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Sandia National Laboratories

Perspectives on Granular Salt Reconsolidation

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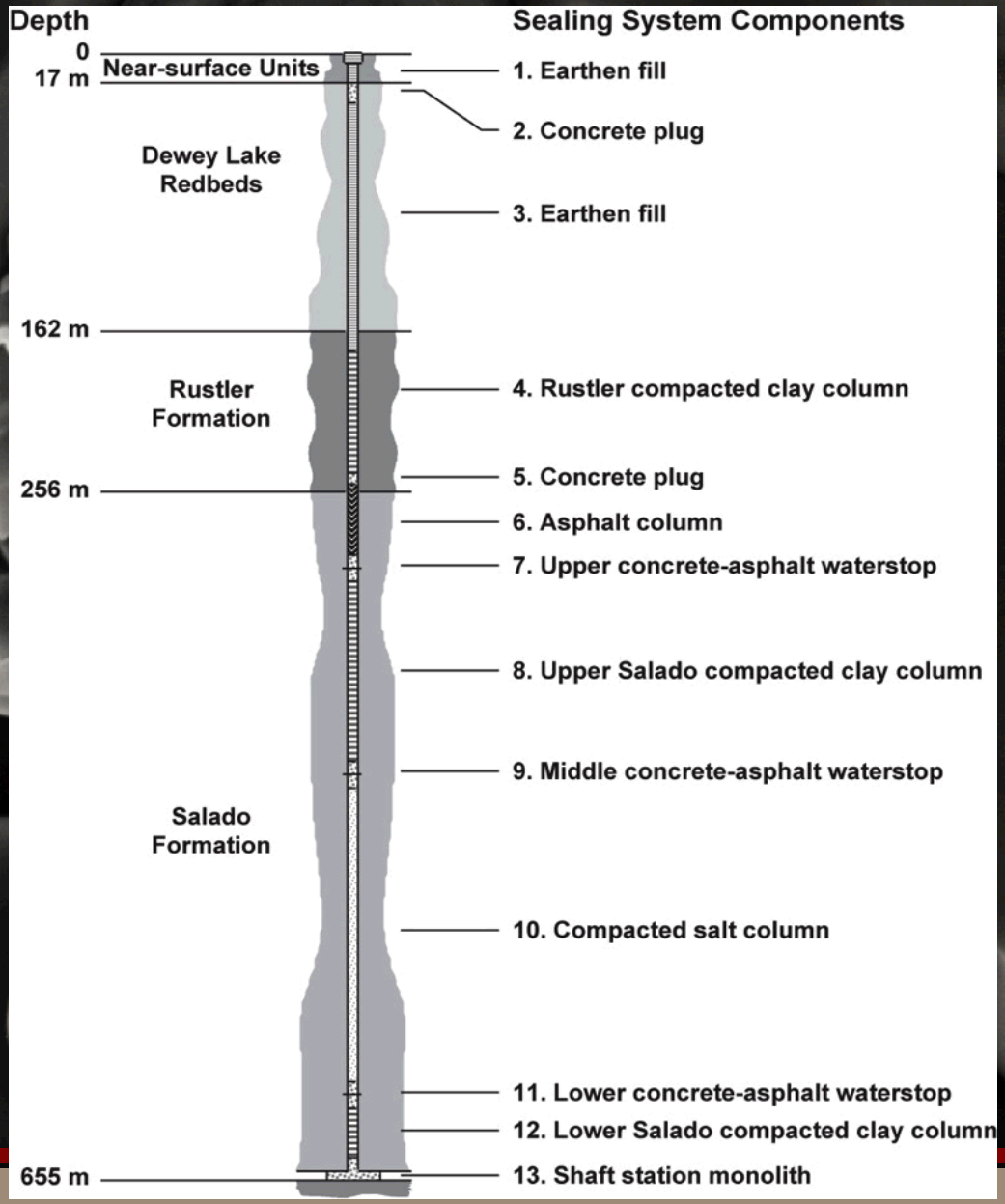
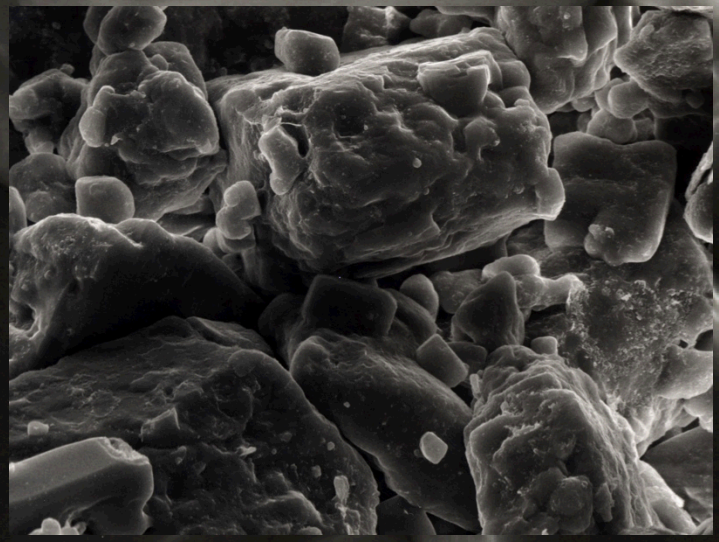
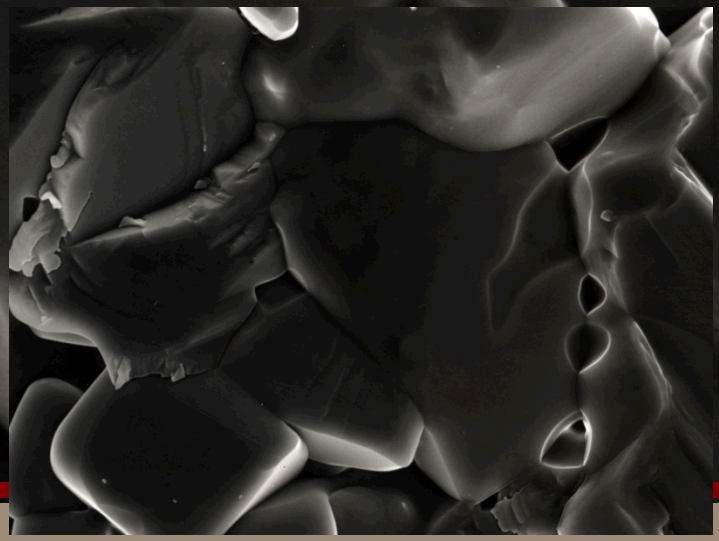
Shaft Sealing System





