

Differentiation and generation processes of alkaline basalts from Seifu Seamount in the Japan Sea

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The Seifu Seamount is located ~250 km to the northeast of the Ulleungdo Island in the southern part of the Japan Sea. Research vessel TANSEI MARU has collected highly porous alkaline basaltic rock samples from the Seifu Seamount by dredging in 1985 (KT85-15). K-Ar age of the basaltic rocks has been reported as ~8 Ma, that is several million years after the end of the Japan Sea opening event. Currently, the Pacific Sea Slab is subducting ~450 km beneath the Seifu Seamount, although cusp of the Philippine Sea Slab subducting toward north from the Nankai Trough has not reached the mantle beneath the seamount.

Olivine, clinopyroxene, and plagioclase are the main phenocryst phases, although phenocryst contents of the most basaltic samples are less than 5 vol%. We selected 60 relatively fresh alkaline basaltic rock samples and measured whole-rock major and trace element compositions by X-ray fluorescence (XRF) and mineral compositions by electron probe micro-analyzer (EPMA). The SiO₂ content and FeO*/MgO of these samples ranges from 47.9 to 53.4 wt% and from 1.1 to 3.3, respectively, showing relatively differentiated basaltic compositions. Whole-rock major element compositions show two types of magmatic groups in terms of K₂O content: high-K (K₂O > 1.7 wt%) and low-K (K₂O < 1.7 wt%). High-K samples (2.0 – 7.5 wt% MgO) are relatively higher in SiO₂, Na₂O, Rb, K₂O/TiO₂, and lower in Al₂O₃, FeO*, CaO, P₂O₅, Sr, Zr, Na₂O/K₂O, Zr/Y, and Sr/Y for a given MgO content, compared with the low-K samples (2.7 – 6.7 wt% MgO). The whole-rock SiO₂, TiO₂, Al₂O₃, CaO, Na₂O, K₂O, and P₂O₅ contents of both the high-K and low-K groups increase with decreasing MgO. However, with decreasing MgO, the increase in the SiO₂ content and decrease in the CaO content of the high-K samples is greater and less, respectively, than those of the low-K samples. K₂O/TiO₂, Nb/Y, and Zr/Y are almost constant with decreasing MgO content for both groups, although those of low-K samples show larger variation for a given MgO content.

We examined whether or not the major element compositions in the two basalts could be explained by crystal fractionation from a common undifferentiated parental basaltic melt on the basis of probability Q, which is the probability in a kai-square test and is a quantitative measure for the goodness of fit calculated from the kai-square value at its minimum. We used olivine, clinopyroxene, plagioclase, and magnetite as potential fractionated crystal phases. Parent and daughter magmas are represented by the samples with the highest and the lowest whole-rock MgO contents for both the high-K and low-K groups, respectively. Consequently, the compositional variation in each basaltic group can be internally reproduced by fractionation of those minerals from a parental basalt in the same group. However, a daughter magma in one group cannot be explained by crystal fractionation from a parental magma in the other group. We, therefore, concluded that the high-K and low-K samples are originated in the different primary magmas.

We estimated a primary melt composition for each group, provided maximum olivine fractionation from the primary melt. After 19 wt% and 24.5 wt% olivine addition for the high-K and low-K, respectively, primary melt can be in equilibrium with olivine with Fo# ($= 100\text{Mg}/(\text{Mg} + \text{Fe})_{\text{mol}}$) = 89. Assuming peridotite as a source mantle for the Seifu Seamount basalts and 2.5 wt% water in the primary melt, we

estimated melting conditions of the estimated primary melts by comparing the primary melt compositions to partial melt compositions of high pressure melting experiments of peridotites. Melting pressures and temperatures were estimated to be 2.1 GPa and 1410 °C for the high-K and 2.2 GPa and 1440 °C for the low-K basalts. These melting conditions can be reproduced by adiabatic mantle upwelling with mantle potential temperature ~1400 °C, which is slightly hotter than the mantle beneath mid-ocean ridges.