ICE-RICH NORTH-FACING SLOPE DEPOSITS IN ALBA PATERA, MARS: YOUNG BUT NOT MOVING

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Introduction: Alba Patera (centered at 39.53°N, 250.82°E) is the summit caldera complex of Alba Mons, which is the northernmost, shortest (~6 km tall) and widest (>1000 km basal diameter) of the large shield volcanoes within the Tharsis region of Mars [1]. Identification of primary volcanic morphologies (such as lava flow boundaries) is challenging within the patera because of an abundance of younger surficial deposits [e.g., 2].

Examination of Alba Patera using primarily Mars Orbiter Context Camera (CTX) images [3], as well as High-Resolution Stereo Camera (HRSC) [4] images, combined with available Mars Orbiter Laser Altimeter (MOLA) data [5] has revealed unconformable deposits that are found on north-facing slopes as well as within impact craters. Here, we report results of recent investigations into the distribution and behavior of these north-facing slope deposits (NFSDs) and conclude that they are essentially small lobate debris aprons (LDAs) that are more commonly found at Mars' mid-latitudes [6, 7].

Background: Water ice appears to have played an important role in recent (Late Amazonian) geologic activity on Mars [e.g., 8]. Lobate debris aprons found along scarp bases, lineated valley fill, and concentric crater fill have been interpreted to be possible glaciers or rock glaciers [9]. The development of mid-latitude ice-rich deposits is most likely controlled by climate cycles with periods of 10^5 to 10^6 years [8]. Although water ice is not currently stable at the surface of Mars, a layer of rocky debris could act to protect underlying ice from sublimation [9].

Hummocky and smooth deposits found hugging north-facing slopes in Alba Patera have received little attention to date [2, 10], even though they represent the highest elevation and the northernmost latitudes where these types of deposits have yet been reported.

Methods: CTX images were imported into ArcMap and georeferenced, and served as the primary dataset because of their combination of complete coverage and high resolution (~5 m/px). Images from the High-Resolution Imaging Science Experiment [11] are rare in the study area as of this writing. MOLA orbital tracks that crossed the north-facing slope deposits were identified and used to construct topographic profiles and to calculate deposit volumes. Impact craters with diameters >500 m were examined for evidence of unconformable fill; MOLA orbit tracks were found to cross 6 of these craters, providing information about the distribution of crater fill.

Results: Within Alba Patera, NSFDs appear to be among the youngest deposits, and are observed to embay impact craters on the caldera floor, conical hills (possibly scoria cones), and a series of ridges that are interpreted to be tectonic slivers generated during caldera collapse (Fig. 1, 2).

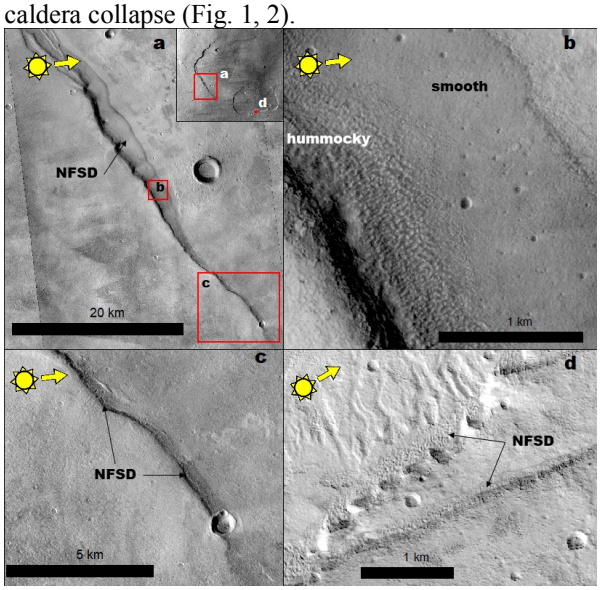

Fig. 1. Examples of NFSDs along the caldera walls of Alba Patera. In all cases, the yellow sun and arrow show the direction of illumination. In the inset image shows the locations of a and d on a basemap of HRSC image H2917_0000_ND2 (a): The largest continuous NFSD, located in the western caldera as shown in CTX image G21_026590_2205_XI_40N110W centered at 39.8 °N, 249.3 °E. Red boxes show locations of b and c. (b): Smooth and hummocky textures observed on lobate deposits; CTX G21_026590_2205_XI_40N110W. (c): Southernmost portion of the NFSD, consisting entirely of the hummocky texture ; CTX G21_026590_2205_XI_40N110W. (d): The narrowest NFSDs observed along the caldera walls, located in the eastern caldera at 39.8 °N 250.84 °E (see red box in inset image) in CTX image G17_024823_2204_XI_40N109W.