ø = 10%
$K = 10^{-14} m^2$

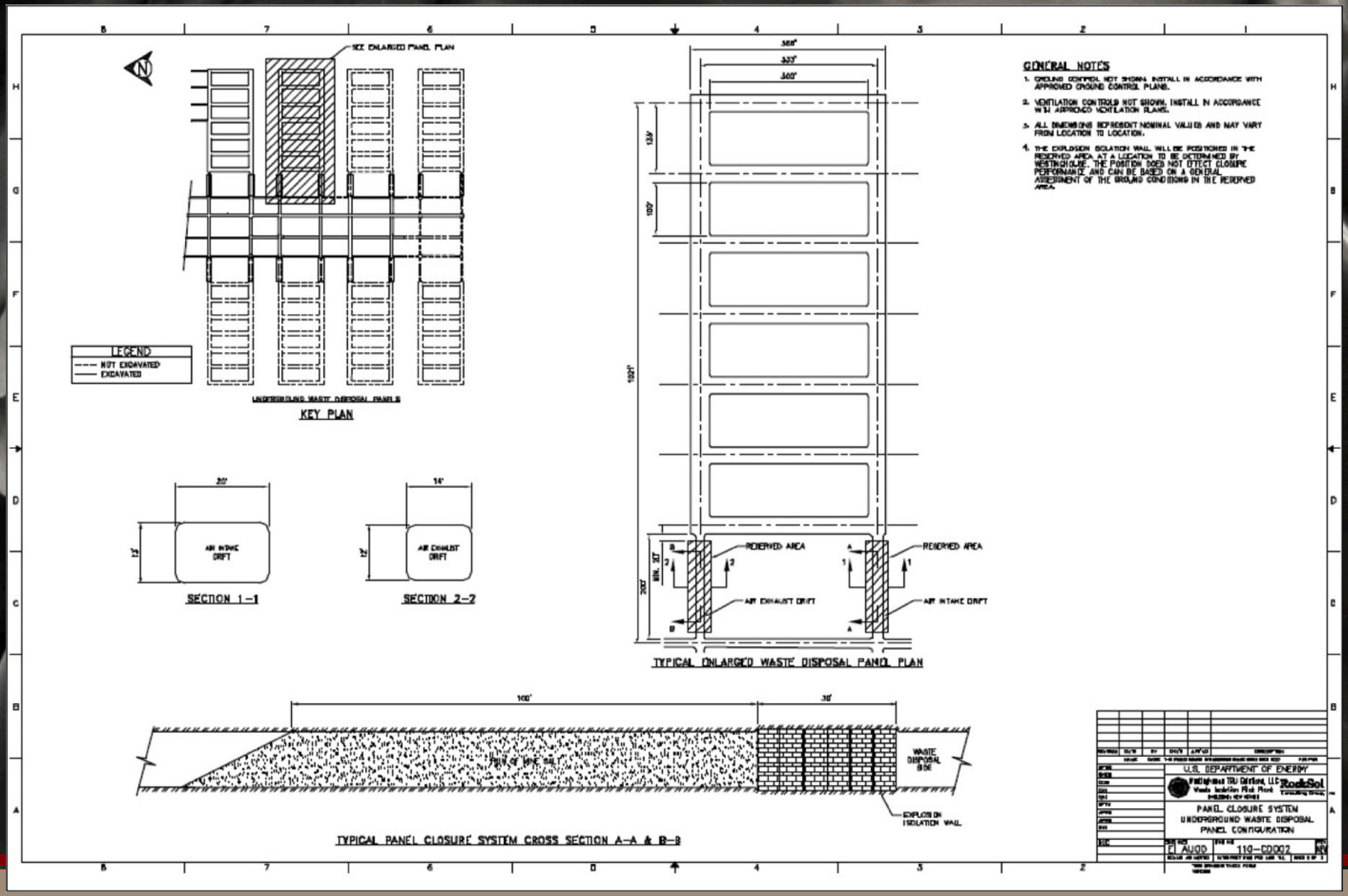
ø = 3%
$K = 10^{-19} m^2$



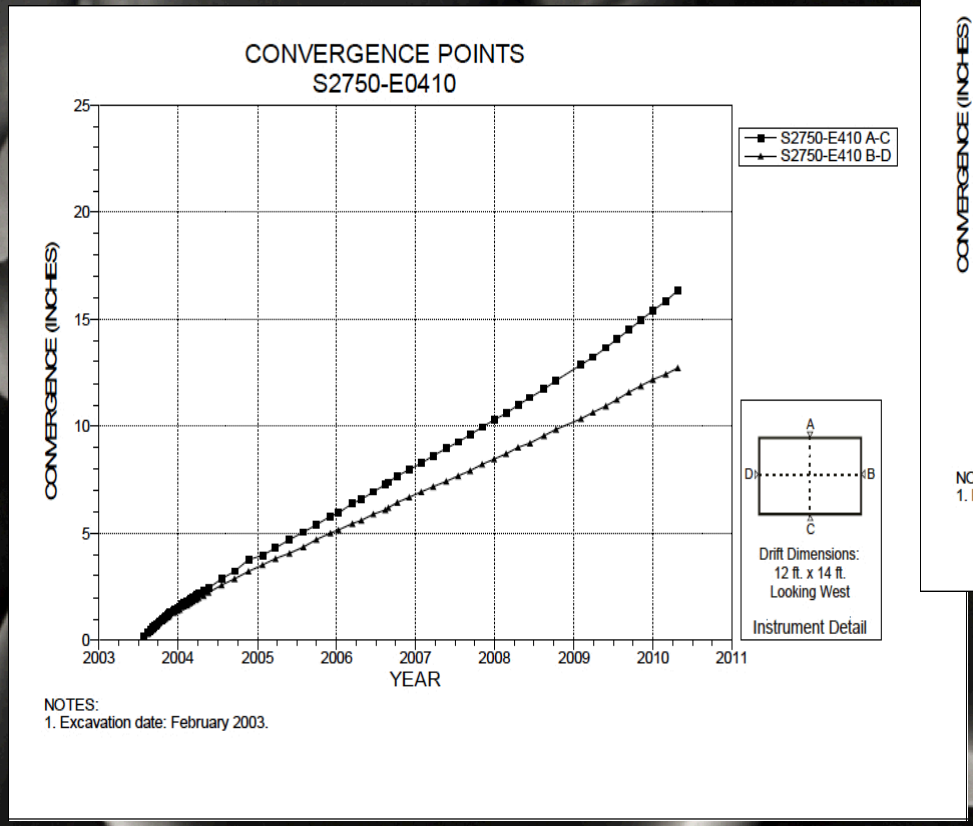
Shaft Seal System Conclusions

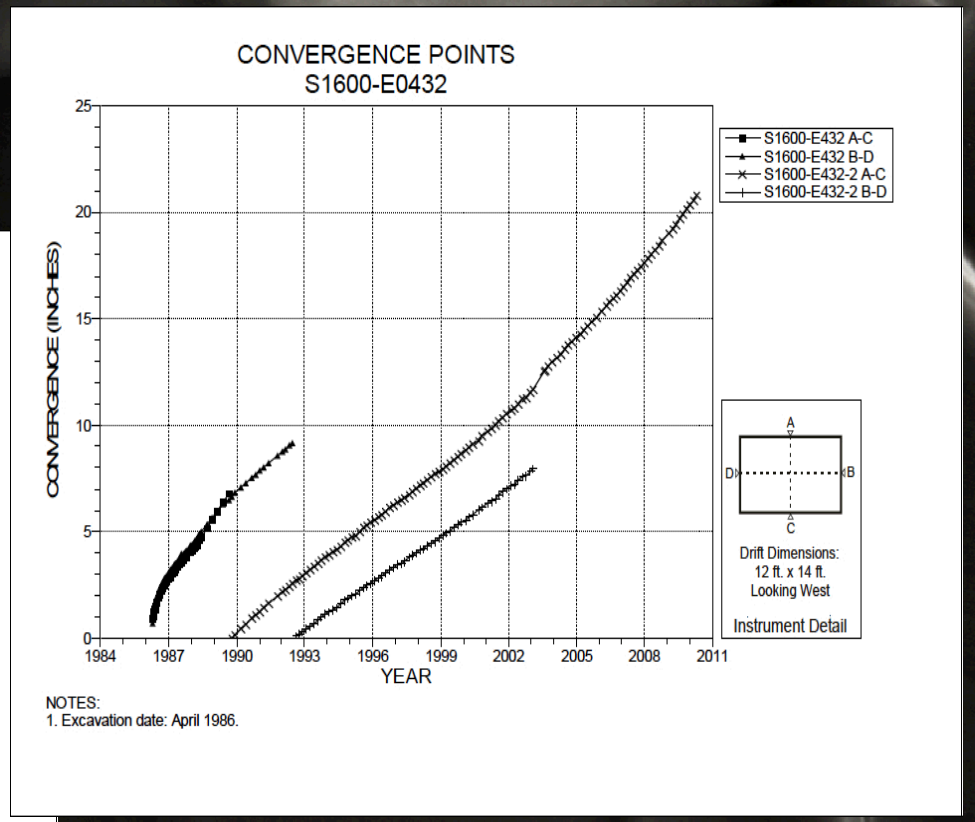
- The WIPP shaft seal system effectively limits fluid flow within the seal system.
- The salt column becomes an effective barrier to gas and brine migration by 100 years after closure.
- Long-term flow rates within the seal system are limited.

