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The Loss of Ancient Mantle Memory

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Geochemical thinking about crust-mantle evolution has historically been dominated by the idea of crustal growth and complementary mantle depletion, as tracked by Nd-Sr-Hf isotopes [1] and incompatible element abundances [2]. This approach has been invalidated by the realization that recycling destroyed much of the ancient continents so there may have been no net crustal growth during most of Earth history [3], and because much of the observed trace element and parent-daughter differentiation was affected by ocean crust recycling [4,5]. Net crustal growth cannot be constrained by counting crustal zircons, because an unknown number of zircons is lost during crustal recycling [3]. But the relative size of the Archean continental crust can be estimated from the $(Nb/U)_n \cong 1.46$ of Archean komatiites compared to the modern $(MORB+OIB)_n \cong 1.68$, indicating a late Archean crustal mass of at least 70% of the modern crust [6,7]. Beyond that, the mantle has largely "forgotten" its Archean and Hadean history:

The residual mantle after Hadean crust extraction was left with heterogeneous $^{142}Nd/^{144}Nd$ ratios and variably elevated Nb/U ratios, both of which were subsequently homogenized. Current mantle memory of continental recycling is limited to extreme EM-type OIBs with late-Archean or younger recycling ages. Post-Archean mantle differentiation was dominated by ocean-crust recycling (6×10^{22} kg Gyr^{-1}), which differentiated the Sm/Nd ratios of the average MORB reservoir (ε(Nd) = 8.6±2.3) from the average OIB reservoir ε(Nd) = 4.4±2.3) without differentiating their Nb/U ratios. Continental recycling (0.5×10^{22} kg Gyr^{-1}) of late Archean and younger crust was subordinate and is traceable only in extreme EM-type OIBs. This general mantle amnesia contrasts sharply with the preservation of near-primordial W and noble gas signatures which must have survived in isolated mantle reservoir(s) or in the core.

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