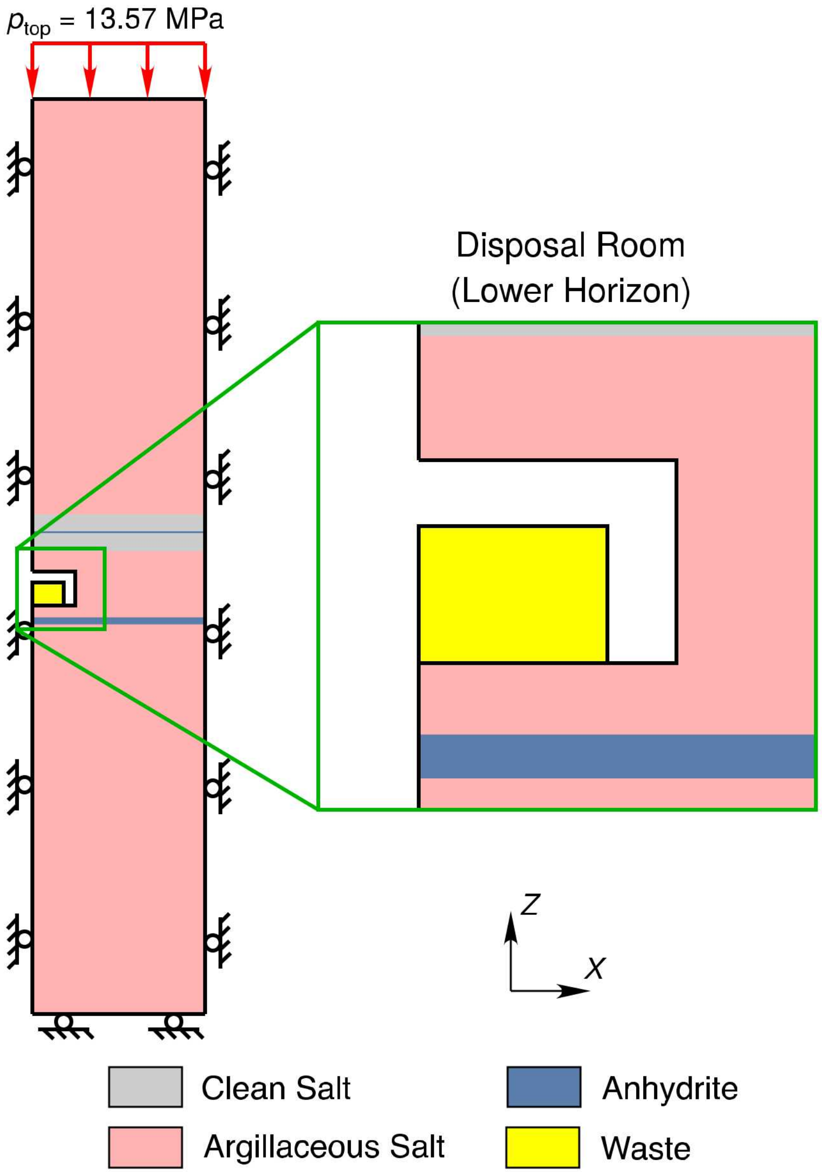


Park, B.Y. and Hansen, F. D., “Determination of the Porosity Surfaces of the Disposal Room Containing Various Waste Inventories for WIPP PA”, 2005, SAND2005-4236

Photo (with surrogate waste)

Broome, S.T., Ingraham, M.D., Flint, G.M., Hileman, M.B., Barrow, P.C., and Herrick, C.G., “Laboratory Testing of Surrogate Non-degraded Waste Isolation Pilot Plant Materials”, 2016, American Rock Mechanics Assoc., ARMA 16-120

