ROLE OF HYDRATED SILICATES IN LONG-DISTANCE TRANSPORT OF LANDSLIDES IN VALLES MARINERIS, MARS. J. A. Watkins[1], B. L. Ehlmann[2], and A. Yin[1], [1]University of California, Los Angeles, Department of Earth, Planetary, and Space Sciences, 595 Charles E. Young Dr., Los Angeles, CA 90095, jwatkins11@ucla.edu, [2]California Institute of Technology, Pasadena, CA.

Introduction: Long-runout (> 50 km) subaerial landslides are rare on Earth, but are common features episodically shaping Mars' Valles Marineris (VM) trough system over the past 3.5 billion years [1]. They display two end-member morphologies: a thick-skinned inner zone, characterized by fault-bounded, rotated blocks near their source region, and a thin-skinned, exceptionally long-runout outer zone, characterized by thin sheets spreading over 10s of km across the trough floor. Four decades of studies on the latter have resulted in two main competing hypotheses to explain their long-distance transport: (1) movement of landslides over layers of trapped air or soft materials containing ice or snow, enabling basal lubrication [2], and (2) fluidization of landslide materials with [3,4] or without [5] the presence of water and volatiles.

To address this issue, we surveyed the structural relationships and mineral composition of the best-exposed and best-imaged basal section of a long-runout (>75 km) VM landslide. Our results suggest that entrained hydrated-silicate-bearing trough-floor deposits lubricated the basal sliding zone and facilitated extensive lateral spreading and long runout of the landslide outer zone [6]. Compositional analysis coupled with geologic mapping and morphometric analysis of landslides across VM is then performed in order to investigate the applicability of this clay-lubrication model on a regional scale.

Understanding the mechanisms of VM landslide emplacement has important implications for past Mars surface conditions, providing insight into the enduring role of water in shaping Mars' surface.

Data and Methods: The mineralogic composition of landslides in VM is examined using Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [7] near-infrared spectral data. This analysis is coupled with geologic mapping of field relationships and analysis of morphometric properties using Thermal Emission Imaging System (THEMIS) [8], Context Camera (CTX) [9], and High Resolution Science Imaging Experiment (HiRISE) [10] satellite imagery data, in combination with MOLA topographic data.

Approximately 30 characteristic long-runout landslides occur in VM and of these, 14 have CRISM coverage of their outer zones. One landslide, Ius Labes, had exemplary exposure of pristine slide deposits due to erosion, and several CRISM full-resolution target (FRT) data covering multiple portions of the deposit permitted detailed coupled structural-mineralogic analysis. Spectral data for the remaining landslide systems covered by the CRISM dataset was then analyzed for the presence of hydrated minerals, indicated by absorption bands at 1.4 and 1.9 um [11].

Morphometric parameters measured for each landslide system include maximum runout length, spreading width, breakaway scarp width as a proxy for initial mass, and outer zone spreading angle as a mass-independent measure of coefficient of friction.

Results: Detailed mapping of geomorphic features and geologic units at the eroded toe of the Ius Labes landslide provides evidence of pervasive deformation within outer zone basal units, indicative of differential shear and lateral spreading at high velocities during landslide emplacement. Compositional analysis of landslide features within the available data reveals hydrated minerals, including Fe/Mg phyllosilicates and hydrated silicate “doublet” material, exclusively in these outer zone units [11].

On a regional scale, of 14 landslide systems with outer zone CRISM coverage, 8 landslides clearly show the presence of clay minerals in materials entrained in their long-runout portions, where dust cover is low and erosion has exposed entrained material at the surface (Fig. 1). CRISM data covers the trough floor in the immediate vicinity of 8 landslide outer zones. Of those, the trough floor is hydrated near 4 landslides (Fig. 1).

Regional morphometric analysis shows that mass-independent basal coefficient of friction decreases with increasing runout, and outer zones with hydrated minerals express more significant lateral spreading than those without hydrated mineral detections.

Discussion: Given that smectite clay absorbs water into its layered crystal structure and can reduce the friction coefficient by a factor of three v. that of dry rocks [12], the observed presence of hydrated silicates in VM landslide sliding zones suggests that clay minerals played a decisive role in the formation of long-runout landslide morphologies. Morphological evidence of the participation of basal lubrication in landslide long runout and extensive lateral spreading supports this. We propose that, concurrent with downslope failure and sliding of broken trough-wall rock, frontal landslide masses overrode and entrained hydrated-silicate-bearing trough-floor deposits, lubricating the basal sliding zones and permitting the landslide outer zones to spread laterally while moving forward over

