Origin of ophiolite pulse and thermal state of the upper mantle in the Ordovician time constrained from the Hayachine-Miyamori Ophiolite

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It is critical to know the thermal history of the mantle in order to better understand the evolution of the earth because the mantle under thermal convection occupies 80vol% of the earth.
The mantle potential temperature (MPT) is a temperature of mantle material adiabatically brought to the surface. The thermal history of the mantle has been examined by revealing secular change of MPT estimated from non-arc basalts and modeled with a parametarized convection model. The so far obtained MPT change and the model, however, cannot resolve episodicity, the critical feature of the earth’s thermal history, which can only be tackled by accumulation of data with higher resolution.
Ophiolite pulses, in which a large number of ophiolites formed in a confined period, are thought to reflect thermal episodes. However, the relationship between the Ordovician ophiolite pulses and the proposed plume model are not clear because of the predominance of arc ophiolites and scarcity of LIPS for the Ordovician pulse. This must be resolved by MPT estimation for the Ordovician mantle, for which two difficulties relevant to arc magma genesis must be overcome: the involvement of H2O and complex thermal state.
In this study, we develop a novel method for MPT estimation for arc environment by using ultramafic dikes from Hayachine-Miyamori Ophiolite, northern Japan. The estimated MPT, melting depth and water content in source mantle are ~1360˚C, ~170km and ~0.15wt% respectively. The geochemical data of the dike indicate passive upwelling of NMORB source-like garnet peridotite from sub-slub mantle without strong influence of slab-derived fluids. The estimated MPT may reflect the global value if operation of small-scale convection is considered. We conclude that the Ordovician upper mantle has a thermal state similar to the current upper mantle. Surface tectonics, such as assembly and breakup of supercontinents and a peculiar water delivery, might be responsible for the Ordovician ophiolite pulse.

Keywords: thermal state of the mantle, mantle potential temperature, ophiolite pulse, arc ophiolite

