ETCHED PLAINS AND BRAIDED RIDGES OF THE SOUTH POLAR REGION OF MARS: FEATURES PRODUCED BY BASAL MELTING OF GROUND ICE?

Alan D. Howard, Department of Environmental Sciences, University of Virginia.

The etched plains of the south polar region of Mars (1) (alias pitted plains (2) and pitted and etched terrain (3)) are composed of small-to-large, irregular, steep-sided, round- or flat-bottomed pits incised into a smooth upland surface. The bottom of some pits expose underlying crated plains. Little layering is exposed on the pit walls.

Narrow braided ridges (Figs. 1, 2, and 3) are a conspicuous local feature of the south polar region (forming the Dorsa Argentia) which have been noted on Viking imagery by many observers but not described in the literature. Individual ridges are characterized by a narrow width (less than 1 km), a meandering plan form (wavelength about 15 km), a great length of some of the ridges (150 or more km), frequent splitting and merging (braiding), and the absence of obvious structural control. The ridges are superimposed upon sparsely cratered plains and they commonly cross large to medium sized craters (although the age relationships are often obscured because the ridges are deflected to follow the rim of the crater). However, several small craters seem to be superimposed upon the ridges, indicating that ridges are old compared to the polar layered deposits but young compared to cratered terrains. The main occurrence of the ridges is organized into a "train" of braids extending from about 78°S 10°W to 70°S 70°W, although scattered ridges occur elsewhere on the smooth plains unit of (1), and some disappear under the polar layered deposits. Similar ridges apparently occur locally elsewhere on the planet (M. Carr, personal communication).

At their southward and eastward termination the ridge system of Dorsa Argentia appears to be covered by etched plains material (Fig. 2, locations marked "X"), indicating either that they are older than the etched plains or that they have formed as a modification of that unit and subsequently erosionally exposed, the view suggested here. This relationship, plus a locally distinct boundary between the unpitted portions of the surface of the etched plains and the surrounding smooth plains (dashed lines on Figs. 2 and 3) indicates that the etched plains are not a modification of smooth plains material as suggested by (1), but are a younger deposit superimposed upon the smooth plains and subsequently eroded.

Interpretation: The etched plains have been interpreted by all previous observers to be an erosional modification of massively structured sedimentary blanket, probably a fine-grained deposit of eolian or volcanic origin (1,2,3,4). They have interpreted the erosional agent to be eolian stripping. Arguments in favor of eolian erosion include a prevalence of eolian erosional and depositional landforms in the south polar region (4), the occurrence on Earth of eolian deflation basins (albeit shallower) (3), local elongation of the pits show little preferred wind direction (4) (although most of the pits along preferred orientation except perpendicularity to a possible regional slope), the absence of obvious structural control to the scarp edges bordering the pits, and apparently structurally-intact cratered plains exposed in pit bottoms (3) (the last two arguments appear to rule out an origin through basin faulting). The eolian hypothesis requires the presence of a caprock or surficial lag deposit to account for the localized rather than general scour (4), and mass-wasting of the marginal pit scarps has obviously modified and widened the pits (3).

A different hypothesis is advanced here; the pits are interpreted to be formed by basal melting of ground ice (which, of necessity would have to be a major component of the etched plains unit) and the braided ridges are considered to represent basal outflow channels from this melting which were laterally and vertically confined by ground ice.

Several investigators in informal discussions have raised the possibility that the braided ridges are eskers, that is, fluvial sediments laid down by basal melting of a thick ice cover, now ablated. The morphological comparisons are favorable, particuarly their occurrence as ridges, the narrow width relative to the wavelength of the meandering (due to ice-confined channel walls), and the braided pattern of the ridges. Open-channel flow is argued against by their narrow width, positive relief and their crossing of crater rims without apparent erosional modification. Former channel deposits with inverted relief created by erosion have been found on Mars (5), but they are relatively wide (compared to wavelength), flat-topped features. Unfortunately, a lack of quantitative studies of morphology of terrestrial esker systems and the poor quality of published maps has prevented a more detailed comparison. The source of the sediments forming the putative eskers would be derived both from debris or dust in the ice and from erosion of cratered plains beneath the ice. The disappearance of certain of the ridges beneath the etched plains suggests that at least some of the source deposit may remain as the etched plains, and that the pits have formed by basal sapping of ice and debris composing the etched plains deoposit. A high ice content in these deposits would be required, but this has already been implicated to be present because of the scarp-wall sapping (3). Some of the pit bottoms expose apparent ridges aligned with the long dimension of the pits, suggesting that they may be equivalents of the braided ridges. It has been suggested that the polar layered deposits may be episodically subject to basal melting (6). Although the massive etched plains deposits seem to be stratigraphically distinct from the layered deposits, they may reflect such basal melting.