Homogenized Waste Compaction

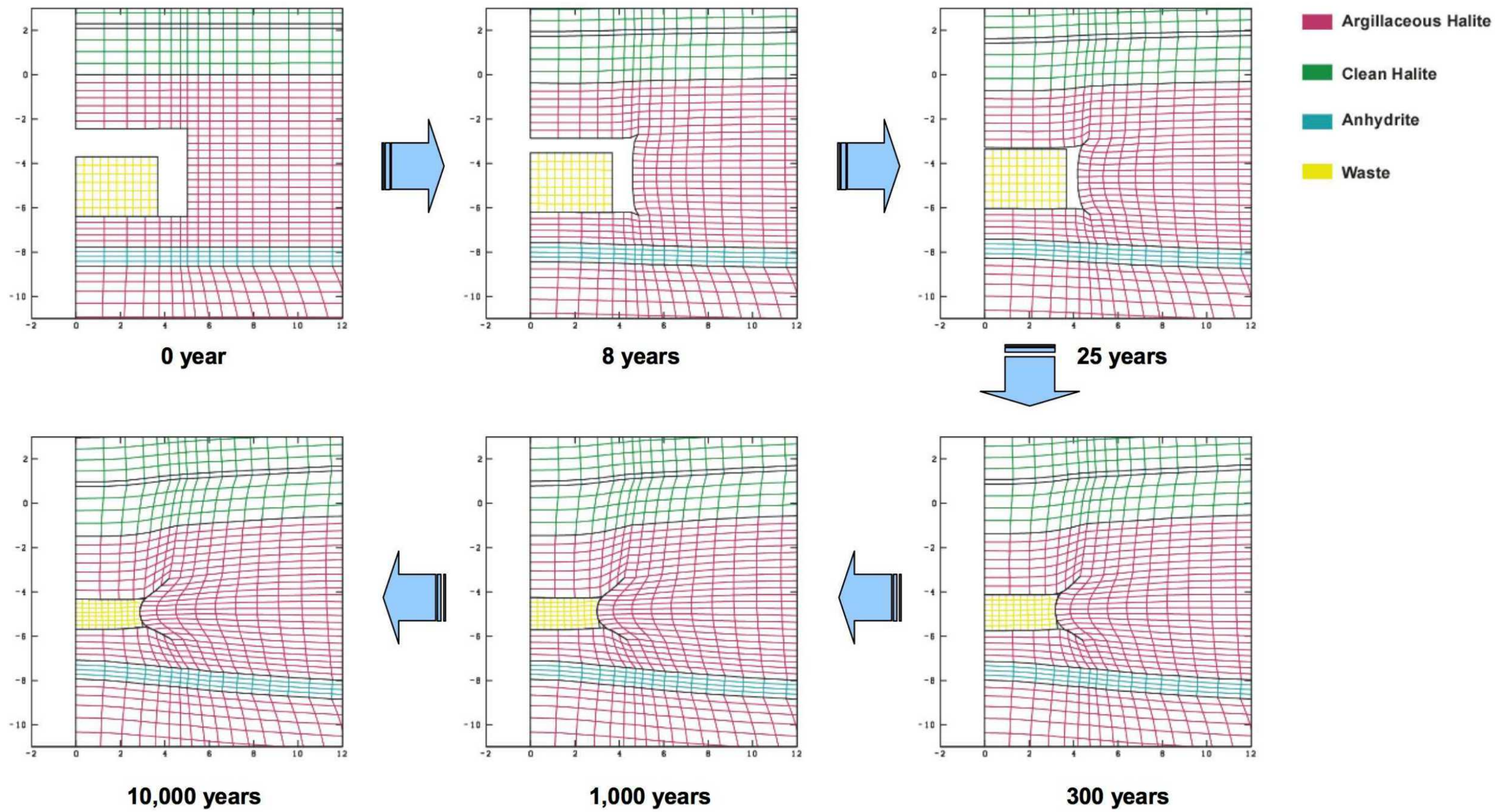


1. Clean and Argillaceous Salt
   a. Munson-Dawson model
   b. Primary & Secondary Creep
   c. No damage / fracture

2. Anhydrite
   a. Drucker-Prager yield surface
   b. No pressure cap
   c. Elastic perfectly plastic

3. Waste
   a. Drucker-Prager yield surface
   b. Includes pressure cap
   c. Elastic perfectly plastic

Homogenized Waste Compaction



Park, B.Y. and Hansen, F. D., “Determination of the Porosity Surfaces of the Disposal Room Containing Various Waste Inventories for WIPP PA”, 2005, SAND2005-4236

