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Mutual Benefits—EU Sandia Collaboration

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EUROPEAN UNION
DELEGATION TO THE USA

Sandia National Laboratories

HORIZON 2020
The University of New Mexico
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Overview

- Case Studies of Sandia National Laboratories' participation in EU Research Projects
- Provide examples of benefits derived from **two** experiences
- Illustrate leveraged research goals and credibility gain
- Share knowledge, expertise, and data at positive Return-on-Investment
- Derivatives
  - Mentoring
  - New alliances
  - Emerging issues

Tale of Two Projects

BAMBUS

- Backfill and Material Behavior in Underground Salt Repositories
- Project was funded by the European Commission and the national governments and authorities (2000-2003)

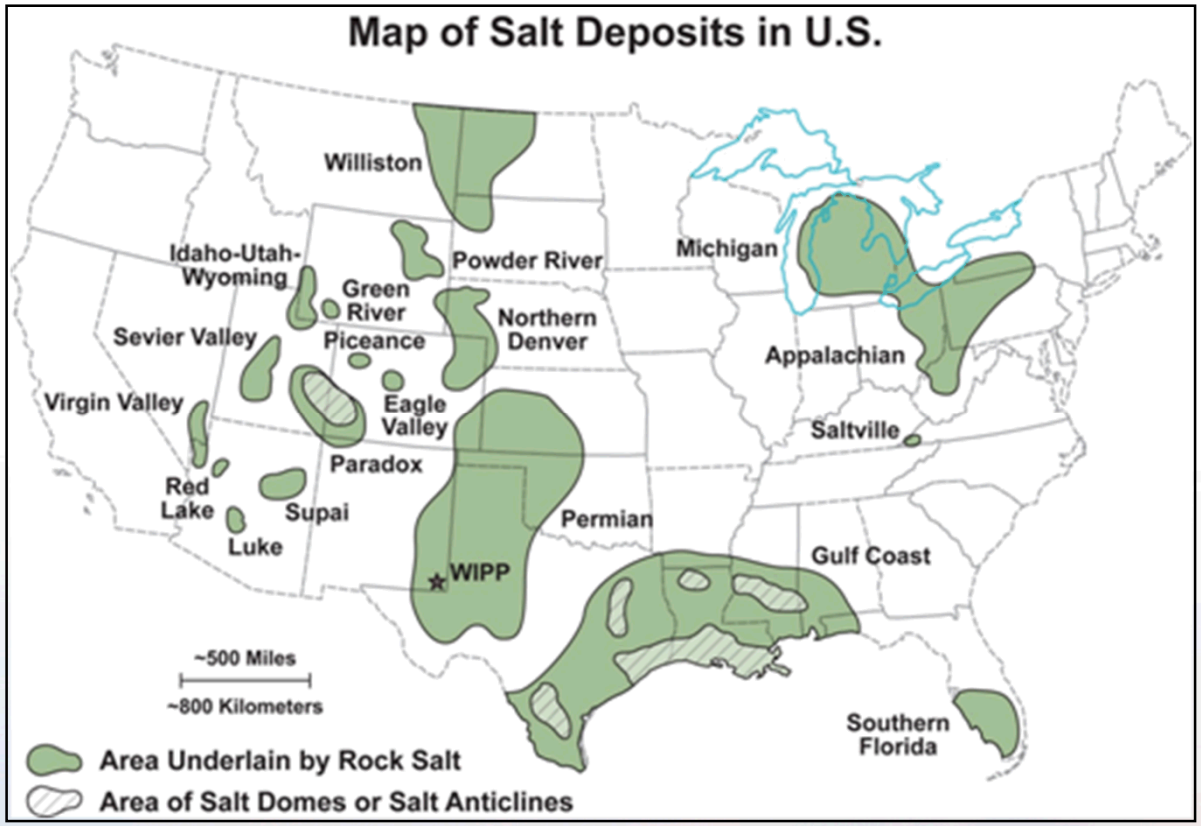
MoDeRn

- Monitoring Developments for Safe Repository Operation and Staged Closure
- Project co-funded by the European Commission under the Euratom Research and Training Program on Nuclear Energy within the 7th Framework Program (2007-2013)

