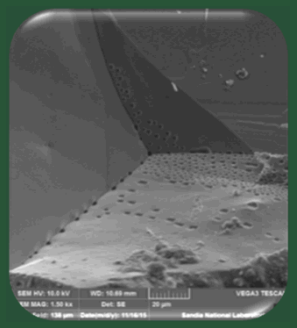
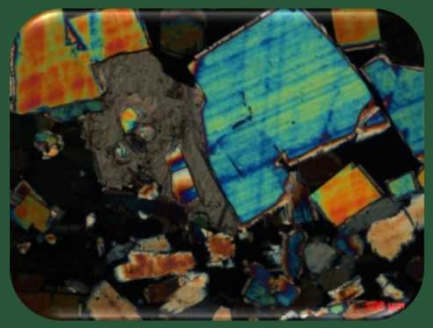

Considerations of the Differences between Bedded and Domal Salt Pertaining to Disposal of Heat-Generating Nuclear Waste

Frank Hansen

Sandia National Laboratories

NEA Salt Club Meeting

Washington, DC

September 6, 2016

Sandia National Laboratories

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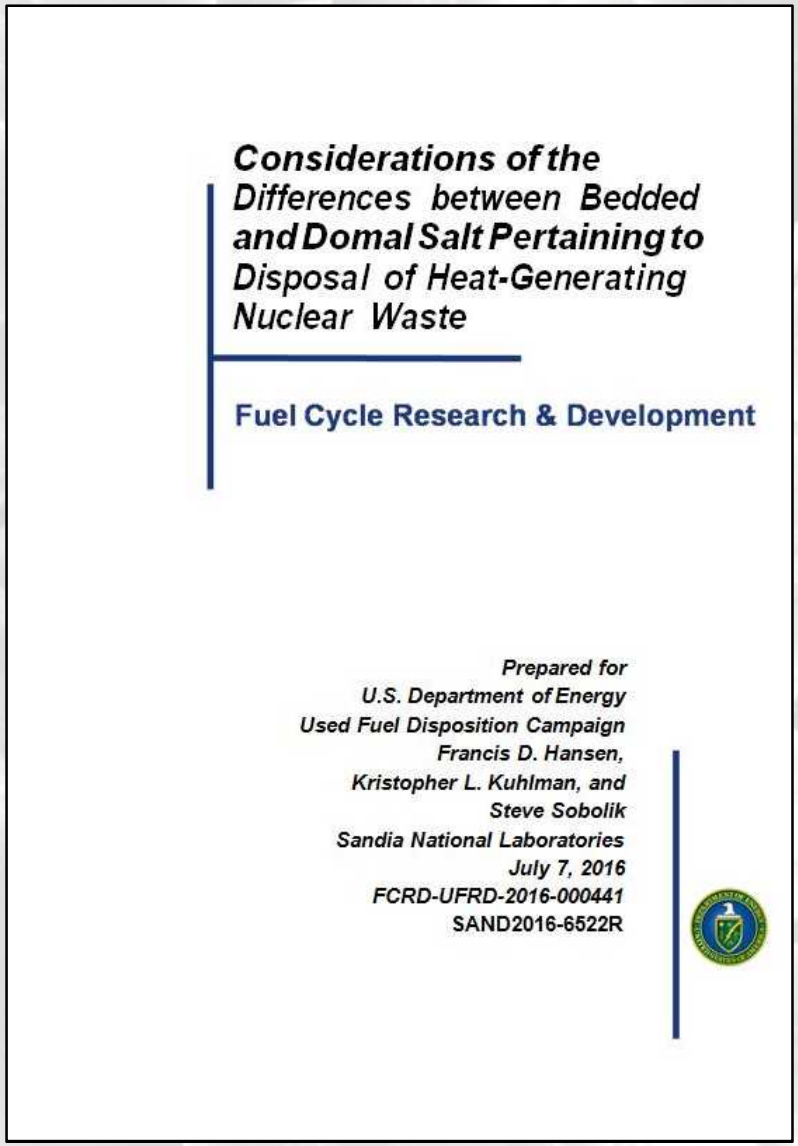
Salt Disposal

- Salt formations hold promise for eternal removal of nuclear waste from our biosphere
- Germany and the United States have ample salt formations
- Between excavation and closure, physical, mechanical, thermal, chemical, and hydrological processes ensue
- Here we identify and discuss high-level differences and similarities of bedded and domal salt formations



Considerations of the Differences between Bedded and Domal Salt Pertaining to Disposal of Heat-Generating Nuclear Waste

Fuel Cycle Research & Development

Prepared for
U.S. Department of Energy
Used Fuel Disposition Campaign
Francis D. Hansen,
Kristopher L. Kuhlman, and
Steve Sobolik
Sandia National Laboratories
July 7, 2016
FCRD-UFRD-2016-000441
SAND2016-6522R

Points of Discussion

- Collaborations
  - WEIMOS
  - KOSINA
  - Features, Events, and Processes
- Scale
  - Large Scale Geology
    - Regional Groundwater Flow
    - Large-scale Geomechanical Modeling
  - Mesoscale
    - Thermal Effects
    - Brine and Vapor Migration
    - Mechanical Properties
    - Applied Modeling
    - Lithology
    - Excavation Damage Zone
    - Mineralogical Comparisons

