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Experimental Phase Relations in the CaS-FeS and MgS-FeS Systems and their Bearing on the Evolution of Mercury

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Sulfide liquids in terrestrial environments are near mono-sulfidic and are FeS-rich with varying amounts of other chalcophile elements. At highly reducing conditions, as on Mercury, elements like Ca, Na and Mg can also form major components of sulfides and coexist with FeS [1,2,3].
Here, we re-examine the FeS-CaS and FeS-MgS binaries at 950 to 1600°C and 1100°C to 1500°C respectively, owing to the limited amount of data on these systems and the uncertainty in the eutectic point of the FeS-CaS binary [4, 5]. We use the determined phase compositions and inferred densities in the systems CaS-Fes and MgS-FeS (± additions of NaS) to assess mechanisms of sulfur accumulation on the surface of Mercury by gravitational separation of sulfides in a portential magma ocean [6]. Experiments were performed with stoichiometric mixes of pure components in graphite capsules sealed in evacuated silica tubes at ~10^{-5} bar. Quenched samples were prepared under anhydrous conditions, and phase compositions determined by energy-dispersive spectroscopy. Because quenched Ca-rich sulfide liquid is labile, its composition was estimated by mass balance and image analysis. The eutectic point of the CaS-FeS system was determined by experimentally bracketing various bulk compositions.
The solubility of FeS in oldhamite is higher than previously reported, reaching 2.5 mol% at 1065 °C. The eutectic is located at 8.5 ± 1 mol % CaS, significantly poorer in CaS than previously suggested [4], at 1070 ± 5 °C. Our data suggest that solid solution phase compositions in the MgS-FeS binary are in accord with those reported in the only other study on this system [7]. However, we find that the liquid phase in equilibrium with MgS (ss) between 1150°C and 1350°C is more FeS-rich than suggested containing <10 mol% MgS up to 1350°C.
Our data show that Ca dissolves extensively in sulfides under graphite-saturated conditions at low pressures, which may have prevailed during crust formation on Mercury [8]. The produced solid phases of the CaS-FeS binary are sufficiently light to be able to float in a Hermean magma ocean.

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