How Primitive is the "Primitive" Upper Mantle: Revisiting the lherzolite-harzburgite relationships of the Lherz massif.

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The composition of the Primitive upper mantle (PUM) is an important goal of modern geochemistry. It forms the basis of modern ideas concerning basalt petrogenesis and is critical in deciphering the accretion history of the early Earth. Two mantle suites were instrumental in defining the PUM Os isotopic composition: peridotite xenoliths from Kilbourne Hole xenoliths and the Lherz orogenic peridotite massif. The Lherz Orogenic massif is the type locality of lherzolite and has always been a key study area for mantle composition and processes. It comprises interlayered spinel lherzolites (Lhz) (±websterites, Wb) and lesser amounts of highly refractory harzburgites (Hrz). The canonical interpretation is that Hrz is derived by partial melting from the Lhz. However, the structural and geochemical relationships between Lhz ±Wb and Hrz cannot be explained by such a model. For instance, the small scale Lhz-Wb-Hrz "layering" (1-10m), as mapped by Conquéré et *al*., (1978), cannot be easily produced by partial melting of the Lherzolite. Although the Lhz used to define the PUM composition yield a $^{187}Os/^{188}Os$ broadly chondritic (ca. 0.1296), the Pd/Ir ≈2 is much higher than any type of chondrite (including EH-chondrite). Yet Os, Ir, Pd and Re are all HSE and thus should behave similarly.

New data on lithophile, chalcophile and sidérophile element abundances have been obtained on the Hrz–Lhz transition and show that the Lhz was developed at the expense of the Hrz via a refertilization reaction involving precipitation of pyroxene (±spinel) and sulfide at the expense of olivine and infiltrated melt. Geochemical evidence are : (1) transient (chromatographic), convex-upward REE patterns in cpx at the transition; (2) nearly constant concentrations of moderately incompatible elements in the Lhz minerals (e.g., Ti in cpx); (3) chalcophile and siderophile element fractionations that are not compatible with partial melting; (4) in-situ measurement of the Os isotopic composition of sulfides in the Hrz yield a constant unradiogenic Os composition indicating a T_{RD} age ≈2 Ga. While Lhz's sulfides show a large spread of Os compositions, from the unradiogenic Os characteristic of the Hrz to extremely radiogenic compositions characteristic of the Lherz's pyroxenite suite.

It is thus clear that the Lherzolite at Lherz does not represent a *pristine/primitive* fertile mantle (i.e. low degree of melting) but rather Hrz that has undergone *refertilization* by interaction with migrating mafic melts at mantle depths. This model for Lherz along with previous work demonstrates that the sulfide-HSE abundance of several of the mantle suites used to derive an Os PUM value were heavily modified by melt interaction events. This casts strong doubt on the validity of the PUM Os composition in terms of starting composition and long-term evolution of the Earth's mantle.