

Timescales of Cl-bearing fluid infiltration estimated by multiple trace elements profiles in apatite for granulite/amphibolite-hosted reaction zones, Sør Rondane Mountains, East Antarctica

Diana Mindaleva¹, Masaaki Uno¹, Fumiko Higashino¹, Atsushi Okamoto¹ and Noriyoshi Tsuchiya¹

¹ GSES, Tohoku University

Aqueous fluid flow could be responsible for changing hydrologic and thermodynamic properties of rocks. Fluid transport mechanism controls geothermal activity and time-scale of fluid infiltration is related to earthquake generation and crustal evolution (e.g., Katayama et al. 2012; Hacker et al. 2003). Fluid transport in the Earth's crust is related to elemental redistribution within the rocks. Especially fluid mobile elements such as Na, Ca, K, Sr, volatiles, and REE distributions are affected by the volume of fluid flux and nature of fluids (Ague, 2017). These geochemical variations between hydrous and anhydrous rocks can be used to estimate timescales of fluid infiltration. Timescales of fluid infiltration events in the crust and mantle remain largely unknown. For example, late stage fluid flow along fractures within greenschist facies metamorphosed quartz-mica schists at Delfini, NW Syros estimated to be 100 to 15000 years (Kleine et al., 2016). However, several authors suggest shorter duration of fluid infiltration. Taetz et al. (2018) reported 1 to 4 months and linked to pulses of high pore fluid pressure and slip events. John et al. (2012) suggested ca. 200 years using Li-Ca-Sr isotope system for subduction zone fluids released by dehydration in a series of short pulses.

This study aims to clarify Cl-bearing fluids infiltration at crustal conditions by multiple trace elements profiles in apatite from fluid-rock reaction zones in the mafic granulite and amphibolite. Samples were collected from from Mefjell, south-central part of the Sør Rondane Mountains (SRM), East Antarctica, during JARE-51. Mafic granulite and amphibolite are cut by numerous randomly-oriented veins. Mafic granulite and amphibolite samples are partially hydrated along veins associated with mm-scale hydration reactions zones. Samples were divided into three domains; vein, reaction zone, and host rock by modal amount of minerals, reaction textures and trace elements concentrations distributions profiles in apatite. The *P-T* conditions for mafic granulite were estimated to be 0.65 GPa, 650°C for the vein formation, and peak *P-T* conditions are 850°C, 0.55-1.0 GPa, using pseudosections, Al-in-hornblende geobarometry, and hornblende-plagioclase geothermometry. On the other hand, *P-T* conditions for amphibolite are estimated to be around 500°C for vein formation, using pseudosections and hornblende-plagioclase geothermometry.

Trace elements concentrations in several apatite grains were gradually increasing with distance from the vein towards the host rock. Distributions of Cl in several apatite grains 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 hydrodynamic dispersion) 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 1.5 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.

Trace elements concentrations (Sr and some REE) in apatite were analyzed with distance from the vein center using EPMA and LA-ICP-MS. The trace element profiles were used to testify the previous studies and insight into multi-element behavior during water-rock interaction. Chondrite-normalized REE patterns of apatite are relatively flat and show enrichment in LREE and MREE, a typical metamorphic profile without negative Eu anomaly (Spear et al., 2002). Sr, La, Ce, Pr, and Nd concentrations in apatite were gradually decreasing with distance from the vein towards the host rock. For example, maximum Sr concentration of apatite in the vein is 167 ppm and decreases to 59 ppm in the host rock. We will discuss time-scales constrained by trace elements concentrations profiles in apatite, fitted to the reactive-transport model.

References

- Ague, J. J., Element mobility during regional metamorphism in crustal and subduction zone environments with a focus on the rare earth elements (REE), *American Mineralogist*, 102(9), 1796-1821, 2017.
- Hacker B. R., Abers G. A., Peacock S. M., Subduction factory 1. Theoretical mineralogy, densities, seismic wave speeds, and H₂O contents, *Journal of Geophysical Research: Solid Earth*, 108(B1), 2003.
- John, T., Gussone, N., Podladchikov, Y. Y., Bebout, G. E., Dohmen, R., Halama, R., and Seitz, H. M., Volcanic arcs fed by rapid pulsed fluid flow through subducting slabs, *Nature Geoscience*, 5(7), 489, 2012.
- Katayama, I., Terada, T., Okazaki, K., and Tanikawa, W., Episodic tremor and slow slip potentially linked to permeability contrasts at the Moho, *Nature Geoscience*, 5(10), 731, 2012.
- Kleine, B. I., Zhao, Z., and Skelton, A. D., Rapid fluid flow along fractures at greenschist facies conditions on Syros, Greece, *American Journal of Science*, 316(2), 169-201, 2016.

- Spear F. S., Pyle J. M., Apatite, monazite, and xenotime in metamorphic rocks, *Reviews in Mineralogy and Geochemistry*, 48(1), 293-335, 2002.
- Taetz, S., John, T., Bröcker, M., Spandler, C. and Stracke, A., Fast intraslab fluid-flow events linked to pulses of high pore fluid pressure at the subducted plate interface, *Earth and Planetary Science Letters*, 482, 33-43, 2018.