Platinum-Osmium isotope evolution of the Earth's mantle

A.D. BRANDON[1], R.J. WALKER[2], AND I.S. PUCHTEL[2] AND M. HUMAYUN[3]

[1]NASA Johnson Space Center, Mail Code KR, Building 31, Houston, TX 77058, USA (alan.d.brandon1@jsc.nasa.gov)
[2]Department of Geology, University of Maryland, College Park, MD 20742, USA
[3]NHMFL & Dept. of Geological Sciences, Florida State University, Tallahassee, FL 32310, USA

Extraction of metal-rich core likely resulted in strong depletion of the silicate portion of Earth in highly siderophile elements (HSE), including Re, Os, and Pt. Replenishment of HSE through a 'late veneer', or high-pressure equilibrium between metal and silicate have been proposed to explain the excess of HSE relative to that expected from core extraction at lower pressures. To address these issues on core extraction, late accretion and terrestrial mantle evolution, 30 Os-rich alloys from upper mantle peridotites, and 13 samples of carbonaceous, enstatite and ordinary chondrites, were measured for high-precision Os isotopic compositions on the JSC Triton. Two of the Os-rich alloys with present-day ^{187}Os/^{188}Os of 0.1095 and 0.1096 have ^{186}Os/^{188}Os of 0.1198320 and 0.1198329, respectively. They have ^{187}Os model ages of 2.8 Ga. The measured ^{186}Os/^{188}Os for these two samples are within uncertainty of the initial ratio of 0.1198323±09 for 2.7 Ga Pyke Hill komatiites and constrains the Pt-Os upper mantle evolution curve. The remaining 28 Os-rich alloys with ^{187}Os/^{188}Os from 0.1167 to 0.1596 have a range in ^{186}Os/^{188}Os from 0.1198352 to 0.1198408, with an average of 0.1198382±29 (2σ). Carbonaceous chondrites have ^{186}Os/^{188}Os of $\leq$ 0.1198352 (n=3). Ordinary chondrites have ^{186}Os/^{188}Os from 0.1198345 to 0.1198408 (n=7), and enstatite chondrites from 0.1198335 to 0.1198401 (n=3), with averages of 0.1198387±12, and 0.1198374±40, respectively. The enstatite and ordinary chondrite time evolution curves match those for the Pyke Hill komatiites and the 2.8 Ga Os-rich alloy mantle sources. These ^{186}Os/^{188}Os relationships between Os-rich alloys and enstatite and ordinary chondrites are consistent with previous arguments based on ^{187}Os/^{188}Os systematics for a late veneer of similar types of materials controlling the HSE budget of the upper mantle. Unless liquid metal/silicate melt partition coefficients for Pt and Os are within about 10% of each other, a high pressure core extraction model will not alone explain these ^{186}Os/^{188}Os compositions.

Pt-Re-Os isotope and HSE systematics of 2.8 Ga komatiites

I.S. PUCHTEL[1], A.D. BRANDON[2], M. HUMAYUN[3] AND R.J. WALKER[1]

[1]Department of Geology, University of Maryland, College Park, MD 20742, USA (ipuchtel@umd.edu)
[2]NASA Johnson Space Center, Mail Code SR, Building 31, Houston, TX 77058, USA
[3]NHMFL & Department of Geological Sciences, Florida State University, Tallahassee, FL 32310, USA

If coupled ^{186}Os-^{187}Os enrichments in Archean komatiites reflect addition of a core component, the Os isotopic compositions could be used to infer the timing of the onset and the rate of inner core crystallization. Here, Pt-Re-Os isotope and highly siderophile element (HSE) abundance data for 2.8 Ga komatiites atKostomuksha are presented. The Pt-Os data for seven komatiitic samples define an isochron with an age of 2816±190 Ma and an initial ^{186}Os/^{188}Os of 0.1198340±8. Corresponding Re-Os data yield an isochron age of 2880±83 Ma and an initial ^{187}Os/^{188}Os of 0.10916±0.00067. These Os isotopic compositions characterize those of the komatiite mantle source and are 64±17 ppm and 1.8±0.6% more radiogenic, respectively, than those of the contemporary convecting upper mantle or chondritic references. The calculated komatiite source had absolute HSE abundances similar to those of the Abitibi komatiite and an average depleted spinel lherzolite. The coupled ^{186}Os-^{187}Os enrichments in the komatiite source are best explained via derivation of the Os largely from the outer core. If this interpretation is correct, the komatiite data provide minimum constraints on the Os isotopic composition of the outer core at 2.8 Ga. The existing models of core crystallization based on experimentally determined partition coefficients for Pt, Re, and Os between solid metal and liquid metal can adequately explain the Os isotopic composition of the Kostomuksha komatiite source, although require the onset of inner core crystallization at 3.5 Ga at the latest. The results of this study indicate that core-mantle interaction might occur in the form of isotopic exchange without significant mass transfer from the core to the mantle, and that at least some komatiites originated from mantle plumes that rose from the core-mantle boundary.