Proposed Panel Closure System



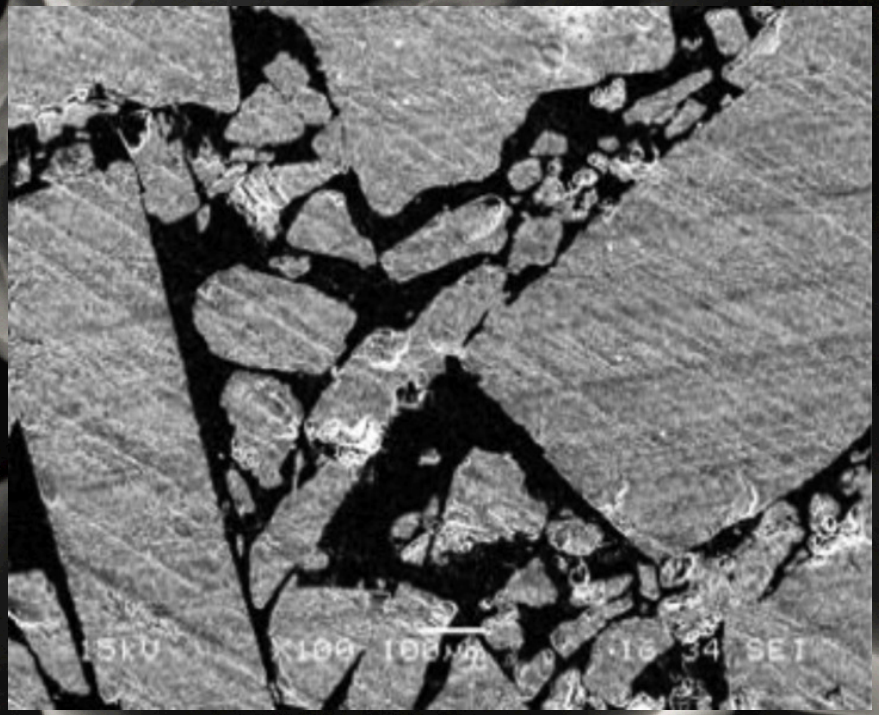
Convergence Point Array

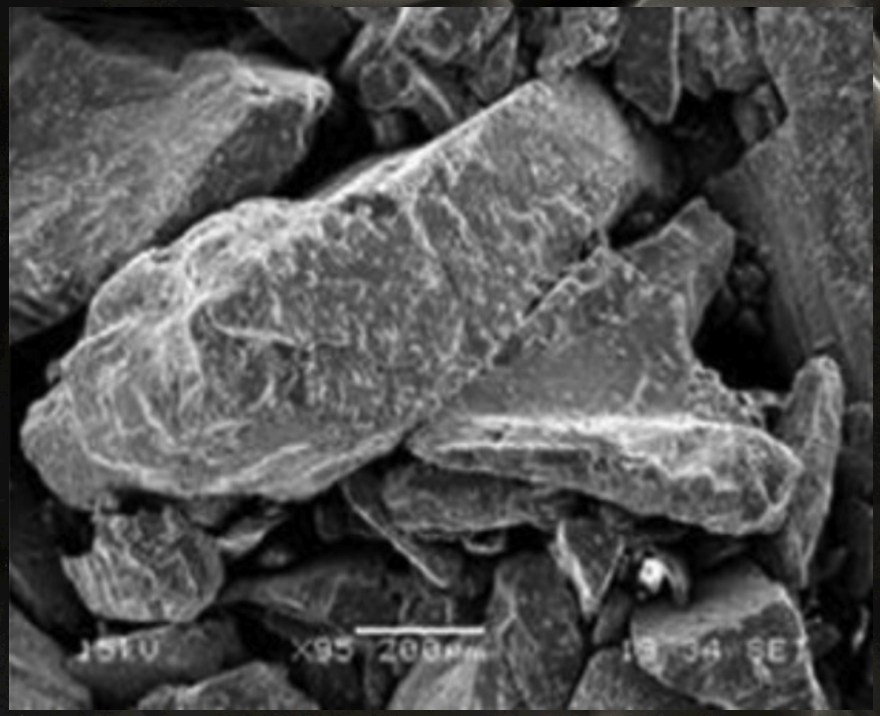




BAMBUS II Heater Surrounded by Reconsolidated Salt

Photomicrographs BAMBUS II (20.7% porosity, K = 4.17e-13 m^2)





Advanced Multi-physics Modeling will Aid Salt Analyses & Performance Assessment

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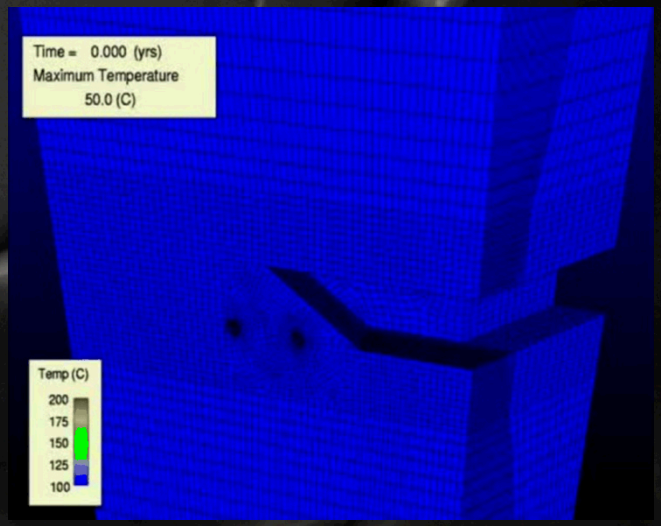
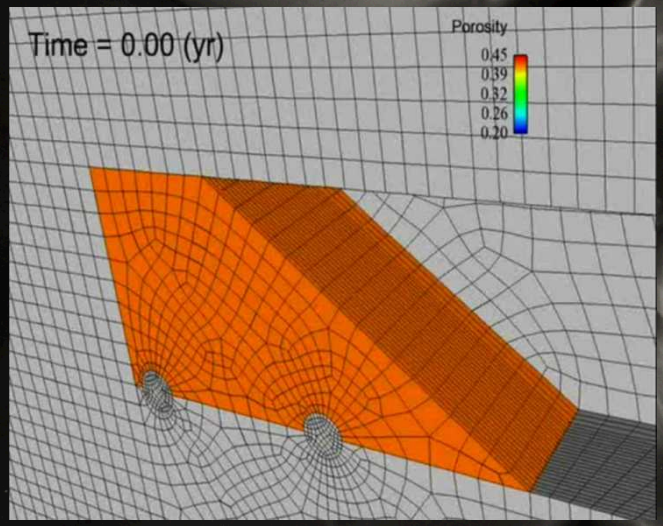
Temperature Contour