Background

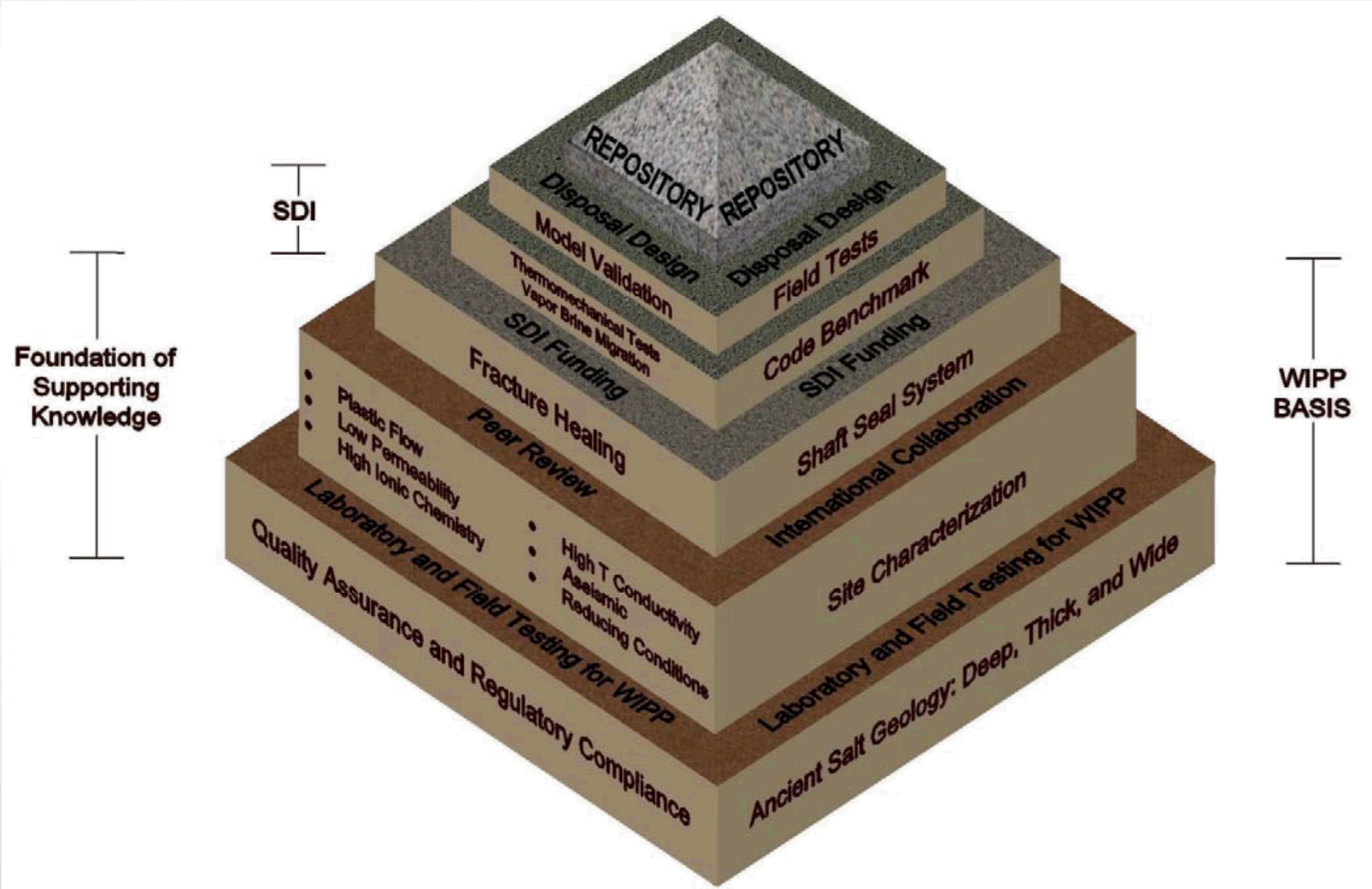
- The USA has many geologic settings suitable for deep geologic disposal of nuclear waste
- There is substantial confidence that compliance with regulatory standards can be demonstrated
- Rock types include salt, shale, and granite (and other massive, competent rock types)
- Commonality with Europe—Internationally recognized disposal concepts
  - Share experimental results
  - Advance computational tools
  - Apply analytical techniques
  - Contribute to Project deliverables

