Origin of geochemical mantle components: Role of spreading ridges and thermal evolution of mantle

*Jun-Ichi Kimura[1], James B. Gill[2], Peter E. van Keken[3], Hiroshi Kawabata[5], Susanne Skora[4]

1. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Scienc and Technology, 2. Department of Earth and Planetary Sciences, University of California Santa Cruz, 3. Department of Terrestrial Magnetism, Carnegie Institution for Science, 4. Institute of Geochemistry and Petrology, Earth Sciences, ETH Zurich, 5. Multidisciplinary Science Cluster, Interdisciplinary Science Unit, Research and Education Faculty, Kochi University

We explore the element redistribution at mid-ocean ridges (MOR) using a numerical model to evaluate the role of decompression melting of the mantle in Earth's geochemical cycle, with focus on the formation of the depleted mantle component. Our model uses a trace element mass balance based on an internally consistent thermodynamic-petrologic computation to explain the composition of MOR basalt (MORB) and residual peridotite. Model results for MORB-like basalts from 3.5 to 0 Ga indicate a high mantle potential temperature (T_p) of 1650–1500°C during 3.5–1.5 Ga before decreasing gradually to ~1300°C today. The source mantle composition changed from primitive (PM) to depleted as T_p decreased, but this source mantle is variable with an early depleted reservoir (EDR) mantle periodically present. We examine a two-stage Sr-Nd-Hf-Pb isotopic evolution of mantle residues from melting of PM or EDR at MORs. At high-T_p (3.5–1.5 Ga), the MOR process formed extremely depleted DMM. This coincided with formation of the majority of the continental crust, the sub-continental lithospheric mantle, and the enriched mantle components formed at subduction zones and now found in OIB. During cooler mantle conditions (1.5–0 Ga), the MOR process formed most of the modern ocean basin DMM. Changes in the mode of mantle convection from vigorous deep mantle recharge before ~1.5 Ga to less vigorous afterwards is suggested to explain the thermochemical mantle evolution.

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