CHARACTERIZATION OF HYDRATED, LAYERED DEPOSITS AT VALLES MARINERIS PLATEAU, A MULTIDISCIPLINARY APPROACH.

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Introduction: Characterizing surface materials is essential for determining the past and present climate of Mars. Critical to this characterization is understanding the mineralogical and physical properties of materials, including their composition and distribution. In rare cases, many orbiting instruments are able to train on deposits in their entiretya. We have located several sedimentary deposits near the rim of Valles Marineris (VM) and neighboring chasmata, which in addition to having distinct radar reflectance in observations by the Shallow Radar (SHARAD) instrument, are mappable using optical imagery from the High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX), spectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), and thermal behavior with the Thermal Emission Spectrometer (TES). Thus, these VM plateau deposits may serve as an ideal location for studying altered sedimentary deposits on Mars.

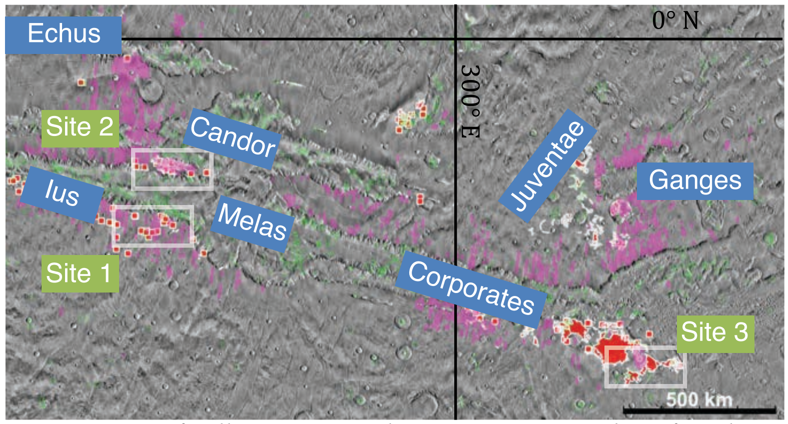


Fig. 1 Map of Valles Marineris showing: SHARAD sub-surface detections (pink lines), mapped LTL exposures (red polygons), HiRISE images with identified LTL (red squares), and locations with CRISM (greens). Map area has ~100% TES and CTX coverage.

Background: Light-toned Layered Deposits (LLD) found near the rim of VM have significantly different properties from the km-thick internal layered deposits within the chasmata of VM and probably formed by separate means [1]. The LLD form multiple, extensive outcrops south and west of Ius and Melas Chasmata. Other smaller outcrops occur near Juventae, Ganges, Candor, and Tithonium Chasmata [1-4] (F1g. 1).

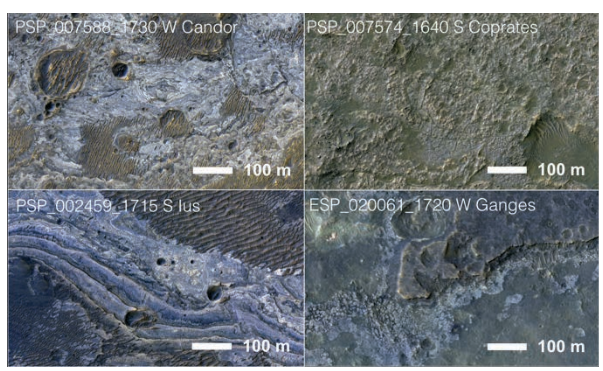
LLD display variations in brightness, color, composition, and morphology (Figs. 2 & 3) [2]. The ~1 m to 10 m thick strata show no crossbedding and likely formed in low-energy deposition systems. These deposits are more easily eroded than the lower bedrock [2,5]. Stratigraphically, LLD in western VM overlay extensive lava plains dated from Noachian to Late Hesperian [4-5] and must predate the opening of VM because these younger materials are not found inside the canyon.

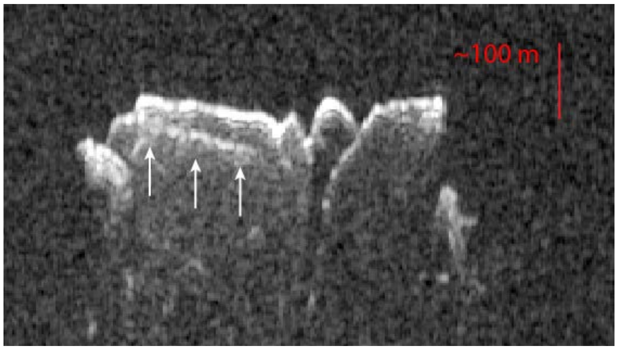
In several locations, LLD appear to have two distinct mineralogical phases, the lower unit composed of hydrated silicas [5] and the upper containing jarosite or Fe-hydroxy sulfates. The presence of Fe deficient, H_3O-bearing jarosite may indicate formation under low-temperature acidic conditions [5], and the stratigraphic positioning of these phases is consistent with evaporation of fluids produced by the acidic dissolution of basaltic material [5,7,8].

