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Salt Repository Geomechanics Research Agenda

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IAEA
International Atomic Energy Agency

DBE TECHNOLOGY GmbH

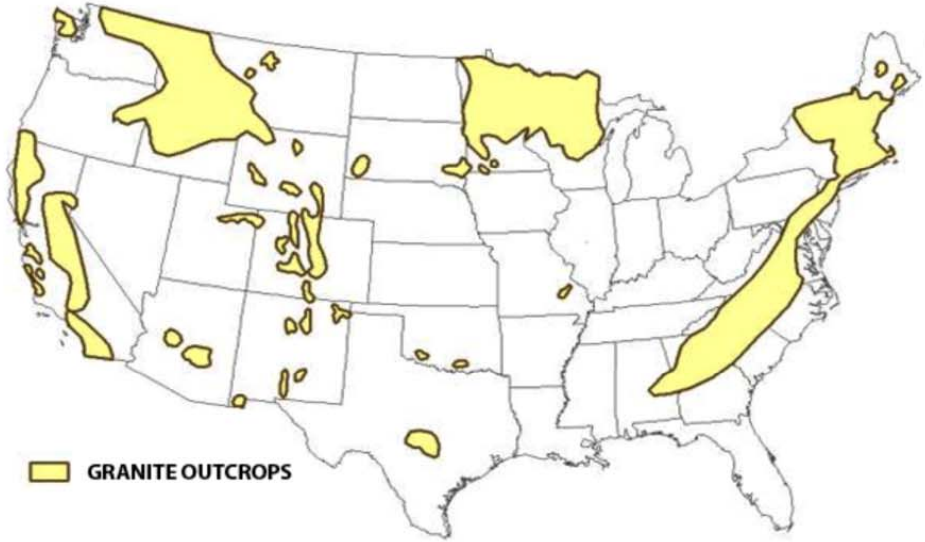
ITC
School of Underground Waste Storage and Disposal

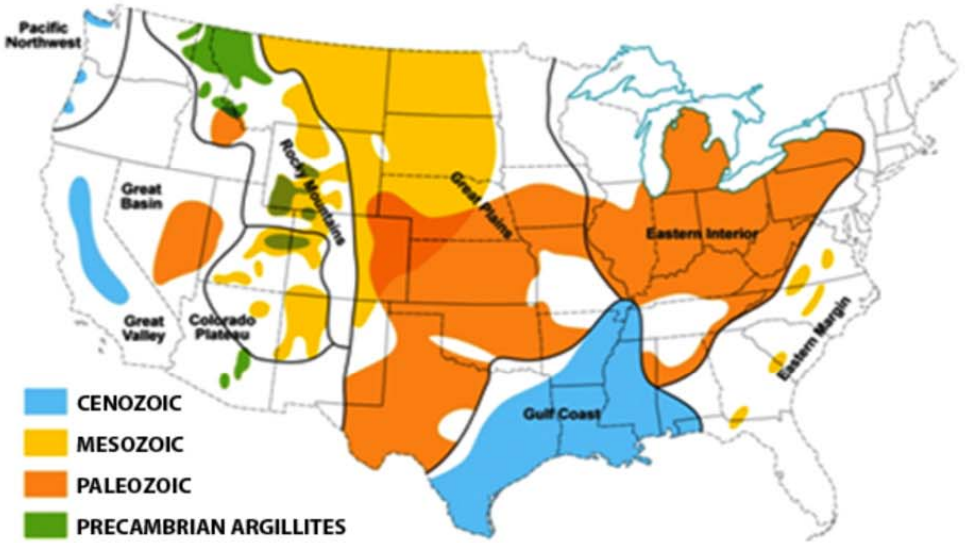
IAEA Network of Centres of Excellence

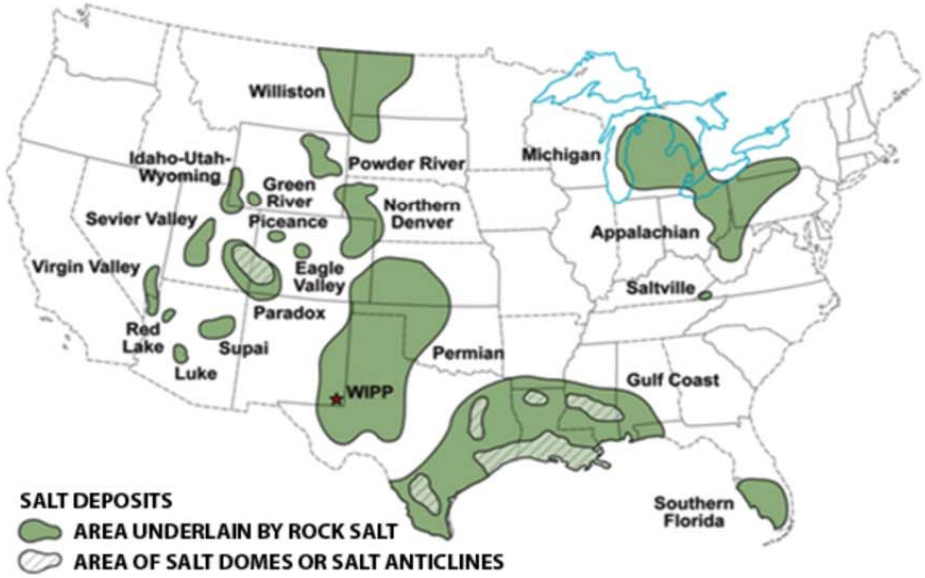
US Repository Future

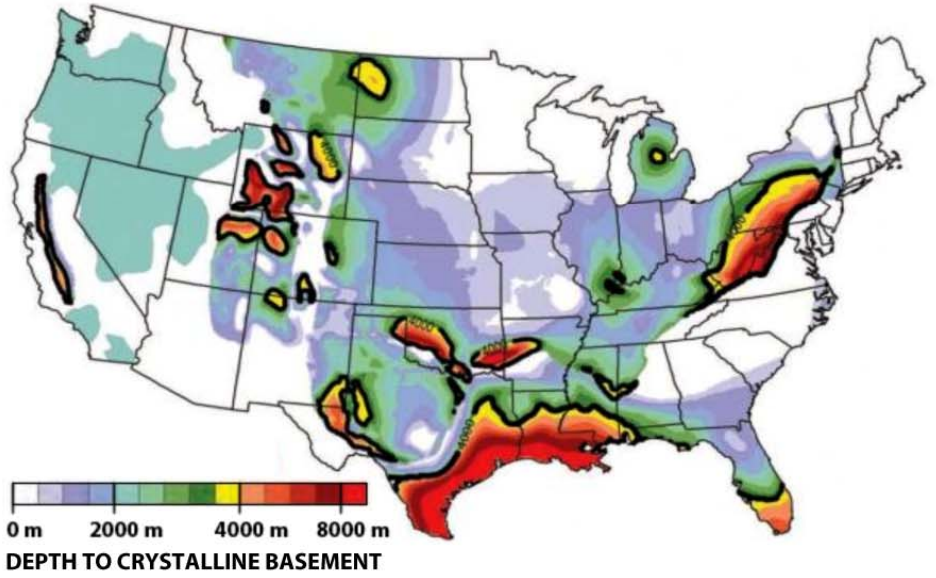
- **Yucca Mountain → "Not an Option"**
- **Blue Ribbon Commission on American Nuclear Futures**
- **Open dialogue on nuclear waste repository future…SALT**
- ***The most promising method of disposal of high level waste at the present time seems to be in salt deposits. The great advantage here is that no water can pass through the salt. Fractures are self-sealing…***
- **Strategy → What are the key next steps in salt geomechanics**

