SPATIAL AND TEMPORAL RELATIONSHIPS OF LANDSLIDES IN VALLES MARINERIS, MARS: CONSTRAINTS ON THEIR TRIGGERING MECHANISMS. J. Watkins[1] and A. Yin[1], [1]University of California, Los Angeles, Department of Earth and Space Science, 595 Charles E. Young Dr., Los Angeles, CA 90095, jwatkins11@ucla.edu

Introduction: The giant canyon system of Valles Marineris spans more than one quarter of the equatorial girth of Mars and hosts the most concentrated system of landslides on the planet. It also exhibits a variety of erosional, depositional, and tectonic features. A thorough understanding of the landslides and their emplacement mechanism(s) would constrain processes that may have been involved in the formation history of this canyon. Landslides are preferentially distributed along the north wall of the Ius, Melas, and Coprates Chasmata (IMC), including a stretch of the Coprates Chasma north wall where there is no comparatively significant slide activity. Systematic mapping of individual landslides has illuminated a clear division in Valles Marineris landslide morphology, thickness, and texture between (at least) two types: thick-skinned and thin-skinned. There are four possible causes for the occurrence of these rotational landslides in Valles Marineris. (1) The IMC wall rocks are stratified with more consolidated material overlying less consolidated material and undercutting of the weaker layer by erosion induced slope instability. (2) An episode of wet and warm climate could have also triggered the occurrence of widespread landslides that slip on nearly frictionless, water (or other medium)-lubricated surfaces. (3) A succession of concentric faults as a result of impacts may have triggered landslides. (4) Seismicity along trough-bounding faults may have both enhanced the steepness of trough walls and triggered landslides, which may explain the preferential concentration of landslides along the north wall of the IMC where trough-bounding faults are present. In addition to the above triggering mechanisms, we note that the location and shape of the landslides are clearly controlled by trough-parallel pre-existing fractures, leading to the collapse of long strips of trough walls as seen in western Ius Chasma. The four competing causes make contrasting predictions on (a) timing of landslides (synchronous vs. diachronous) and (b) their spatial relationships to trough-bounding faults, nearby craters, and the strength of lithologic units comprising the trough walls. A systematic mapping of a representative sample of individual landslides of each type is currently in progress to address the above issues.

Surface Morphology: Both of the landslide types are rotational landslides. This is evident in circular failure of mechanically homogenous slope rocks combined with rotational sliding along the spoon-shaped breakaway down the surface of rupture. The two landslide types, however, can be easily distinguished from satellite imagery by their surface morphology. Thick-skinned landslide morphologic features include transverse, convex forward ridges, an increasingly thick succession of C-shaped, imbricated structures at the toe, and a coherent and well-ordered internal structure. Thin-skinned landslide morphological features, conversly, include rough, chaotic, and brecciated internal structures, mountainous debris at the head, a headwall lined with ribbed cliffs, rotated blocks below the head, hummocky, longitudinal ridges in the debris apron which are separated by V-shaped grooves, transverse radial fractures, highly elongated debris apron runout, and a discernibly thin debris apron. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) spectral data is also being utilized to facilitate a slope map analysis to determine composition of rocks at various topographic levels in the canyon wall. This analysis will also help determine where in the stratigraphy zones of lithologic weakness may cause slope failure. This information will allow the determination of whether a difference in composition exists, distinguishing the two landslide types. CRISM data may also provide information about the presence of water as a lubricating slip surface in the emplacement of these landslides, based on the chemical composition of minerals in the region.

Landslide Thickness and Runout Ratio: One of the main, most obvious differences between the two types is the difference in runout length. Analysis of the development of the scar geometry across the runout over time illuminates that this distance correlates directly to the thickness of the landslide along the trough floor. In the thin-skinned landslides, most of the mass is lost at once at the base of the slide, causing the slide to sustain speed and extended horizontal distance from the base. The thick-skinned landslide, on the other hand, loses its mass gradually and consistently, always leaving the landslide with enough mass to slow and stop itself before the debris apron reaches the lengths observed with the thin-skinned landslides. Boundary conditions, including whether the landslide is confined or unconfined, of a representative sample of each type are analyzed. Measurements of the geometry of the scarp breakaway and runout are determined as well in order to help characterize the development of these two landslide types.

Conclusions: There is a clear and significant correlation between runout morphology and rotational movement, and rheology and trigger mechanisms. Two possible emplacement mechanism models are proposed. In the first model, the thick-skinned landslide slides on a rough trough floor, creating enough friction to decelerate the landslide, precluding a longer runout. Contrarily, in the first model, the thin-skinned landslide slides on a smooth trough floor, decreasing the amount of friction the landslide experiences, allowing the runout to reach the extended lengths observed. The second model of emplacement differentiates the two landslide types based on the number of compositional layers of slip underneath the landslide. In this model, the thick-skinned landslide slides on a single compositional layer of slip, again creating the amount of friction necessary to slow the landslide down. The thin-skinned landslide is proposed in this model to slide along a second compositional layer of slip (water, ice, steam, air, gas or other), creating an essentially frictionless environment in which the debris apron would spread to the extents observed (see figures).

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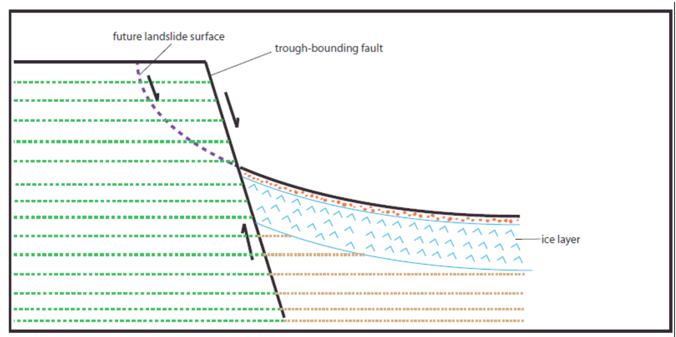
Cliffside scarp pre-landslide



Scarp breakaway post-landslide