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Different mechanical behavior at the same P-T conditions in biotite-quartz assemblage: interconnectivity and composition effect of experimentally deformed mica

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The effect of composition on microstructural development and mechanical strength was tested using mica-quartz-aggregates during deformation experiments.

This study used two chemically different biotite minerals mixed with quartz: (1) high F-phlogopite and (2) intermediate biotite in order to investigate the role of biotite-bearing systems for the development of shear zones and strain accommodation. Shear experiments (Griggs-type apparatus) were performed using mica (30 vol. %) and quartz (70 vol. %) assemblages at 750 and 800°C, 1000 MPa and a shear strain rate of ~10^{-5} s^{-1}.

Mechanical results for the F-phlogopite-bearing assemblage indicate strong samples, approximately equivalent to pure quartz samples (Richter et al., 2018), deforming at differential stresses of 764-1097 MPa). F-phlogopite flakes are preferentially oriented parallel to the main shear direction, but poorly interconnected. Most of the strain is accommodated by quartz behaving as an interconnected network. Cathodoluminescence imaging reveals that quartz recrystallizes mainly by local pressure-solution and its strength controls the overall strain accommodation.

In contrast, intermediate biotite assemblages are significantly weaker and deform for lower differential stresses of 290-327 MPa, as expected for natural rocks. Biotite flakes form an interconnected network accommodating most of strain.

The interconnectivity of biotite grains thus plays a major role in weakening quartz-biotite assemblages. However, at similar P-T-strain and grain size conditions, the capacity of biotite grains to interconnect may also depend on its chemical composition, particularly considering the effect of trace elements incorporation (as fluorine) on the strength of the biotite interlayer bounds (Dahl et al., 1996, Figowy et al., 2021). This led us to conclude that different types of mica, behaving differently, strongly affect strength, deformation mechanism, and microstructure of the rock due to their structure, composition and stability fields.