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Mind the eutectic: The effect of sulfur on MSE partitioning during core formation

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Core-mantle partitioning of moderately siderophile elements (MSE - e.g. Co, Ni Mo and W) is widely used to constrain conditions prevailing during Earth's core-formation. The partitioning behaviour of MSEs depends largely on $P-T-fO_2$ conditions, but also on the compositions of the phases involved. Sulfur is regarded as one of the light elements in the core and may have a significant effect on the partitioning behaviour of siderophile elements during core formation: The presence of S may change the metal-silicate partitioning behaviour of MSEs and may also lead to the removal of a FeS sulfide melt to the Earth's core, which would affect those MSEs that are also chalcophile (e.g. Co and Ni). In this study, we experimentally studied the effect of S on the metal-silicate partitioning of Co, Ni, W and Mo at 11 GPa and 2350 ˚C, as well as the sulfide-silicate partitioning of these elements with varying P-T conditions.

Results of our experiments show, that at 11 GPa the metal-silicate exchange coefficient (K_D) of Ni remains constant with increasing S-content of the metal, whereas those of Co, W and Mo decrease. We see that the effect of S on metal-silicate partitioning of the MSEs determined here is different from previous results at lower pressure (1.5 GPa - Wood et al. 2014). At s1.5 GPa, the effect of S on Ni and Co metal silicate partitioning is much stronger than at 11 GPa, to the extent that S doesn't affect the partitioning of Ni at all at 11 GPa. Therefore, using a single parameter to describe the effect of S at all pressures will likely lead to incorrect results when modelling the behaviour of these elements during core formation.

Furthermore, we observe a continuous trend of K_D with increasing S content for Ni and Co up to stoichiometric FeS (X_S = 0.5). In contrast, the linear trend for Mo and W only continues until the eutectic composition in the Fe-FeS system ($X_S \approx$ 0.3 at 11 GPa) and a distinct drop in KD is observed for more S-rich compositions. These results underline the importance of verifying whether linear trends can be used for the complete range of compositions along the Fe-FeS binary, or if FeS sulfide-silicate partitioning needs to be determined individually. Overall, our sulfide-silicate partitioning experiments show that Co, Ni and Mo behave as chalcophile elements, while W shows a strong S-avoidance. Therefore, segregation of a sulfide melt to the core is expected to influence mantle abundances of Ni, Co and to a lesser extent Mo, whereas W will remain largely unaffected.

Wood et al. (2014), GCA **145**, 248-267.