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Probing Earth's pre-late-accretion mantle using highly siderophile elements, Re-Os and Ni isotopes

JINGAO LIU[1], YONG XU[2], KRISTOFFER SZILAS[3], JIANMING ZHU SR.[4] AND D GRAHAM PEARSON[5]

[1]China University of Geosciences (Beijing)
[2]China University of Geosciences, Beijing
[3]University of Copenhagen
[4]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences
[5]University of Alberta

Presenting Author: jingao@cugb.edu.cn

Moderately siderophile (e.g., Ni) and highly siderophile elements (HSEs) in the Bulk Silicate Earth (BSE) are believed to be partly or near-completely delivered by late accretion after the depletion caused by metallic core formation. However, the extent and rate of re-mixing of late accreted materials that equilibrated with the Earth's pre-late-accretion (PLA) mantle have long been debated. Ultramafic rocks in the early Archean assemblage of Southwest Greenland have not incorporated the full amount of late accretion, and therefore possibly record the mass-dependent Ni isotopic composition (expressed as δ^{60}Ni, the per mil deviation of $^{60}Ni/^{58}Ni$ ratios relative to NIST SRM 986) of the Earth's PLA mantle. We firstly present high-precision δ^{60}Ni values of ~3.8 Ga (this age is further evidenced by our new Re-Os isotopic data, with a mode $^{187}Os/^{188}Os$ of 0.101–0.102) Narssaq ultramafic body (NUB). Both our new PGE data and previously characterized s-process Ru excess also demonstrate these NUB rocks were derived from the PLA mantle source experienced incomplete (~36±8%) chondritic accretion. There is no correlation between their δ^{60}Ni values and lithophile or siderophile indices (e.g., Al_2O_3, Ni, Mg# and $Ir_N/(Pt_N+Pd_N)$ ratios) of silicate and sulfide partial melting, fractional crystallization, and secondary alteration processes, suggesting that they can faithfully reveal the Ni isotopic signature of their mantle source. The δ^{60}Ni (0.16±0.01‰, 95% CI) of the PLA mantle is uniformly lighter than that (0.23±0.02‰, 95% CI) of different groups of chondrites, but obviously heavier than that (0.11±0.01‰, 95% CI) of modern Bulk Silicate Earth (BSE) estimated from post-Archean unmetasomatized mantle peridotites. Taking the isotopically mediate PLA mantle as an anchor point, we tentatively build at least three-stage evolution processes including core formation, Moon-forming giant impact and onset of global mantle convection for the final establishment of BSE's sub-chondritic Ni isotopic signature.

[1]Related publication: Xu, Y., Szilas, K., Zhang, L., Zhu, J.-M., Wu, G., Zhang, J., Qin, B., Sun, Y., Pearson, D.G. and Liu, J.* (2023) Ni isotopes provide a glimpse of Earth's pre-late-veneer mantle. ***Science Advances*** 9, eadj2170.