TITAN: SURFACE COMPOSITION FROM CASSINI VIMS. T. B. McCord[1], G. B. Hansen[2], B. J. Buratti[3], R. N. Clark[4], D. P. Cruikshank[5], E. D'Aversa[6], C. A. Griffith[7], K. H. Baines[3], R. H. Brown[7], C. M Dalle Ore[5,8], G. Filacchione[6], V. Formisano[6], C. A. Hibbitts[9], R. Jaumann[10], J. I. Lunine[6,7], R. M. Nelson[3], C. Sotin[11], and the Cassini VIMS Team. [1]Space Science Inst., Bear Fight Center, Box 667, Winthrop WA 98862 mccordtb@aol.com, [2] Dept. of E. & Sp. Sci, 351310, U. of Washington, Seattle WA 98195, [3]Jet Prop. Lab., Pasadena CA 91109, [4] USGS, M.S. 964, Box 25046, Denver Federal Center, Denver CO, [5] NASA Ames Res. Center, Astrophysics Branch, Moffett Field, CA 94035, [6] Istituto Fisica Spazio Interplanetario, CNR, Via Fosso del Cavaliere, Roma, Italy, [7] Dept. Pl. Sci. and LPL, U. of AZ, Tucson AZ 85721-0092, [8] SETI Institute, 515 N. Whisman Rd., Mountain View, CA 94043, [9] Johns Hopkins U. Appl. Phys. Lab., Columbia MD, [10] DLR, Inst. for Planet. Expl. Rutherfordstrasse 2, D-12489 Berlin, Germany, [11] U. of Nantes, B.P. 92208, 2 rue de la Houssinière, 44072 Nantes Cedex 3, France.

Introduction: Titan's bulk density and Solar System formation models indicate a differentiated object with considerable water as well as silicates as major constituents. Deposits or even oceans of organic compounds have been suggested to exist on Titan's solid surface due to UV-induced photochemistry in the atmosphere. Composition of the surface is a major piece of evidence needed to determine Titan's history. However, studies of the surface are hindered by the thick, absorbing, hazy and in some places cloudy atmosphere. Groundbased telescope investigations of the integral disk of Titan attempted to observe the surface albedo in spectral windows between atmospheric methane absorptions by calculating and removing the haze effects. Their results [1] were reported to be consistent with water ice on a surface that is contaminated with a small amount of dark material, perhaps organic material like tholin.

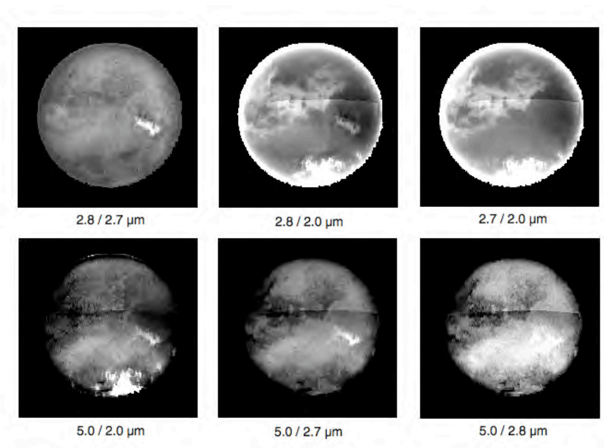

Fig. 1: Ratio images of Titan from a VIMS T_a encounter data set.

Data Analysis: Recent Cassini Mission's Visual and Infrared Mapping spectrometer (VIMS) observations detected distinct surface features on Titan. We searched for spectral diversity on Titan [2] first by calculating ratio images among methane windows beyond 1.8 µm in the VIMS IR spectral range without attempting to remove any atmospheric haze scattering and absorption or residual methane absorption effects. Since the haze and methane opacities are thought to be fairly uniform across Titan's disk, any variations seen in a ratio image are likely due to clouds that exist mainly near the south pole and the surface materials. In Fig. 1 we show that there are bold as well as subdued features in some of the ratio images including a striking anomalous bright feature in the IR channel ratio image 2.8/2.7 µm near lat. 26 S, long. 118 W. This is evidence of spectral units existing that are likely due to surface compositional differences.

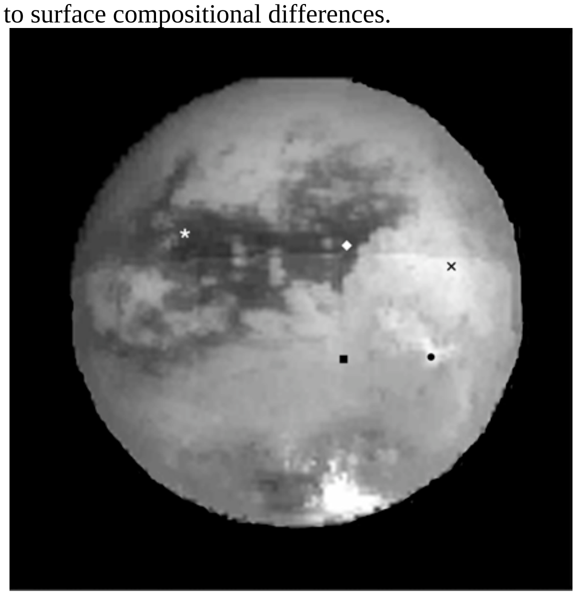

Fig. 2: Location of five regions on Titan chosen for deriving surface spectral reflectances in a T_a encounter VIMS data set.

