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FTIR determination of intragranular water content in quartzites experimentally deformed with and without added water in the ductile deformation field

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Small amounts of water have a large effect on the ductile flow behaviour of quartzite in experiments, and cause a significant mechanical weakening effect. The mechanism responsible for this “water-weakening” effect remains, however, poorly understood. It is commonly assumed, that added water dissolves in the crystal lattice as water-related point defects, and promotes the nucleation and mobility of dislocations (the classical hydrolytic weakening theory), but it was suggested recently, by contrast, that water would promote solution-precipitation creep (SPC) and micro-cracking, rather than dislocation-plastic processes.

We wanted to test the validity of the hydrolytic weakening versus SPC hypothesis in experiments on quartzite. By using Fourier Transform Infrared (FTIR) spectroscopy (spotsize ~70 µm) we investigated whether water-weakening effects are associ-ated with changes in *intragranular* water content (IWC). Samples of Dongelberg quartzite (150-250 µm grain size) were experi-mentally deformed at T=800°C, P≈1200 MPa, and a strain rate of ~10^{-7}/s, to ≤14% bulk finite strain, in a Griggs solid-medium deformation apparatus, both with and without ~1 vol% of added water.

The FTIR-measurements showed, that the average IWC of the starting material was 1250±300 ppm H/Si (16 grains measured) with IWC’s of individual grains in the range 200-2900 ppm H/Si. The average IWC, and spread in individual-grain IWC’s, determined in the samples deformed both with and with-out added water, appeared to be broadly similar to the values measured in the starting material. Hence, on average, and within measurement resolution (100-500 ppm H/Si), water did not diffuse into (nor out of) the grains during deformation, and no equilibration of the spread in individual-grain IWC’s occurred. Yet, the samples were ≥9 times weakened by the added water.

Our results seem inconsistent with the classical hydrolytic weakening theory,which predicts that much more than 100-500 ppm H/Si is required for a weakening effect of the order of a factor ≥9 in a material with an average starting IWC of 1250 ±300 ppm H/Si (namely, several 10000 ppm H/Si). The results are consistent with a SPC origin of the water-weakening effect.