Deformation of quartz single crystals under the coesite-stable conditions

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The mechanisms of deep-focus (> 300 km) earthquakes are fundamentally different from those of shallow (< 40 km) earthquakes, because frictional sliding of faults is quite difficult at upper mantle pressures due to strong pressure dependency of friction coefficient (i.e., Byerlee’s law). It has been believed that deep-focus earthquakes are triggered by the pressure-induced olivine-wadsleyite/ringwoodite transition (i.e., the anticrack model). Shubnel et al. (2013) conducted deformation experiments on Mg_2GeO_4 olivine and reported that grain size reduction through the olivine-spinel transition triggers a faulting. To revisit the process of anticracking, we conducted deformation experiments on single-crystal quartz (alpha phase) at pressures of 3-4 GPa and temperatures of 1000-1100℃, corresponding to the coesite-stability field. Phase transition from quartz to coesite was mostly limited around the surface of the samples. Microcracking along a cleavage associating acoustic emissions was common in each deformation runs. Even though both quartz and coesite phases coexisted under each conditions, faulting was limited at 3.5 GPa and 1000℃. Gouge layer developed along a fault consists of fine-grained quartz (coesite was not observed), suggesting that faulting occurred due to high differential stress exceeding the confining pressure (i.e., Goetze’s criterion). Microstructural observations suggest that quartz-coesite phase transition proceeds via nucleation and growth of coesite lamellae, namely grain size reduction does not occur as a result of the phase transition. The absence of anticracks in quartz samples might be related with the intracrystal nucleation of high-pressure phase (i.e., lamellae).

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