# Assessing Engineered Systems in Geologic Repositories: WIPP

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**Sandia National Laboratories**

**Albuquerque New Mexico**

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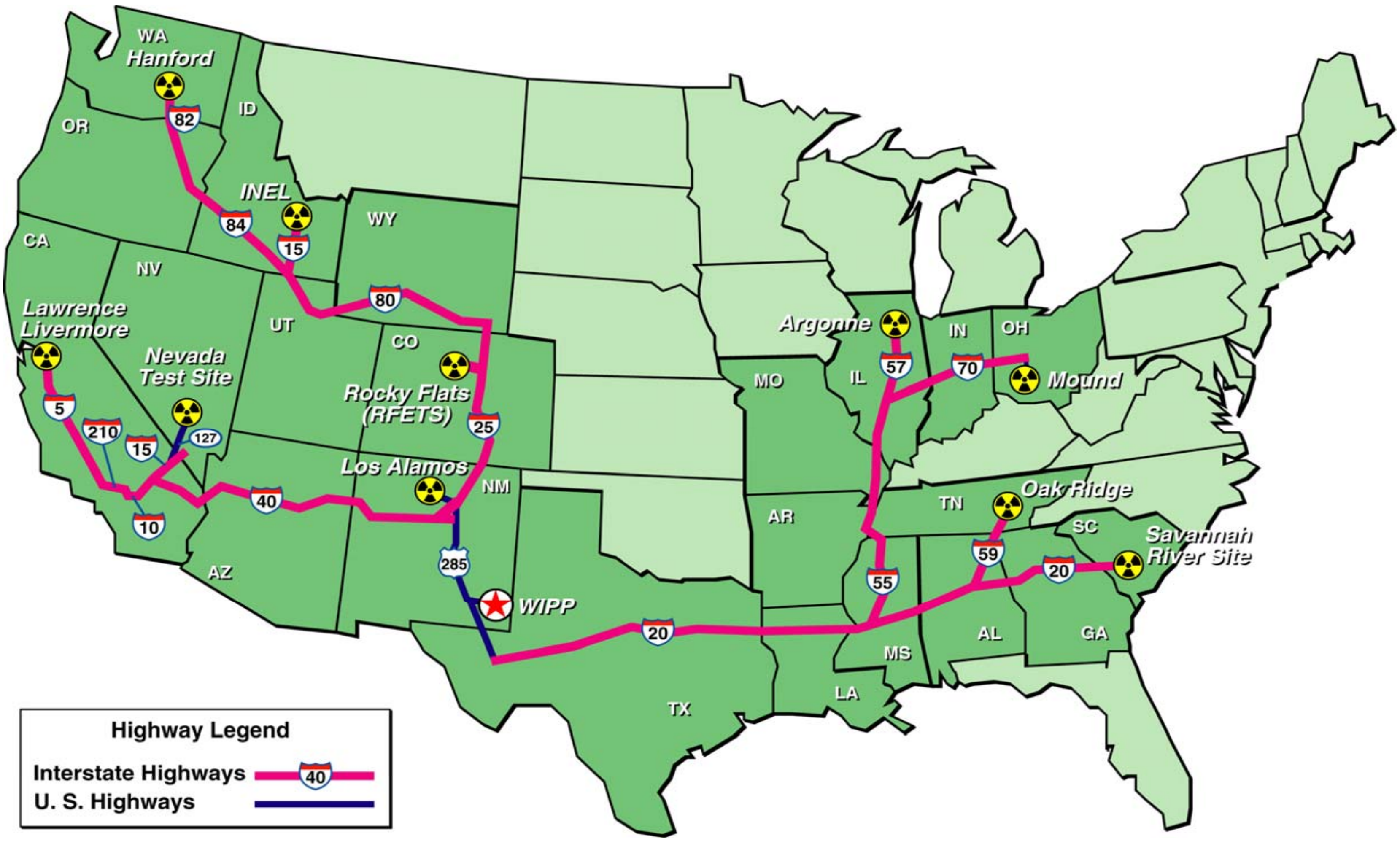
# WIPP: A Solution of a National Problem



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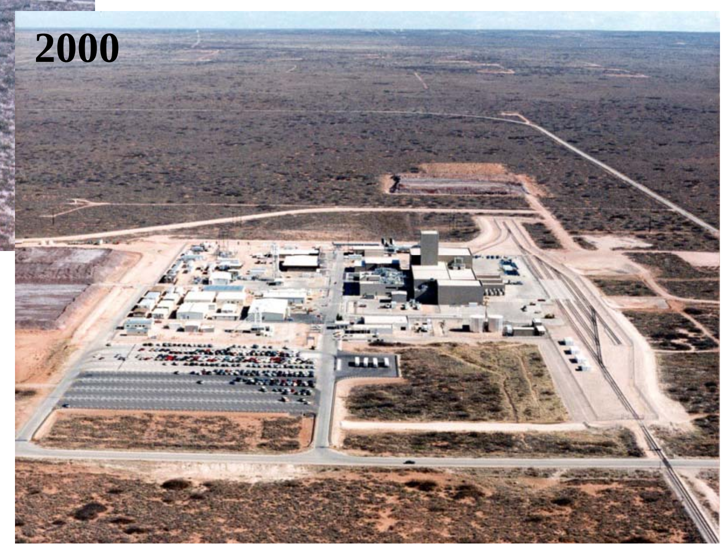
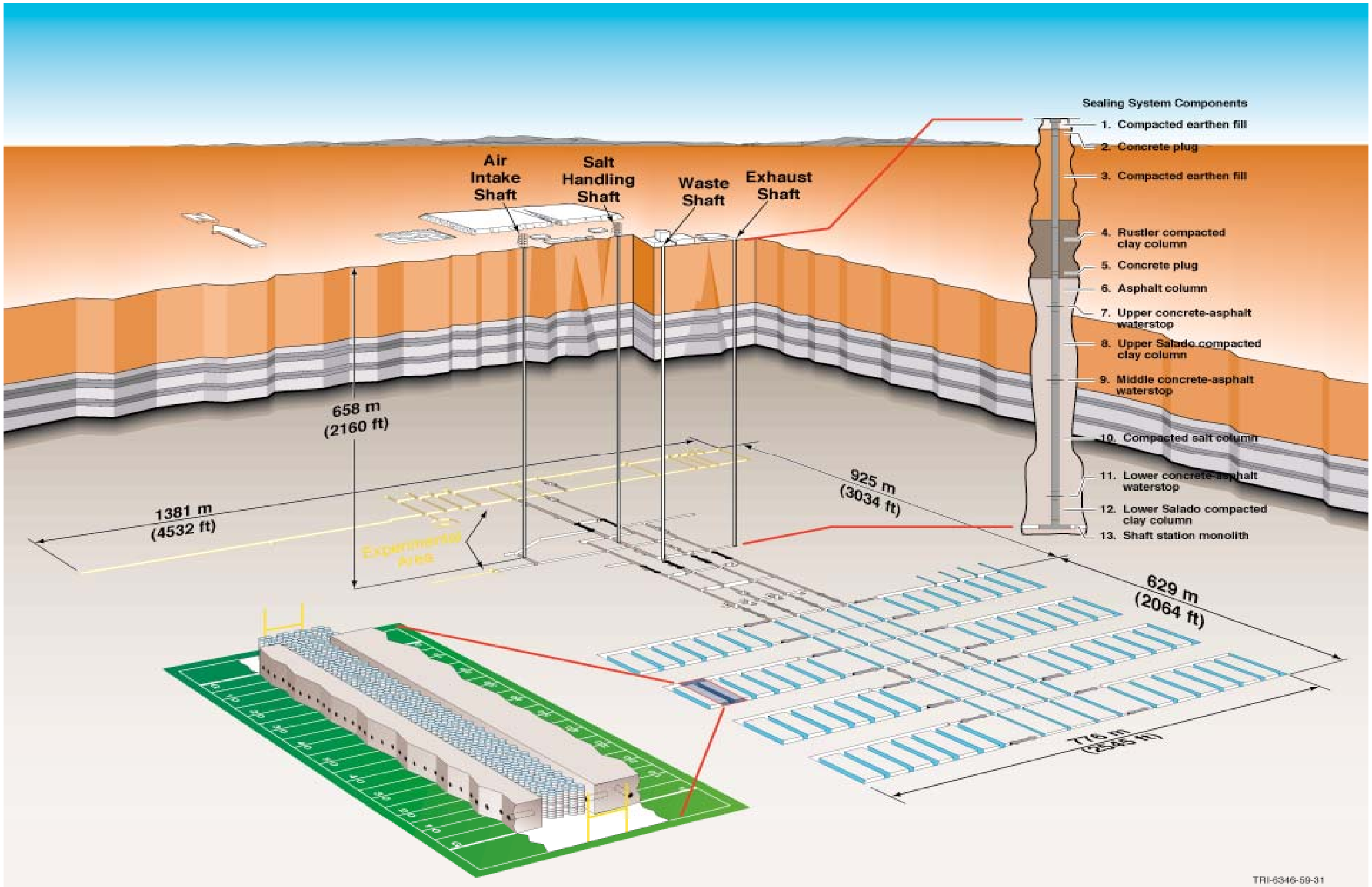
# Waste Isolation Pilot Plant Chronology 1975-2009





