Fe-FeS-silicate partitioning of chalcophile and siderophile elements: Implications for core formation

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The concentrations of weakly siderophile and chalcophile elements in the primitive mantle provide important constraints on the conditions of accretion and terrestrial core formation, in particular the possible role of late sulphide addition and of late volatile loss.

In order to explore the possible impacts of these processes, we have determined the partitioning of V, Cr, Cu, Zn, Ga, Nb, Ag, Tl and Pb between Fe-FeS liquids and a range of liquid silicate compositions at 1.5-14 GPa and temperatures of 1280-2300 ^{o}C.

Many of the observed variations in partition coefficient are consistent with the known properties of Fe-alloys. For pure Fe metal coexisting at 1700 ^{o}C with a silicate melt of mantle FeO content, the metal/silicate partition coefficients are as follows: V(0.12), Cr(0.3), Cu(36), Zn(0.9), Ga(6), Nb(0.015), Ag(20), Tl(1.1) Pb(3.5). Adding C (at graphite saturation) to the metal increases Metal/silicate partition coefficients of Nb by an order of magnitude, those of V and Cr by a factor of 3, has small negative effects on Cu and Zn and larger negative effects on Ag and Pb partitioning. On going from Fe to FeS liquid the sulphide/silicate partition coefficients change approximately to: V(0.6), Cr(0.9), Cu(100), Zn(2), Ga(3), Nb(0.4), Ag(100), Tl(40), Pb(35).

Using these and literature data, a protracted period of accretion under reducing conditions appears to be required to satisfy the observed V and Cr contents of the mantle. This type of accretion path leads to around 30% of earth's Nb residing in the core. Application of these constraints to the other elements indicates that late sulphide addition to the core can explain the Pb and Tl contents of the mantle and their isotopic signatures, but the amount required (1.5-2%) seems precluded by the strongly chalcophile nature of Cu.