Coupled Salt Consolidation

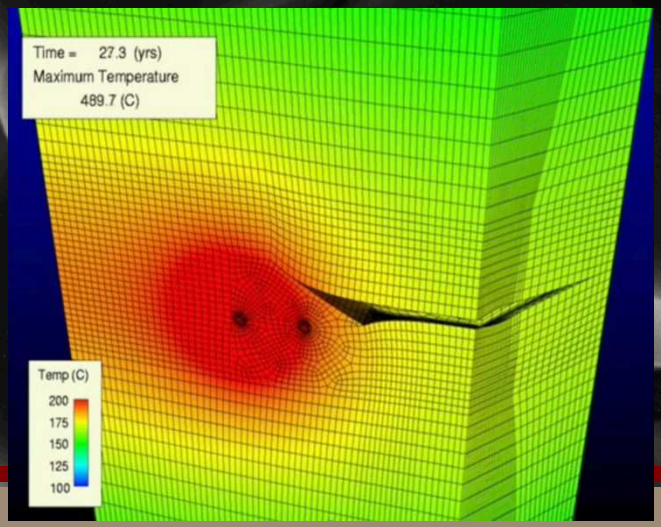
0 YEARS

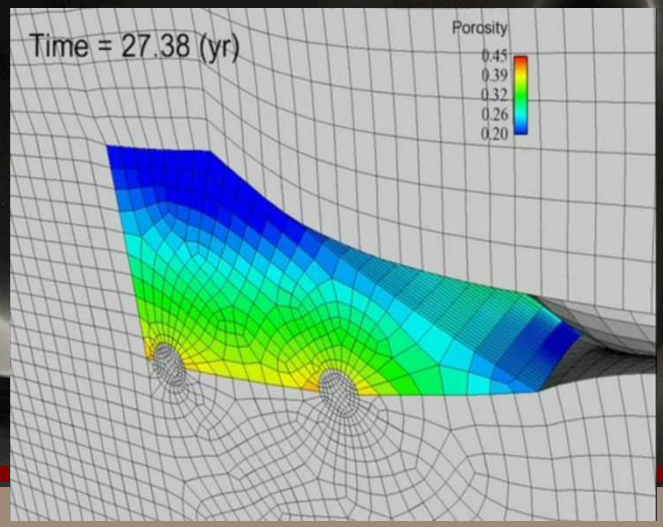




0 YEARS

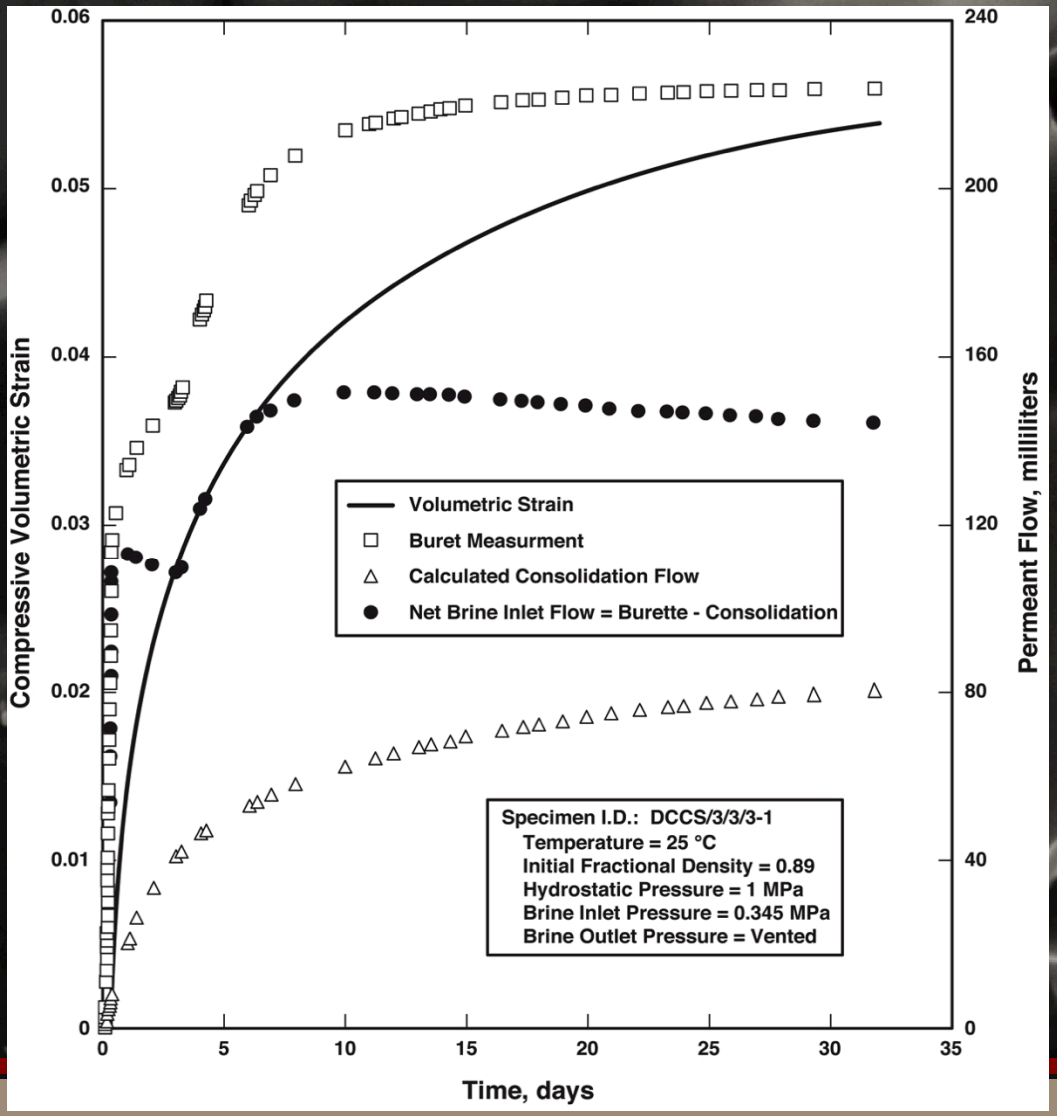
27.3 YEARS



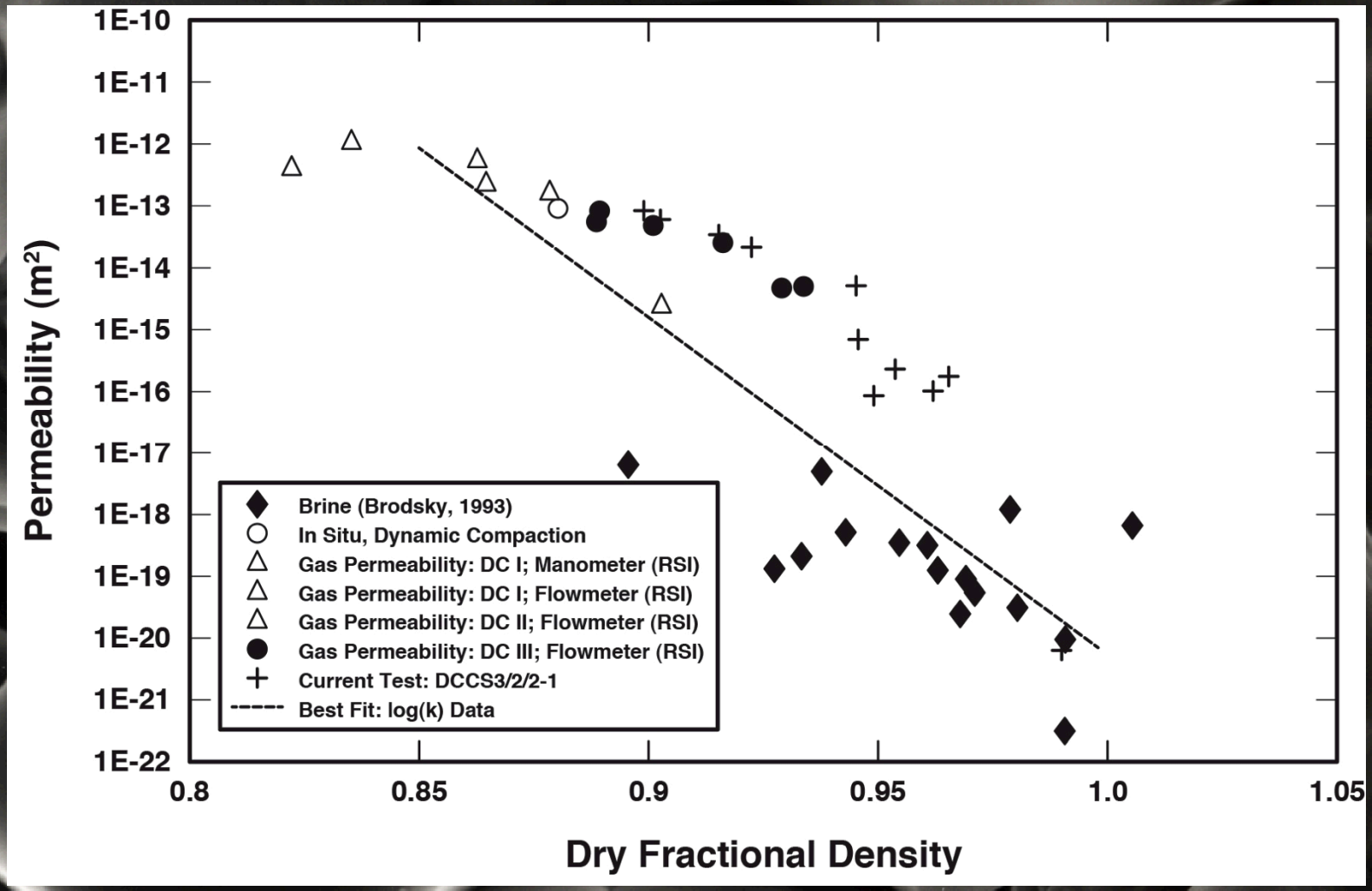


27.38 YEARS

Volumetric Strain and Brine Flow for Tamped WIPP Salt



Permeability Density Function for Reconsolidating Salt



Observational Methods

- Optical microscopy
  - Thick thin sections
  - Etched cleavage chips
- SEM microscopy
  - Broken surfaces
