DARK HALO: ENIGMATIC FEATURES OF DARK STREAKS AT MARTIAN VOLCANOES. Takenori Toyota[1] and Kei Kurita[2], [1]toyota@eri.u-tokyo.ac.jp / Earthquake Research Institute, 1-1-1 Yayoi Bunkyo-ku Tokyo, Japan [2] Earthquake Research Institute, 1-1-1 Yayoi Bunkyo-ku Tokyo, Japan.

Introduction: On the planets having atmosphere such as Mars, there are various types of interactions between the atmosphere and the ground surface. Such interactions cause observable changes in the surface patterns. Polar caps and aeolian features are typical examples. With the accumulation of satellite-based exploratory data, time-variable surface patterns have been recognized and investigated extensively, because they can be direct indicators of the changing surface environments. Here we report a new kind of time-variable surface pattern called "Dark Halo" near the top of high altitude volcanoes in Tharsis region.

Figure 1 shows an example of "Dark Halo" on Pavonis Mons. The large caldera can be seen at the top of the volcano. Surrounding the caldera there exists "Dark Halo".

"Dark Halo" is first described in detail by [1]. They interpreted it is a kind of a wind streak pattern, an aeolian product. Following researches [2, 3] took over their idea, and suggested contributions of rolls of the boundary layer and surface material interaction with the atmosphere.

Observation and enigma: Recent continual and high resolution observations have revealed enigmatic features of "Dark Halo":

- "Dark Halo" is composed of assemblage of dark spire-shaped streak, hereafter we call "Spire Streak" (Close-up image of Figure 1).
- Each "Spire Streak" starts from a point-like very narrow region.
- In most cases, no topographical obstacles can be identified at initiation point.
- Each "Spire Streak" starts at high position and increases its width downward.
- "Dark Halo" and "Spire Streak" universally exist near the top of high mountains (Olympus, Elysium, Pavonis and Ascraeus) and on Alba Patera although the actual heights are not uniform.
- "Spire Streaks" are aligned in radial direction from the top (caldera center). Each unit is spindle-shaped with length of 30-50km and width at the middle part of 5 km. "Spire Streak" seems to start from higher position, and the initiation point is quite narrow region, which can be considered as a point. In many cases, there exist no recognizable obstacles at the initiation point. This is a remarkable difference from the wind streaks, which are caused by erosion/sedimentation of material by wind due to local turbulence behind topographical anomaly such as craters.

These features are not compatible with existing models of aeolian streaks.

It is the purpose of this paper to determine the relative importance of the factors affecting the formation of "Spire Streak". The characteristics of the regions in which "Spire Streak" occur are deduced from visible/IR images, spectral data, in situ measurement data that are obtained by rovers and theoretical estimates. Of particular interest to this study is the reason why the shape of "Spire Streak" changes, as this should reflect near-surface environment that is hard to investigate with satellite-based remote sensing systems.

Temporal changes of "Dark Halo": In Figure 2, time-sequential images taking the summit of Pavonis Mons show temporal variation of the dark halo. Between Ls = 177.81 and 250.8 drastic change occurred. All the previous halo disappeared and newly formed ones appeared at Ls = 148.92 but at the different location. Previous halo still remains, but is too pale to see in un-enhanced images. In this period (2001 from Ls = 177 to 212) huge global dust storm occurred [4]. Sedimentation of fine dust during the dust storm should be responsible for erasing the preexisting pattern.

Distribution of Dark Halo: Dark halo is universally observed near the summit area of high mountains such as Tharsis volcanoes and Elysium Mons. The common feature in the distribution among mountains is the highest position of the dark halo. In most cases the mountains with the dark halo have a caldera at the top and the surface slope around the caldera is gentle while it turns to steeper at lower positions. The uppermost point of the dark halo is always located at this boundary(Figure 3) although the actual height varies from mountain to mountain and the main part distributes at high-sloped area. This strongly support slope wind is responsible for the formation, particularly night wind blowing down the slope. At the mountain where this slope change is not eminent such as the western flank of Alba Patera the dark halo as an assemblage of spire streaks can not be identified though the spire streaks exist.

Dust covered surface as the background: Dust Cover Index (DCI) [5], an indicator for the presence of silicate dust, shows the brighter region encircled by the dark halo at the summit area is highly dust covered. Since large difference in the thermal inertia is not detected between the dark halo and this brighter region in the daily temperature variation [6], the corresponding surface structure is similar or only different in the very thin surface region(<1mm).

Surface pressure and brightness temperature.: Figure 4 shows a phase diagram on the surface of "Dark Halo" and its surroundings. There is no apparent phase difference between dark region on "Dark Halo" and inner bright region of "Dark Halo".