Recommendations for a Salt Compendium

- 6th US/German Workshop on Salt Repository Research, Design, and Operation in September 2015
- Compendium will be accomplished as collaborations continue
- Proposed Nuclear Energy Agency (NEA) Salt Club deliverable
- Content to provide high-level summary with references
- Not intended to determine preference for bedded or domal salt formations

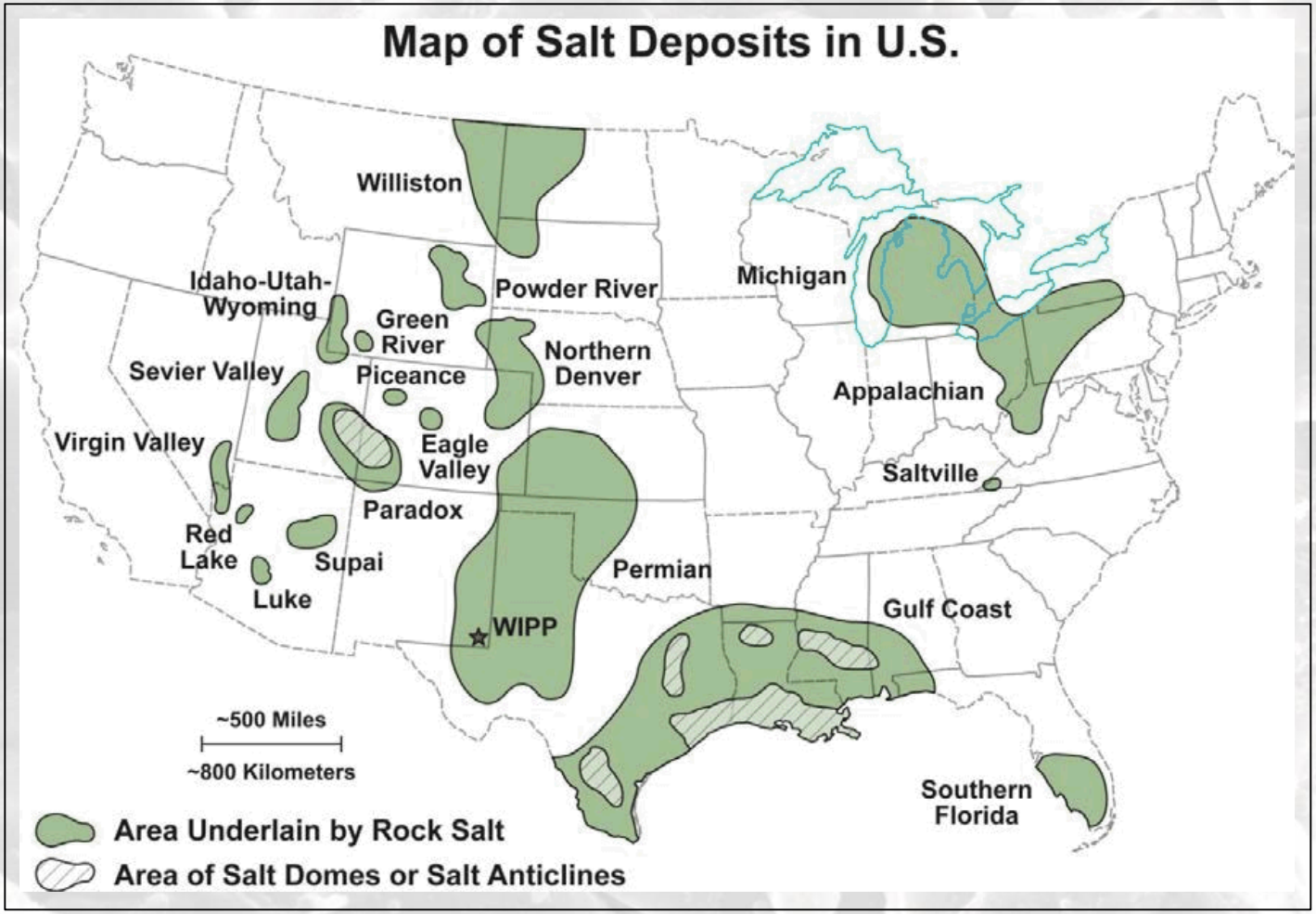
General Attributes for Geologic Disposal

- Depth
- Thickness
- Uniformity and Structure
- Seismicity
- Hydrogeology
- Self-sealing
- Hydrogeochemistry

Salt Characteristics

- Salt can be mined easily
- Salt flows around the buried material and encapsulates it
- Salt is essentially impermeable
- Fractures in salt are self-healing
- Salt has a relatively high thermal conductivity
- Suitable salt formations exist in wide geographic distributions
- Saline environments are biologically simple