  - Coated thin sections

Mechanisms of salt densification well described by Spiers and Brzesowsky

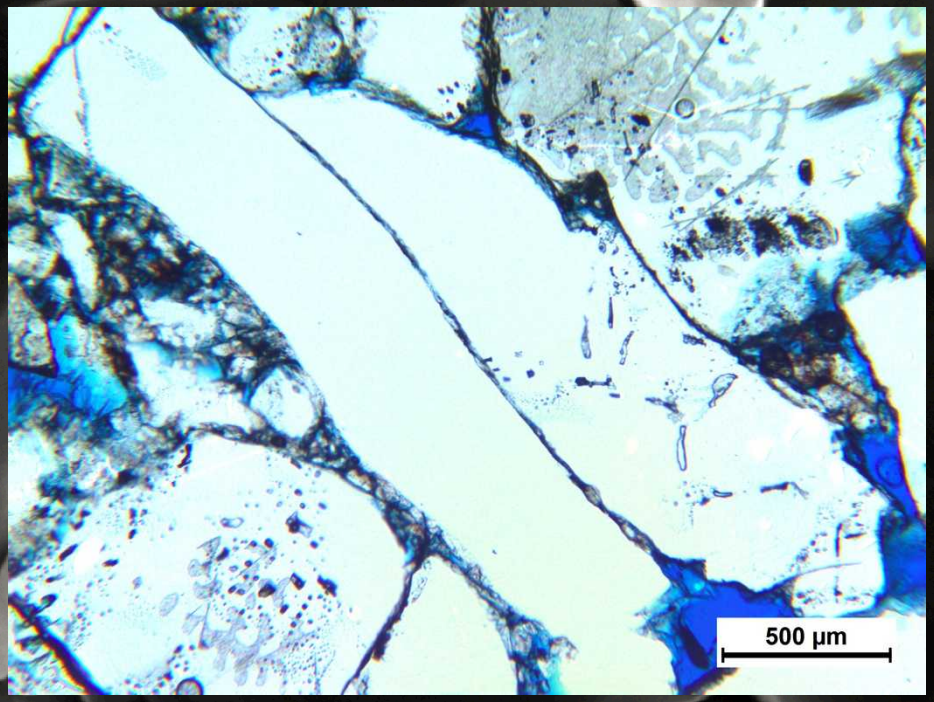
Processes at high porosity

- Instantaneous processes of grain rearrangement and microfracture

Processes at low porosity

- Plasticity coupled pressure solution

C.J. Spiers and R.H. Brzesowsky. 1993. *Densification Behaviour of Wet Granular Salt: Theory versus Experiment*. 7th Symposium on Salt. Vol. I. Elsevier Science Publishers B.V. Amsterdam.



