Making the planet Mercury: Constraining Mercury's core formation and composition through laboratory experiments

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In 2011, MESSENGER became the first spacecraft ever to orbit Mercury and since then has returned a wealth of new data that is revolutionizing our understanding of the Solar System's innermost planet. Elemental composition information [1-3] has revealed that Mercury's surface is Fe-poor, but not Fe-free, and also S-rich. Gravity information [4] has led to new models proposed for Mercury's internal structure, notably with a large S- and Si-bearing metallic core with a top layer of solid FeS. Thus, the overall picture of Mercury is of a terrestrial planet very different from Earth, Venus, and Mars. As such, Mercury provides important constraints on planet formation in the inner Solar System.

In this work, we present results from an experimental study to understand the conditions and compositions involved during core formation on Mercury. Specifically, we use the Fe and S contents measured on Mercury's surface to constrain the amount of S and Si in Mercury's core. In total, 19 metal-silicate experiments were conducted at 1 atm and 1500°C, with varying amounts of S and Si in the metallic phases. We find that none of the experiments are able to match both the wt% levels of Fe and S measured on Mercury's surface, indicating a more complex history for the measured silicate compositions or that the Fe is meteoritic. To produce 2-4 wt% S in the silicate, as measured on Mercury's surface, our experimental results indicate core compositions with >3 wt% Si and a range of S and Si combinations. Nearly all of the determined S and Si core combinations yield bulk planetary Fe/Si and/or S/Si ratios that do not overlap with common chondrites, suggesting that Mercury formed from unique starting materials or is the remnant of a once larger body.

[1] Nittler *et al.* (2011) *Science* **333**, 1847-1850. [2] Weider *et al.* (2012) *JGR* **117**, E00L05, 10.1029/2012JE004153. [3] Evans *et al.* (2012) *JGR* **117**, E00L07, 10.1029/2012JE004178. [4] Smith *et al.* (2012) *Science* **336**, 214-217. [*Acknowledgements*] NASA grant NNX12AH88G; Student Research Participation Program at APL administered by the Oak Ridge Institute for Science and Education.

Biostimulation of silica and sulfur on crude oil biodegradation

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Clays have been used for stimulating oil spill bioremediation to prevent the eutrophication of the marine sites, showing that SiO_2 in the form of clays facilitates bacterial usage of hydrocarbon [1]. Likewise, sulfur (S), a component of crude oil, is reported to be a stimulator for oil biodegradation. Hence, in the current work, biostimulation of silica (Si) and S was employed for enhancing biosurfactant production by a novel species of *Pseudoclavibacter* sp. and *Dietzia* sp. DQ12-45-1b using the D-Daqing crude oil as sole carbon source for bioremediation purposes. Silica (in liquid form) enhanced bacterial growth and biosurfactant production for both strains. Interestingly, Si was capable of being stimulatory for an inactive cell of *Pseudoclavibacter* sp., thus shortening its lag phase. High S concentration did not inhibit or stimulate bacterial growth and biosurfactant production of both strains. Thus, dissolved Si derived from the Earth's crust is not inhibitory and even environmentally and economically beneficial for biosurfactant-producing bacteria. It can thus be concluded that the Si in liquid form could be considered to be a more eco-friendly and economical material source for the improvements in reliability, cost efficiency and speed of oil bioremediation.

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[1] Chaerun & Tazaki (2005) *Clays Miner* **40**, 481-491.

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