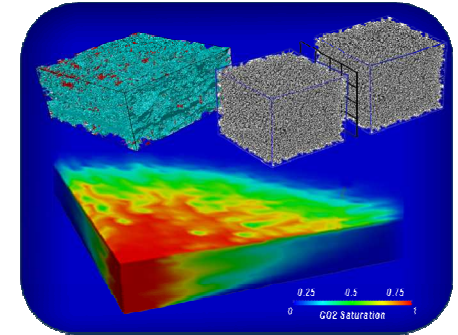
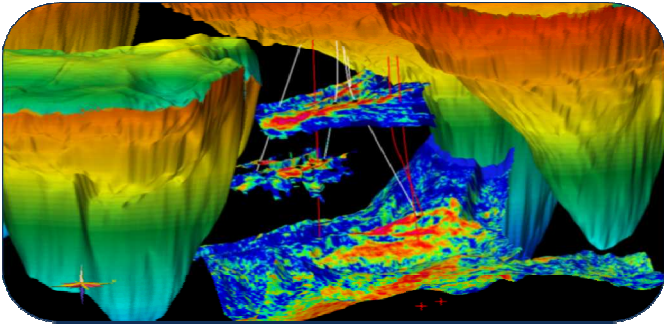


Exceptional service in the national interest



Salt Reconsolidation: Principles and Applications

Frank D. Hansen PhD PE

Sandia National Laboratories

Presentation at Salt Club Meeting

Berlin Germany

September 16, 2013

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

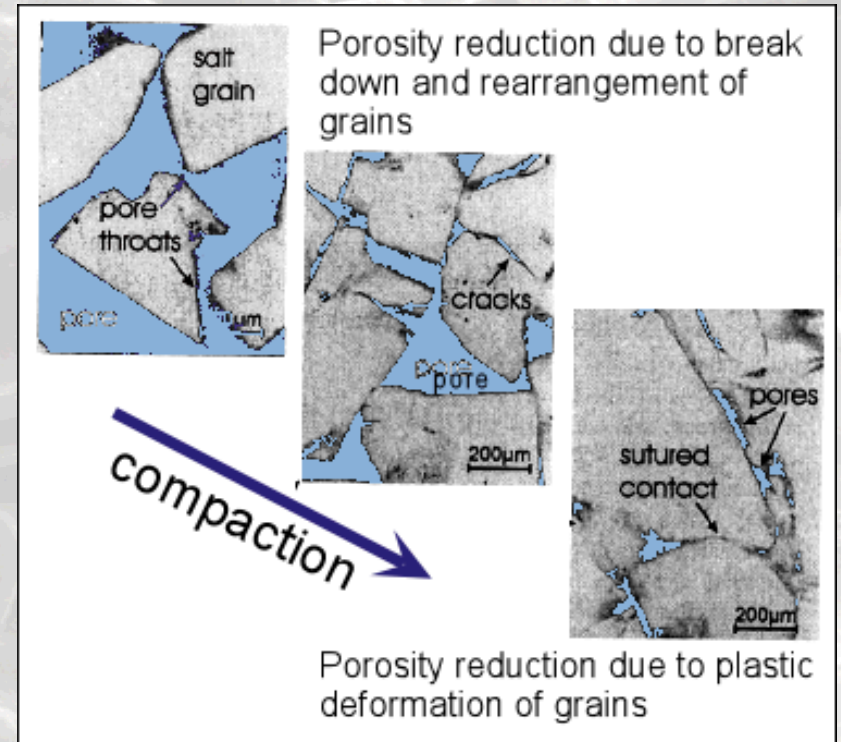
Laboratory Results



Reconsolidated
Salt

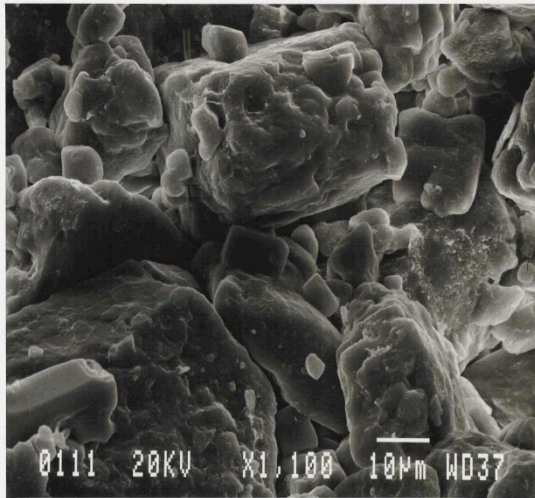


Optical
Section

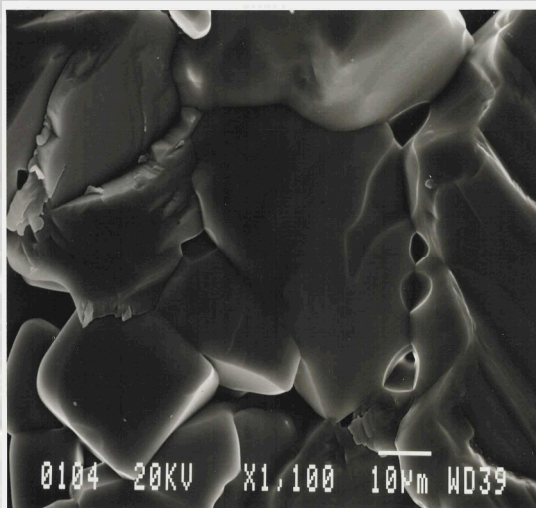


From Popp et al., 2011

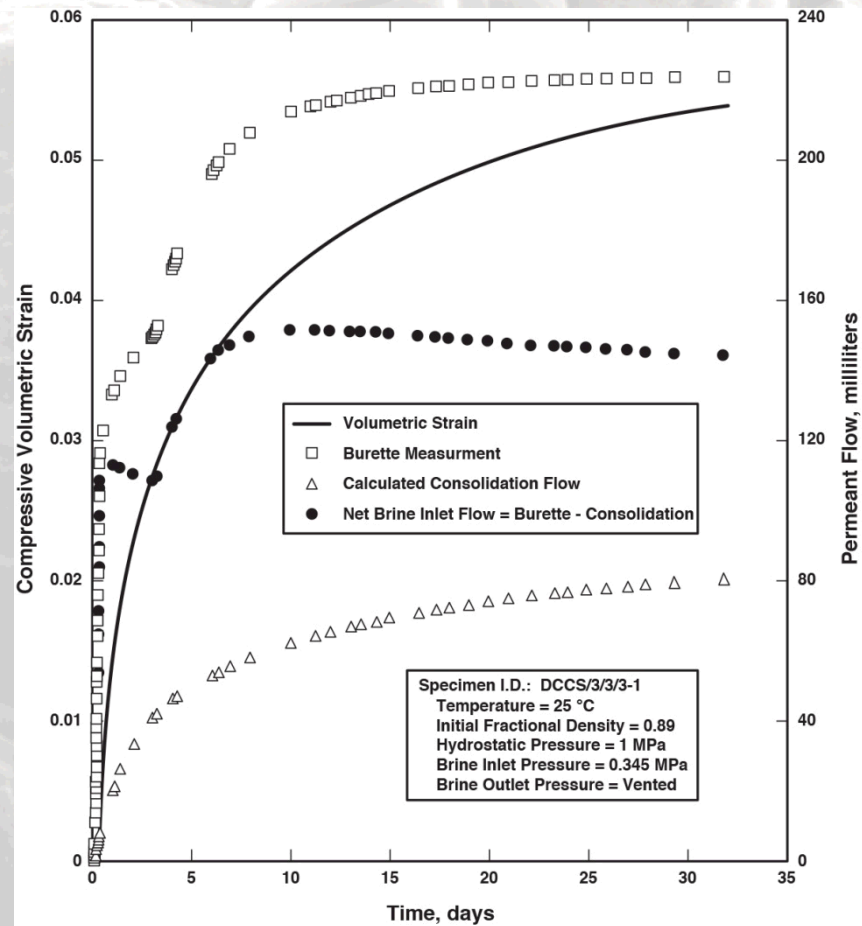
Laboratory Results



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 Preß-
lufthammer in zukonvergierten
