DEGRADATION AND DEFORMATION OF SCARPS AND SLOPES ON IO: NEW RESULTS.

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Introduction: Throughout the Galileo Orbiter mission the SSI Team has undertaken the study of all forms of mass movement and landform degradation of the Galilean satellites [1]. These geologic processes operate to reduce the topographic relief of landforms by the movement of surface materials to a lower gravitational potential. In this abstract we will focus of degradation and deformation of scarps and slopes on Io seen in the recent I24 and I25 encounters with that very active satellite.

Scarp Observations and Interpretations: Scarps bounding a plateau seen in a 183 m/pixel, I25 observation at 60°N, 120°W have characteristics consistent with mass-wasting. A plateau-bounding, east-facing scarp has a steeper, probably cliff-forming component above a less-steep component, consistent with the presence of debris accumulating at the foot of the slope derived from back-wasting of plateau edge. The south-eastern plateau margin is more deeply and consistently scalloped into a series of adjacent concave-outward alcoves distinguished by sharp brinks and slopes becoming less steep as they descend (Fig. 1). Image resolution is insufficient to determine whether material partly covering the floor and lower slopes of individual alcoves represents deposits from major landslides, or the products of less catastrophic mass-wasting; in fact, the lowermost debris derived from these processes may be buried by extensive plains units deposited by nearby volcanic activity. Erosional remnant outliers from the plateau are few and indistinct, and do not provide an instructive erosional sequence for further clues to the processes affecting the walls.

The northeastern portion of the plateau is dissected by a rectangular pattern of alcove-rimmed troughs. This morphology may reflect sapping of, or perhaps the plastic deformation and “glacial” flow of, interstitial volatiles (e.g., SO_2) that are exploiting and enlarging structural patterns of weakness (e.g. joints and fractures), causing disaggregation and further back-wasting into the plateau. Both putative mechanisms rely on locally high geothermal energy to mobilize the volatile.

Slope Observations: Io’s several-kilometer high mountains commonly have one slope (usually the shallower of simple, asymmetric, 2-faceted mountains) that exhibits a corrugated texture formed by small ridges. An example can be seen an I25 image obtained at 160 m/pixel and low sun (Fig. 2). The west side of the mountain shows a surface covered with ridges typically 2 by 10 km in plan and spaced ~ 4 km cross-trend. The ridges along trend pinch and swell and, as sets, appear interleaved or en-echelon. In some cases ridges bifurcate to form 3-shaped junctions. Ridges have convex to convex-ramp to tapered terminations. Ridges in cross-trend profile appear to range from rounded (most commonly) to triangular.

Figure 3 shows one image from an 11-image observation of a very small portion of Ot Mons (in Colchis Regio) obtained at very high resolution (9 m/pixel) and low sun that can be interpreted as a close-up view of ridge texture on mountain flanks such as is shown in Figure 2. Unfortunately the best context available is a ~2 km/pxl image acquired during the E14 encounter. Never the less, if pre-encounter pointing is reliable, Fig. 3 is an image of northern-sloping facet of Ot Mons. In the images from this observation, the surface is covered by E-W trending ridges ~1-2 km long and 0.25-0.5 km wide. Just as with the ridges seen at lower resolution in Figure 2, the Ot Mons ridges exhibit similar pinch and swells, ridge sets appear interleaved or en-echelon, in some cases ridges bifurcate, and have convex to convex-ramp terminations. Ridges in cross-trend profile appear rounded. However, unlike the ridges in Figure 2, some of the Ot ridges appeared breached or disrupted. These breaches or disruptions take the form of steep-walled amphitheaters. These amphitheaters are often elongate and trend the same direction as the ridges. The floors of the amphitheaters are often covered with dark material that is inferred to have moved down-slope to accumulate there. There is terracing within the walls of the amphitheaters that can be interpreted as layering exposed by the amphitheater-forming process.

