A DYNAMIC MECHANISM FOR VALLES MARINERIS FORMATION. L. F. Bleamaster III[1, 2], [1]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719 (lbleamas@psi.edu), [2]Trinity University Geosciences Department, One Trinity Place #45, San Antonio, TX 78212.

Introduction: Valles Marineris, collectively 4000 kilometers long, up to 600 kilometers wide, and 11 kilometers deep in places, is arguably the most prominent and recognizable feature on the surface of Mars. Since its discovery by Mariner 9 in 1971, several processes have been invoked to explain its mode of formation. The role of ice and water as erosional mechanisms were first introduced [1 - 4]; tectonic processes were also brought forward [5 and 6]. Shultz [7] attempted to reconcile the two main schools of thought (collapse and tectonic) by proposing a multi-process, multi-temporal mechanism whereby different processes acted at different times, which superimpose each other to produce Valles Marineris' extant morphology. With regard to most studies of Valles Marineris, the Tharsis Rise plays a quintessential role as the main driving force behind its location and formation; the main trough of Valles Marineris is on a nearly radial trend to the center of the Tharsis Rise [1, 2, 6, 8, 9, 10].

Since those early studies, the acquisition of higher resolution images and topography has allowed workers to elaborate on, and refine, the temporal and kinematic history of Valles Marineris and Tharsis Rise structures [11 - 18]. However, a comprehensive dynamic mechanism that explains the initiation, unique location, and the breadth of Valles Marineris is lacking as the dynamic evolution of Tharsis up-warping and loading alone do not account for the asymmetric nature of circum-Tharsis deformation. Of specific concern is why did only Valles Marineris, the largest canyon in the Solar System, form with no other radially oriented Tharsis structures opened? Herein, I propose that although Tharsis uplift plays an important role in Valles Marineris formation, Tharsis-driven tectonics is secondary to the dynamic influence of the northern Borealis basin. Valles Marineris' relatively large amount of strain is driven by subsidence of the northern lowlands and relaxation of the Tharsis volcanic pile over paleo - basement structure, -crustal thickness variations, and -topography related to the margin of the Borealis basin impact structure (the true dichotomy boundary) [19].

Timing and Patterns: Anderson et al., [15] analyzed nearly 25,000 structures in the western hemisphere around Tharsis and placed them into a stratigraphic framework; five distinct stages and centers of radial and concentric deformation were proposed. Valles Marineris falls at the Late Noachian-Early Hesperian boundary, consistent with age estimates by Lucchita et al., [20]. In order to address the regional stress fields during the intitaion of Valles marineris, it is necessary to evaluate pre-Valles Marineris structures. Figure 1 shows generalized trends of major structural suites around Tharsis from the Noachian to the Early Hesperian.

Near central Tharsis (centered at 12.5°S, 250E°) many of the ancient extensional structures are radial and point directly back toward this point; however, in the far field (greater than about 3500 km), the strikes of extensional structures diverge from radial and become parallel to the Borealis ellipse (Figure 1-purple). The divergence of these ancient minor structures is indicative that some other stress influenced their orientations suggesting their orientation is not solely controlled by Tharsis but are rather influenced by the combined stress of Tharsis and Borealis. Because the Borelais basin existed prior to Tharsis and is significantly larger, its influence would have been felt during the earliest development of Tharsis and eventually Valles Marineris. This is consistent with the idea that the stress regime needed for Valles marineris evolution would have been stable for a significantly long period of time (at least from Late-Noachian to present), unlike the transient and shifting Tharsis bulge.

Discussion: The specific location of Valles Marineris, and lack of other large Tharsis radial troughs, is attributed to three complimentary circumstances, which only occur in eastern Tharsis (or the Valles Marineris location): 1) radially-oriented principal tensile stress related to Tharsis uplift in the Noachian and Early Hesperian, 2) concentrically-oriented principal tensile stress related to the Borealis basin that would have existed prior to Tharsis development, and 3) crustal anisotropy, both lateral (variations in the Tharsis Rise volcanic pile) and horizontal (thick and thin crust of the hemispheric dichotomy). The coincidence of the two stress fields produce two locations of potentially enhanced extension both east and west of the center of Tharsis; however, only eastern Tharsis, the Valles Marineris location, achieves such strain because of the older and thinner volcanic material associated with eastern Tharsis. Western Tharsis experiences significantly more and relatively younger volcanic activity (Arsia Mons) that would preclude or bury earlier deformation. With continued growth of Tharsis onto the Borealis basin floor and degradation of the highlands, the Borealis basin is episodically filled with material that establishes a positive feedback between isostatic rebound of the highlands and subsidence of the basin thus perpetuating north-south extension in the region that further localizes strain along Valles Marineris.

