East-west mantle geochemical hemispheres and their implications for top-down hemispherical dynamics

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Abstract

Global geochemical structures of the mantle have been statistically investigated in both spatial and compositional domains, using a total of 6854 young basalt data consisting of five isotopic ratios of Sr, Nd and Pb from almost all tectonic settings (mid-ocean ridge, ocean island, arc and continent). Characteristic features hidden in the data have been extracted using multivariate analysis "Independent Component Analysis" and "Whitening K-means Cluster Analysis" (Iwamori and Nakamura, 2015, Gondwana Res.; Iwamori et al., 2017, G-cubed). Two independent components (IC1 and IC2) explain most of the sample variance (95%), and the third minor component (IC3) accounts for 4%. Therefore, almost all young basalts covering the whole globe plot on a single compositional plane, and can be explained by only two differentiation processes (i.e., melting and aqueous fluid-rock interaction). IC1 represents 'anciently subducted melt component' stored for 0.8 to 2.4 Gyr in the mantle, and positive IC1 characterizes the hotspots except for Hawaii and Iceland. IC2 represents 'anciently subducted aqueous fluid component' stored for 0.3 to 0.9 Gyr in the mantle, and defines the fluid component-rich (=positive IC2) eastern hemisphere. We have also found a striking geometrical similarity between the IC2 and the inner core hemispheric structures: the eastern hemisphere shows positive IC2 in the mantle and high seismic velocities in the inner core. Combining these constraints, we propose 'top-down hemispherical dynamics' (Iwamori and Nakamura, 2015, Gondwana Res.): focused subduction within and around the supercontinent has created a fluid component-rich hemisphere with a lower temperature, compared to the oceanic mantle. The colder hemisphere seems to have been anchored to the asthenosphere during the continental dispersal, and may affect the temperature and growth rate of the inner core, resulting in the coupled hemispherical structures in the mantle and the core.

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