XANADU – DISAGGREGATION OF TITAN'S BRIGHT TERRAINS. C. A. Wood[1], E.R. Stofan[2], R.D. Lorenz[3], R.L. Kirk[4], R.M. Lopes[5], P. Callahan[5], B.W. Stiles[5]. [1]Wheeling Jesuit University, Wheeling, WV26003; chuckwood@cet.edu, [2]Proxemy Research, Bowie, MD 20715; [3]Johns Hopkins Applied Physics Lab., Laurel, MD 20723; [4]US Geol. Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001; JPL, [5]Cal Tech, Pasadena, CA 94305.

Introduction: A landform inventory of the satellites of the outer solar system is largely limited to craters, cracks and flows. Only Titan has a diversity of features far beyond those common planetary landforms. Some of Titan's landforms are a consequence of atmospheric processes (dunes, lakes and rain-fed river systems) but many appear to result from internal processes that produced volcanism, mountains and other terrains that are harder to interpret. Here we describe Xanadu, the largest known feature on Titan, and discuss evidence it provides of the geologic processes and history of this excellent world.

Discovery: Xanadu is one of the rare outer solar system satellite landforms discovered from Earth. In 1996 infrared images from the Hubble Space Telescope revealed albedo variations including the detection of a continent-size bright spot subsequently named Xanadu [1]. Although it is large (~4000 X 2000 km) and bright, Xanadu is unique in being dimmer at 5 micrometers than other bright areas [2]. From the telescopic and Cassini spectral information there is little detailed evidence of the nature of Xanadu.

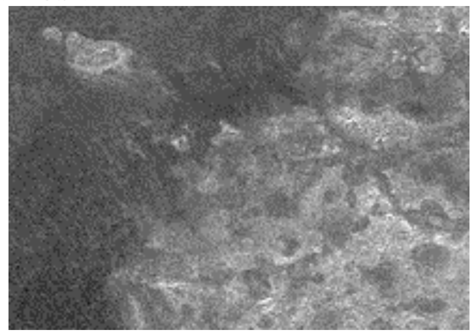
Radar Evidence: The geology of part of Xanadu has been revealed by Cassini radar swath T13, which crosses Xanadu from east to west, and T3 which nips its northern-most extent. Xanadu is radar bright and has complex patterns of surface texture.

The Shangri-la Shore. The western edge of Xanadu has a sharply defined boundary with its irregular bright edge abutting east-west trending dark dunes. A number of bright "islands" appear to be highlands that are surrounded by dunes. These suggest that Xanadu previously extended further west. In some places dunes stop at the western edge of Xanadu and in other areas they lap up onto it. The western edge of Xanadu is thus higher than the adjacent dunes. This is consistent with a general relation on Titan – bright areas are observed to be local highs that dunes diverge around [3].

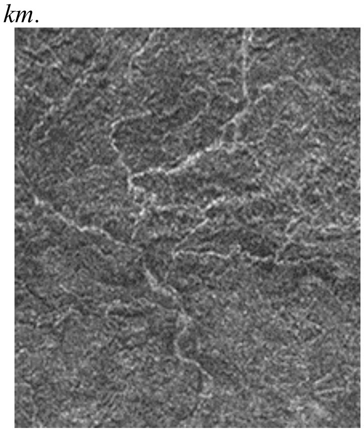
Mottled Riverland: From the west end of Xanadu inland about 650 km is a distinctive terrain. It is slightly bright, relatively flat and includes dozens of roughly circular dark units typically a few tens of kilometers wide. This area is completely transected by four major dendritic river systems. These rivers start near the northern and western edges of Xanadu and all flow to the south. The two major drainages are the centers of darker and rougher terrain.

Knobby Terrain: The largest portion of Xanadu (about 2000 km width) is characterized by small bright interconnected ridges. A few river segments cut through flat spaces between ridges and occasionally through the ridges. Although most of these ridge bits are interconnected they do not form what would be called mountain ranges. They are more like a pervasive ground cover.

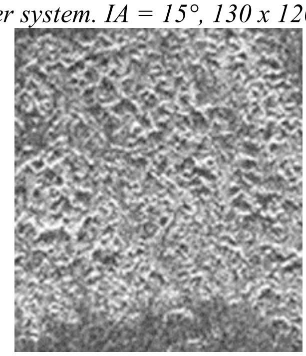
Dark, flat and elongated embayments become more common toward the eastern section of the Knobby Terrain. They create a linear mountain and flat plain look reminiscent of Basin and Range terrain in the Western US on Earth.



Mottled Riverland (right) and Shangri-la Shore (left). All look directions from top; incidence angle (IA) 21°, 190 x 310 km.

