THE GEOMORPHIC EXPRESSION OF NORTH VERSUS SOUTH POLAR LAYERED OUTCROPS ON MARS AT METER TO DECAMETER SCALES.

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Synopsis: Mars Orbiter Camera (MOC) images acquired by the Mars Global Surveyor (MGS) since 1997 show that the layered outcrops and general geomorphic character of the two martian polar regions are radically different. These differences occur at scales of hundreds to thousands of meters, and are likely to indicate differences in depositional, erosional, and climate history between the two poles over long periods of time (perhaps millions of years).

Observations: MGS began orbiting Mars in September 1997. As of April 2000, hundreds of MOC images cover portions of the north and south polar residual caps and surrounding layered terrain at scales ranging from 1.4 to 15 m/pixel under illumination and seasonal conditions that include winter, spring, and summer in the south and spring, summer, and autumn in the north. These images reveal major differences in the morphology of the two residual cap surfaces and neighboring polar layered terrain.

Residual Caps. The two residual polar caps differ geomorphically from each other as well as from the rest of the martian surface. Initial observations were summarized by *Thomas et al.* [1]. What is most striking is the "swiss cheese"-like morphology of much of the south residual cap (Fig. 1a). No surfaces elsewhere on Mars have this pattern of circular depressions and sags among arcuate-scarped mesas. The north residual cap, in contrast, is largely flat at the hectometer scale but exhibits abundant decameter-scale pits (Fig. 1b)—these pits have not been seen on the south residual cap. The "swiss cheese" terrain in the south is a long-term geologic feature, not an expression of seasonal wintertime frost. In summer, this terrain has been observed in a state of defrosting such that the arcuate scarps (Fig. 2)—some of them exhibiting alternating light- and dark-toned layers (Fig. 3)—are dark relative to their winter/spring appearance.

Dark Lanes. Like everything else about the two polar caps, the dark "lanes" that occur in each residual cap differ between the poles. In the north, the equator-ward slopes exhibit banding and ridge-and-trough morphologies indicating layers of material of differing thickness, albedo, and resistance to erosion; while the poleward slopes are usually mantled and show no evidence of layering (Fig. 4a). Dark lanes in the south polar region show a semi-symmetric pattern of somewhat stair-stepped and folded/wrinkled layers on either side of a trough; these typically bound a rugged, medial ridge (Fig. 4b).

Polar Layered Terrain. The layered units that surround each residual polar cap (and which are more extensive in the southern hemisphere) also exhibit different geomorphic expressions between the north and south poles [2]. Though there are exceptions, in general the layers in the north tend to be expressed in the walls of the 'dark lanes' as a sequence of ridges and depressions while southern layers tend to have a stair-stepped or cliff-bench topography (Fig. 5). Layered outcrops in both hemispheres exhibit considerable evidence for a diversity of physical properties, for example layers that are expressed as ridges must consist of material that is more resistant to erosion than those expressed as depressions. When exposed at the surface in planimetric form, some layers in the south polar region develop spidery networks of closed gully-like depressions that are confined to that specific layer (Fig. 6a); others have a smooth-textured surface (*e.g.*, bright mesas in Fig. 6b); still others are rugged or rough at meter scales (Fig. 6c). Low albedo dunes superposed upon layered units in both hemispheres (Fig. 6d) indicate that the layers form a hard substrate across which sand can be transported via saltation—this observation might indicate that the upper surfaces of the polar layered units are not mantled by thick dust as has been interpreted on the basis of thermal inertia mapping [3].

Conclusions. MGS MOC images are giving us a new perspective on the geomorphology and geologic history of Mars. The observations presented here lead to two basic conclusions:

(1) The polar layered units include individual layers that have properties that differ from other layers. This means that individual layers probably record changes in materials deposited and processes that have operated over geologic time scales.

(2) The polar layered materials both on and off the residual caps are different in the north relative to the south, and different as well from other parts of Mars. The two polar regions have likely been quite different from each other—in terms of climate and materials deposited—for a very long time.

References. [1] Thomas P. C. *et al.* (2000) *Nature, 404,* 161–164. [2] Malin M. C. and Edgett K. S. (2000) *LPS XXXI,* #1055. [3] Paige D. A. and K. D. Keegan (1994) *JGR, 99,* 25993–26013.

Figure 1

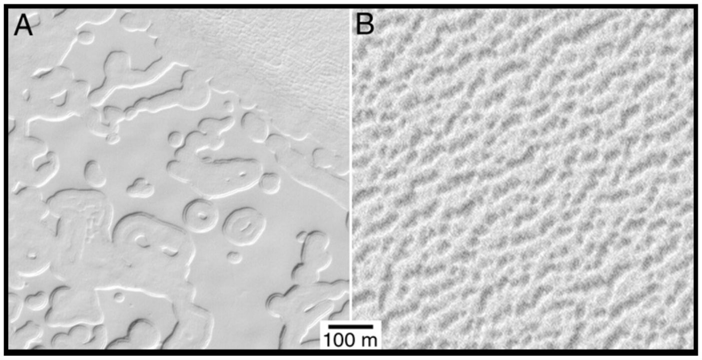
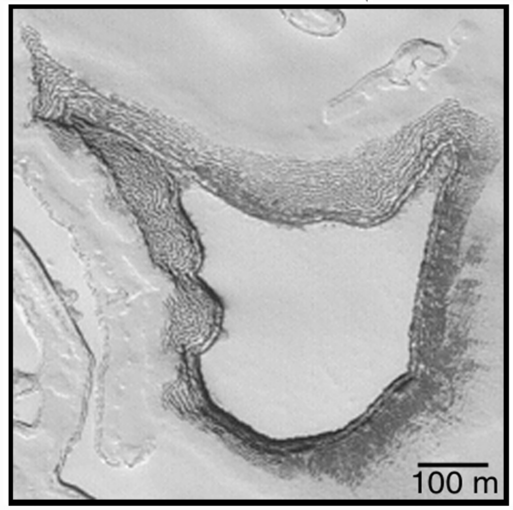


