Short fluid infiltration events in the low permeable metamorphic rocks triggered by crustal fracturing at amphibolite–granulite facies conditions

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Aqueous fluids flow could be responsible for changing hydrologic and thermodynamic properties of rocks. It is generally accepted that fluids play a key role in the generation of earthquakes, tremors, and slow slip events. For example, it was suggested that tremors are related to fluids released during dehydration processes in the subduction slab (e.g., Abers et al., 2009; Katsumata and Kamaya, 2003; Obara et al., 2004). Hydrous minerals in subducting slabs release H_2O due to dehydration reactions. Released water increases fluid pressure rapidly. However, fluid pressure gradients within the crust remain poorly constrained due to their heterogeneity. Therefore, it is important to constrain timescales of fluid infiltration to understand fluid pressure gradient, permeability, and tectonic evolution.

We have investigated fluid-rock reaction zones in mafic granulite and amphibolite samples from Mefjell, south-central part of the Sør Rondane Mountains (SRM), East Antarctica, and constrained pressure gradient and permeability. Mafic granulite and amphibolite samples are cut by numerous randomly-oriented veins. Samples are partially hydrated along veins associated with mm-scale hydration reactions zones. Reaction zones fingerprint relationship between fluid infiltration and rock response. We divide samples into several reaction zones increasing distance from the vein center by modal amount of minerals, reaction textures, and trace elements concentrations distributions profiles in apatite. The P-T conditions for the fluid infiltration in mafic granulite were estimated to be 0.65 GPa, 650°C , and that for peak P-T conditions were 850°C, 0.55-1.0 GPa. On the other hand, P-T conditions for the fluid infiltration in amphibolite were estimated to be around 500°C.

Trace elements concentrations (Cl, Sr, and some REE) measured by EPMA and LA-ICP-MS in several apatite grains were gradually decreasing with distance from the vein. Cl distributions profiles were analyzed by a reactive-transport model to define transport mechanism by fitting to Peclet number (Pe#=vL/D, where v is pore velocity, L is length of reaction zone, D is self-diffusion coefficient) and time-scales of fluid infiltration. For mafic granulite Pe# is 0.025, for amphibolite is 90. Whereas diffusion transport is revealed to be dominant for mafic granulite, advection transport is likely for amphibolite. Duration of fluid infiltration was estimated to be 5.5 h for mafic granulite and 1-3 h for amphibolite, which is very short in geological timescales. This suggests rapid and intense fluid flux through the mantle wedge and onto overlying crust. Short timescales of fluid infiltration may reflect linkage to the seismic events.

To estimate permeability, the pressure gradient for the reaction zones was calculated from the water and other elements activities constrained by pseudosection analysis for different reaction zones. Bulk compositions at each reaction zone were used to create pseudosections. Permeability was calculated from the estimated pressure gradient and total flux $q=-\kappa(\partial P/\partial x)/\eta$, where q is total flux, k is permeability, η is viscosity, and $(\partial P/\partial x)$ is pressure gradient. Results suggest low and contrasting permeability between mafic granulite dominated by diffusion and amphibolite dominated by advection mass transport mechanisms. This difference may be explained by different P-T conditions for fluid infiltration and heterogeneity of the pressure gradients. Therefore, it suggest that fluid infiltration in low

permeable rocks caused fracturing and formed narrow reaction zones, which released fluid pressure in a short time. Above results of our study suggest importance of fluid transport phenomena in relation to the evolution of rocks hydrological properties.

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