MOUNTAINS ON TITAN OBSERVED BY CASSINI RADAR. J. Radebaugh[1], R. Lorenz[1], R. Kirk[2], and J. Lunine[1], and the Cassini Radar Team, [1]Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721 (jani@LPL.arizona.edu), [2]United States Geological Survey, Flagstaff, AZ.

Figure 1. Titan T3 Radar swath obtained Feb. 2005. Strip extends from approximately 0° – 20° N and 10° – 128° W.

Introduction: Among the diverse array of geological features found by Cassini instruments on Titan's surface, such as impact craters, possible dunes, shorelines, and cryolava flows, are features best described as mountains. Using data from the T3 and T8 flyby swaths obtained in 2005 by the Cassini Radar instrument (2.17 cm) in synthetic aperture radar mode [1], we observe that these features range in size and morphology from isolated, <5 km blocks to chain-like "ranges" >100 km in length (Figs. 1-4). These features reveal topography in the presence of light/dark pairs, indicative of radar illumination across a sharp topographical boundary. Each feature is surrounded by a diffuse deposit, oriented in the same direction as nearby cat scratches [2], that is likely shed from a centrally high region through erosion.

Study area: Mountains are found in two main regions in the T3 swath, with unique morphologies exhibited in each region.

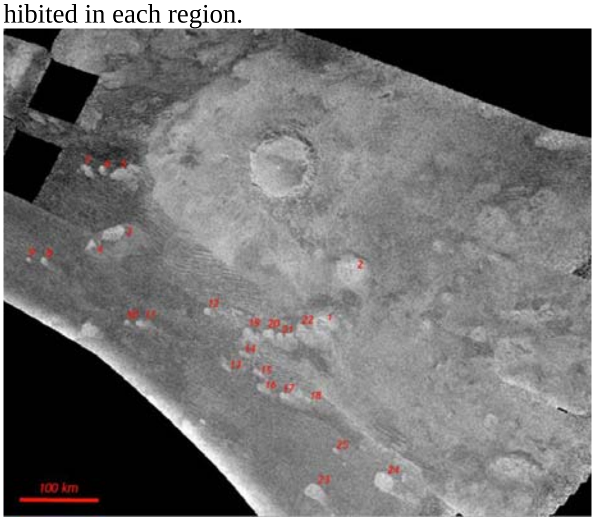

Figure 2. Area A from Fig. 1. Impact crater seen in upper middle; mountains (numbered) surrounded by blankets showing orientation parallel to cat scratches.

Mountains in Area A (Figs. 1, 2) are generally isolated blocks found in flat plains. Copious dark cat scratches found in this region abut the mountain margins and light-colored surrounding blankets that may be slightly elevated over the plains, like bajadas in western U.S. deserts. Mountains in Area B (Figs. 1, 3) form long, linear chains with some surrounding isolated blocks. Light blanket-like deposits also surround the mountains in this area, though indicators of erosion-modified flow direction are not as strong as in Area A.

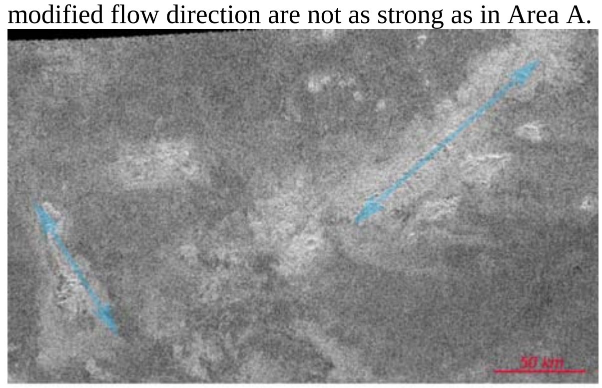

Figure 3. A portion of Area B from Fig. 1. Mountains generally form linear chains, traced in blue.

Mountains in the T8 swath (Fig. 4) are curvilinear in planform and form ranges that extend over 100 kilometers.

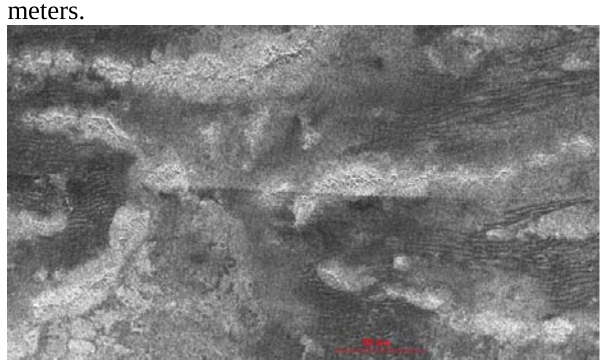

Figure 4. Part of T8 swath. Light, curvilinear features are mountain ranges.

Heights and slopes – radarclinometry method: We undertook measurements of mountain heights and slopes in these regions using shape-from-shading; essentially using knowledge of how the Radar instrument reads values from surfaces pointing at varying angles to the direction of Radar illumination [3]. This method requires the initial assumption of level endpoints and no substantial differences in scatterometry of the surface due to compositional or other changes in material properties. For short distances (< 50 km) and a strong topographic signal, this method provides viable results, but over long distances in which surface property variations swamp altitude signals, topographic returns are suspect.

