Exceptional service in the national interest

SAND2015-3651C

Sandia National Laboratories

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

RESPEC

Sandia National Laboratories

Salt Reconsolidation Applied to Repository Seals

Hansen, F. D., Sandia National Laboratories, Albuquerque, New Mexico, USA
Popp, T., Institut für Gebirgsmechanik (IfG), Leipzig, Germany
Klaus Wieczorek, Gesellschaft für Anlagen – und Reaktorsicherheit (GRS), Braunschweig, Germany
Dieter Stührenberg, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany

SALT MECH VIII Mechanical Behavior of Salt Conference
Rapid City, South Dakota, USA
May 26-28, 2015

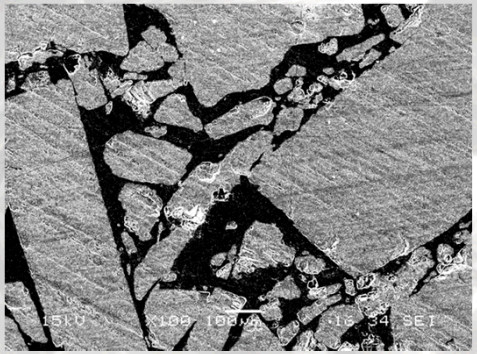
U.S. DEPARTMENT OF ENERGY

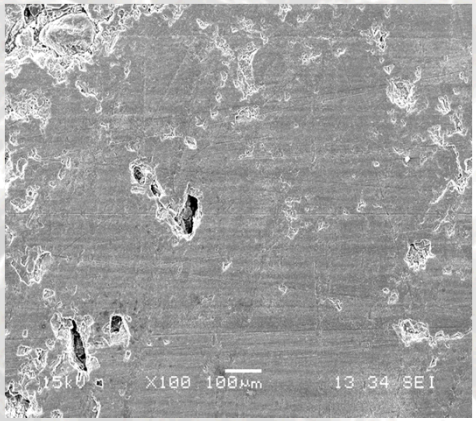
NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. All slides were extracted from SAND2014-4502P. SAND 2015-XXXX

Presentation Content

- Background
- Micromechanics
- Experimental results
- Transport properties
- Analogues
- Perceptions
- Future research





Role of Reconsolidation

Sandia National Laboratories

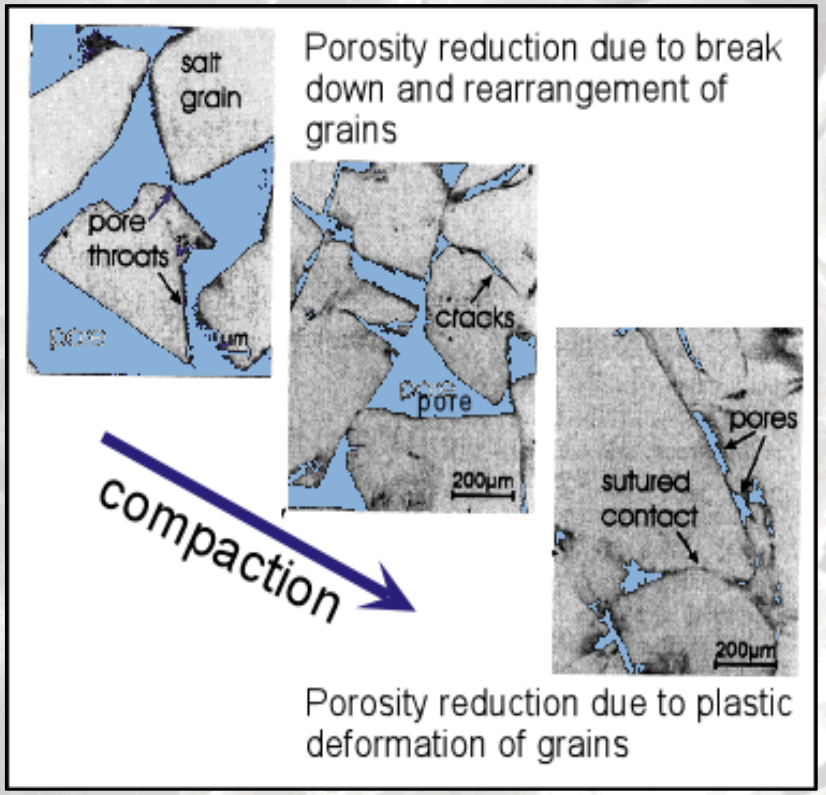
- Characteristics of the geologic formation itself are the most important to accomplish isolation of nuclear waste
- Salt formations are nearly ideal for permanent disposal because they are impermeable, deform plastically for the most part, and can be engineered to satisfy an array of disposal concepts
- Achievement of high-performance engineered barriers assumes a role as important as the formation
- The license to open a repository will depend on our demonstrated ability to close it

Background—Role of Reconsolidated Salt

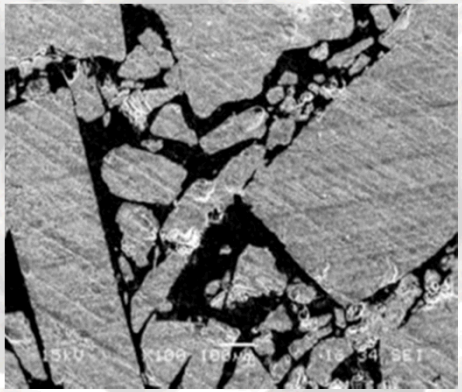
Sandia National Laboratories

- Act as a long-term barrier against inflowing brine or water and eliminate release pathways via drifts and shafts
- Conduct heat generated by radioactive decay from the waste to the host rock
- Stabilize repository excavations
- Provide low permeability and/or diffusivity and/or long-term retardation
- Key questions involve how, when, and to what degree properties of reconsolidating granular salt approach or attain those of the native salt formation

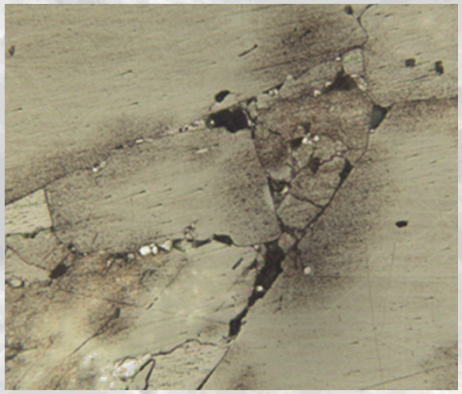
Reconsolidating Salt Forensics



Consolidation Mechanisms

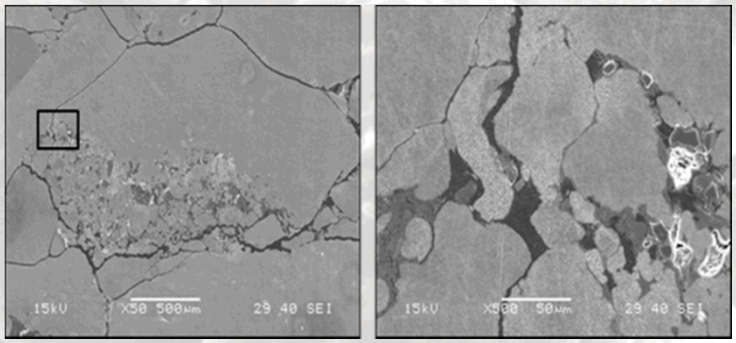


BAMBUS reconsolidated backfill 25% porosity; brittle cleavage translational sliding

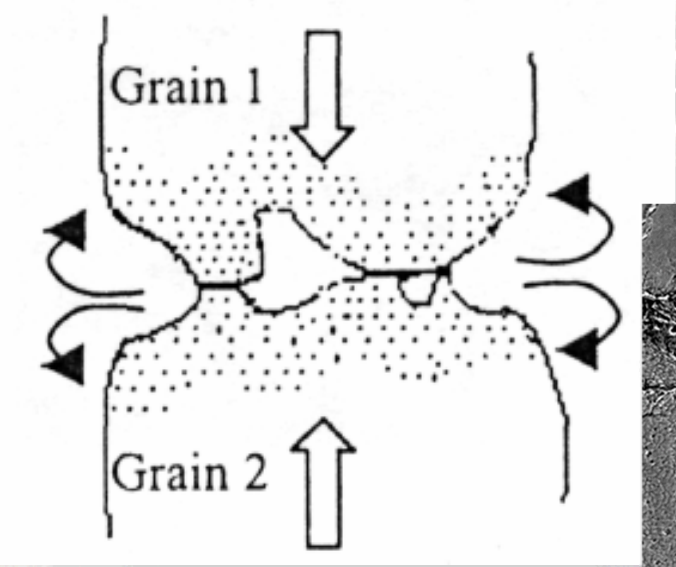


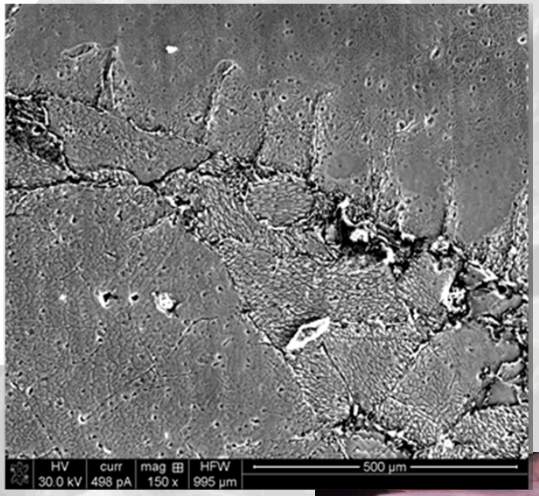
Backfill slurry. Cubic habit with pulverization and pressure solution

High temperature, low porosity sutured grains, extensive plasticity



Plasticity-Coupled Pressure Solution





SEM Micrograph

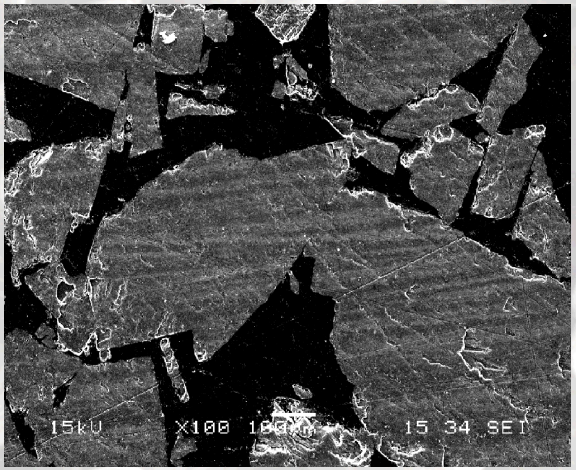
Consolidation Around Test Heater

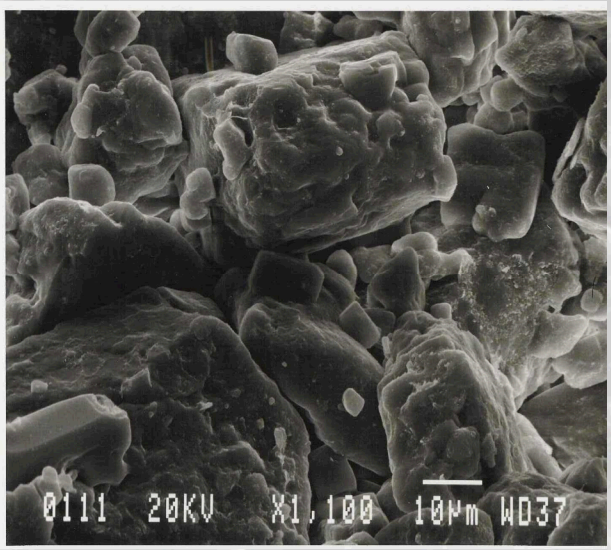
After Spiers and Brzesowsky 1993

Case Studies

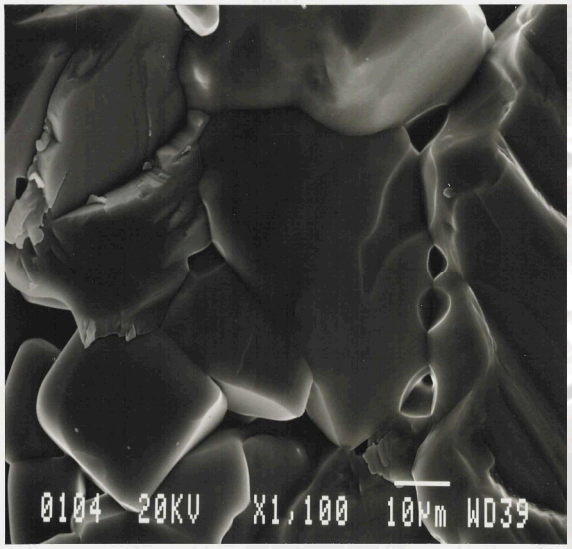
Sandia National Laboratories

BAMBUS

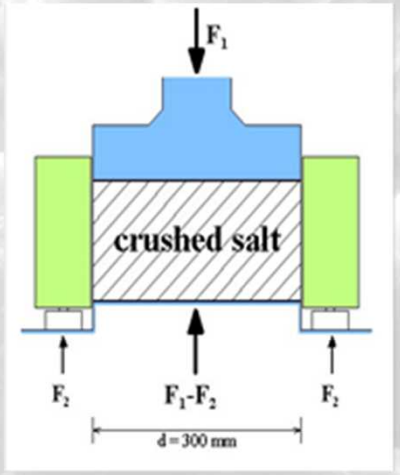
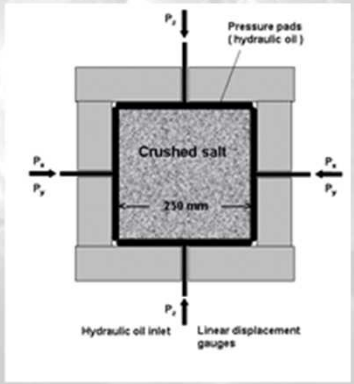
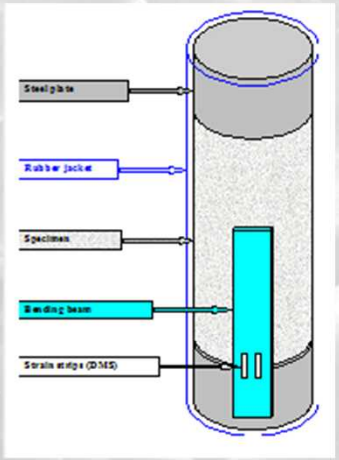
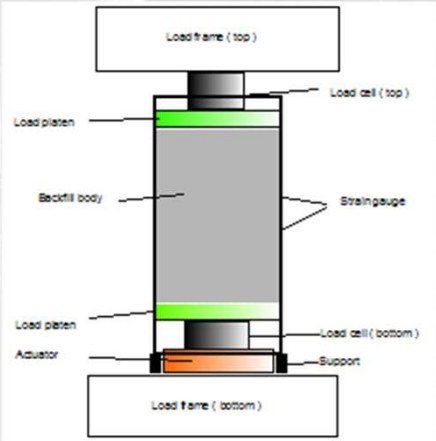




WIPP SHAFT

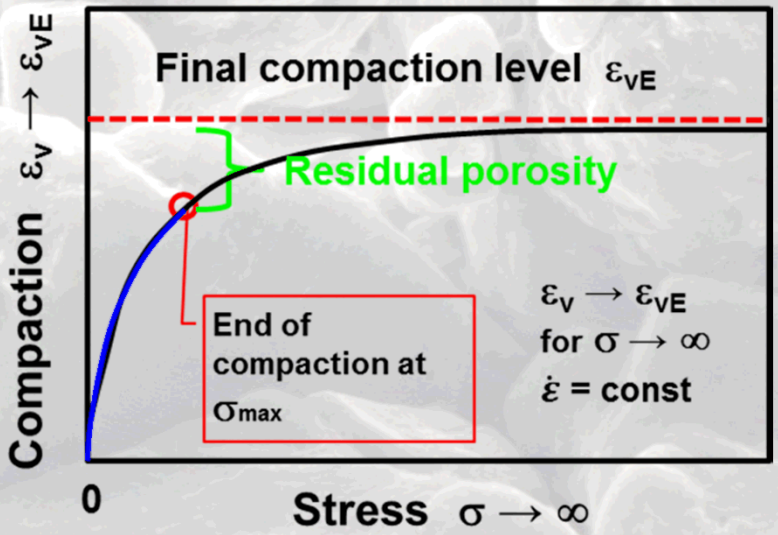


Experimental Test Arrangements

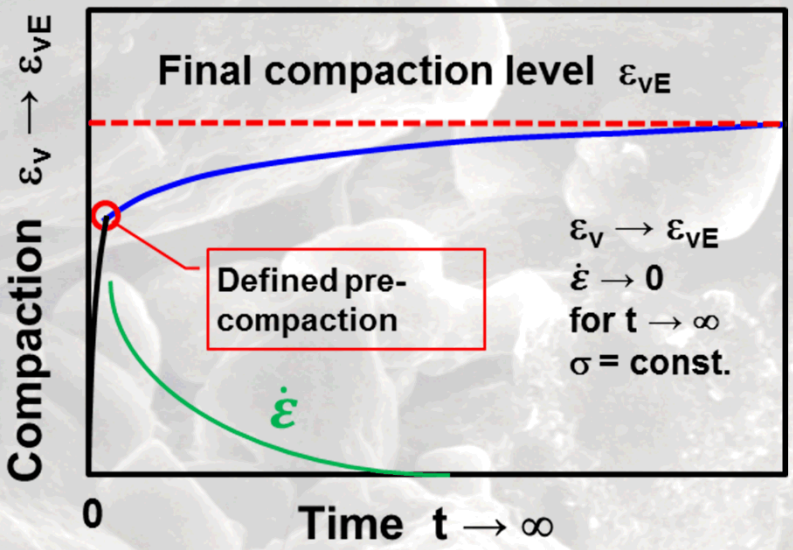
			
Oedometer cell (BGR) $\sigma_1 = (F_1 - F_2)/A$	True triaxial testing device (FZK-INE)	Triaxial cell (GRS)	Backfill compaction cell (IfG)

After Bechthold et al. 2004

Experimental Procedures

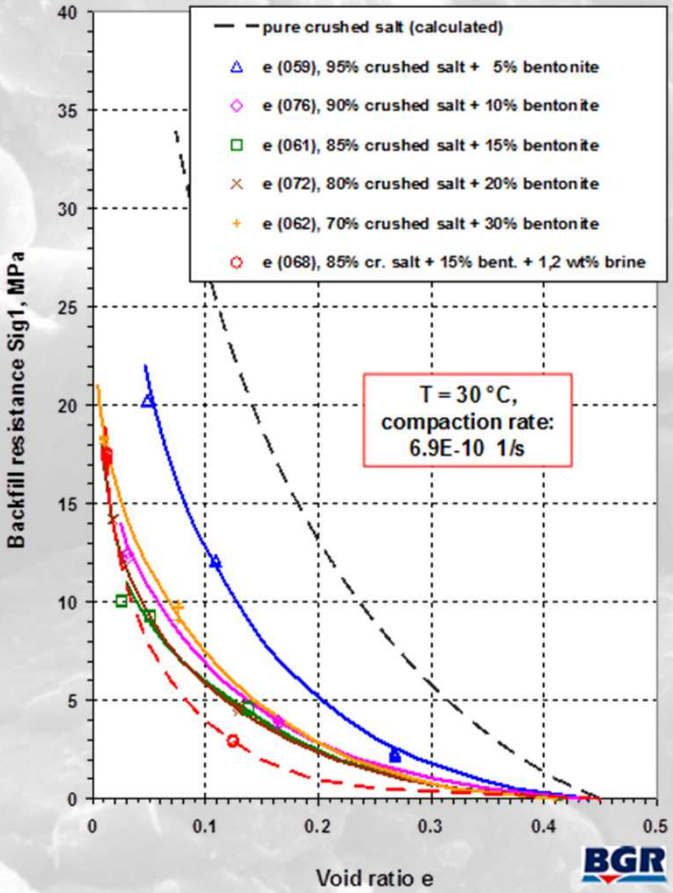


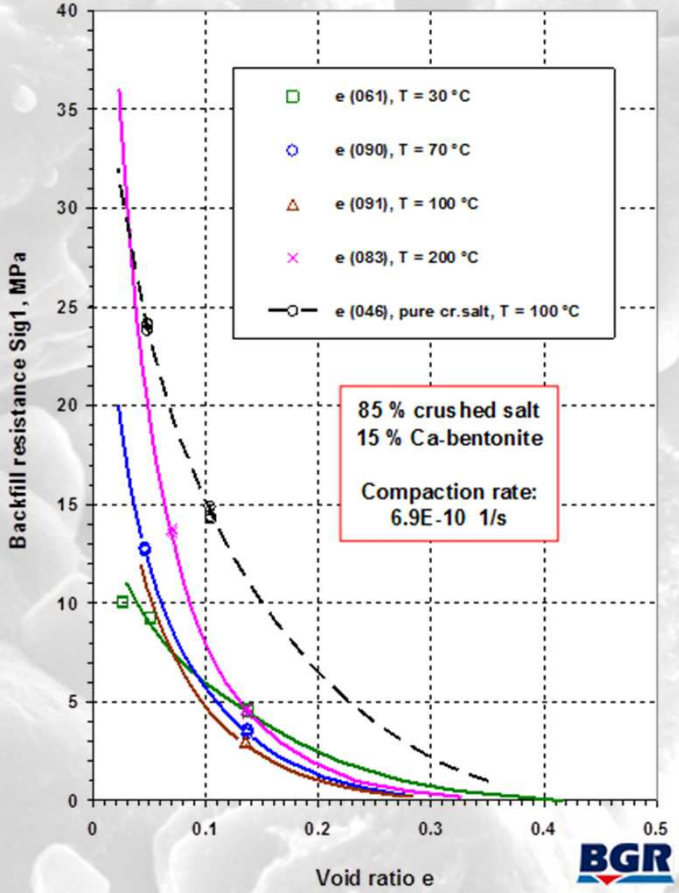
Type I Constant strain rate



Type II Constant load creep

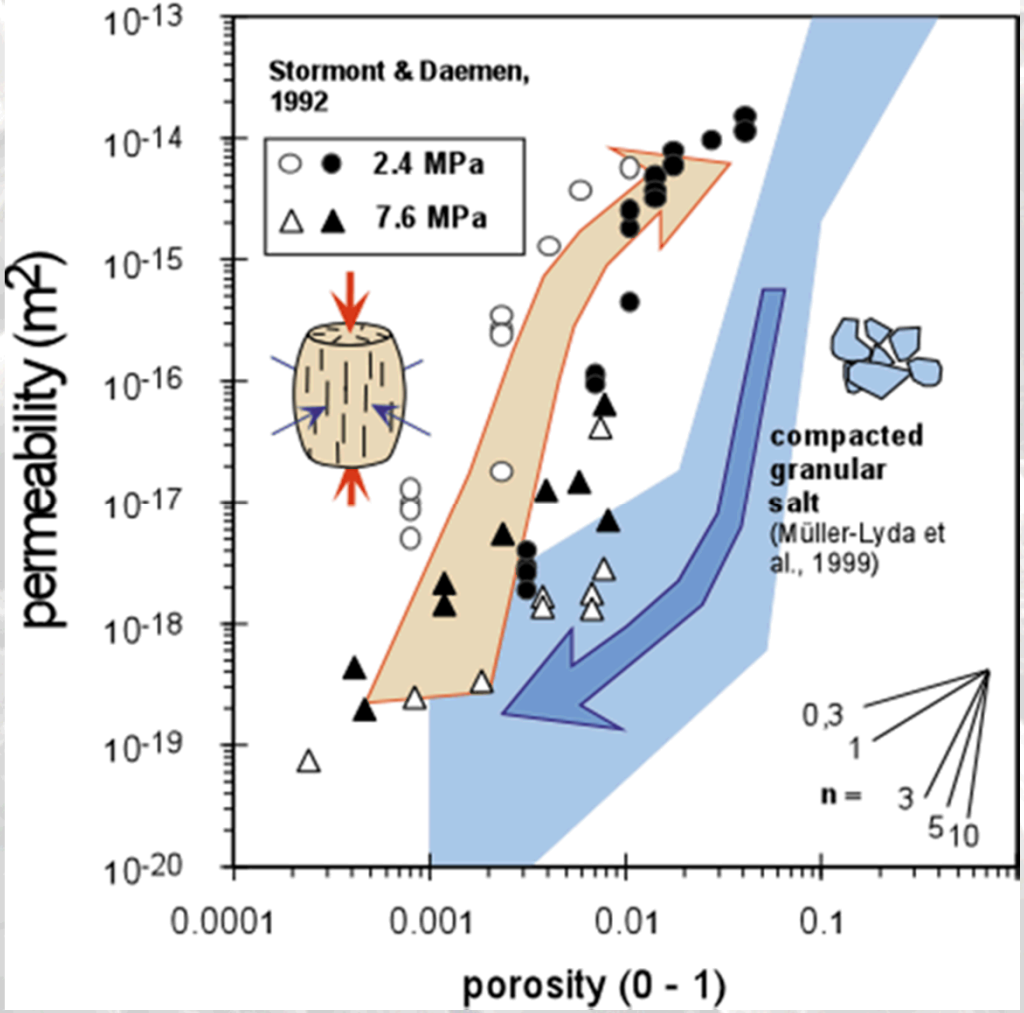
Additives and Consolidation Behavior



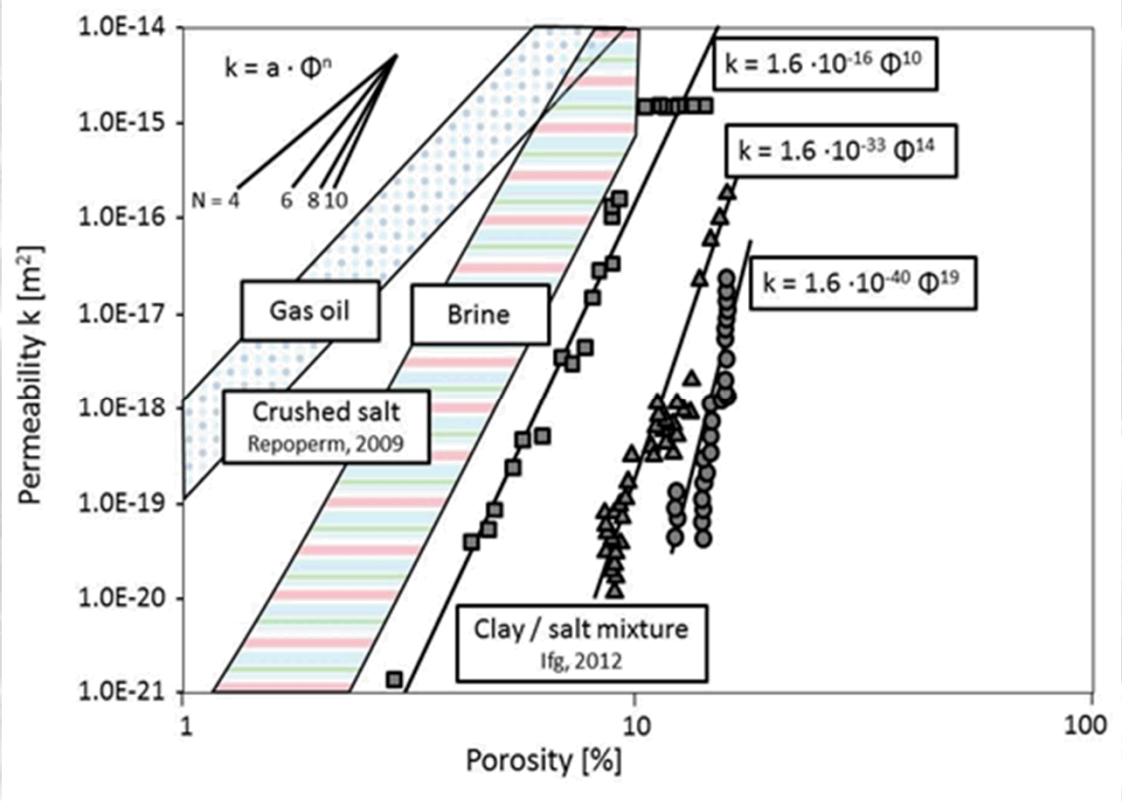


