GEOMORPHOLOGIC MAPPING OF THE MENRVA REGION OF TITAN.

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Introduction: The *Cassini* RADAR experiment [1] has provided detail on the surface morphology of Saturn's moon Titan over regional scales (tens to hundreds of kilometers), enabling the recognition of surface features produced by specific geologic processes, including fields of longitudinal dunes [e.g., 2], impact craters [e.g., 3], river channels [e.g., 4], lakes [e.g., 5], potentially active cryovolcanic edifices [e.g., 6], and mountains and tectonic features [e.g., 7]. Geologic and geomorphologic mapping is a critical tool that is required to relate spacecraft observations to the geologic history of planetary bodies, the results of which can provide crucial information to refine models of surface and interior processes. For Titan, the systematic characterization of surface features in specific regions and their distribution in time and space is essential for identifying any evolution in geologic processes working on the surface. It is also desireable to investigate whether application of planetary mapping techniques to *Cassini* RADAR images can provide a relative stratigraphic timescale on which processes have affected parts of Titan's surface.

We made a detailed geomorphologic map of the Menrva region of Titan, using *Cassini* RADAR data with a spatial resolution of 350 m to >1 km as our map base. The goal was to test whether geologic mapping techniques as applied to the *Cassini* RADAR images can be used to identify and determine the relative roles of the various geologic processes that have formed this part of Titan's surface. This was done by mapping the distributions of process-related material units, determining their stratigraphic relations, and producing a complete geomorphologic map of this region (**Figure 1**).

Approach: Using similar techniques and approaches that were applied to mapping *Magellan* radar images of Venus, and earlier, more generalized Titan maps, we were able to define and characterize 10 radar morphologic units, along with inferred dunes and fluvial channels, from the RADAR data. Structural features, such as scarps, ridges, and lineaments were also identified. Using principles of superposition, cross-cutting, and embayment relations we created a sequence of map units for this region (**Figure 2**).

Results: We interpret Menrva to be a 440 km wide degraded impact basin, in agreement with earlier studies by [8] and [3], and we identify it as the oldest feature in the map region. Exogenic processes including hydrocarbon fluid channelization forming the Elivagar Flumina channel network and dune fields resulting from aeolian activity are the current geologic processes dominating our map area, and these processes have contributed to the erosion of the crater's ejecta field. There is evidence of multiple episodes of channel formation, erosion and burial by aeolian deposits, as observed elsewhere on Titan by e.g., [9]. Channel outflow regions have morphologies suggestive of streams formed by flash floods, and dune fields are small and restricted rather than forming large dune seas, consistent with a desert-like environment for this region with low supply of hydrocarbon particles, also consistent with other studies by e.g., [4]. There is no evidence of cryovolcanism or non-impact-related tectonic activity in the Menrva region, although this region is too small to infer anything about the roles of these processes elsewhere on Titan. This work suggests detailed geomorphologic mapping can confidently be applied to *Cassini* RADAR data, and we suggest that more extensive mapping should be done using RADAR, ISS, and VIMS data geographically distributed across Titan to assess its usefulness for a future combined RADAR-ISS-VIMS-based global geologic map.

References: [1] *Elachi et al.* (2004), *Space Sci. Rev. 115*, 71-110; [2] *Radebaugh et al.* (2008), *Icarus 194*, 690-703; [3] *Wood et al.* (2010), *Icarus 206*, 334-344; [4] *Lorenz et al.* (2008), *Planet. Space Sci. 56*, 1132-1144; [5] *Stofan et al.* (2007), *Nature 445*, 61-64; [6] *Lopes et al.* (2007), *Icarus 186*, 395-412; [7] *Radebaugh et al.* (2007), *Icarus 192*, 77-91; [8] *Elachi et al.* (2006), *Nature 441*, 709-713; [9] *Barnes et al.* (2008), *Icarus 195*, 400-414.

