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Geochemistry and genetic conditions of primary boninites from the Ogasawara Island Group and Oman ophiolite

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Subduction initiation and arc crust evolution along oceanic plate boundaries are fundamental processes that modify oceanic lithosphere and promotes the material evolution of the Earth. How subduction of oceanic plates initiates and develops largely depend on the thermochemical structure and mechanical strength of the colliding two plates. The resulting conditions of the wedge mantle can be best represented by the varying geochemistry of primary magmas produced through the subduction initiation. For example, the subduction zone in the Izu-Bonin (Ogasawara)-Mariana (IBM) arc started with an intense high-Si to low-Si boninite magmatism during 48-45 Ma (Ishizuka et al., 2006; Kanayama et al., 2012). By contrast, the subduction stage of the Oman Ophiolite lacked typical boninite and is characterized by the low-Si boninite magmatism (Ishikawa et al., 2002; Kusano et al., 2014). Because of its high Mg#s and andesitic chemistry, boninite is generally considered to be a candidate of a primary magma derived from the hydrous upper mantle, and therefore, its compositional variations reflect various thermochemical conditions of the source mantle. The geochemical and petrological studies on boninite magma genesis can provide crucial information on the evolution of arc and the formation of continental crust. Boninites are distinct from ordinary arc magmas in highly depleted U-shaped and depleted spoon-shaped chondrite-normalized rare earth elements (REE) patterns.

We have investigated melt (glass) inclusions enclosed by boninite-derived chrome spinel grains in beach sand, called “uguisu-zuna” from Ogasawara islands, and in wadi sand from the Oman Ophiolite. We analyzed major- and trace-element compositions of the boninitic melt inclusions by EPMA and LA-ICP-MS (Kanazawa Univ.) and H2O by SIMS (Hokkaido Univ. Creative Research Institution). Glass inclusions in spinel have more Mg-rich compositions than aphyric whole rocks, indicating their primitive nature since derivation from the source mantle, which experienced least modification by the processes such as crystal fractionation, and assimilation and contamination by the crust. Volatile measurements of melt inclusions confirmed that they were only slightly degassed and retain primitive contents. Five geochemical types (BIC-1~5) are identified among boninites from the Ogasawara Islands and a single geochemical type from the Oman Ophiolite. Both Ogasawara and Oman low-Si boninites show lower H2O contents than high-Si boninites. Assuming that the most magnesium-rich melts of each geochemical type in Ogasawara and Oman boninites coexisted with olivine and orthopyroxene, the P-T conditions of these primary boninite magmas were estimated by using the geothermobarometers of Putirka et al. (2007) and Putirka (2008). High-Si boninites erupted on the Ogasawara Islands during 48-46 Ma were generated at 1400-1440 ℃ and 0.7-0.9 GPa, whereas the subsequent low-Si boninite at 45 Ma formed at 1380-1400 ℃ and 0.8-0.95 GPa. This suggest that the geothermal gradient descended from 48 Ma to 45 Ma. On the other hand, low-Si boninite from the Oman Ophiolite was generated at 1320 ℃ and 0.5 GPa. Hence, it is apparent that the wedge mantle beneath the proto-IBM arc was significantly hotter than that in the Oman paleoarc.

Keywords: subduction initiation, IBM forearc, Oman Ophiolite, high-Si boninite, low-Si boninite, melt inclusion