GEOMORPHOLOGIC MAPPING OF A POSSIBLE HESPERIAN SUBGLACIAL ENVIRONMENT IN THE SISYPHI MONTES, MARS. S. E. Ackiss, A. Campbell, M. Suda, B. Horgan, Purdue University, Department of Earth, Atmospheric, and Planetary Sciences, West Lafayette, IN 47907 (sackiss@purdue.edu)

Introduction: The Sisyphi Montes region (55-75°S, 335-40°E) is located in the southern highlands between the Argyre and Hellas basins (Figure 1). It is composed of isolated domical features [1, 2] and a unit interpreted to be portions of the ancient Dorsa Argentea ice sheet [3, 4]. While the domes are thought to be volcanic in nature, it is still unclear whether they were formed subglacially or subaerially. [1] proposed that the morphologies seen are consistent with volcanoes that were built and erupted under a more extensive Hesperian-aged ice sheet. [5] conducted a mineralogic study of the edifices using Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) to see if the mineralogy of the edifices is also consistent with a subglacial origin. The assemblage found consists of sulfates (polyhydrated and gypsum) and a smectite-zeolite-iron oxide mixture most consistent with palagonite. While this is consistent with a subglacial formation environment, it does not definitively distinguish if the volcanic edifices were subglacial or subaerial. The creation and analysis of this proposed geomorphologic map strives to answer the overarching question: What is the origin/environment of formation of the Sisyphi Montes?

Data Sets and Methods: This region has been previously mapped at the 1:2,000,000 scale [6] using data from Viking and was recently mapped in broad geologic units at a scale of 1:20,000,000 [7] using higher resolution datasets including the MGS Mars Orbiter Laster Altimeter (MOLA) [8], Thermal Emission Imaging System (THEMIS) [9] mid-infrared daytime images, and the MRO Context Camera (CTX) [10].

While the previous maps of this region [7-8] have contributed to the interpretation of the region, there are still some major knowledge gaps that could be answered using a finer-scale, higher-resolution map. We propose to construct a geomorphologic map of this region at scales between 1:600,000 and 1:250,000. Basemap data includes MOLA topographic data (128 pix/deg or ~460 m/pix), THEMIS daytime infrared (18 m/pix), and CTX (6 m/pix) for morphologic data. This map will be supplemented with CRISM hyperspectral targeted images and multispectral mapping strips used to show large outcrops of hydrated and mafic minerals (e.g. sulfates, clays, zeolites, olivine, and pyroxene). Standard geomorphologic contact mapping methods will be utilized. Additionally, mineralogic outcrops observed in CRISM will be mapped where clear spectral signatures are present. Crater counts at the edifice scale (50-100km) will also be conducted and used to verify the age of the Sisyphi Montes in comparison to the surrounding Sisyphi Planum. Using this scale and the added spectral datasets will combine geomorphologic and spectral data to construct a more complete picture of the Sisyphi Montes region.

Discussion: By correlating the morphology with the mineralogy of this region, we can place constraints on the formation of the edifices. Because of the previous research in this area [1, 2, 4, 5], our preferred hypothesis is that these edifices are subglacial in origin. In volcanic eruptions beneath ice sheets and glaciers on Earth, the combination of heat and large quantities of melt water lead to the production of unique morphologies. These morphologies include “tuyas” or table mountains that are steep sided and flat topped edifices and “tindars” or ridges that are flat-topped and linear. Subglacial mounds, which are conical in shape, are made when the eruption does not breach the ice-sheet [11]. The dominant spectral signatures for this environment are expected to be glass, zeolites, and smectites [5, 12-13]. A possible smectite-zeolite-iron oxide mixture has been recently identified on the edifices using CRISM spectra [5], consistent with a volcanic origin.

We are also considering three other hypotheses for the origin of the high latitude edifices:

1. Subaerial volcanism: Subaerial volcanism includes stratovolcanoes, complex volcanoes, compound volcanoes, somma volcanoes, shield volcanoes, pyroclastic shields, lava cones, and lava domes [14]. The morphologies of these edifices are typically cone-shaped and on average 5° less steep than glaciovolcanic edifices [15]. The dominant spectral signatures for this environment are expected to be crystalline mafic minerals and a variety of clay minerals [5, 16].

2. Impact cratering: Because some of the Sisyphi Montes are encircled by local moat-like features with raised rims, [17] hypothesized that the edifices were formed due to a combination of volcanic and impact-related processes. They proposed that the magma that created the structures was sourced from magma bodies intersecting large impact-induced zones of crustal weakness circumferential to the Hellas basin. The magma was then brought to the surface by subsequent small impacts, building edifices in the centers of the smaller impact craters [17]. We can test the hypothesis of volcanism inside impact craters by seeing if all of the edifices are associated with moat-like features. We hypothesize that the expected mineralogy of this environment would be variable because impact craters bring up old crust that is buried in the subsurface [18].
Erosional remnants: Erosional features can form in different landscapes including deserts (e.g. mesas, plateaus, canyons, inselbergs, yardangs), glaciated regions (e.g. drumlins and depositional features including moraines and eskers), and karsts (e.g. caves and sinkholes) [19]. The key to mapping erosional remnants is differentiating them from “unaltered” or primary landforms. For example, inselbergs (an isolated hill rising from a plain) and kipukas (an isolated hill surrounded by lava) can look similar from orbit but have very different formation environments. Similarly, mesas (isolated flat-topped, steep-sided hills made of horizontal strata) can resemble tuyas (flat-topped, steep-sided volcanic edifices). We hypothesize that the expected mineralogy of erosional remnants would include clay minerals and carbonates in depressions and stratified layers.

Implications: This research will provide the first comprehensive map comprised of compositional and morphological information of the Sisyphi Montes region at this scale, which will use to answer the question: What is the origin/environment of formation of the Sisyphi Montes? Because the Sisyphi Montes may record the presence of ice outside of the south polar region, measurements including edifice height and location can provide insights into the extent of the sub-polar paleoicesheet. This will provide regional information about the history of the Dorsa Argentea Formation, as well as surrounding volcanic features such as Pityusa and Malea Paterae. In particular, it will provide new information pertaining to the martian paleoclimate, possibly helping to address the validity of the current “warm and wet” [20] and “cold and icy” [21, 22] climate models. The results from this study will provide novel insight into regional volcanic and glacial processes.

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