Petrogenesis of picrite from Kumejima Island, Ryukyu Islands; implications for the opening of the Okinawa Trough

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Picrite occurs along with abundant Tertiary calc-alkali volcanic rocks in Kumejima Island, Ryukyu arc. The volcanic rocks are dominated by andesites, although picrites are found in the lowermost of the Pliocene Uegusukudake Formation.

Picrite occurs as a subareal lava flow of more than 50 m thick on the northern shore of Kumejima, and contains 8-16.5 wt% of MgO. Fo contents of olivine phenocrysts range from 83 to 92.4, but NiO content (0.15-0.34 wt %) is below the mantle olivine array composition, suggesting those olivine crystallized after some crystal fractionation of primary olivine phenocrysts. Spinel inclusions in olivine phenocrysts have Cr/(Cr+Al) ratio of 0.6-0.87, but associated olivine-spinel pair composition shows fractionated composition compared with olivine-spinel mantle array of Arai(1994), reinforcing that even the magnesian olivine phenocryst is the product of slightly differentiated magma. Back-calculation of olivine fractionation in terms of NiO versus Mg# of olivine indicates that primary olivine crystals had Mg# of ca. 0.93, and the primary magma of the picrite of Kumejima Island has MgO contents of 16-18 wt.%. These values coincide with the most magnesian picrite composition. We conducted high temperature-pressure melting experiments on a picrite with MgO content of 16.5 wt.%, to find out the temperature-pressure conditions for coexistence of liquidus olivine and orthopyroxene. Water-free experiments showed that olivine and orthopyroxene coexist at 1450C and 1.6 GPa, whereas, at water content of 2 wt%, the three phase stability occurs at 1400C and 1.9 GPa. There are few evidences for direct estimate of water content of the picrite, but when we apply the correlation between K2O (or other incompatible elements) and H2O contents for abyssal basaltic glasses, the picrite shows that it may originally contain ca. 0.3-1 wt. % of H2O. Therefore we estimate the condition of picrite magma generation as 1425C and 1.75 GPa. This condition, when plotted in the adiabatic temperature profile of McKenzie and Bickle (1988), yields mantle potential temperature of 1580C, much exceeding usual potential temperatures of 1280C for MORB generation. Exceedingly high mantle potential temperature of the Kumejima picrite formation suggests that strong mantle upwelling took place at ca. 2 Ma beneath the Okinawa trough, and the upwelling caused the back-arc spreading. It is also conceived that large amounts of picritic-basaltic magmas beneath the Okinawa trough possibly were underplated into the crust of the trough.