Enigmatic Surface Features of the South Polar Layered Deposits. M. R. Koutnik[1], S. Byrne[2], Z. Crawford[3], and B. C. Murray[2], [1]University of Washington (Box 351310, Seattle, WA 98195, mkoutnik@geophys.washington.edu), [2]California Institute of Technology (shane@gps.caltech.edu, bcm@gps.caltech.edu), [3]University of Colorado (zane.crawford@colorado.edu).

Introduction: Data from the Mars Orbiter Camera (MOC) and the Mars Orbiter Laser Altimeter (MOLA) aboard the Mars Global Surveyor (MGS) mission have provided important new clues to the past history of the south polar layered deposits (SPLD). There are distinct features presented here that have been observed almost exclusively with these data sets and are unique to the south polar region of Mars. *Crawford et al.* [1] have studied these features initially and we now present the current perspective on this region after a period of detailed study. We present a descriptive discussion and provide evidence for different possible interpretations. Although we do not conclusively know the origin of these features, we consider that subglacial volcanism as well as strong surface winds may have been active in forming these features visible today.

Regional Description: Enigmatic large-scale grooved features, termed here the "Wire Brush" terrain, became evident from the MOLA topographic shaded relief map. The precise topography data was better suited to expose subtle surface features that were poorly resolved in visual images. This region can be identified in Viking coverage of this area (image f307a88) and shows that the grooves possibly have a connection with the current residual cap. This unusual area of grooved terrain occurs in the region 190° - 230° W, 85° - 87°S (no MGS coverage south of 87°), shown in Figure 1 and Figure 2. At the poleward tip of Chasma Australe is the only other location where we see this grooved pattern on Mars. The grooves are suggestive of erosion by an external agent that maintained a coherent pattern over several hundred km scale.

The overall grooved pattern is continuous for more than 300 km, though tracing of individual grooves is difficult to do with certainty for more than about 50 km. The grooves do continue linearly across local topography and are several hundreds of meters across with vertical relief of only a few tens of meters. The slope over the extent of the wire brush terrain is very slight and the grooves to do not seem to be influenced by any larger scale topography. The grooves also seem to cut right across smaller topographic features, not deflected by them in local areas. This is shown in Figure 3. A feature observed using the MOLA data has been resolved in the MOC Narrow Angle (NA), showing how the linear grooves cut right over a circular feature (example image m1001286). Using the MOC NA images it is also possible to observe that individual grooves have undergone significant weathering (example image m1200517).

There are numerous, unique features in association with the Wire Brush that may provide other clues to origin and timing of formation of the large-scale grooves. There are sinuous positive features cross-cutting the Wire Brush which we have termed "Snakes". The association of the Snakes with the Wire Brush Terrain is highlighted in Figure 2. The Snakes are as much as 2 km in width and tens of km long, though are only a few tens of meters in relief relative to the surrounding terrain. The presence of such vertical features is unusual. It could imply an episode of deformation or fracturing that has been filled subsequently with more resistant material than the surrounding layered deposits. Individual snakes have differing structural properties and differing appearances in MOC NA image coverage. Some of the Snakes appear to expose many layers on one side and none on the other, whereas other Snakes seem to show no layering at all. The Snakes are found primarily within the Wire Brush region but do extend out from this region as well. One Snake extends into an adjacent elongated depression and can be seen to interact with layering in this adjacent chasma. The walls of the chasma are finely layered and these layers are continuous, traceable over tens of km through different MOC NA frames. The layers near the location where the Snake coincides with the wall of this chasma are highly deformed. MOC NA m1002701 illustrates this deformation of the layers by the Snake feature. This adjacent chasma is possibly a significant feature in association with the Wire Brush terrain. Unlike Chasma Australe, this chasma does not cut all the way through the layered terrains to the underlying basement rock and does not have an outlet. Given the positions of these two chasmas, on both sides of the Wire Brush Terrain, it is possible that all of these features have a similar origin.

Another interesting component of the Wire Brush and adjacent region is the presence of small, circular pits. They are found distinctly in the regions 190° - 230° W, 85° - 87° S and 135°-175° W, 85°-87° S. A search of the south polar layered deposits using MOC imagery data through extended mission 12 (e-12) has been done in the search area for impact craters designated by *Koutnik, et al.*[2]. Out of this entire search area, these potholes are found only within the two bounds listed above. Most interesting is that the potholes are predominantly found in association with the Wire Brush Terrain.

The distribution and morphology of these features is clear evidence that they are not impact craters. There are no large impact craters near these features and the organized clustering of the potholes indicates an endogenic origin. The distribution of these features has been mapped according to coverage in MOC NA images. The potholes are found in two distinct regions and can be roughly grouped by morphology and orientation. All of the individual polar potholes in both regions are approximately 50 – 100 m in diameter. The density of potholes over a given area in each image is variable, though these features are always seen in groupings of multiple features, never isolated. The potholes found within the Wire Brush region are circular, distinct forms. They are often observed with no particular orientation relative to each other or local topography. More interesting, potholes of the same morphology in the Wire Brush region are found to be located in regions of low topography or clustered in local circular depressions. Figure 4 shows the groupings of potholes in areas of low topography. Figure 5 shows the larger circular depressions containing clusters of small potholes. The larger depressions are 150 – 500 m in diameter in this image and are not distinct features. It is apparent that some of the larger depressions are made up of one or more circular shapes. The entire population of potholes is found only on the south polar layered deposits and these clustered forms are only in the Wire Brush region.

