High temperature hydration of gabbros by fracturing before and during shearing: implications for equilibrium scales and strain localization

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Résumé

Fluid influx is of primary importance for strain localization in mafic crust since it promotes coupled deformation-reaction processes. However, the timing and mechanisms of fluid percolation relative to viscous strain and implications for equilibrium length-scales during shearing remain debated. We show that in deformed gabbros of the Poroshiri ophiolite, along the Hidaka Shear Zone (Hokkaido, Japan), hydration of gabbros occurred mainly by fracturing from at least 800-850$\circ$C- 5 $\pm$1 kbar before shearing to 750-600$\circ$C-3.5 kbar during mylonitization. High temperature hydration is attested by textures of hydrous partial melting at grain boundaries, formation of hydrous coronas around olivine and the occurrence of granoblastic aggregates made of Cl-poor pargasitic amphibole, anorthite and secondary pyroxene at igneous mineral interfaces and in cracks. This stage was accompanied by grain size reduction of two orders of magnitude. Local equilibria prevailed at the scale of 100-500 μm, with amphibole and plagioclase composition controlled by different element diffusion length-scales. Viscous deformation occurred during the retrograde path and was localized in mm to m-sized shear zones. Out-of-equilibrium mineral compositions from high-temperature stage and relicts of igneous minerals were preserved within 500 μm despite deformation intensity and water saturated conditions. High water activity and amount (H2O $\geq$ 1.2 wt%) were maintained throughout the tectonic evolution of metagabbro, with a contribution of see water at temperature $>$ 750$\circ$C and depths of 12-15 km. However, during the early, high-temperature stage of gabbro hydration, water saturated conditions were achieved only locally. Shear zone formation was accompanied by recycling of water stored during the high temperature stage -as indicated by samples deformed in isochemical conditions- or additional pervasive fluid influx as in amphibolitic mylonites. High volume proportion of amphibole and distributed deformation in high strain zones point to amphibole-rich domains as preferential loci for the viscous strain localization and to a strong feedback between hydration and development of shear zones. However, the amount and composition of amphibole, the size of re-equilibrated domains and of phase mixing are partly inherited from the pre-shearing hydration stage that therefore strongly controlled the contrasts in mechanical strength of mafic protolith and eventually the strain localization.

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Mots-Clés: pre, shearing hydration, mafic amphibolites, granulite, facies fracturing, dissolution, reprecipitation, viscous strain localization