GEOLOGIC MAPPING OF THE ARSIA MONS FAN SHAPED DEPOSIT, MARS. A.M. Dapremont[1], W. B. Garry[1], and D.A. Williams[2], [1]Planetary Geodynamics Laboratory, Code 698, NASA Goddard Space Flight Center, Greenbelt, MD 20771, [2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, amdapremont@gmail.com, brent.garry@nasa.gov.

Introduction: Arsia Mons has the most expansive fan shaped deposit (FSD) of the three large shield volcanoes that make up the Tharsis Montes on Mars **[1]**. The FSDs are thought to be remnants of Amazonian aged cold based tropical mountain glaciers that have modified the western flanks of the Tharsis Montes **[2-4]**. The FSD of Arsia consists of three main morphologic facies: ridged, knobby, and smooth (Figs. 1,2). Ridged facies occur as curvilinear, subparallel sets and are most prominent at the furthest extent of the FSD. Knobby facies contain irregularly shaped hills that are hundreds of meters in diameter. Smooth facies occur as broad patches and have subtle arcuate lineations across the surface and lobate margins.

Previous work has suggested that the morphologic facies mapped within the fan shaped deposits represent deposits from the retreat of a cold based glacier on the western flanks of the volcanoes along with features formed by subglacial-lava interactions **[3-5]**. Drop moraines are thought to have formed ridged facies, sublimation till has been argued to form the knobby facies, and smooth facies are interpreted as debris covered glaciers **[4]**. We have also mapped a new facies, that we refer to as 'fingerprint' terrain in the FSD which is found in association with smooth material and is characterized by an elevation transition from high (uplifted features) to low (depressed terrain).

Recently, updated impact crater size frequency distribution (CSFD) analyses of the tropical mountain glacier deposits have suggested the Arsia FSD glaciers were present over hundreds of millions of years **[6]**. Overall, CSFD age estimates for the Arsia, Pavonis, and Ascraeus Mons FSDs are 210 Ma, 125 Ma, and 220 Ma, respectively and establish that ice was present in the Mars equatorial region during the Middle to Late Amazonian **[6]**. However, detailed CSFD ages for the outer ridged facies deposits at the boundary of Arsia's FSD are older than the average (725 to 345 Ma from outer to inner ridged sections) **[6]** which has implications for constraining the age of possible post-glacial geologic processes and landforms. We have mapped the FSD facies to acquire additional information about possible interaction between glaciers and geologically recent volcanic activity during the formation of Arsia.

Methods: We used a Thermal Emission Imaging System (THEMIS) basemap and Context Camera (CTX) mosaic in ArcGIS 10.2 to produce a 1:1,000,000 scale geologic map of the FSD deposit and surrounding lava flows (Fig. 1). High Resolution Imaging Science Experiment (HiRISE) images were used to produce 1:100,000 detailed geologic maps of post-glacial deposition on the FSD (Fig. 3). Mapping of the Arsia FSD units were based on units and volcano-ice interactions mapped by **[5]**.

Geologic Observations:

Primary Geomorphic Units. We mapped ridged, knobby, and smooth facies within the Arsia FSD (Figs. 1,2). Additional mapped units included lobate flow facies, main shield lobate flows, degraded material on the flank of the main shield, smooth lower western flank material, and fingerprint material.

The Arsia FSD partially buries older tabular flows that extend from the base of the main shield. Mapping of the lava plains surrounding Arsia showed that the FSD is surrounded primarily by tabular flows and raised ridge flows (lava tubes).

Post-glacial deposit. We conducted detailed mapping of HiRISE images in an effort to confirm the presence of post-glacial volcanism or a catastrophic flood outburst **[5]**. The geomorphic units associated with this deposit that we have mapped in the HiRISE images include a northeast trending line of cones, tabular flow material and channel (blue), a hummocky texture (green), a breach in the terminal moraine (red), and older ridged facies (yellow) (Fig. 3).

The channel within the flow deposit is traceable from an interior moraine downslope towards the breach in the terminal moraine. The line of cones is present on either side of an older tabular flow (20-40 meters (m) high) buried by ridged facies **[7]**. There is also a set of cones present outside of the FSD, but there are no related flow features.

This older tabular flow is important for determining the sequence of geologic events. The flow is thicker than the adjacent flow material associated with the line of cones and/or outburst and is buried by ridged units, but the line of cones and surrounding material is not buried by this facies deposit.

Discussion/Conclusions: We have previously suggested evidence of recent volcanism associated with the line of cones within the Arsia FSD based on mapping of flows that appear to emanate from the cones, embay the ridged facies, and breach the terminal moraine of the FSD **[7]**. These flows have also been mapped as catastrophic outburst deposits from a subglacial eruption by **[5]**. They argued that in order

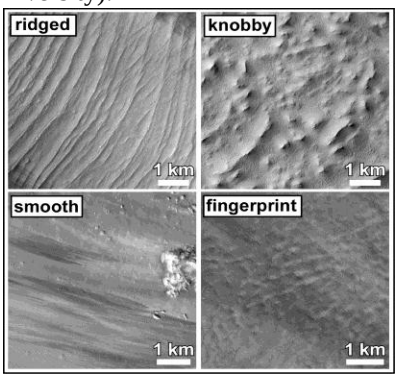
for this material to be volcanic the flows that traveled east would have had to breach several ridges and continue in a direction nearly ~ 50 m higher in elevation based on present day MOLA topography. If these deposits are volcanic, then the area east of the line of cones would have had to be at a lower elevation possibly due to overburden of a thick glacier to cause such a drastic change in the local slope and permit flows to travel east. However, the line of cones on the southwest side of the older tabular flow have flow material connected to the line of cones, but this area is not connected to the source of the proposed outflow material by **[5]**. This suggests that there are lava flows associated with the line of cones, but it is difficult to distinguish lava flows from the outburst material that embays the line of cones on the northern side of the older tabular flow.

