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Deciphering the conditions of formation of Mercury

Thomas Ronnet, Pierre Vernazza, Olivier Mousis and Bastien Brugger
Laboratoire d'Astrophysique de Marseille, Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France
(thomas.ronnet@lam.fr)

Abstract

The Earth, Venus and Mars all have approximately chondritic ratios of the major rock-forming elements (Si, Mg, Fe, S, Ca, Al, and Ni) and are characterized by metallic cores (mostly made of iron) comprising $\sim$30% of their total mass surrounded by a silicate mantle accounting for the remaining $\sim$70% of their mass. In stark contrast, Mercury's high density suggests that the planet has a large metallic core accounting for 70% of its total mass and hence a much less massive silicate mantle as compared to other terrestrial planets. The origin of the high metal/silicate ratio of Mercury is a longstanding puzzle and the data recently collected by the MESSENGER mission revealed that the planet's surface and mantle is also more reduced than almost any known Solar System material [2].

It is unlikely that the composition of Mercury is a direct result of condensation processes due to the narrow temperature range within which gas should be removed to match the metal/silicate ratio of the planet. Moreover, MESSENGER's data indicate that Mercury is not depleted in moderately volatile elements such as S, Na, Cl or K relative to Mg, which is in contradiction with a scenario where condensation temperature controlled the planet's composition [1]. Scenarios based on removal of Mercury's mantle after its completion (following an impact or due to evaporation from a young hot Sun) are difficult to achieve because debris or vaporized silicates tend to re-accrete or recondense onto the planet, yielding only moderate metal/silicate fractionation [3, 1].

Here we investigate the conditions of formation of Mercury's precursor material and the processes that could have led to the planet's peculiar properties. We consider the early evolution of the protosolar nebula and the conditions for the formation of planetesimals in the inner Solar System. We show that the innermost planetesimals (at distances $\lesssim$0.5 au from the Sun) could have formed from material that was sublimated and subsequently condensed, implying very reduced compositions consistent with that of Mercury (Mercury's inferred oxygen fugacity is close to that of a solar composition vapor). Planetesimal formation further out from the Sun would however be the result of the pile-up of material coming from the outer regions of the disk and would therefore involve material with much more oxidized compositions. The subsequent thermal/collisional evolution of the planetesimals is considered where we argue that metal/silicate fractionation is rendered easier in the early phases of terrestrial planets formation (rather than in the late giant impact phase) due to the smaller masses of the objects involved.

References

[1] Ebel, D. S. and Stewart, S. T.: To appear in *Mercury: The view after MESSENGER*, S. C. Solomon, B. J. Anderson, L. R. Nittler (editors), Cambridge University Press.

[2] Nittler, L. R., Chabot, N. L., Grove, T. L., and Peplowski, P. N.: To appear in *Mercury: The view after MESSENGER*, S. C. Solomon, B. J. Anderson, L. R. Nittler (editors), Cambridge University Press.

[3] Stewart, S. T., Lock, S. J., Petaev, M. I., et al. 2016, Lunar and Planetary Science Conference, 47, 2954