NORTH AND SOUTH: POSSIBLE TUYAS AND HYALOCLASTITE HILLS ON THE NORTHERN PLAINS AND IN THE SOUTHERN DORSA ARGENTEA REGION OF MARS.

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Introduction: With the recognition of past [1] and possibly present [2] glaciers on Mars, evidence for larger ice sheets extant in the past [3] gains new credence. Coupled with the history of extensive volcanic activity on Mars, the search for products of volcano-ice interactions gains new value as a tool for constraining the extents of past martian ice sheets and understanding their history. In this study, we examine a set of domes on the northern plains of Mars and larger hills in the high southern latitude Dorsa Argentea region and consider the hypothesis that they are tuyas and/or sub-ice volcanic mounds as suggested in [4] and [5]. Here we examine spectral evidence from the OMEGA, CRISM, THEMIS, and TES sensors to see if data from these instruments support this interpretation.

Areas of Interest: The Dorsa Argentea region lies at high southern latitudes centered at approximately 65˚ S, 4˚ E. A set of hills within this region, originally mapped by [6], lie within the mid-Hesperian aged Dorsa Argentea formation. The features generally are between 1 and 1.5 km in height and their basal diameters are generally between 30 and 40 km [5]. The morphologies of these hills vary considerably. Some are flat-topped, others are cone shaped or form low domes, some have summit craters/calderas and at least a few have smaller cones on their tops. In [5] these features were interpreted as volcanic in origin. Those with low dome morphologies were suggested to have formed from subaerial eruptions, but most were interpreted to have formed from sub-ice eruptions. This interpretation is plausible given the association of the features with the Dorsa Argentea formation, interpreted by [7] as a volatile-rich unit constituting the remnants of a former south polar ice sheet. According to [5], the conically shaped peaks did not breach the surface of the ice sheet/englacial lake (formed from the eruption) and are the equivalent of sub-ice volcanic mounds. The flat-topped peaks did breach the top of the ice sheet/englacial lake and are the equivalent of tuyas.

A set of dome-shaped structures have been identified in the Arcadia Planitia region, most prominently between 34 and 46°N and 167-180°E and also in Utopia Planitia, primarily between 38 and 45°N and 76 to 86°E. These features are more numerous and considerably smaller than those in the Dorsa Argentea region (diameters on the order of 1 to 5 km). Those in the Arcadia region were examined by [8], and were described as “core, annulus, and aureole” features since they have an upraised core, a surrounding apron or annulus and a surrounding ring or aureole. In [8] these features were interpreted as silica-rich volcanic domes; these authors did not consider that they might be mafic sub-ice mounds.

Multi- and Hyperspectral Analysis: In **Fig. 1**, a THEMIS daytime IR band 8, 7, 5 decorrelation stretch image is shown over two of the Dorsa Argentea features. Here these large hills show up as blue, a distinct color from the background. Analysis of OMEGA spectrometer C (Short-Wave Infrared or SWIR) data also indicates that these features have a spectral signature distinct from the background and this spectrum, corrected to approximate surface reflectance is shown in **Fig. 2**. In **Fig. 3**, a georeferenced version of the OMEGA scene is shown along with a pseudo-colored constrained energy minimization (CEM) [9] fraction image with high fractions of this spectrum showing up in yellow. The spectrum in **Fig. 2** has low reflectance values shortwards of 1 and 2 μm which is consistent with a low Ca pyroxene mineralogy. The spectrum does not show evidence of hydrated water bands near 1.9 μm or a metal-OH band in the 2.2 to 2.3 μm region- features that would be indicative of a high palagonite (or devitrified palagonite, clay rich) content [10]. However, visible wavelength imagery of these features show that they have a relatively high albedo, commensurate with the light-toned plains. Nighttime THEMIS imagery also indicates that these features are cool at night and in nighttime brightness temperature images they show up as darker than low albedo, nominally basaltic, sands. In contrast, the domes in Arcadia and Utopia, and their associated aprons are dark-toned relative to the background plains at visible wavelengths (**Fig. 4**) and are warm at night relative to the background plains in THEMIS nighttime imagery. In a THEMIS band 9, 7, 5 decorrelation stretch (DCS) combination of THEMIS daytime imagery, these domes tend to have a light-tone, attributed to a higher thermal inertia (same color and tone as low albedo, nominally basaltic, sands), although some isolated examples have colors more consistent with light-toned plains.