Slope Interpretations: The morphology of individual ridges and the arrangement of ridge sets might best be interpreted as the manifestation of compressional folds in a surface layer overlying a shallow decollement, or perhaps a ductile sub-surface [2]. This ridge texture is most pronounced on slopes, which suggests that they formed by gravity sliding of a detached surface layer. If Io’s mountains form by the tilting of pre-existing crustal blocks, the shallower ridged facet may be the original (formerly flat) pre-mountain surface. Cumulative successions of plume fall-out, SO_2condensates, landslide material, and lava flows probably form stacks of thin, areally extensive layers within the plains, and may have formed the layers seen on Ot Mons. If such stacks of material have weak layer-to-layer contacts, they would be susceptible to deformation and detachment when tilted. Schenk and Bulmer [3] proposed a similar configuration as a contributor to mountain landslides on Io.

Preliminary modeling of horizontally compressed folds with ~1 to 4 km wavelength suggests formation in a single competent elastic layer of thickness h of order 20 to 100 m. In the likely case of n possible elastic layers (such as silicate flows) separated by incompetent material (such as plume fallout) the total thickness H of the competent material will be $H = n^{0.67} \times h$.

Anticlinal ridges commonly have extensional features along their crests [e.g., 2]. This could, at least in part, explain the amphitheaters among the ridges seen on Ot Mons (Fig. 3). The dark material within the amphitheaters may be accumulations of plume fall-out. However, the amphitheaters are, relative to the ridge size, very large compared to terrestrial examples of extensional features along uneroded anticlinal ridges. The amphitheaters may be enlarged by sapping or sublimation-degradation, in which case the dark material may be erosional detritus. SO_2 sapping is a plausible model [4], but the amphitheater walls do not exhibit obvious sapping morphologies. The appearance of amphitheater walls is consistent with sublimation-degradation [5], but it is difficult to identify a suitable volatile (e.g., H_2S) that has been clearly observed at Io.

References: [1] Moore, J. M. et al. (1999) *Icarus, 140,* 294-312. [2] Pappalardo, R. T. and Greeley, R. (1995) *JGR., 100,* 18985-19007. [3] Schenk, P. M. and Bulmer, M. H. (1998) *Science, 279*, 1514-1517. [4] McCauley J. F. et al., (1979) *Nature, 280*, 736-738. [5] Moore, J. M. et al. (1996) *Icarus, 122*, 63-78.

