IMPORTANCE OF AEOLIAN PROCESSES IN THE ORIGIN OF THE NORTH POLAR CHASMATA, MARS: **N. H. Warner[1], J. D. Farmer[1] ([1]School of Earth and Space Exploration, Arizona State University, P.O. Box 871404, Tempe, AZ 85276-1404; Nicholas.Warner@asu.edu)**

Introduction: In this report, we re-examine the debate over the origin of the Martian polar chasmata based on new imaging data provided by the Thermal Emission Imaging System (THEMIS) [1], topographic data from the Mars Orbiter Laser Altimeter (MOLA), and high resolution images from the Mars Orbiting Camera (MOC) [2]. Our primary focus is the north polar region of Mars, including Chasma Boreale, largest of the Martian polar re-entrants, and two adjacent smaller chasmata (Figure 1). We conclude that a model for chasmata formation that emphasizies long-term aeolian erosion and modification of the polar layered material best explains the available data. We focus our analysis on the aeolian depositional and erosional features within and surrounding the chasmata and the stratigraphic and morphologic relationships exposed within walls of the arcuate and sinuous head scarps.

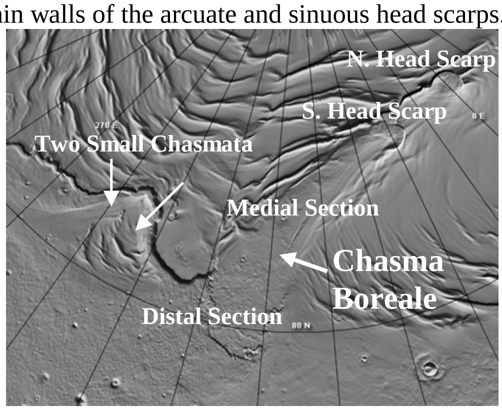

Figure 1: MOLA shaded relief context map of Chasma Boreale and the nearby smaller polar chasmata.

Observations: Figure 2 is a color THEMIS mosaic of the northern-most head scarp of Chasma Boreale. This image reveals the presence of numerous barchan dunes located at the base of the headscarp. In several places, barchan dunes have coalesced to form larger transverse forms. The geometry of the dune field in this location is controlled by the orientation of the scarp. A majority of the barchan dunes have a single extended horn, suggesting a multi-directional wind regime [3, 4]. Winds descending off the scarp from the E, NE, and N control the dune morphology. Figure 2 shows that the dune covered chasma floor is separated from the steep (15 - 25°) head scarp by a narrow moat located at its base. The floor and walls of the moat expose low albedo layered materials. Downvalley from the moat, the chasma floor climbs in elevation and becomes dune covered. Collectively, these observations suggest that the base of the head scarp is a region of active scour. The low albedo floor materials are being eroded by the wind (to form a moat) resulting in accumulation of material a few km down-chasma. A similar relationship exists at the southern-most arcuate scarp at the head of Chasma Boreale (Figure 1). Here, low albedo basal layered materials are removed from the base of the scarp and transported several km down chasma. These observations are consistent with the hypothesis of active aeolian undermining of the north polar arcuate scarps [5]. The saw tooth pattern of dune deposition in the THEMIS mosaic suggests a variation in down scarp wind velocity. This variation in wind velocity and uneven scarp retreat, is also suggested by many smaller wavelength arcuate forms that collectively make up the main head scarp.

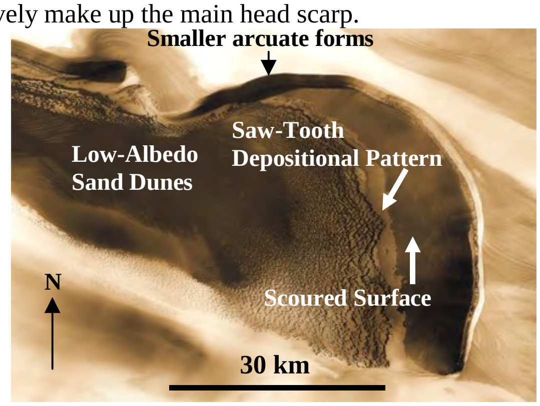

Figure 2: Color THEMIS VIS mosaic of Chasma Boreale's head arcuate scarp.

The medial section of Chasma Boreale is dominated by low albedo barchan, seif, and transverse dunes and local bright dust mantles. The orientation of sand dunes in this region suggests a dominant wind direction from the NNE and NW, consistent with the flow of katabatic winds down chasma and off the steeper NW wall toward the chasma.

