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Estimating accurate chemical composition of primitive magma by using mantle derived Opx: Targeting at the HMA in Kiyama

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High-Mg andesite (HMA) is a peculiar magma erupted in the Setouchi Volcanic Belt (SVB). On the basis of petrologic/experimental studies, Tatsumi (2006) et al. showed that HMAs in the SVB were in equilibrium with mantle peridotite and estimated the generation conditions. Petrologic study of HMA in the Kiyama district, Kagawa prefecture, shows that various crust-mantle processes were involved before its eruption. It is, therefore, necessary to accurately estimate the true composition of melt separated from the mantle by considering the processes that the HMA magmas underwent.

Chemical composition of a primitive magma is commonly estimated from an erupted differentiated magma by adding olivine in equilibrium with the melt (Tamura et al., 2000). Because the mantle olivine composition is not known, it must be assumed with or without information from phenocrysts or xenocrysts (Putrika, 2005). We discovered mantle derived Opx crystals in HMA in the SVB, the rim of which has a record of a primitive melt composition. We were successful to obtain accurate composition of the primitive magma of the HMA by using the information.

We conducted field survey in Kiyama and Kanayama (Sato, 1982), central part of Kagawa Prefecture. We also observed thin sections and analyzed whole-rock and mineral chemical composition by XRF and EPMA, respectively, and evaluated the chemical composition and generating pressure and temperature of the primary magma of the HMA.

The Sanuki Group (middle Miocene series) in Kiyama and Kanayama, referred by Sato (1982), consists of rhyolitic tuff breccias and dacitic volcanic breccias covered by sanukitoid lava flows (1, 2, 4). Lava 4 can be subdivided into 3 types according to their phenocryst combination, whole-rock composition, and amount of xenocrysts. Lava2 is abundant in olivine and Opx phenocrysts, while Lava1 and Lava4 are poor in them. Lava2 is classified into HMA and rich in Ni and Cr (8.6wt%, 180ppm, 560ppm for MgO, Ni, Cr content and 0.4 for FeO∗/MgO atomic ratio), and the chemical composition is comparable to that of HMA lava flow in Goshikidai (Henmi et al., 1976).

The Lava 2 contains normally-zoned euhedral olivine phenocrysts, whose core Mg#[=100 x MgO / (MgO + FeO∗)] is in equilibrium with the whole-rock composition, The olivine phenocrysts are thought to have been crystallized from the HMA melt in a closed system. The HMA also contains Opx crystals, which are either euhedral or anhedral surrounded by polycrystalline olivine rim. The Opx is reversely zoned and has Mg# much higher than that in disequilibrium with the whole-rock composition, suggesting xenocrystic origin. The very high-Mg# at the rim (up to 92.2) and Cr_2O_3 content (up to 1.2 wt%) suggests that they were in contact with a mantle derived melt. The Opx contains about 1.4 % CaO, from which a minimum temperature of 1100 degrees Celsius is estimated by using QUILF program (Andersen, 2008).

Because the rim of Opx probably records chemical signature of a primitive magma, from which the HMA was derived, it is possible to estimate its composition by the following procedure. First, the Mg# of olivine and melt in equilibrium with the HMA is calculated by using Fe-Mg exchange partition coefficient between olivine and melt (Beattie, 1993). The composition of primary magma is then calculated by adding fractionated olivine to the HMA until it is equilibrated with the Opx rim in terms of Mg-Fe exchange. The obtained primary magma composition in still HMA. Since olivine could have been fractionated before reaching the Mg# recorded on the Opx rim, the primitive magma could be much higher in MgO.

The composition of primitive magma of HMA in other areas might be estimated if similar mantle derived Opx is available.

Keywords: HMA, Setouchi Volcanic Belt