

## Olivine-spinel systematics and redox state of alkali olivine basalt from the Higashi-Matsuura district, SW Japan

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Spinel has been used as a petrologic indicator because its composition depends chiefly on compositions of coexisting silicate melt and crystallization conditions such as temperature and oxygen fugacity ( $fO_2$ ). Spinel is an initially crystallized phase together with olivine in basaltic magma, and it is often observed as inclusions in olivine phenocrysts. Spinel inclusions are expected to record chemical conditions at the time of their entrapment because they have been effectively shielded by olivine from post-entrapment modifications. In this study, chemical compositions of spinel inclusions and their surrounding olivine in alkali olivine basalt from the Higashi-Matsuura district, SW Japan, are analyzed to constrain the redox state of their primary magma.

The Higashi-Matsuura district is located at backarc side of Southwest Japan arc. In the district, a relatively massive succession of basaltic lava flows covers basement that comprises the Middle-Late Miocene Sasebo Group and Cretaceous granitic plutons. The basaltic succession consists of nine flow units (Kobayashi et al., 1955, 1956) and their K-Ar ages are all within 3.00 (+/- 0.03) Ma (Nakamura et al., 1986). The basalt varies from relatively undifferentiated alkali olivine basalt to highly differentiated mugearite, and shows trace element characteristics of intra-plate volcanism. In this study most undifferentiated samples in each flow unit are analyzed. Whole rock major and trace element compositions are analyzed by XRF at the Kitakyushu Museum of Natural History and Human History. Major element compositions of minerals are analyzed by EPMA at Kobe University.

In olivine MnO and CaO contents increase and NiO contents decreases with decreasing Fo number [ $=100Mg/(Mg+Fe^{2+})$ ], respectively. These compositional variations are explained by fractional crystallization. The maximum Fo number is ca. 85.5 with NiO, MnO, and CaO contents of ca. 0.26, 0.15, and 0.22 wt.%, respectively. This composition is similar to liquidus olivine calculated from whole rock composition.  $Fe^{3+\#}$  [ $=Fe^{3+}/(Al+Cr+Fe^{3+})$ ] of spinel increases as Fo number of coexisting olivine decreases.  $Cr^\#$  [ $=Ca/(Al+Cr)$ ] and  $Fe^{3+\#}$  of spinel coexisting with liquidus olivine is ca. 0.35 and ca. 0.07 regardless of flow unit, respectively.

The  $fO_2$  of the basalt at liquidus temperature is estimated by the method of Danyushevsky and Sovolev (1996). The method is based on the combination of the partition relation of ferric and ferrous between coexisting spinel and silicate melt proposed by Maurel and Maurel (1982) and the relationship between ferric/ferrous ratio and  $fO_2$  of silicate melt proposed by Kress and Carmichael (1991). The accuracy of the method is evaluated to be +/- 1 log units. The effect of pressure on partitioning of ferric and ferrous between coexisting spinel and silicate melt is negligible. Estimation of  $\Delta QMF$  [ $=\log fO_2(\text{estimated})-\log fO_2(QMF)$ ] only slightly increases with increasing pressure (+0.5 log unit at 2GPa; Kress and Carmichael, 1991), which is within analytical error. The effect of  $H_2O$  on the relationship of ferric/ferrous ratio and  $fO_2$  is negligible (e.g., Botcharnikov et al., 2005).

The liquidus temperature at 1atm is estimated to be ca. 1520K. The redox state of the basalts at their liquidus temperature are estimated to be 0.5 log unit below QMF buffer. The estimated redox state is more reduced than that of typical arc peridotite (Parkinson and Arculus, 1999) and in the range of typical abyssal peridotite. The estimated state is almost similar to that of lithospheric mantle beneath backarc side of SW Japan estimated from mantle xenoliths in alkali basalt (Arai et al., 2001). The consistency between the redox state of basaltic magma and mantle xenoliths implies that  $\Delta QMF$  in upper mantle beneath the district is almost constant and similar to oceanic condition.