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"Geochemical and Geodynamic Consequences For a Non-Chondritic Earth"

ABSTRACT: It has been a decade since a landmark discovery showed that modern terrestrial mantle-derived lavas have $^{142}Nd/^{144}Nd$ ratios ~18 ppm higher than ordinary chondrites (Boyet and Carlson, Science, 2005). One interpretation of this discovery is that the accessible Earth has a Sm/Nd ratio that is 5-7% higher than chondrites, which resulted from an early (within 20-30 Ma after accretion), catastrophic extraction of geochemically-enriched crust from the Earth's mantle. The location of this early-formed enriched reservoir is unknown: it is either hidden in the deep Earth or was lost to space by impact erosion. However, the location of the hidden enriched reservoir is critical, as it hosts the equivalent of the modern continents' budget of the radioactive heat-producing elements: U, Th and K. If the early-enriched reservoir was lost to space by impact erosion of early-formed crust, the equivalent of the modern continents' budget of U, Th and K was lost from the planet, which has profound implications for the geochemical and thermal evolution of the planet. First, the bulk silicate Earth has a bulk composition closer to the depleted mantle sourced by MORB than chondritic. Second, instead of derivation from a chondrite-based silicate Earth, all modern terrestrial mantle and crustal reservoirs were ultimately derived from a non-chondric mantle with superchondritic Sm/Nd. Third, the composition predicted from a non-chondritic Earth matches the most frequently-occurring $^{143}Nd/^{144}Nd$ ratio (0.5130, PREMA) in ocean island basalts, including lavas with primitive $^{3}He/^{4}He$, and suggests that large portions of the mantle sampled by OIB remain little-modified with respect to $^{143}Nd/^{144}Nd$. Fourth, the modern continents were extracted from a previously depleted mantle, meaning that the modern mantle is pervasively depleted in highly incompatible elements, and that the mantle's radiogenic heat production is 50% lower than in chondrite-based models. The new bulk silicate Earth composition presents challenges for describing the thermal history of the planet, and may lead to a stable plate tectonic regime over time and that may be more conducive to supporting a habitable world.