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Phobos low density: are macroporosity and/or water ice ‘condiciones sine quibus non’?

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In this work we present a new approach to the study of the interior structure of Phobos. The low density of Phobos (1.876 $\pm$ 0.02 g/cm3, Witasse et al., 2013) has been repeatedly used in the past as the possible evidence for the in situ formation scenarios, as the re-accretion of debris blasted into Mars’ orbit by the collision between Mars and a large body (Craddock 1994, 2011) or the formation from a debris disk left over from the formation of Mars (Safronov 1986).
As often presented in the literature, the resulting re-accreted body would then contain large voids in its interior, suggesting at least a macroporosity of 30 $\pm$ 5% (Andert et al., 2010). The use of different values of macroporosity supports several kinds of rock material constituting Phobos, without compromising its measured low density. Following Rosenblatt (2011) equations, a porosity range between 25% and 35% would justify the presence of mineralogical material on Phobos with a density range between 2.50 g/cm3 and 2.88 g/cm3.
Alternatively, the low density of Phobos has been explained by including water ice as part of its composition (0.97 g/cm3, Fanale et al., 1989, 1990): the problem of this approach is that no evidence of water ice spectral features have yet been observed (Rosenblatt 2011) on the surface of Phobos even if some content of water ice below the surface cannot be a priori excluded.
A third viable solution, as presented by Rosenblatt (2011), could be a mixture of the above mentioned macroporosity and water ice content, as also presented in Paetzold et al., 2013.
However, it is not yet possible to distinguish between a homogeneous and heterogeneous case for the internal structure of Phobos (Paetzold et al., 2012, 2013 and Witasse et al., 2013). In fact, the corresponding error bar of the C20 gravity coefficient of Phobos measured from the closest Mars Express flyby at Phobos on 3rd March 2010 at a distance of 77 km, is still consistent with both a homogeneous as well as an heterogeneous mass distribution.

Our work originates from this simple question: are macroporosity and/or water ice really necessary to justify Phobos low density? Are these ‘condiciones sine quibus non’? Is it not possible to identify a mineralogical rock content which agrees both with the surface spectra and the low bulk density of Phobos without introducing bulk macroporosity and/or water ice content? The mineralogical model used to explain the surface reflectance of Phobos presented in Pajola et al., 2013, brings new insights about the interior composition of Phobos reconciling both Phobos surface spectra and its low bulk density.