EXPERIMENTAL INVESTIGATION OF CHROMIUM BEHAVIOR DURING MERCURY'S DIFFERENTIATION.

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Introduction: Mercury is the most reduced terrestrial planet with the largest core/mantle size ratio and highest sulfur concentration on the surface [1, 2]. The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft data allowed mapping of Mercury's surface elemental composition. Recent chromium mapping suggests Mercury's surface has on average 800 ppm Cr with the highest values in the High Magnesium Region [3, 4]. These new data can give clues about Mercury's internal structure and the redox conditions under which it differentiated. In the present study, we present experimental data on the distribution of Cr among metal, silicate and sulfide liquids. We then combine them with data from previous studies and a model of planetary differentiation to discuss Mercury's bulk composition and its oxidation state.

Methods: Experiments were conducted from 0.5 to 5 GPa and 1250 to 1700 °C using piston cylinder and multi anvil press apparatuses at NASA Johnson Space Center. We used a synthetic powder similar to enstatite chondrites in composition. Measurement of Cr concentration in coexisting phases with electron microprobe (EPMA) allowed determining Cr solubility in liquid sulfide and its partition coefficient between liquid metal and silicate.

Results and discussion:

Experimental results. We found that Cr is highly compatible with sulfide liquids (2 to 7 wt%), and its abundance increases with pressure. On the other hand, Cr becomes increasingly siderophile as fO_2 decreases, with the metal-silicate partition coefficient ($D_{Cr}^{met/sil} = X_{Cr}^{metal}/X_{Cr}^{silicate}$) ranging from 5 to 80 at log fO_2 of IW-3 to IW-5 respectively. We compiled literature data on Cr partitioning with our experimental data and retrieved a linear relationship giving log $D_{Cr}^{met/sil}$ as a function of log fO_2.

Model of Mercury's differentiation. Using these results and a model of Mercury's differentiation, we can investigate whether a chondritic bulk composition for Mercury could yield the observed Cr concentration on its surface (800 ppm) [3, 4]. For that, we calculated the distribution of Cr between Mercury's mantle, crust, Fe-rich core and possible sulfide layer at the base of the mantle [2], assuming a chondritic Cr concentration for bulk Mercury of 0.33 [5]. We also considered core and crust mass fractions of 0.68 and 0.032 based on Mercu-

ry's gravity field [2, 6] and a distribution of Cr between mantle and crust of 0.05 to 1 based on literature data [7]. Results show that Cr concentration on Mercury's surface is compatible with a chondritic bulk Cr composition. For a model of Mercury's differentiation without any sulfide layer between core and mantle, Mercury's core segregation should have occurred at an fO_2 of 4.5 to 3 log units below iron-wüstite buffer (Fig. 1A), which is in agreement with previous estimations [8-10]. With the presence of a sulfide layer containing 2 to 7 wt% Cr (based on our experimental data), Mercury's fO_2 would be more oxidized (Fig. 1B).
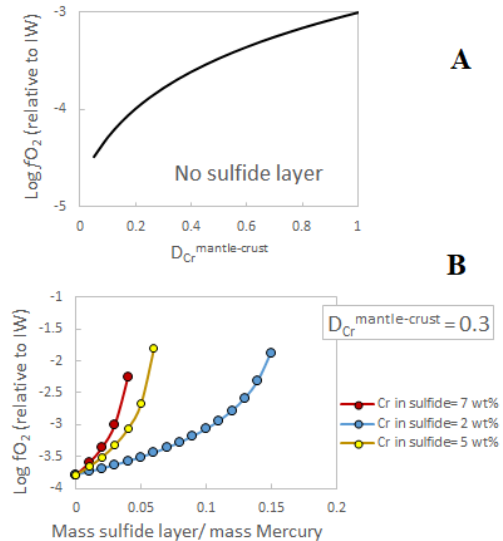

Figure 1: **A:** Resulting oxygen fugacity during Mercury's differentiation, based on surface Cr concentration, as a function of the assumed Cr distribution between mantle and crust, for a model without any sulfide layer at the base of the mantle. **B:** Calculated oxygen fugacity during Mercury's differentiation as a function of the relative mass of the possible sulfide layer.

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