# WIPP Underground Layout



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# Bedded Salt Was Chosen for the Siting of the US Defense Nuclear Wastes

- Salt can be mined easily
- Salt has a relatively high thermal conductivity
- Wide geographic distribution (many potential sites)
- Salt is plastic *
- Salt is essentially impermeable *
- Fractures in salt are self healing *
- Salt has existed underground for millions of years *

* Attributes of Natural Barrier

# Assessing Engineered Barriers

EPA defines barriers as “any material or structure that prevents or substantially delays movement of water or radionuclides toward the accessible environment”

1. Salt – the Most Important Barrier
2. Shaft Sealing System
3. Panel Closure System
4. Magnesium Oxide Engineered Barrier
5. Materials Interaction

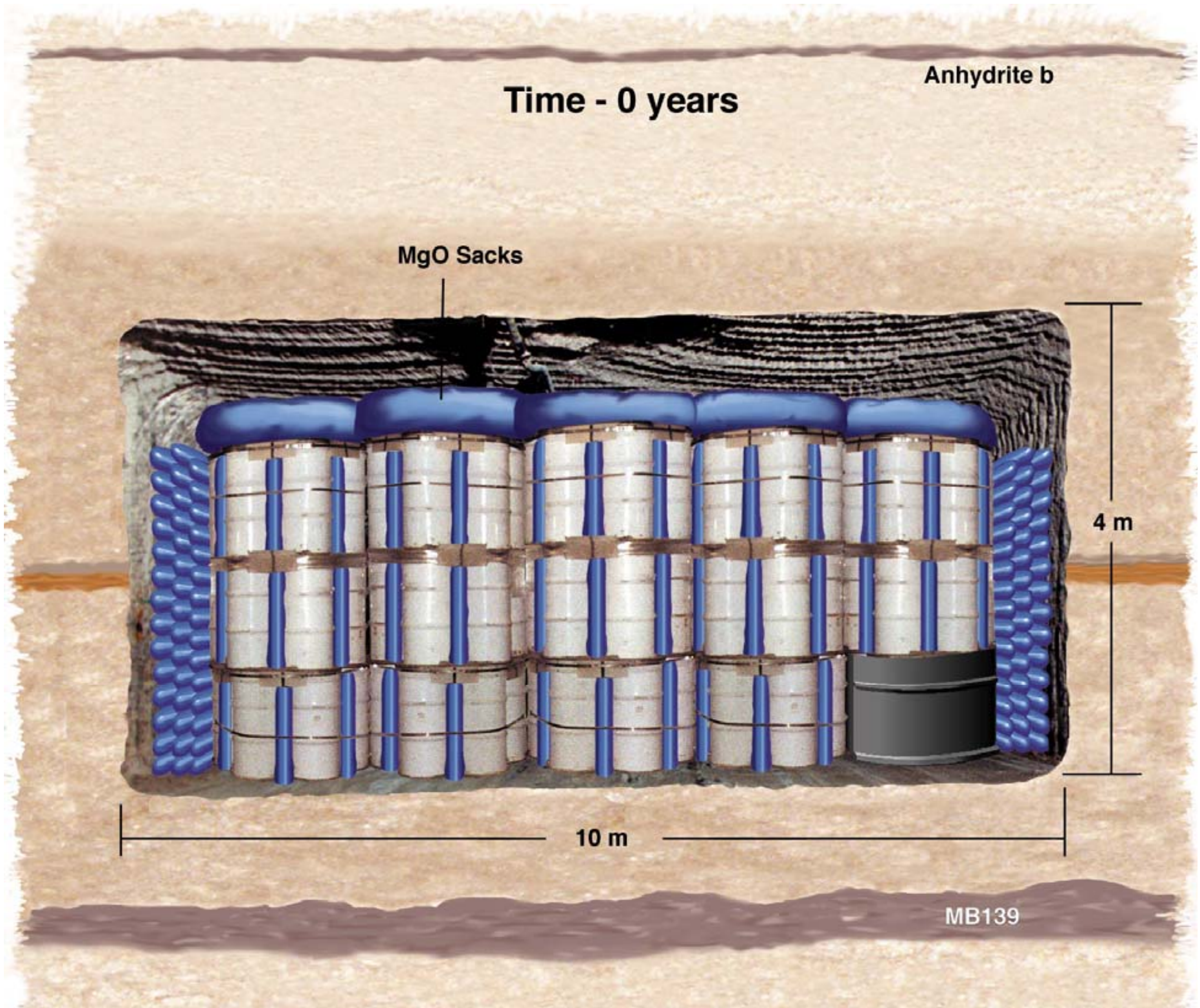
Discussion will reverse the order

# Waste Package Performance

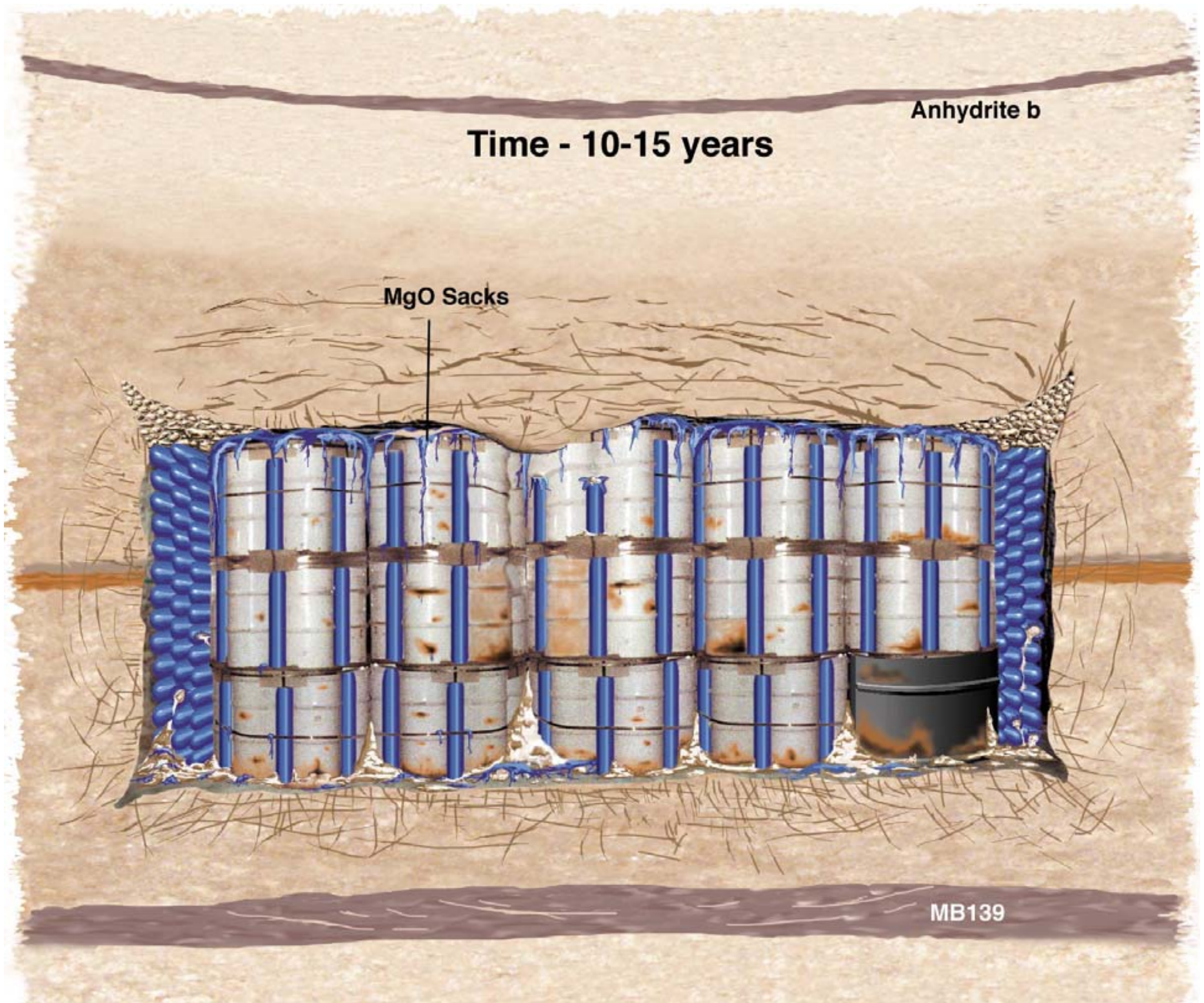
- HLW waste package material
- Materials Interface Interaction Tests
- Simulated RH and CH TRU corrosion/durability
- BAMBUS II
- Potash Basin Experience (1930’s)

