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Exhumation stage fluid migration recorded in Na-rich phengite in Sanbagawa metamorphic rocks

Kenta Yoshida[1*], Takao Hirajima[1]

[1]Graduate School of Sciences, Kyoto University

High-pressure metamorphic rocks and corresponding fluid inclusions are excellent natural laboratories to study deep fluid activities in subduction-zone processes. However, they usually suffer multi-stage fluid activities during subduction and exhumation stages.

A metasediment sample (IR04), collected from the Western Iratsu body, central Shikoku, has suffered eclogite facies metamorphism (550-650 C, 1.5-2.0 GPa). IR04 mainly consists of hornblende, phengite and garnet with minor amount of chlorite and other accessory/retrograde minerals. Yoshida and Hirajima (2012) found three types of fluid inclusions from the foliation-parallel quartz vein corresponding to IR04 and reported their trapping timing based on the textural observation as follows: (1) prograde P-increasing stage; (2) *P*-increasing or near-peak stage; (3) exhumation stage. Thus IR04 is thought to have suffered at least three stages of fluid activity. However, exact entrapment conditions of these fluid inclusions have not been determined yet.

Phengites contained in IR04 have Na-rich composition (paragonite component up to 20 mol%) and show composition modification along deformation parts and grain boundaries, with the direction crosscutting the cleavages. That modification is not derived from the retrograde element re-distribution with adjacent minerals because of their occurrence at the grain boundaries between phengites. Unmodified part (Na-rich core) have the composition with X_{Na} = Na/(Na+K) = 0.16-0.20 and Mg# = Mg/(Mg+Fe) = 0.68-0.72 while the modified part (Na-poor rim) have X_{Na} <0.04 and Mg# = 0.62-0.68. The boundaries between Na-rich core and Na-poor rim are very clear and have composition gaps.

In order to estimate the timing of Na-poor rim formation, we performed the forward modeling of exhumation and H_2O-fluid migration, i.e. we calculated the XH_2O-$P(T)$ phase diagram along the exhumation P-T trajectory from the peak stage of 650 C and 2.0 GPa to 400 C and 0.3 GPa, using the bulk composition of IR04. The result shows that Mg# of phengite does not account for the P and T deceasing but decreases with the increasing of total amount of H_2O of the system. On the other hand, X_{Na} of phengite shows decreasing with cooling and decompression, but almost constant value with H_2O content of the system. Assuming the effective bulk composition accounting for the Na-poor rim forming water-rock interaction can be approximated as the bulk composition of IR04, composition modification from Na-rich core to Na-poor rim, i.e. X_{Na} decreasing from 0.2 to <0.04 and Mg# decreasing from 0.7 to 0.62, can be explained by the increase of H_2O content at the temperature below 450 C. As Na-poor rim has compositional gap with the Na-rich core, that during exhumation, continuous water supply did not exist but H_2O increase should have taken place after water-unsaturated decompression and cooling to <450 C. Compared to the fluid inclusion stages of the corresponding quartz vein, the H_2O-fluid observed here is probably closely associated with the above-mentioned (3) exhumation stage fluid inclusions.

Additional two metapelites (IR27 and IR28), collected from the northern proximal to the Iratsu body and ca. 3km far from IR04 locality, show very similar composition modification of Na-rich phengite. Those metapelites belong to the biotite zone of the Sanbagawa metamorphic belt and have peak metamorphic conditions lower than IR04 (IR27 = ca. 600 C and 1.0 GPa; IR28 = 550 C and 0.8 GPa). The biotite zone of the Sanbagawa metamorphic belt is thought to have incorporated with higher grade Iratsu body at the depth of 25-30 km and to have exhumed together along the same *P-T* trajectory. The estimated conditions of H_2O-fluid migration (<450 C) correspond to the stage subsequent to the incorporation of the biotite zone and the Iratsu body, suggest that H_2O-fluid migration took place over the relatively wide area around the Iratsu body, at that stage of the exhumation.

Keywords: Sanbagawa metamorphic belt, retrograde fluid, pseudosection, fluid-rock interaction