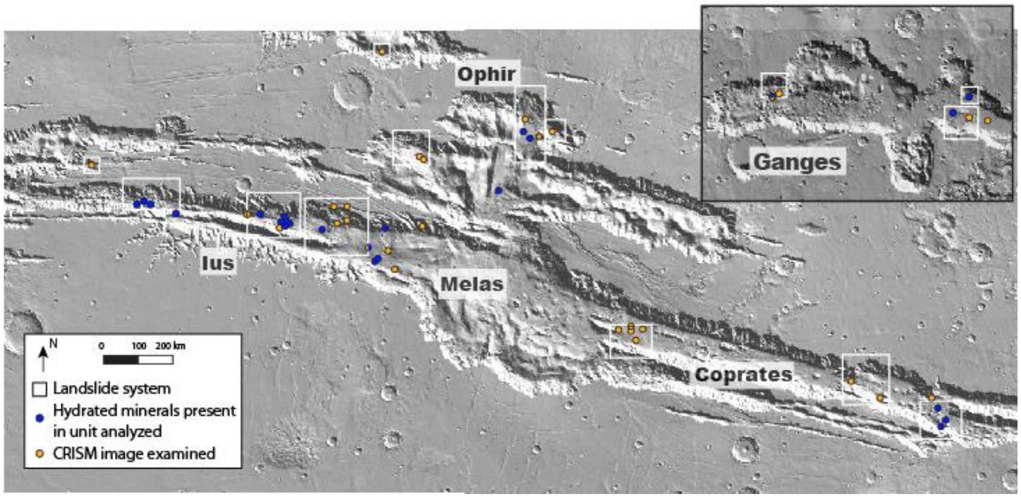

Figure 1. Regional composition of long-runout landslide outer zones. Blue circles, clays detected; orange circles, not detected.

the low-friction surface (Fig. 2). Leda quick clay landslides may provide a terrestrial analogue for emplacement, whereby seismic shaking induces liquefaction to form retrogressive slumping, lateral spreading, and earthflow long runout.

Conclusions: Analysis of VM landslide geomorphologic, compositional, and morphometric properties suggests that hydrated silicates played a key role in facilitating landslide transport by lubricating the basal sliding zone. This clay-lubrication model for episodic, sustained landslide activity throughout the canyon implies that clay minerals, generated by water-rock interactions in the Noachian and Hesperian (4.1-3.3 Ga), exert a long-lasting influence on geomorphic processes that shape the surface of the planet.

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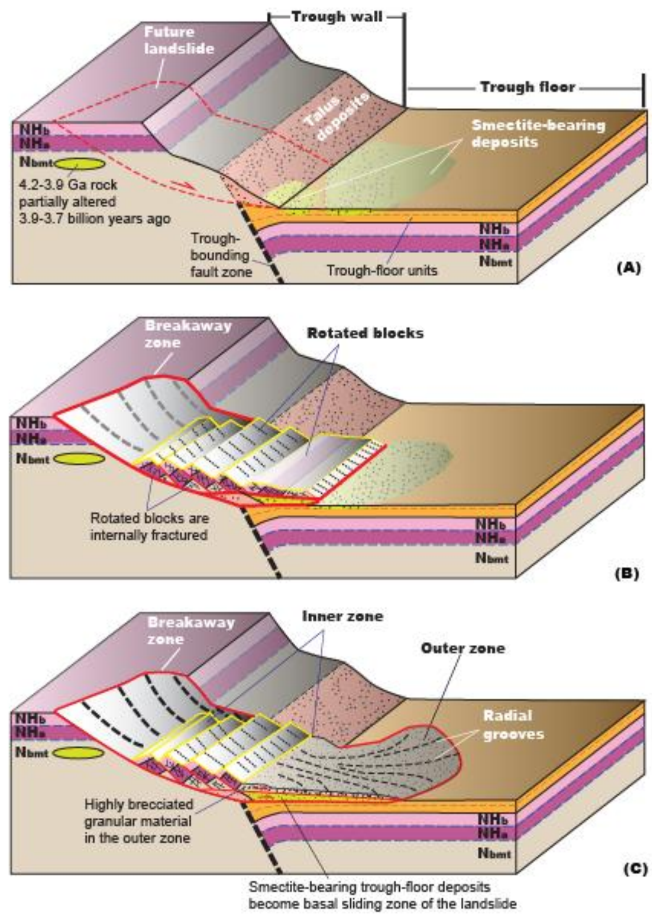

Figure 2. Clay-lubrication model for long-runout VM landslide emplacement. Failed trough-wall rock slides downslope and entrains low-friction hydrated-silicate-bearing trough-floor deposits, lubricating the basal sliding zones and facilitating lateral spreading and long-distance transport.