Mapping Structure in a Member of the South Tharsis Ridge Belt in Northeast Terra Sirenum, Mars. J. N. Adrian[1,2]*, A. G. Siwabessy[2,3], R. C. Anderson[4], [1]Department of Geography, California State University-Long Beach, Long Beach, California, United States 90840, john.adrian01@student.csulb.edu [2]Department of Earth Sciences, University of Western Ontario, London, Ontario, Canada N6A 3K7, [3]Institute of Earth and Space Exploration, University of Western Ontario, London, Ontario, Canada N6A 3K7, [4]Geosciences Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, United States 91109

Introduction: Preliminary structural and paleotectonic mapping of a member of the South Tharsis Ridge Belt (STRB) [1] and its surrounding plains has been completed (Fig. 1).

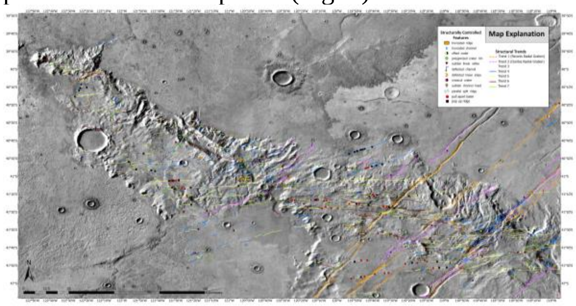

Figure 1: The map region showing THEMIS imagery of the South Tharsis Ridge Belt member and surrounding plains centered on 120°24'32.37"W, 40°50'13.60"S. Structures are marked with solid lines and colored according to trend group. Morphological features marking possible evidence of tectonic activity are denoted with point feature symbols according to feature type.

This STRB member is located southwest of the provisionally named Bathys Planum region, which is thought to be a transition zone between the volcanics of Tharsis and the older highlands materials of Terra Sirenum [2] (Fig. 2).

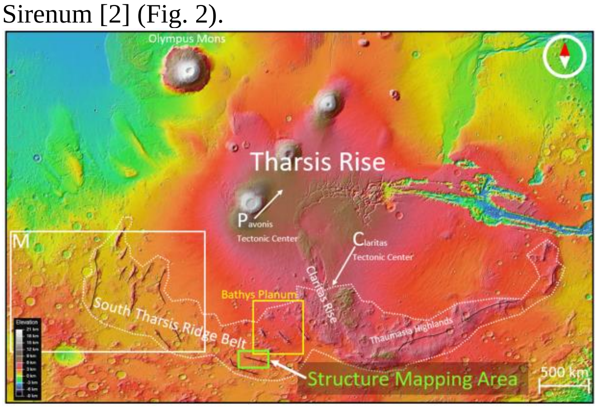

Figure 2: Mars Orbital Laser Altimeter (MOLA) hillshade regional map of the southern Tharsis Rise and the South Tharsis Ridge Belt [1], as denoted with a white dotted outline. The mapping area for this project is outlined in green. Also shown are ridges initially mapped by Schultz and Tanaka (1994) [3] (black lines), centers of Tharsis-driven tectonism [4], including Claritas (C—Stage 1) and Pavonis (P—Stage 3), the Memnonia-Sirenum map (Anderson et al., 2019b [5]) (white box, left) and the Bathys Planum map region (yellow box, center). This field of view is centered on the following coordinates: (7° 4'50.12"S, 110° 9'37.17"W)

This region was chosen for structural mapping to expand our understanding of the influence and interactions of pre-existing fault structures within the highlands and plains materials on the growth and development of long running (thousands of kilometers) grabens extending through Bathys Planum, NE Terra Sirenum, and further southwest. These grabens are radial to two Tharsis-related tectonic centers, Claritas (Stage 1) and Pavonis (Stage 3) located further north on the Tharsis Rise [4] and may represent two of the more recent tectonic events to propagate through the region.

It is the interaction between these grabens and the pre-existing structural features that prompted this investigation, as wherever there are older fault structures intersecting the younger graben sets there is an apparent offset or “zig-zag” in either set. Further examination of this area revealed that it is not only the grabens that are zig-zagged, but within the mountains as well as the plains there are channel-forms and otherwise linear ridges also taking on this apparent offset pattern. The presence of apparent offset at most structural intersections is coupled with observations of true offset in some places, though this evidence is relatively rare and mostly concentrated within two trends of the observed east-west and northeast-southwest faults, not including the grabens.

Methods: Mapping was performed at 1:12,000 scale using Esri’s ArcGIS Pro (Fig. 1). The Mars Global Surveyor’s (MGS) Thermal Emission Imaging System (THEMIS with average resolution of 100 m/px) [5] daytime infrared global mosaic was used as a basemap. Additional imagery from the Mars Reconnaissance Orbiter (MRO) Context Camera (CTX with average resolution of 6 m/px) [6] was overlaid and co-registered to the THEMIS basemap in ArcGIS Pro to assist in contextual interpretations associated with the digitization process. All data is displayed in a simple cylindrical projection based on the THEMIS basemap.

Faults are mapped with a solid line where scarps or fault trends are clearly identifiable, while inferred fault trends are mapped as dashed lines. The slip direction on fault trends is demarcated only where the sense of motion is clearly indicated by the presence of offset or other landforms typically associated with fault movement such as pop-up ridges, or restraining bends, or pull-apart basins. Such features, in addition to other common indicators of tectonic motion (truncated ridges and channels, offset crater rims, polygonised crater rims, deflected channels and linear ridges or slopes (near 90°), crosscut crater with visible crosscutting scarps, sudden channel heads or cirques with linear edges) are marked with point feature symbols. