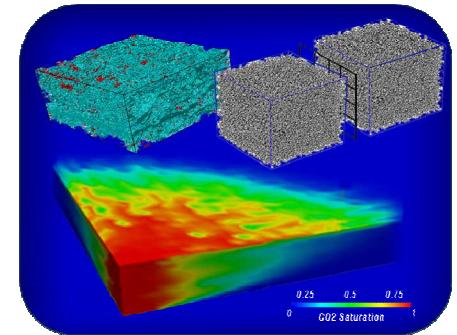
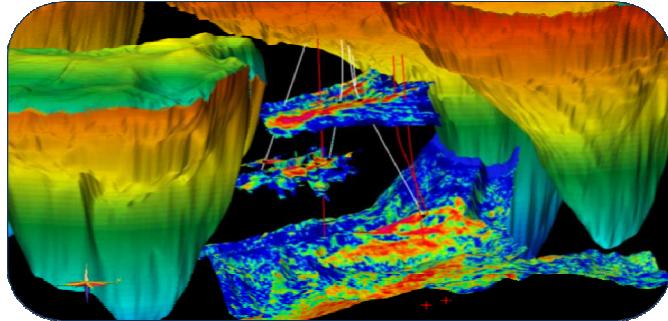


Exceptional service in the national interest



Salt Reconsolidation: Principles and Applications

Frank D. Hansen PhD PE
Sandia National Laboratories
Presentation at Salt Club Meeting
Berlin Germany
September 16, 2013



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On Principles and Application

- Overview of subject matter
- Principles
 - 1. Laboratory testing
 - 2. Room temperature
 - 3. Elevated temperature
- Application
 - 1. Shaft
 - 2. Drift
 - 3. Analogues
- Where do we go from here?

Laboratory Testing

- **Overview of subject matter**
- **Theory and microstructural observations of densification processes (Spiers and coworkers, 1988, 1990, 1993...)**
- **REPOPERM Phase 2 (Czaikowski et al., 2012)**
- **Vorläufige Sicherheitsanalyse Gorleben (Popp et al., 2011)**
- **3rd US/German workshop on salt repository research, design and operations (Hansen, et al., 2012).**
- **Temporal evolution of granular salt compaction**

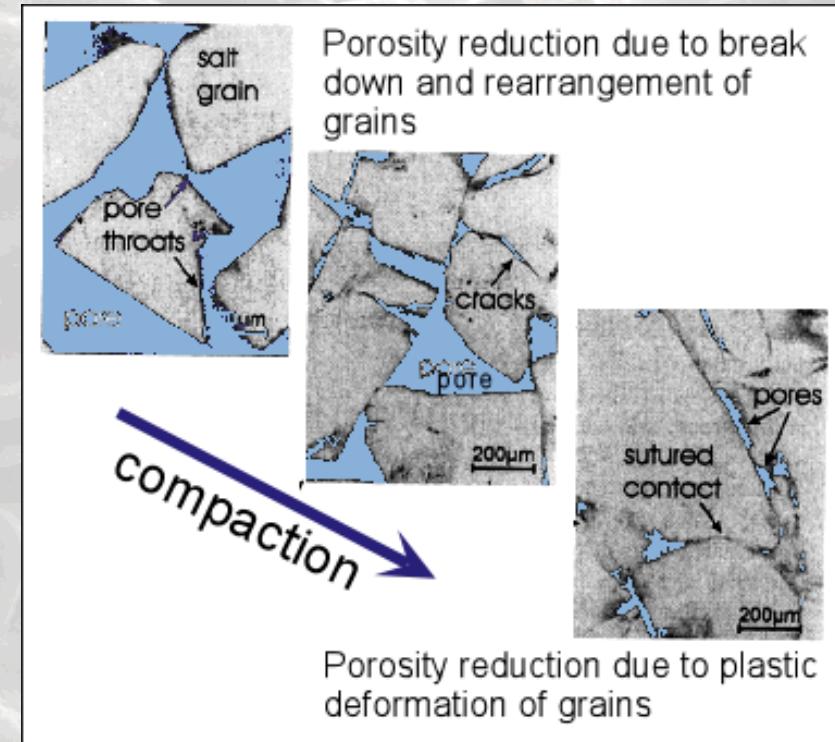
Laboratory Results



Reconsolidated
Salt

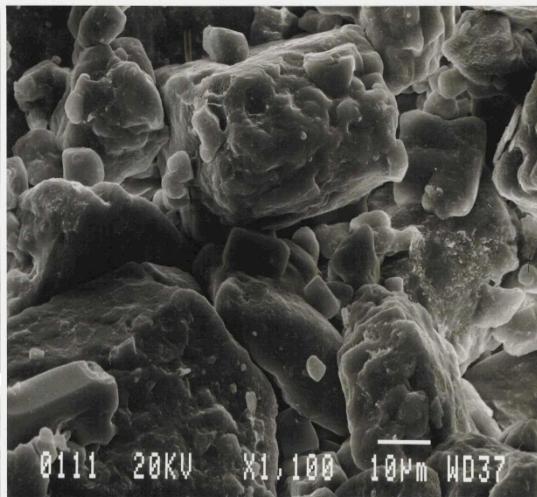


Optical
Section

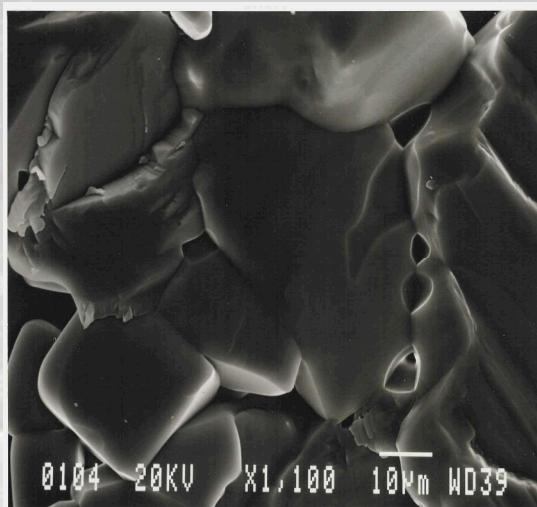


From Popp et al., 2011

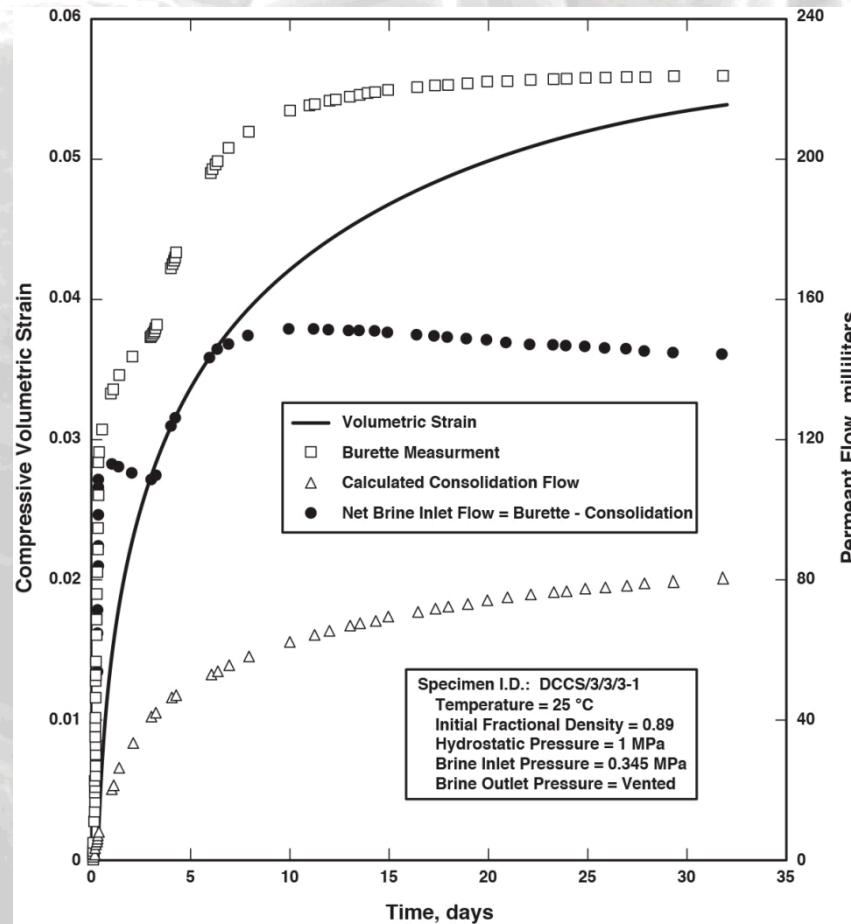
Laboratory Results



Compacted



Reconsolidated

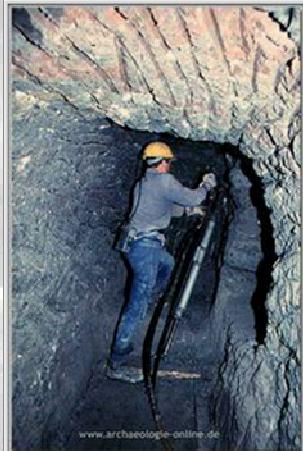


Reduction of brine permeability

Applications

- WIPP shaft seal RD&D
- BAMBUS II
- Operating mines
- Drift closures at WIPP
- Vorläufige Sicherheitsanalyse Gorleben

Natural Analogues



Vortriebsarbeiten mit dem Preßlufthammer in zukonvergierten Alt-Strecken im Dürnberger Salzbergwerk (A)

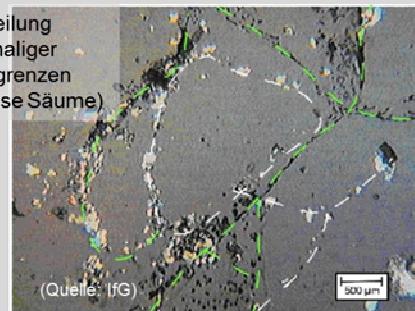
Bronzezeitlicher Steinsalzbergbau Österreich

Heidengebirge
6. - 4. Jh. v. Chr

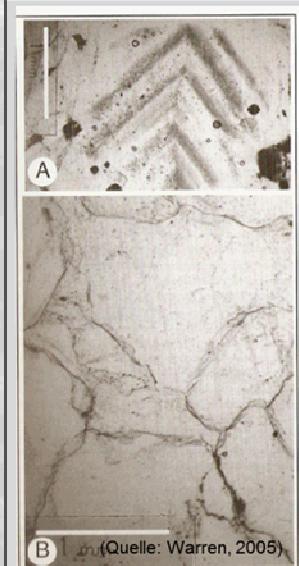


Konvergenz von Alt-Versatzstrecken

Verheilung ehemaliger Korngrenzen (weisse Säume)

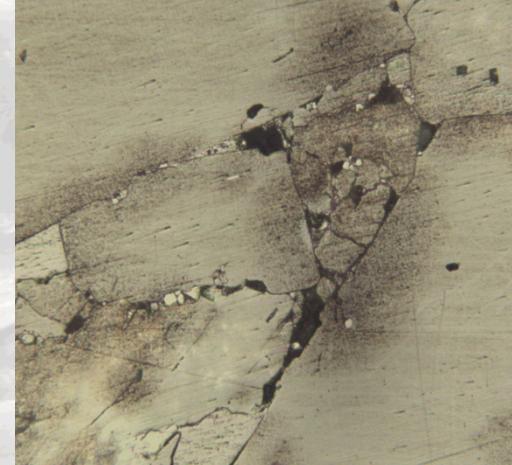


Verheilung Dilatanz / ALZ (\varnothing = wenige %)



A) Chevron-Strukturen infolge Kornwachstum
B) 120° Polygon-Strukturen infolge Rekristallisation

Diagenese von Salzlagerstätten



Slurry after 30 years



Hallstatt

From Popp et al., 2011

Salt compaction in mining and natural analogues

Where do we go from here?

- Establish the scientific basis for granular salt evolution in repository applications
- Summarize state of knowledge for preservation, reference and research
- Demonstrate progress on US/German collaborations
- Additional analogues and mining experience
- Large-scale short-duration consolidation in situ
- Use of the WIPP URL
- *The End*