Deformation experiment on quartz aggregates with high water contents at high pressure and temperature

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Large earthquakes typically nucleate near the depth limit of seismogenic zones. In these areas, high V_p/V_s ratios are commonly observed, indicating the presence of high pore fluid pressures. Thus, it is important to understand how the water content (both water in the crystal and in the pores) and the pore structure affect the rheology of polycrystalline materials.
We conducted deformation experiments on quartz aggregates using a Griggs-type deformation apparatus. Samples were hot-pressed from silica gels, which contain ~9 weight percent water within the amorphous structure and absorbed on the surface. Hydrostatic experiments within the alpha-quartz stability field at a pressure of 1.5 GPa and 900oC indicate that hot-pressed samples are composed of quartz and no relict of amorphous material is present. The average grain size and porosity of the hot-pressed aggregates is about 6 um and 0.23, respectively. The grain shape is equigranular and no crystallographic preferred orientation (CPO) is observed.
Initial results from general shear experiments on the hot-pressed quartz aggregates at the equivalent strain rate of 1.5 x 10^{-4} 1/s, a pressure of 1.5 GPa and 900°C show very low strength (equivalent stress of 140 MPa) and nominally steady state flow at shear strains up to 3.5. The samples show weak CPO; a-axis of quartz aligned parallel to the P direction. We also found an evidence for strain localization along R_1 riedel shears, which structure is characterized by high porosity zones. In contrast, deformation experiments on cores of quartzite show dislocation creep at this pressure/temperature condition.
The stress exponent n is 2.8–3.4 indicating that the dislocation creep of quartz presumably controls the overall rate-behavior in the quartz shear zone. The measured stress from the new experiments is significantly lower than predicted by the wet quartz flow law (e.g., Hirth et al., 2001). The low flow stress and R1 reidel shear zones suggest that the stress enhancement process (Hirth and Kohlstedt, 1995) is activated by the high volume amount of water or perhaps the effective pressure law is still applicable and the sample deforms by a semi-brittle flow process.

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