Pitted terrains on Vesta: Thermophysical analysis

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Launched in 2007, the Dawn spacecraft, after one year spent orbiting Vesta, is now on its way to Ceres. In the science payload, the Visible and Infrared mapping spectrometer (VIR) is devoted to the study of the mineralogical composition and thermophysical properties of Vesta's surface [1]. Disk-resolved surface temperatures of Vesta have been determined from the infrared spectra measured by VIR [2]. The observed temperatures, together with a thermophysical model, have been used to constrain the thermal properties of a large part of the surface of the asteroid [3]. The average thermal inertia of the surface is quite low, consistent with a widespread presence of a dust layer. While the global thermal inertia is low, the characterization of its surface in terms of regions showing peculiar thermophysical properties gives us the possibility to identify specific areas with different thermal and structural characteristics. These variations can be linked to strong albedo variations that have been observed, or to other physical and structural characteristics of the first few centimeters of the soil. The highest values of thermal inertia have been determined on areas coinciding with locations where pitted terrains have been found [4]. Pitted terrains, first identified on Mars, have been found in association with 4 craters on Vesta: Marcia, Cornelia, Licinia, and Numisia. The Marcia area is characterized by high hydrogen and OH content [5]. By analogy with Mars, the formation of these terrains is thought to be due to the rapid release of volatiles, triggered by heating from an impact event. A question arises on the origin of volatiles: hydrated minerals, or ground, buried ice? In order to discuss the second hypothesis, we have to assume that a comet impact delivers ice that gets buried under a layer of regolith. Successively, another impact on the same area would give origin to the pitted terrain. The buried ice has obviously to survive for the time between the two impacts (ice is stable against sublimation till 120 K, and can survive for million of years if kept under 150–160 K). A thermophysical model, solving both the heat conduction and the diffusion equations, can give a contribution to the discussion related to this hypothesis. From our analysis, we demonstrate that, on Vesta, water ice could probably survive for millions of years if buried under tens of meters of an insulating layer of regolith [6]. Our conclusion is that the hypothesis of an origin related to ice buried in the Vestan soil cannot be ruled out. A definitive answer on the origin of pitted terrains on Vesta must be found, anyway, taking into account also the results of the geomorphological and compositional analysis.

Acknowledgements: The authors gratefully acknowledge the support of the Dawn Instrument, Operations, and Science Teams. This work is supported by an Italian Space Agency (ASI) grant and by NASA through the Dawn project.

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