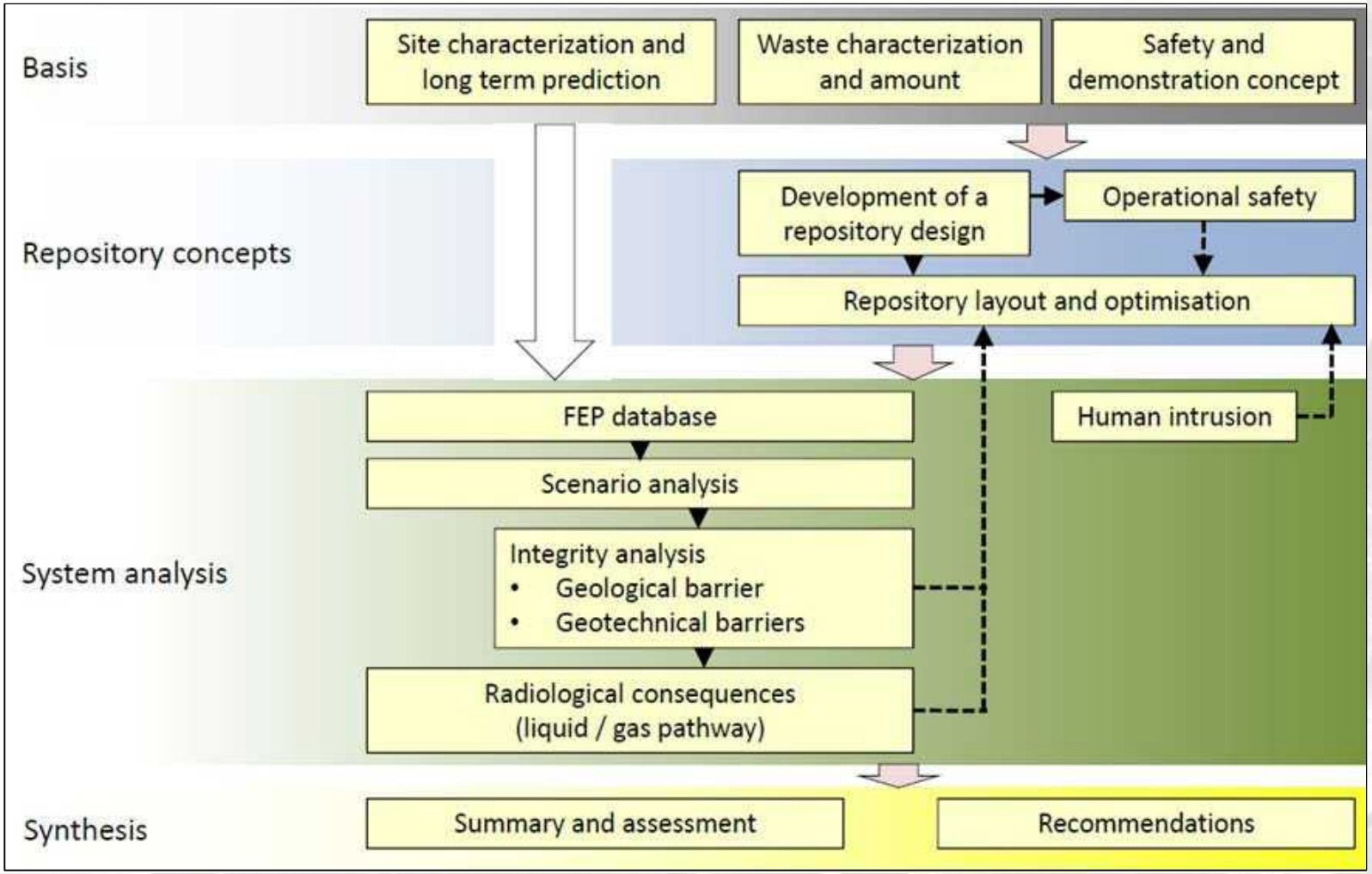
Bedded and Domal Salt in the U.S.



