**ALLUVIAL FANS ON TITAN REVEAL MATERIALS, PROCESSES AND REGIONAL CONDITIONS.** J. Radebaugh[1] R.D. Lorenz[2], T. G. Farr[3], R. L. Kirk[4], J. I. Lunine[5], D. Ventra[6], A. Le Gall[7], R. M. C. Lopes[3], J. W. Barnes[8], A. Hayes[5], E. R. Stofan[9], S. D. Wall[3], C. Wood[10]. [1]Department of Geological Sciences, Brigham Young University, Provo, UT 84602 (janirad@byu.edu); [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD; [3]Jet Propulsion Laboratory, Pasadena, CA; [4]USGS Astrogeology Division, Flagstaff AZ; [5]Cornell University, Ithaca, NY; [6]Utrech University, Utrecht, NL; [7]LATMOS-AVSQ, Paris, France; [8]University of Idaho, Moscow, ID; [9]Proxemy Research, Laurel MD; [10]Wheeling Jesuit University, Wheeling, WV.

**Introduction:** River channels are seen abundantly on the surface of Titan with Cassini's Synthetic Aperture RADAR (SAR) at 300 m resolution [1]. They cut through a variety of terrains, as evidenced by different morphologies, are SAR-dark where filled with liquid or fine sediments and are SAR-bright where cm+-sized grains fill their beds [2,3]. In polar regions, where there are lakes and seas of methane/ethane, river channels terminate in deltas, but at the dry mid-low latitudes, the channels end in alluvial fans. These fans indicate vigorous fluvial processes occur or occurred on Titan, they delineate regional drainage areas, and they reveal local maintenance of relief and changes in slope, factors otherwise difficult to determine.

**Alluvial Fans:** Alluvial fans represent the distal end of an erosion/deposition system, where materials are derived from uplands, transported through channels, and deposited in lowlands. They are commonly subject to episodic sedimentation and ephemeral runoff, especially in desert environments. Different regions of the fan surface are active at any one time, rather than the entire fan surface, and the current deposition/erosion style reflects the most recent topographic and climatic conditions.

**Fans on Titan:** The region far to the north of Xanadu contains a unique set of landforms that may be impact, fluvial, or cryovolcanic in origin, Ganesa Macula and surroundings (partly revealed in the first image returned from the surface of Titan by Cassini SAR, Ta). Just over 100 km east of Ganesa (51°N, 80°W) are features identified as overlapping fans emerging from long river systems, termed Leilah Fluctus (Fig. 1). The fan system is generally SAR-bright, indicating the presence of >cm-sized grains derived from erosion through rainfall and mechanical fluvial processes. Variations in SAR brightness indicate the presence of SAR-dark fines and other materials and perhaps pre-existing structures. Alternating SAR brightnesses in arid fans on Earth indicate deposition of different-sized materials resulting from changes in flow velocity or bedload characteristics in the feeder stream or changes in location of active fan lobes. Brightness differences can also illuminate fan surface ages and changes over time [4]. All of these possibilities indicate a prolonged history and long-term changes in depositional processes.

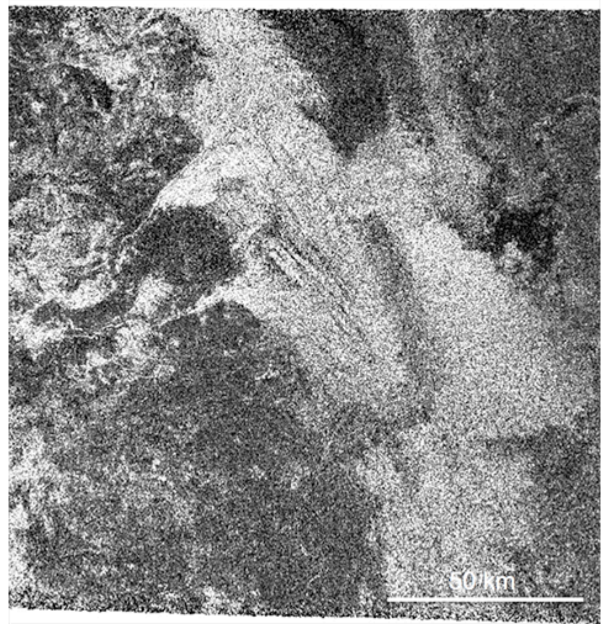


*Figure 1. SAR-bright fans (triangular deposits) north of Xanadu terminate channels from the west. Leilah Flucus, Ta, 10/26/04, 51°N, 80°W.*

A broad, coalesced fan terminates a large river system, Elivagar Flumina [1], which is immediately north of Xanadu at 20°N, 77°W and ~150 km east of the 450 km diameter Menrva crater (Fig. 2). The fan system extends laterally at least 120 km (perhaps twice that, according to lower-resolution HiSAR data) and contains more than seven fans clearly visible to Cassini SAR. In Titan's southern hemisphere, rugged, fluvially dissected highlands give way to moderately bright deposits containing long, interlaced, SAR-dark distributary channels (60°S, 358°W) (Fig. 3). This fluvial system drops ~1.3 km over ~450 km, according to SAR-Topo data [5]. This indicates the fans are part of an erosion/deposition system begun in highlands to the north and ending in lowlands to the south.

