The compatibility of W during silicate differentiation

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The short-lived ^{182}Hf-^{182}W chronometer is a powerful tool for estimates of the time scales of both metal/silicate segregation and early silicate differentiation, arising from the contrasting geochemical behaviour of Hf and W. Tungsten is moderately siderophile and highly incompatible in silicate melts, while Hf is non-siderophile and moderately incompatible. Here we present new Hf and W concentration data for carbonaceous chondrites, eucrites, terrestrial basalts and depleted ophiolite peridotites that are of relevance to estimates of core formation times.

^{182}Hf-^{182}W systematics of eucrites and angrites have been used to estimate timing of core formation on Vesta [e.g. 1] and the angrite parent body (APB) [2]. Both studies reasoned that because W is more incompatible than Hf, the Hf/W ratio of the planetary mantle had to be at least as high as that of the basalt with the highest Hf/W ratio. In the case of the eucrites, [1] proposed a relatively late core formation on Vesta, followed almost immediately by silicate differentiation.

The relative incompatibility of W and Hf is well-known for pure silicate differentiation [3] in the absence of a metal phase, leading to the widely held convention adopted above [1, 2], namely that the Hf/W will be lower in the melt than its source. However, two terrestrial observations strongly question this convention.

First, average N-MORB has a much higher Hf/W (ca. 200) [4] than recent estimates of the depleted mantle (e.g. 57 [5]). Second, highly-depleted ophiolite peridotites yield a far lower Hf/W, 0.7 ± 0.65 (mean $\pm$ 1σ, n=12), than both N-MORB and depleted mantle estimates. In other words, W is less depleted than the similarly incompatible U and Th by *several orders of magnitude*. This indicates that W is effectively much more compatible during mantle melting, probably implying the presence of a metallic alloy in the mantle, whose nature is yet to be confirmed.

The consequence for estimates of the timing of core formation on Vesta and the APB becomes the opposite conclusion of earlier studies. Given that the mantle source regions have a lower Hf/W than the basalts, it follows that core formation would have occurred within the first 1-2 Ma from solid formation in the Solar System with a longer time interval before silicate differentiation.

[1] Quitté & Birck (2004) *EPSL* **219**, 201-207. [2] Markowski *et al*. (2007) *EPSL* **262**, 214-229. [3] Arevalo & McDonough (2008) *EPSL* **272**, 656-665. [4] Sun & McDonough (1989) *Geol. Soc. Special Publication* **42**, 313-345. [5] Salters & Strack (2004) *Geochem. Geophy. Geosys*. **5**.

Mantle xenoliths from the Kodamali kimberlite pipe, Bastar Craton, Central India: Evidence for decompression melting and crustal contamination in the mantle source

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Here we present and discuss rare features of decompression melting of garnet lherzolite xenoliths from the Kodamali kimerlite pipe, Mainpur Kimberlite field (MKF) of the Bastar Craton, Central India. MKF has several diamondiferous kimberlites of which the Kodamali kimberlite pipe sampled several suites of mantle-derived mafic and ultramafic xenoliths. The garnet-lherozlite xenoliths have a mode of 15% garnet (8% Cr_2O_3), 30% olivine (Fo_{91}), 25% cpx (2-4% Na_2O), 12% opx (Mg# 0.89) with 15% melt and 3% secondary Cr-spinel. Most of the garnet grains in the host lherzolite show extreme resorption textures with atleast two glassy zoned rims with increasing K_2O and decreasing MgO content from internal to external zones suggesting metasomatic changes during the ascent in the kimberlite magma. Such glassy zones are also dusted with minute (20-200 micron) Cr-spinel grains. Application of the equilibrium thermodynamics with the core composition of the different phases indicate P-T range of 1140-1270°C and 4.3-4.7 GPa suggesting their deep origin. The melt pockets show glassy matrix with crystallites of olivine, clinopyroxene and phlogopite and secondary Cr-spinel. The formation of Cr-spinel within the glass pockets suggest the melting of the xenoliths in a rising kimberlite column close to the garnet-spinel transition in the sub-continental lithospheric mantle. Presence of high Ba (4-9%) apatites and phosphatic glass slivers interstitial to large pyroxene grains in some of the garnet-free lherzolites from the Kodamali kimberlites further indicates assimilation of the crustal components in the sub-continental lithospheric mantle (SCLM) of the Bastar Craton.

Our data suggest that the Central Indian SCLM sampled by the Kimberlite magma were enriched with ancient crustal components prior to melting.