Physical and chemical properties of endmember magmas relating to production of High Mg-andesite from Hachimantai volcanic field

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Kimura et al. (this conference) reported that magma mixing resulted in production of high-Mg andesite of Ebisumori, Hachimantai volcanic field. The felsic endmember (FEM) is andesite magma with 57-58 wt% SiO2, and the mafic endmember (MEM) is primitive basalt with 51-52 wt% SiO2 and 10-12 wt% MgO. From paragenesis and compositions of phenocryst minerals, it can be assumed that the FEM contained low-Ca plagioclase, augite, orthopyroxene, magnetite, and ilmentite, and that the MEM contained olivine (Fo81-87), picotite, and high-Ca plagioclase (An90-). Using MELTS, phase equilibria were calculated to estimate physico-chemical properties of these endmembers. The calculation for FEM indicates that the actual assemblage (plagioclase, augite, orthopyroxene, magnetite, and ilmentite) was produced at magmatic temperature of 1000 C and pressure of 1kb. On the other hand, actual assemblage of ol-pl-sp in MEM could not be calculated at any conditions of temperature, pressure, oxygen fugacity, and water content. In particular, we could not find any crystallization condition of high-Ca plagioclase. Neglected presence of plagioclase, we estimated crystallization condition of olivine and spinel as 2kb or more, 1200C, and QFM+2log.

The rock rarely contains reversely zoned olivine and its core composition is Fo73-75 (rim is Fo86). At nearby volcanoes of Hachimantai (Iwate, Akita komagatake, and Hakkoda) olivine basalts occur and their phenocrysts are plagioclase (An90-) and olivine (Fo 70-80). These olivine basalts are highly differentiated and have high Fe/Mg. Mineral assemblage of MEM can account for magma mixing between such a differentiated magma (HFB) and a primitive magma (PB). MEM is a MgO-rich, low Fe/Mg basalt magma, but PB must be a more primitive basalt with higher MgO because MEM had undergone magma mixing with the differentiated magma. Since MEM was in equilibrium with Fo86, PB was possibly in equilibrium with mantle peridotite, and may have ascended to shallow level without any differentiation.

Since we can not estimate magma composition of HFB, we assume the composition of HFB was same as those of olivine basalts from nearby volcanoes. Composition of these olivine basalts are similar each other, and compositions of olivine basalts from Iwate were used for the phase equilibrium calculation by MELTS. Presence of high-Ca plagioclase indicates high water contents which requires some high pressure because water solubility in magma is very low at low pressures. However, at high pressures, clinopyroxene crystallizes at high temperatures prior to olivine or plagioclase. Hence, assemblage of high-Ca plagioclase and olivine can not account for isobaric crystallization. It is feasible that these minerals crystallized during successive decompression of hydrous basalt (simple ascent of degassing magma). This idea is consistent with the previous study (Ishikawa et al. 1984) that concluded the clinopyroxene fractionation at depth and the discrepancy between phenocryst and fractionated minerals.

From MELTS calculation, we can conclude that two basalt magmas (HFB and PB) ascended to shallow level (less than 1kb) and then mixed to produce MEM. The mixing with FEM occurred after the mixing of two basalts. Therefore, the andesite magma(FEM) had situated at shallower level (less than 1kb).