Extreme elongation experienced by individual grains and comminuted fine grains

Test conditions 250C

Hydrostatic consolidation

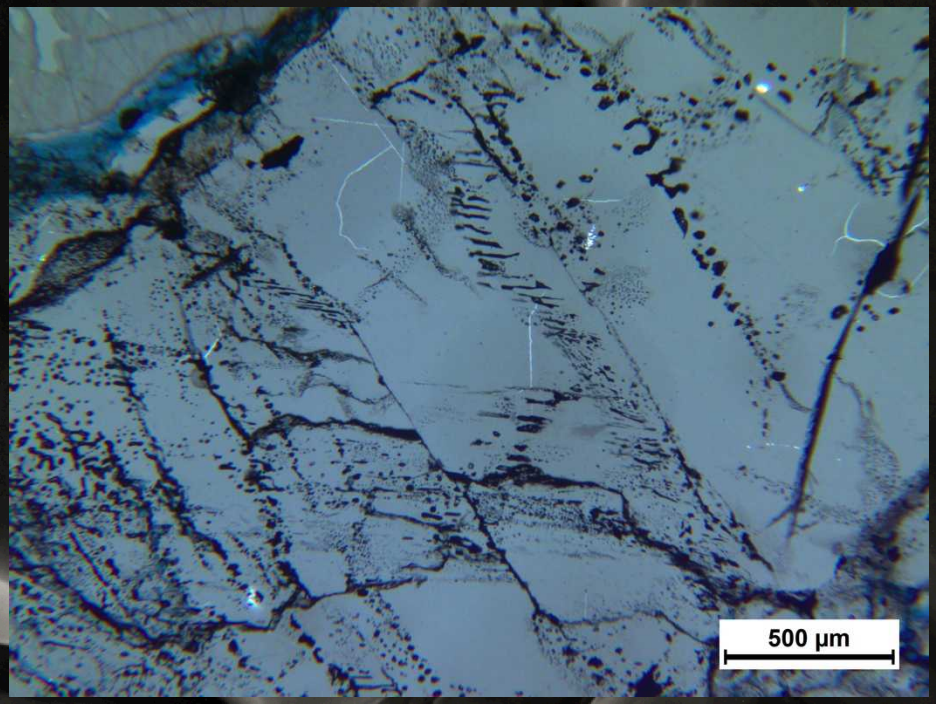
Volumetric strain 37%

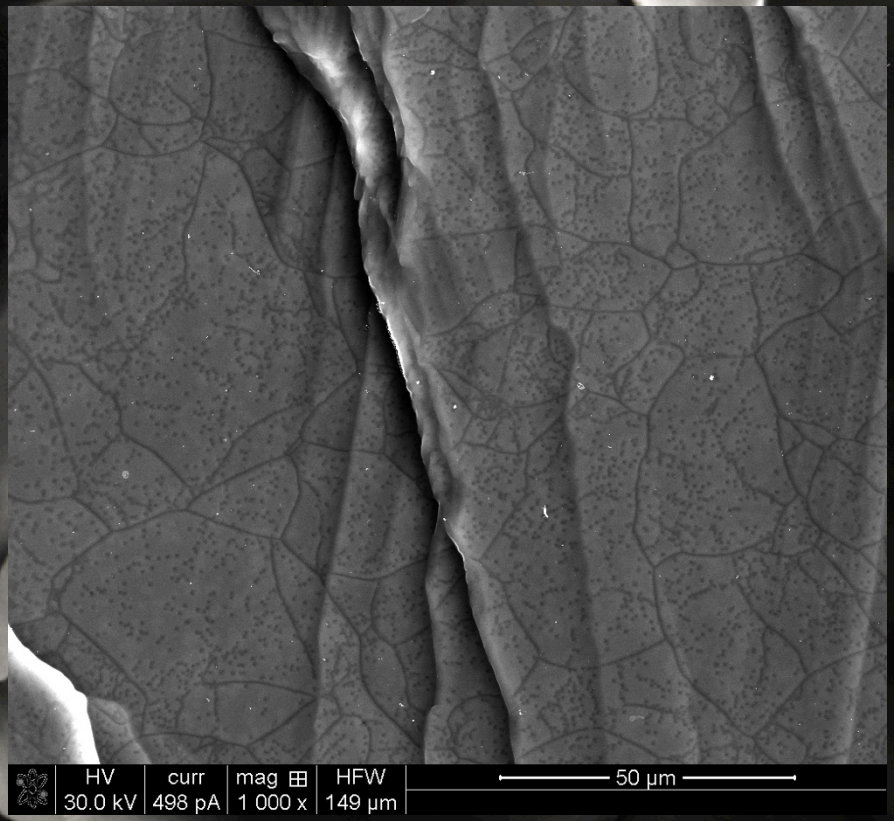
Quantity and mobility of fluid inclusions

