PROGRESSIVE EVOLUTION OF THE VALLES MARINERIS FAULT ZONE AND ITS ROLE IN CONTROLLING INTERIOR LAYERED DEPOSITS AND OUTFLOW CHANNELS. 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: At the eastern end of Valles Marineris (i.e. Eos Chasma), the chasma floor is covered by chaotic terrains from which the circum-Chryse outflow channels arise and extend northward towards the northern lowlands. The surface ages of these features are Late Hesperian to Early Amazonian and show morphological and compositional indications that they have been affected by fluvial erosion. Most recent studies of Valles Marineris concluded that its Interior Layered Deposits (ILDs) were accumulated after the formation of the Valles Marineris trough system. Some workers also suggest that the ILDs originated from sedimentation in lakes within the Valles Marineris troughs, and that the sudden release of lake water to the northern lowlands created the catastrophic outflow channels at the eastern end of the Valles Marineris trough zone, leaving mounds of isolated ILD sediments exposed within the troughs. The sudden release of water has been commonly related to erosion of damming of the troughs induced by glacial or mass-wasting depositional processes. All existing models linking the ILDs to the outflow channels lie within the framework of a static Valles Marineris system with a constant shape. However, this notion is at odds with the new observation that the development of the Valles Marineris fault zone, a left-slip transtensional structure, continued to be dynamic throughout at least part of the sedimentation of the ILDs. This conflict prompts the testing of the hypothesis that the Valles Marineris trough system was a single intra-canyon lake and its outlet was progressively opened by normal faulting at the eastern end of the trough zone, releasing the floodwaters that formed the equatorial outflow channels and thus controlling the spatial and temporal evolution of ILDs (see figure). Our model sharply contrasts alternative static-system mechanisms for producing the outflow channels such as progressive overtopping of structurally isolated lakes, rapid release of a subsurface groundwater aquifer, rapid release of stored ice, and episodic flooding. Here, we address the question of their formation mechanism by conducting detailed structural and geomorphic mapping of the eastern Valles Marineris trough zone and outflow channels using high-resolution satellite imagery. Constraint on how the outflow channels were produced is essential to our understanding of not only the formation and evolution history of Valles Marineris, but the processes at work on and beneath the surface of Mars as well. It is also important to investigate the potential for an active system of regional tectonics integrated with sedimentation shaping the landscape observed on the surface of Mars today, as opposed to more recent sedimentation modifying the remnants of a stagnant, ancient, seismic system.

Stratigraphic Relationships: The timeline of events hypothesized within this tectonic damming model is constrained by specific predicted spatial relationships among (1) the evolution of the Valles Marineris fault zone, (2) the deposition and development of the ILDs, and (3) the timing and location of major outflow channels. Postdepositional fault morphology, under the proposed timeline of ILD formation, is indicative of tectonic activity after the opening of the canyon, permitting tectonic activity to be the mechanism for opening the dam at the eastern outlet of Valles Marineris and releasing floodwaters from inside the canyon. These fault morphologies include tilting of layered deposits; postdepositional block rotations and modification; evidence of internal deformation, including linear features, parallel joints and fractures, and offset; drag folding; and fault scarps. Morphologic evidence for catastrophic flooding is present on the trough and channel floor. These streamlined mounds and longitudinal grooves indicate the downstream convergence of flow from the VMD towards the circum-Chryse outflow channels and can be used as a proxy for the flooding event that formed the outflow channels. Detailed geologic and geomorphologic mapping of the eastern Valles Marineris fault zone, the circum-Chryse channels region, and these cross-cutting relationships at potential tectonic dam locations in northeastern Valles Marineris is currently in progress in order to systematically investigate the regional stratigraphy and geologic history and quantify regional extension. .

Crater counting is another mechanism by which to determine ages and relative timing of surficial events. Because resurfacing indicates outflow channel activity (flooding), updated impact crater statistics from flood surfaces, fan surfaces, the trough floor, and fault scarps are obtained to help constrain the temporal relationships of events illuminated by geologic mapping.

Terrestrial Analogue: Because the most efficient and effective way to understand planetary surface processes is through initial understanding of the principles of terrestrial surface environments and their processes, study of Earth analog regions will be used as controls for comparison. On Earth, catastrophic floods are often formed by natural or man-made dam failure. This mechanism is exemplified in the flooding of Lake Missoula to form the Channeled Scablands of Eastern Washington. Though they differ in scale, the striking resemblance of the Martian outflow channels to the Scablands, including the longitudinal groove morphology observed in both regions, suggests that they share a similar formation mechanism, i.e. ponding and dam failure. Bench features, as well as the extent and distribution of layered sulfate in the canyon and on the trough floor, can be used as a proxy for the water level within the canyon. With this information, taking into account the average Martian erosion rate and the age of the outflow channels, the volume of water that was removed from Eos/Capri Chasma during flooding is calculated. This volume is then compared to the volume of water required to produce sufficient head to break the dam, based on the scaled volume of water which broke the dam at Lake Missoula. This analysis tests the feasibility of previously proposed erosional models for catastrophic flood initiation and investigates whether the proposed tectonic opening of a dam would have been necessary to release the floodwaters and carve out the outflow channels.

Conclusions: Evidence of temporal, oblique spatial, and transtensional structural relationships between the Valles Marineris and Capri-Eos fault zones suggest that the circum-Chryse outflow channels may be explained by a leaky transform fault formation mechanism for the southern Valles Marineris fault zone, with NW-SE extension along Valles Marineris being accommodated by the formation of an extensional basin and tectonic outlet at its eastern end, namely the Capri-Eos rift zone. Constraint of the formation mechanism of the circum-Chryse outflow channels is vital, first, to informing Valles Marineris formation and evolution history. This work also has the potential to expose a dynamic system of regional seismic activity integrated with sedimentation on the surface of Mars. In addition, this study could have significant climatic and astrobiological implications pertaining to the potential flow of water on the surface of Mars in the recent past, as well as implications for the potential presence of an ocean at the outflow channels' termini in the northern lowlands.

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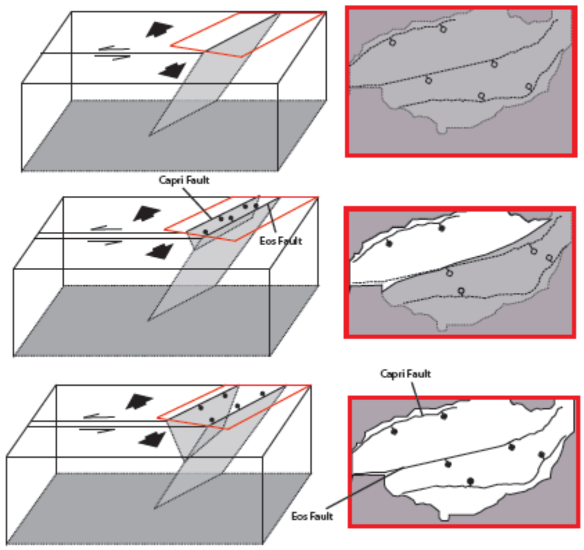
Structural evolution of Capri/Eos Chasma

$t=t_0$

$t=t_1$

$t=t_2$



Present day configuration: Stored lake water flowed through the newly opened outlet at the eastern end of the chasma, forming the circum-Chryse outflow channels.