Possible Interior Layout of (16) Psyche Constrained by a Three-layer Model and Finite Element Model (FEM) Approach

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Abstract

Asteroid (16) Psyche was dominantly thought to be a remnant of a core that is a pure-metallic body because of the higher radar albedo (~0.37) detected than other main-belt asteroids (0.14 - 0.15). However, there are some features Psyche has incompatible with this hypothesis. The most inconsistent physical parameter is the bulk density. The reported bulk density of Psyche (~4.0 g cm^{-3}) is remarkably lower than that of iron meteorites (~7.5 g cm^{-3}). Another feature is that Psyche has radar albedo variations across the surface, indicating non-uniformly distributed surface compositions. Recent observations and investigations [1-3] also support the existence of orthopyroxene and hydrated silicates on the surface. Following this, Psyche is interpreted as a mixed metal and silicate world.

Given this surface composition, a key issue is Psyche's internal structure. The most plausible structure is a metallic core covered with a silicate-rich layer; however, this structural condition is unsuited to the detected highest albedo, possibly representing metals on the surface. Thus, we numerically estimate the internal structure distribution (i.e., the size of iron core and thickness of the silicate-rich layer) using our technique, combined with a three-layer model and FEM approach, and show that this structure condition is still thin enough to reveal the metallic materials in the iron core onto the surface. The three-layer model represents Psyche's possible structural layout consisting of a spherical iron core and two types of the silicate-rich layer (compressed and uncompressed one) resulting from the compaction process in the silicate-rich layer (Fig. 1(a)), while the FEM accesses the stress field of Psyche with a varying bulk density on each layer. As a result, we find that Psyche is likely to have an iron core sized 76 to 103 km in radius (Fig. 1(b)). Given this core size, the silicate-rich layer, consisting of both compressed and uncompressed regions, has a thickness ranging between 0 and 64 km. Assumed a spherical iron core, a very thin silicate-rich layer on the polar region is still sufficient to expose the metallic components at crater-like regions and experience ferrovolcanic surface eruptions at localized regions.

[1] Sanchez et al. (2016) AJ 153
[2] Landsman et al. (2018) Icarus, 304
[3] Shepard et al. (2021) PSJ, 2

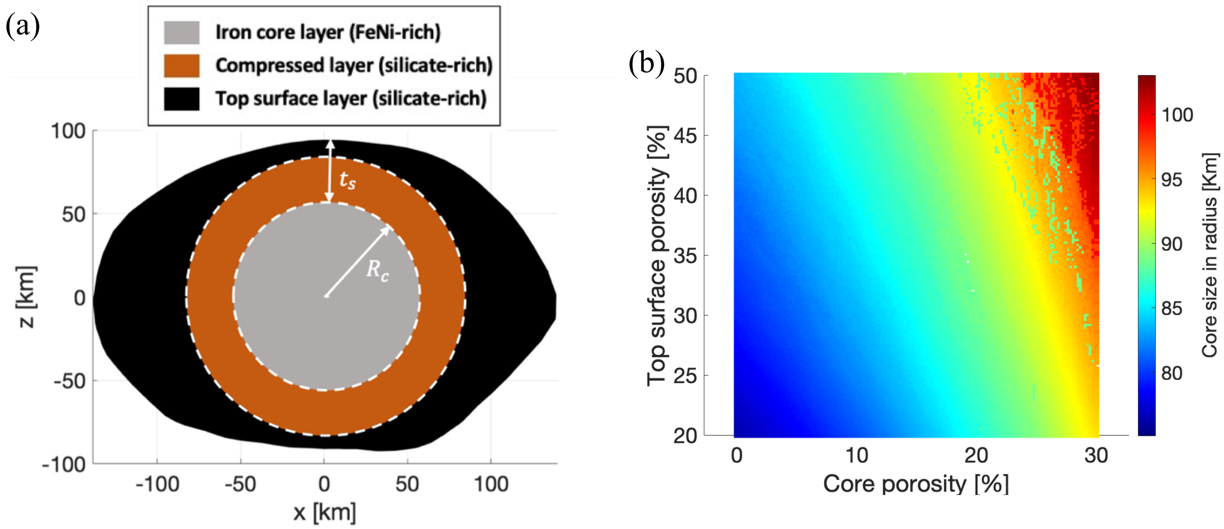

Figure 1. (a) Three-layer model layout (R_c: Iron core radius, t_s: the thickness of the silicate-rich layer), (b) A colormap that shows the constrained core size within the possible porosity ranges