# WIPP Disposal Room Evolution

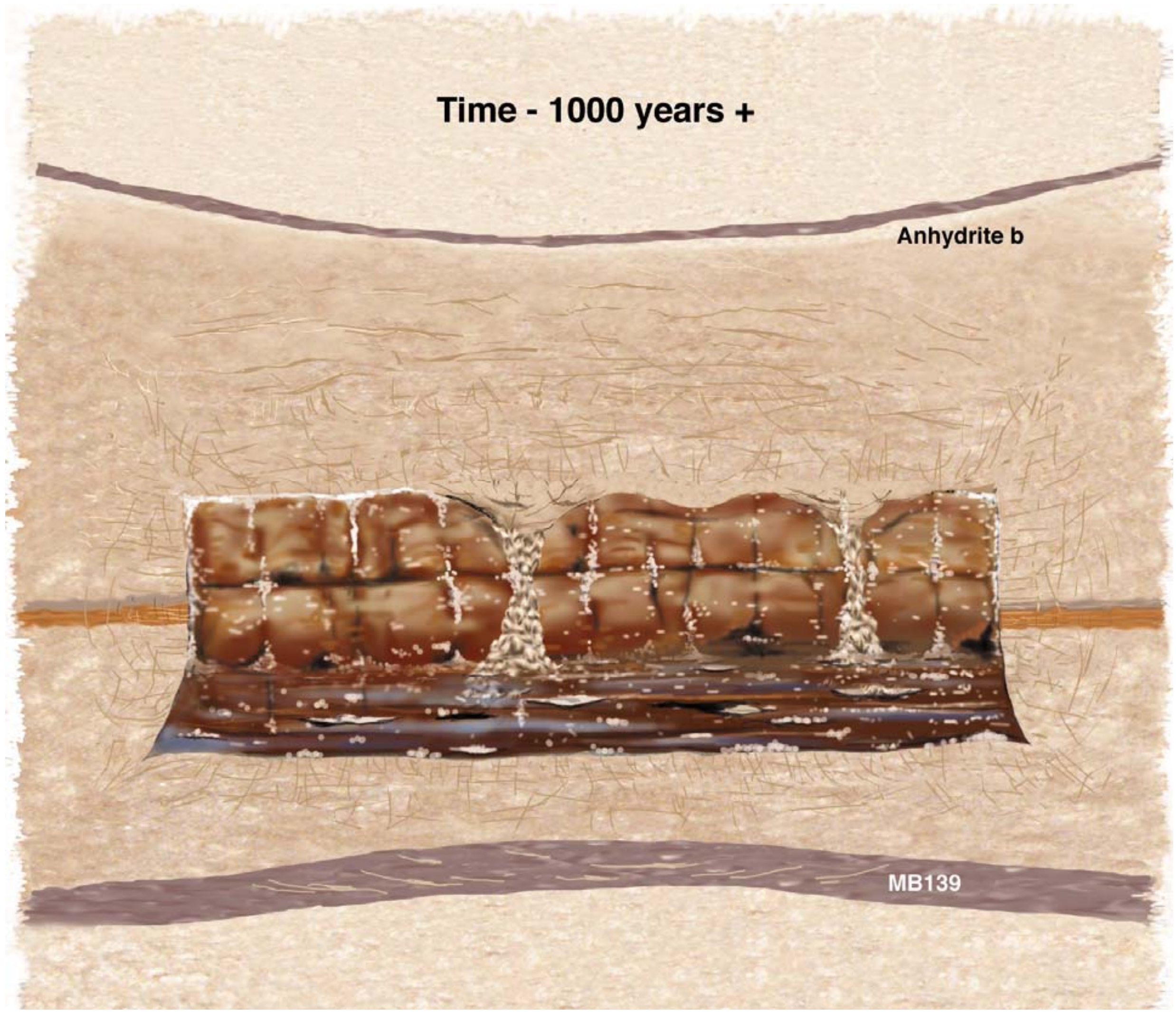
# WIPP Room Evolution at Time=0 years



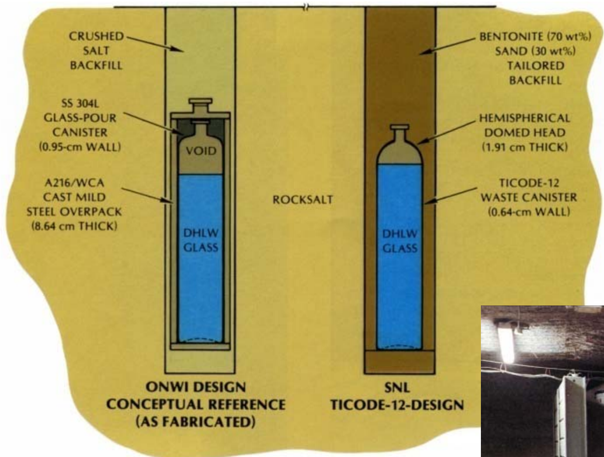
# WIPP Room Evolution at Time=12 years

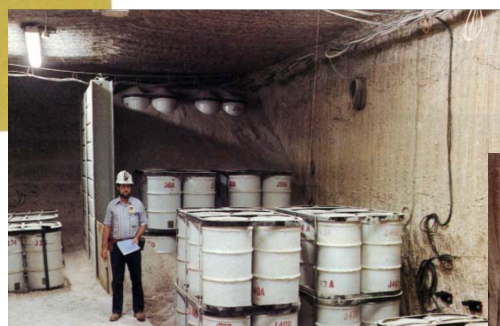


# WIPP Room Evolution at 1000 years



# Waste Package Interactions



# MgO Engineered Barrier

- MgO will act as an engineered