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Grain size effect on brittle to viscous behaviour of quartz gouge in high-PT experiments

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In order to explore the microstructural development across the brittle to viscous transition of quartz we have conducted a series of shear experiments on quartz gouge in a modified Griggs-type solid medium deformation apparatus under high confining pressure ($\sim$1.5 GPa), temperatures of 500 °C to 1000 °C and constant shear strain rates (5x10^{-5} s^{-1}). The starting material is crushed dry quartz (grain size 2 to 100 m), with 0.2 wt% H_2O added. At elevated temperatures, this material is expected to form a "wet" matrix in regions of small grains whereas the larger grains should remain dry.

First results show that the yield strength decreases with increasing temperatures (1300 MPa > τ > 70 MPa from 500 °C to 1000 °C). Continued deformation indicates steady-state stress for the high-temperature experiments and strain hardening for the lower temperatures. The grain sizes of the low-temperature experiments reflects the initial grain size distribution. With increasing temperature the size of the old grains decreases and that of recrystallised grains increases. The crystallographic preferred orientation (CPO) of the c-axis evolves from a random distribution towards two elongated maxima or to one single maximum.

Some of the experiments included a hot pressing stage (20 h at 1000 °C/$\sim$1.5 GPa) in the apparatus before the temperature has been decreased to the conditions for the deformation. The resulting shear stresses of those experiments are significant lower ($\sim$50 %) than those without the hot pressing. In addition, the final grain size distribution of the hot pressed samples was more homogenous (clasts 20-45 m) compared to those without hot pressing (clasts 50-95 m). The CPO of the c-axis shows similar patterns for the same deformation temperatures. Obviously, a reduction of the larger grains as well as the growth of the smaller grains during the hot pressing results in a more uniform grain size distribution.

The flow strengths of the hot pressed experiments are comparable with the quartzite samples of Hirth and Tullis (1992). Hence, we assume a quartzite-like behaviour of the material with uniform grain size distribution. Whereas the samples without hot pressing behave more like a heterogeneous aggregate, where deformation partitions into the fine grained material. Greater strength may result from faster strain rates in the localized regions.