New Container Design

Schematic

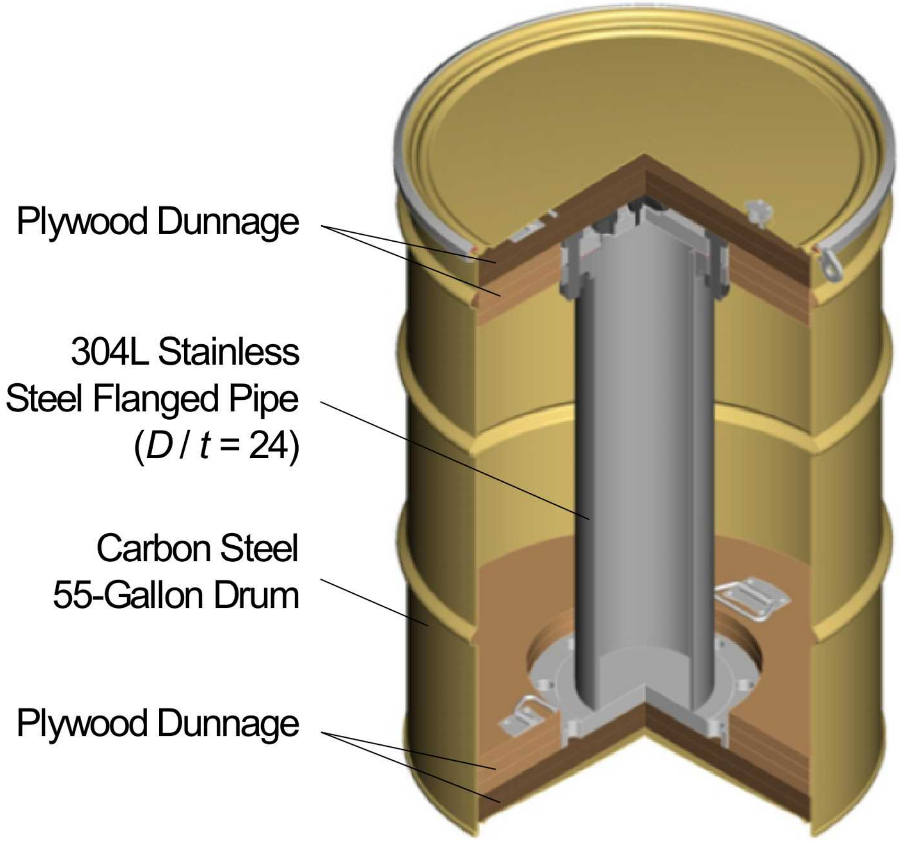
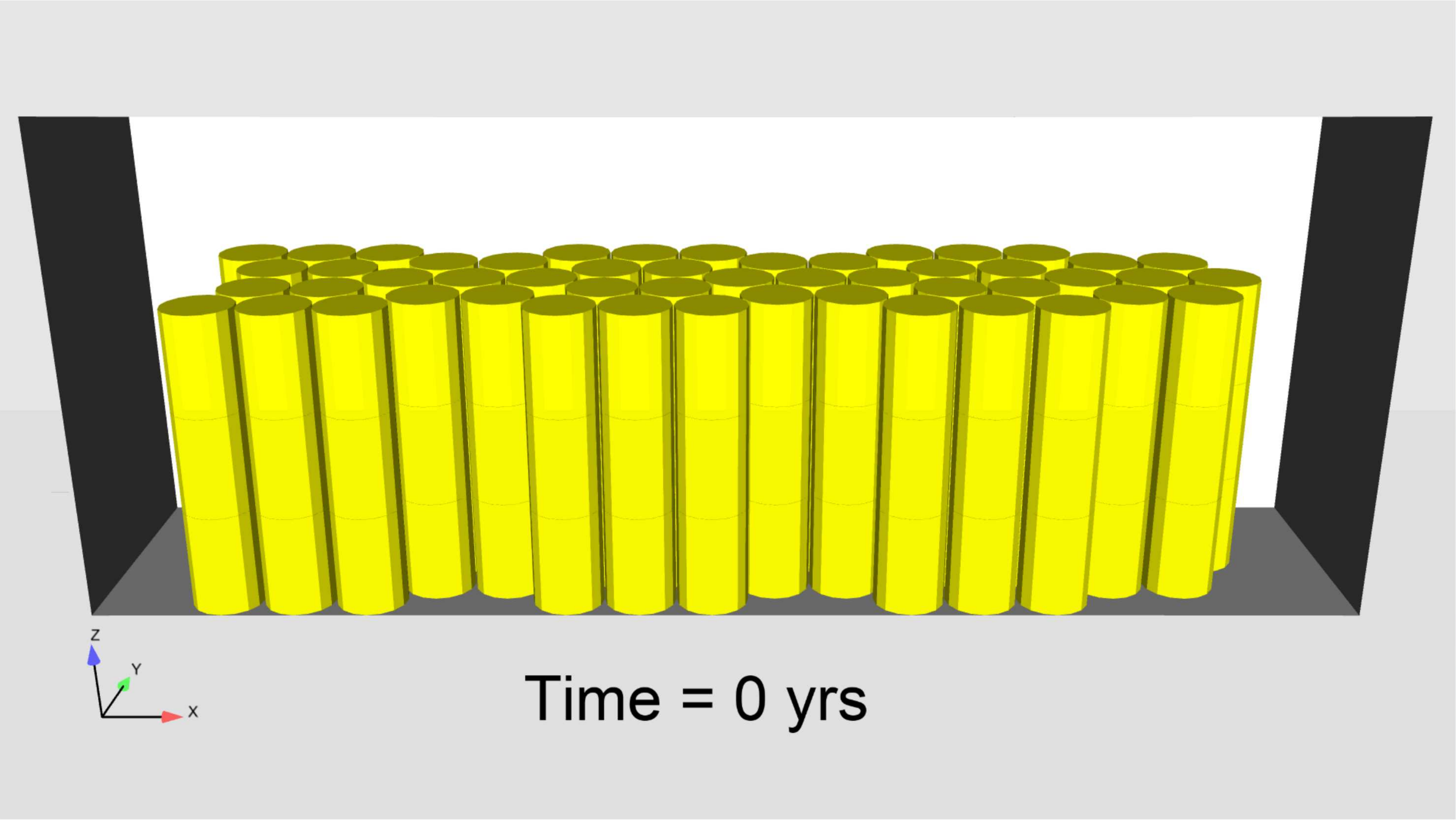


