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Trace element partitioning in the presence of sulfur under reduced conditions

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Oxygen fugacity (fO_2) plays an important role in the physicochemical properties of that system because fO_2 has a substantial impact on the partitioning behavior between and solubility of elements in various phases. The reduced nature of Mercury and the aubrite parent bodies (APB) have raised many questions regarding the geochemical behavior of typically lithophile, heat-producing, and rare-earth elements (REE) in magmas at low fO_2. In fact, interpretations of magmatic processes on reduced rocky bodies are difficult at present because of the small number of experimental studies relevant to the extremely low fO_2 and high sulfur content of Mercury and the APB, and our only natural analogs are the highly reduced enstatite chondrites and aubrites [e.g., 1]. Preliminary observations suggest that major and minor elements exhibit different geochemical affinities in highly reduced, S-rich systems compared to terrestrial rocks [e.g. 2,3].

The partitioning behavior of major, minor, and trace elements between silicate melt, sulfide melt, and metal under highly reduced conditions will be determined in a suite of super-liquidus experiments at a range of pressures (1 bar to 4 GPa) at NASA Johnson Space Center (JSC). Based on previous studies, heat-producing elements U and Th become more chalcophile, while K becomes less chalcophile, with more reducing conditions [2]. The nominally lithophile elements Mg and Ca becoming more chalcophile and appear as minor elements in (Fe,Mg,Ca)-S with more reducing conditions [3]. Additionally, it appears that nominally siderophile elements become more siderophile and chalcophile with more reducing conditions, although the partitioning behavior into Mg- and Ca-bearing sulfide melts, rather than FeS, is less understood. Current work is focused on investigating elements for which we currently have MESSENGER data (K, Na, TH, U, Si, Mg, Fe, Ti, Ca, Al, Cr, Mn, S, Cl) as well as a host of geochemically relevant trace elements such as REEs (P, Co, Ni, Mo, Ce, Nd, Sm, Eu, Gd, Dy, Yb).

[1] Udry et al. (2019) *MAPS*, 54, 785-810. [2] Boujibar et al. (2019) *Am Min*, 104, 1221-1237. [3] Steenstra et al. (2020) *Icarus*, 335, 113408.