Crust recycling produces the large-scale mantle domains: constraints from Pb isotopic evolutions of the Paleo-Asian and Tethyan mantles

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Plate tectonic-driven material circulations between plate and deep Earth is the first order force to control the Earth geodynamic system. Tethys realm and Paleo-Asian (or Paleo -Pacific) mantle domains are the largest and long-lived mantle domains, but their origin are unclear. We present the compared Nb-Pb isotope evolution of these two mantle domains and found that the Paleo-Asian and Tethyan mantles share similar evolution history of Sm/Nd ratios, but underwent marked different Th/Pb and U/Pb fractionation events. The Paleo-Asian mantle displays lower $^{207}Pb/^{204}Pb_{(t)}$ and $^{208}Pb/^{204}Pb_{(t)}$ for given $^{206}Pb/^{204}Pb_{(t)}$ ratios than that of Tethyan mantle, a typical characteristic of Pacific MORB-type mantle. Mantle Pb isotopes are very sensitive to crust cycling, whereas Nd isotopes are insensitive to crustal conitbrution. So, such a large-scale and long-lived decoupling between Nd and Pb isotopes in oceanic mantle domains most likely reflects the contribution of plate tectonics-driven crustal recycling in producing large-scale mantle domains. The Paleo-Asian Ocean (PAO) and Tethys underwent different tectonic evolution history. The PAO 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 result in the low Th/U PAO 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 Tethyan mantle domain. This study shows that plate tectonic-driven material circulation should play a role in producing large-scale and long-lived mantle heterogeneity and thus plate tectonic evolution may genetically link mantle chemical geodynamics. This is crucial for understanding how Earth system works.