

The role of sulfur on liquidus temperature and olivine-orthopyroxene equilibria in highly reduced magmas

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Mercury is the innermost planet of the solar system and is characterized by a large metallic core, an ultramafic mantle, and a volcanic crust [1, 2]. Analyses of spectrometric data returned by NASA's MESSENGER spacecraft unveiled a chemically heterogeneous surface and several geochemical terranes [3, 4]. A high amount of sulfur and low iron content were detected, which imply highly reducing conditions [5]. Sulfur solubility in silicate melts depends on intensive (temperature, pressure, fO_2) and extensive (melt composition) parameters. Several experimental studies have shown high S solubility in silicate melts at reducing conditions [6-8]. High S contents can deeply affect phase relations, as highlighted by multiple studies which have shown that reduced S-bearing melts (1) have a lower liquidus than corresponding S-free compositions and (2) stabilize orthopyroxene over olivine [7]. In this study, we investigate the influence of sulfur on the liquidus temperature of reduced Mg-rich melts and silicate phase equilibria, with implications for the crystallization of Mercury's magma ocean and the formation of its primordial mantle. We performed high temperature (1500-1950 °C) and high pressure (1.5-3 GPa) piston-cylinder experiments on Mercury-like mantle compositions. The starting materials correspond to the silicate portion of an enstatite chondrite, the most accepted building block, with decreased Si contents in order to consider Si incorporation into the metallic core. Experiments were performed in graphite capsules on S-free and FeS-saturated starting materials. Two compositions were prepared to track the stability fields of olivine and orthopyroxene in S-saturated melts. Reducing conditions were obtained by using different Si/SiO₂ in the mixes. Near-liquidus S-bearing experiments show increasing S in the melt (2-7 wt%) as fO_2 decreases. Multiple linear regression on the experimental melts predicts a 9-21 °C liquidus depression for 1 wt% S in the melt. The enstatite stability field expands at the expense of forsterite. Clinopyroxene appearance is delayed, due to the lessened activity of CaO.

[1] Margot et al. (2018) [2] Byrne et al. [2018] [3] Nittler et al. (2018) [4] Vander Kaaden et al. (2017) [5] Zolotov et al. (2013) [6] McCoy et al. (1999) [7] Berthet et al. (2009) [8] Anzures et al. (2020)