Geologic Repository Options



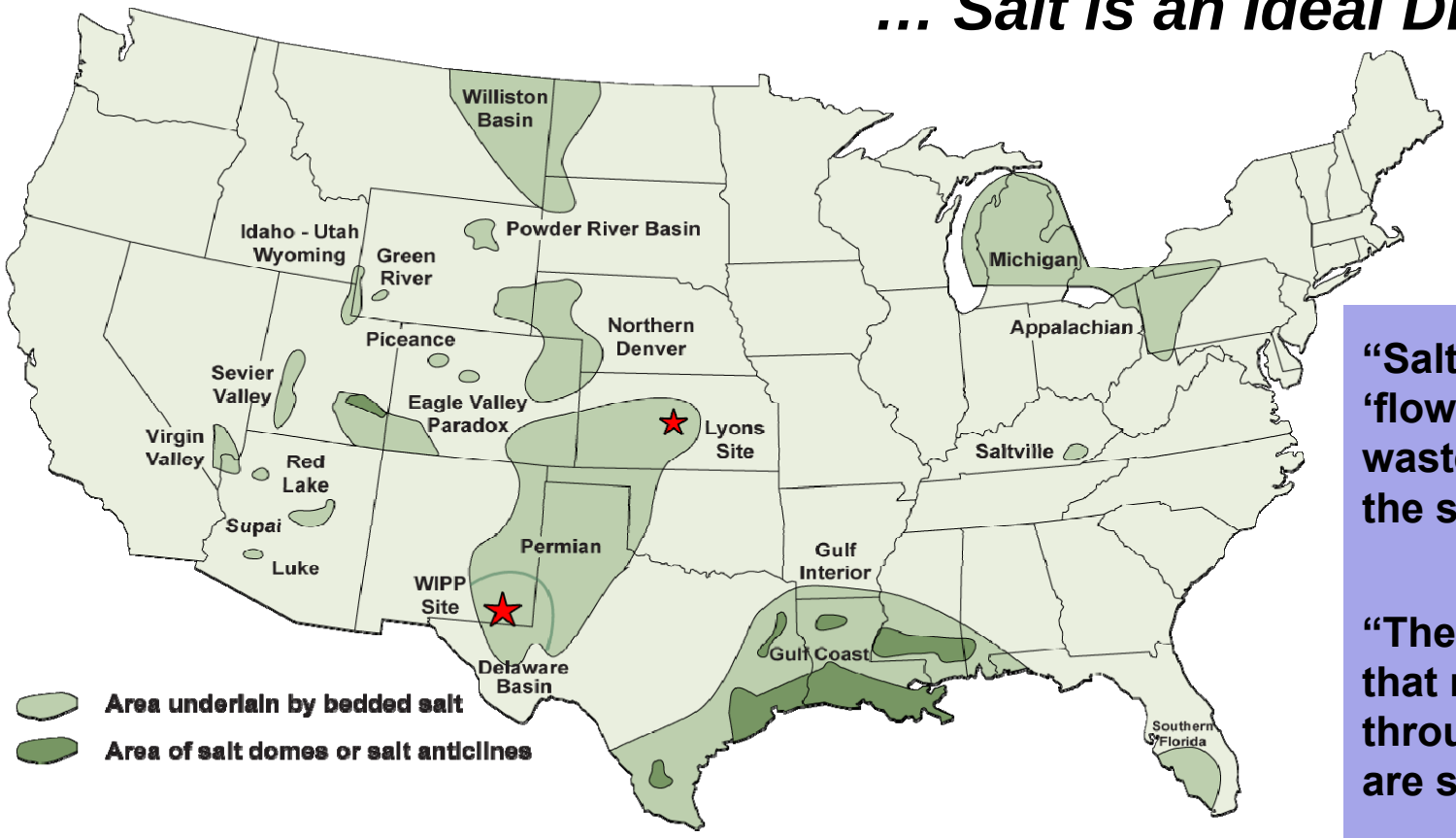






Salt Disposal Investigations

… Salt is an Ideal Disposal Medium



"Salt at great depth 'flows.' It will encapsulate waste and isolate it from the surface for eons."

"The great advantage is that no water can pass through salt. Fractures are self healing…."

National Academy of Sciences, 1957

"No engineered barriers are needed – the natural barrier alone makes disposal in salt permanent."