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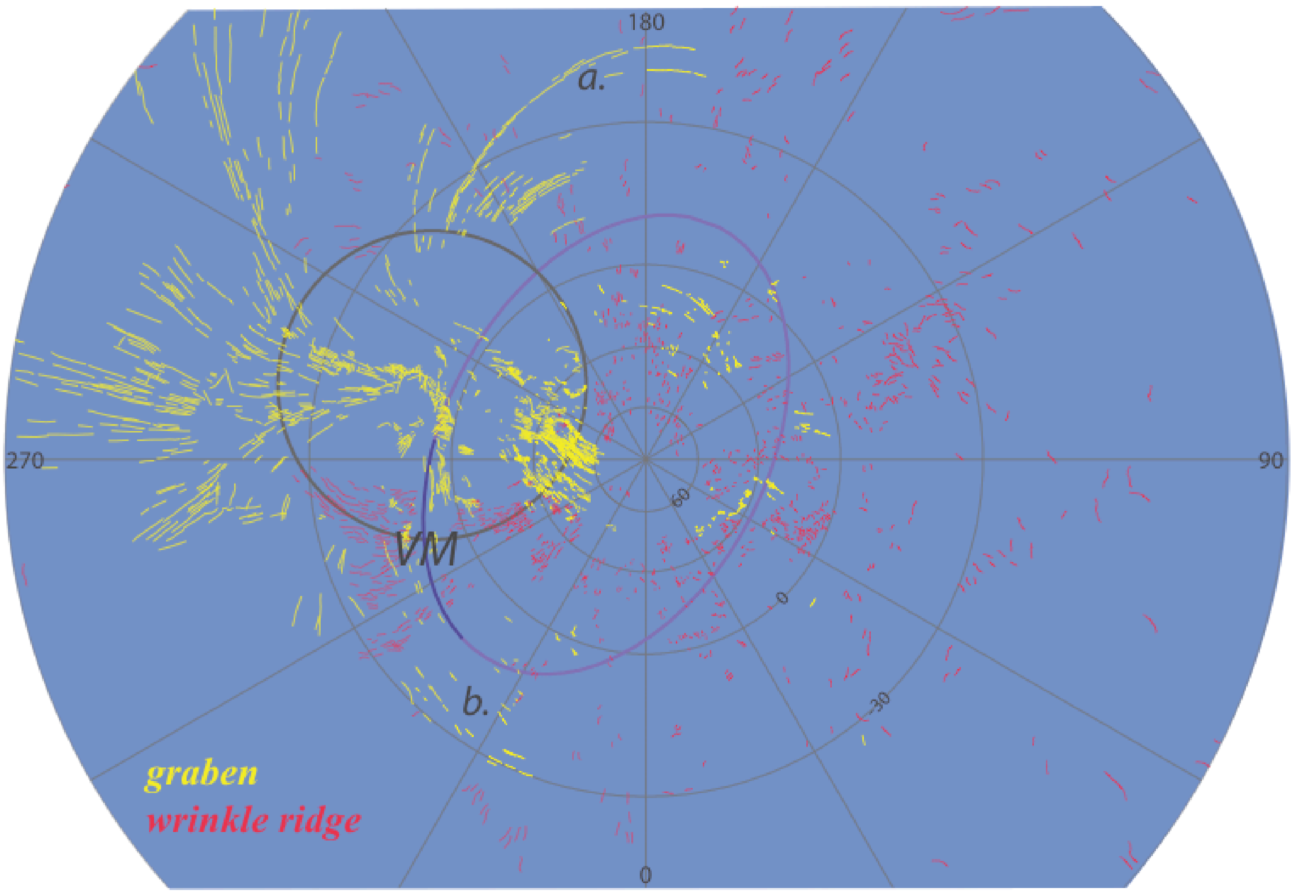

Figure 1. Extensional (graben) and contractional (wrinkle ridges) structures show a global (or at least a hemispheric) pattern of strain related to the cumulative effect of Tharsis uplift and Borealis basin subsidence. Within the gray circle, most graben are radial to the center of the Tharsis rise; outside of that circle, extensional structures diverge from radial and some sets (a. and b.) become parallel to sub-parallel with the margin of the Borealis basin (purple ellipse). Notice that Valles Marineris (*VM* – dark purple) is located where the radial component of Tharsis and the concentric component of Borelais intersect. Polar stereographic (conformal) projection centered on the north pole.