Roter Kamm Impact Structure, Namibia : New Field and Remote Sensing insights and analogies with Titan Dune:Crater Interactions R. D. Lorenz[1] R. McG. Miller[2], A.G. Hayes[3], J. Radebaugh[4], J.W. Barnes[5], K.D. Arnold[4], C.K. Chandler[4] [1]Space Department, JHU Applied Physics Laboratory, Laurel, MD 20723, USA. (Ralph.lorenz@jhuapl.edu) [2]Consulting Geologist, Windhoek, Namibia; [3]Cornell University, Ithaca, NY; [4]Brigham Young University, Provo, UT; [5]University of Idaho, Moscow, ID

Introduction: Roter Kamm [1] is a 2.5km diameter impact structure (figure 1,2) in the Sperrgebeit in southern Namibia, estimated to be ~4 million years old, and has a striking appearance, being rather ,shallow (~150m deep)and intruded upon by linear dunes. In this respect it may resemble many Titan craters imaged by the Cassini radar, (figure 3).

Figure 1. The 2.5km Roter Kamm Impact structure, viewed from a small camera suspended from a kite at an altitude of about 150m during our field visit in August 2013. Note the dunes intruding from left, and the sharp slip face on the nearside rim which tails off into a dune at center right. Photo : R. Lorenz

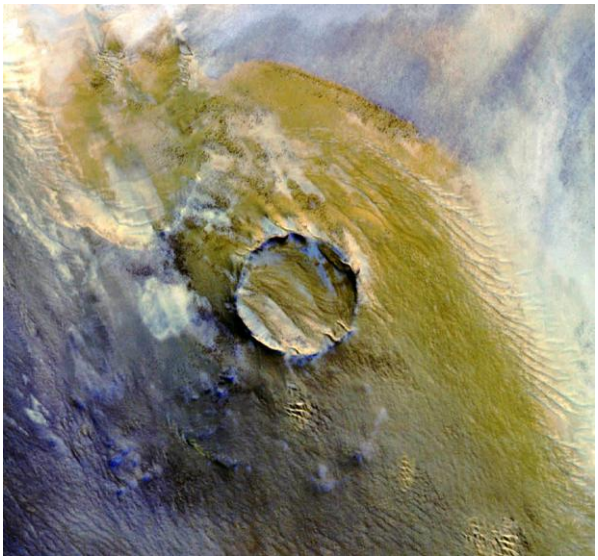

Figure 2. An ASTER near-infrared composite image of Roter Kamm that shows particularly well the dune arrangement.

The structure (and Wolfe Creek and Arounga) was imaged by spaceborne radar on the SIR-C mission [2]It was studied as a Mars analog (where aeolian infill of craters also occurs, essentially without fluvial action) by Grant et al. [3] who used a Ground Penetrating Radar (GPR) to examine the bedding structure of some of the sediment fill.

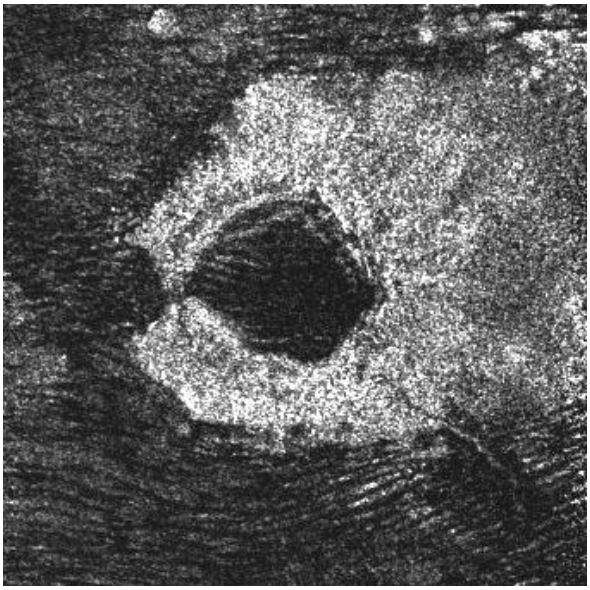

Figure 3. An unnamed impact crater on Titan, about 40km across. The bright rim and ejecta blanket is narrower on the western side from which the dominant sand transport appears to flow. Has the sand broken through the rim by itself, or was there a breach left after an azimuthally-nonuniform crater excavation (many Titan craters are somewhat polygonal rather than perfectly circular), or did fluvial erosion carve a gap in the crater wall ?