ARMA Conference

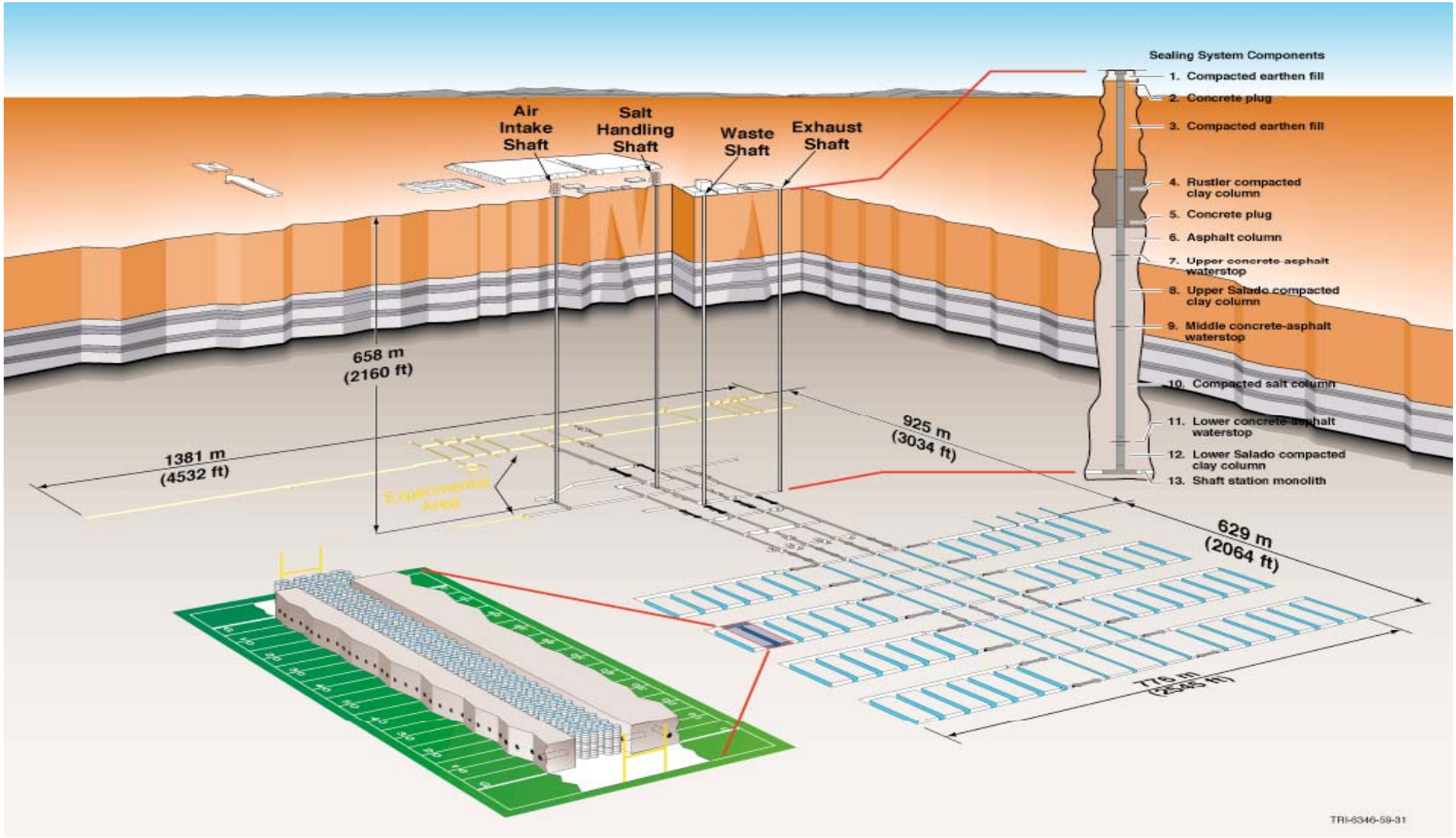
Waste Isolation Pilot Plant Chronology

1975

1979

2000

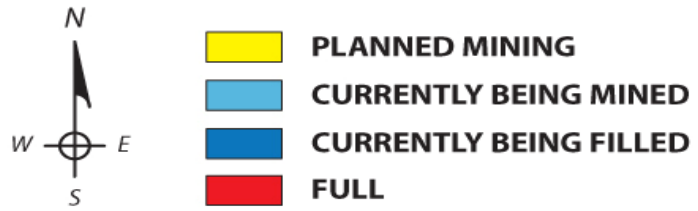
WIPP Underground Layout



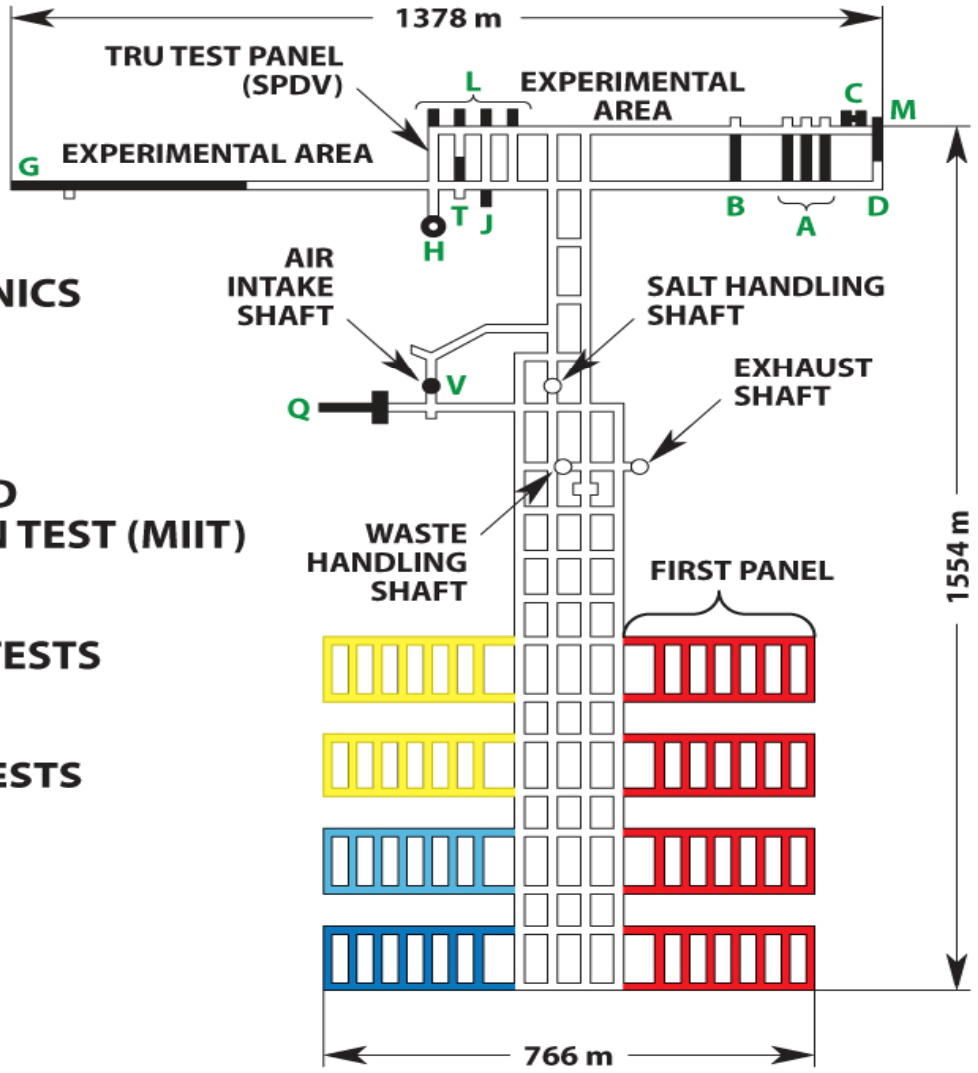
WIPP Major Tests

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

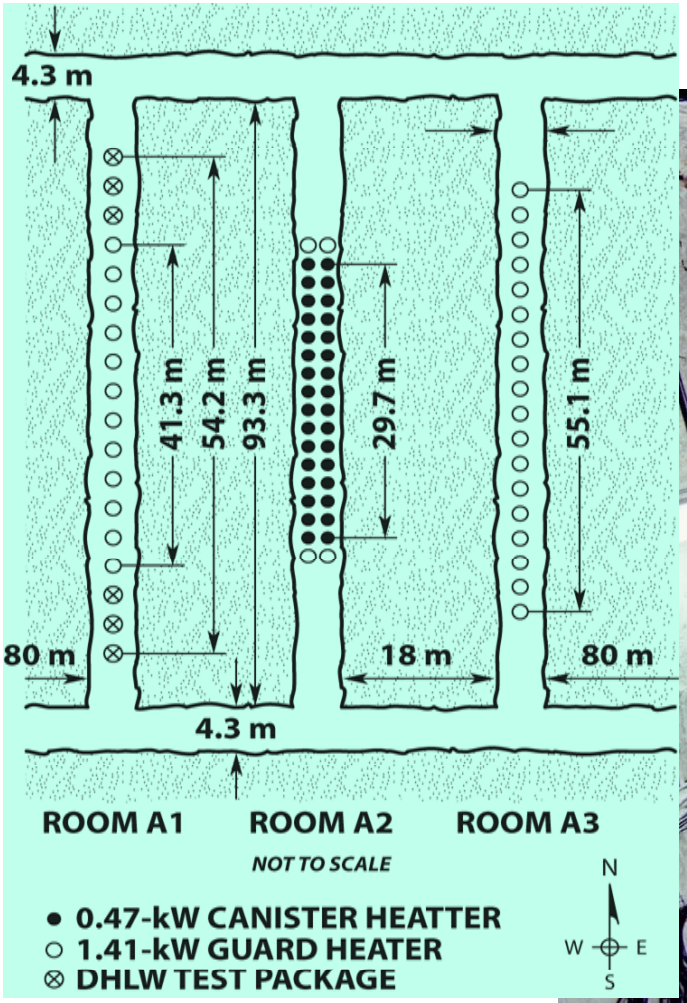


[NOT TO SCALE]

