EXPLORING SURFACE AND SHALLOW SUBSURFACE VOLATILE PRESENCE ON VESTA USING A BISTATIC RADAR EXPERIMENT.

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Introduction: In the summer of 2011, Dawn entered orbit around 4 Vesta. An evolved and differentiated body, Vesta has been described as more of a protoplanet than an asteroid, and is similar in surface composition and history to the Moon. While differentiated and airless bodies such as these were assumed to have depleted any initial water content, recent missions to the moon have discovered water and hydroxyl across the surface [1]. As a result, an interesting topic of concern is the presence or lack of volatiles on Vesta. Both GRaND and VIR will help address this uncertainty by detecting evidence of hydrogen and OH respectively, but another experiment will be attempted to assist the search in the shallow subsurface. By using the communication antennas onboard the Dawn spacecraft to send electromagnetic pulses to the Earth's DSN network during the Low Altitude Mapping Orbit, a bistatic radar (BSR) experiment can be undertaken. With this method, the dielectric signature associated with volatile presence in the surface and shallow subsurface can be explored. Resulting data will require interim surface roughness and topographic models in order to obtain the surface and shallow subsurface dielectric properties.

Role of Volatiles: While Vesta is expected to have long ago depleted any volatile content, the detection or lack thereof will shed light on the surface processes involved in its formation history. Possible sources of volatiles include its initial composition, hydrated objects that have impacted the surface over time, and solar wind. The last of these is the most likely source, where the thought is that the solar wind reacts with "unsatisfied oxygen bonds on the soil grain surfaces and in internal crystal defects," producing OH and/or H_2O [1]. If either is detected, this would significantly support the understanding of solar weathering processes.

Consequent areas of interest for the seeking of volatiles are those that display anomalies in spectral and/or thermal data. This accordingly includes the unusually "bright" and "dark" regions of material discovered on Vesta's surface, which have been correlated with anomalously high and low temperatures respectively, and also show a difference in spectroscopic data from surrounding material. The interiors of craters also deserve scrutiny, as these will have exposed a variety of materials from the subsurface, and may create shaded regions from the sun that could sustain volatiles at sufficiently low temperatures. Areas of different roughnesses also pose interest, as these could reveal thermal erosion caused by diurnal expansion and contraction of any volatiles in the shallow subsurface.

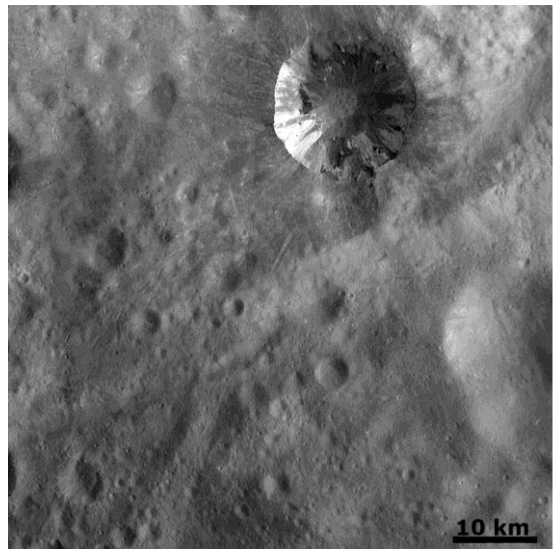

Fig. 1. This Framing Camera image (taken at 670 km altitude at ~63 meters per pixel) displays an example area of interest for seeking volatiles on Vesta. Shown is a crater with "bright" and "dark" material that correlate with anomalies in thermal and spectral data.

The Bistatic Radar Experiment: The recent addition of a bistatic radar experiment is aimed to assist GRaND and VIR in the search for volatiles. In this setup, the spacecraft reflects its telemetry signal off Vesta near the Brewster angle, while using the Earth's DSN as the receiving end. The resulting amplitude, polarimetric and phase change of the radar wave is due to scattering at the surface, which is primarily affected by surface topography, roughness, and electromagnetic properties that vary with surface composition and geophysical properties. This results in a sensitivity to textural variations, and a sensitivity to dielectric variations, which could indicate compositional variation and/or signs of volatile enrichment.

In order to support the analysis of data return from the experiment, models of the distribution of dielectric constant must therefore be developed for the surface and shallow subsurface. These are based on current knowledge of Vesta's surface properties in terms of regolith thickness, temperature, porosity and mineralogy, and are combined with laboratory measurements of the dielectric properties of asteroid analog materials. Consideration of multiple models of the dielectric structure will aid in the interpretation of expected data return.

At the conference, parametric dielectric modeling of the shallow subsurface of Vesta will be presented along with the associated radar backscatter return, as will the bistatic radar experiment results, if available.

Acknowledgements: The authors acknowledge the support of the Dawn Science, Instrument and Operations Teams.

References: [1] Pieters, C. M. et al. (2011) *Space Sci. Rev. 163*, 117-139.