The distal region of Chasma Boreale is characterized by isolated, low albedo dune forms and bright deposits interpreted to be dust mantles. The orientations of aeolian features in this region suggest three major source directions for winds in this area. The first source direction is to the NNE, and is derived from winds directed down chasma. The second source is located to the NW and is likely related to katabatic winds flowing down the steeper NW chasma wall. The third source is from the ESE. This dune orientation is likely controlled by winds flowing down the gentle SE wall. Sand dunes and dust mantles are notably absent at the base of the unusually steep scarp (~ 8 - 10°) of the distal section of the NW wall. This region, centered at 80.56° N, 300.09° W, exhibits well-defined polygonal troughs. A localized erosive wind regime appears to explain the absence of depositional features and the sharply defined appearance of the polygonal troughs in this area.

The floors of the two smaller chasmata west of Chasma Boreale also contain isolated barchan dunes, seif dunes, transverse dunes, and dust mantles. The inferred wind directions suggest strong off-pole winds, oriented perpendicular to the unusually steep (8 – 10°) sinuous scarp located at the headreaches and along the northern margins of the two chasmata. MOLA topographic profiles across the scarp front reveal the presence of a depression or moat immediately at the base of the scarp. This depression is comparable to that seen at the base of the head scarps of Chasma Boreale and appears to be erosional, owing to the absence of dunes or other deposits. The sinuous scarp exposes a resistant unit that has eroded to form small mesas and coniform features (Figure 3). Some of these small coniforms and platy-weathering forms can be seen on the slope of the scarp front, suggestive of active aeolian modification and erosion of the scarp by off-pole winds.

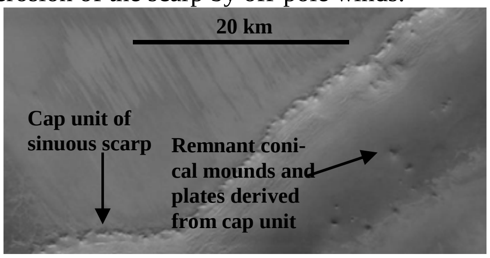

Figure 3: THEMIS image V12685006 of the sinuous scarp located near the head of the two small polar chasma.

Discussion and Conclusions: Based on inferred wind directions and the geomorphology of the head scarp regions of Chasma Boreale and associated smaller chasmata, we propose the following qualitative model for the long term evolution of the north polar chasmata. Off-pole katabatic winds have ablated polar cap materials and exposed layered materials along the margins of the polar cap. In some regions, differential erosion of specific layers in the PLD has resulted in the formation of scarps by headward retreat. The induration of polar layered materials is assumed to depend primarily on the relative abundances of dust and water ice. Examination of polar troughs that trend parallel to the NW wall of Chasma Boreale reveals that their equatorial slopes are unusually steep, compared to other troughs across the cap. The relatively steep sloped, sinuous scarp at the head of the two smaller chasmata, also suggests an increased material resistance relative to other marginal areas of the polar cap. Along this scarp a resistant cap-forming unit is visible (Figure 3). Scarp retreat is occurring in places where the cap unit is being actively undercut by descending slope winds. The observation of scoured surfaces at the base of the modern head scarps, coupled with evidence for scarp rim modification, are consistent with this hypothesis. We suggest that the amphitheater-shaped head scarps of Chasma Boreale are regions where retreat has occurred at a faster rate, possibly as a result of unusually strong off-pole, Coriolis-directed, regional katabatic winds [6].

The large remnant of polar layered material located south of the head scarps of the smaller chasmata attests to the once broader extent of the cap in this region. This stack of layered material may have been left behind because of greater induration of the deposits and/or as a result of the diminished erosive capacity of the winds descending from the sinuous scarp rim. In this view, several small conical mounds present along the margin of the sinuous scarp and at the mouth of Chasma Boreale are more likely to be remnants of layered materials removed during scarp retreat, than volcanic landforms, as suggested previously [7]. An important observation along the sinuous scarp is the presence of two identical amphitheater forms located above the sinuous scarp cap-forming unit, ~ 20 km NE of main scarp rim (Figure 1). These two forms are developing within a younger section of polar layered materials. The identical shape and orientation of this feature, compared to the arcuate head scarps of the smaller chasmata, suggests a similar aeolian erosion mechanism, controlled by the local slope, wind direction, and material properties of the polar layered deposits. Scouring of the base of this scarp by wind is also evident. We suggest that this second set of arcuate forms represents an early stage of scarp formation in the polar cap. The enhancement of katabatic wind velocities downslope from this feature could be expected to cause erosional deepening at its base and retreat of the rim. It is conceiveable that over geologic time scales, such erosional dynamics could produce features comparable in size to Chasma Boreale.

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