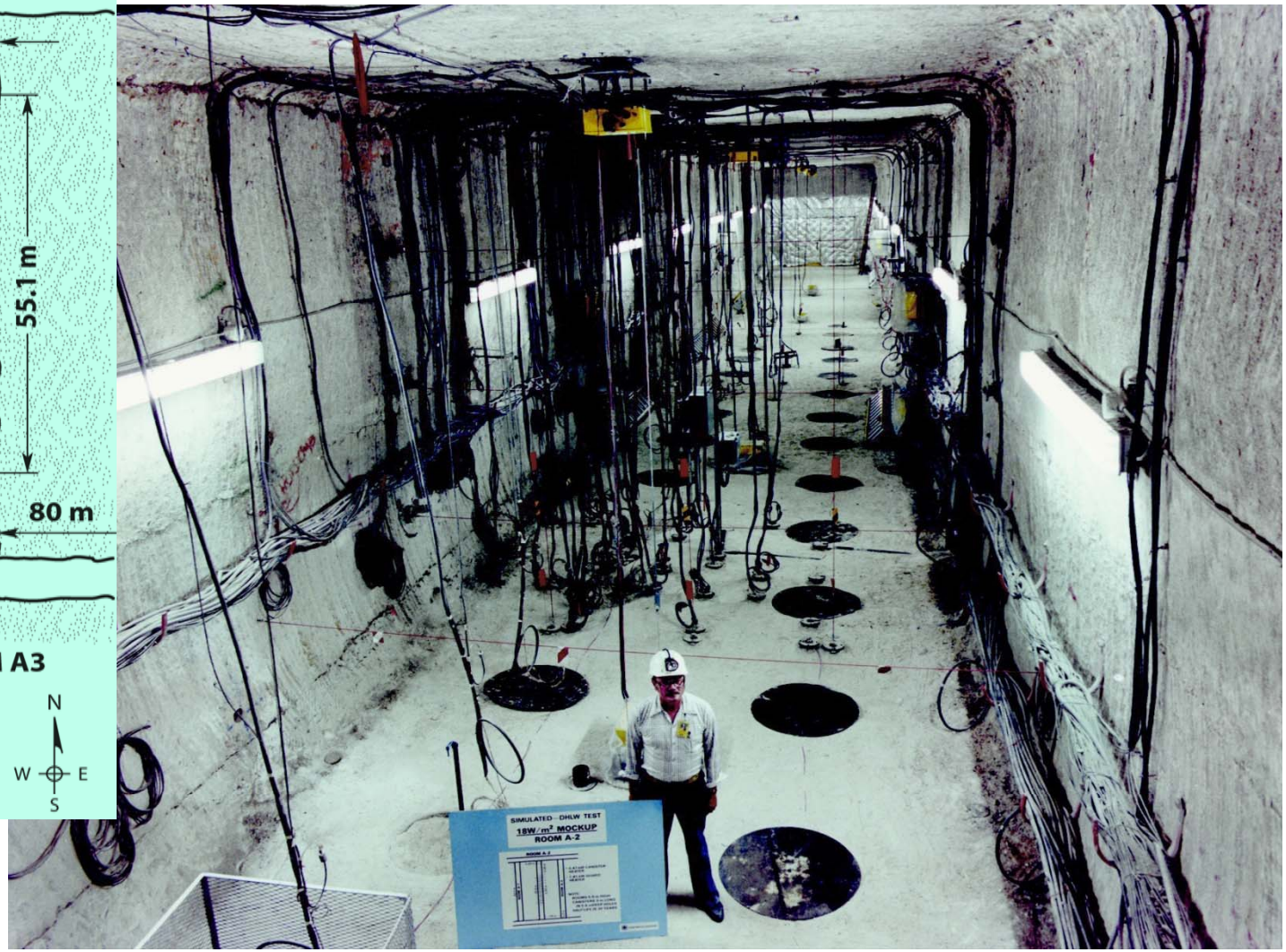
Axisymmetric Test with Insulation

Room H

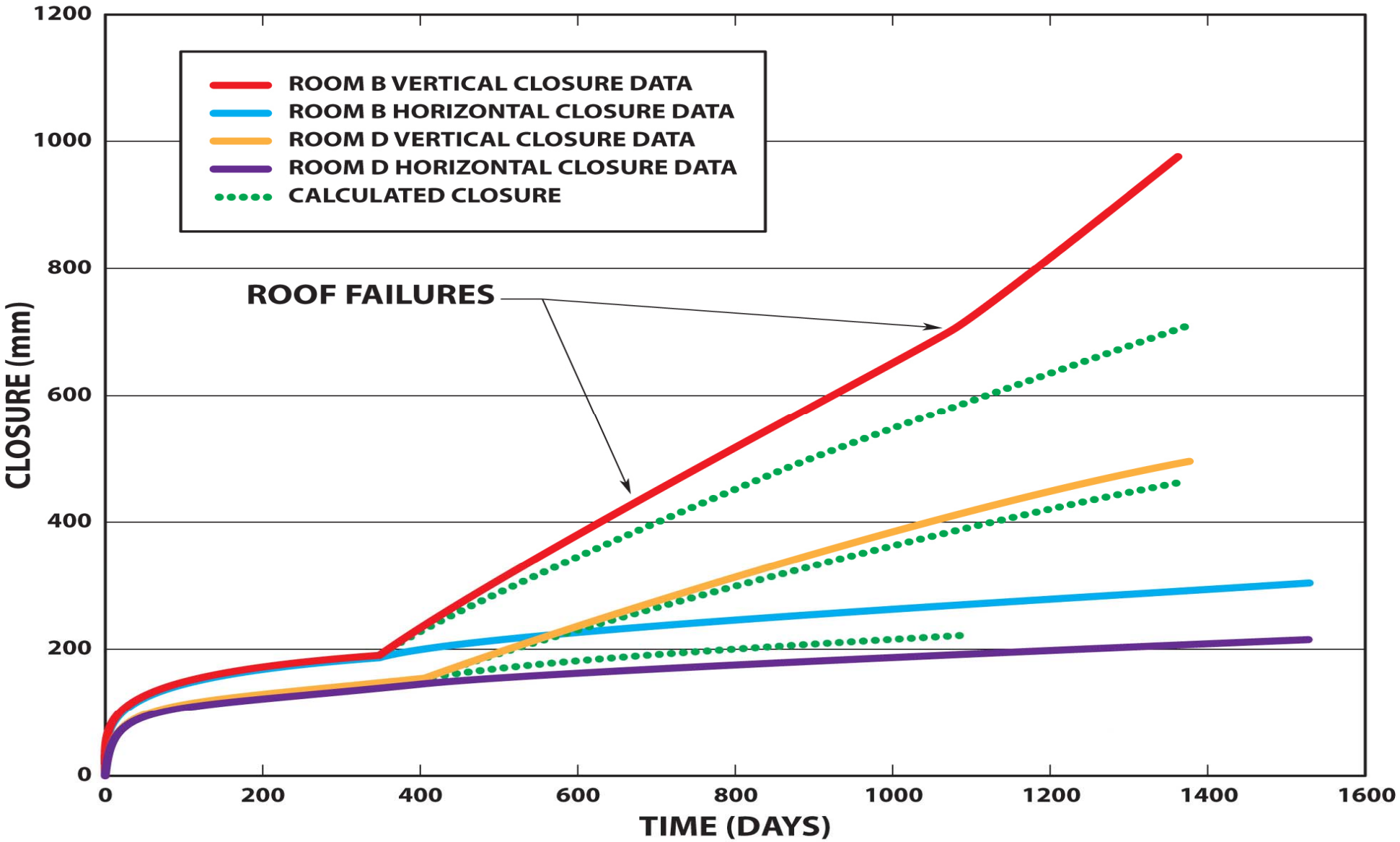
18 W/m^2 Thermomechanical Test



A Rooms



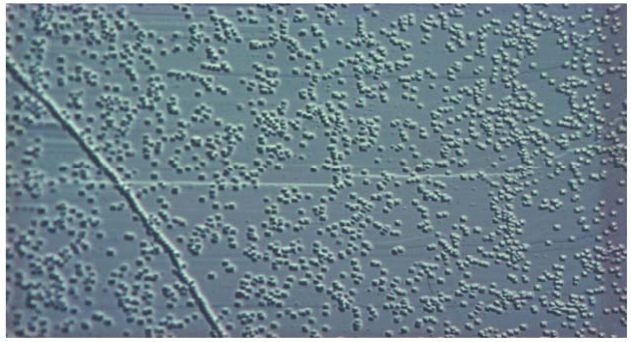
Measured vs. Predicted Room Closure

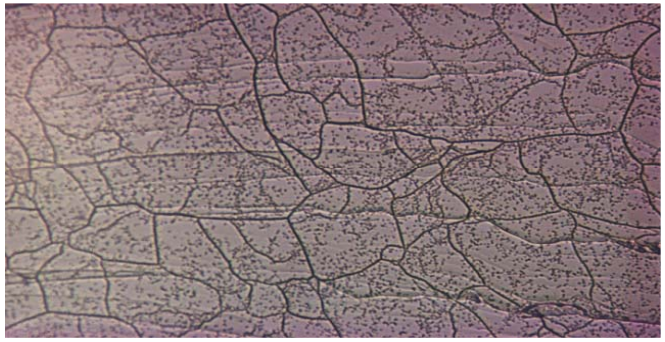


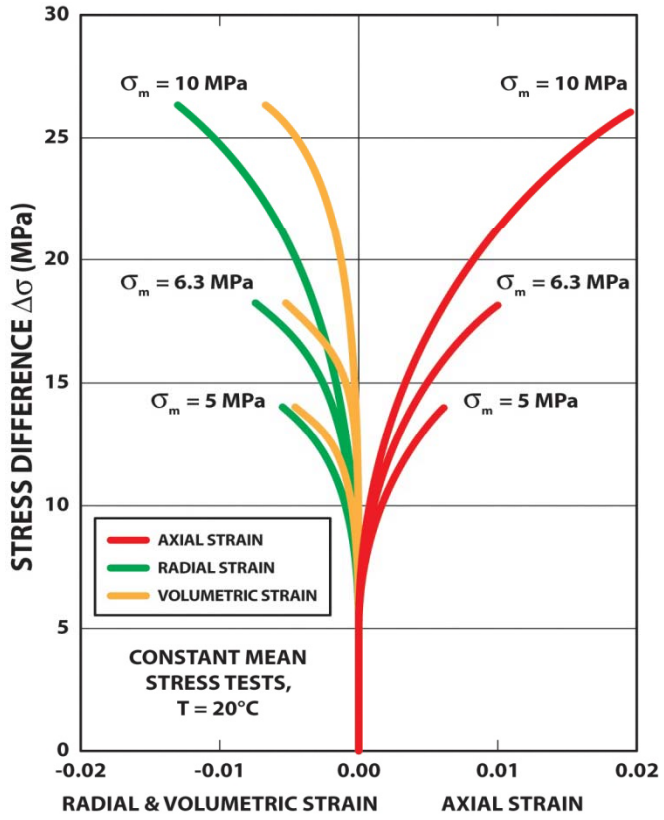
Thermomechanical Response of Salt