barrier in the WIPP by decreasing actinide solubilities.
- Control $P_{CO2}$ and pH within favorable ranges.
- Only engineered barrier recognized by EPA.
- Ongoing lab studies imply MgO will effectively remove $H_2O$ and $CO_2$.



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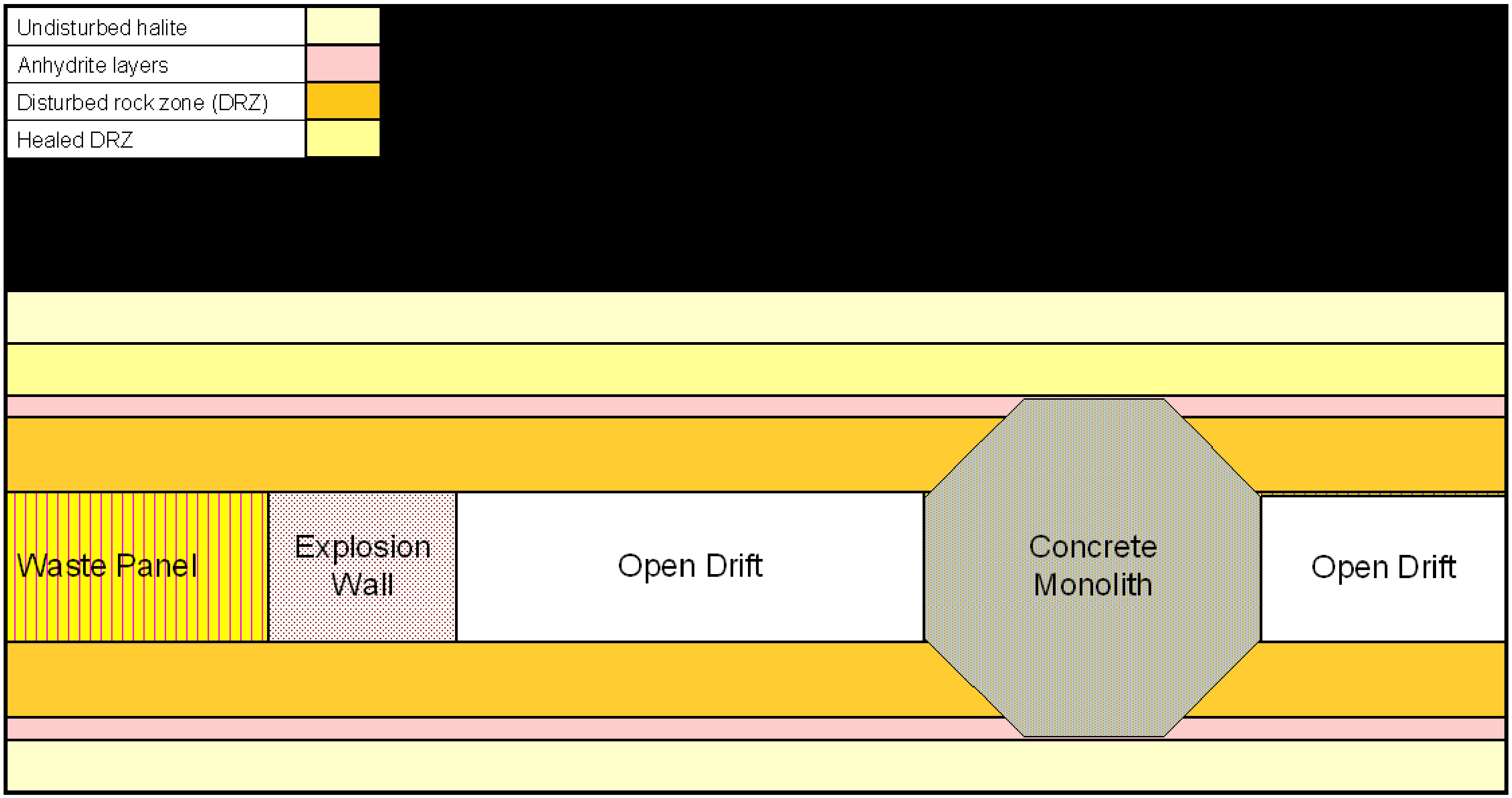
# Option D Panel Closure System



