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Temperature of primary magma from Sannome-gata volcano, NE Japan Arc

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Materials and energy transport in subduction zones has played important roles in the Earth's evolution, and has been investigated extensively from petrological, geochemical, experimental, numerical, and geophysical studies. In these approaches, petrological studies on volcanic products can provide direct information on the thermal and geochemical states of the sub-arc upper mantle. However, arc volcanic rocks are commonly differentiated from their primary compositions, and it is not easy to extract reliable information of the source mantle from the rocks.

In this study, the temperature condition is estimated for a primitive basaltic scoria from Sannome-gata volcano, which is located in the rear arc of the NE Japan arc. A petrological study was carried out on the scoria by Yoshinaga and Nakagawa (1999), and they showed that some scoria represent nearly primary magmas. We have collected many scoria samples from the same outcrop, and detailed petrological and geochemical analyses have been performed for selected samples. The samples show significant variations in whole-rock compositions (SiO_2: 46.7-56.2 wt.%; MgO: 2.4-11.1 wt.%). The samples with MgO $>$˜9.5 wt.% (”magnesian samples”) are mostly homogeneous in $^{87}Sr/^{86}Sr$ ratios (˜0.70318), whereas those with MgO $<$˜9.0 wt.% (”less magnesian samples”) have higher $^{87}Sr/^{86}Sr$ ratios ($>$0.70327) and the ratios tend to increase with decreasing the whole-rock MgO contents. The phenocrysts contents correlate with the whole-rock compositions; the magnesian samples are aphyric, containing ˜5 vol.% olivine microphenocrysts, and the less magnesian samples contain plagioclase, alkali feldspar, and quartz phenocrysts, as well as olivine microphenocrysts. The Mg# of olivine microphenocrysts is up to Mg#90.

The phenocrysts assemblage and the correlation between the $^{87}Sr/^{86}Sr$ ratios and the whole-rock major element compositions clearly suggest that the less magnesian samples experienced extensive interaction with the crust. In contrast, the magnesian samples may have been essentially free from crustal assimilation, because they are aphyric and the $^{87}Sr/^{86}Sr$ ratios are homogeneous irrespective of the variations in the whole-rock major element compositions (9.5-11.1 wt.% in MgO). Considering that the magmas can equilibrate with ˜Mg#90 olivine, the magnesian samples may represent primary magmas. Using thermodynamic calculations and the observed petrological features of the magnesian basalts, the temperature of the magmas shortly before eruption is estimated to have been ˜1220^{o}C, and the water content of the magma at depth is estimated to have been $>$˜3.1 wt.%. Given that the water content of the magma was 3.1 wt.% and the magma was generated at 2 GPa (Kimura and Yoshida, 2006), the temperature of the source mantle is estimated to have been ˜1300^{o}C.

Keywords: Island arc magma, mantle, temperature, water content