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Transport pattern of fluid and fracturing in lower crust

Noriyoshi Tsuchiya[1]

[1] Environmental Studies, Tohoku Univ.

http://geo.kankyo.tohoku.ac.jp/

Geofluids and Rock Interaction is one of essential phenomena of Earth process to realize crustal evolution. Geofluids and Rock Interaction could be subdivided into the following factors: T (temperature) - P (pressure) - C (chemical) - H (hydrological) - M (mechanical) and their coupled factors. Temperatures and pressures depend on crustal condition, and geofluids show wide range diversity in terms of chemical reaction (Tsuchiya and Hirano, 2007). Hydrological and mechanical behavior of geofluids have not well investigated in lower crustal condition. Roles and properties of geofluids for hydrological and mechanical characteristics under relatively high temperatures and pressures could be investigate in metamorphic terrane. In this presentation, I will show some evidences for understanding transport phenomena and role of geofluids for rock failure in the lower crust.

Diffusion and Advection: The Sor Rondane Mountains is one of the largest inland mountain ranges in East Antarctica, which is mainly composed of high- and medium-grade metamorphic and plutonic rocks. Marble and calc-silicate rocks are distributed in the northern, eastern and central parts of the Sor Rondane Mountains. Carbon and oxygen isotopic compositions could be effective indicator to identify origin of carbon such as biogenic and/or mantle derived source, to estimate metamorphic temperatures using oxygen isotopic equilibrium and tracer of metamorphic fluid flow.

Delta values of carbon and oxygen isotopic compositions within the marble layers in granulite facies (Menipa in the central part of Sor Rondane Mountains) decreased for approaching wall rock along traverse line of the marble layers, and was systematically changed as a function of distance from the wall rock which is pelitic gneiss and mylonite. Profiles of isotopic composition of carbon and oxygen indicates flow pattern of CO2-rich fluid during metamorphism, which diffusion or advection is dominant. In case of symmetrical profile, diffusive transport were significant, but asymmetrical variation indicates advective flow is effective. Stable isotopic composition of marble and other rocks could be adequate tracer to estimate the dynamics of geofluids flow.

Mechanical effects: The Hidaka Mountains was located in the central part of Hokkaido, and high grade metamorphic rocks in granulite facies are well exposed. Mineral filling veins in tonalite and pelitic gneiss in which granulite facies was observed along the Nishuomanai river (Motouragawa river) to realize fluid flow and behaviors of fluid to generate flow path in high temperature condition. In Hidaka metamorphic terrane, three type of vein, such as Type I (pegmatitic and aplite veins), Type II and Type III, were recognized. Type II and III, which were mainly composed K-feldspar and plagioclase with extremely small amount of quartz, were occurred as network in high grade rocks. Texture of vein was similar to volcanic rocks. Vein networks were caused by fracturing of host rocks, and breccias of host rocks were observed inside vein without chemical reaction between host and vein materials. Those facts suggest that the following characteristics:1) Formation fluids of vein had feldspathic and magmatic composition. 2) Small amount of liquid component because of no hydrothermal reactions. 3) Aphyric texture indicates low pressure cooling from high temperature condition. 4)Timing of vein formation was under high temperature during retrograde stage.

Even in high temperature which is over brittle-plastic transition, host rock was failed as brittle-like fracturing. In lower crust, geofluids was considered to be in supercritical condition. Depending on physicochemical properties of geofluids in supercritical state and amount of liquid phase, geofluids could have some effects on fracturing of the crustal material even in plastic conditions.

Tsuchiya, N. and Hirano, N. (2007), Island Arc, 16, 6-15.