Heights and slopes – initial results: Most mountains in our study regions are not dramatic features. Mountains in Area A display heights ranging from 250 – 500 m, with a mean of ~300 m (see Fig. 5 for example trace); preliminary heights in Area B show a similar range ~100 m higher. Slopes are fairly gentle, since the mountain traces are typically 10 – 20 km in distance. We report 90th percentile slopes from 5° – 10°, noting that slopes are sometimes complicated by possible shading along the away-Cassini slope.

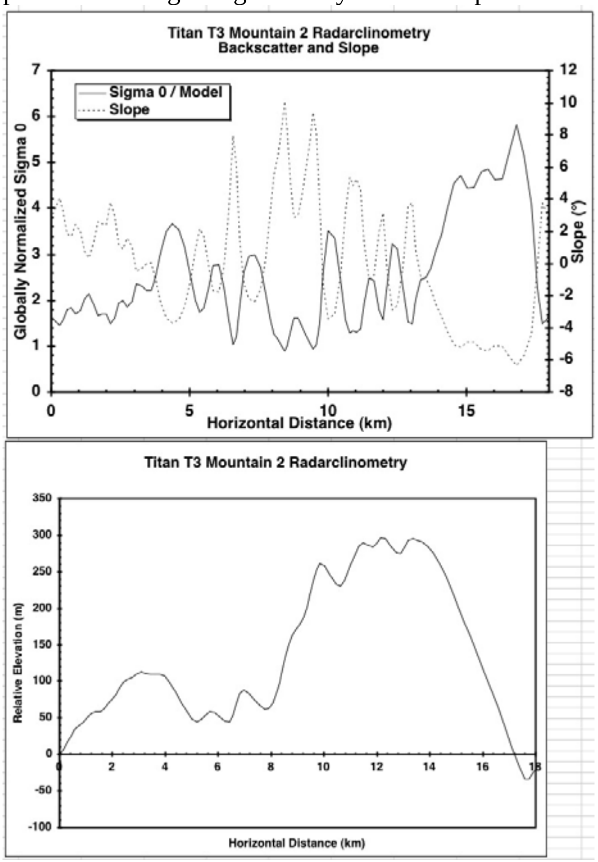

Figure 5. Mountain 2 (Area A) backscatter and slope (upper) and cross section (lower) with vertical exaggeration.

Mountain formation scenarios: Three major scenarios for mountain formation are evident. 1 – The blocks were thrust up from below due to compressional forces in Titan's brittle, icy lithosphere, 2 – blocks have dropped from the sky, by volcanic eruption or impact ejecta, and 3 – a preexisting layer of material was stripped away to leave isolated blocks. We assume that any of these scenarios leads to a high-standing feature that is now subject to the erosional forces of Titan (likely dominated by rain or wind) and evolves to eroded peaks and surrounding blankets of material. We favor scenario 1 for the mountains in Area B (Figs. 1, 3) because their linear-like traces are reminiscent of mountain chains across the solar system that have been created by compression. We consider the possibility of part of scenario 2 for the mountains in Area A (Figs. 1, 2) in the following paragraph.

Mountain Emplacement as Ejecta Blocks: The association of the mountains with the 80 km crater Sinlap is striking and although an origin as ejecta blocks may be surprising, consideration of the relevant ballistics establishes this as at least a possible origin. The mountains are at a range of around 200 km from the crater center: on a flat, airless Titan this would require a launch velocity of only about 500 m/s. For a typical mountain of ~10 km across by 300 m high, the volume of material corresponds to a 2-3 km block. Inspection of secondary craters on the lunar surface [4] shows that at least one block from the Copernicus crater was 2 km across and was launched at 500 m/s. 1000 m sized blocks of limestone are known around the 25 km Ries crater in Germany [5]. Even for high-velocity impacts on present-day Titan, materials are rapidly decelerated by the atmosphere and deposited near the crater [6]. The orientation of mountains 3 and 4 (160 – 200 km away from Sinlap) seems to be approximately radial to the crater, supporting the hypothesis that this is the source.

Further simulations are underway, to model the trajectory across a round, rotating Titan with an atmosphere (effects which can produce curved 'rays'). It may be that in the low gravity and dense atmosphere of Titan, ejecta blocks are uniquely preserved.

References: [1] Elachi, C. e.a. Titan Radar mapper observations from Cassini's Ta and T3 flybys, *Nature*, submitted. [2] Boubin, G. M., e.a. 2005, Mapping and characterization of "cat scratches" on Titan, AAS DPS 37th, Abs. 46.04. [3] Kirk, R. L. e.a. 2005, Radar reveals Titan topography, LPSC 36, Abs. 2227. [4] Vickery, A. M., 1986, Size-velocity distribution of large ejecta fragments, *Icarus*, 67, 224-236. [5] Melosh, H. J., 1986, *Impact Cratering*, Oxford University Press. [6] Artemieva, N. and J. Lunine 2005, Impact cratering on Titan II. Global melt, escaping ejecta, and aqueous alteration of surface organics, *Icarus* 175, 522-533.