

Mantle potential temperature in Ordovician estimated from ultramafic dikes in the Hayachine-Miyamori Ophiolite

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Estimation of the secular variation of thermal state of the Earth's mantle is imperative to understand the evolution of the solid Earth. One of the key proxies of the thermal state is mantle potential temperatures (McKenzie and Bickle, 1988) estimated from chemical compositions of magmas erupted at particular tectonic settings: spreading centers or non-arc environments (Herzberg et al., 2010). This restriction of tectonic setting is necessary to guarantee that the estimated potential temperatures represent that of the entire mantle. In this regard, an arc environment is avoided to estimate potential temperature because of its complex tectonics and strong influence of water dehydrated from subducting slab for magma genesis. However, we must use even arc environment to estimate mantle potential temperature to achieve a dense distribution of potential temperature over the wide age span of the Earth's history.

An ophiolite is a rock body having a mantle section overlain by oceanic crust exhumed to the Earth's surface at various ages at least from the Paleoproterozoic time to the very recent past (Stern, 2005). Moreover, ophiolite pulses, in which a large number of ophiolites were formed and exhumed in a confined period, are thought to reflect the mantle thermal state (e.g., Abbate et al., 1985). Ophiolites thus provide very useful information on magma generation in the mantle and thus have large potential for elucidating secular variation of mantle potential temperature. However, accumulated studies on ophiolites have revealed that many ophiolites were formed in subduction zones, from fore-arc to back-arc basin (Dilek and Furnes, 2011).

In this study, we estimate a mantle potential temperature at ~500Ma from an Ordovician arc ophiolite: Hayachine-Miyamori Ophiolite located in the South Kitakami Massif, northern Japan, which is shown to have been formed in an arc environment on the basis of extensive geological, petrological, and geochemical studies (Ozawa et al., 2015). We use porphyritic ultramafic dikes intruded into near the base of the cumulate members (Ozawa, 1984). The dikes, which intrude orthopyroxene-bearing dunite, have phenocrysts of euhedral -subhedral olivine (~5 mm in size and ~30 vol%) and minor clinopyroxene (~3 mm in size and ~2 vol%) set in finer matrix consisting of pargasite, orthopyroxene, clinopyroxene, and plagioclase. Some dikes show multiple branching, and shape-preferred orientation of phenocrysts and concentration of olivine phenocrysts in the middle of the dikes suggesting operation of flow differentiation. From these field observations, it is inferred that dikes were solidified rapidly in closed system after intrusion at a liquid state in order to keep the suspension of olivine crystals in the middle of the dikes. We obtained chemical composition of rocks with variable amounts of phenocrysts. Effects of alteration, metamorphism, and diffusional elemental exchange with the host peridotite are subtracted to obtain compositional variation right after the solidification of dikes. A linear trend of the bulk composition plotting on Harker diagram is obtained through this procedure, indicating that a two-component mixing took place with one end component of the trend extending toward the olivine composition. Subtracting the estimated average composition of olivine in an amount of the phenocryst mode for each rock sample, the compositions are plotted in a restricted region of the Harker diagram. This suggests that the composition represents that of melt intruded into the host peridotite as a crystal-loaded magma. The water content of the magma is estimated to be ~1.5 wt% from the amount of amphibole in the dikes. After correcting fractional crystallization, a primary melt composition is obtained, from which melting temperature and pressure, partial melting degree, and mantle potential temperature

are estimated.

Keywords: arc ophiolite, mantle potential temperature, partial melting degree, primary melt