Erosion or Deposition?, further enigmas: Although it is clear that wind process(possibly slope wind)is responsible for the formation of the spire streaks and the dark halo, the initiation from point-like region is enigmatic as growth of turbulence. The spire streaks can be continuously traced in depressed regions such as crater floor and local troughs by lava tube. This suggests the dark halo is formed by deposition of materials in stead of erosion of the surface. The fact the dust devil tracks in the dark halo are brighter also suggests the darker material thinly covers the brighter surface. If so where is the dark material transported? [7] investigated the origin of dark streaks at the north end of Victoria crater and conclude the streaks are deposit of basaltic sand from the dark dunes. But the spire streaks at high mountains start from very narrow dust-covered region where we can not identify the source material. The pattern of the spire streak give us an impression something emanates from underground and is blown off by the mountain slope wind and deposited in the downwind part.

References: [1] Sagan J. et al. (1974) *Icarus*, 22, 24-47 [2] Thomas P. et al. (1981) *Icarus*, 45, 124-153. [3] Thomas P. et al. (1984) *Icarus*, 60, 161-179. [4] Strausbarg et al., (2005) *JGR,* 110, E02006. [5] Ruff S. W. and Christensen P. R. (2002) *JGR*, 107, E125127. [6] Putzig N. E. et al. (2005) *Icarus*, 173, 325-341. [7] Geissler et al., (2008) *JGR*, 113,E12S31. [8] Smith M. D. et al. (2006) *JGR*, 111, E12S13.

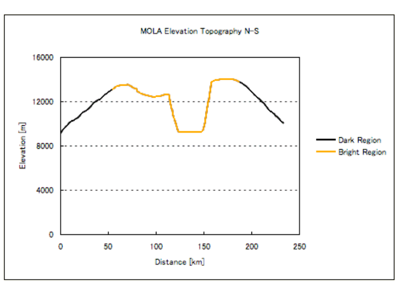

Figure 3. Elevation topography of Pavonis Mons (North-South profile). Black and orange lines indicate dark and bright region respectively.

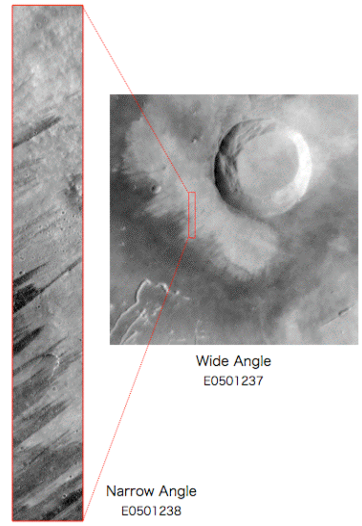

Figure 1. "Dark Halo" on Pavonis Mons and close-up image of "Spire Streak". Images were obtained by MGS MOC.

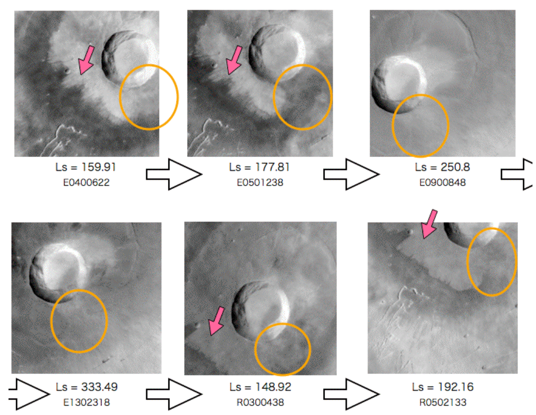

Figure 2. Temporal changes of "Dark Halo" through May 2001 to May 2003. Images were obtained by MGS MOC.

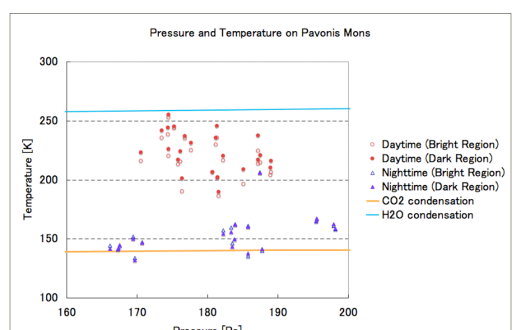

Figure 4. Pressure and temperature on Pavonis Mons. Temperature was derived from THEMIS IR image from 2002.3.31 to 2007.12.14. Pressure was estimated from the model fit equation [8] and the scale height of Mars.