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

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We explore the element redistribution at mid-ocean ridges (MOR) using a numerical model to evaluate the role of the decompression mantle melting process in the Earth' s geochemical cycle, particularly in 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 1320°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 two-stage Sr-Nd-Hf-Pb isotopic evolution of the mantle residues from melting of PM or EDR at MOR that formed ancient MORB-like basalts. Formation of depleted MORB source mantle (DMM) is also examined using modern MORBs. 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. During cooler-T_p 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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