Context—Case for Salt Disposal



- The USA has supported significant salt repository investigations
  - Project Salt Vault
  - Avery Island
  - WIPP
- International interest is high (e.g., Germany)

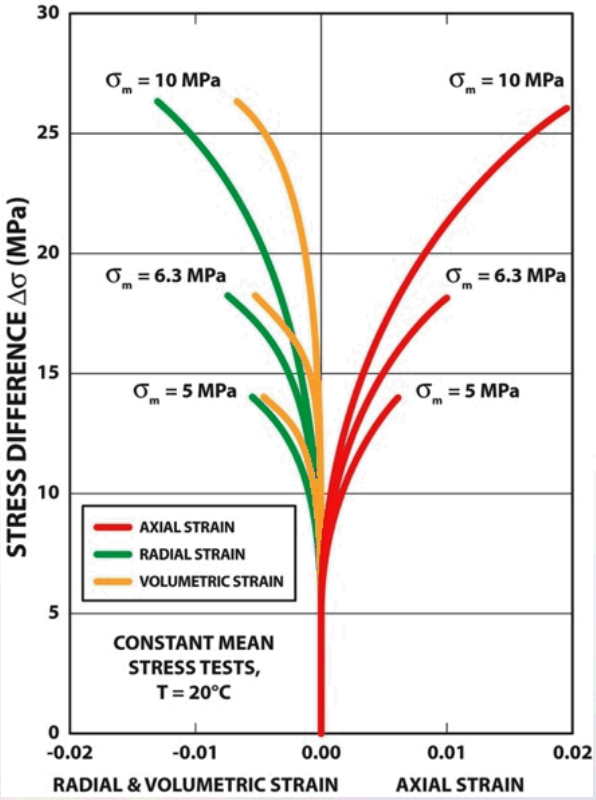
How Much is Enough?