Stührenberg 2004; 2007

Permeability-Porosity Relations

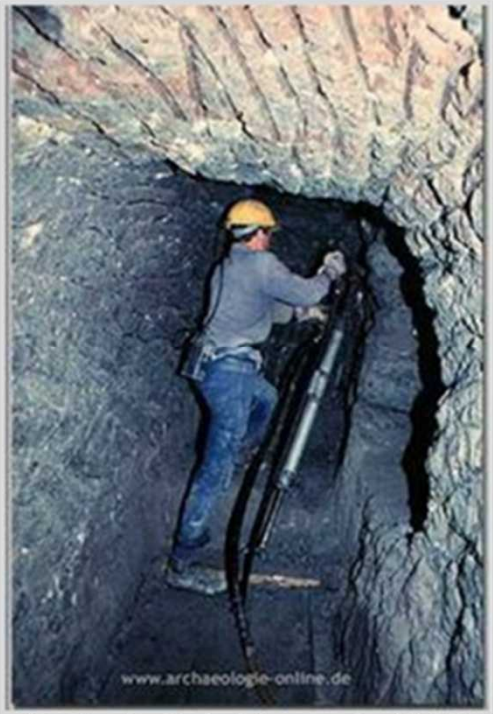


Permeability-Porosity Data



Kröhn et al. 2009

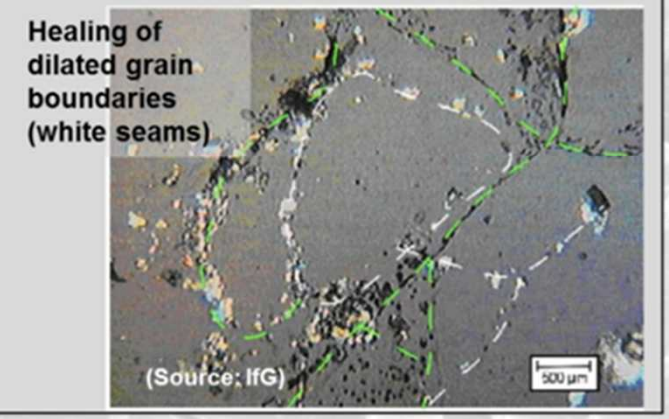
Summary of Analogues



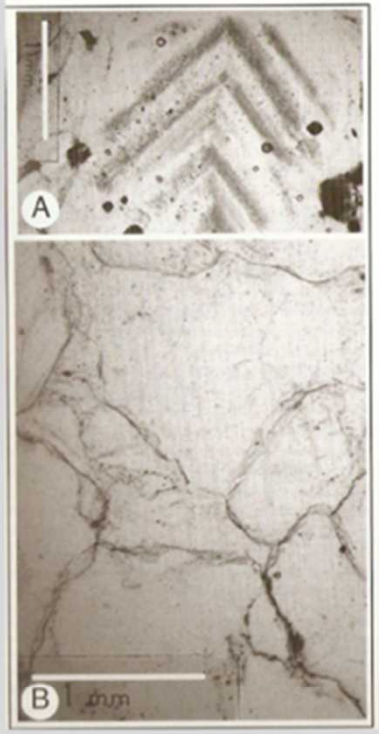
Headwork with jack-hammer in old-drifts in the salt mine Dürnberg (A)

a)

b)



