The geochemical behaviour of Pb during core formation and accretion

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The lead isotope signature of the Bulk Silicate Earth (BSE) is not consistent with a simple single stage evolution model but requires an early process that has fractionated U from Pb. Core formation might be such a process, as previous studies suggested that significant amounts of Pb are sequestered in the Earth's core. To examine the role of metal segregation, we have determined sulfide-silicate and metal-silicate partition coefficients (D) of Pb at upper mantle PT conditions. Our results indicate that Pb is incompatible in Fe melts but compatible in Fe-S melts at O_2-fugacities representative for terrestrial core formation. Uranium on the other hand is incompatible in both iron melt and sulfide melt [1]. Modelling shows that Fe-dominated melts do not sufficiently fractionate U/Pb ratios whereas pure sulfide melt segregation could have formed a $\mu_{(BSE)}$~8, assuming that the bulk Earth started with low initial μ~0.7 [2]. However, segregation of a pure sulfide melt is probably not consistent with mantle abundances of chalcophile elements.

It has been also assumed that U-Pb chronometry might date a late stage of core formation with a small amount of sulfide-dominated melt sequestered to the Earth´s core [3]. The late addition of oxidized impact material (~ 10 %) with a maximum CI-chondritic sulfur content after segregation of a Fe-rich melt would limit the amount of segregated sulfide melt to 2-3 %. Such a small amount of sulfide melt would require a $D_{Pb}^{(sulf/sil)}$~1000 assuming complete sulfide-silicate equilibration, much higher than measured. This indicates that Pb-model ages probably do not date a late stage of sulfide segregation to the Earth´s core but rather reflect a volatile depletion process.

References

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A light lithium source for komatiites

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Komatiites provide key information on melting processes and the geochemical composition of the Archean mantle. To gain more insight we have analysed the Li isotopic composition of komatiites of various ages and from different localities. Li was chosen because it has been shown that its isotopes can be used to study melting processes within the mantle and characterise mantle sources [1].

Care was taken to analyse only the least altered whole rock samples and, in addition, seperates of olivine phenocrysts. The olivines from the Phanerozoic komatiites of Gorgona range in δ^7Li from +6.9 to -7.5‰ (5 samples). Exceptionally well-preserved late Archean komatiites from the Abitibi greenstone belt have δ^7Li from +1.9 to +6.0‰ (4 bulk rocks). Their primary olivines (3 samples) yield much lighter compositions from -0.8 to -4.3‰. Samples from several localities within the early Archean Barberton Greenstone belt yield δ^7Li between +0.2 to +7.1‰. Although no primary minerals are available, it is noticeable that the best-preserved sample has the lightest δ^7Li.

Li-isotopes of bulk rock komatiites roughly coincide with the value for Bulk Silicate Earth of δ^7Li = 3.3 to 4.0‰ [1, 4], while fresh olivine phenocrysts give varying and strongly deviating negative values. Even the freshest komatiites have suffered some degree of low temperature alteration and metamorphism so that the olivines should reflect the original isotopic signature of the magma. However, such negative values have not been observed in any modern type basaltic magma. Komatiites must tap a source not accessible to present day magma genesis. We speculate, in conjunction with the high Helium isotopic ratios in these olivines [2, 3], that the source material once resided in the lower mantle.

Reference

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