Fingerprinting the source of Earth's siderophile elements using platinum stable isotopes

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Highly siderophile elements (HSE) are strongly partitioned into the cores of terrestrial planets during core formation, and the abundances of HSE in Earth's mantle compared with primitive meteorites have provided key constraints on models of Earth's early evolution. Leading models to explain the HSE abundances in the silicate Earth involve a late-veneer of chondritic material that was added after core formation, or core formation in a deep magma ocean. The recently developed platinum (Pt) stable isotope system represents a novel tool for investigating these processes.

We report Pt stable isotope results for enstatite, ordinary and carbonaceous chondrites, primitive achondrites, diogenites, iron meteorites and terrestrial mantle samples measured by double-spike MC-ICPMS. Results, expressed as the per mill difference in $^{198}Pt/^{194}Pt$ ratios ($\delta^{198}Pt$) relative to the IRMM-010 Pt isotope standard, show that the Pt stable isotopic composition of Earth's present-day mantle ($\delta^{198}Pt_{mantle}$ = –0.11 ± 0.13‰) overlaps with chondrites from all groups ($\delta^{198}Pt_{chondrites}$ = –0.14 ± 0.09‰). Carbonaceous chondrites have an average composition similar to the other groups of chondrites but show greater variability, potentially relating to isotopic differences among the components of these meteorites. Primitive achondrite and diogenite samples show heavier compositions ($\delta^{198}Pt$ = –0.04 ± 0.10‰ and $\delta^{198}Pt$ = 0.24 ± 0.18‰, respectively). These data suggest that metal–silicate differentiation fractionates Pt isotopes, with heavy isotopes being preferentially retained in the silicate phase. Thus, Earth's mantle would be expected to have been significantly enriched in the heavy isotopes of Pt during core formation. The absence of an offset between chondrites, representing the composition of the undifferentiated Earth, and the mantle is consistent with the signature of core formation having been overprinted in Earth's mantle by a late-veneer of chondritic material added after the core had formed.