Elements partitioning during Mercury's two shells core formation

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MESSENGER physical data were used to demonstrate that Mercury's metallic core constitutes ca. 70 % of the planet mass [1-3]. The core is possibly surrounded by a FeS layer [1,3], with a thickness of about 90 km, as constrained by very recent experiments on sulfur solubility in silicate melts under reducing conditions [4]. This study also provides a mean value for the Mercurian mantle fO_2 of IW-5.4 ± 0.4. Here, we combine new experiments with some literature data to define the partitioning of major and trace elements under suitable P, T, fO_2 conditions in an analogous system, i.e. a silicate magma ocean + two immiscible metallic melts constituting the core (FeNiSi and FeS). During Mercury early core-mantle equilibration:

* Fe strongly partitioned into the two shells core. As a consequence, the primordial mantle should not contain more than ca. 0.5 wt.% Fe. Mercury would need an exotic mechanism or a late veneer to explain the Fe content of surface lavas.

* 40 – 60 wt.% of the bulk Si would have been extracted to the inner core, strongly depleting the primordial silicate mantle in Si compared to Mg. A resulting high Mg/Si would be consistent with the estimated mantle mineralogy (olivine + orthopyroxene) [5].

* A maximum of 7-11 wt.% S would have been distributed in the primordial mantle, which may have a strong influence on phase equilibria, melting conditions and physical properties.

* ca. 7 wt.% of the bulk U would have been distributed in the FeS outer core, resulting in a only few ppb U in this layer if considering chondritic building blocks.

As a progress of this work, the data will be parameterized and used to model the composition of individual reservoirs of Mercury, to infer its bulk composition and identify its potential building blocks. Our preliminary results indicate that Mercury cannot be made of known chondritic material.

[1] Hauck et al. 2013 JGR; [2] Rivoldini and Van Hoolst 2013 EPSL; [3] Smith et al. 2012 Science; [4] Namur et al. under review; [5] Namur et al. 2016 EPSL