- 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

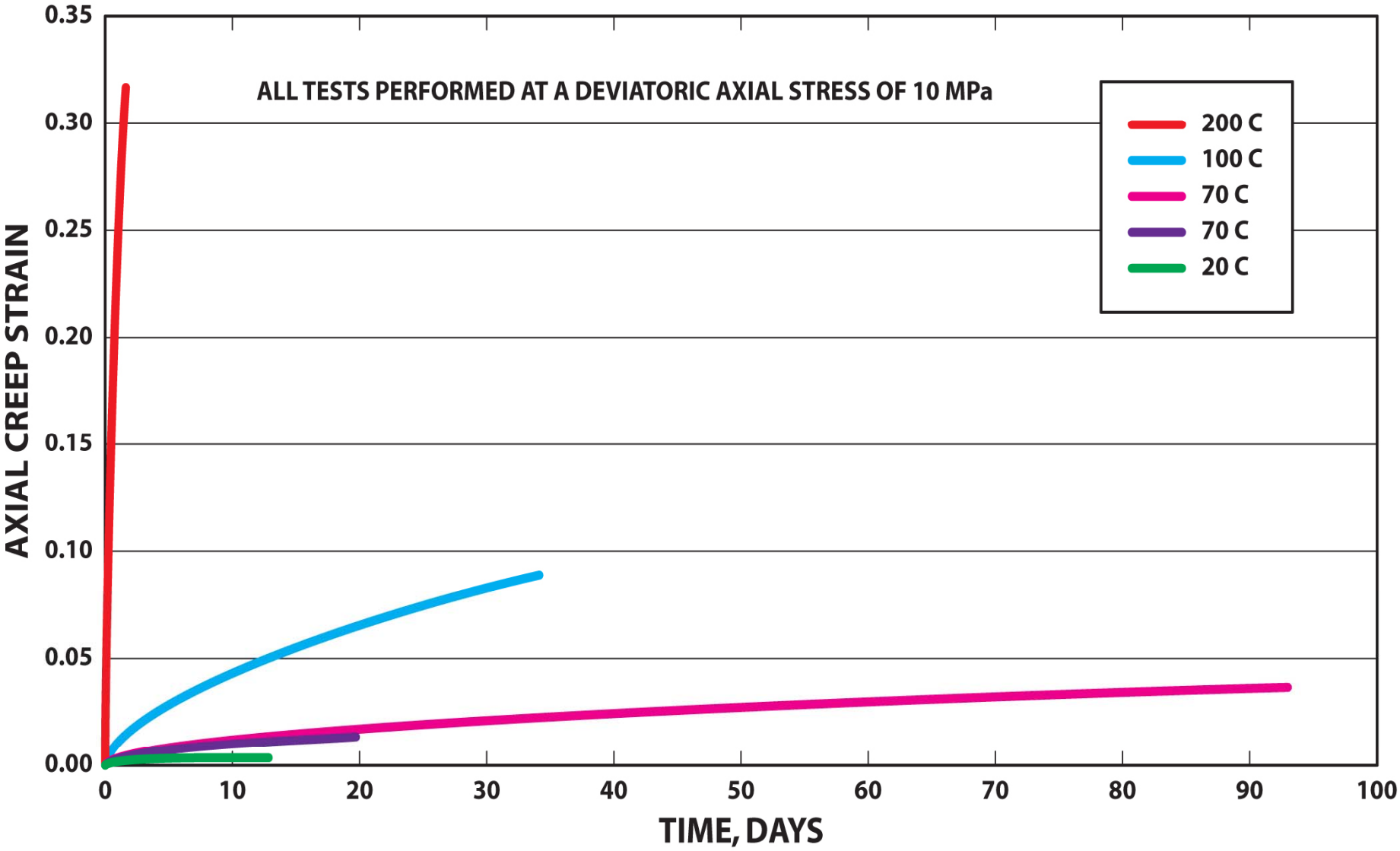
Salt Behavior is Well Understood



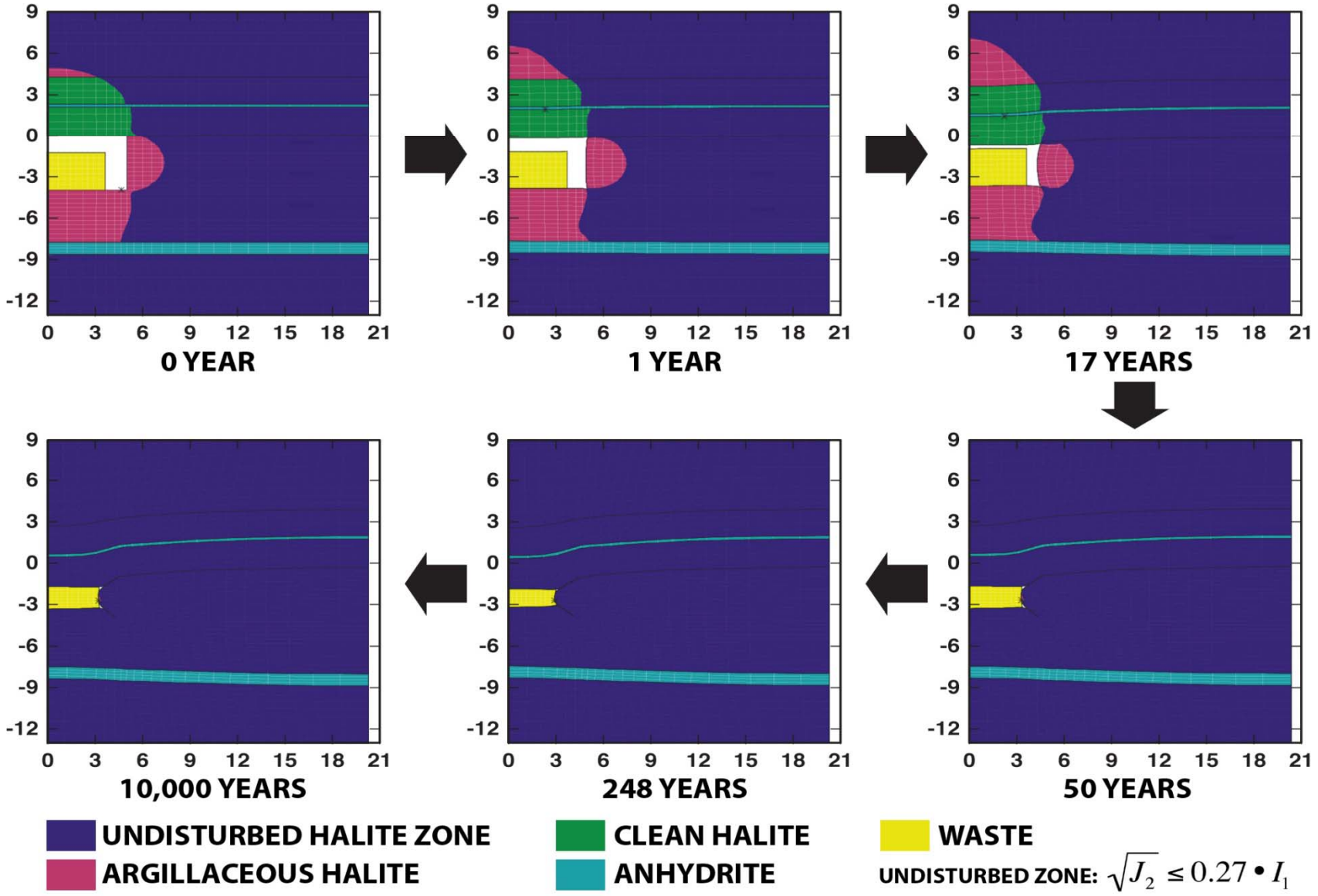




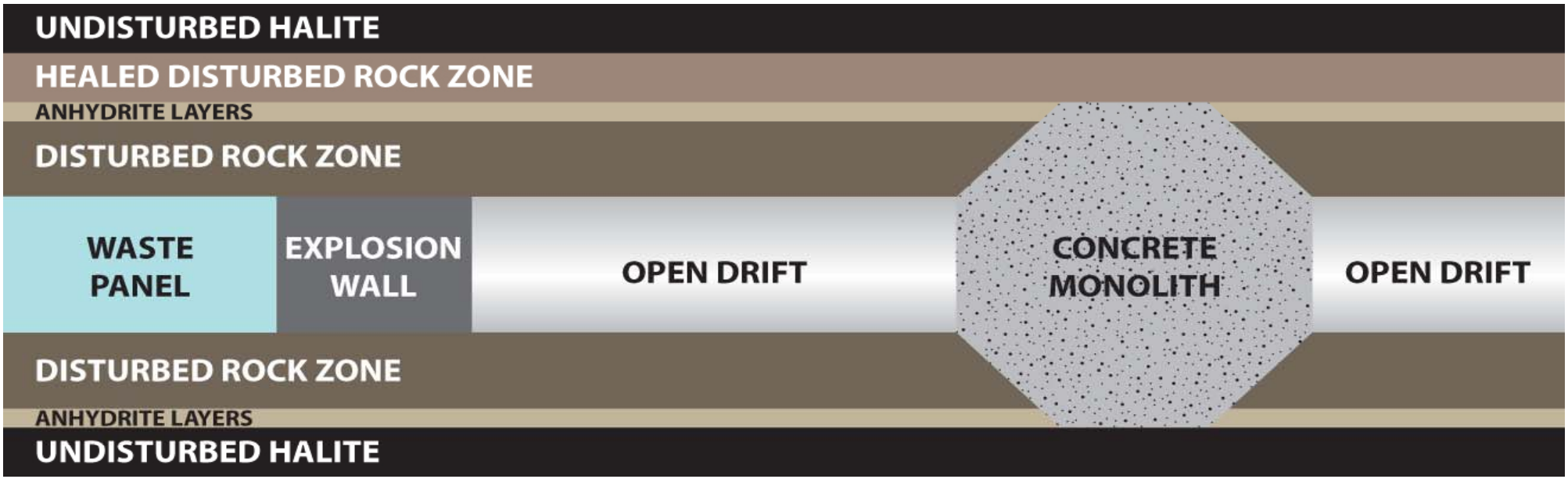
Temperature Effect on Salt Deformation



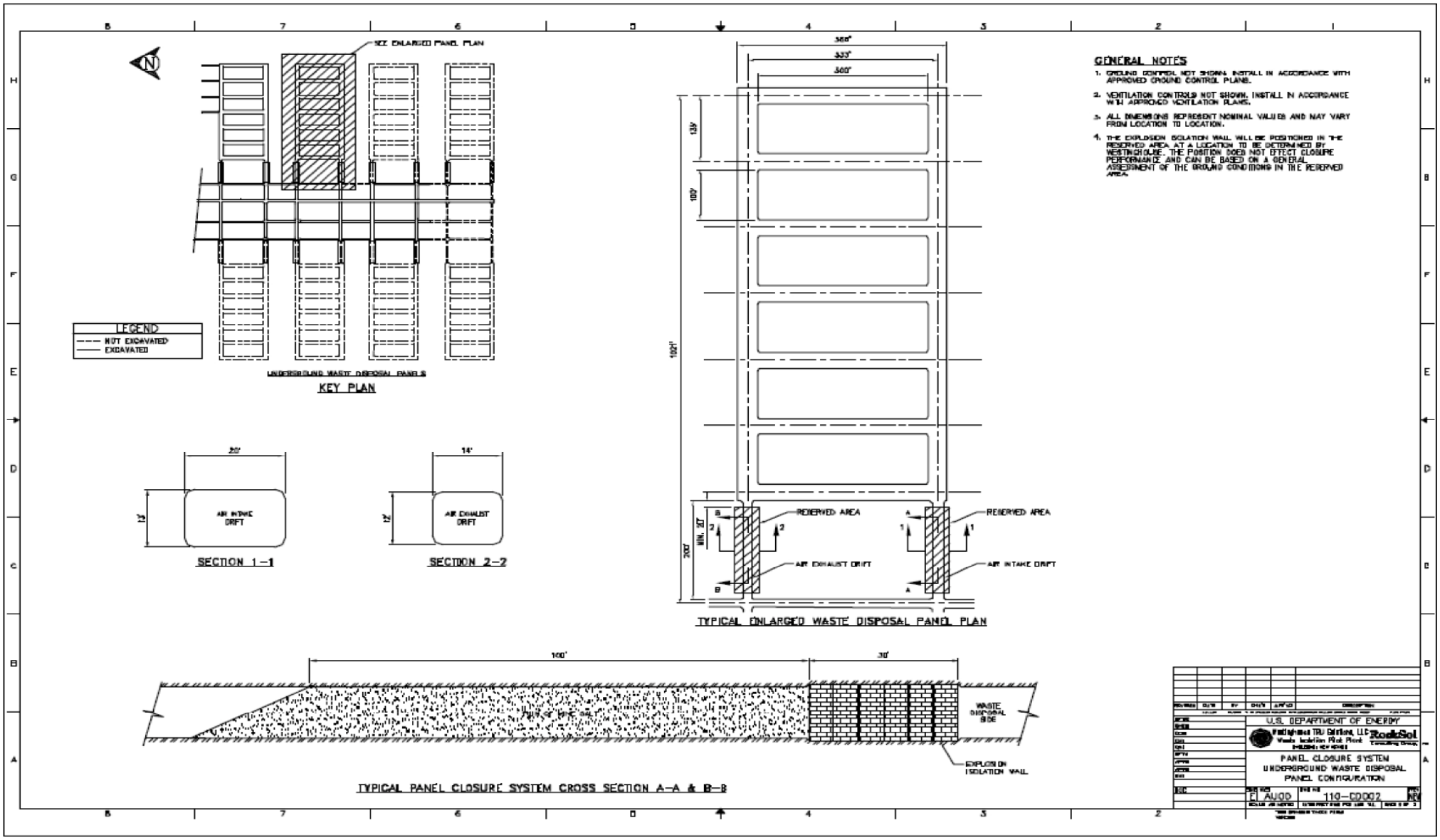
Disturbed Rock Zone Around a Disposal Room