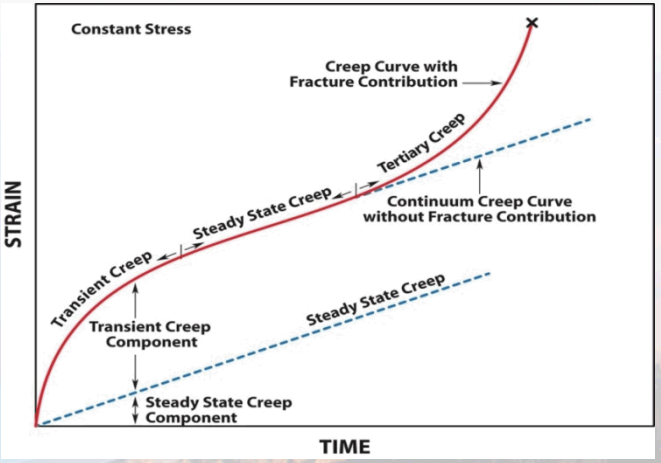
Thermal Mechanical Behavior

Large Test Rigs Needed

Deformed Salina Basin Salt

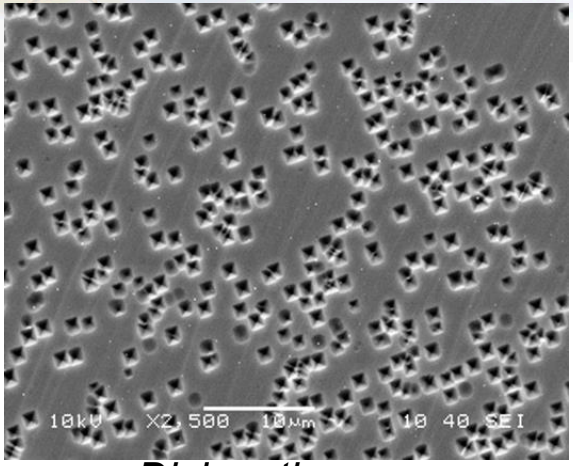


Mean Stress Testing

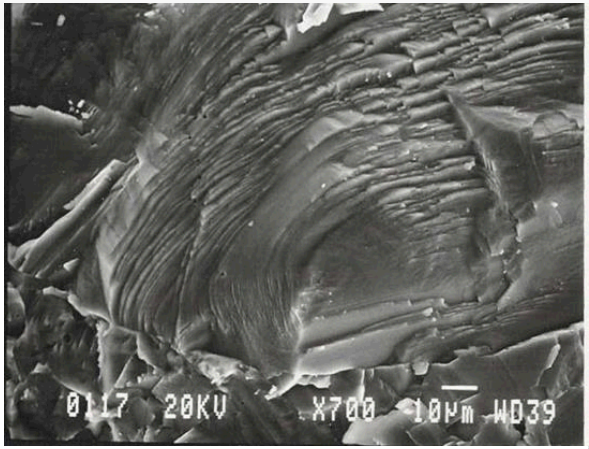


Classic Response

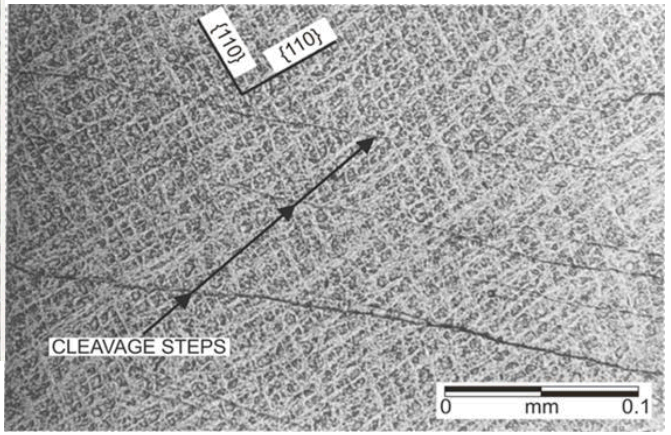
Micromechanics of Isochoric Deformation



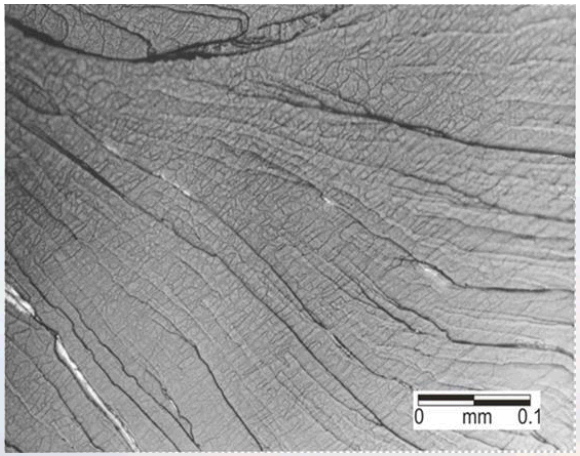
Dislocations



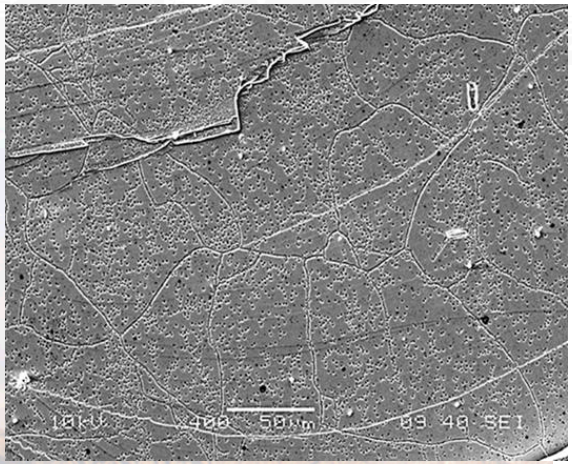
Glide



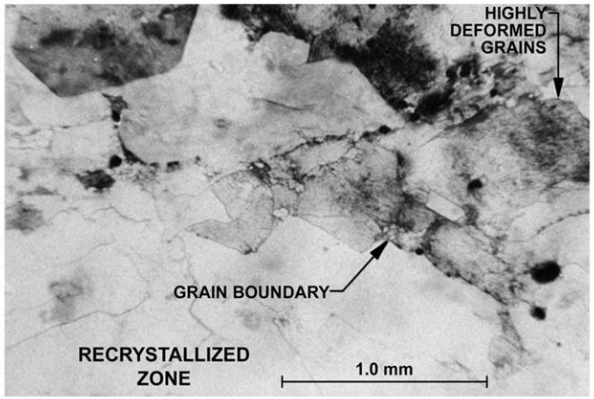
Cross Slip



Cross Slip and Climb



Polygonization



Recrystallization

Hansen, F. D. 2014 in preparation. *Isochoric Deformation of Salt.* American Rock Mechanics Association. Minneapolis MN.

