A COMPARISON OF IMPACT-RELATED DEPOSITS SURROUNDING CRATERS ON THE MOON, VENUS, AND MARS. R. R. Ghent, L.M. Carter, D.W. Leverington, and B.A. Campbell[1]
[1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, PO Box 37012, Washington, DC, 20013-7012 (ghentr@nasm.si.edu).

Introduction: The goal of this work is to explore the distribution and properties of surficial impact-related deposits on the Moon, Mars, and Venus. We have previously reported on radar-dark haloes surrounding impact craters on the lunar nearside based on newly acquired and previously existing Earth-based 70-cm radar observations of the Moon [1]. In the present work, we continue to explore lunar ejecta deposits using Earth-based radar observations. Further, we use the results obtained for lunar craters as a framework for exploration of the nature and distribution of potentially similar deposits on Venus and Mars. Because the deposits responsible for radar-dark crater haloes on the Moon are likely produced during impacts, similar deposits should be produced in impacts on Venus and Mars as well. The emplacement mechanisms differ in some respects for Venus and Mars because of the presence of atmospheres on those planets; likewise, the spatial distribution and long-term survival prospects of such deposits may be different from the lunar case because of aeolian and other alteration processes active on the other two planets.

Methods: For each planet, we utilize available datasets that can yield information regarding particle size and texture for crater-related deposits. For the Moon, we use Earth-based radar observations at 70-cm, together with compositional information derived from Clementine UV/VIS multispectral data and textural information from Apollo and Lunar Orbiter images. For Venus, we use Earth-based radar observations at 12.6-cm, along with Magellan SAR images and emissivity and reflectivity data. For Mars, we use nighttime thermal infrared observations obtained by the Thermal Emission Imaging System (THEMIS) aboard the Mars Odyssey spacecraft. Each of these datasets yields different information regarding the nature and distribution of materials; we attempt to relate these disparate observations in a way that will allow us to investigate the intrinsically similar processes of cratering on the three planets.

Lunar craters: Lunar radar-dark haloes reported by [1] are most likely comprised of ballistically emplaced fine material produced in the impact process. These haloes show characteristically low 70-cm backscatter and circular polarization ratios (Fig. 1), indicating depletion in blocks larger than ~10 cm in diameter. Nectarian-aged craters do not show radar-dark haloes; we interpret this to mean that over time, the haloes disappear as the surrounding regolith is homogenized through bombardment and eventual overturn. Outstanding questions for these radar-dark haloes remain, including: 1) What are the relative rates of degradation and homogenization of radar-dark haloes versus radar-bright haloes comprised of blocky ejecta? 2) What is the importance of horizontal transport relative to ballistic "rainout" of fine ejecta for the current distribution of lunar radar-dark halo materials?

Venusian craters: Recent work using 12.6-cm radar observations of Venus from Arecibo has shown that certain impact craters are associated with significant enhancements in the degree of linear polarization in the reflected radar signals, suggesting the presence of a surface mantling layer in these areas [2]. These Venusian deposits cover much larger areas than the radar-dark haloes observed on the Moon in [1], and commonly appear discontinuous, in contrast with the fairly uniform lunar haloes (Fig. 1). Several mechanisms can be envisioned for the association of a mantling deposit with impact craters, including the existence of ballistically- or atmospherically-emplaced ejecta, or trapping of windblown debris in areas of low topography. Also, the textural properties of such deposits need not remain constant through time, particularly under the hot, high-pressure conditions that prevail at Venus's surface. Both the degree of linear polarization and the emissivity values for a given surface are influenced by the dielectric properties and the roughness of the surface materials [2, 3]. We use these two datasets to explore the physical properties of Venusian impact-related deposits. We seek to address the following questions: 1) Is it possible to deconvolve the effects of small-scale roughness, wavelength-scale subsurface texture, and variations in dielectric constant in order to distinguish between deposits of fine, loose materials, or deposits that may have become welded by chemical or thermal processes? 2) Can we resolve differences in texture between the Venusian and lunar deposits, and do textural similarities or differences reflect similarities or differences in formation or deposition processes?

