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Siderophile element heterogeneity of the mantle: evidence from komatiites

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Osmium and W isotope and highly siderophile element (HSE: Re, Os, Ir, Ru, Pt, and Pd) abundance systematics of komatiites can shed light on early Earth processes, such as the nature and longevity of primordial mantle heterogeneities, as well as the specificities and timing of late accretion to Earth. ^{187}Re - ^{187}Os , ^{190}Pt - ^{186}Os , and ^{182}Hf - ^{182}W isotope and HSE abundance data for Precambrian komatiite systems worldwide, ranging in age from 3.6 to 2.1 Ga, provide evidence for the presence of remarkably ancient heterogeneities in the Earth's mantle. Calculated HSE abundances in the mantle sources of the komatiite systems range between 29 ± 5 and $114\pm 5\%$ of those in estimates for the present-day BSE. $\mu^{182}\text{W}$ values range from $+15.0\pm 4.8$ to -8.4 ± 4.1 (2SD), $\mu^{186}\text{Os}$ values from $+22\pm 6$ to -12 ± 8 (2SD), and $\gamma^{187}\text{Os}$ values from $+3.7\pm 0.3$ to -0.14 ± 0.04 (2SD). The data show no systematic variations in either the HSE abundances or the sign or intensity of the ^{182}W and $^{186,187}\text{Os}$ anomalies in the mantle as a function of the age of the komatiite systems or the inferred depths of their magma generation. The ^{182}W and $^{186,187}\text{Os}$ isotope and HSE concentration variations observed in the studied komatiite systems reflect the presence of (1) diverse post-magma ocean mantle domains characterized by variably-fractionated HSE and (2) silicate reservoirs containing poorly mixed material of large accreted differentiated planetesimals, the bulk of which were delivered to Earth prior to 4.40 Ga during the main phase of stochastic late accretion. The persistence of ^{182}W and $^{186,187}\text{Os}$ isotope and HSE abundance anomalies in late Archean and Proterozoic komatiite systems indicate that the mantle domains comprising the products of primordial planetary differentiation and late accreted materials survived subsequent, presumably vigorous, convective mantle mixing during the Hadean and ensuing plate tectonic processes. These observations indicate a heterogeneous nature of the terrestrial mantle in terms of siderophile element concentrations and isotopic compositions due to sluggish post-magma ocean and post-late accretion mixing on the scale of the mantle domains sampled by komatiites.