SEDIMENTARY BEDDING FEATURES OF MARTIAN POLAR LAYERED TERRAIN. K. S. Edgett and M. C. Malin, Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191-0148, USA.

Synopsis: The polar layered materials of Mars exhibit many of the bedding characteristics of terrestrial sedimentary rock, including continuity over 100s of km distance, deformed beds, erosional unconformities, and beds exhibiting different degrees of resistance to erosion. In addition, more and thinner beds are observed by MOC than could be seen in earlier Mariner 9 and Viking orbiter images, suggesting that climate-induced control on deposition and erosion patterns have occurred on time scales of much less than 10^6 or 10^5 years. These results suggest that the Mars Polar Lander might have indeed found small layers had that mission successfully landed.

Background: "Laminated terrain" or "polar layered deposits" have been known since the Mariner 9 spacecraft first obtained high resolution images of the south polar region in 1971-1972. The layered nature of the polar material led to immediate speculation that these units are a type of sedimentary deposit, most likely a mixture of silicates (dust fallen from suspension and sand transported along the ground via saltation and traction) and ice accumulated on a seasonal basis. The fact that the material is expressed in layered form suggested that something in the depositional environment must change from time to time, causing pauses or changes in deposition and perhaps erosional unconformities that would mark boundaries expressed as bedding planes. The apparently similar thickness and repeatability of the layers as seen in Mariner 9 and Viking orbiter images suggested that these might be the result of climate change-induced control.

When it was proposed to NASA in 1985, one of the original objectives of the Mars Observer Camera (MOC) was to determine whether the polar layered deposits—then thought to consist of 10 to 100 layers each between 10 and 100 meters thick—have more and thinner layers in them. The layers were thought to have formed by slow accumulation of dust and ice—perhaps only 100 µm per year. A layer 10 meters thick would take 10^5 to 10^6 years to accumulate, roughly equal to the scale of predicted climate changes induced by obliquity and eccentricity variations.

Early MGS MOC Results: The Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) has obtained hundreds of high resolution (1.4–10 m/pixel) images of layer outcrops in both the north and south polar regions of Mars. This paper presents some of the basic sedimentological features of the north polar layered outcrops and is intended to illustrate features that are also common to the south polar region. Note that a companion abstract [1] describes the differences between north and south polar regions.

More Beds, Resistant Beds: Figure 1 shows a slope along the edge of the permanent north polar cap that has dozens of layers exposed in it. The image shows many more layers than were visible to the Viking orbiters (*e.g.,* Viking image 560B60). The layers appear to have different thicknesses (some thinner than 10 m) and different physical expressions. Some of the layers form steeper slopes than others, suggesting that they are more resistant to erosion. The more resistant layers might indicate that a cement (possibly ice) is present, making those layers stronger. Alternatively, the resistant layers might be less volatile-rich and hence less sensitive to insolation-induced erosion. All of the layers appear to have a rough texture that might be the result of erosion and/or redistribution of sediment and polar ice on the slope surface.

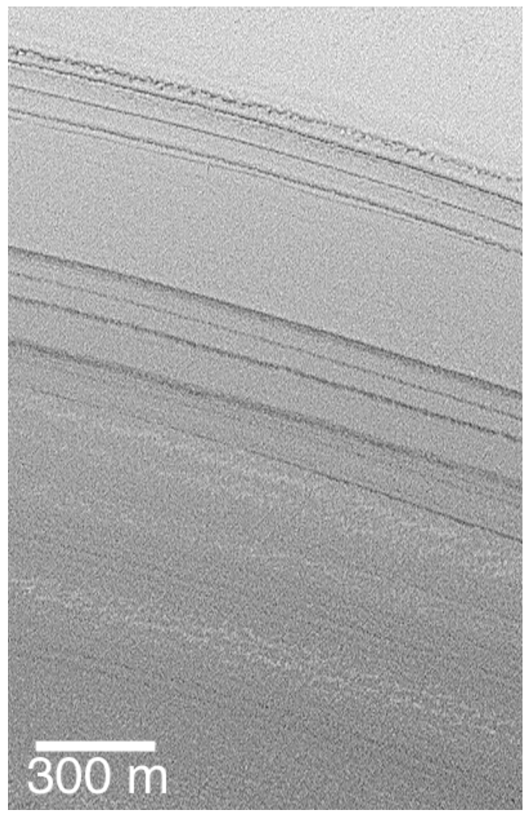

Figure 1. MOC images show many and more layers than visible in Viking and Mariner 9 images. Subframe of SP2-46103 near 79.1°N, 340.8°W.

Continuity of Beds: The beds of the polar regions exhibit continuity over distances of greater than 100 km. An example is shown in Figure 2, wherein 3 MOC images of 3 locations along the wall of a single trough in the north polar cap were found to exhibit the same stratigraphic sequence, including the presence of a rugged "marker bed" in each location ("MB" in each subframe). The presence of marker beds and the lateral continuity of beds suggests that mapping and analysis of the regional-scale stratigraphy of the polar layered terrain is possible using high-resolution MOC images.