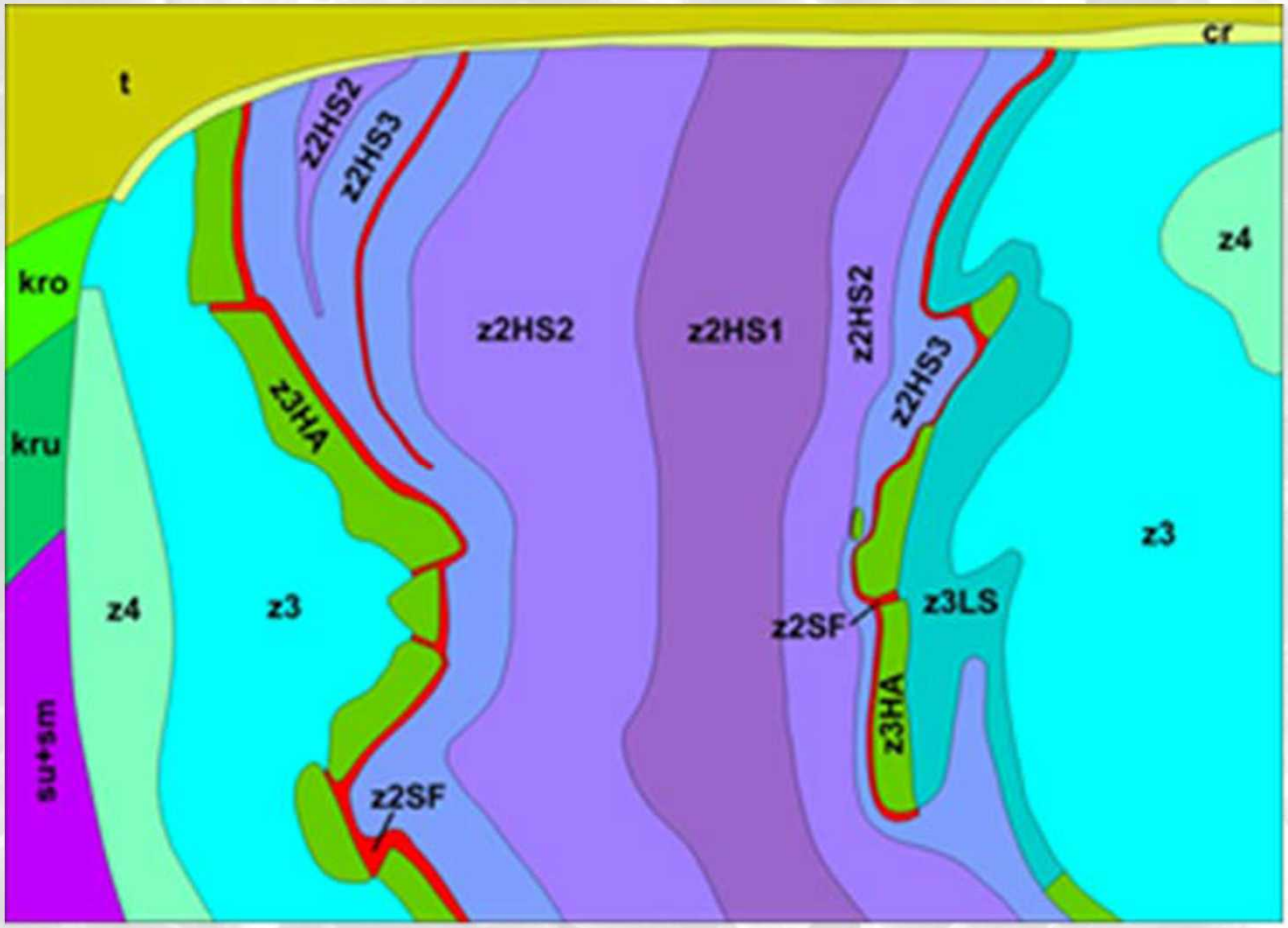
Collaborations

- WEIMOS reflects the current stage of our respective repository programs
  - Research Agenda
    - Shearing of inhomogeneities (e.g., clay seams)
    - Tensile and extensile salt properties
    - Damage and healing behavior
    - Creep of salt at low deviatoric stress
- KOSINA focuses on integrity analysis for generic locations in bedded salt and salt pillows
- Features, Events, and Processes
  - FEPs analysis must be observable, measureable, and quantifiable to some degree