Examples of Field Tests

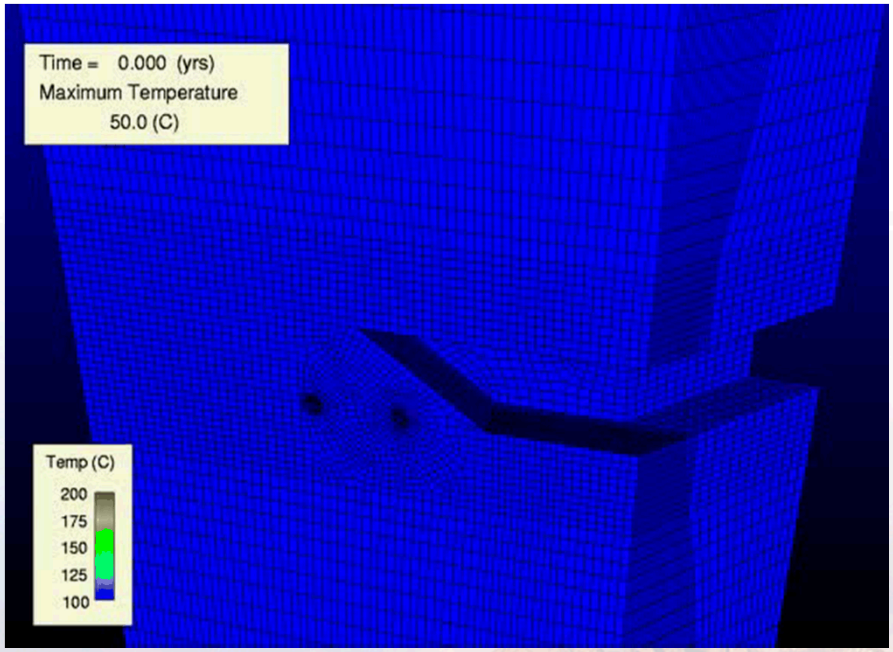
Heated axisymmetric pillar

Heated room

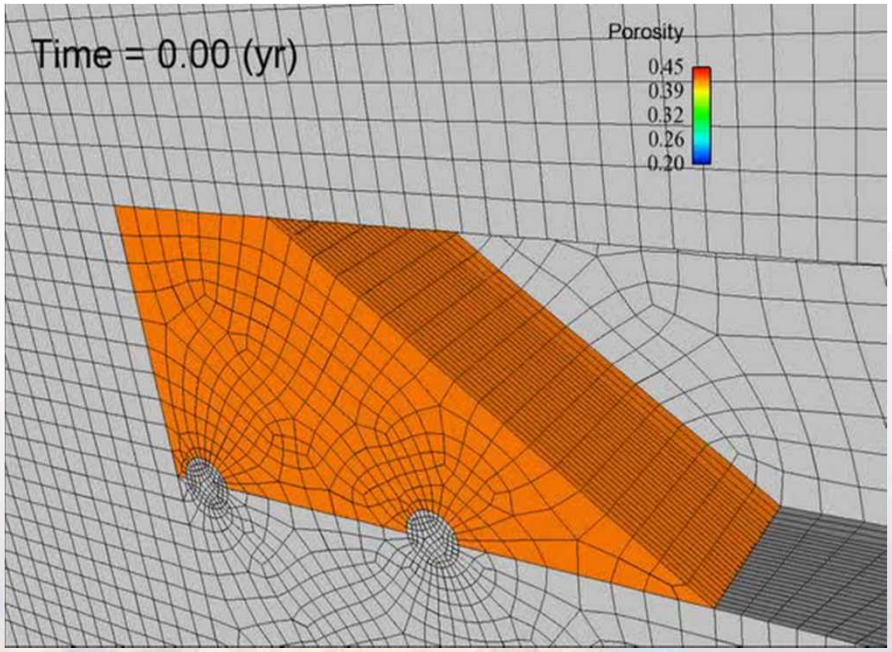
BAMBUS

Computational Geomechanics

- Computational effort is common theme in EU collaboration
- A BAMBUS II derivative effort includes benchmarking of codes and models
- Finite strain, coupled, thermal mechanical analyses
- Advanced constitutive models
- Fundamental physical mechanisms



