LIGHT TONED SEDIMENTARY DEPOSITS AT EASTERN VALLES MARINERIS, MARS: CONSTRAINTS FROM RADAR OBSERVATIONS AND FUTURE LABORATORY EXPERIMENTS.

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Introduction: Understanding the nature of surface materials and their formation processes on Mars is vital to our understanding of its past and present climate. In particular, sedimentary surface deposits potentially contain a record of habitability, the water cycle and variability, and geologic processes. One key to understanding these materials and their history is constraining their geophysical properties in the context of geomorphology, spectroscopy, and thermophysical signature.

Valles Marineris (VM), in the Tharsis region of Mars, exhibits widespread light-toned deposits (LTDs) on the plateaus between chasmata. These LTDs have been identified to contain widespread deposits of phyllosilicates and other soil forming minerals [1]. In the eastern portion of VM, surrounding Ganges Chasma and extending towards Capri Chasma (Figure 1). This particular region is vital to study, because other regions on Mars with clays do not support Shallow Radar (SHARAD) instrument [2] observations because of their surface topography, which creates many off-nadir returns, or clutter. Thus, this plateau is the best yet identified location on Mars to perform this type of analysis.

Studying the properties of these deposits will reveal clues about their history, especially regarding surface and subsurface water in the Noachian.

Background: The LTDs are theorized to have formed during wet periods of the Noachian epoch, and further altered by lacustrine processes late into the Hesperian, and then further eroded and altered throughout the Amazonian [3]. The phyllosilicate clays specific to the region around Ganges and Capri Chasmatas are found to be Al-rich smectites, such as Al-rich Montmorillonite, and Fe/Mg-rich smectites, such as nontronite [4] (Figure 2).

The history of these deposits involves dehydration post formation as evidenced by polygonal fracturing on the order of tens of meters (Figure 3) [5]. Further, it is evident from the depth of the layers, that a portion of the Fe/Mg clay alteration took place in the subsurface [1] This is supported by a Terrestrial analogue study that identified water table retreat as a primary factor in forming similar sized polygons in similar sedimentary environments [6].

A recent study has suggested that radar signals should not be able to penetrate more than ~0.2-0.6 m into any phyllosilicate deposits [7]; however, SHARAD radargrams of the plateaus between Ganges Capri Chasmata penetrate through the LTD and reveal a subsurface reflection [5] (Figure 4).

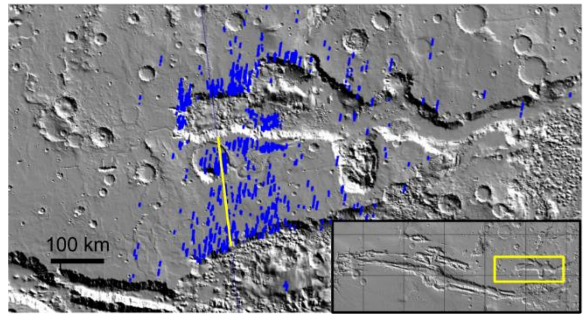

Figure 1: A map of the region around Ganges and Capri Chasmatas. The Ganges region is represented the yellow box in the inlet. The blue colored regions are representative of known subsurface layers as detected by [5]. The portion of SHARAD track 3649101 represented in Figure 4 is represented by the yellow line.

One favored hypothesis is that after the retreat on the water-table around Ganges and Capri Chasmatas, the bound water molecules were left to desiccate from the clays, leaving mineral deposits that attenuate radar waves more slowly than previous experiments have predicted – allowing deeper penetration and a subsurface reflector >10 m beneath the current surface.

Proposed Research: In order to test this hypothesis, we aim to constrain the dielectric properties of the phyllosilicates present around Ganges and Capri Chasmatas by measuring them using SHARAD radar