Figure 3



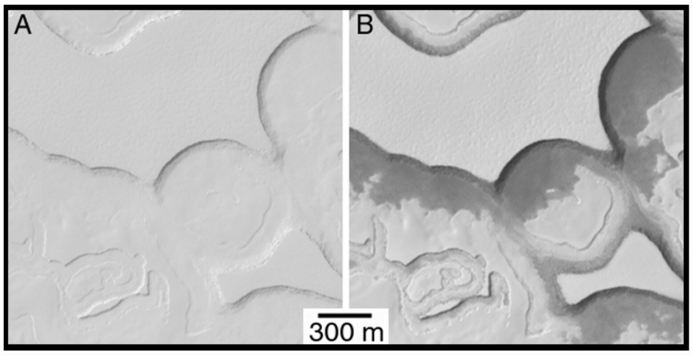
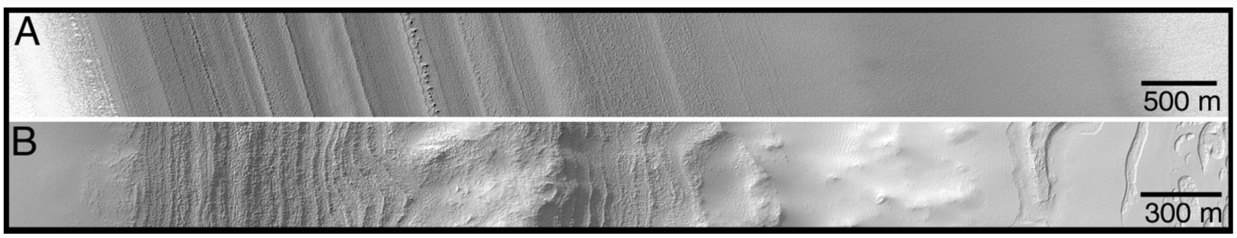


Figure 2

Figure 4



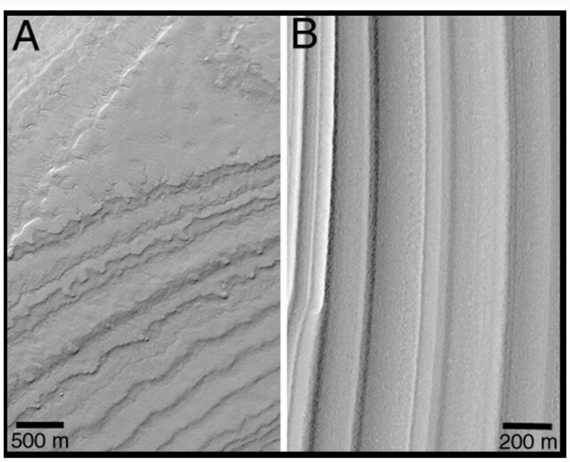
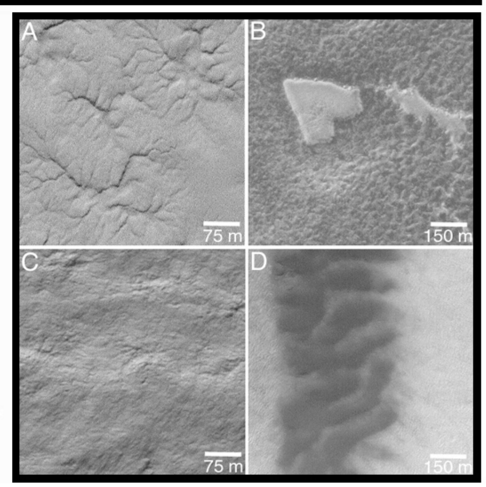


Figure 5

Figure 6



All illuminated from upper left. **Figure 1:** Typical surface morphology of south (A) and north (B) residual caps; (A) M09-05133; 87.1°S, 95.4°W. (B) CAL-00433; 86.9°N, 207.5°W. **Figure 2:** Defrosting south residual cap (A) at Ls 254° (M10-00093) and (B) Ls 320° (M13-01121); 86.5°S, 344.7°W. **Figure 3:** Banded slopes on mesa in south residual cap at Ls 306°, M12-02295; 87.0°S, 341.2°W. **Figure 4:** Dark lane crossings in (A) north polar cap, M00-02072; 86.0°N, 258.4°W and (B) south polar cap, M08-05817; 86.8°S, 350.8°W. **Figure 5:** Typical layer expressions (A) stair-stepped in south, M13-00253; 87.0°S, 187.7°W and (B) ridged-and-troughed in the north, SP2-52406; 86.3°N, 199.2°W. **Figure 6:** South polar layered unit surfaces in planview; (A) gullied surface, M12-00228; 77.9°S, 193.0°W; (B) smooth, mesa-forming units (light-toned), M09-06148; 79.6°S, 298.3°W; (C) typical rugged polar surface, M12-00563, 86.7°S, 264.9°N; (D) eolian dunes traveling across layered terrain surface, M12-00230; 76.7°S, 195.4°W.