Martian craters: Finely textured, loose material generally shows lower nighttime infrared temperatures than solid rock [4]. Thus it is in principle possible to use high-resolution nighttime THEMIS images to distinguish deposits of fine, loose material from surrounding bedrock. However, Mars' surface is characterized by a large volume of mobile dust and active aeolian processes; thus the thermal signature of a given area must be analyzed carefully to determine whether it reflects the characteristics of the primary surface or those of a later coating of windblown dust. Reconnaissance of a number of nighttime THEMIS images of relatively young lava flows in the northern plains reveals that many small, recent impact craters (up to ~10 km in diameter) are surrounded by haloes of material with nighttime IR temperatures distinct from the surrounding terrain (e.g., Fig.2). These haloes are symmetric and do not show the streamlined or asymmetric geometries common to aeolian features, and some display radial ray-like features. We propose that these deposits may be primary impact-related deposits of fine material analogous to the lunar deposits reported by [1]. In contrast with the lunar case, these haloes are not generally present for large craters, suggesting that for those craters, either 1) the primary fine material may have been either stripped away or buried by aeolian dust, and so does not have a distinctive IR signature detectable by THEMIS; or 2) finely-textured primary ejecta is not preserved during impacts that create large craters on Mars. We are interested in addressing the following questions related to these Martian crater haloes: 1) How ubiquitous are these primary ejecta deposits for small craters? 2) Are they limited to relatively young surfaces, or is there a unique age range for which such haloes are visible? 3) How does the range of particle sizes in these deposits compare with those in the lunar radar-dark haloes?

Summary: Using ballistically-emplaced lunar ejecta deposits as a basis for comparison, examination of variations in the nature, extent, and distribution of impact-related materials on Venus and Mars can yield insight into the differences between deposition of these materials on planets with and without atmospheres. Furthermore, these traits result in part from the processes by which surface materials are degraded, altered, or reworked, and thus have implications for the surface processes unique to each of the three planets.

References: [1] Ghent R.R et al., (2005) *JGR, in press.* [2] Carter L.M. et al. (2004) *JGR 109*, E06009, doi:10.1029/2003JE002227. [3] Campbell, B.A. (1994), *Icarus 112*, 187-203. [4] Kieffer, H.H. et al. (1977), *JGR 82*, 4249-4291.

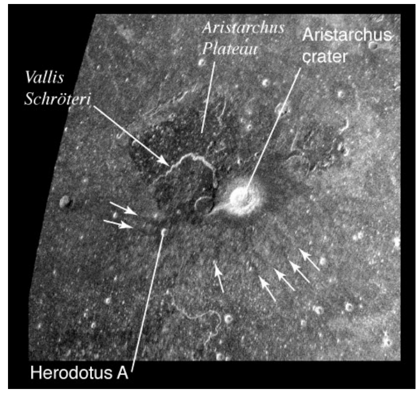

Figure 1. Earth-based 70-cm delay-Doppler radar image of the Aristarchus region of the moon showing radar-dark haloes and radial features associated with the craters Aristarchus (23.7N, -47.4W, 40 km diameter) and Herodotus A (from [1]).

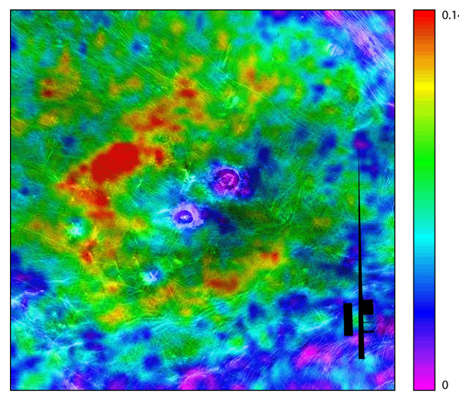

Figure 2. Degree of linear polarization overlain on Magellan fmap image for Barton and LaChapella craters (centers: 27.1N, 337.1E and 26.7N, 336.7E, respectively).

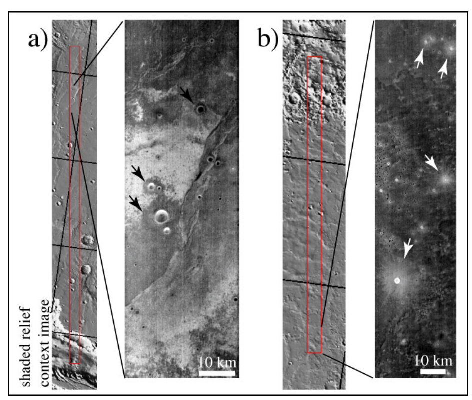

Figure 3. (a) THEMIS nighttime IR image I05402005 (center, 17.3 S, 284.6 E). (b) THEMIS nighttime IR image I06045009 (center, 11.9N, 97.1E). Arrows denote relatively cool crater haloes (a) and relatively warm haloes and radial features (b) compared with surrounding terrain.