DEVELOPING A THERMOPHYSICAL AND GEOMORPHOLOGIC FRAMEWORK TO IDENTIFY EVIDENCE FOR ANCIENT EXPLOSIVE VOLCANISM ON MARS. G. C. Garcia[1], B. D. Brand[1], J. L. Bandfield[2]. [1]Department of Geosciences, Boise State University, Boise, Idaho, 83725 (gabrielgarcia430@u.boisestate.edu), [2]Space Science Institute, Boulder, Colorado, 80301.

Introduction: Accurately identifying the products of explosive volcanism on Mars is critical for unraveling the evolution of the martian crust and interior. Furthermore, recent work using high-resolution datasets [2,3,4] suggests explosive processes were likely a much more dominant component of early martian volcanism. However, distinguishing the products of explosive volcanism from non-volcanic sediments remains challenging. Thus, the style and extent of explosive volcanic features on Mars remains unknown.

Apollinaris Mons, located near 174°E, 9°S, is one of the best known candidates for an explosive volcano on Mars [5]. The volcano covers an area of ~46,000 km^2, and includes a large caldera ~80 km in diameter (Fig. 1). Previous studies found that the channels along the flanks, especially along the large fan south of the caldera (Fig 1, location A), suggest erosion though weak, friable material, consistent with pyroclastic deposits [5].

In addition, the adjacent Medusae Fossae Formation (MFF), a large volume friable deposit interpreted as volcanic in nature, may also originate from Apollinaris Mons [5]. Our work builds on these previous studies by mapping and describing additional terrains around Apollinaris Mons and the MFF, and comparing surfaces, patterns, and textures to pyroclastic deposits on Earth.

Methods: This study identifies possible distinguishing morphological and thermophysical characteristics of possible explosive volcanic deposits on and around Apollinaris Mons using CTX, THEMIS, and HiRISE visible and thermal infrared imaging datasets. We compare our findings to the surface textures and patterns from the arid, wind-eroded Altiplano-Puna volcanic complex (APVC) in Chile, Bolivia and Argentina.

Results: Thermal inertia data from TES record an average value of ~90 $J \cdot m^{-2} \cdot K^{-1} \cdot s^{-1/2}$ across Apollinaris Mons, which corresponds to poorly consolidated sediments. We've identified new surface textures that are consistent with friable materials.

Fluted terrain: More than 1,200 km^2 of material displaying an interference pattern of sharp ridges above a scalloped interior covers the southwestern rim and flank of Apollinaris Mons (Fig. 2A, 2B). The northern edge of the deposit makes a sharp contact with the dust mantled surface that covers most of the edifice. Pits ~100 m long, ~50 m wide are present within the caldera and on a few valley ridges down flank. The pits share a similar shape to the fluted surface, but are deeper and more ovate. The concentration of pits within the caldera grades from 9% in the eastern portion to 1% westward. Beyond the caldera rim, the pattern of the fluted terrain begins to transitions from an interference-like pattern to more elongated and linear in a northeast to southwest orientation. Farther down the flank, coverage of the deposit begins to thin out and become discontinuous; here the terrain forms linear ridges similar to yardangs.