Roter Kamm will serve as an important analog as we attempt to decode what we are seeing at Titan. Specifically, how have the moving dune sands interacted with the ejecta blanket around the crater (and specifically, what is the relation of dune deviation angle to distance from and slope of an obstacle)? To what extent have fluvial processes filled the crater, or is its shallow depth entirely due to aeolian infill ? Are breaches in the crater wall and ejecta blanket due to jointing in the target rock, or are they due to fluvial action?

Observations: Unlike at Titan, we can (with some effort) supplement the remote sensing of Roter Kamm structure with field inspection, which we performed in August 2013. In addition to field photography, GPS transects give us high resolution, high precision topog-

raphy data to support the geological interpretation and geophysical models.

We found that our GPS traverse of the crater (using Trimble GeoExplorer XH 6000-cm receiver with differential correction from the TrigNet Springbok station 263 km away to achieve a 68% precision of 0.5 m) rim in fact appears to be very nearly circular (figure 4), with an eccentricity of only ~40/2500~0.02. This is quite different from the ~0.1 estimated in previous work [1] and if correct precludes any inference that the impact was oblique (see [4]).

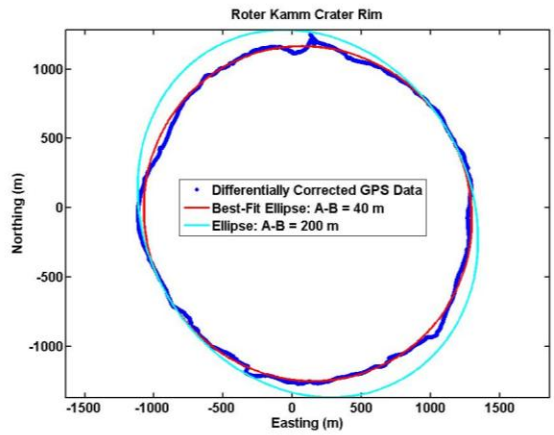

Figure 4. GPS traverse of the crater rim, with a best fit-ellipse having axes that differ only by 40m.

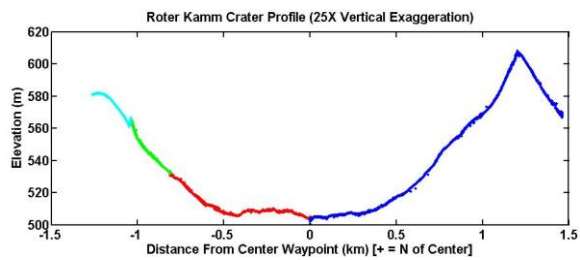

Figure 5. GPS profile of the crater, which has a depth:diameter of ~0.03, comparable with many Titan craters [ref Neish]

Our survey, as previous ones [1,3] shows that the crater rim rises over about 1km to only ~100m above the surrounding plains, i.e. a slope of ~6° (note that the crater is fairly small and thus only just-resolved in orbital topography datasets such as ASTER or SRTM). It is clear that the dunes are able to climb this gradient and breach the crater, rather than being deviated around it. An early reconnaissance showed [5] that a 200m obstacle over 10km on Titan would block dunes abruptly, whereas over longer horizontal scales, obstacles of this height would cause dunes to 'veer'. The question of what the controlling parameters are on this interaction will need to be explored with numerical simulations -it may be that the ratio to the obstacle height to the local planetary boundary layer thickness [6], may be more important than slope.

Future Work : The field visit allows features in the SIR-C/X-SAR data to be correlated with features on the ground (notably the dunes, outcrops and vegetation) and the dune pattern to be related to the somewhat subtle topography of the crater : these relationships may be generalized to Cassini observations of dune diversions at Titan. The GPS profile across the crater (figure 5) will permit comparison with quantitative geomorphic models [7] that discriminate aeolian infill from fluvial downslope migration of sediment. We additionally conducted some GPR observations which will be reported elsewhere.

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