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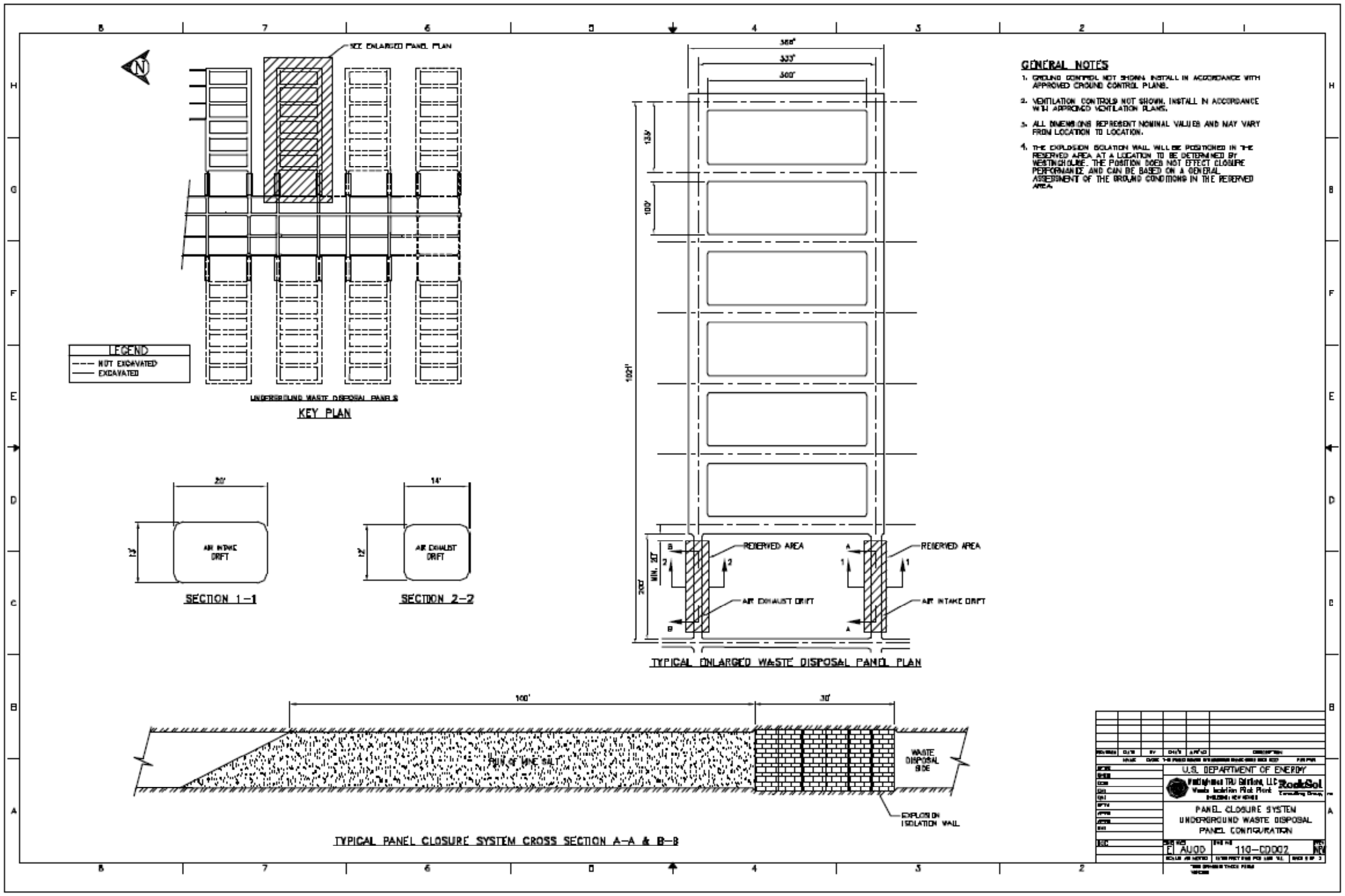
# Proposed Panel Closure System



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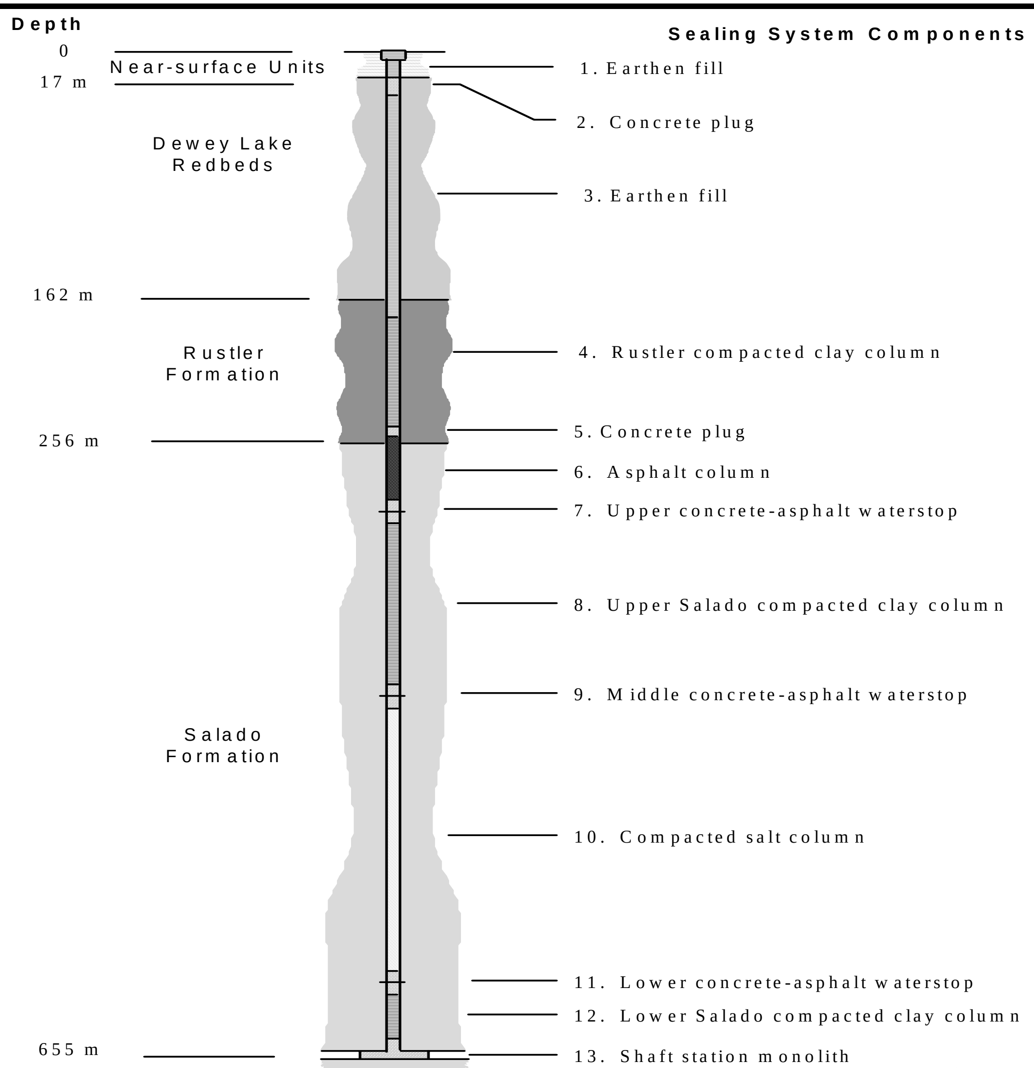
# Shaft Seal System Design Guidance

- Limit hazardous constituents reaching regulatory boundaries
- Restrict groundwater flow through the sealing system
- Use materials possessing mechanical and chemical compatibility
- Protect against structural failure of system components
- Limit subsidence and prevent accidental entry
- Utilize available construction methods and materials

# Shaft Sealing System



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# Shaft Seal System Conclusions

- The WIPP shaft seal system effectively limits fluid flow within the seal system.
- The salt column becomes an effective barrier to gas and brine migration by 100 years after closure.
- Long-term flow rates within the seal system are limited.

# Natural Barrier – It's the salt

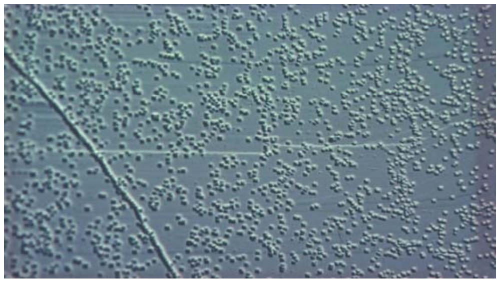
Salt formations are used for disposal at WIPP.