Interpretations: The Wire Brush region and associated features could conceivably be the signature of unusual past winds, ancient ice sheet motion, or episodes of catastrophic flooding originating from beneath earlier residual caps. Each of these possible explanations has strong and weak points, though some features are better explained by certain processes than others. The Wire Brush grooves as a wind-formed feature offers a straightforward explanation. This requires an episode of extremely high winds (many tens of m/s) that lasts long enough to carve out these grooves and possibly contribute to the formation of the adjacent chasmas. A possible problem with the wind theory is the nature of the grooves cutting straight over local topography, in a way that seems inconsistent with wind action alone.

Interpretations involving ice motion require a past climate episode where higher temperatures would have allowed a process of this nature to occur. The grooved pattern is visually similar to such features on Earth as ice streams, though we are unable to determine as of now if the mode of formation might be similarly analogous. Evidence for ancient ice streams have been proposed by *Lucchitta* [3] for elsewhere on Mars.

The influence of water over this landscape could also have been important in creating some of the features we see in this region today, if there were a past episode where water was temporarily stable at the surface or near-surface. This could either have been a period of climatic warming or possibly a period of sub-surface volcanism. The presence of a number of peculiar mounds north of the Wire Brush Terrain may be supporting evidence for the influence of subsurface heating on current topography, as may be the closed depressions of the adjacent chasma. Elsewhere in the south polar region, *Ghatan and Head* [4] have proposed a past episode of subglacial volcanism of Hesperian age. Given that characteristic grooves forming the Wire Brush terrain also appear at the poleward tip of Chasma Australe, the formation of this feature might have the same origin. It has been proposed by *Howard* [5] that Chasma Australe is a wind-formed feature and has also been proposed by *Anguita et al.* [6] as evidence of a past outburst flood, so there is support for both processes which we consider.

It is possible, perhaps even likely, that several different processes have acted on these unusual features at different times to produce composite results. We are beginning to piece together the connection between all these features in this region of the SPLD, in order to understand their origin. The unique location of all these features is evidence of a significant event in the Martian past that had a considerable influence on the SPLD.

References: [1] Crawford, Z., et al. (2002) AGU Fall Meeting. [2] Koutnik, M., S. Byrne, and B. Murray (2002) *J. Geophys. Res.*107 (E11). [3] Lucchitta, B. (2001) *Geophys. Res. Letters* 28, 3, 403-406. [4] Ghatan, G. and J. Head (2002) *J. Geophys. Res.* 107, E7, 2002. [5] Howard, A. (2000) *Icarus* 144, 267-288. [6] Aquita, F. et al. (2000) *Icarus* 144, 302-312.

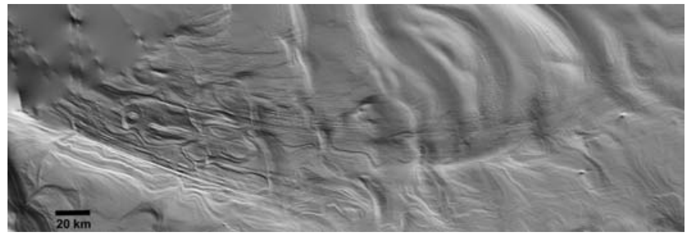

Figure 1. MOLA shaded relief map of the full extent of the Wire Brush Region, 190° - 230° W, 85° - 87°S.

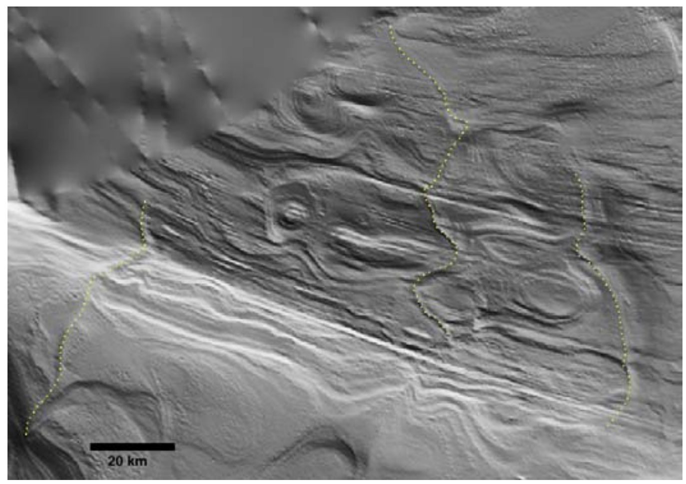

Figure 2. Further zoomed view of the Wire Brush terrain and outlines of the Snakes cutting through this region. The upper left corner is an area where there was no MGS data coverage.

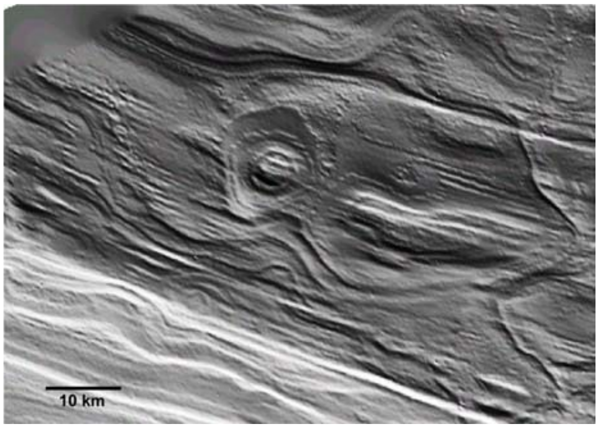

Figure 3. Close-up of topographic feature within the Wire Brush terrain where the grooves cut straight across. Also in the mid-right of this image is a close-up view of one of the Snake features.

Figure 4. MOC NA m1104171 showing the pothole features in the Wire Brush terrain and how they are grouped in regions of lower topography.

Figure 5. MOC NA m1102900 showing another distribution of potholes in the Wire Brush terrain that are grouped in larger circular depressions.