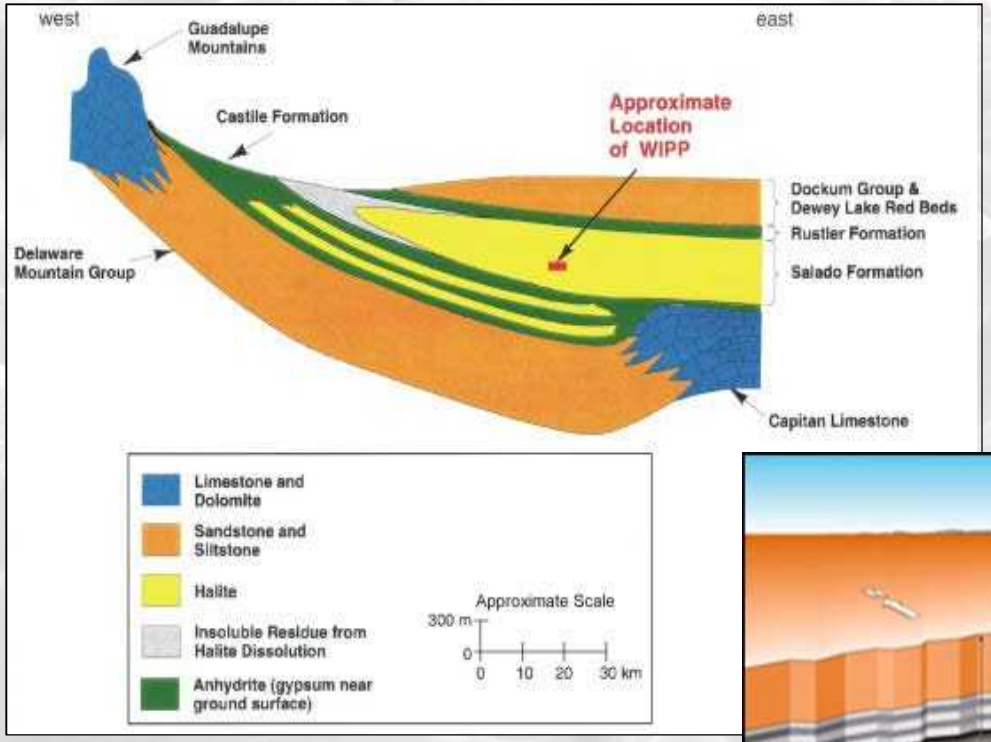
VSG Safety Demonstration

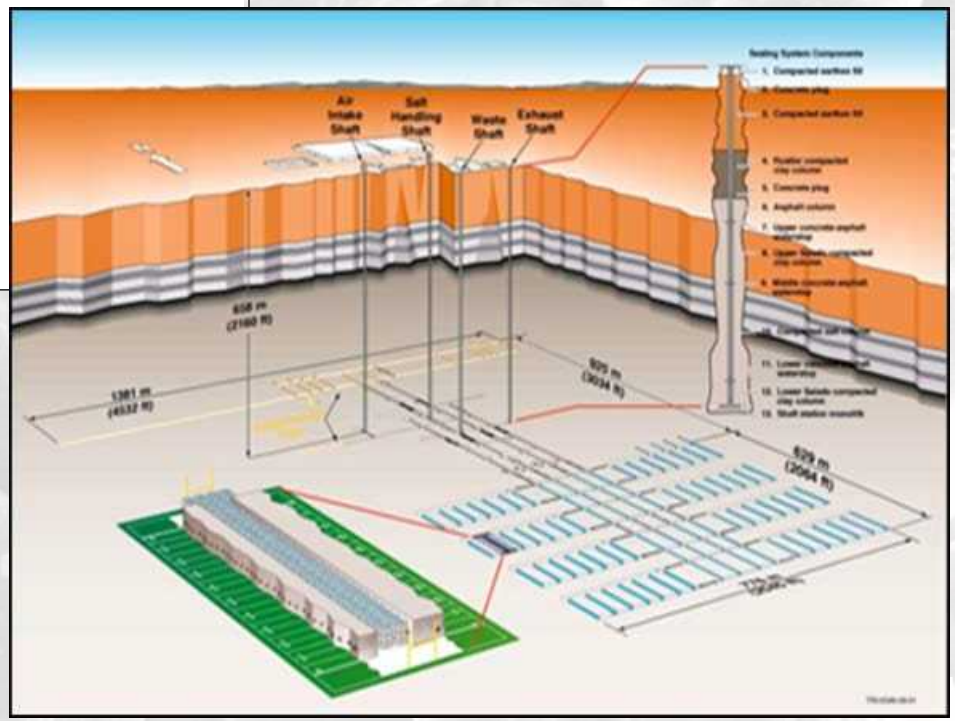


Simplified Cross Section of Gorleben Salt Dome

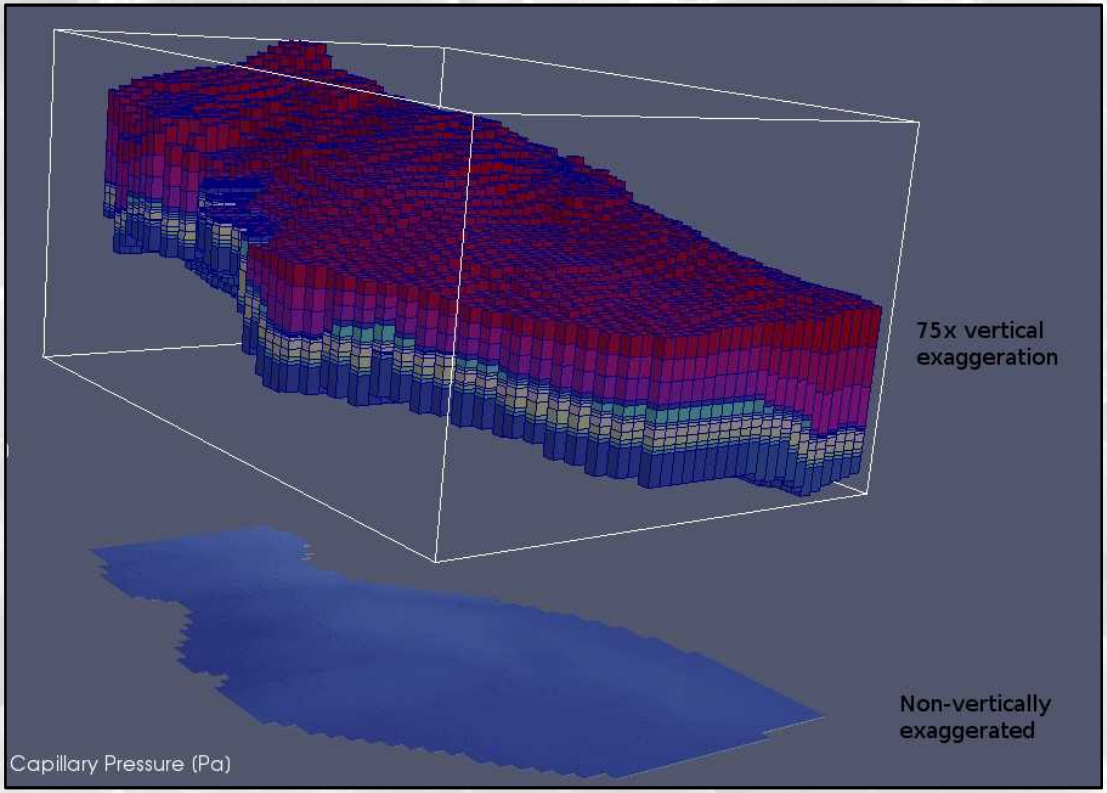


Local and Regional Flat-Lying Salt at WIPP





Regional Groundwater Flow