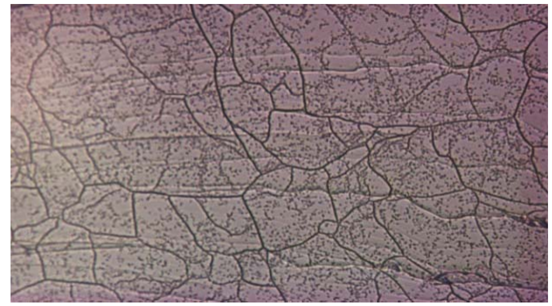
Germany has several disposal facilities for toxic and radioactive waste in salt:

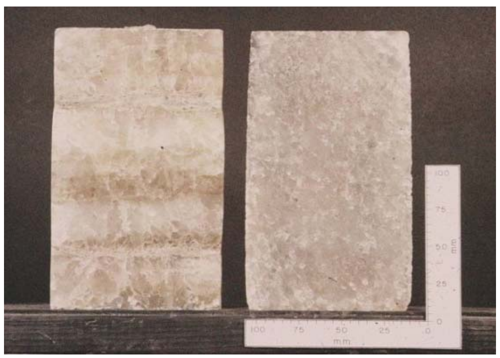
- Herfe-Neurode
- Morsleben
- Asse

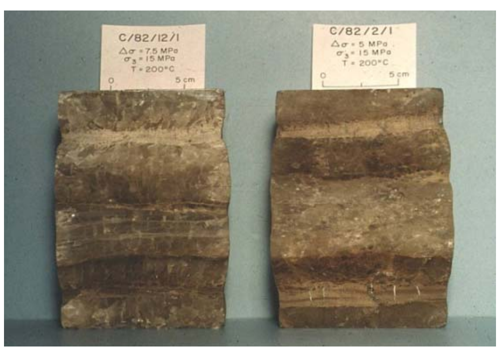
Salt is an attractive disposal medium. Additional heat from the disposed waste can accelerate encapsulation. Salt provides a viable disposal option for heat-generating nuclear material, such as fission products resulting from recycling fuel rods

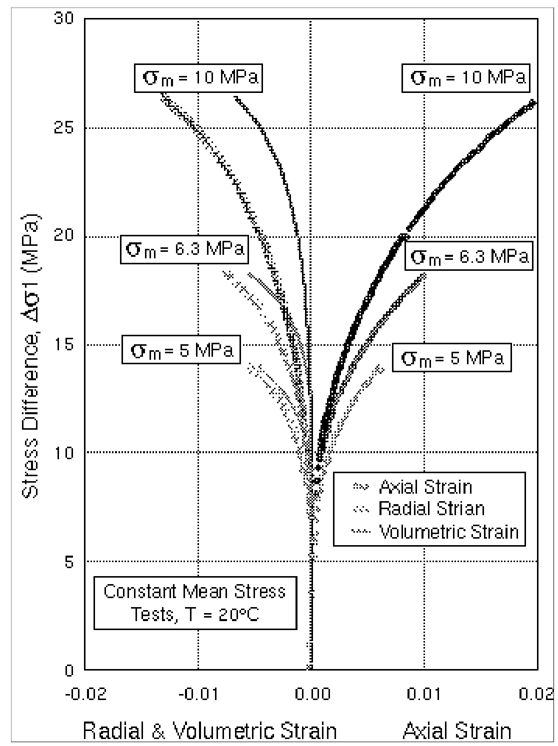
# Salt Behavior is well Understood



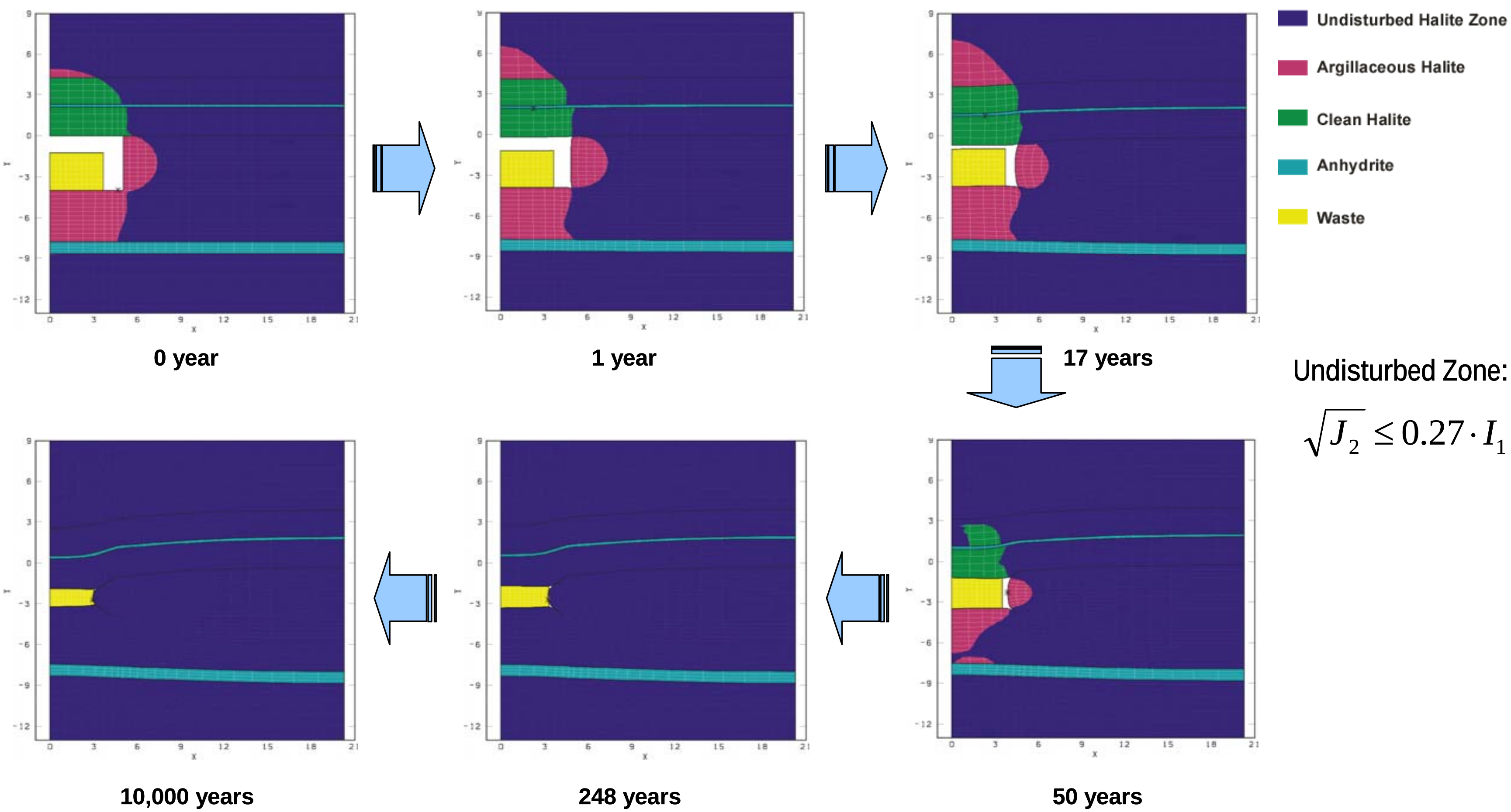








# Disturbed Rock Zone around a Disposal Room




Undisturbed Zone:

