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Top Down? Bottom Up? Earth's Siderophile Element Riddles

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Siderophile elements offer unique perspectives from which to study important aspects of Earth's formation, differentiation, and current workings. Both moderately and highly siderophile elements (MSE, HSE) are largely concentrated in the core. The core is inaccessible, so it is the abundances, and in some cases isotopic compositions of these elements in the silicate portion of the Earth that provide us with the key information. Most of the MSE, such as Mo and W, were largely added to the bulk silicate Earth (BSE) during a final 10-20% of Earth's accretion, and numerous studies have concluded the abundances of the MSE were established through the integrated effects of metal-silicate partitioning at the base of one or more magma oceans under high pressure-temperature conditions. The origin of the HSE in the BSE are more controversial. The broadly chondritic relative abundances, and comparatively high absolute abundances of HSE in the mantle have been interpreted to either reflect metal-silicate partitioning under high pressure-temperature conditions, similar to MSE, or as a result of final additions of 0.5-2% of Earth's mass through a process termed "late accretion" or "late veneer". Nature has provided us with some ambiguities regarding the evidence favoring one scenario relative to the other. Even more controversial is the origin of negative $^{182}W/^{184}W$ isotopic anomalies recorded in certain young, plume-derived rocks. Tungsten-182 is the decay product of ^{182}Hf which was extant during only the first ~60 Myr of Solar System history. These anomalies may either result from some sort of as yet ill-defined isotopic exchange process between the core and the mantle, or as a result of the plumes accessing one or more mantle domains characterized by the long-term preservation of primordial isotopic heterogeneities generated while ^{182}Hf was extant. Given the very short-lived nature of this isotopic system, surviving mantle domains would likely have been witness to and survivors of the putative giant Moon-forming impact. Some of these concepts have made Bill McDonough uneasy through the years, but he may yet come around to them. Current pros and cons of these concepts, as well as some new insights, will be discussed.