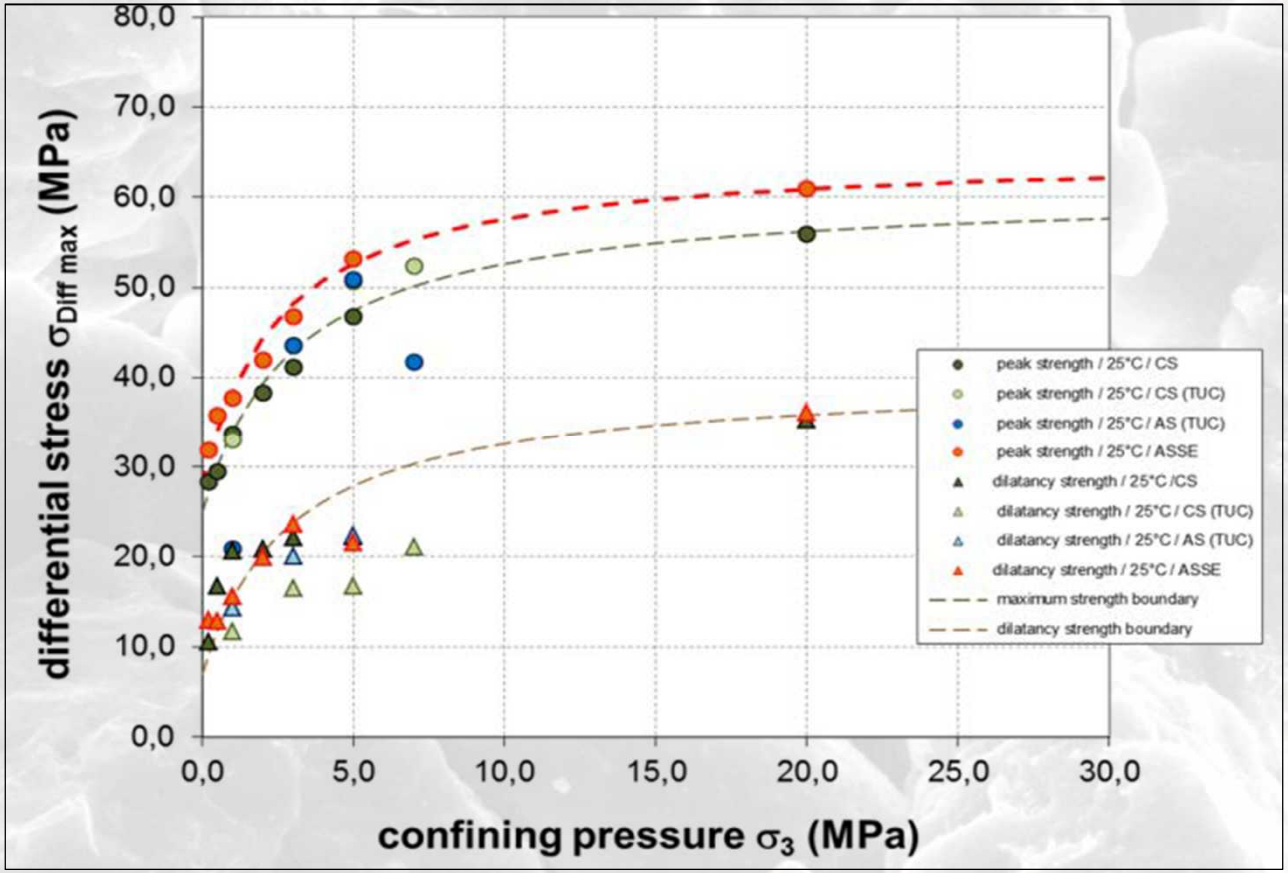


- **Flow System Geometry**
  - **Layers vs. dome**
  - **Regional borehole data vs. 3D geophysics**
  - **Simpler layered mesh vs. complex 3D mesh**
- **Flow System Domain**
  - **Extent of sedimentary basin**
  - **Area up/down stream of salt dome**

