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Fabric characterization associated with asthenospheric upwelling in the uppermost mantle, back-arc region of the southwest Japan arc: Evidence from peridotite xenoliths, Oki-Dogo Island

Takako Satsukawa (1) and Katsuyoshi Michibayashi (2)

(1) Educational Division of Science and Technology, Shizuoka University, Shizuoka, Japan (f5944004@ipc.shizuoka.ac.jp),
(2) Institute of Geosciences, Shizuoka University, Shizuoka, Japan (sekmich@ipc.shizuoka.ac.jp)

Oki-Dogo Island is an important site in terms of xenoliths because it makes the most continent ward occurrence of mantle peridotite xenoliths in the back-arc region of the southwest Japan arc. We describe the microstructure of peridotite xenoliths obtained from Oki-Dogo Island with aim of understanding the evolution of the uppermost mantle beneath the back-arc side of the Japan arc. Basement on the island consists of gneissic metamorphic complex. The alkaline basalts that contain the xenoliths were erupted during the Pliocene-Pleistocene after the opening of the Japan Sea which is thought to have occurred during the Oligocene-Miocene as a consequence of back-arc spreading. Peridotite xenoliths found on Oki-Dogo Island are up to 10 cm in size, show granular texture, and are mainly spinel lherzolites, with some harzburgites. Large xenoliths (> 3 cm) contain a foliation defined by compositional banding and aligned spinel grains, and a lineation defined by the long axes of spinel grains.
All spinel lherzolites contain spinel with a low Cr# (=Cr/Fr+Al) (< 0.45); this feature, combined with their mineral assemblages and high NiO content in olivine, suggests that they are of residual origin. The Mg# (=Mg/Mg+Fe) of silicate minerals in some spinel lherzolites is lower (e.g. down to Fo86) than that in typical residual peridotites of the upper mantle, indicating that the observed Fe enrichment occurred in mantle rocks during metasomatism.
We have measured crystallographic preferred orientations (CPOs) of olivine grains from highly polished thin sections using a scanning electron microscope equipped with an electron backscatter diffraction system. The dominant slip system in olivine, as determined from kink bands and CPO data, was {0kl}[100] slip. Moreover, peridotites with low olivine Mg# tend to show a AG-type ([010]-fiber) CPO pattern. This finding suggests that the peridotites were deformed in the presence of melt and represent various degrees of rock-melt interaction as supported by petrologic and geochemical studies. In particular, the decreasing of olivine Mg# is correlated with not only a decrease in crystallographic fabric strength (J-index) but also the change in olivine CPO. Thus, heat transfer from a neighboring large-scale partial melting domain (or 'asthenospherized' mantle) results in an extremely high thermal gradient in this domain, which controls both deformation distribution and the melt migration ahead of the partial melting zone. The variation of in olivine CPO intensities implies that the presence of melt result in a higher contribution of diffusion to deformation, leading to a slower CPO evolution. Thus, peridotites in SW Japan derived from the uppermost mantle were deformed in the melting field due to asthenospheric upwelling associated with back-arc spreading. Consequently, the uppermost mantle peridotites in the back-arc region of the SW Japan were deformed on a condition that melts distributed no homogeneous field due to the asthenosphere upwelling of back-arc spreading. And now, they erupt with keeping structures formed by the back-arc spreading.