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Slope Morphology of Twin Peaks, Mars Pathfinder Landing Site

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Development of slope form over time has long been a concern of geomorphologists, although recently this concern has been moved to slope processes rather than form.

There are two basic approaches. The first is theoretical, involving modeling of different types and rates of processes, and calculation of results in terms of slope evolution over time. Comparisons with real-life slopes can follow this approach [1], [2]. The second, inductive, approach involves field measurements to test ideas about slope evolution starting from the assumption that observed slopes represent different stages of an essentially similar evolution [3]. Space is substituted for time, and a number of slopes, assumed to be of increasing age, are measured and placed in an evolutionary sequence (e.g. [4], [5], [6]).

[5] showed that slope angles are modally distributed, with the modal angles controlled by the materials (regolith) of which the slopes are formed, and by the processes operating on them. Data can be obtained directly from field work or from digital elevation models (DEM) derived from remote sensing investigations [7]. DEMs are particularly useful to study inaccessible planets, such as Mars, where on site observations are restricted to only a few landing sites. Here we present a study of slopes on the Twin Peaks, two small hills located 780 m north and 910 m south of the Mars Pathfinder landing site at the mouth of the Ares and Tiu flood channels. The presence of streamlined hills, jumbled surfaces and conglomerates suggested the region was modified by massive flooding 1.8 – 3.5 billion years ago [8], [9]. The streamlined forms and terraces of the Twin Peaks were taken to indicate catastrophic flood conditions that were believed to be prevalent in the area [8]. It was also suggested that the northernmost peak was topped by floodwater, causing its flatter appearance. Other researchers postulated alternative geomorphological origins for the features observed at the Pathfinder landing site. Processes such as ice flow or deposition were proposed as being the principal cause of most of observed features, by analogy with similar features observed on Earth [10].

Here we propose that the slopes on the Twin Peaks may provide an indication of the processes that shaped them after they were formed. This work shows the results of a detailed morphometric analysis of slopes on the southernmost peak, conducted to gain a greater understanding of past and present slope processes at work at the Pathfinder landing site.

The southern Twin Peak is a conical hill rising 38 m above the local terrain. A portion of the Pathfinder super panorama was used to analyse the hill-slope morphology. The camera horizon was used as a baseline and all slope angles were measured from this. The hill comprises four separate regions including the top of the hill, which is convex in shape. The convex nature of the hilltop is a common if not ubiquitous feature of hills regardless of their origin. It is related to the creep processes that frequently dominate the tops of hill slopes. In this case it was probably caused by heating and cooling during the Martian diurnal cycle, by the action of soil water, or a combination of both.

All slope sections were observed to be similar in length. The slopes nearest the hill top measure 21° and

22.5° respectively on the north and south sides of the Southern Twin Peak. Mid way down the hill the next sequence of slopes have north and south angles of 9° and 15° respectively. Shallow end-slopes measure 4° and 5° north and south respectively. Similarity of slope angles and lengths indicates symmetry, suggesting that the rocks are the same all around the hill.

Our analysis suggests that slope angles are controlled by a combination of the materials of which they are formed and the processes that are operating on them. Their primarily symmetrical outlook indicates no structural control, suggesting that the hill is formed by flat-lying or massive homogeneous rocks. This being the case, slope morphology results from shallow processes related to mass wasting and surface erosion, although it is obvious from the difference in slope angle between the upper and lower slopes that there is a difference either in lithology across the section of the hill, that the erosional effects were different, or that the surficial processes acting on the slopes were different.

On Earth slopes frequently evolve by lower facets expanding upwards at the expense of the facet above, a process defined as slope retreat and replacement - lower slope facets replace upper slope facets. Therefore we conclude that the second possibility is more likely. The mid slope region marks a departure from symmetry with a 6° difference between the two sides. This may indicate separate processes operating on either side of the hill. Further investigation is currently underway to clarify the nature of the mid-hill slope differences. Additional studies are also being conducted to determine the sequence of lithologies forming the peak.

References

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