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Experimental phase relations in the CaS-FeS system and their bearing on the evolution of Mercury

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Sulfide liquids in terrestrial environments are near mono-sulfidic and contain predominantly FeS with varying amounts of other chalcophile elements (mostly Ni, Cu and Zn). At highly reducing conditions, as found in enstatite chondrites or on Mercury, oxygen fugacities (fO_2) are sufficiently low such that elements that are otherwise lithophile on Earth, Ca, Mn and Mg, form major components of sulfide phases and coexist with FeS (troilite)[1]. The importance of these phases lies in their utility as geothermometers, that is, as proxies for minimum temperatures experienced during enstatite chondrite formation [1] and their likely presence on very reduced planetary bodies, such as Mercury [2]. Here, we re-examine the troilite-oldhamite (CaS) binary at 950 to 1450°C, owing to the limited amount of data on this system and the spread in its reported eutectic temperatures [3, 4].

Experiments were performed with stoichiometric mixtures of pure components in graphite capsules sealed in evacuated silica tubes at ~10^{-5} bar, equilibrated at the desired temperature for 24h. Because Ca-sulfides are hygroscopic, quenched samples were prepared under dry conditions, and mineral compositions determined by energy-dispersive spectroscopy, while phase proportions were computed by image analysis. Because sulfide liquid is labile, its composition was estimated by mass balance. The eutectic point was determined by experimentally bracketing various bulk compositions.

The solubility of FeS in oldhamite was found to be higher than previously reported, reaching 7±2 mol% at 1100 to 1350°C. The composition of the eutectic was found to lie at 10±3 mol% CaS, significantly poorer in CaS than previously suggested [4]. Its temperature lies between 1070 and 1100°C. Our data are consistent with the exprimentally determined temperature by [4], not however with the composition.

Our experimental data suggest that Ca dissolves extensively in sulfides under graphite-saturated conditions at low pressures, which may have prevailed during crust formation on Mercury [5].

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