**Fans Reveal Materials:** That fans are generally SAR-bright on Titan indicates they are composed of materials near the size of the SAR wavelength, 2.17 cm. Additionally, some river bed materials are unusually bright, indicating they may be especially good SAR reflectors. These are best modeled as round grains of water ice or solid organics transparent to

SAR at 2.17 cm [2]. Visual and Infrared Mapping Spectrometer (VIMS) data indicate the presence of water ice in the Elivagar Flumina fans, in contrast with surrounding materials that have an organic signature. Thus, transport and erosion of water-ice-rich bedrock may dominate the formation of the fans observed so far. However, channels are also found in cohesive materials on Titan, which may be organic sedimentary layers derived from processing of atmospheric methane. Thus, organics are also likely present in Titan's fans.

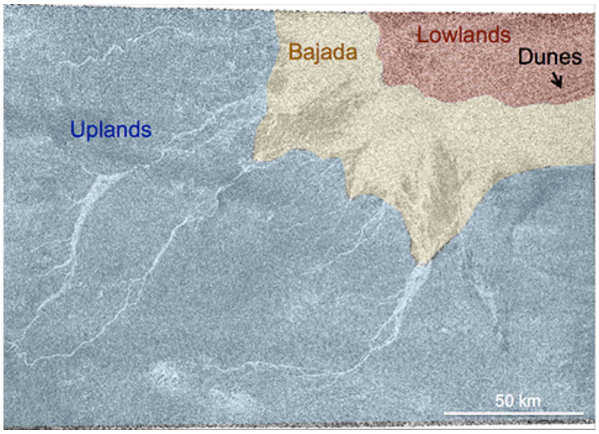


*Figure 2. Elivagar Flumina channels erode through the uplands and material is deposited in fans at the bajada, near lowlands to the NE. T3, 20°N, 77°W.*

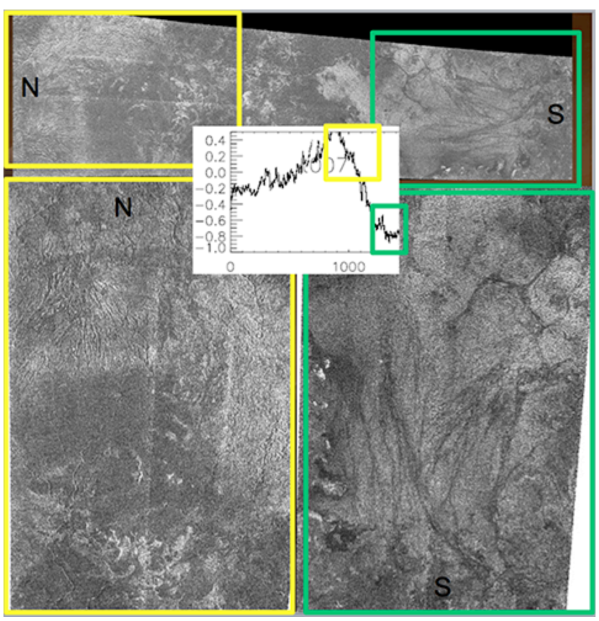


*Figure 3. Rugged highlands (left) descend to broad fans (right) in Titan's southern hemisphere, T7, 9/7/05, 60°S, 358°W.*

**Fan Drainage Relationships:** Fans are correlated with their drainage areas according to the relationship $A_f = cA_d^n$, where $A_f$ and $A_d$ are fan and drainage areas, respectively, n is the slope of the relationship on a log-log plot, generally close to 1 on Earth, and c is a constant that varies more widely and is related to how much the fan spreads out [6]. Where drainage basin boundaries are clear, we can map drainage/fan areas to determine n for a collection of fans and c for individual fan systems. This will provide new information about material differences, since different values for c could indicate there is a variety of materials making up the fans. If c values are consistent across Titan, or if there is a regularity to c values based on location or other factors, then we can utilize the relationship to find drainage basin areas where these are difficult to determine.

**Fans Reveal Slopes:** Where fluvial systems transition to alluvial fans, often there is a corresponding break in slope. This can be seen where Elivagar Flumina terminates in the fan system. Channels run southwest from the crater approximately 150 km to the west, and they end in a uniformly aligned fan system. This indicates slopes have leveled off and deposition has occurred. A few large, linear sand dunes are present in the region to the northeast of the fan system, indicating it is serving as a depositional sand sink. Perhaps the fans are contributing sands to the dunes, which do not form on the fan surfaces because they are wetted, actively transporting material fluvially, or are slightly elevated above the dune region. In an alluvial framework, these regions could be termed erosional uplands, bajada (where fans are being deposited downslope), and depositional lowlands (Fig. 2).

**Fans Reveal Climate:** The largest fan systems on Titan are found at low-mid latitudes, regions thought to undergo episodic wetting and drying [7], similar to terrestrial deserts. The anabranching character of Elivagar Flumina, for example, is consistent with an episodic rainfall regime [1]. Thus, a study of fans may reveal climate conditions, precipitation rates and transport characteristics.

**Conclusions:** Alluvial fans on Titan are indicators of active fluvial processes, now or in the past. Fan morphologies on Titan reveal drainage areas, regional geology, slopes, and past and present climate details where this information is otherwise difficult to obtain.

**References:** [1] Lorenz R. D. et al. (2008) *PSS 56*, 1132-1144. [2] Le Gall A. et al. (2010) *Icarus 207*, 948-958. [3] Perron T. J. et al. (2006) *JGR 111*. [4] Farr T. G. Chadwick O. A. (1996) *JGR 101*, 23,091-23,100. [5] Stiles B. A. et al. (2009) *Icarus 102*, 584-598. [6] Bull W. B. (1964) *USGS Prof Pap 437-A*. [7] Turtle E. P. et al. (2011) *Science 331*, 1414-1417.