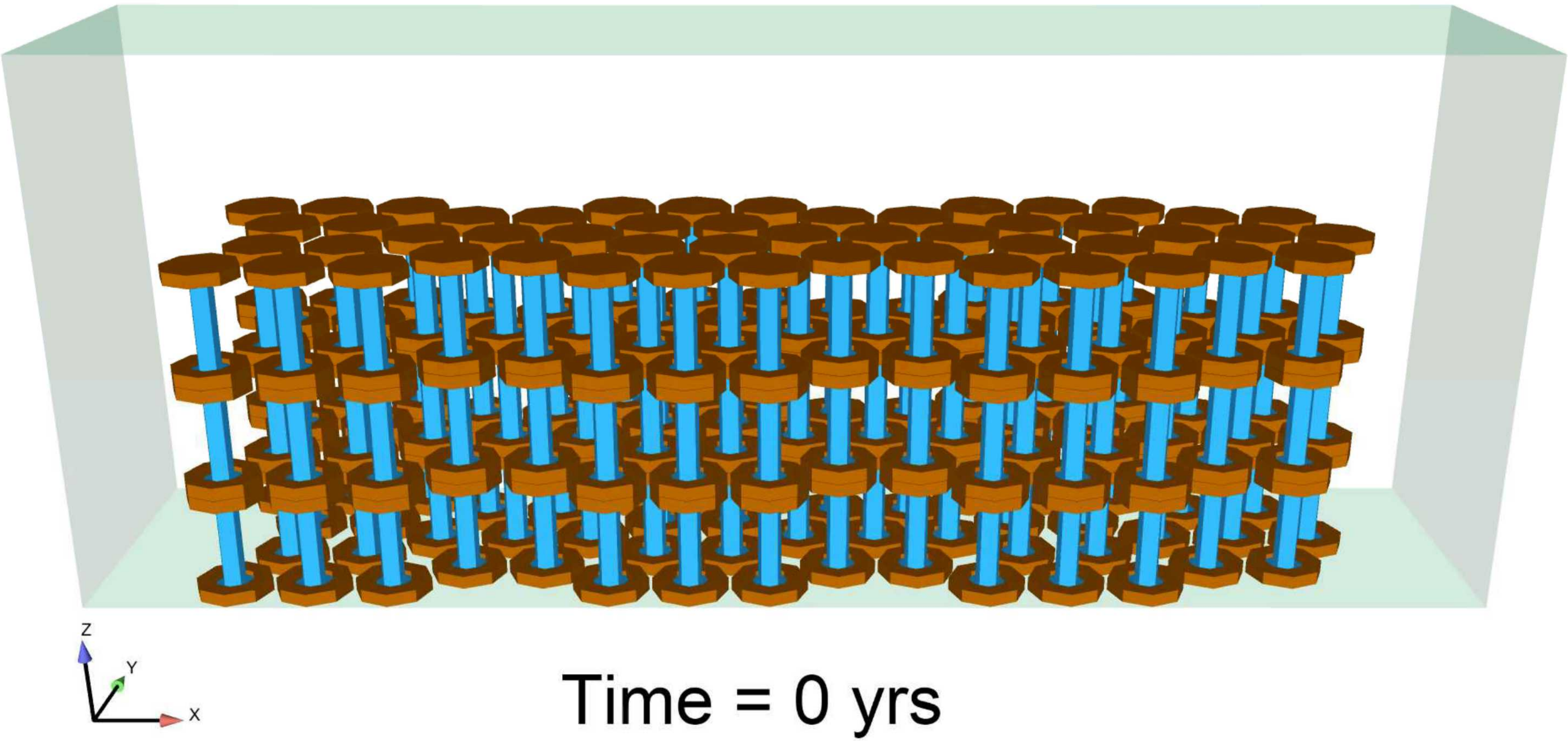
Photo
(lid and upper dunnage removed)

