Geophysical Research Abstracts
Vol. 18, EGU2016-9535, 2016
EGU General Assembly 2016

Composite grain size sensitive and grain size insensitive creep of bischofite, carnallite and mixed bischofite-carnallite-halite salt rock

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Deformation experiments have been conducted on rock samples of the valuable magnesium and potassium salts bischofite and carnallite, and on mixed bischofite-carnallite-halite rocks. The samples have been machined from a natural core from the northern part of the Netherlands. Main aim was to produce constitutive flow laws that can be applied at the *in situ* conditions that hold in the undissolved wall rock of caverns resulting from solution mining.

The experiments were triaxial compression tests carried out at true *in situ* conditions of 70°C temperature and 40 MPa confining pressure. A typical experiment consisted of a few steps at constant strain rate, in the range 10^{-5} to 10^{-8} s^{-1}, interrupted by periods of stress relaxation. During the constant strain rate part of the test, the sample was deformed until a steady (or near steady) state of stress was reached. This usually required about 2-4% of shortening. Then the piston was arrested and the stress on the sample was allowed to relax until the diminishing force on the sample reached the limits of the load cell resolution, usually at a strain rate in the order of 10^{-9} s^{-1}. The duration of each relaxation step was a few days.

Carnallite was found to be 4-5 times stronger than bischofite. The bischofite-carnallite-halite mixtures, at their turn, were stronger than carnallite, and hence substantially stronger than pure bischofite. For bischofite as well as carnallite, we observed that during stress relaxation, the stress exponent $n$of a conventional power law changed from $\sim$5 at strain rate 10^{-5} s^{-1} to $\sim$1 at 10^{-9} s^{-1}. The absolute strength of both materials remained higher if relaxation started at a higher stress, i.e. at a faster strain rate. We interpret this as indicating a difference in microstructure at the initiation of the relaxation, notably a smaller grain size related to dynamical recrystallization during the constant strain rate step. The data thus suggest that there is a gradual change in deformation mechanism with decreasing strain rate for both bischofite and carnallite, from grain size insensitive (GSI) dislocation creep at the higher strain rates to grain size sensitive (GSS, i.e. pressure solution) creep at slow strain rate. We can speculate about the composite GSI-GSS nature of the constitutive laws describing the creep of the salt materials.