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# Quantitative analysis of material transfer during the ascent of Garnet-amphibolite mass in the Sambagawa belt, Japan

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Fluid behavior at plate boundary is of great importance on the deformation of the crust, generation of earthquakes and formation of melt. Although recent advances in seismology visualized the localized distribution of fluid at plate boundary, fluid behavior in oceanic and continental crusts, its form of existence, and the time and the amount of transfer are not understood. To understand the fluid related phenomena at plate boundary, analysis of natural sample that experienced plate boundary is essential.
The aim of this study is set to develop a method to evaluate fluid behavior from natural samples with information of Pressure and Temperature. In rocks, fluid behavior is recorded as material transfer.
Garnet amphibolites in the amphibolite mass of the Sambagawa metamorphic belt was chosen for the study, because (1) it is well studied area and tectonic settings, geochronology and P, T data are available, and (2) two distinct zoning mineral; garnet and amphibole, record various chemical conditions.
The pressure-temperature-time history of the amphibolite mass has been well estimated in previous study(Uno, Toriumi, 2009 in JGUM), by application of Gibbs method to garnet-amphibole system. The rim of the garnet was estimated to be formed at 600 ℃, 11kbar by hornblende-garnet-plagioclase thermobarometer. The obtained P-T paths from both garnet and amphibole yielded heating decompression paths with steep dP/dT. The peak P-T conditions for the amphibolite mass was estimated to be at least 550℃, 15kbar.
The amount of growth of garnet during decompression P-T path was quantitatively evaluated with the outputs of Gibbs method. Outer part of garnet (about half in volume) was assured to have grown during decompression. In closed system, garnet has been thought to break down during decompression. Thus, the observed garnet growth during decompression implies that mass transfer occurred.
To estimate the amount of mass transfer during the obtained P-T paths, a new method to evaluate the amount of mass transfer from anisotropic distributions of minerals is proposed. It is formulated to make use of the mineral banding distributions, a new information that was previously ignored. The new method was applied to the mineral banding of the garnet amphibolite. It is inferred from the results, that Na, Mg, Fe, Ca and Al components have transferred among layers or to the directions parallel to layers. It was quantitatively confirmed that the behavior of mass is not to uniform the heterogeneity, but to intensify the heterogeneity of rock composition and mineral modes. The flow of Na component was estimated to be in the order of $1x10^{-13}$[mole/$m^2$s].
Unlike previous methods, the proposed method can evaluate the amounts of mass transfer with following features: (1)no assumption of initial composition (2)mass transfer along the P-T path (3) multicomponent system (4)detailed spacial distribution. The dimensions of data obtainable from metamorphic rock increase, and better understanding of the forms and mechanisms of mass transfer around plate boundary would be expected if applied to rocks with various P-T histories.

Keywords: material transfer, subduction zone, metamorphism, amphibole, garnet, fluid