Discussion: The large hills in Dorsa Argentea are distinct in several important ways from the smaller dome-shaped hills in Arcadia and Utopia. The former are significantly larger and display a spectral signature distinct from the background plains. Spectral information in the VNIR/SWIR is currently unavailable for the smaller Arcadia/Utopia domes; however, the multispectral character of these features in THEMIS data is similar to that of basaltic sands. The features also have thermal inertia characteristics opposite to those of the Dorsa Argentea hills- high relative to the background plains for the former and low relative to low albedo basaltic sands for the latter. Given the differences between these two sets of features, different origins appear to be dictated. However, another significant difference between the two regions is that the Dorsa Argentea region is older. The hills in this region are associated with the Dorsa Argentea Formation [6] which is of Hesperian age. The Arcadia domes occur in association with Amazonian age deposits [8]. We suggest that despite some significant differences with the Dorsa Argentea hills that the Arcadia/Utopia domes could be smaller sub-ice volcanic mounds of a younger age than the much larger Dorsa Argentea features. The younger age might mean that they are not as weathered as the Dorsa Argentea hills and so have rougher, higher thermal inertia surfaces than do those hills. They could also be somewhat different in composition since the OMEGA data indicates the presence of low-Ca pyroxene in association with the Dorsa Argentea hills and, if the interpretation of [11] is correct, the northern plains might contain material of basaltic andesite to andesite composition.

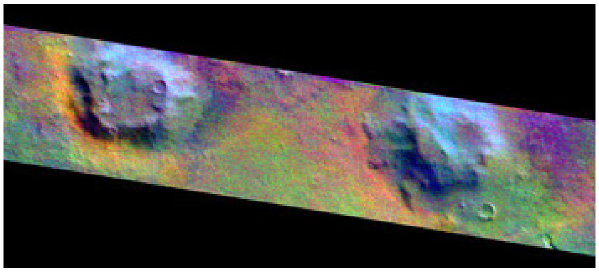

Fig. 1. THEMIS scene I17025008 band 9, 7, 5 composite.

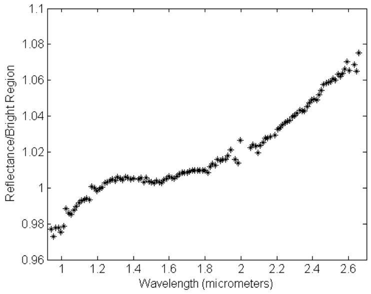

Figure 2. OMEGA C spectrometer spectrum from Dorsa Argentea hills.

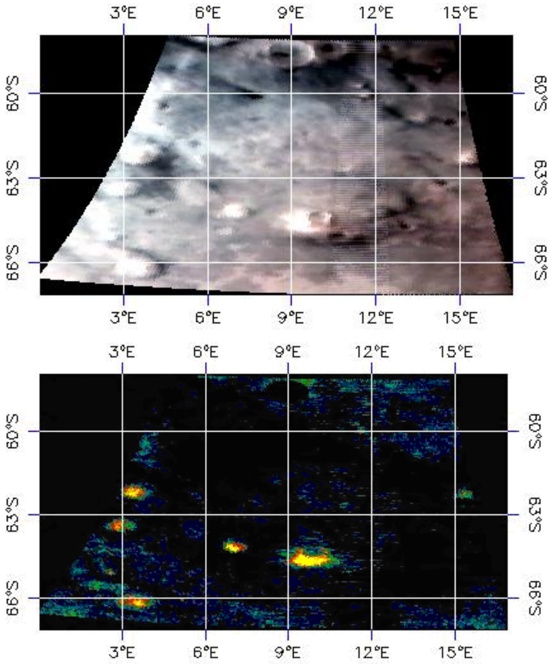

Fig. 3. (top) OMEGA scene covering several of the Dorsa Argentea hills. (bottom) CEM fraction image with yellow indicating highest fractions of the spectrum shown in **Fig. 2**.

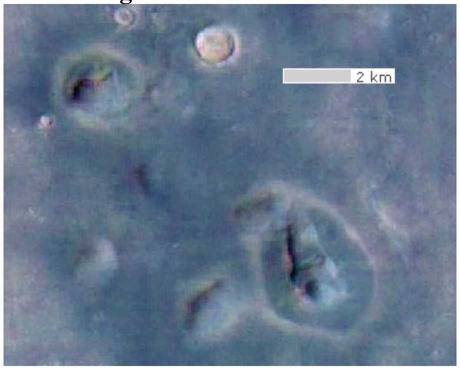

Fig. 4 HRSC scene h1606_0000 color, centered at 37.3N, 170.2E showing dome-shaped structures.

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