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The behaviour of S in reduced systems and its application to 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, such as on Mercury, elements like Ca, Mn and Mg can also form major components of sulfides and coexist with FeS [1]. Studies on the binary and ternary phase diagrams of the MgS-FeS-CaS systems have been conducted (separated from the influence of silicic melts) , owing to the limited amount of data on these systems [2,3]. With this study we also re-examine the behaviour of sulfur-enriched, highly reduced silicate melts (komatiitic and basaltic compositions) to asses formed phases as well as their gravitationally possible separation during the magma ocean stage of Mercury. The effect of and on the formation of phases is evaluated at 1 atm, similarly to a limited amount of foregone experiments conducted by [4]. We use both the acquired sulfide-phase diagram data and the information on the sulfide-silicate-melt interaction to assess mechanisms of sulfur accumulation on the surface of Mercury by gravitational separation within the magma ocean [5].
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 (binary and ternary phase diagrams) and electron probe micro-analysis (EPMA) (silicate-melt experiments).
The solubility of FeS in oldhamite (CaS) is higher than previously reported, reaching 2.5 mol% at 1065°C. The eutectic is located at 8 ± 1 mol % CaS, significantly poorer in CaS than previously suggested [6], at 1065 ± 5 °C. Our data suggests that solid-solution compositions in the MgS-FeS binary are in accord with those reported in the only other study on this system [7]. However, we find the system to be eutectic in nature, with the eutectic point being located at 1180°C ± 2 °C and 0.3 mol% MgS. Formed liquids have been found to contain much higher concentrations of FeS than previously reported.

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]. However, in silicate-melts, liquid FeS and solid niningerite (MgS) phases dominate for all investigated silicate compositions (komatiitic and basaltic compositions). The produced solid phases are not light enough to be able to float in a Hermean magma ocean. Formed oldhamite solid solutions are small and interspersed in liquid FeS, which prohibits their effective separation of these dense phases.

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