MORPHOLOGY OF FOUR FLOW FIELDS ON TITAN: IMPLICATIONS FOR MODES OF ORIGIN.

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Introduction: Flow fields of varying morphology have been observed in Cassini Radar swaths of Titan (e.g., 1, 2). Some fields are composed of lobate, radar-bright deposits (e.g., Winia Fluctus, Rohe Fluctus), some of which originate from a single source, and are interpreted to be cryovolcanic in origin [1]. Other fields are more complex with multiple flow units, and are associated with channels that may be fluvial in origin. We describe four of these complex flow fields below, and discuss key observations that may distinguish between a fluvial and a cryovolcanic origin, including the relationship between the channels and flows and flow morphology.

Examples of Flow Fields Associated with Channels: Deposits associated with channels were first observed in the Ta (October, 2004, Leilah Fluctus) and T3 (Feb., 2008, Elivagar Flumina) radar swaths [1, 3, 4]. These radar-bright deposits were located at the apparent terminus of radar-bright channels, as seen at Leilah Fluctus. The radar brightness of these units is likely caused by enhanced surface roughness at the scale of the radar wavelength (2.2 cm). However, the dielectric properties of the surface also affect the returned radar signal. On Titan, the likely surface materials are water ice, possibly with ammonia in places, hydrocarbons, and tholins; and volume scattering is likely to be significant [1-4]. The Leilah Fuctus deposits tend to fan out from the channels, in a manner similar to alluvial fans on Earth. These deposits were interpreted to be sedimentary deposits [3, 4].

In the T39 swath obtained in December 2007 and covering the south polar region, bright deposits associated with channels were observed forming an approximately circular radar-bright feature. As at Leilah Fluctus, the bright deposit fans out from the terminus of radar-bright channels and are relatively uniformly radar-bright, but in this case the deposits extend several hundred km beyond the channels to form a large deposit.

The Hotei Arcus flow field was imaged in the T41 (Feb., 2008) and T43 swaths (July, 2008) [2]. The area is of particular interest, as it is one of the brightest features in ISS near-IR data and in the 5 micrometer VIMS channel [5]. In addition, fluctuations in infrared brightness have been observed at Hotei [6]. While the Hotei field also has associated channels, in this case the deposits do not fan outward from the channels. Instead, the flow deposits appear to superpose the channels, and many of the flows appear to originate at multiple sites within the field. And, unlike the fields observed in the previous three examples, the Hotei flow field consists of more digitate flows of variable radar backscatter that strongly resemble radar images of volcanic lava flow fields on Earth and Venus [2]. Recent stereoradargrammetric analysis of a portion of the flow field indicates that some of the flows are relatively thick, also supporting a cryovolcanic origin [7]. Wall et al. [2] suggest that the flows might be relatively geologically young, as they superpose the fluvial channels.

The T48 swath, obtained December 5, 2008, covers a portion of Tui Regio (Fig. 1). The northern half of the field consists of relatively uniform to mottled radar-bright deposits that appear to fan outward from radar-bright floored channels. To the south, the flows are more digitate, interleaved, and vary in radar backscatter from dark to intermediate to bright flows. These flows appear to originate from within the field, rather than from channels. This southern portion of the field is similar in appearance to the flows at Hotei, however, the origin of the flows in this field is uncertain, although it has been previsouly suggested to be cryovolcanic [8].

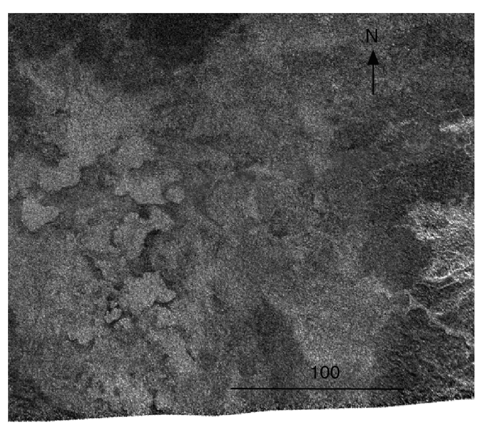

Fig. 1. Radar-bright deposits at Tui Regio.

Discussion: Evidence of fluvial processes has been seen over much of the surface of Titan, and the close association of channels with flow fields makes it likely that some are related to fluvial processes. The primary candidates for this are Leilah Fluctus in Ta and the field in T39, which fan outward from channels to form a relatively uniform, radar-bright deposit, consistent with a large scale debris flow. For these flows, all of which are associated with bright-floored channels, understanding how Titan rivers can produce debris flows that cover in excess of 2500 km^2 is the challenge. More complete coverage of the surface of Titan would allow us to constrain the distribution of these features (now identified in the south polar region and at mid- to high northern latitudes), which, given the low slopes on Titan, likely require a significant amount of methane rainfall to occur over short periods.

The flow field at Hotei differs significantly from these flow fields, as the flows appear to have multiple points of origin, a more digitate character, a range of radar backscatter characteristics typical of lava flow fields on other planets, and superpose the channels. The Tui field is more problematic, as some of its flows do appear to originate from channels, while others appear to originate from within the field. The radar backscatter characteristics of the southern portion of the field are more similar to Hotei. It could be that this field is of mixed origin, with the northern radar-bright deposits interpreted as debris aprons that partially superpose a cryovolcanic field.

Analysis of these fields is ongoing, including comparisons to other mottled plains regions on Titan. It has been speculated that much of the surface of Titan could be cryovolcanic in origin (e.g., 9), now masked by erosional processes and atmospheric deposition. Constraining the origins of these flow deposits on Titan, and understanding how they become obscured over time, may provide insight into the origin of Titan's plains.

References: [1] Lopes R. et al. (2007) *Icarus 186*, 395. [2] Wall S.W. et al.. (2008) in review, *Icarus*. [3] Elachi C. et al. (1997) *Science., 308,* 90. [4] Elachi, C. et al. (2006) *Nature 441,* 709. [5] Barnes J.W. et al. (2005) *Science 310*, 92. [6] Nelson, R.M. et al. (2008) *Icarus*, in press. [7] Kirk, R.L. et al. (2008) *Eos Trans AGU 89(53)*, Abstr. P11-D09. [8] Barnes J.W. et al. (2006) *GRL, 33*, L16204. [9] Mousis, O. et al. (2008) *Astrophys. Jour. 677*, L67.