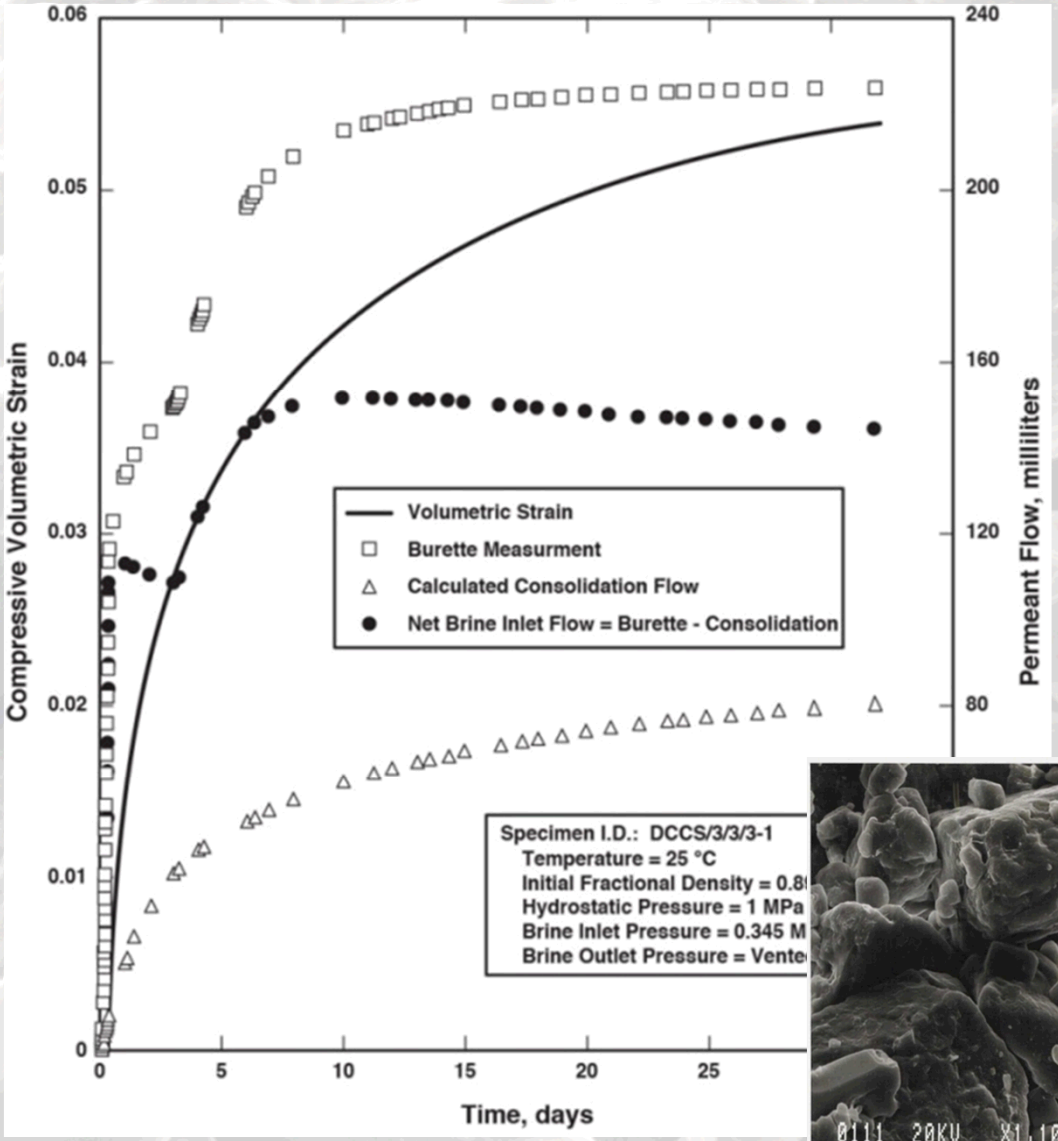
c)



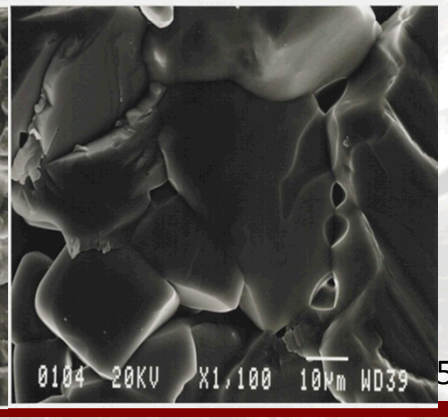
A) Chevron-structures due to grain grow by precipitation
B) B) 120° polygon-structures developed by recrystallisation

d)

