Siderophile Element Constraints on the Deep Earth: What's Down There and How and When Did It Form?

RICHARD J. WALKER

Department of Geology, University of Maryland, College Park, MD 20742 USA, rjwalker@umd.edu

Our belief that Earth has a sizable metallic core stems largely from geophysical observations. Low abundances of siderophile elements in the silicate portions of the Earth, compared to chondrites, provide a modicum of reassurance that the geophysical observations have not been grievously misinterpreted. Despite this happy concordance of geophysics and geochemistry, related topics, such as the chemical nature of the core and lowermost mantle, and whether or not chemical and/or isotopic exchange between the core and mantle occurs (past or present), remain shouded in mystery. Advances on these issues may come from further studies of siderophile element abundances and isotopic compositions. The generally chondritic relative abundances of highly siderophile elements (HSE), including ^{187,186}Os isotopic evidence, has commonly been cited as evidence that progressive core formation stripped the mantle of these elements, and that they were replenished by late stage accretion that followed core formation. Differences in absolute abundances of HSE between the mantles of the Earth and Moon, coupled with a small but significant difference in their ^{182}W isotopic compositions, suggest that the dominant period of late stage accretion occurred soon after the putative Moon-forming giant impact. This means a final stage of core formation accompanied the giant impact, and that the merging of the two cores was effective in stripping HSE from much of the Earth's mantle. The discovery of ^{182}W anomalies in ancient and modern mantle-derived materials, however, suggests that some mantle domains were chemically processed well before the giant impact, and yet survived the giant impact, as well as the subsequent attempts of 4.5 Gyr of convective mixing to make them go away. Highly siderophile element abundance data, coupled with ^{182}W isotopic evidence in rocks with anomalous ^{182}W suggest that these primordial domains achieved some level of chemical uniqueness as a result of multiple metal-silicate and silicate-silicate processes. Whether or not the processes responsible for creating the domains and their present locations can be better constrained by combining siderophile element data with other geochemical data, such as for noble gases, remains to be seen. The ability of Earth's mantle to generate ^{182}W-enriched and depleted domains, alas, diminishes the use of tungsten isotopes to trace possible core-mantle interactions.