Questions remain regarding stratigraphic evidence of post-glacial volcanism within the Arsia FSD: is there a mix of both lava flow and catastrophic outburst material? How can we tell the different units apart? Could the glacial material have ever been thick enough to depress the terrain so that lava could have flowed east of the line of cones? Is the material surrounding the line of cones on the southwest side of the older tabular flow volcanic in origin? Why is there no flow material associated with the line of cones outside of the FSD?

The stratigraphic relationship between the lava flows and channel deposits at the northern end of the Arsia FSD requires further analysis, through geologic mapping, to determine the sequential geologic events resulting in current observations and the interactions of glacial and volcanic activity in the area.

References: [1] Bleacher J.E. et al. (2007) *JGR,112*, E09005 doi:10.1029/2006JE002873. **[2]** Carr M.H. (2006) The Surface of Mars Cambridge University Press, 322 p. **[3]** Head J.W. and Marchant D.R. (2003) *Geology, 31*, 641-644. **[4]** Shean D.E. et al. (2007) *JGR, 112*, E03004, doi:10.1029/2006JE002761 **[5]** Scanlon, K.E. et al. (2014) *Icarus, 237*, 315-339. **[6]** Kadish, S.J. et al. (2014) *PSS, 91*, 52-59. **[7]** Garry, W.B. et al. (2013) *LPS XLIV*, Abstract # 1647.

Acknowledgements: This research is funded by NASA's Mars Data Analysis Program (MDAP) grant NNX10AO15G awarded to D.A. Williams (Arizona State University).



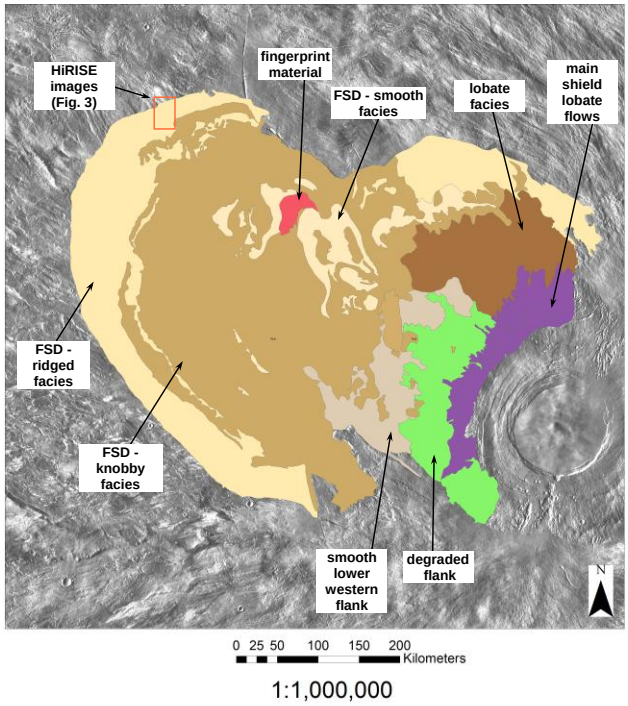


Figure 1. Geologic map of the FSD on Arsia Mons, Mars overlain on a THEMIS Daytime IR basemap.

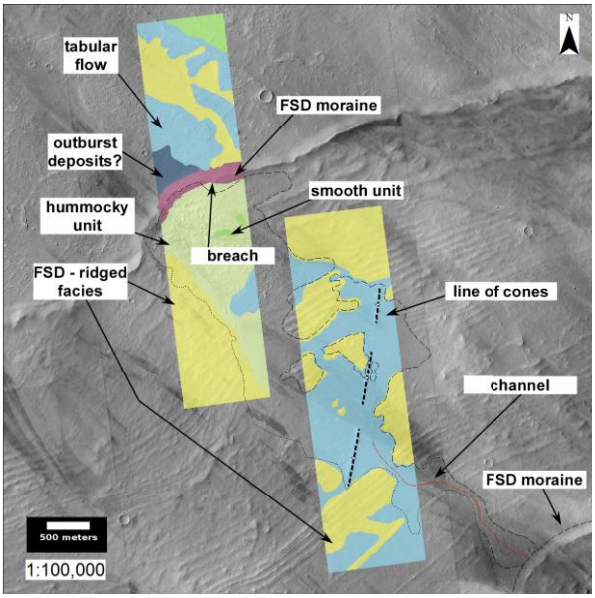


Figure 3. Geomorphic map of the line of cones and flow features on HiRISE images [NASA/JPL/UA]. Outline of older tabular flow and channel on CTX basemap.

Figure 2. To left, subsets of CTX images that show examples of the ridged, knobby, smooth, and fingerprint facies within the FSD at Arsia Mons [NASA/JPL/MSSS].