Similar to the NSFDs, the crater fill tends to be concentrated on the north-facing slopes of the impact crater walls, although a minor subset of craters appears to contain flat-lying unconformable fill (Fig. 3).

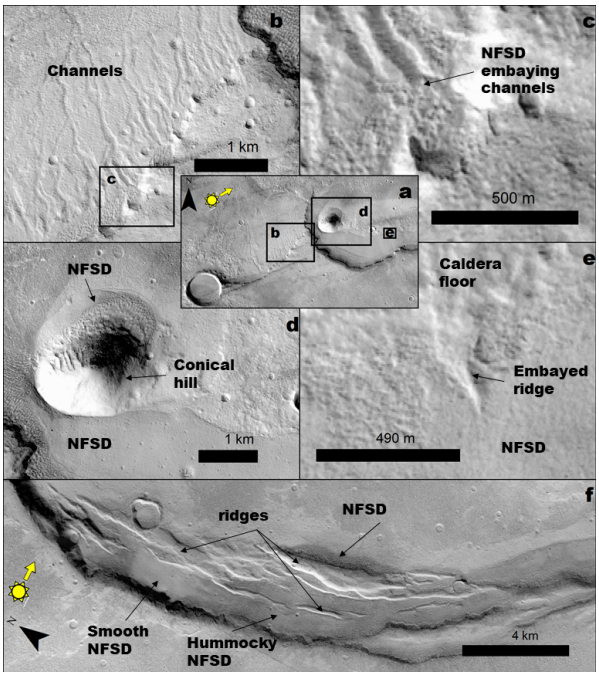

Fig. 2. Features embayed by NFSDs. (a): Locations of b-e, centered at 39.13 °N, 250.88 °E in CTX image G17_024823_2204_XI_40N109W. (b-e) use the same CTX image. (b): channels in the eastern caldera that are (c) embayed by hummocky NFSDs. (d): NFSD embaying a conical hill. Another NFSD is present on the flank of the hill. (e); NFSD embaying a ridge on the caldera floor. (f): NFSD embaying ridges at the western edge of the western caldera (CTX images G21_026590_2205_XI_40N110W, G20_026023_2205_XI_40N111W, centered at 40.18 °N, 248.94 °E).

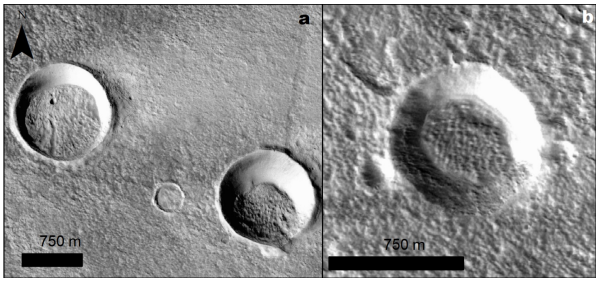

Fig. 3. Impact crater fill. (a) A pair of impact craters with north-facing fill. The northward slope can be inferred from the greater exposure of the south-facing crater walls than of the north-facing walls. (b): An impact crater with level fill. (Images courtesy of NASA/JPL/MSSS).

Results and Interpretations: Morphology and topographic profiles suggest that both the NSFDs and the impact crater fill are ice-rich deposits that were generated during Mars' last glacial cycle [12]. We interpret their presence on north-facing slopes as a result of the total amount of annual solar insolation received during a given year at given obliquity. Investigations on Earth (using the Area Solar Radiation Tool in ArcMap) reveal that the annual insolation received by a north-facing, 20° slope (similar to the caldera walls) at 40°N latitude is significantly less than the total annual insolation received by a flat surface (such as the caldera floor). Thus, these deposits are essentially small LDAs, with the internal ice protected by a layer of rocky debris. We interpret the hummocky texture on the NFSDs to be caused by the dissection and subsequent sublimation of the seasonal ice-rich dust mantle [8]. That the hummocky textures are preferentially found on steeper slopes suggests that there may be a kinematic contribution to the disruption of the ice-rich dust mantle. However, there is no morphologic indication, such as deformed impact craters, that the NSFDs are currently moving or flowing.

Impact crater fill is found in almost all craters within the study area, but the relative amount of fill was different for each crater (see Fig. 3). It may be that the amount of fill is related to crater age: older craters may simply have had more time to accumulate more ice-rich fill through more climatic cycles.

References:

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