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Long-lived low Th/U Pacific-type isotopic mantle domain

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The presence of Pacific-type and Indian-type mid-ocean ridge (MORB) isotopic source domains in the upper mantle is a clear manifestation of global-scale mantle compositional heterogeneities. The Indian-type mantle domain is a long-lived feature that can be traced back to, at least, the Palaeozoic Tethyan mantle domain. Little temporal constraints currently exist, however, regarding the longevity of Pacific-type mantle domain. The extinct Paleo-Asia Ocean (PAO), a subsidiary ocean of the Panthalassic Ocean that formed during the breakup of the Rodinia Supercontinent in Mesoproterozoic to Neoproterozoic, can provide a solution to this dilemma. Here, we report the first complete geochemical and Sr, Nd and high-precision Pb isotopic data set for representative mafic rock samples from ophiolites representing remnants of the PAO basement ranging in age from 275 to 624Ma to constrain the composition of their mantle provenance. Data suggest that the sub-PAO mantle has a similar long time-integrated, high Sm/Nd ratio as the global depleted upper mantle, but also shows typical Pacific MORB-like Pb isotopic compositions with lower $^{207}Pb/^{204}Pb_{(t)}$ and $^{208}Pb/^{204}Pb_{(t)}$ for given $^{206}Pb/^{204}Pb_{(t)}$ ratios, and low radiogenic $^{208}Pb^{*}/^{206}Pb^{*}$, indicating a long time-integrated, low Th/U ratios. Thus, the Pacific-type mantle domain, like the Indian-type mantle domain, is a long-lived secular mantle domain that can be traced back to early Paleozoic or even to the Neoproterozoic. Data further indicate that the Nd and Pb isotopic distinction between such two large-scale and long-term mantle domains is due to the different evolutionary and tectonic histories of the circum-Pacific (PAO, Paleo- and modern Pacific) and sub-Tethys-Indian oceanic mantle realms. The Panthalassic-Pacific ocean realm had remarkable permanency existing as a big ocean at lease throughout the Phanerozoic, that implies that continental materials were limit to recycle into underlying mantle, thus the underlying mantle was relative free of the continental material contamination and then produce the low time-integrated Th/U Pacific-type mantle domain. In contrast, the break-up of the Gondwana supercontinent makes the Tethys realms to experience repeated opening and closures, which transferred large volume of continental materials into the underlying mantle and then produce the high Th/U Indian-type mantle domain. Our results indicate that the high Sm/Nd and low Th/U ratio of Pacific-type mantle domain most likely are an inherited, long-standing intrinsic feature of the depleted upper mantle derived from the Earth's primordial mantle with less contamination of continental materials. In contrast, the large-scale and long-lived Indian-type mantle heterogeneity is produced by plate tectonic-driven continental material circulation in the upper mantle. Such a genetic link

between plate tectonics and mantle chemical geodynamics is crucial to our understanding of how the Earth system works.

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