In-situ experimental study of the morphological instability of stressed sodium chlorate crystal surfaces

Armann, M. & den Brok, B.
Geologisches Institut, ETH-Zürich, Switzerland. marina.armann@erdw.ethz.ch, denbrok@erdw.ethz.ch

Pressure solution is an important rock deformation mechanism, but a reliable pressure solution creep law does not exist. The major difficulty is that we do not understand the microstructure of grain boundaries in rocks that deform by pressure solution. It appears that the initially flat surface of a solid under stress is unstable and turns into a rough structure when material transport can take place, e.g. by solution transport through an aqueous fluid film.

Pressure solution creep flow laws based on flat ("thin film") grain boundaries are entirely different from those based on rough ("island-channel") grain boundaries.

We are systematically investigating in experiments the effect of stress (magnitude and orientation) on the surface microstructure. On stressing, a surface roughness develops, consisting of fine grooves (or channels) oriented perpendicular to the maximum compressive surface-parallel stress. This was shown by den Brok and Morel (2001) in ex-situ experiments on K-alum ($KAl(SO_4)_2{\cdot}12H_2O$) and by den Brok et al. (2002) in one successful in-situ experiment on K-alum. The surface instabilities (the grooves) migrate: they grow in size with time and change shape and orientation. If stress is removed, the grooves slowly disappear and the surface becomes smooth again.

We now present experimental results obtained in-situ on sodium chlorate ($NaClO_3$), which is also a brittle, very soluble salt, similar to K-alum. The experiments were carried out in a newly designed "see-through" deformation rig, in which the surface under stress was oriented horizontally - in previous experiments it was oriented vertically. A horizontal orientation was chosen so as to minimise possible effects due to gravity; Koehn et al. (2004) proposed that gravity-induced convection in the saturated solution would possibly be responsible for migration of the grooves.

Our results support previous observations made on K-alum. On sodium-chlorate surfaces, and in a horizontal position, a dynamically stable surface roughness is developed, with grooves moving around and changing shape and orientation. As soon as stress is removed, grooves stop moving and slowly disappear. Our results are documented in video clips.

References

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