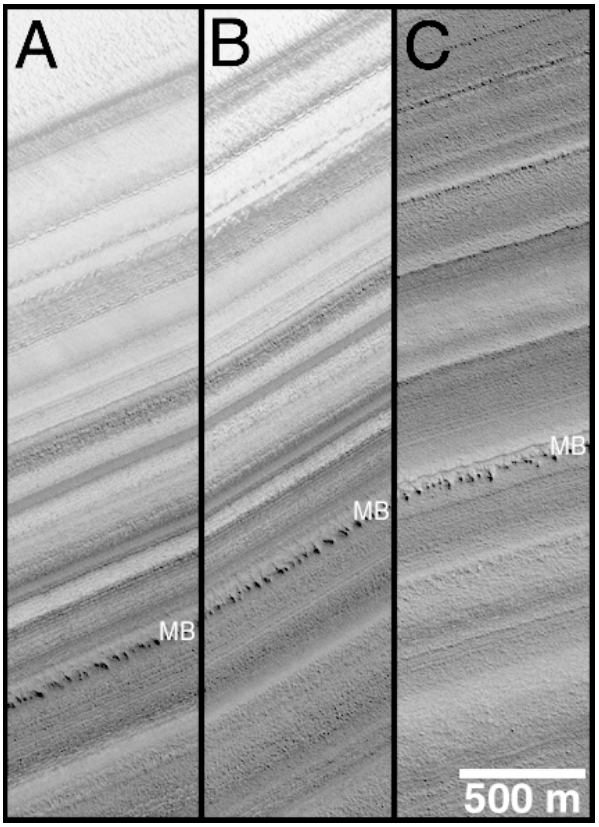

Figure 2. Continuity of polar layers over >100 km distance in a single north polar trough. All are illuminated from the upper right. Bright surfaces have remnant frost. Images taken in April 1999 during northern summer. (A) Subframe of MOC image M00-01754 near 86.5°N, 281.5°W. (B) Subframe of M00-02100 near 86.4°N, 278.7°W. (C) Subframe of M00-02072 near 85.9°N, 257.9°W.

Deformed Beds and Unconformities: Sedimentary geologic structures in the martian polar layered terrain also include angular unconformities and deformed beds. Figure 3 shows an example of each taken from some of the first high resolution views of the north polar cap ever obtained by MOC. Figure 3a shows an angular unconformity in a north polar trough wall exposure. The unconformity indicates a period of erosion that cut across pre-existing beds, and might also indicate tilting of the earlier beds. The erosion was followed by deposition of new beds. Figure 3b shows folded, warped, or deformed beds in a north polar trough; these are perhaps indicative of some form of soft sediment deformation, perhaps involving flow of ice-rich strata and/or compaction-induced volume changes.

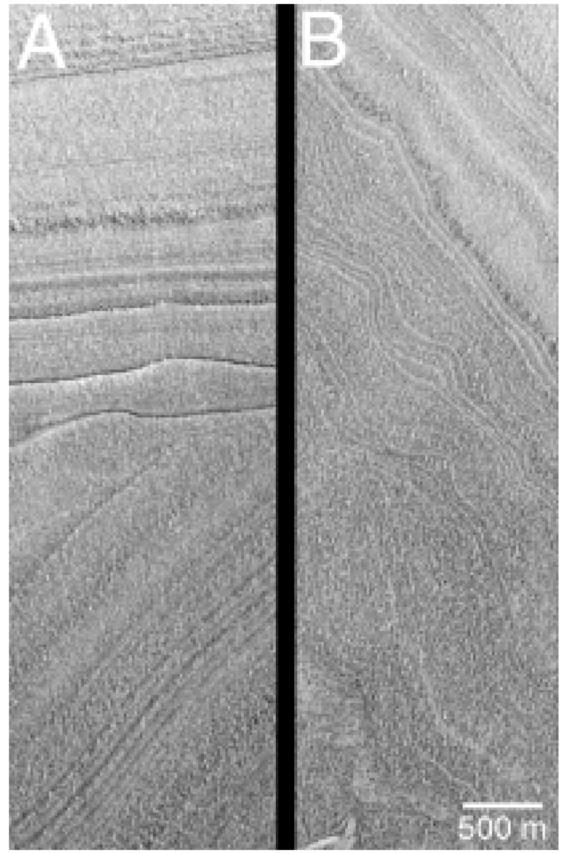

Figure 3. (A) Example of angular unconformity among beds of the north polar layered terrain. Subframe of MGS MOC image SP2-44503 near 84.5°N, 113.9°W. (B) Example of deformed beds in subframe of SP2-44504 near 83.4°N, 123.7°W.

Discussion: As had been noted from examination of lower-resolution Mariner 9 and Viking orbiter images, the polar layered terrains exhibit many of the characteristics of terrestrial sedimentary rock units. Erosional unconformities—either along bedding planes to create the layered pattern or along some paleosurface creating sometimes an angular unconformity—are observed as they had been in earlier images. The high resolution MOC data contribute observations of many and thinner layers than seen before—beds of differing resistance to erosion, indicating differences in the strength, competence, and perhaps composition of the materials being deposited over time. Deformed beds may suggest that some of the ice in the polar layered terrain can be deformed by flow and/or compaction, but there is no clear evidence for full-borne flow as might occur in a terrestrial glacier. MOC images provide further indication that the polar layered units are sedimentary materials that likely preserve a record of climate change over a long period of martian time.

Reference: [1] Malin M.C. and Edgett K.S. (2000) LPS Abstract #1055, submitted to this volume.