Discretized Waste Compaction



Simulation courtesy of James Bean

Discretized Waste Compaction



Simulation courtesy of James Bean

Empty Room Collapse and Reconsolidation

Examples of Rubble Piles from Roof Falls

Upper Horizon

Lower Horizon

Relevant Physical Phenomena

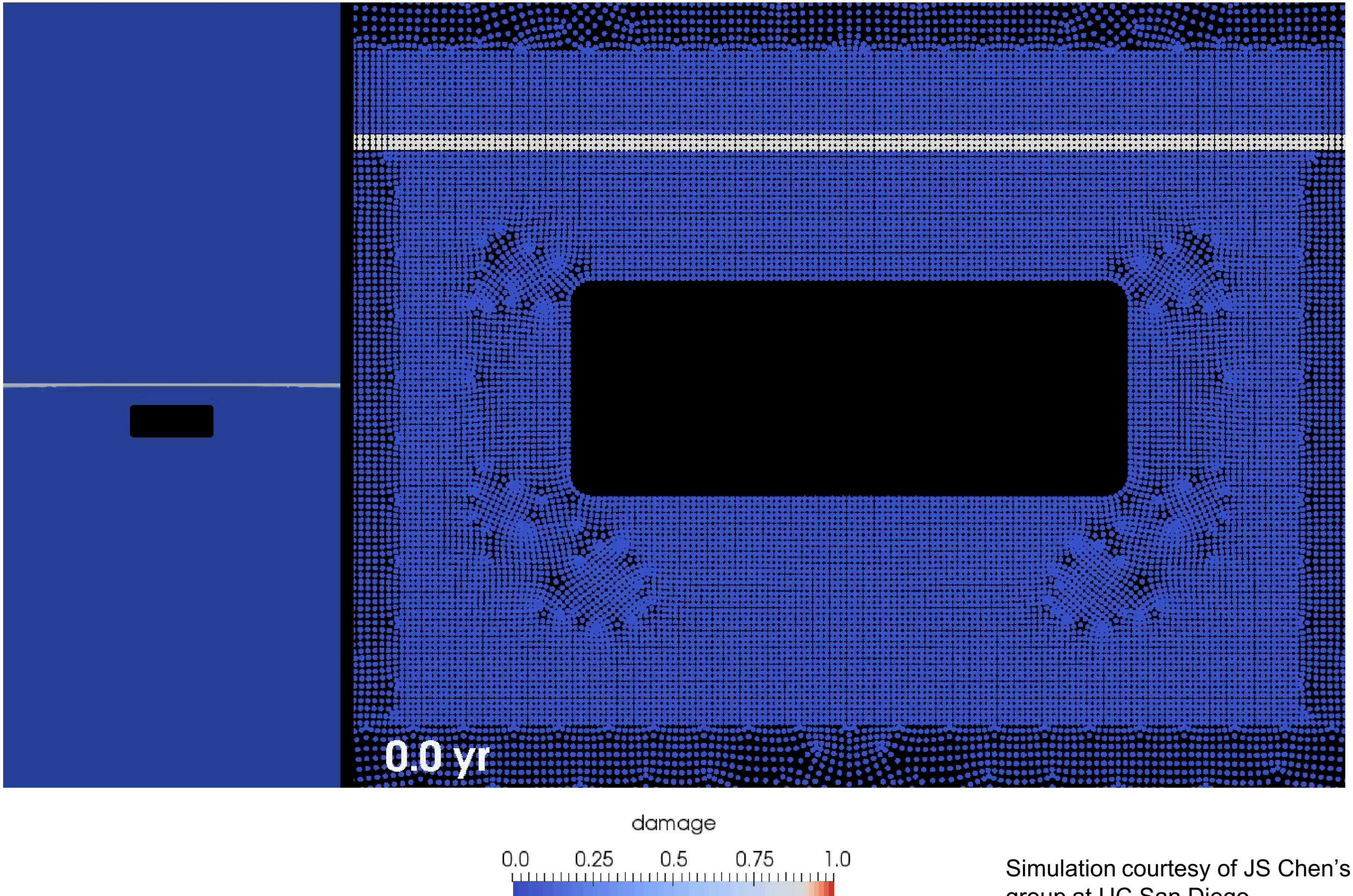
1. Gradual room closure
   a. Driving force for empty room closure

