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Role of S on Rare Earth Elements mobility in Nebular Gas: Experimental study

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Introduction: Our aim is to study REE mobility in nebular gas conditions. Here we report the first experimental study on REE elements volatility and gas/liquid partitionning at solar nebula conditions. A natural equilibrated enstatite chondrite has been ground, doped in REE (1000ppm) and mixed with CaS or FeS to vary sulfur fugacitiy in the system. The starting mixtures were loaded in graphite crucibles and run between 1300 and 1400°C at 10^{-3} atm during 1 to 100 hours in evacuated silica tubes. Deposits on the silica tubes indicate transport in a vapor phase. The residual part contained in the graphite crucible (silicate glass and minerals, and sulfides) has been analyzed with an electron probe micro analyzer for major elements and with Laser-Ablation-Inductively Coupled Plasma-Mass Spectrometer for trace elements. REE concentrations in the condensates were obtained after leaching and analysis by ICP-MS in solution mode. Some of the condensates were analyzed with Scanning Electron Microscope.
Results and discussion: REE fractionation spectra in the condensate from the vapor phase show anomalies in Eu and Yb. For all experiments, the deposits from the top of the tube showed positive Eu and Yb anomalies and the deposits from the bottom showed negatives Eu and Yb anomalies. Abundance spectra from the top deposits show an upward concavity, which is inconsistent with sulfide/liquid partitioning experiments ([2], [3] and our experiments) but resembles REE distribution observed in CaS from unequilibrated enstatite chondrites of EH type [4]. These results confirm that sulfides from EH could be directly formed by condensation during solar system formation. Our experiments also suggest that it is possible to identify the origin of CaS within enstatite chondrites on the basis of their REE patterns. The fractions of REE transported in the vapor phase was estimated by mass balance. The fractions obtained for experiments with FeS were up to 10^4 times higher than those from experiments with CaS and nearly 10^6 times those from experiments without sulfides. This comparison illustrates the role of sulfide on REE transport in the vapor phase. Our experiments provide preliminary insights into REE volatility in a S-rich very reducing Solar Nebula medium.

References: [1] Lodders K. and Fegley B. (1993) EPSL. Vol. 117, 125-145. [2] Lodders K. (1996) Meteoritics Planetary Science Vol. 31, Issue 6, 695-937. [3] Dickinson, T.L. McCoy, T.J. (1996) Meteoritics, Vol. 32, 395-412. [4] Gannoun A (2011) GCA. Vol. 75(11), 3269-3289.