Figure 1 (next page). Geomorphologic map of the Menrva region of Titan. Ten map units have been defined and characterized based on the *Cassini* RADAR image from the T3 flyby, along with dunes and channels, and structural features such as scarps, ridges, and lineaments. The map legend is listed in approximate stratigraphic order. This map is presented as "proof-of-concept" that detailed planetary mapping can be applied to the *Cassini* RADAR data.

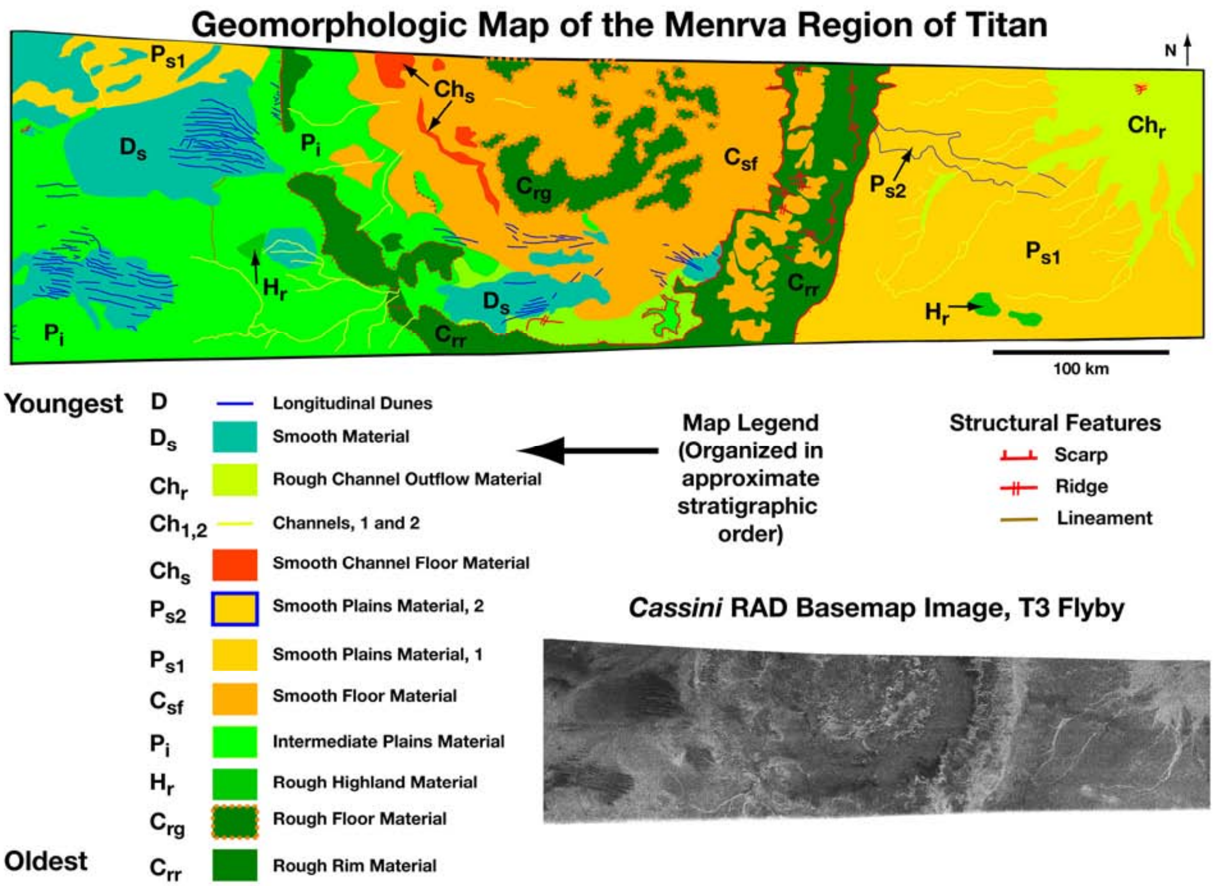

Figure 2. Sequence of map units (COMU) for the map of the Menrva region of Titan (Figure 1). Both distinct events and ongoing activity can be recognized from this mapping effort.