2. Fracturing around room
   a. Changes room shape and size
   b. Controls the size and character of rubble pile

3. Rubble pile reconsolidation
   a. Involves rearrangement, fracture, dislocation-based viscoplasticity, and pressure solution redeposition
   b. Rubble supplies back pressure

4. Flow through the rubble pile
   a. Depends on flow network as well as pathway size, roughness, and tortuosity.

Room Collapse and Reconsolidation Simulation



Simulation courtesy of JS Chen's group at UC San Diego

Potential Future Work

Potential Future Work

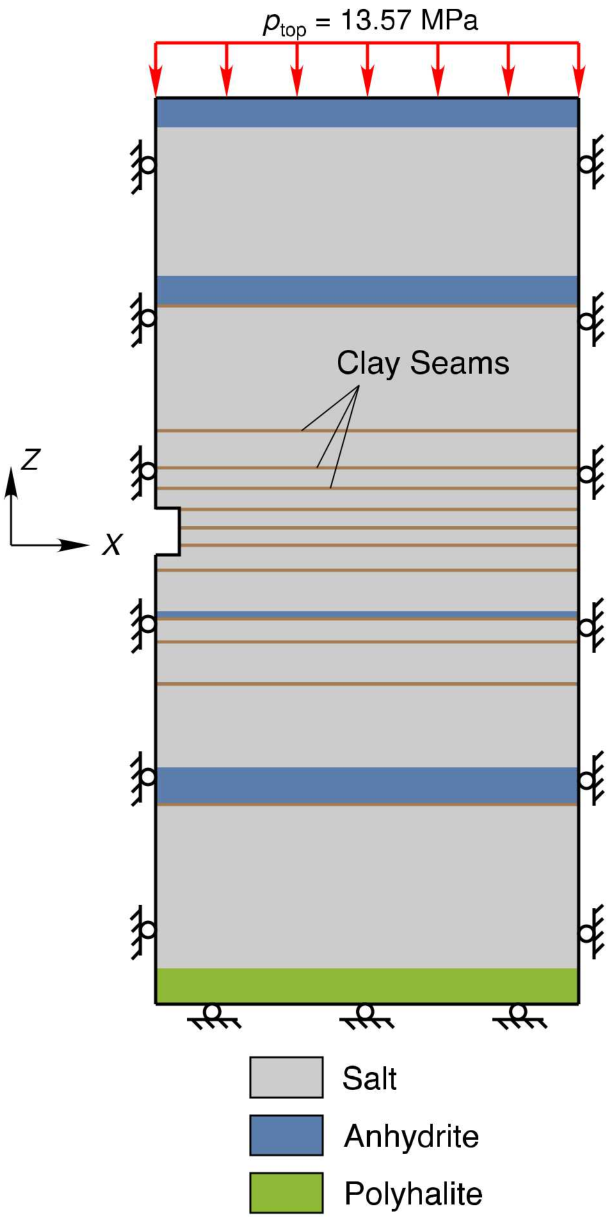
1. Gradual room closure
   a. Improve intact salt model
   b. Reassess anhydrite model
   c. Create a clay seam model
   d. Improve crushed salt model

2. Waste compaction
   a. Study whether roof falls are important
   b. Improve standard waste constitutive model
   c. Investigate container homogenization
   d. Uncertainty quantification

3. Empty room collapse and reconsolidation
   a. Add damage and healing to intact salt model
   b. Implement a meshless method into Sierra/Solid Mechanics
   c. Validate against crushed salt experiments and natural analogs
   d. Uncertainty quantification

Extra Slides

Gradual Room Closure



1. Salt
   a. Munson-Dawson model
   b. Primary & Secondary Creep
   c. No damage / fracture

2. Anhydrite and Polyhalite
   a. Drucker-Prager model
   b. Elastic perfectly plastic

3. Clay Seams
   a. Coulomb friction

Gradual Room Closure Validation