Effect of phlogopite on the strength of mica-quartz assemblage and underlying chemical processes

Khadija Alaoui*[1], Laura Airaghi[1], Holger Stünitz[1,2], Hugues Raimbourg[1], and Jacques Précigout[1]

[1]Institut des Sciences de la Terre d'Orléans - UMR7327 – Bureau de Recherches Géologiques et Minières (BRGM), Observatoire des Sciences de l'Univers en région Centre, Institut National des Sciences de l'Univers, Université d'Orléans, Centre National de la Recherche Scientifique – France
[2]Department of Geosciences, UiT – Arctic University of Norway, Norway – Norvège

Résumé

While rock mechanical behavior is commonly described using experiments conducted on monophase assemblages, natural rocks contain multiple mineral phases that deform simultaneously and contribute to bulk strength. For the upper crust, the strength of mica+quartz assemblages is of prime importance and was investigated in this work. Assemblages made of phlogopite (Phl) and quartz (Qz) were experimentally deformed in simple shear (Griggs-type apparatus) at 800°C, 10kbar, bulk shear strain rate ~10e-5 s-1 and 0.1 wt. % H2O. For well-constrained grain sizes (63μm < Phl < 125μm, 10μm < Qz < 20μm), the phase proportions of phlogopite were varied (10, 20, 30, 50, 70 and 100% vol. Phl).
Mechanical results indicate that overall strength decreases as mica is added. Nonetheless, this decrease is not monotonous, as samples with 50 and 70% vol. Phl appear stronger than samples with 20 and 30% vol. Phl. This complex behavior of the quartz+mica assemblages implies that deformation mechanisms operating in the mixture cannot be described only on the basis of deformation mechanisms of pure phases.

In all samples, a grain size reduction is observed from 100 to < 5μm for phlogopite and from ~15 to ~2μm for quartz. Grain size reduction of quartz becomes more pervasive with the decreasing phlogopite proportion in the assemblage. In samples up to 30% vol. Phl, strain is accommodated by an interconnected quartz network, while in samples with more than 30% vol. Phl, quartz grains are isolated in an interconnected phlogopite network. In sample with 10% vol. Phl, quartz deforms plastically as attested by elongated parent grains (Qz1) and core-mantle structures formed by dynamic recrystallization. Hyperspectral cathodoluminescence and composition analyses show that recrystallized quartz (Qz2) has lower luminescence and higher Al3+ content than Qz1. Qz2 is also defined by widespread micro-porosity. With increasing phlogopite proportions, quartz reworking mainly occurs by dissolution-precipitation rather than dynamic recrystallization.
Dissolution-precipitation mechanisms are particularly prominent in the 30% vol. Phl sample. Reactivity of quartz, dependent on mica proportion, may therefore strongly contribute to rock weakening and deviating the assemblage mechanical behavior from an ideal mechanical mixture of the two pure end-members.

*Intervenant

Mots-Clés: Simple shear experiments, Mica+Quartz assemblage, Quartz plasticity, Dissolution, precipitation, Rock weakening