NEW EVIDENCE FOR EARLY EXPLOSIVE VOLCANISM ON MARS. J. Huang[1,2], M. Kraft[2], P. Christensen[2] and L. Xiao[1], [1]Planetary Science Institute, China University of Geosciences, Wuhan, 430074, P. R. China (jhuang.cug@gmail.com; longxiao@cug.edu.cn), [2]Mars Space Flight Facility, Arizona State University, Tempe, AZ, USA.

Introduction: Recent studies have shown that widespread volcanic activity occurred in Early Noachian [1] and the Noachian rocks exposed at the surface are related to the intense volcanism [2] rather than the remnants of a primary crust forming during the solid-state overturn of a crystallized magma ocean [3]. There has been a debate over the dominate style of volcanism in early martian history, which are the fundamental processes forming the crust of Mars. Extensive exposures of possible layered, undisrupted lava flows provide evidence for effusive volcanism [4]. However, the widespread occurrence of mechanically weak mafic materials in ancient terrains indicates that explosive mafic volcanism was perhaps the major style of volcanism on early Mars [5, 6]. Here, we identify and characterize knobby terrains on the slopes of Noachian volcanoes in the Thaumasia Highlands. We interpret them to be eroded remnants of pyroclastic flows, which supports the idea that explosive volcanism was an important process on early Mars.

Methods: We used imaging data from the Thermal Emission Imaging System (THEMIS: 100 m/pix) [7] global mosaic [8] and gridded topographic data of Mars Orbiter Laser Altimeter (MOLA: 128 ppd) [9] to show the overall regional context (Fig. 1A). Then we showed local (Fig. 1B) and detailed (Fig. 1C) geomorphology using data of Context Camera (CTX: ~6 m/pix) [10] and High Resolution Imaging Science Experiment (HiRISE: ~30 cm/pix)[11]. Using THEMIS nighttime IR data converted to thermal inertia [12] we derived the thermophysical nature of the materials in these terrains.

Preliminary Results and Discussion: The knobby terrains we observed occur on the southern slope of a heavily modified ancient volcano (~6000 m above datum: Fig. 1A). The volcano has a crater retention age of ~3.94 Ga [1] and stands1500-2000 m above the surrounding area. The volcano is cut through by a pair of large parallel rifts (Fig. 1A) [13]. The slopes of the volcano are incised by channels. The channels vary in width and depth, and form a radial pattern, which might indicate erosion by multiple periods of fluvial activity (Fig. 1B).

Knobby terrains occur in the areas between channels (Fig. 1B). The knobby terrains have a rough and blocky appearance. They are curved near their bases as in a style of erosion (Fig. 1C). Individual knobs are separated by topographically low lineations. The lineations generally trend NW or ENE and most likely are joints occurring in bedrock. Knobs occur in clusters with knobs of similar size, as can be seen in Fig. 1C, in which larger knobs (~30-40 m in diameter and ~10-20 m high) occur in the western half of the image, while smaller knobs (~5-15 m in diameter and ~5-10 m in height) are seen in the eastern half. What causes knobs to cluster by size is unknown, but it could be related to differences in material properties, material thickness, or local slope. The knobby materials have a sharp appearance and maintain steep slopes, indicating the material is well consolidated.

The knobby terrains are relatively dark-toned and dust-free (Dust Cover Index [14] > 0.97); however, the thermal inertia of the knobby terrains is surprisingly low (~190-210 $Jm^{-2}K^{-1}s^{-1/2}$). These properties could be consistent with bedrock covered by dark, fine-grained material, such as volcanic ash. It is also plausible that the knobs themselves are consolidated fine-grained material, such as a volcanic tuff.

We suggest that knobby terrains are rocks made of fine-grained pyroclastic material. The consistent sharpness and angularity of the knobs are more consistent with fine-grained rock than with blocky rock covered with fine-grained materials, which we would expect to have a smoother, draped-on appearance. One possible formation scenario could be: 1) the pyroclastic flow erupted and covered the slope and adjacent area; 2) fractures were generated by extensive regional tectonic stress; 3) snow melting or rain eroded preferentially along the pre-existing faults; 4) wind erosion further modified these terrains; 5) later lava flows covered the much of the pyroclastic material in the surrounding area, but exposures of knobby terrain were preserved on the slope.

Future Work: We expect to add to these initial results with further work to: 1) investigate the distribution of these unique knobby terrains; 2) determine the composition of the knobs; and 3) further analyze morphology and assess possible erosion mechanisms.