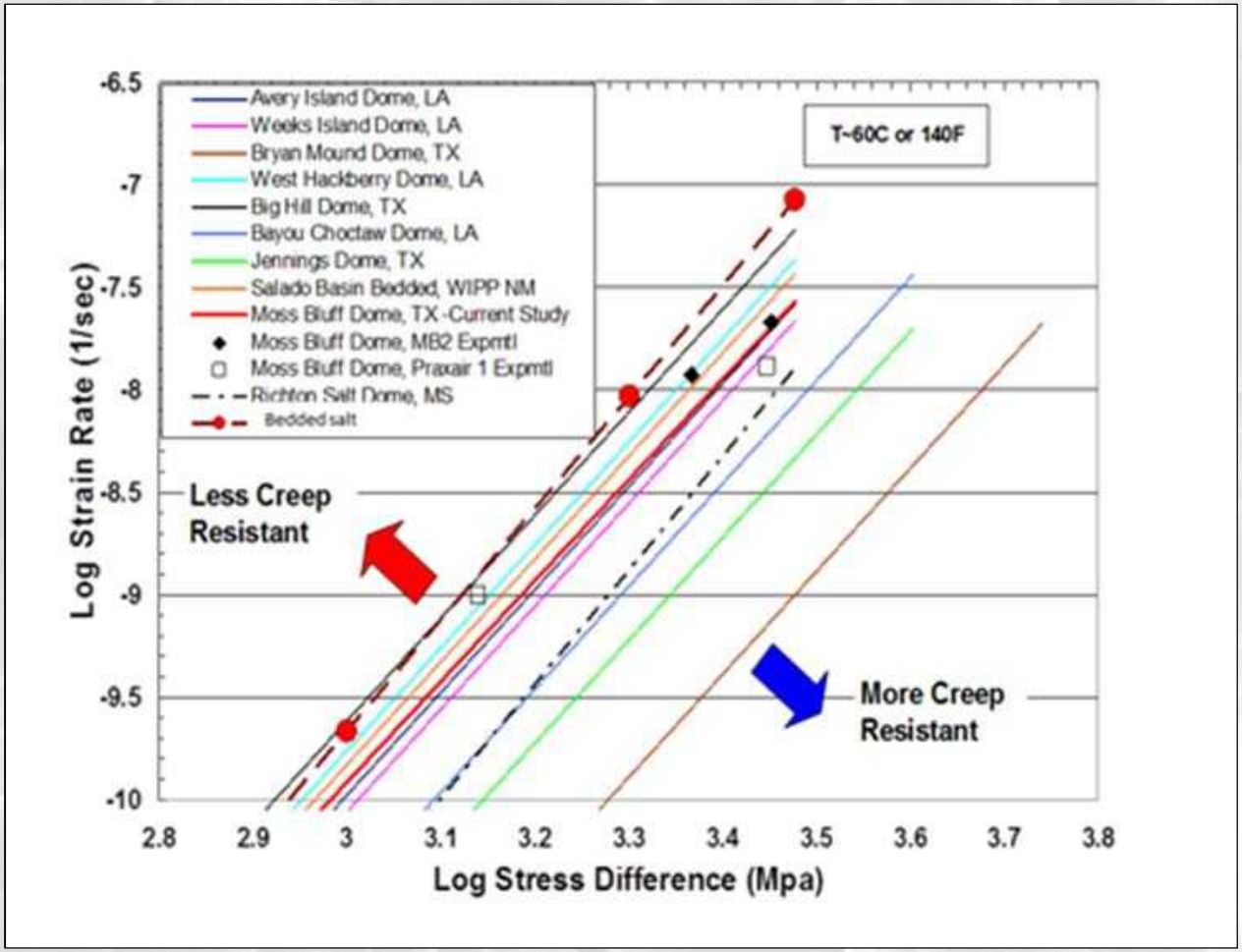
Mesoscale

- Thermal Effects
- Brine and Vapor Migration
- Mechanical Properties

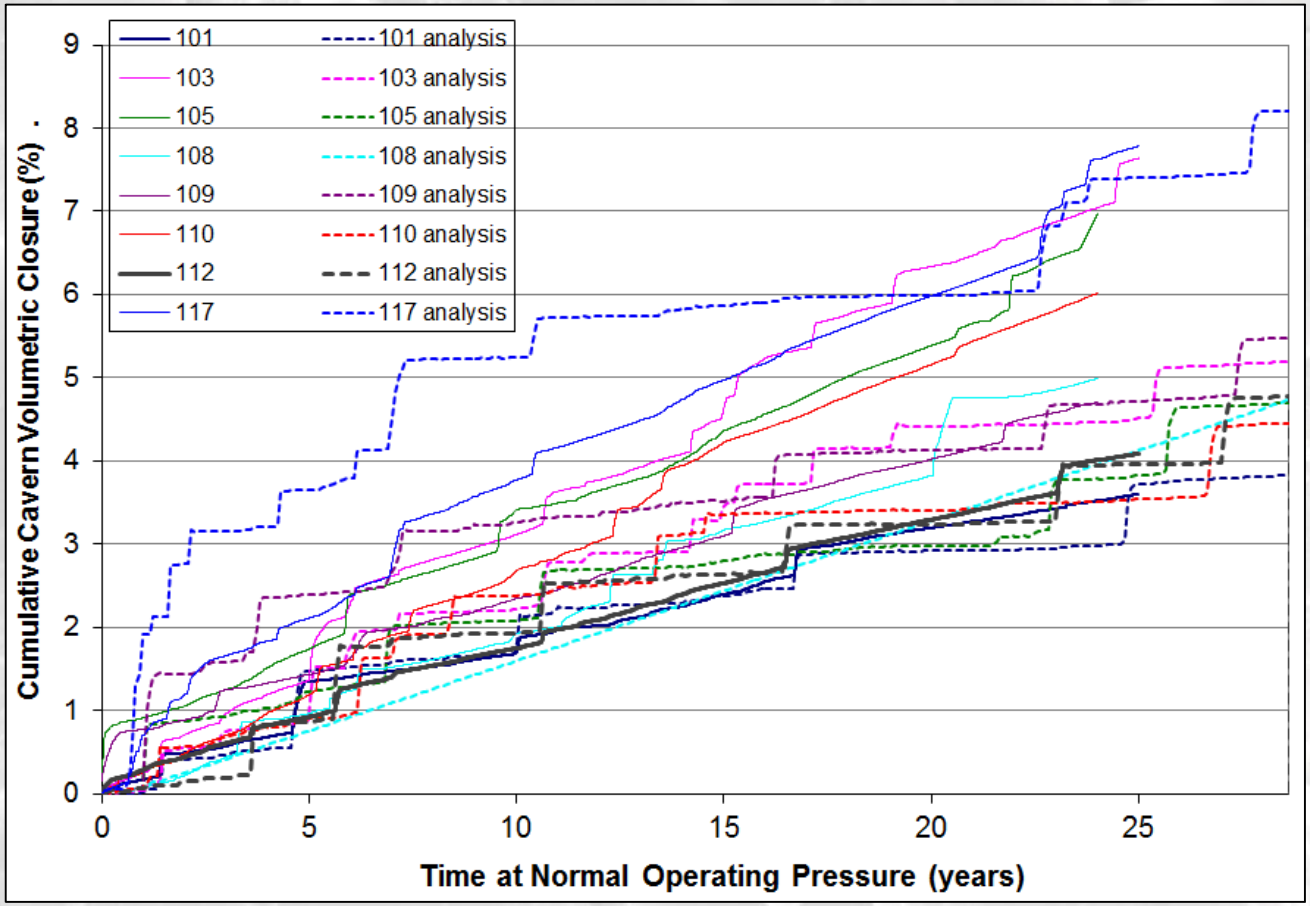
Ultimate and Dilatant Strength (Asse Dome WIPP Bedded)



Broad Comparison of Salt Creep Rates



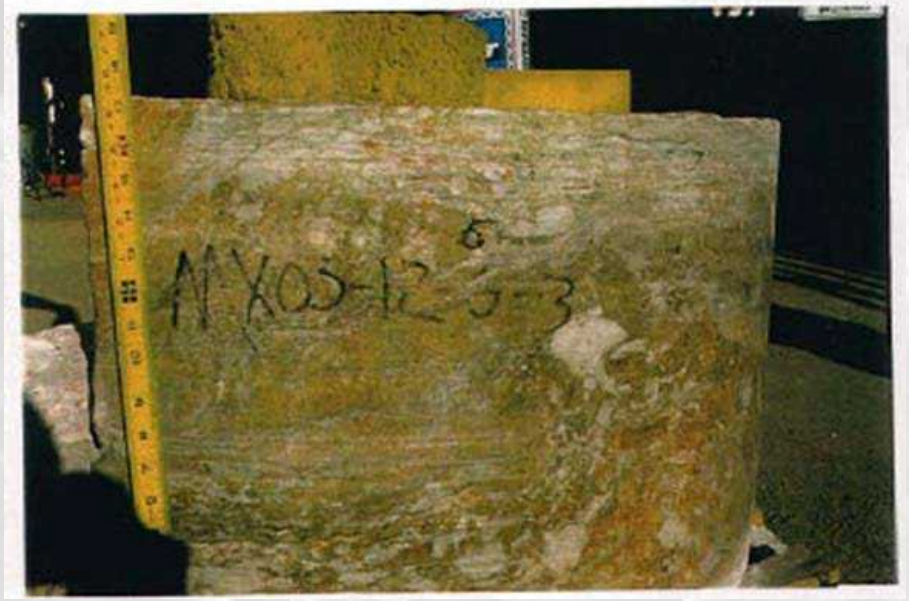
Measured and Predicted Cumulative Cavern Volumes of West Hackberry



Lithology


C/82/12/1
Δσ = 7.5 MPa
σ3 = 15 MPa
T = 200°C
0
5 cm
C/82/2/1
Δσ = 5 MPa
σ3 = 15 MPa
T = 200°C
0
5 cm

Lithology



Excavation Damage Zone at WIPP

a)

b)

Discussion

- Transferability – Some information will unavoidably be site specific
- Design Attributes – Lateral and vertical dimensions
- Closing Remark – If and when a consent-based site is identified, the technical basis for a salt repository stands ready, regardless of whether the formation is bedded or domal.