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Progressive mixing of the late-accreted materials into the early Earth's mantle: Evidence from the highly siderophile elements in the Maniitsoq mafic-ultramafic complex

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The overabundances and essentially chondritic relative abundances of highly siderophile elements (HSE) in the modern Bulk Silicate Earth (BSE) compared to the predicted result of core formation are commonly attributed to late accretion. However, debates persist regarding the timing, extent, and mechanisms of mixing between the convecting mantle and late-accreted materials. Here we present the geochemical compositions of mafic–ultramafic rocks from the Maniitsoq region in the Akia terrane, southwest Greenland. These rocks exhibit high Cr contents and variable Ni systematics distinct from mantle residues. Spinel and olivine compositions are consistent with an cumulate origin. Positive correlations between IPGE and MgO contents, together with suprachondritic Ru/Ir ratios, further support this interpretation. Re–Os isotopic systematics constrain their formation age to ~3.2 Ga, aligning with the first major crust forming event in the Akia terrane.

The Ir abundance in the mantle source of the Maniitsoq mafic-ultramafic rocks is estimated to 1.9 ± 0.4 ppb, significantly lower than that of the modern BSE (3.5 ± 0.4 ppb). Other Archean ultramafic rocks likewise display variable HSE deficiencies relative to the BSE: 1) 17%-60% of the BSE in Eoarchean mantle [1,2]; 2) 17%-50% and 60%-85% of the BSE in Paleoarchean mantle [3,4]; 3) 18%-50% and 40%-80% of the BSE in Mesoarchean mantle [5,6]; 4) 60%-100% of the BSE in Neoarchean mantle [7,8]. This observation indicates the progressive mixing of the late-accreted chondritic materials into the early Earth's mantle. From 3.2 to 2.7 Ga, with the progressive cooling of the Earth, the slab subduction initiated and began to widely appear, marking a transition in geodynamic regime from stagnant-lid toward modern-style plate tectonics. Concomitantly, the HSE deficiency gradually vanished.

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