$$\sqrt{J_2} \leq 0.27 \cdot I_1$$



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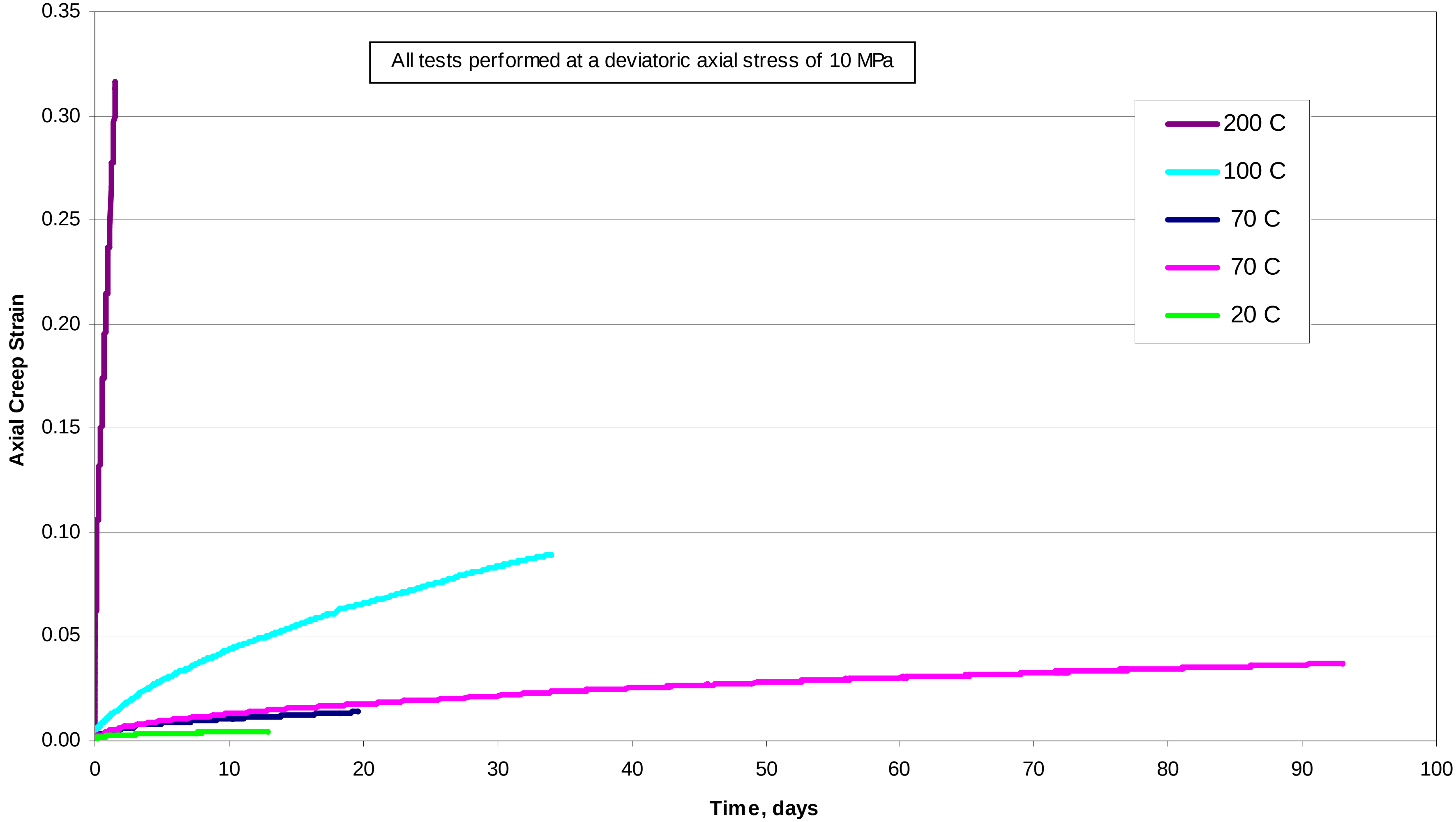
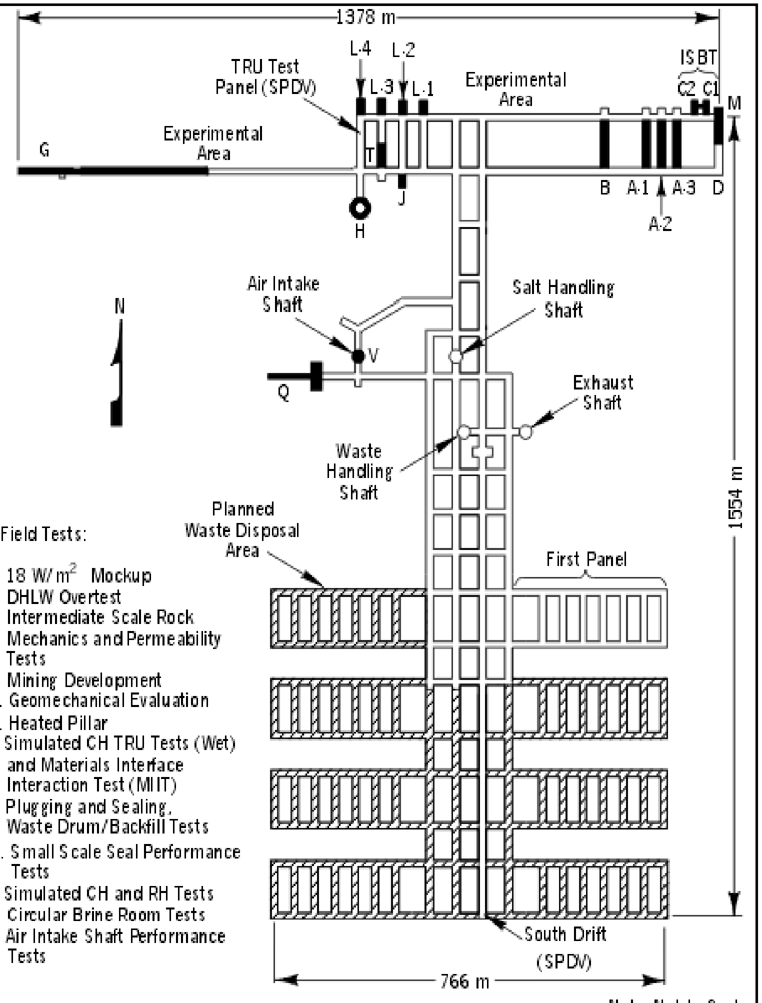
# Thermomechanical Response of Salt

- Thermal activation will increase creep of the salt
- Plastic creep deformation would enhance room closure and encapsulation
- WIPP's original mission included defense HLW and spent fuel
- Thus, there is a considerable amount of information on heat-generating waste in a salt repository

# Temperature Effect on Salt Deformation



# Major Tests in the WIPP




Field Tests:

A. 18 W/m² Mockup
B. DHLW Overtest
C. Intermediate Scale Rock Mechanics and Permeability Tests
D. Mining Development
G. Geomechanical Evaluation
H. Heated Pillar
J. Simulated CH TRU Tests (Wet) and Materials Interface Interaction Test (MIIT)
L. Plugging and Sealing, Waste Drum/Backfill Tests
M. Small Scale Seal Performance Tests
T. Simulated CH and RH Tests
Q. Circular Brine Room Tests
V. Air Intake Shaft Performance Tests

