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N91-27062

HAVE GRABEN WALL SCARPS ACCUMULATED SAND AND DUST ON MARS?

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Grabens are linear fault bounded troughs that are extremely abundant on Mars (about 7000 cover the western hemisphere). Their dimensions are variable, but commonly are a few kilometers wide, a hundred meters deep and tens to hundreds of kilometers long. In their simplest form, grabens have flat floors, parallel bounding scarps of equal width (and height), flat shoulders at equal elevations, and extend for many kilometers in length with only small changes in width. In surface appearance and morphology many look fresh and unmodified.

Analysis of lunar and martian grabens as well as analogous structures on Earth indicates that grabens form under extension when the crust is pulled apart. The graben accommodates the extension by slip along inward dipping normal faults that allow the floor of the graben to drop. Measurement of the increase in width of simple grabens over local regions of high relief on the Moon (e.g., 1) and observations of the trace of faults bounding grabens where they intersect the walls of steep troughs on Mars (2) shows that faults bounding grabens dip at about 60°. Nevertheless the slopes of graben wall scarps are substantially shallower than this. On the Moon, measurement of graben wall slopes (1), where high resolution topographic maps exist (Lunar Topographic Orthophotomaps), shows slopes of 15-23° (average of 18° for 17 determinations). It is not clear how graben scarps weather from their initial steep slopes to slopes lower than the angle of repose (about 30° for unconsolidated material applicable to the outer layers of the Moon). A possible explanation is mass wasting by seismic shaking and impact by micrometeorites. Mass wasting involves unconsolidated material along the top of the scarp sliding and crumbling down the graben walls thereby reducing the slope down to the angle of repose. Micrometeorite bombardment could be responsible for reducing angle of repose slopes to those observed.

On Mars topographic maps are not of sufficient resolution to measure graben wall slopes. However, about 150 measurements have been made using photoclinometry, a technique based on pixel brightness variations along a profile being due to topographic relief (assuming the albedo is constant), which has been shown to be accurate to within 15% over areas of local relief (e.g., 3). Results show low slopes of 7-11° (2, 3), with an average of 9° or about half that of lunar graben scarps. Even if there is a factor of 2 uncertainty in the slopes they are still well below the angle of repose expected simply from mass wasting and micrometeorite bombardment cannot be appealed to on Mars. Although the cause of such low slopes is not known, the deposition of sand and dust is a possible explanation.

Seismic shaking on Mars might be capable of reducing 60° fault scarps to the angle of repose. Some other process must be responsible for further reducing graben wall slopes. Whatever process this is, it has not altered the fresh appearance and simple symmetric profile observed at the resolution of the Viking images. This seems to rule out water driven processes such as sapping or runoff (erosion), as such processes would not preserve the parallel linear scarp edges across the structure, but would tend to scallop out and further make the edges irregular, which is not observed. In contrast the deposition of sand and dust along graben walls might be capable of producing a smooth even scarp of low slope.

If the deposition of sand and dust along graben walls is responsible for their extremely low slopes, then a variety of implications are possible. Sand and/or dust movement and deposition is ubiquitous in grabens over most of Mars, as similar looking grabens are found over the entire western hemisphere and this requires a plentiful supply of sand or dust. If the material that accumulates is of low density and cohesion, attempts to traverse graben walls might be difficult. Finally, rimless shallow depressions could be more effective sinks for sand and dust on Mars than has been realized.

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