HILLSLOPE LANDFORMS ON VENUS: PRELIMINARY RESULTS FROM MAGELLAN

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Introduction

Preliminary interpretation of Magellan radar images of the surface of Venus suggest that gradational processes are relatively weak, with estimates of eolian re-working rates for crater ejecta, for example, being < 10^{-1} µm/yr (Arvidson *et al.*, 1991). Reflectivity measurements suggest much of Venus is covered, at most, by a relatively thin veneer of unconsolidated material. Environmental geomorphic processes thus appear to be ineffective on Venus.

Tectonic processes, on the other hand, appear to be extremely effective in creating significant relief variations, at least on a regional scale, and many local to regional scale slopes show evidence of formation of escarpments by displacement across faults or other bedrock fractures. Given the locally high slope gradients found in, for example, the mountain belts surrounding Lakshmi Planum, it is not surprising that evidence of mass movements is visible in Magellan data, despite their relatively low resolution (75 m/pixel). Arvidson *et al.* (1991) note that mass movements may be a principal mechanism for exposure of fresh material at the venusian surface, thus playing a critical role in the limited rock cycle apparent on Venus.

This work describes a preliminary assessment of small scarp-form and local relief relationships being conducted under the auspices of the Magellan Guest Investigator Program.

Observations

Analysis has centered on three hillslope forms: 1) steep (≥10°), intermediate width (~5-10 km), high-relief (~1-2 km) single slopes; 2) gentler (5-10°), wider (several 10's km), intermediate-relief (0.5-1.5 km) multiple escarpments; and 3) steep or gentle, narrower, relatively low-relief single escarpments. Strong viewing asymmetries are apparent in the Magellan data, and make interpretation difficult. Slopes oriented approximately perpendicular to the radar viewing direction display foreslope shortening and layover and backslope lengthening, which acts to exaggerate features both geometrically and in brightness such that longitudinal (downslope) features are seen primarily on the darker, viewing-geometry elongated slopes facing away from the radar. Transverse features are enhanced on the radar-facing slopes in this viewing geometry. On slopes oriented parallel to the radar, longitudinal features display characteristic ">" shapes, pointing away from the radar for depressions and towards the radar for ridges. Transverse forms are nearly invisible in this viewing geometry.

Steep, intermediate length, high-relief escarpments are rare on Venus. Such escarpments typically show the best evidence for mass movements, including spur and gully forms, repetitiously cuspate (adjacent) main scarps, and, occassionally, multiple block units and transverse ridges. Weak evidence suggests that the upper slopes are steeper than the lower slopes (i.e., a concave upward slope profile). Only a few unusal occurances show thick debris accumulations at the base of the escarpment (for example, at 60°N, 338°W - NE Danu Montes - F-MIDR.60N334); more typically, only a faint albedo pattern indicates the extent of runout of debris from the superjacent slopes. These slope-forms occur under relatively restrictive tectonic conditions--in areas of subsidence (associated with magma withdrawal or differential uplift) or is areas of highly localized and extreme uplift or extrusion (e.g., the laccolithic dome at 36°N, 330.5°W - F-MIDR.35N330).

The majority of the concentrated differential relief on Venus appears to be accommodated in sets of roughly parallel escarpments. Each scarp or ridge tends to be only a few hundreds of meters across and at most comparable in height. The largest relief on the planet (for example, that across the mountain belts) occurs in the form of these multiple escarpments superimposed on larger, gentler slopes, thus resembling stairsteps. At the available resolution there is little evidence that these slopes shed more than a minor amount of debris--no aprons are visible at the feet of the escarpments and the scarp brink is relatively smooth and unmarked by crenelations associated with block failures. Individual scarp gradients appear relatively uniform (i.e., the slopes appear straight), while the slope upon which the scarps are superimposed often appear convex upward.

Single or paired escarpments occur in many places in the venusian lowland plains. These are graben associated with regional extension, and ridges and/or fractures/faults concentrated in ridge or groove belts (Solomon *et al.*, 1991). The surfaces immediately adjacent to these escarpments are often brighter in the radar images than are surfaces some distance away, suggesting roughness associated with debris shed from these slopes (e.g., Arvidson *et al.*, 1991). However, this debris is not sufficiently thick to create debris aprons, the slopes are too small to allow longitudinal features to be recognized, and hence description of the mechanism of mass movement is not likely. Relief and slope values for these escarpments are intermediate between the two previously discussed scarp-forms.

Discussion

The paucity of large single escarpments, and the preponderance of segmented slopes, argues for a weak near-surface layer (e.g., Solomon *et al.*, 1991, discuss several examples where strain has been limited to a layer only a few hundred meters thick). Relatively naive application of factor of safety calculations suggests that, even in the limited occurrences of large and steep slopes, the slope behavior is mostly like unconsolidated or weakly consolidated material. The abundance of talus is difficult to establish owing to the lack of specific features related to this debris form (it is marked mostly by smooth, straight slopes at or near the angle of repose). Given local relief relationships and overall slopes, talus must be relatively restricted (talus cone growth is limited by the height of steeper slope exposed above the cone and the distance debris shed from that slope must move down the cone). Two rates interact to establish the limits of talus development--the rate of removal of debris from the talus slope (dependent on its rate of break-up and its rate of transport) and the rate of supply of debris from the superjacent slope (dependent on the slope-steeping rate and the weathering rate of *in situ* material). Obviously, if the supply rate is less than the removal rate, the slope appears denuded. If, on the other hand, the supply rate is greater than the removal rate, the process chokes in its own detritus and ceases to be effective (i.e., the talus cone extends nearly to the brink of the slope). On Earth and Mars, weathering and transport process effectiveness and slope-steepening rates can be estimated from the position of the apex of the talus on the slope; it is the goal of this project to attempt to establish similar relationships for Venus.

References

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