Frequency of ice sheet growth recorded on Mons Pavonis, Mars

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On present-day Mars, large scale ice bodies are only found at each pole. However, in mid latitudinal areas, LDA (lobate debris apron), LVF (lineated valley fill), CCF (concentric crater fill) are reported and interpreted to have a glacial origin (Levy et al., 2014). Also, inequatorial areas, fan-shaped deposits at northwestern rim of three shield volcanos in Tharsis region though to have a glacial origin (e.g. Fastook et al., 2008).
Fan-shaped deposits sit beside three Tharsis montes and have characteristic geomorphologies extending for roughly 100-500 km from the foot of mountain, typically consisting of three facies: Smooth facies at the top, Knobby facies at the middle, and Ridged facies at the rim. Smooth facies are smooth-surfaced mounds which superpose on other facies, Knobby facies are collective hillocks a few hundred meters in radius, and Ridged facies are linear ridges (moraine-like features) parallel to the rim of the fan. At Arsia (Kadish et al., 2014) and Pavonis (Shean et al., 2005) Mons, ridged facies are especialy well-developed - containing tens to few hundreds of ridges interpreted to be moraines that indicates the varying extent of a former ice sheet. Such geomorphologies potentially record the advance and retreat of ice sheet for tens of kilometers during the Amazonian adjacent to Arsia and Pavonis Mons.
The association of these geomorphologic features to glacial processes is supported by global climate simulations of Mars during high-obliquity (Forget, 2006). The obliquity of the rotation axis of Mars is considered not stable as on the Earth, reaching 45° in the past 20 Myrs (Laskar et al., 2004). Such high obliquity can cause sublimation of the polar cap, enhancing the water vapor content in the atmosphere compared to present-day Mars. By diffusion and condensation model, Mellon & Jakosky (1995) found that in the surface environment of present-day Martian obliquity (25.2°) water ice is stable only at 40° latitude or higher, however, when obliquity gets higher than 32.3°, with enough amount of atmospheric water vapor, water ice becomes stable globally. This result suggests Martian surface environment has experienced such climate condition that water ice condenses and deposits in mid and low latitudinal areas. Therefore, the existence of Martian "ice age" during Amazonian high-obliquity periods is being proposed (Head et al., 2003).
If ice sheet growth and disappearance on the flanks of Tharsis Montes are an indication of the climate change caused by orbital parameters, each of moraine-like features should correspond to a paleoclimate cycle. However, fluctuation of its spacing, scale and correlation to orbital parameter have not yet been discussed. Hence, as basic study to associate distribution of moraine-like features to extent of the ice sheet, we made DEM data from CTX imagery at the rim of fan-shaped deposits at the foot of Mons Pavonis, and using the DEM data, we measured spacing and cross-sectional area of each moraine, and conducted frequency analysis on the cross section of DEM data.
As a result, spacing of moraine-like feature appeared to fluctuate from few hundred meters to 4.5 km, showing drastic change of the density. Also, cross sectional area of moraine-like feature fluctuates up to 1.4×10^4 m^2. These fluctuations potentially record the change of frequency of events that caused accumulation and ablation of ice sheet or change of velocity of ice sheet flow. In Tharsis region, these two periodic events are assumed to affect ice sheet: global climate change caused by orbital parameter, and local volcanic activity. To prove the spacing and moraine-size are driven by global climate forcings, there should be similarities between the ridges found at Pavonis, Arsia, and a correlation to orbital parameters. Therefore, frequency analysis of cross- sectional view of the terrain is being conducted. The result will be shown in the presentation.

Keywords: Mars, Martian climate, Tharsis region, Milankovich cycle

