マントルポテンシャル温度の地球史推移：ホットスポットとリッジ
Change in mantle potential temperature through Earth time: Hotspots versus Ridges

*木村 純一[1]、川畑 博[2]
*Jun-Ichi Kimura[1], Hiroshi Kawabata[2]

1.海洋研究開発機構・地球内部物質循環研究分野、2.高知大学・理学部
1.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Scienc and Technology, 2.Research and Education Faculty, Kochi University

Mantle potential temperature is the key parameter that determines rolls of mantle upwelling in mid ocean ridges (MORs) and hotspots including large igneous provinces (LIPs). We calculated mantle potential temperature (Tp), degree of partial melting (F), depth of melting column (Pmt), and source mantle depletion (expressed by fractions of DM and PM components) for MORB-like and some hotspot basalts of various ages using a forward trace element mass balance and heat balance calculation model named Ocean Basalt Simulator ver. 1 (OBS1). The samples examined include Cenozoic, Cretaceous, Jurassic, neo-Proterozoic, Proterozoic, and Archean basalts over 3.5 Gyrs covering the entire geological records available on the earth. Primary MORB-like basalt trace element compositions changed with time from unfractionated (flat relative to PM) with low abundances (3.45–2.70 Gyr), to flat with higher abundances (1.90–0.81 Gyr), to LREE-depleted with even higher HREE abundances (0.15–0.07 Gyr), to modern LREE-depleted N- and D-MORB (0 Myr). These temporal changes require an increasingly depleted mantle source and a decreasing degree of mantle melting through time and with decreasing mantle potential temperature. Our results using trace elements are similar to those using major elements by Herzberg et al. (2010), with the highest T_p ~1650 °C in the Archean and early Proterozoic (3.5 to 1.7 Gyr), some ancient basalts have T_p down to ~1400 °C but not lower. Our results suggest T_p maxima at around 2.7 and 1.7 Gyr, although we have few basalts between those ages. After 1.7 Gyr, T_p decreased linearly to T_p ~1300–1400 °C today. This long-term change is consistent with models of the Earth's thermal history that use a low Urey ratio in the convecting mantle. OBS1 models for non-MORB-like komatiites and picrites from large igneous provinces (LIPS) and hotspots have higher T_p up to ~1780 °C in the Archean to Paleoproterozoic, 1600 °C in the Jurassic, and 1500 °C today. These rocks may have formed from deep plumes. In contrast, the decreasing temperatures with time in MORB-like basalts reflect the cooling history of the upper mantle.

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