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Cassini VIMS Preliminary Exploration of Titan's Surface Hemispheric Albedo Dichotemy and Constraints on Precipitation

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We present preliminary evidence that suggests a hemispheric albedo dichotomy on Titan and we studied the photometric properties of several dark circular features on Titan's surface to test if they might be of impact origin. The evidence is derived from photometric analysis of selected surface regions taken at different longitudes and solar phase angles using images from the Cassini Saturn Orbiter Visual and Infrared Mapping Spectrometer (VIMS). The VIMS instrument is able to image Titan's surface at 'spectral windows' (e.g. 2.02 μm) in its atmosphere where methane, the principal atmospheric absorber is transparent.

We established a limited set of photometric control regions on Titan's surface with low and high I/F (0.06-0.12). The I/F of the same regions was measured in VIMS images at that were taken at two different solar phase angles (12^o and 16^o). This permitted us to establish preliminary phase coefficients. Our analyses of VIMS images of Titan's hemisphere centered near longitudes between 130^o and 160^o finds that the low albedo and high albedo regions on this hemisphere of Titan are backscattering. We also studied VIMS images taken of Titan's approximately opposite hemisphere (longitude 330-80^o) at a single phase angle (48^o). Backscattering behavior is consistent with the scattering properties of most planetary regoliths and regoliths of planetary satellites throughout the solar system. Assuming that both hemispheres are similarly backscattering, then the most reflective regions are found on Titan between 50-130^o longitude. A preliminary estimate of the normal reflectance of high albedo regions is $\sim$20%. The lowest albedo regions are found near zero degrees longitude. Preliminary estimate of normal reflectance of these is $\sim>5\%$.

The VIMS images show several low albedo circular features on Titan centered approximately at lat=-36, lon=31 and lat=-7, lon=357.These bear a striking similarity to circular features exhibiting topographic relief caused by impact events on a wide range of solar system objects. We undertook a photometric analysis of two circular regions using 2.02 μm images taken near the time of closest approach. We measured the reflectance along lines that passed through the sub-solar point on Titan's surface and traversed the center of each feature. The extracted reflectance profiles enabled us to search for vertical relief by comparing our photometric profiles with the profiles expected from a circular depression, a circular depression with a raised rim, and a circular depression with a raised rim and a central peak using a model based on the widely used bi-directional reflectance equations developed by Hapke (1993). We assumed: 1) The surface was covered by a regolith whose particles scattered isotropically and had uniform single scattering albedo, 2) The haze was optically thin, did not extend to the surface, and was uniformly mixed laterally with the atmosphere.

Albedo dichotomies are commonly seen on planets and planetary satellites that have no atmosphere. Observing the scattering properties of Titan's surface has been difficult using ground based instruments due to the methane absorption of Titan's atmosphere at visible wavelengths. However, recent work by ground based and Hubble Space Telescope observers at infrared wavelengths suggests a global albedo variation consistent with a disproportionate amount of more reflective material being on the leading side (longitudes 0-180 degrees) compared to the opposite hemisphere (Smith et al., 1996; Combes et al., 1997; Gibbard et al., 1999; Meier et al., 2000). Groundbased radar evidence consistent with hemispheric albedo variations has also been reported (Campbell et al., 2003).

The hemispheric albedo dichotomy we tentatively suggest here is that most reflective material on the brighter hemisphere of Titan has higher albedo than the high albedo material on the approximately opposite hemisphere. This is also true for the low albedo material. Therefore, the higher albedo hemisphere not only has more areal coverage of high albedo material but the material itself is intrinsically more reflective than the highest albedo material on the opposite hemisphere. We find no evidence for widespread regions of reflectance <0.05 as suggested by Gibbard et al. however our coverage of Titan's surface is not complete and the data from future flybys is required in order to thoroughly address this issue.

Despite our best effort to adjust the depression parameters to fit the data our data do not fit that expected for a craterlike depression. In one case the model fit does not agree with the data at large distances from the sub-solar point. In the other, the photometric profile expected from the central peak is in the opposite sense to that which we measured. In both cases the crater depths required to accommodate these best-fit models are extremely, if not unreasonably, large ($\sim$50 -100 km.) with diameters of 1000 and 2000 km.). We believe it is unlikely to have two craters of such depth on Titan. Therefore, we suggest that these are albedo features and are not caused by topographic relief and are not true craters. They are consistent with palimpsests-expressions of darker reflectance on a surface where the vertical relief has been lost to lithospheric plastic flow. If these features are palimpsests and are the remains of ancient impacts then their persistence on the surface suggests that widespread weathering processes, such as a planet-wide precipitation of aerosols, on Titan are severely limited. This result is consistent with Keck observations at shorter wavelengths by Bouchez. This work carried out at JPL under contract with NASA and with the support of ESA

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