

Partitioning of Siderophile Elements in the Fe-Ni-S System: Evolution of Asteroidal Cores and Geochemistry of Earth's Core

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The partitioning of some moderately siderophile elements and Si between solid metal (SM) and liquid metal-sulfide (LM) in the Fe-S system at 1000 to 1400°C and low pressure has been investigated at minor abundances using EPMA, and the effect of S content of LM on partition coefficient (D) quantified by linear regression. The parameters (C) and (β) for the Jones and Malvin (1990) equation $\ln D = -\beta \ln(1-2\alpha X_S) + C$ are: W -0.2(4), 2.1(2); Mo -0.3(2), 1.0(2); As -1.3(1), 1.2(2); Ag -2.1(1), -1.77(9); Ge -0.8(2), 2.0(1); Ga -0.15(3), 1.36(3); Sn -1.82(8), 0.40(5), and Si -0.9(4), 2.6(2), respectively, where $\alpha = 1.05$ and X_S is the mole fraction of S in LM. These results are compared with earlier measurements of D for highly siderophile elements (HSE) at 1000 to 1200°C and abundances close to those in nature, which resulted in parameterization values of: Re 0.1, 3.4; Os 0.2, 3.5; Ir 0.11(9), 3.42(7); Ru-Pt 0.5, 2.5; Pd -1.8, 0.9; Au -1.37(5), 1.06(4), respectively ($\alpha = 1.09$). The negative slope parameter (β) for Ag points to a chalcophile affinity for this element. The laboratory partitioning behaviour of these siderophile elements in the Fe-Ni-S system is in very good qualitative agreement with their fractionation patterns in magmatic iron meteorites; note the broadly similar partitioning and fractionation for: Re, Os and Ir; Ru and Pt; Au, As and Pd; and Ge and Ga. The fractionation patterns of individual magmatic iron meteorite groups are reproduced quantitatively

using non-equilibrium crystallization models; e.g., batch crystallization with 5-10% crystallization steps. The selective partitioning behaviour of siderophile elements is related to the extreme range in melting point of the pure elements, and is unlikely to be erased completely by pressures in the Earth's core, even in the hypothetical absence of S. It is predicted that the Earth's inner core is enriched in the more refractory HSE [with (Ir, Os and Re) > (Ru and Pt)] relative to C1 chondritic abundances. Using the present low-pressure D values and assuming 6 wt% S in the bulk core and equilibrium partitioning, Pd/Ir is 0.10 in the inner core and 1.33 in the outer core, relative to 1.16 in C1 chondrite. This divergence in Pd/Ir may be increased if the extrapolation of the laboratory D values for the most refractory HSE to the S-free limit is non-linear. However, the composition of the outer core is not markedly different from the metallic component of C1 chondrite, due to the small fraction of SM crystallized. The enhanced abundances of Pd and Pt in some OIB remain problematical. Fractionation of partial melts against SM in the lower mantle might explain the enhanced abundance of Pd, but Pt is likely to have a greater affinity for the SM.

Jones JH & Malvin DJ, *Metall. Trans.*, **21B**, 697-706, (1990).