EROSION AND STRATIGRAPHIC RELATIONS ON TITAN. R. Jaumann[1,2,*], K. Stephan[1], C. Sotin[3], R. H. Brown[4], M. Langhans[1], J. Soderblom[3], L. A. Soderblom[5], S. Le Mouélic[6], R. N. Clark[7], B. J. Buratti[5], K. H. Baines[5], D. P. Cruikshank[8], P. D. Nicholson[9], G. Filacchione[10], R. Wagner[1], J. Barnes[11] and R. M. Nelson[3]
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Introduction: The surface of Titan has been revealed globally by the Cassini observations in the infrared and radar wavelength ranges as well as locally by the Huygens optical instruments [e.g. 1,2,3,4]. Extended dune fields, lakes, distinct landscapes and dendritic erosion pattern indicate dynamic surface processes [4,5,6,7,8,9,10,11]. During Cassini's 47th Titan flyby on 19 November 2008 the Visual and Infrared Mapping Spectrometer (VIMS) [12] observed the Huygens Landing Site (HLS) at 192.4°W and 10.2°S with spatial resolutions better than 500 m/pixel. This provides the opportunity to compare surface units at the landing site with similar surface features at 30°W and 7°S observed by VIMS at similar spatial resolution during Cassini's 20th Titan flyby on 24 October 2006. In this Quivira-Aztlan region a deep incision called Bohai Sinus is one of the most prominent disintegration areas between bright and dark materials indicating both erosion and deposition and thus provides insight into exogenic processes on Titan [13]. As both areas, HLS and the Bohai Sinus area, also exhibit similar spectral signatures, morphological and compositional information can be brought into context based on the ground truth of the HLS, and can be used in order to derive stratigraphic relations. **Geological Units:** Based on the spectral signature in the infrared methane windows - expressed as VIMS wavelengths ratios at 1.27/1.09 μm, 2.03/1.27 μm 1.59/1.27 μm, and composed to a color image (RGB) in order to enhance the overall contrast of the observations - three major units can be distinguished: whitish material which is mainly distributed in the topographically high areas indicates equal reflectivity in all atmospheric windows; bluish material exhibits a higher reflectivity at the longer atmospheric wavelength windows implying a clear spectral separation from the whitish material, and brownish material characterized by a higher reflectivity at the shorter wavelength atmospheric windows correlates with dunes [11,13,14]. Although the spectral units are distinct, their compositions are not known at this time. Bright materials may consist of precipitated aerosol dust composed of methane-derived organics [14] superimposed on water-ice bedrock. The bluish component might contain some water ice [14,15]. However, it is no simple matter to distinguish between specific organics and ices because all these molecules have comparable absorptions, resulting in similar spectral slopes. In addition, different particle sizes will have an effect on the depths of absorption bands and corresponding spectral slopes. Nevertheless, the spectral signature variations are real and indicate compositional differences and/or changes in particle sizes that are related to geological processes [11,14]. **Geology at the Huygens Landing Site:** Although there are no liquid hydrocarbon pools at the Huygens landing site, traces of once flowing liquid are obvious [4]. Surprisingly like Earth, the brighter highland regions show complex systems draining into flat, dark lowlands. Images taken after landing appear to be of a dry riverbed. If the darker region is interpreted as a wide dry riverbed, it is too large to have been caused by the creeks and channels visible in bright areas. It may have been created by other larger river systems or some large-scale catastrophic event, which predates deposition by the rivers seen in these images. The major elements of the Titan surface albedo variations can be interpreted to be controlled by flow of low-viscosity fluids driven by topographic variation, whether caused by precipitation as indicated by dendritic networks or spring-fed flows as indicated by stubby networks. Rounded cobbles at the site vary between 3mm in diameter, the resolution limit of the Huygens imager, and a maximum of 15 cm [4]. The geology at the Huygens landing site strongly implies intense resurfacing by erosion and deposition. Mapping the HLS based on the spectral signatures in VIMS data [11,13,14] yield that the high standing material which is dissected by dentritic valley networks is composed of optically bright material whereas the darker plains are represented by the bluish component which transforms into brownish dune materials (Fig. 1). **Geology at Bohai Sinus:** Bohai Sinus is a disintegration areas between bright and dark materials and is expressed as an indentation tending northwards into the bright material about 100 km deep and 90 km wide. Similar to the HLS the whitish material seems to be high standing material and probably dissected by dentritic valley networks.

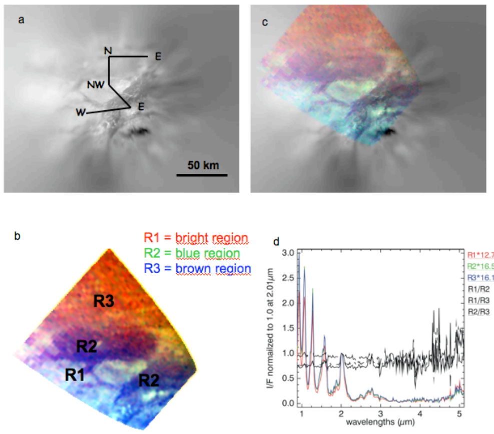

Fig. 1 (a) DISR image of the Huygens Landing Site; (b) color coded (1.27/1.08 µm, 1.59/1.27 µm, 2.03/1.27 µm) VIMS image of the HLS; (c) overlaid spectral information on DISR image; (d) spectra of the regions R1, R2, R3 and ratios.