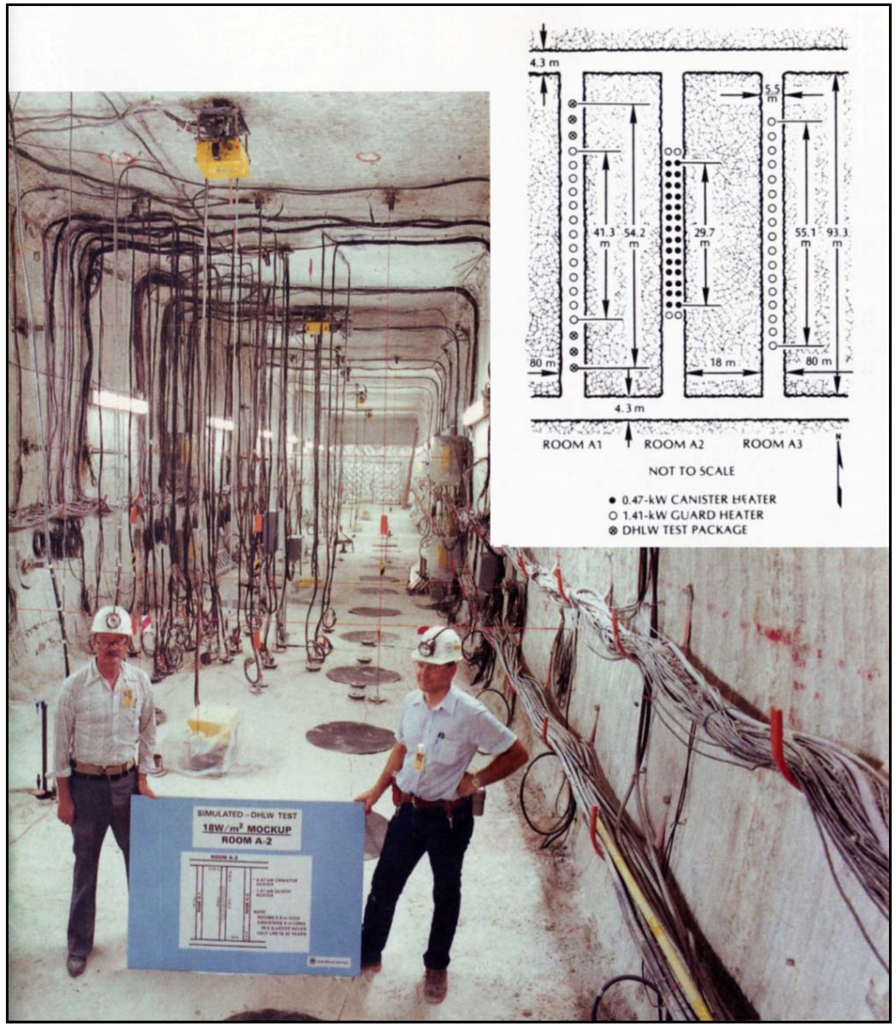
Salt and Interbed Permeability and Brine Seepage tests at numerous locations

# Axisymmetric Test with Insulation

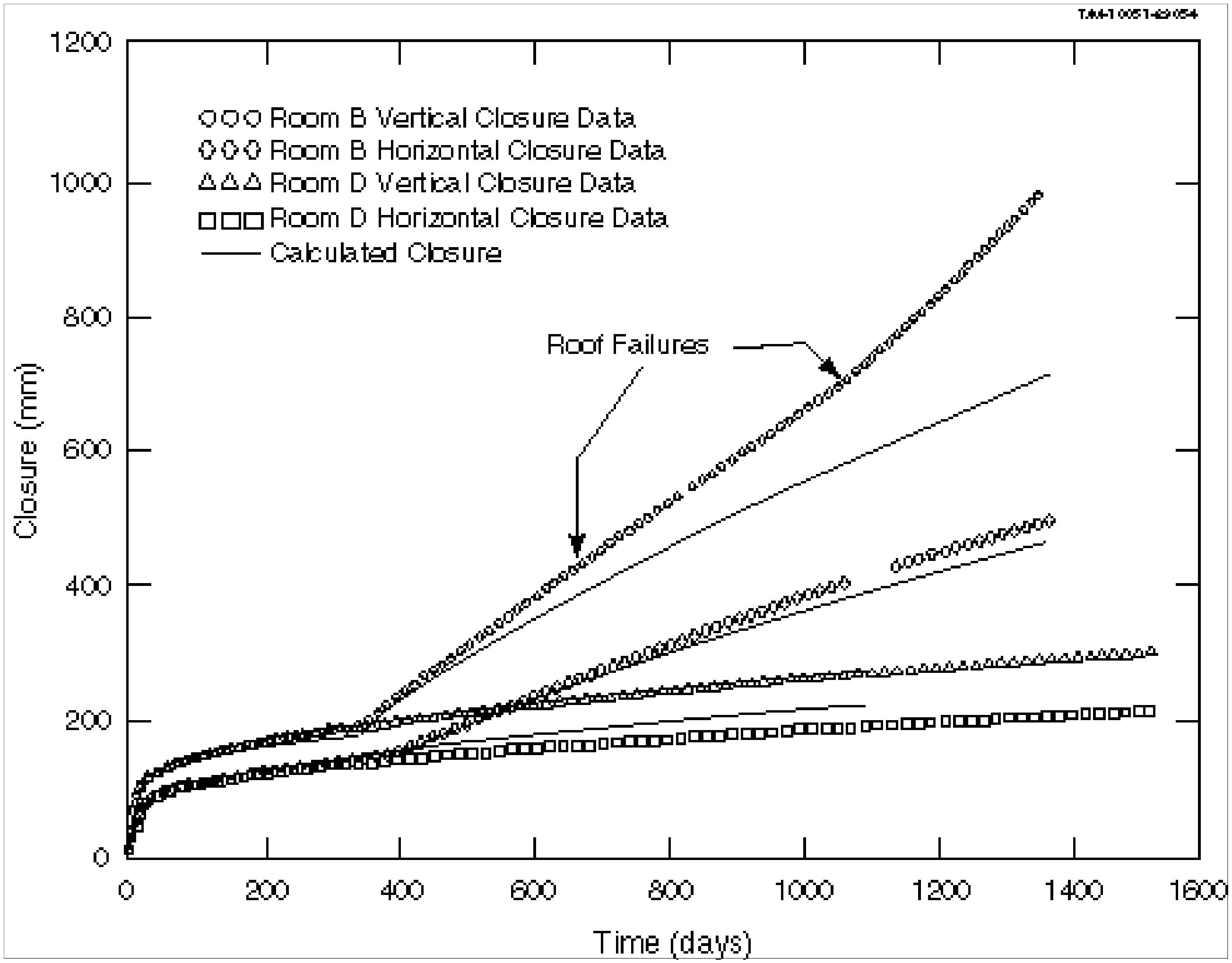
Room H

# 18 W/m$^2$ Thermomechanical Test

- "A" Rooms



# Measured vs. Predicted Room Closure



# Summary – It's the salt

- The concept of disposal of heat generating nuclear waste in salt has been considered viable for many years
- Thermal acceleration of plastic creep deformation can positively affect encapsulation
- A significant number of full-scale field demonstrations of heater tests in salt have been completed
- Salt remains an attractive medium for disposal of nuclear waste

# ReCap

- Several barriers engineered for WIPP
- No performance credit for waste package
- MgO engineered barrier (assurance)
- Panel closure performance implication
- Shaft seal system
- It’s the salt

  Next: Salt thermal studies indicate balance of local and far field heat provides considerable volume for disposal of large volumes of other possible inventories (GTCC).