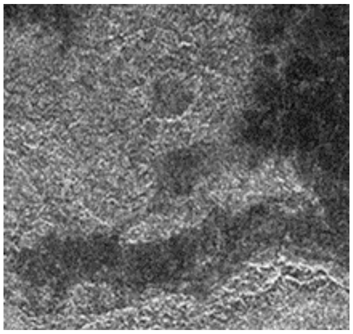


River system. IA = 15°, 130 x 120 km.



Knobby terrain. IA=26°, 70x60 km.

Subdued Cratered Terrain: The easternmost 1200 km of the T13 radar swath of Xanadu has yet another surface texture. It has a subdued mountainous look, lacks the individual ridge peaks, and appears flatter than Knobby Terrain. It is extensively cut by straight-sided, lower and smoother dark material that is the same as that bordering the eastern end of Xanadu. Both the dark and bright material are cut by rivers, but they do not form an integrated drainage pattern as in the Mottled Riverland. The Subdued Cratered Terrain contains eight possible impact craters in various erosional states. No other impact craters are visible in the rest of Xanadu, although two possible ones occur on the islands to the west.



Subdued Cratered Terrain. IA=17°, 110x110 km.

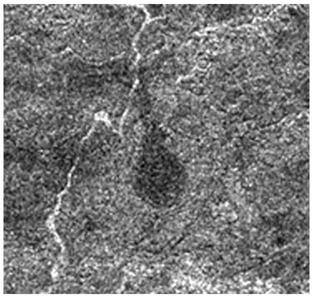
The Eastern Shore: At its eastern edge some of the dark troughs that cut bright Xanadu open up to smooth dark terrain. Irregular patches of bright Subdued Crater Terrain are completely surround by the dark unit, and it is cut by a number of bright rivers.

Interpretations: Xanadu is not a homogenous terrain, as is generally true for such large areas on Earth and other worlds. Xanadu's brightness at radar wavelength is due to its many peaks and hills, but there is little evidence that the topographic relief is very great. The overall impression is that the different terrains of Xanadu are relict from an earlier time. The fact that the subdued cratered terrain contains numerous likely eroded impact craters suggests that it is older than other observed surfaces on Titan.

Both the eastern and western ends of Xanadu are broken and replaced by lower dark terrains. On the Shangri-la side the dark material is dunes, and on the eastern end it is simply a smooth surface. The disaggregation appears to have reduced the extent of Xanadu, as evidenced by the bright islands at each end. At the eastern and northeastern edges the radar-bright highland mass is sundered by dark troughs that appear caught in the act of transforming the surface. This disaggregation may be an ongoing process, and appears to be happening elsewhere on Titan where optically bright terrains are bordered by dark ones with nearby white islands. A characteristic of the replacement of bright with dark terrains is that often the created boundaries are linear, suggesting a tectonic influence.

The mechanism of transformation from bright hilly terrain to smooth dark terrain is not certain, but one clue is that the transformations are most pervasive near the edges of Xanadu. Also, the linear boundaries of the dark areas implies that the process is more deeply seated than simple surficial erosion.

Another possible clue to a mechanism for transforming bright hilly terrain to dark smooth material is the occurrence of roughly circular dark blobs in western Xanadu. One is teardrop shaped, suggesting viscous flow. These may be diapirs of lower density material that were heated at depth and moved upward. The dark blobs do not occur elsewhere on Xanadu and are different from the linear dark troughs in the east. Perhaps there are multiple processes for transforming bright material.



Teardrop dark blob surrounded by collar of modified country rock. IA=21°, 80x80 km.

Global Speculations: Broad scale coverage by ISS and VIMS shows that Titan has surfaces of various reflectivity and hue, but a zero order division exists of bright and dark terrains. The larger dark terrains (e.g. Senkyo, Belet, Shangri-la, Fensal) are interconnected by narrower linear ones (Aaru, Ching-tu, Aztlan), and nearly all are within 30° of the equator. All the adjacent bright areas (Tsegihi, Adiri, Dilmun, Xanadu) appear to be being broken up and disaggregated.

This leads to a speculation that Titan may have been initially surfaced by bright hilly terrain such as Xanadu and that within the equatorial zone it is being destroyed and replaced by lower elevation dark material. This may be a planetwide process with Xanadu being the largest relatively intact older terrain in the equatorial region. The existence of eight possible old impact craters in eastern Xanadu supports its interpretation as older material. Indeed, all three of the accepted impact structures (Menrva, Sinlap and Krs) occur on patches of bright terrain. A proposed working relationship for Titan is bright equals old and high, dark equals young and low. Now we need more radar coverage to test it!

References:

[1] Smith, P.H. et al, 1996, Icarus 119, 336-349. [2] Barnes, J. et al, 2007, *Icarus*, in press. [3] Radebaugh, J. et al, 2007, *Icarus*, in press.