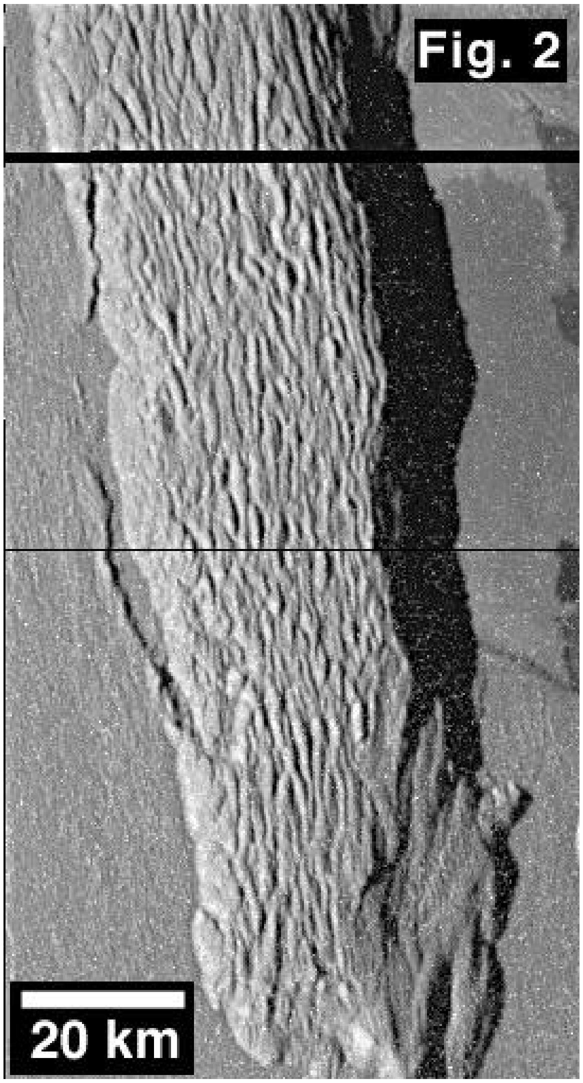
Fig. 2

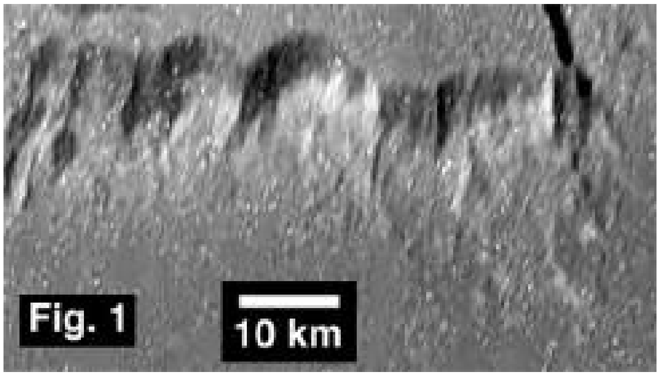
Fig. 1

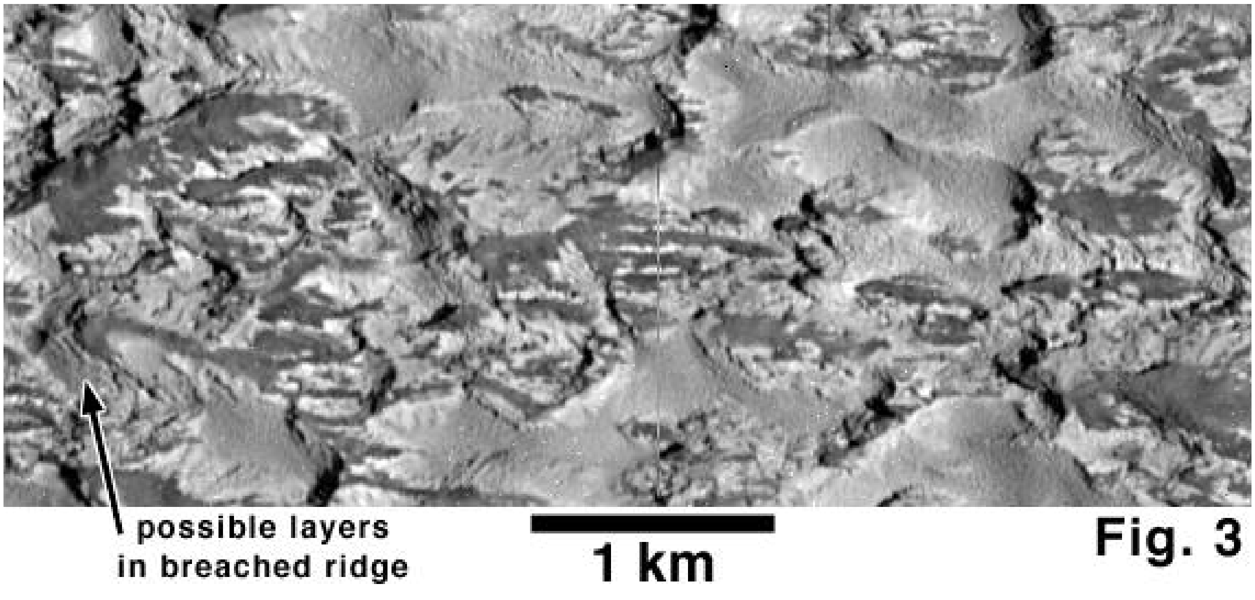

Fig. 3