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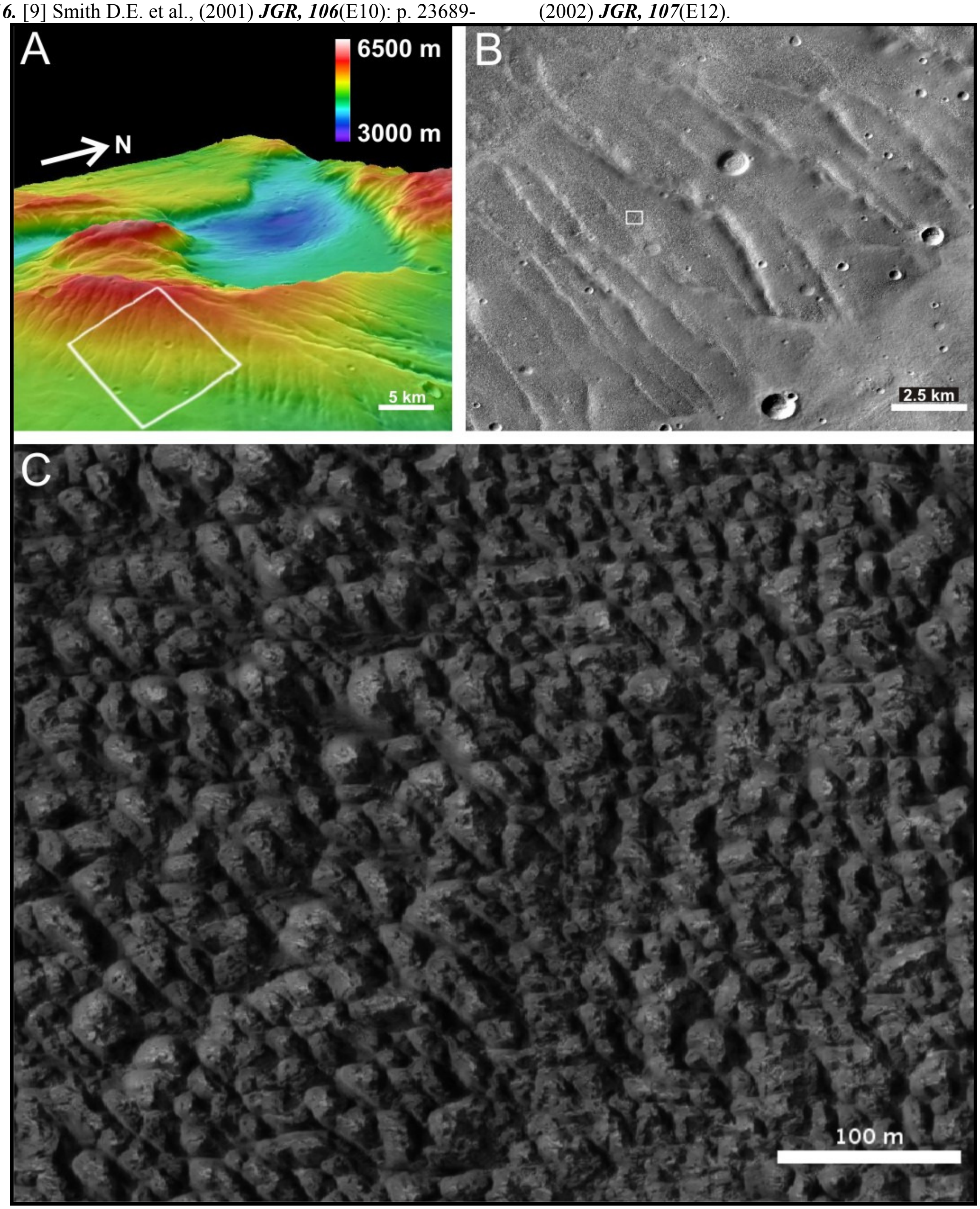

Figure 1. A) 3-D view of colorized, gridded MOLA topographic data overlain on THEMIS daytime IR mosaic (centered at 37.87S, 272.12E, 10× vertical exaggeration). The box shows the outline of B; B) Local context showing channels and the knobby terrains. The box show the outline of C (CTX: B03_010621_1419_XN_38S087W); C) Close-up view of the knobby terrain (HiRISE: PSP_010621_1420_RED).