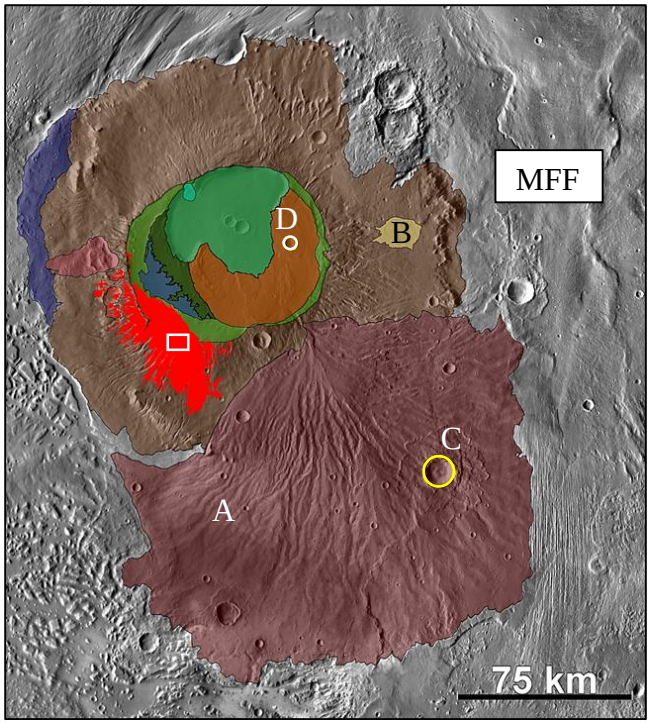

Figure 1: Apollinaris Mons. Colors correspond to different geomorphic units. Red shapefile indicates extent of fluted terrain in Fig. 2A, 2B (white box). The yellow circle correspond to crater wall morphologies in Fig. 2D. Background is a map-projected HRSC image, ID: H0637_0000_ND3.

Knobby terrain: A knobby terrain is present on the eastern flank of the volcano near 175.5° E, 8.5° S, (Fig. 1, location B; 2C). The knobs occupy 7% of the terrain, are 30 - 500 m in width, and commonly ~50 m tall. The larger knobs display flat topped surfaces resembling mesas, and the smaller knobs display a more rounded, mound-like appearance. Near 175.5° E, 8.1° S, more mound-like structures are present; these knobs appear layered, and less prominent than those in Fig. 2C. The presence of knobs also extends beyond the eastern flank, into the MFF.

Sinuous surface texture within MFF: A ~42,000 km^2 region of the MFF located near 180° E, 7° S exhibits a sinuous surface texture unique to the MFF in Lucus

Planum. The two main textures include curvilinear ridges above a smooth surface (resembling stucco on a wall), and serpentine, channel-like ridges that appear to overlap one another. Because the surface features are only observable in CTX and HiRISE resolutions, variations in solar incidence angles within each image stamp may be contributing to the perceived differences in texture across the deposit. In areas where many overlapping serpentine features comprise the surface, average ridge width is ~100m. Ridge height is unobtainable due to shallow shadow lengths. The orientation of the ridges follows a general NE-SW trend. Horizontal layering is present and observable on ridge walls in HiRISE stamps.

Crater wall morphologies: All craters on or around the volcano with exposed outcrops contain materials that erode in a friable manner. For example, Figure 2D shows a crater located on the southeastern region of the debris apron (Fig. 1, location C; 2D) shows distinct, resistant layers between 1-10 m thick. Incised valleys cut through the layers, but boulders are not found down slope. This morphology in consistent with craters across the flanks of the volcano. In contrast, morphologic observations of the crater in the eastern region of the caldera (Fig. 1, location D) suggest blocky material with no defined layering, and boulders that persist more than 1 km down slope. The surface is visibly rough and appears more fragmented relative to the outer-caldera crater walls.

Implications: The radial channels around the caldera that incise down the flanks and debris apron on Apollinaris Mons suggest erosion through weakly indurated, friable materials [5]. The presence of a fluted terrain on the southwestern flank resembles blowout features formed in the APVC [6] as a result of Aeolian activity through uneven topography. Yardang structures present in the MFF beyond the flanks of Apollinaris resemble yardang structures on earth [7], but on a larger scale.

A possible explanation for the knobby terrain on the eastern flank may result from fumarolic mounds as a consequence of trapped gasses on the pyroclastic material [8], that indurates the deposit. Later erosion of the deposit will leave behind mounds of more resistance materials that sit above surrounding topography. A second possibility is simply erosion of layered, variably cemented, friable deposits. Regardless, the implications for soft, layered materials on a volcanic slope suggest these features may be common in volcanic terrain.