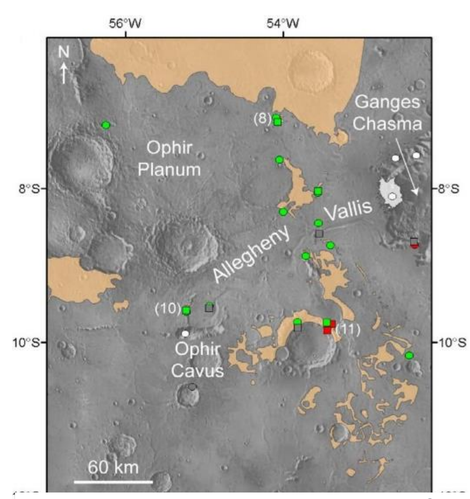

Figure 2:Figure 2: A Phyllosilicate map of the region just West of Ganges Chasma, prepared by [4]. The green squares are representative of Al-phyllosilicate rich material, the red squares are representative of Fe/Mg-phyllosilicate rich material

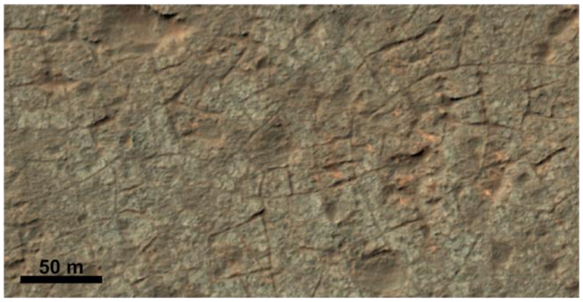

Figure 3: An example of polygonal fractures thought to be desiccation features near Ganges Chasma.

time delay analysis and compare to stereo topography derived from High Resolution Imaging Science Experiment (HiRISE) images [8].

Further, we plan to perform dielectric analysis on terrestrial analog soils containing pure Al-Montmorillonite and Nontronite in laboratory conditions. To accomplish this, we will repeat the methodology of and use the equipment established for this type of work in [9]. In the proposed experiments we will verify the analysis of [7] and then desiccate the samples by baking them above 600 C for over 24 hours and then leaving them in vacuum for 24-72 hours to remove all the bound water molecules.

The experiments deploy a network analyzer to transmit a signal through a sample contained within a coaxial sample holder (Figure 5). The network analyzer measures the attenuation and phase of the output signal over a frequency range of 300kHz to 8.5 GHz. The attenuation and phase parameters are used to calculate the loss tangent of the material which will then lead to solving for the permittivity of the material. The sample is packed into the sample holder using a custom funnel attached to the sieve shaker to help ensure thorough packing and reduce air pockets which may produce a source of error in our measurements. A vacuum chamber will be used to simulate Mars pressures and to control the moisture content of the sample.

Summary: We have identified SHARAD reflections at the basal interface of light toned deposits at the plateau between Ganges and Capri Chasmatas. Contrary to expectations based on laboratory measurements of similar materials, these deposits permit radar transmission and basal reflection. We

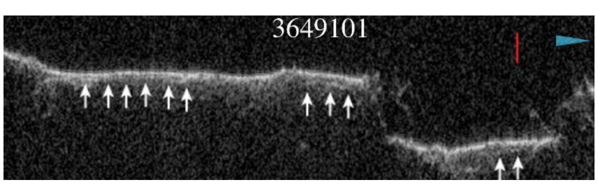

Figure 4: A portion of SHARAD radargram track 3649101. Potential subsurface reflections are indicated by the white arrows. The blue arrow points north, and then location of this observation can be seen in Figure 1.

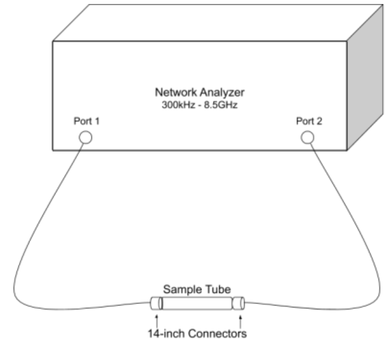

Figure 5: A diagram of the setup that will be used to conduct the dielectric measurements.

hypothesize that water table retreat, followed by desiccation of the phyllosilicates dehydrated the materials sufficiently that the radar can propagate through and reflect off the basement lavas ~ 525 ns below, even while retaining some characteristic spectrographic signatures. Assuming a dielectric permittivity (ε') of 4-8, this corresponds to a depth of 39.38-27.48 m.

We are developing an experimental procedure to confirm measurements of the dielectric values of clays and then desiccate them to reach Martian conditions. Upon determination of the thickness of the LTD from comparisons of stereo imagery-derived digital terrain models, we will have sufficient inputs to directly calculate ε'.

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