Option D Panel Closure System



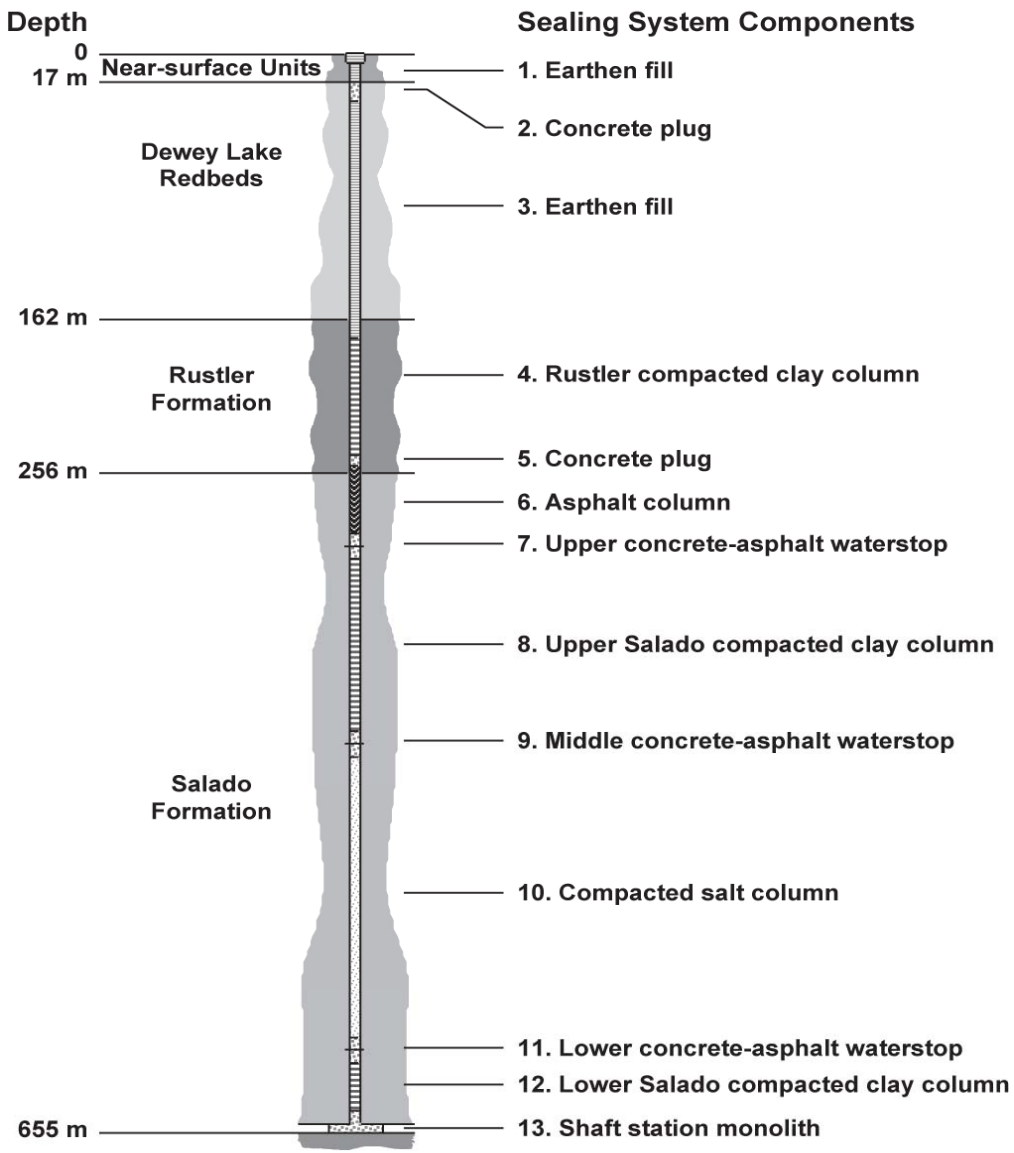
Proposed Panel Closure System



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



Shaft Seal System Conclusions

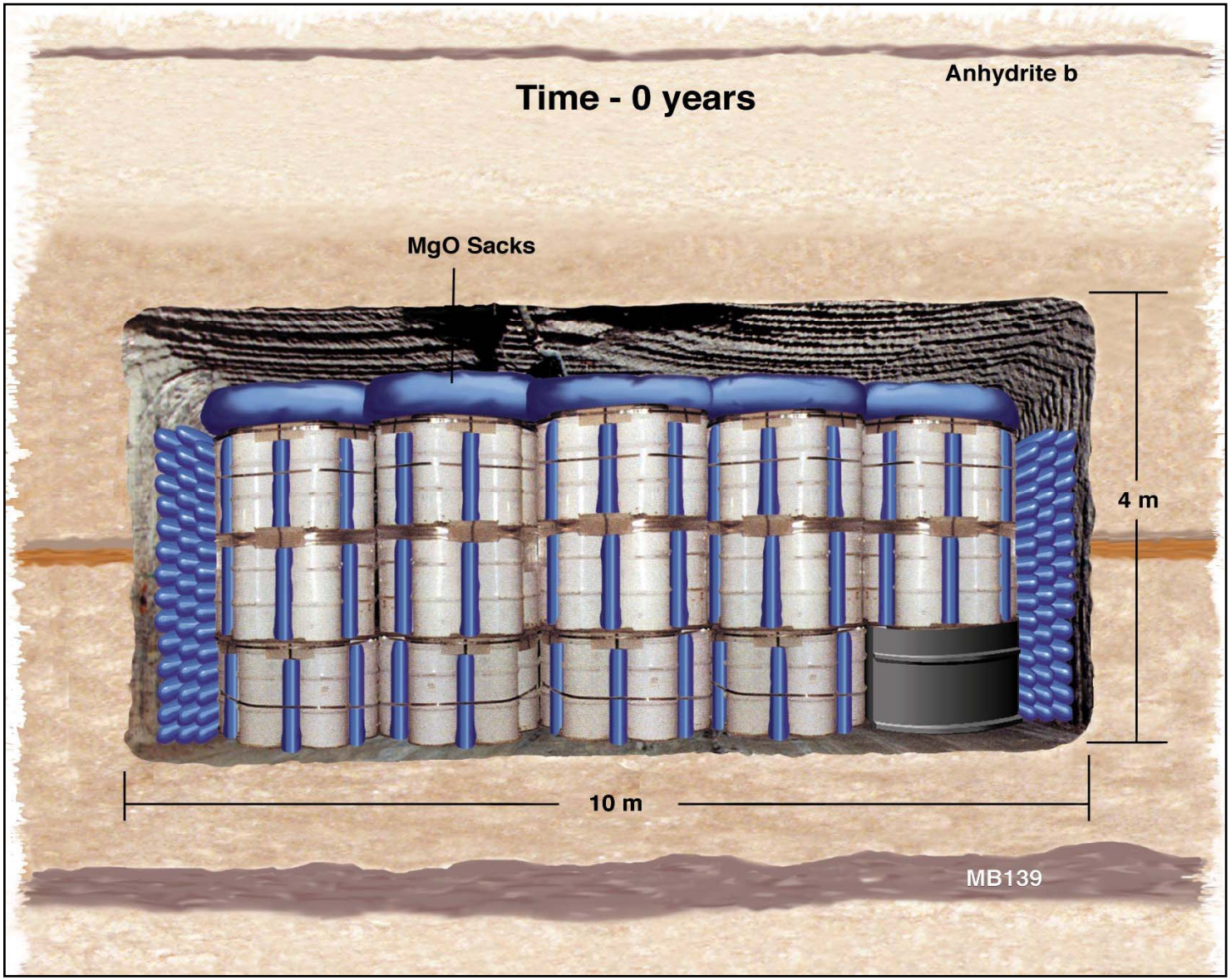
- **The WIPP shaft seal system effectively limits fluid flow within the seal system.**
- **The salt column becomes an effective barrier to gas and brine migration by 100 years after closure.**
- **Long-term flow rates within the seal system are limited.**

