Amphibolite-facies metamorphism of the subducted slab and boninite magma genesis: An inference from the Oman ophiolite

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The Oman ophiolite contains boninite and other arc-related volcanic rocks generated after the magmatism of spreading-ridge ceased. The initiation of subduction of a young, hot oceanic lithosphere (and obduction of the future Oman ophiolite) near the spreading ridge and the resultant melting of the hydrous shallow mantle wedge represent the most favorable mechanism for the genesis of the Oman boninites. On the other hand, this ophiolite is underlain by a thin sliver of amphibolite-granulite-facies metamorphic rocks. These rocks (metamorphic sole) are believed to represent oceanic crust overridden and “ironed” by the ophiolitic lithosphere, and may be analogous to the subducted slab that contributed to producing the geochemical signature of the boninites. Thus the Oman ophiolite provides a best opportunity for investigating the link between the amphibolite-facies metamorphism of the slab and the boninite magma genesis in the mantle wedge.

The amphibolites in the 230 m-thick metamorphic sole in Wadi Tayin area show significant variation in fluid-mobile element concentrations across the transect of the sole. The observed variations suggest that the amphibolites (>600°C in peak metamorphic temperature) near the contact with the overlying peridotite were equilibrated with evolved, B-Rb-K-Ba-rich fluids formed through successive fluid-rock interactions during prograde metamorphism. The estimated amphibolite-derived fluids are characterized by striking enrichments of B, Rb, K and Ba and moderate to minor enrichments of Sr, Li, Be and Pb. It is also suggested that at higher temperature (up to 700 °C), the fluids become considerably enriched in light REE and Nb in addition to the above elements. Model calculations showed that the trace element characteristics of the Oman boninites, including their U-shaped REE patterns and relatively low Ba/Rb ratios, are successfully explained by partial melting of the highly depleted mantle that had been metasomatized by the amphibolite-derived fluids. The Sr and Nd isotope compositions of the boninites and related volcanic rocks in the Oman ophiolite are also consistent with the involvement of such fluids. The compositions of the fluids librated from the amphibolite-facies slab are likely to vary dependent on the metamorphic temperature, and the evolution and hybridization of such fluids may produced considerable variations in trace element and isotope compositions observed in the boninites.

The magmatic plumbing of the submarine volcanic chain of an oceanic island arc volcano: Long distance lateral magma transport?

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Recent geophysical observations on basaltic composite volcanoes in Izu arc reveal the process of long distance lateral magma transport within the arc crust. Such intrusion events sometimes caused flank fissure eruption and also triggered a formation of collapsed caldera (Miyakejima 2000). To clarify a long-distance magma transport system of the basaltic volcano in volcanic arc from geological and petrological aspects, we investigated a submarine volcanic chain (Hachijo NW chain) and satellite cones nested Hachijo Nishiyama volcano, a frontal composite volcano in the northern Izu arc.

Basalts from the Hachijo NW chain generally have more primitive composition compared to those from the Nishiyama. The bulk compositional trend of Hachijo NW chain magma is controlled by crystal fractionation while plagioclase accumulation was indicated by aluminum-rich character of the Nishiyama volcano and its subaerial and submarine satellite cones other than NW chain edifices.

Trace element ratios unaffected by melting or crystal fractionation (e.g., Nb/Zr) and isotopic compositions are not significantly different between the Nishiyama and the Hachijo NW chain. This implies that the sources of magma for these volcanic systems are identical. However, Hachijo NW chain shows lower LREE/HREE and Zr/Y. These differences in trace element ratios could be ascribed to difference in degree of partial melting of the source or crustal assimilation. Assuming difference in degree of partial melting, Nishiyama magma, which is much more voluminous than Hachijo NW chain magma, should have lower degree of melting relative to Hachijo NW chain. Instead we prefer a model considering larger extent of crustal assimilation for Nishiyama magma, where assimailated crust is expected to have higher LREE/HREE and Zr/Y, but simialr isotopic comsposition to basaltic primary magma.

Nishiyama magma is assumed to form shallow crustal magma chamber where it experienced crustal assimilation and plagioclase accumulation. Satellite cones other than NW chain can be explained by magma transport from this magma chamber in the shallow crustal level. On the other hand, Hachijo NW chain was tapped by the same primary magma as Nishiyama volcano, but experienced much less crystal fractionation and assimilation in the crust during ascent without forming shallow magma chamber. Long distance magma transport is assumed to have occurred in the lower crustal level, which is consistent with the depth of hypocenters of seismic event in 2002.