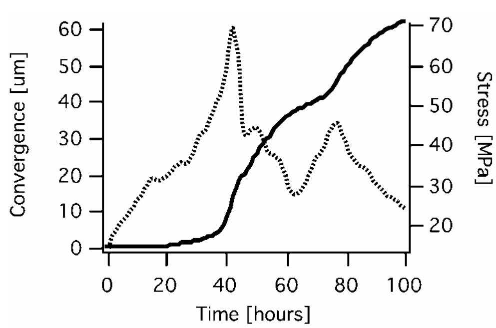
The importance of plastic flow in the deformation of a sodium chloride indenter undergoing pressure solution

Z. KARCZ[1,2], E. AHARONOV[2], D. ERTAS[2], R. POLIZZOTTI[2] AND C.H. SCHOLZ[1]

[1]Lamont-Doherty Earth Observatory, Columbia University, New York, USA (zk17@columbia.edu)
[2]ExxonMobil Research and Engineering, New Jersey, USA
[3]Weizmann Institute, Rehovot, Israel

We conducted experiments to study the deformation of a loaded single crystal sodium chloride indenter immersed in saturated solution. The contact between the indenter and an inert silicate window was viewed with a confocal microscope. The indenter exhibits two stages of deformation: The first involves rapid inward dissolution of the contact (undercutting) accompanied by slow vertical convergence caused by the elastic response to the shrinking contact and vertical ("thin-film") dissolution. The second stage consists of rapid vertical convergence by plastic flow and removal of the flowed material by strain-energy driven inward dissolution. The transition from stage 1 to stage 2 occurs when the contact stress is 75MPa on average, which indicates that the indenter undergoes significant strain hardening to this point. During the second stage we observe oscillations in the rate of convergence, which are closely related to oscillations in the area of the contact. These oscillations reflect the counteraction of plastic flow and inward dissolution.



Convergence (solid) and stress (dashed) curves for experiment 45. t=0 is the time when brine was added to the system.

3D microtomography of a salt aggregate during pressure solution

FRANÇOIS RENARD[1,2]

[1]LGIT-CNRS-OSUG, University J. Fourier, BP 53, F-38041 Grenoble, France (francois.renard@ujf-grenoble.fr)
[2]Physics of Geological Processes, University of Oslo, Norway

Pressure solution creep is one of the possible processes of mechano-chemical deformation that controls porosity and permeability variations in the upper crust. The three-dimensional geometry of the porous network of halite aggregates was imaged during compaction driven by pressure solution creep using X-ray synchrotron computed microtomography. With this technique the whole aggregate textural changes during deformation (Fig. 1a) as well as individual grain contacts (Fig. 1b) were imaged at several stages of the deformation. By reconstructing subvolumes, the 3D porosity of the aggregates was extracted. The time-resolved decrease in permeability during porosity reduction was calculated by solving the Stokes equations. The permeability remained isotropic and decreased from 2.1 to 0.15 Darcy after 18.2% compaction. Two microscopic mechanisms can explain the permeability reduction: grain indentation and pore connectivity reduction by precipitation on the free surface of pore throats.

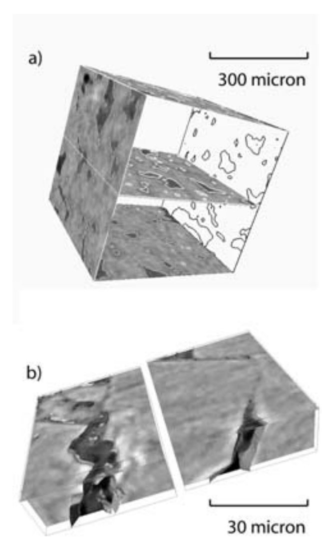


Figure 1: a) X-ray tomography of a salt aggregate during compaction in the presence of a saturated brine. Individual grains appear in light gray, whereas the pores are dark. b) Zoom on two salt grains before (left) and after compaction (right).