Key findings of Hansen and Leigh

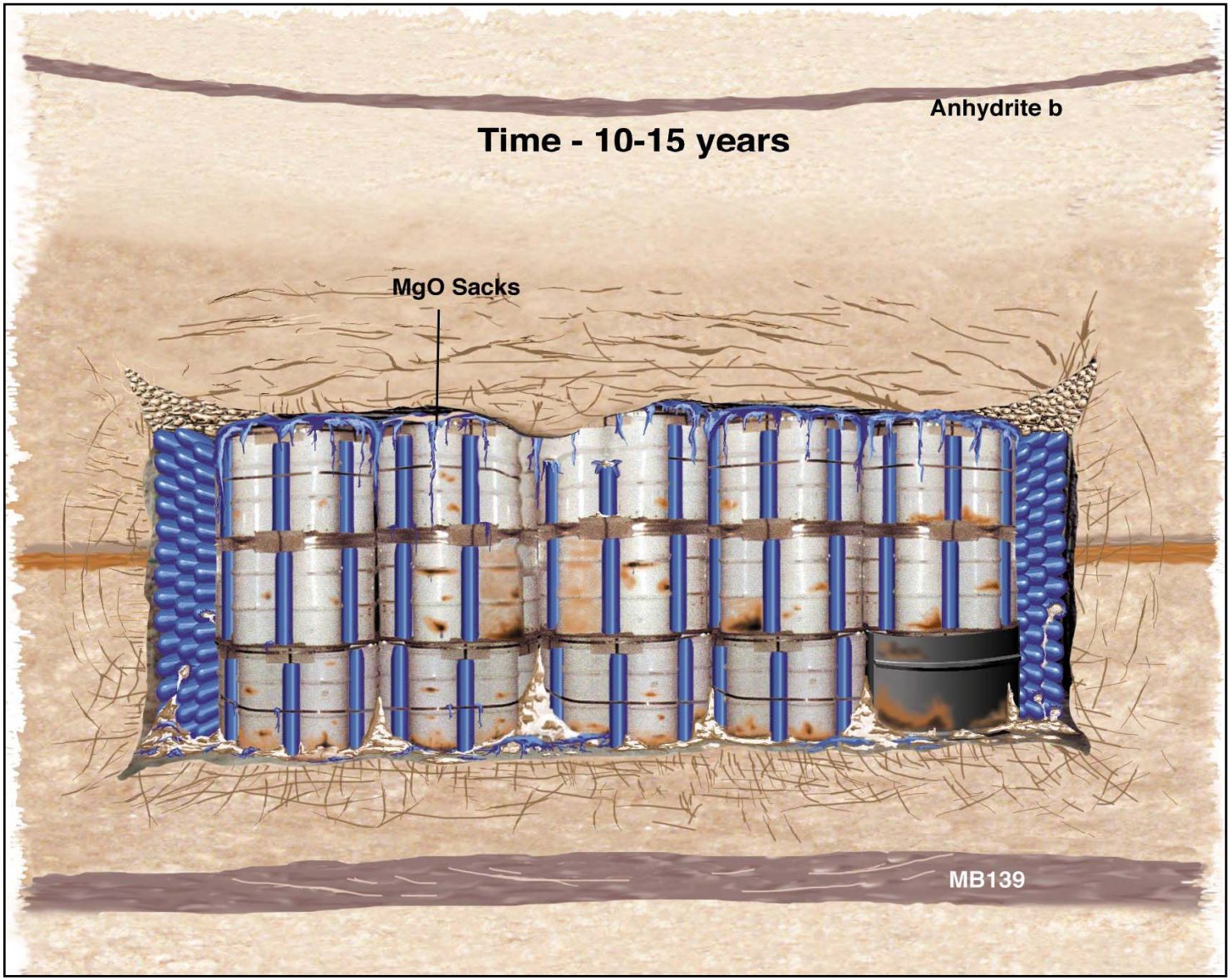
1. Thermal, hydrologic, and geochemical considerations suggest that radionuclides in a salt repository for HLW would not migrate from the disposal horizon.
2. Current knowledge of thermal effects supports a viable concept of repository operations.
3. Three-dimensional multiphysics capabilities offer advanced capabilities for PA modeling and field test development.
4. The suitability of salt as a medium for HLW disposal has been recognized by national and international repository programs.

