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Experimental evaluation of effects of water on grain growth and deformation of quartz

We prepared quartz powder (Min-U-Sil5) and a quartz aggregate (Novaculite) for grain growth experiments. Both samples are composed of fine-grained quartz of $\sim 2\ \mu\text{m}$ and were enclosed together in a platinum capsule with water of 0.2 or 2.0 wt%. The powder becomes an aggregate at high pressure and temperature. We used a gas-pressure-medium vessel and solid-pressure-medium piston cylinder. Grain growth of Novaculite is faster than the powder (Fig. 1). An interesting finding is an effect of added water on grain growth. The added water of 2.0 wt% water enhances the grain growth until the quartz grain size increases up to $\sim 10\ \mu\text{m}$ (Compare Fig. 1a with f). When the grain size becomes larger than that, the grain growth behaviors were not different between 0.2 and 2.0 wt% added water (Others in Fig. 1). This result may correspond to formation of water films at grain boundaries with different grain sizes, which are also estimated by calculation (Fig. 2). The calculation infers that the added water of 2.0 wt% is an enough amount for the initial samples to form water films at grain boundaries, while the formation of water films with 0.2 wt% water may require grain growth to a certain grain size (probably around $10\ \mu\text{m}$).

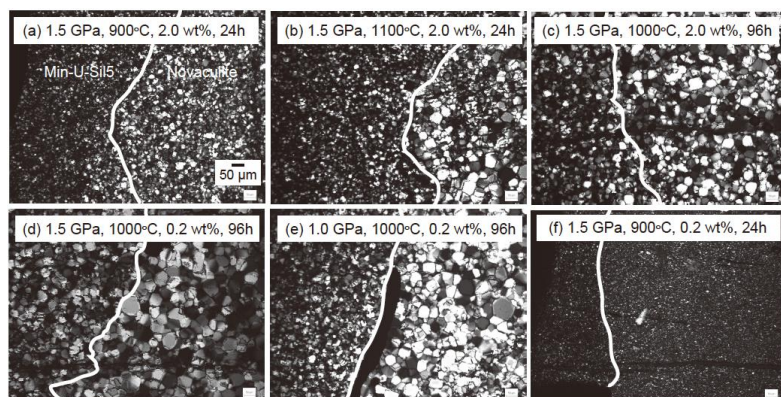


Fig. 1. Optical photomicrographs after grain growth experiments. Boundaries between the powder samples (Min-U-Sil5; left) and quartz aggregate samples (Novaculite; right) are shown with white lines. All scales are the same.

For future grain growth experiments, we will go up to $\sim 2.8\ \text{GPa}$. We will also perform longer durations of up to ~ 240 hours. We will also measure infrared spectra and determine water contents as well as water species.

For deformation experiments, we use a gas-pressure-medium (Paterson-type) deformation apparatus. We have chosen the type of assembly, which includes talc. Talc dehydrates during experiments and keeps the wet condition. We will use the powder quartz sample which we use for the grain growth experiment.

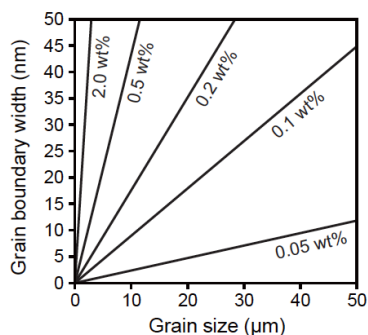


Fig. 2. Calculated widths of water films at a grain boundary of a grain assuming different amounts of water.