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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 associated with changes in *intragranular* water content (IWC). Samples of Dongelberg quartzite (150-250 µm grain size) were experimentally 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 without 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.