Highly Siderophile Elements: a window into the Earth's mantle

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The past 30 years have seen an ever increasing number of studies of the highly siderophile (i.e. "iron-loving") elements (HSE), particularly as applied to the understanding of high temperature processes. This fascinating group of elements consists of Re, Au and the platinum group elements (PGE: Ru, Rh, Pd, Os, Ir, Pt) and includes two long-lived radiometric systems (^{187}Re-^{187}Os, $t_{1/2}$ ~ 42 Ga and ^{190}Pt-^{186}Os, $t_{1/2}$ ~ 450 Ga). As the name suggests, the HSE were strongly segregated into the Earth's metallic core during planetary accretion. The very low concentrations of the HSE now present in the mantle and crust are dominantly partitioned into base metal sulfides and in their absence, into ultratrace phases such as alloys, arsenides and PGE sulfides. The HSE thus provide a unique perspective on mantle processes, distinct from and complementary to that provided by the more commonly studied lithophile elements.

After briefly reviewing the geochemical behavior of the HSE, the seminar will focus on the constraints these elements place on our understanding of how the mantle formed and evolved through time. This necessarily includes discussion of current hypotheses about the addition of HSE to the mantle after core formation, a process that is thought to have delivered essentially the entire mantle HSE budget. HSE behavior during the plate tectonic cycle of oceanic lithosphere production and subduction will also be summarized, providing a framework for discussion of the differences between the HSE systematics of sub-cratonic mantle lithosphere, young subcontinental lithosphere, and asthenosphere. Perhaps surprisingly, most asthenospheric peridotite samples (abyssal peridotites and harzburgites from non supra-subduction ophiolites, as well as peridotite xenoliths from ocean islands) have Os isotopic compositions less radiogenic than the estimated primitive mantle value. This implies that these samples experienced substantial ancient partial melt extraction, unrelated to production of the oceanic crust with which they are currently associated. If such samples are representative of the asthenosphere, models of MORB melt generation that assume a fertile peridotite source may need to be reevaluated.