The scenario outlined above faces several difficulties. The area of strongest development of the braided ridges (Dorsa Argentia) offers no other evidence of an ice cover (e.g., moraines, grooving, or remnant deposits). Secondly, many contacts of the etched plains deposits with the adjacent smooth plains near the braided ridges seem uneroded (Fig. 3) (e.g., the size of the pits diminshed gradually near the contact, suggesting an original thinning of the deposit). Thus, if the channels were confined during their origin, a complex stratigraphy and a hypothetical ice cover distinct from the etched plains unit are required. Finally, there is no clearly-identifiable lateral extension of the ridge system into outwash channels or fans.

The braided ridges and associated etched plains are clearly intriguing and important features that deserve further study. If they have formed as outlined above, then they share a close relationship to periglacial features elsewhere on the planet, with the distiction being the occurrence of melting from the bottom rather than the top in the cold polar region.

REFERENCES: (1) Condit, C.D. and Soderblom, L.A., 1978, U.S. Geol. Survey Map I-1076; (2) Murray, B.C., Soderblom, L.A., Cutts, J.A., Sharp, R.P., Milton, D.J., and Leighton, R.B., 1972, Icarus, 17, 328-345; (3) Sharp, R.P., 1973, J. Geophys. Res. 78, 4222-4230; (4) Cutts, J.A., 1973, J. Geophys. Res., 78, 4211-4221; (5) Rhodes, D.D., 1980, NASA TM-82385, 397-399; (6) Clifford, S.M., 1980, NASA TM-82385, 405-407.

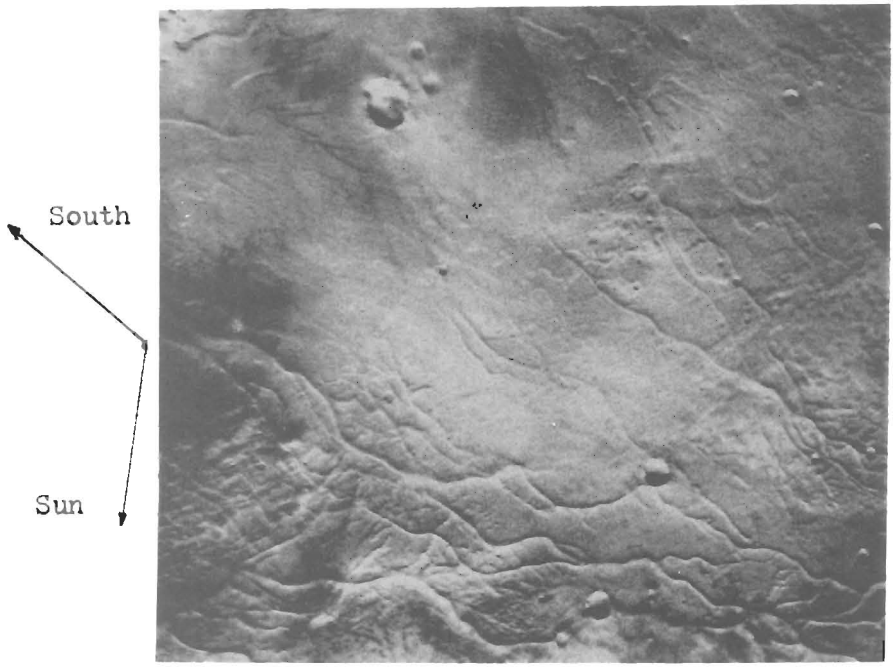

Figure 1: Image 421B53. Image width about 210 Km. Braided ridges disappear beneath etched plains and smooth, young layered? deposits in upper left corner. Picture center at -77.7°S 40.4°W.