However VIMS resolutions are to low to confirm this assumption. The dark plains appear bluish in the color composite with a systematic change of its spectral signature towards the south away from the whitish material indicating a change in the compositional or physical state of these materials. [13] (Fig. 2).

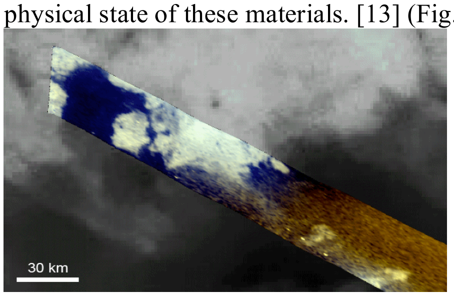

Fig. 2 (a) Color coded VIMS spectral image of Bohai Sinus overlaid on ISS observations.

Comparison of spectral signatures: Rationing the spectra of the bright, blusih and brownisch areas yield spectral differences (Fig. 1 and 3) which are most significant in the atmospheric windows centered at 1.59 µm, 2 and 2.7/2.8 µm. The R1/R2 and R1/R3 ratios indicate distinct spectral differences between whitish and bluish as well as whitish and brownish material, whereas the R2/R3 ratios are almost equals 1 (Fig. 3) suggesting that the bluish and brownish materials just differ in albedo which might be mostly due to differences in physical properties such as photometric reflection and probably particle size [13].

Stratigraphic Relations: Both, HLS and Bohai Sinus, exhibit a distinct relationship between overall bright, bluish and brownish materials with bluish material dissecting and surrounding the bright areas, and bluish areas finally transforming into brownish dune like features. The brownish dune-like material, however, contacts or overlays both bright and even blue areas (north of HLS) indicating its high mobility. At the HLS the bluish material is identical with the dark plains suggesting a fluvial origin [4,9] and a

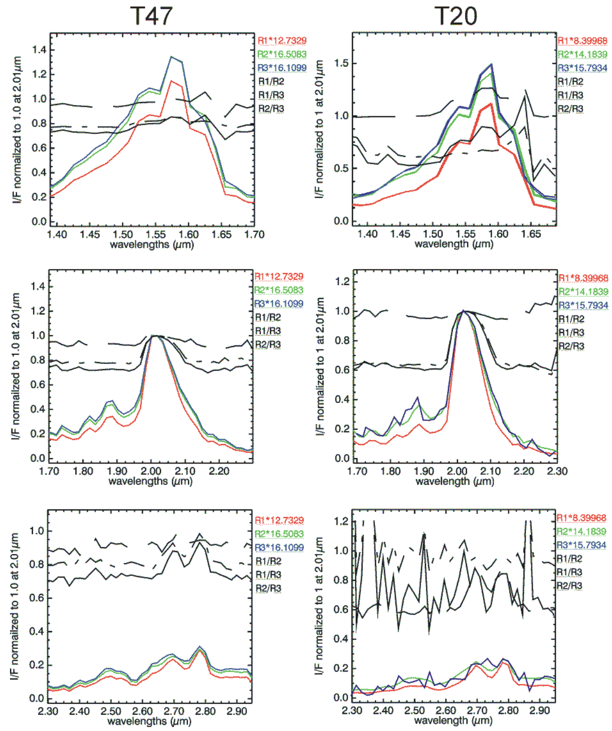

Fig. 3 Normalized spectra of the regions R1, R2, R3 and ratios (see Fig. 1) for HLS (T47) and Bohai Sinus (T20) in the atmospheric IR-windows centered at 1.59 µm, 2 and 2.7/2.8 µm.

depositional evolution. This is also confirmd by the systematic change of spectral signatures within the bluish region of Bohai Sinus as a function of the distance from the whitish material [13]. In addition, the bottom of longitudial depressions within the bright areas – identified as dentritic valley networks at the HLS - is mostly covered by bluish material. Thus, the bluish plains and depression fillings indicate young areas where eroded material is deposited and probably erosion is still active.

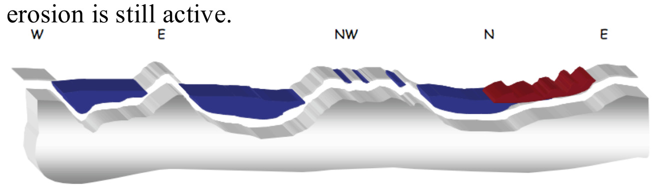

Fig. 4 Schematic cross- section at the HLS following the line indicated in Fig. 1 (a); bright = bedrock, blue = plains material, brown = dunes.

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