The presence of drainage networks at Melas and Echus Chasmata and of inverted channels at Juventae Chasma suggest that water flowed over these areas during the late Hesperian [1,6,9,10]. Fluvial evidence, combined with superposed mineral phases led to the hypothesis that the units were emplaced by air-fall of pyroclastic material and that water flowed over them, altering the minerals [2].

Other scenarios posit either that the hydrated silica formed prior to the emplacement of the upper, sulfate-rich unit or that it precipitated from water altered these deposits together in situ [2]. While there are many disparate interpretations, the consensus is that abundant surface water was available on the VM plateau well into the Hesperian.

Fig. 2 HiRISE COLOR images of various LTL exposures at the same scales.





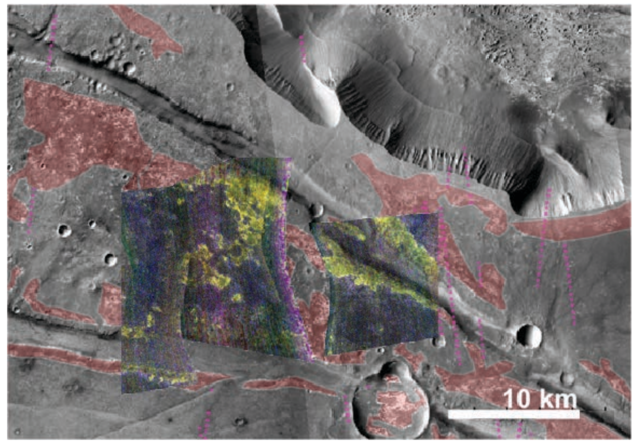


Figure 3. Characterization of LLD at Site 2. Left: SHARAD. Right: HiRISE (red highlights LLS locations), and CRISM (yellow = hydrated silica).

Results: We identified three locations at the VM rim where all instruments in our study can characterize light-toned deposits. HiRISE images show variations in brightness, texture, erosional style, crater retention, and relationship to neighboring geologic units. For example, LLD may occur as ancient, km-scale circular crater remnants (Fig. 4, left) within moderately preserved craters, adjacent to structural troughs or canyon rims (Fig. 4, right), or as part of broad, flat plains removed from chasm edges.

Many of the LLD display a diversity of hydrated/hydroxylated features in CRISM, including hydrated silica (Fig. 3, right), Fe-hydroxy sulfate, jarosite, and Al- and Fe/Mg-bearing phyllosilicates (Fig. 4, right). CRISM mineral mapping both at the 18-m/pixel targeted and 200-m/pixel mapping scale has extended the distribution of these hydrated phases and provided an improved regional interpretation and spatial correlation with the LLD. Spectrally-unremarkable (dehydrated) capping units that include thin, sedimentary units (e.g., airfall dust mantles, aeolian bedforms) or evidenced by thermal behavior as well as thicker volcanic units (e.g., lava flows, putative pyroclastic deposits) provide some constraints on stratigraphy.

Thousands of SHARAD observations were used to determine the deposit boundaries beyond where they outcrop, extending their known coverage, and new deposits have been discovered. Furthermore, we measure time delay and deposit thickness, as determined by digital terrain models, to estimate the loss tangent and permittivity of the LLD for the first time.

We compared seasonal variations in apparent thermal inertia as derived from TES [11] to that modeled for a suite of two-component models of layered or horizontally mixed materials. Most of the deposits have thermal behaviors consistent with a thin mantle of fines (sand or dust) over a substrate of rock or duricrust.

Acknowledgments: MDAP grant 80NSSC17K0437 funded this work. Thanks to *SeisWare* for the radar interpretation academic license.

References: [1] Weitz et al (2010) *Icarus*, 205, 73–102. [2] Weitz et al, (2008) *GRL*. 35, L19202. [3] Le Deit et al. (2010) *Icarus* 208, 684–703. [4] Mangold et al. (2008) *J. Geophys. Res.* 113, E08009. [5] Milliken et al. (2008) *Geology* 36, 847–850. [6] Mangold et al. (2004) *Science* 305, 78–81. [7] Tosca et al. (2004) *J. Geophys. Res* 109, E5. [8] Haskin et al. (2005) *Nature* 436, 66–69. [9] Treiman et al. (1995) *JGR*. 100, 26339–26344. [10] Bishop et al. (2009) *JGR*. 114. [11] Putzig and Mellon, (2007) *Icarus* 191

Figure 4: Characterization of phyllosilicates at Site 3. Left: HiRISE mapping. Right: CRISM mineralogical map.