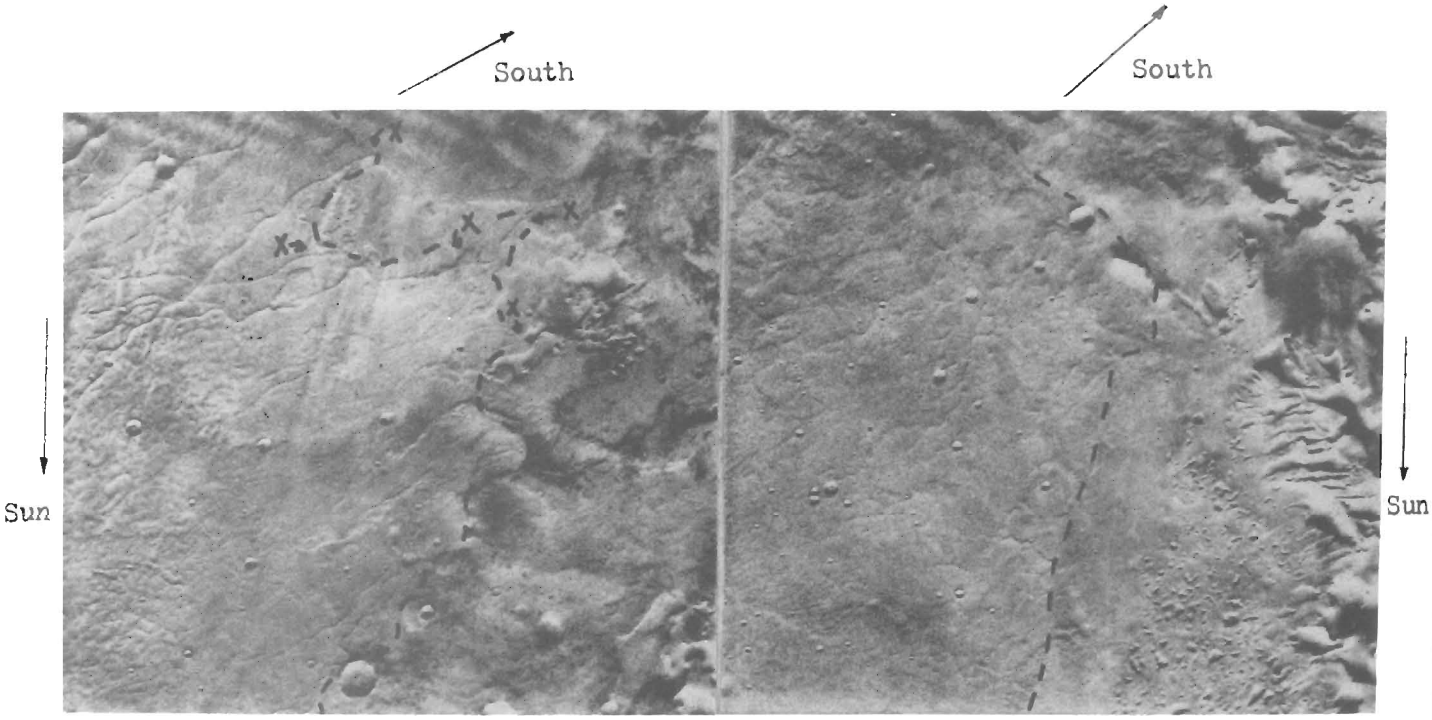

Figure 2 Figure 3

Images 390B85 (left) and 390B89(right). Picture widths about 210 km. Centers at -78.6°S 48.8°W and -75.7°S 62.9°W. Sparsely-cratered plains to left of dashed line, etched plains to right. "X's" mark disappearance of braided ridges beneath etched plains, which also occurs (less distinctly) elsewhere on pictures.