Alt- Strecken im Dürnberger Salz-
bergwerk (A)

Bronzezeitlicher Steinsalzbergbau Österreich

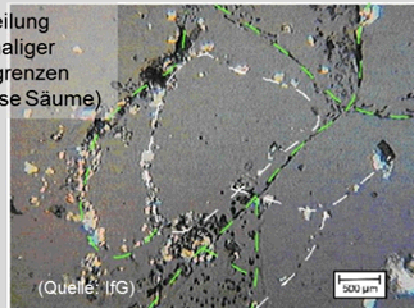
Heidengebirge
6. - 4. Jh. v. Chr



Asse (Quelle: GRS)

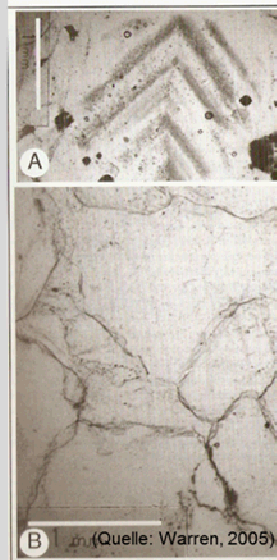
Konvergenz von Alt-Versatzstrecken

Verheilung
ehemaliger
Korngrenzen
(weisse Säume)



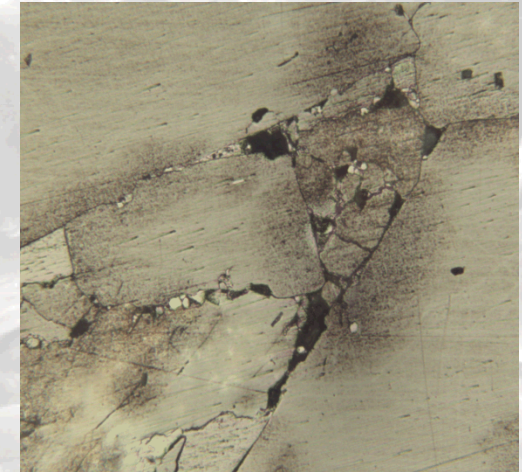
(Quelle: IfG)

Verheilung Dilatanz / ALZ (Ø = wenige %)

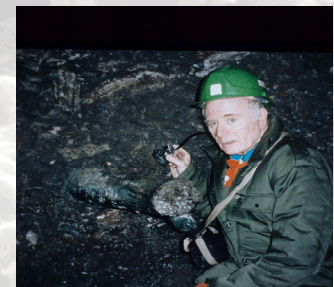


- A) Chevron-Strukturen infolge
Kornwachstum
- B) 120° Polygon-Strukturen
infolge Rekristallisation

Diagenese von Salzlagerstätten



Slurry after 30 years



Hallstadt

Salt compaction in mining and natural analogues

From Popp et al., 2011

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*