Volumetric Strain and Brine Flow



Evolution of substructure

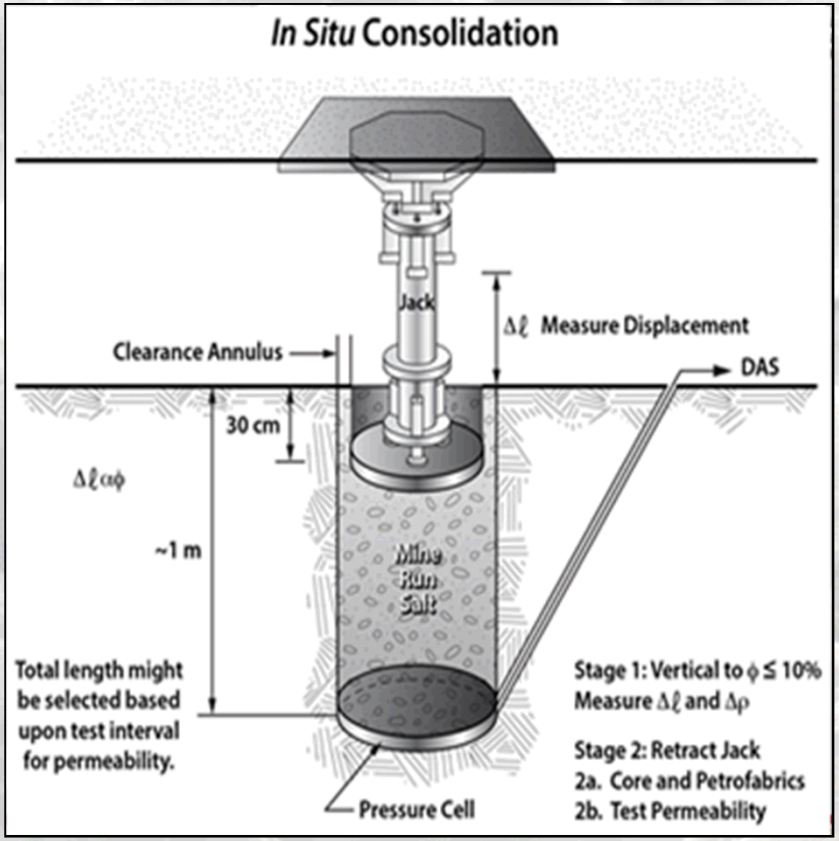


Perceptions-Future Work

Sandia National Laboratories

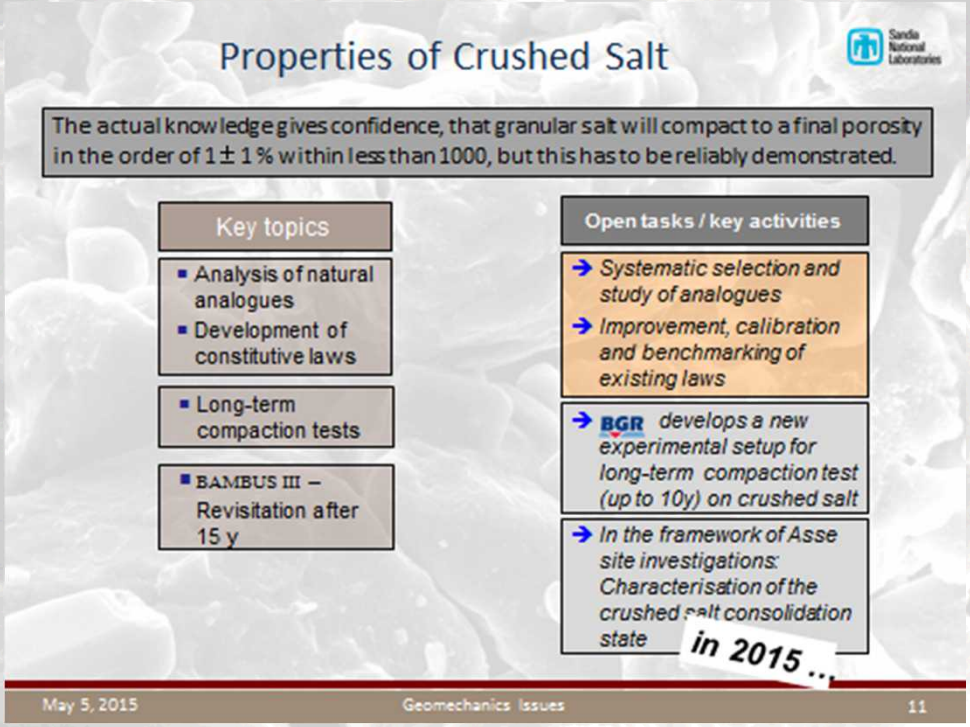
- What final porosity of crushed salt is necessary to achieve an efficient seal and when can it be reached?
- Capability of additives such as moisture and clay can be optimized for construction and attainment of sealing properties
- The nature of testing fluids (brine or gas) and the resultant permeability/porosity relationships warrant further examination
- Numerical modeling provides capabilities but lacks low porosity verification
- Further analogue experience from underground sources is imperative

Field-scale Test



Future Research

Andreas Hampel	Dr. Andreas Hampel, Wissenschaftlicher Berater, Mainz
Sandra Fahland, Jörg Hammer	BGR
Nina Müller-Hoeppe	DBE TECHNOLOGY GmbH
Klaus Wieczorek	GRS
Till Popp, Wolfgang Minkley	IfG Institut für Gebirgsmechanik GmbH Leipzig
Frank Hansen	Sandia National Laboratories
Joachim Stahlmann, Christian Missal	Technische Universität Braunschweig
Karl-Heinz Lux	TU Clausthal



- *Finis* -

Hansen and Popp 2015