We then selected several Titan regions to study in a T_a data set, shown in Fig. 2, including for both visually bright and dark regions. We obtained I/F spectra for these Titan spots by several methods. We first assume no atmospheric effects and took the peak reflectance from the VIMS I/F spectra in each of the methane windows as being due to the surface material. We then used radiative transfer calculations of several degrees of sophistication, following earlier procedures [1], in an attempt to remove the effects of the methane absorption and the haze scattering from the methane window spectral regions, and then we compared and combined them. The result is a set of spectral albedoes, one for each methane window, for the several Titan surface spots [Fig. 3].

The IR reflectance values in Fig. 3 are also shown scaled to unity at the 2-µm point. This displays the relative spectrum shapes with overall brightness differences removed. All visually bright region spectra are similar to each other, with some variation, Visually dark region spectra are more similar to each other, much redder and have a more subdued 1.6-µm dip. We compared these surface spectral albedo values with spectral reflectances for candidate materials, including water ice, tholin, icy Galilean satellite material, and simple organic molecules.

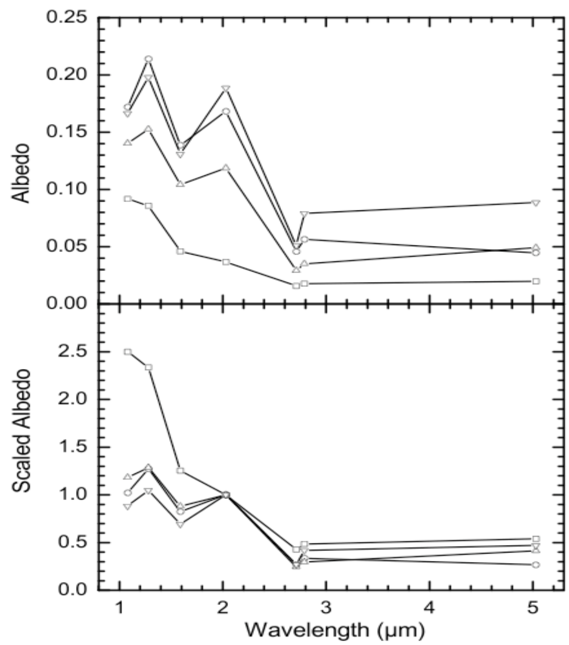

Fig. 3: Spectral albedos at methane windows for four regions on Titan. In the scaled plot (bottom) three visually bright region spectra are shown compared with one visually dark region spectrum.

Results: Of the spots studied, there appears to be two compositional classes present that are associated with the visually darker and the visually brighter regions, with more variety among the brighter regions. The spectrum of water ice contaminated with a darker material matches the reflectance of the visually darker Titan regions if the spectral slope from 2.71 to 2.79 µm in the poorly-understood 2.8-µm methane window is ignored [Fig. 4]. The spectra for visually brighter regions are not matched by the spectrum of water ice or unoxidized tholin. We find that the 2.8-µm methane absorption window is complex and seems to consist of two weak subwindows at 2.7 and 2.8 µm that have unknown opacities [2, 3]. Thus, the albedos obtained so far for this window and perhaps some of the others are uncertain and should be refined.

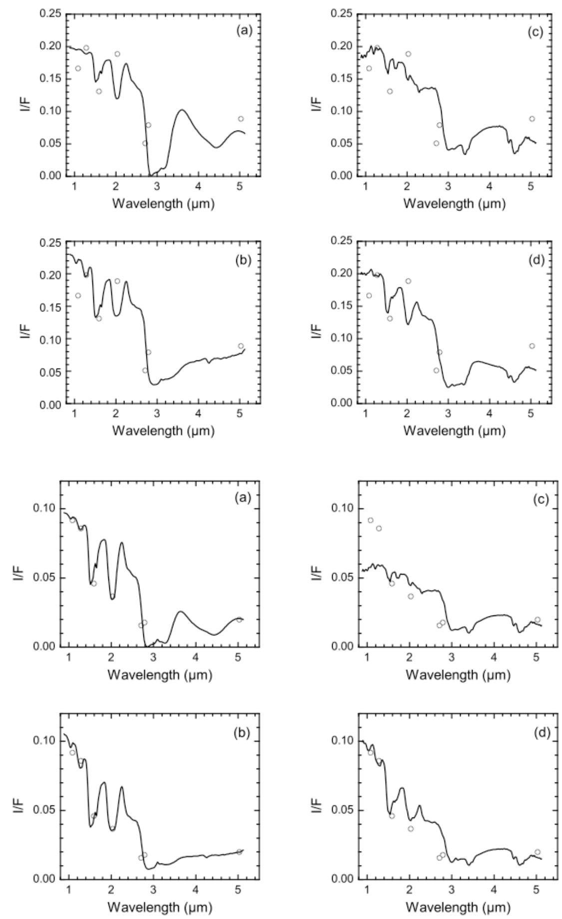

Fig. 4: Reflectance (unfilled circles) for the visually bright Titan regions (upper set of four plots) and the visually dark regions (lower set of four plots) in the methane windows are shown compared with the spectrum of candidate materials (solid lines): In each of the two quadrant plots, the material spectra are: upper left, water ice; lower left, Ganymede; upper right, tholin; and lower right, tholin with water ice.

References: [1] Griffith, C. A., et al. (2003), *Science 300*. [2] McCord T. B., et al. (2006) *Planet. and Sp. Sci.* in press, [3] Coustenis, A. et al. (2006), *Icarus, 180*.