Test conditions 250C

Shear consolidation

Volumetric strain 37%





Individual grain - etched cleavage chip exhibiting climb recovery substructures

Test conditions 250C

Shear consolidation

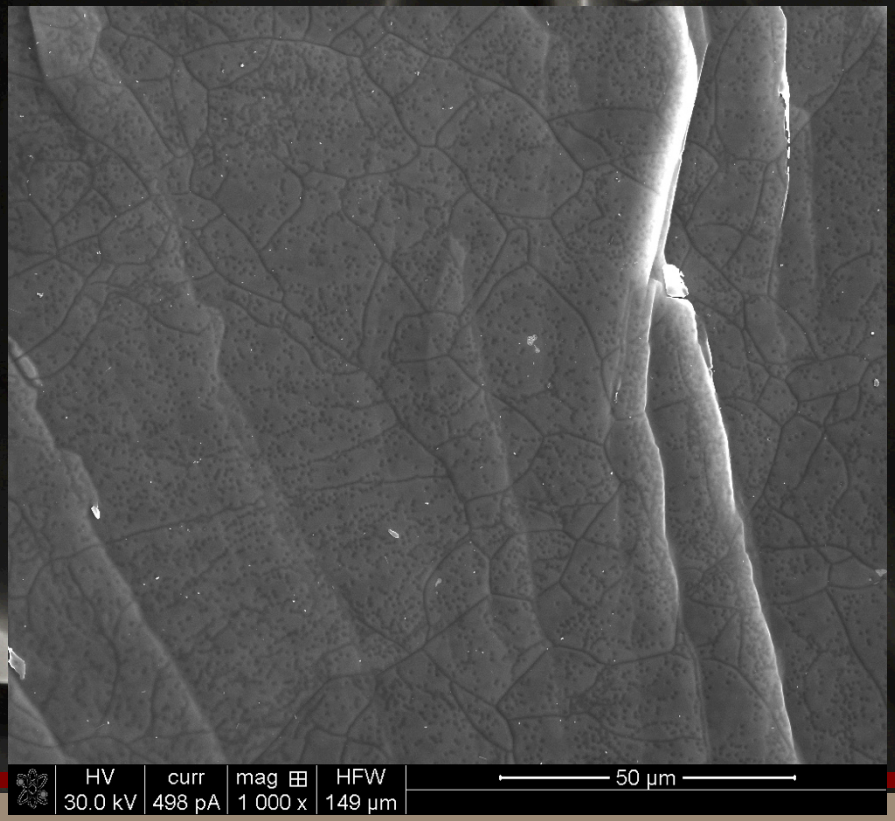
Volumetric strain 31%

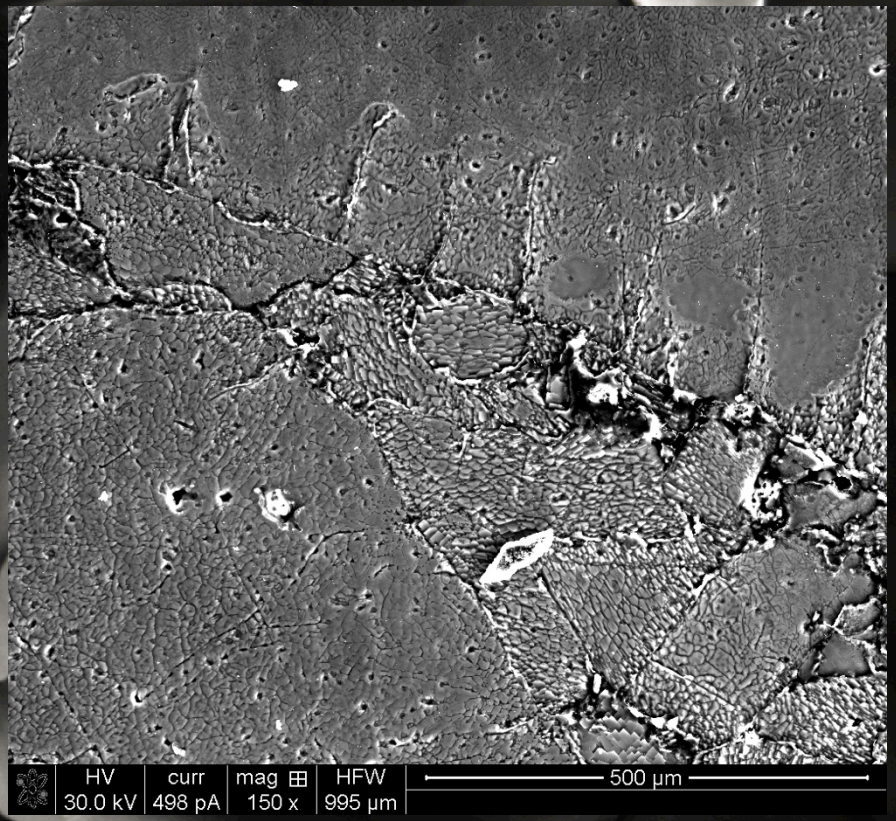
Note well developed polygons, low dislocation density, and wavy cleavage plane

Test conditions 250C

Shear consolidation

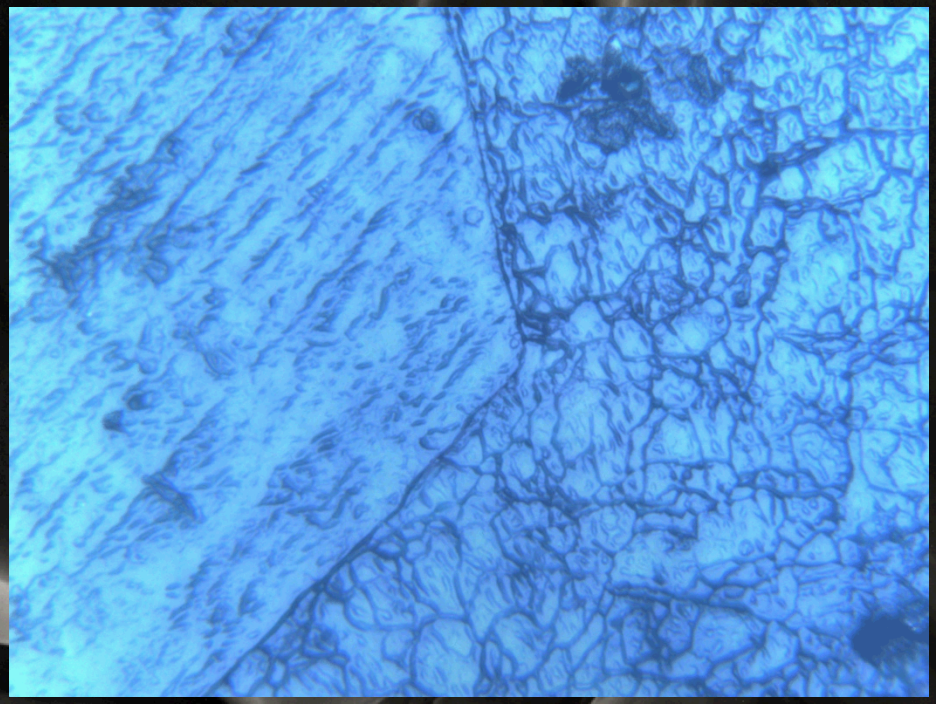
Volumetric strain 37%





Etch thin section captures rampant crystal plasticity via polygonization

Test temperature = 250C



Etched thin section showing recrystallization in process

Test temperature = 250C

Conclusion

- Shaft seal system elements—ambient reconsolidation is well understood in terms of design, construction and performance.
- Drift seal system elements—the orientation is less favorable for initial construction, but evidence and experience provide confidence in performance.
- Dry versus wet consolidation—evidence strongly supports fluid aided consolidation processes for bedded salt, even when mine-run salt is dried

Recommendation

- Further analogue studies of backfilled chambers in operating salt mines