Summary: Our evidence for extensive friable deposits along the slopes of Apollinaris Mons and into the MFF, and consistently low thermal inertia of exposed layers in crater walls and caldera cliffs, further supports an explosive volcanic history for Apollinaris Mons. After detailed mapping, we see no evidence for effusive activity, although we recognize that we cannot access the entire volcanic history. Therefore, we suggest that the surface textures and morphologies described herein, in combination with similar features in the APVC on Earth, may be used as diagnostic criteria for identifying similar deposits elsewhere on Mars.

References: [1] Self (2006) *PTRS*, 364, 2073-2097. [2] Bandfield J. L. et al. (2013) *Icarus*, 222, 188-199. [3] Dalton and Christensen (2006) *LPS XXXVII*, Abstract #2430. [4] Krysak (2011) *M.S Thesis*. [5] Kerber et al. (2011) *Icarus*, 216, 212-220. [5] de Silva et al. (2010) *Planet. Space. Sci.*, 58, 459-471. [6] Bailey J. E. et al. (2007) *Rem. Sens. of Env.*, 108, 24-41. [7] de Silva et al. (2010) *Planet. Space. Sci.*, 58, 459-471. [8] Ragan and Sheridan (1972) *GSA Bulletin*, 83, 95-106.

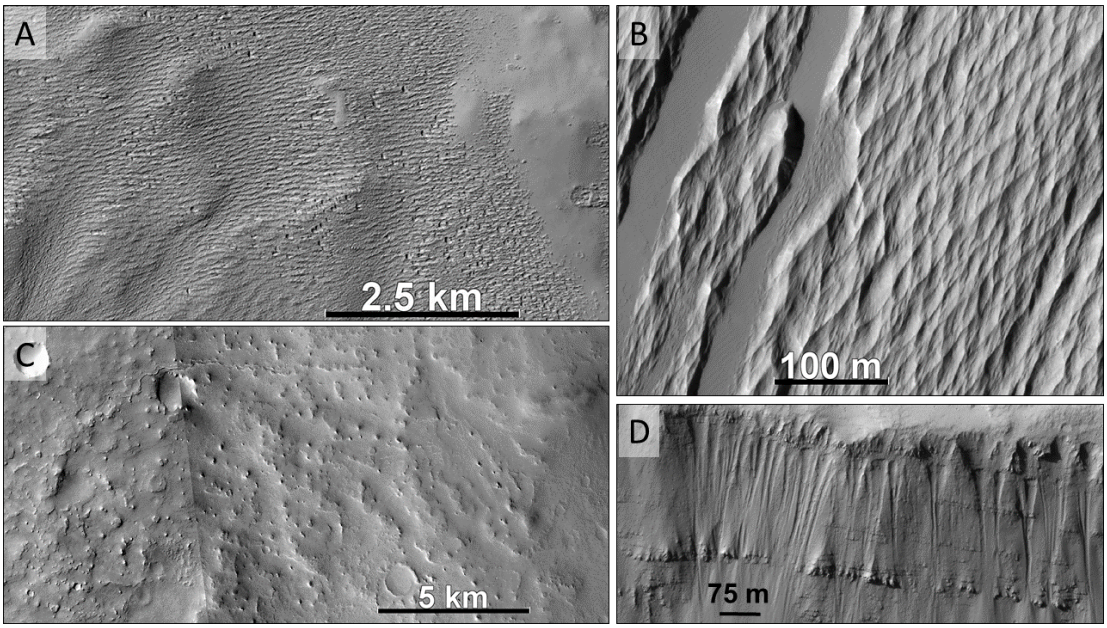

Figure 2: Unique surface textures observed across Apollinaris Mons. Fluted terrain (A, B) present only on the southwestern rim and flank. Knobby terrain on the eastern flank (C) shows more resistant material on an eroded plain that slopes to the southeast. Crater wall morphology of a crater in the southeastern region of the debris apron.