WIPP Disposal Room Evolution

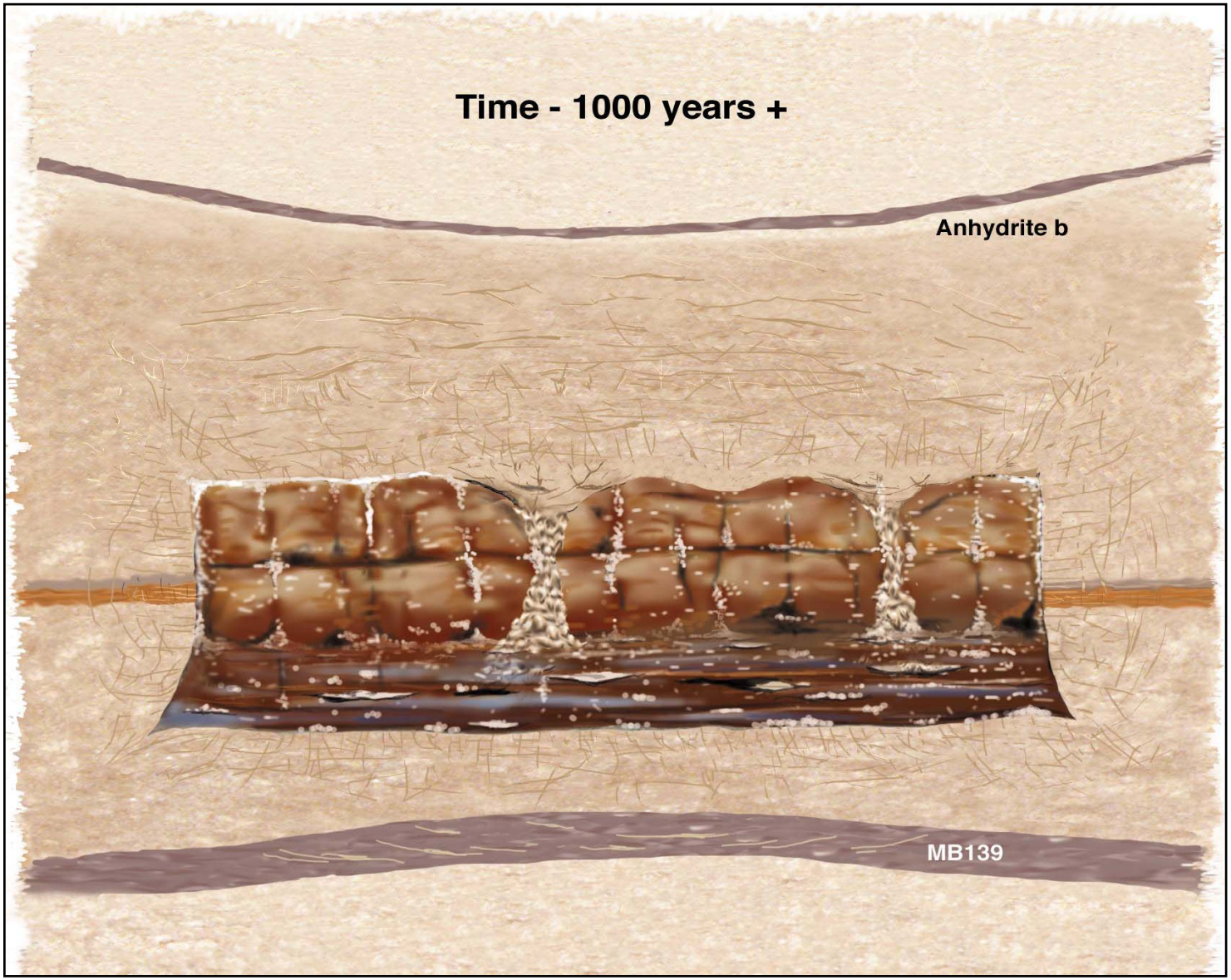
WIPP Room Evolution at Time=0 years



WIPP Room Evolution at Time=12 years

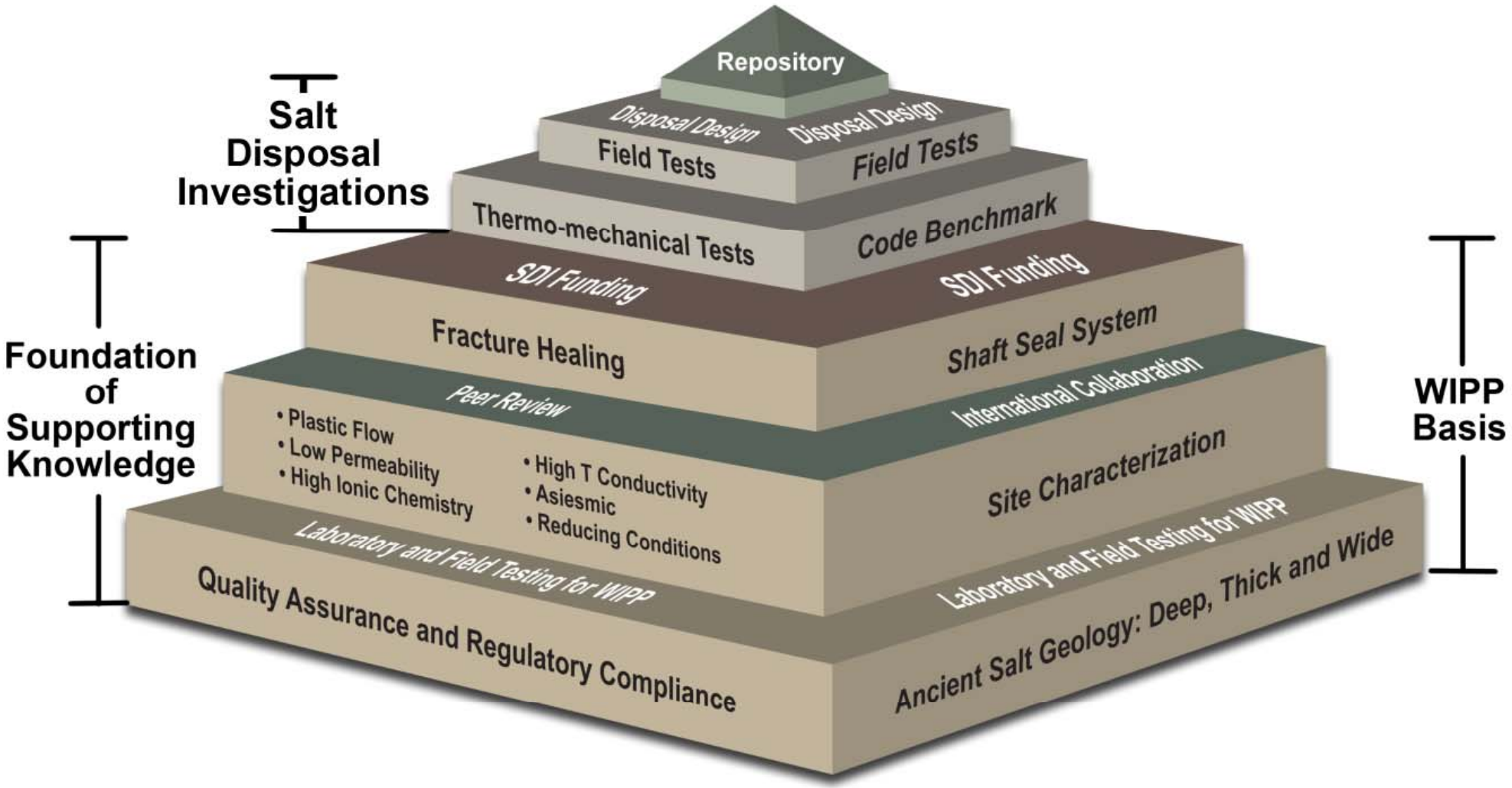


WIPP Room Evolution at 1000 years



WIPP Room Evolution Animation

Science Based Foundation for TRU and HLW Disposal in Salt



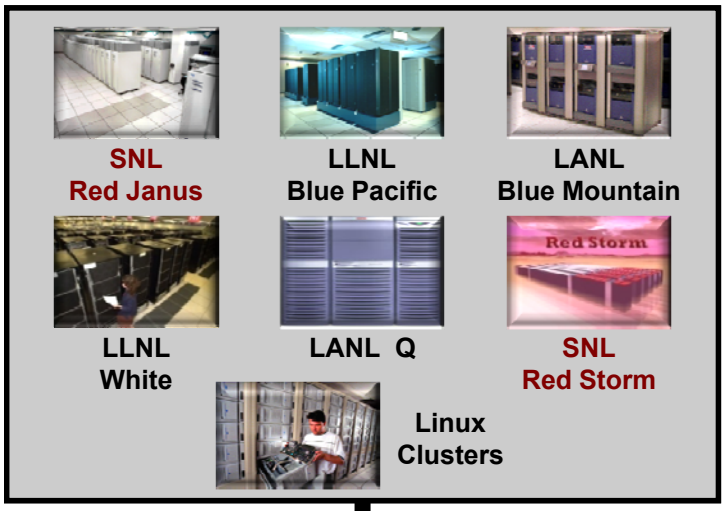
Key Geomechanics Areas of Interest

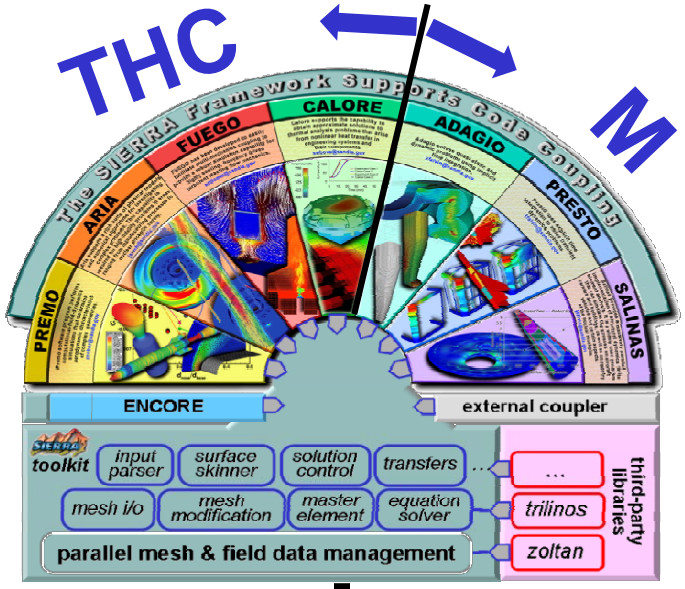
- **DRZ Evolution and Healing**
- **Consolidation of Backfill Materials at Elevated Temperature**
- **Availability and Movement of Brine**
- **Vapor Phase Transport Mechanism**

SIERRA Mechanics overview

- DOE ASC program funded for ~10 years
- Massively parallel multi-physics capabilities for Sandia's engineering science mission

Designed and developed for MP hardware



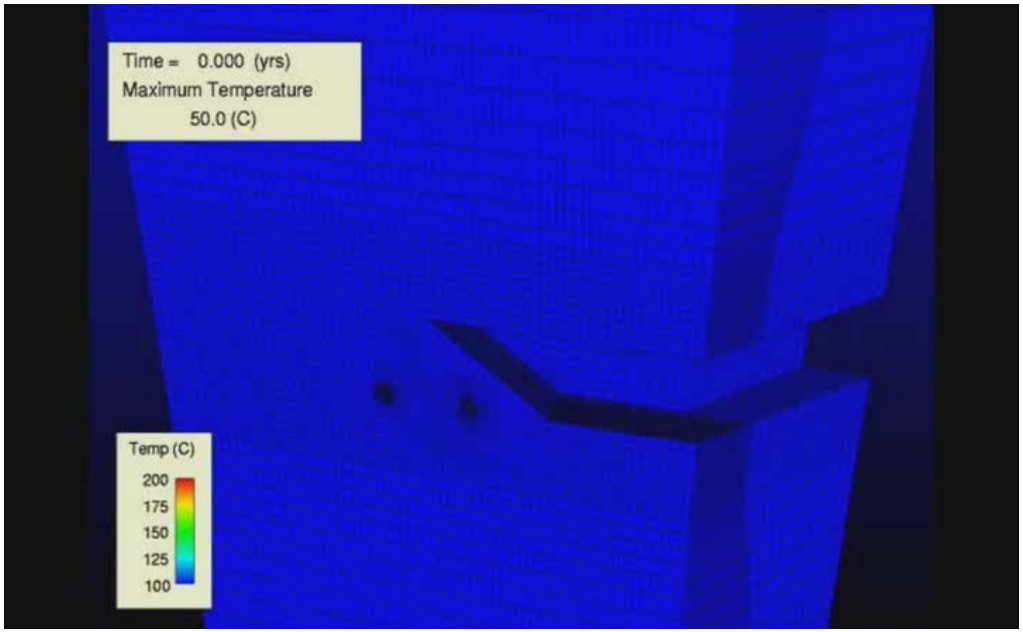


- For Geologic and Repository Systems, Sierra/Thermal-Fluid Dynamics and Sierra/Solid Mechanics Will Provide Next-Generation Coupled T-H-C-M Capability

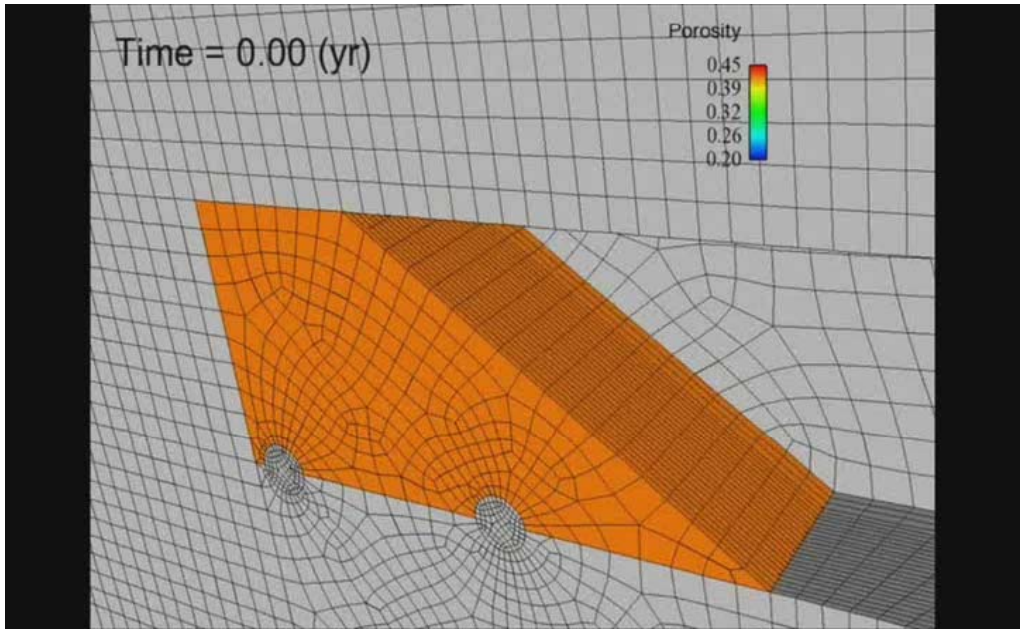
The Future

Advanced multi-physics modeling will aid salt analyses and performance assessment

Temperature Contour



Coupled Salt Consolidation



Salt Disposal Investigations

- **Laboratory Testing—could begin immediately, as the state-of-the-art is known and incremental R&D identified.**
- **Modeling and Simulations—international collaboration in this effort can position salt repository sciences in a very favorable position for field testing, design and analysis.**
- **Workshops and International Collaborations—a workshop environment with subject matter experts can reconcile many of the issues.**
- **Field Testing—a proof-of-principle test could advance salt sciences sufficiently to lead to efficient and safe disposal.**

Looking Forward

- Define the state of the art
- Continue to build international collaboration
- Ensure our nation has been introduced to geologic repository options
- Provide the solutions