Repository Temperature Contours



Crushed Salt Backfill Porosity Contours

[Stone, C.M., Holland, J.F., Bean, J.E., & Argüello, J.G. 2010. Coupled Thermal- Mechanical Analyses of a Generic Salt Repository for High-Level Waste (ARMA-10-180). *Proc. American Rock Mechanics Association (ARMA) 44th US Rock Mechanics Symposium, 27-30 June 2010.* Salt Lake City: American Rock Mechanics Association.]

Summary BAMBUS

- Response of salt to heat
- Porosity permeability function
- Determine how a salt repository will be closed
- Collaboration between modelers and experimentalists
- In situ and laboratory studies
- Established the SOA—guided future work
  - Example **Joint Project**—US/German collaboration
  - Constitutive model benchmarking—hardware and software
  - Domal versus bedded salt treatise
  - Best tools for future salt repository design and analysis

MoDeRn

EUROPEAN COMMISSION
Community research

EURATOM

MODERN
Monitoring Developments for Safe Repository Operation and Staged Closure

- Role of monitoring
- U.S. provided two case studies WIPP and YMP
- Monitoring and safety functions
  - Post MoDeRn period

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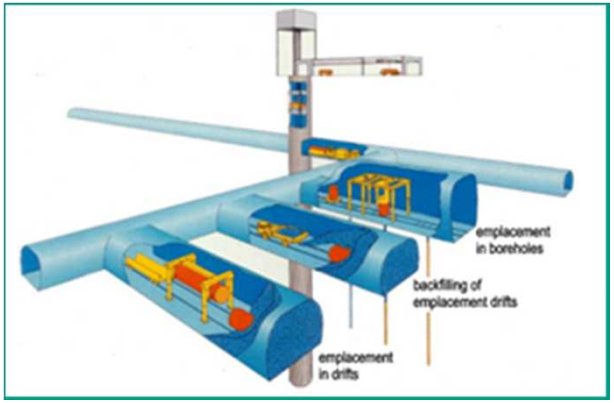
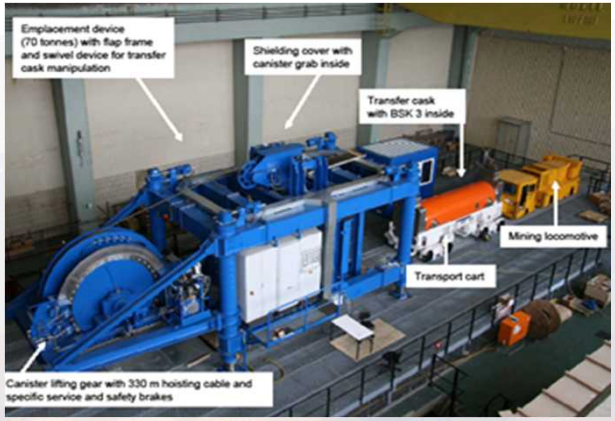
Shared Accumulation of Expertise

- Reference repository concepts
- Instruments, tools, and methodologies
- Modeling and safety analysis
- WIPP was a successful operation 1999-2014





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Performance Confirmation

- Monitoring repositories dictated by Regulatory requirements (e.g., 10 CFR 63)
- Integrated into long-term science program
- Sandia has most MoDeRn experience by virtue of YMP and WIPP license applications
- Iteration with the total system performance assessment
- Establish technical criteria
- Stakeholder confidence

Key Technical Advances

- BAMBUS
  - Important phenomena and process
  - Expand knowledge for repository design and performance assessment
  - Test and refine modeling
- MoDeRn
  - National context
  - Tied to the safety case
  - Post MoDeRn era
- Derivative international collaborations

EU Research Projects

- Two examples of Sandia/EU collaboration
- Plus-up for both
  - Technology
  - Cost
  - Credibility
- Contacts PI-to-PI
- Position for future—

UNCERTAINTY TREATMENT: SANDIA'S PERSPECTIVE

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IGD-TP

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WIPP Schematic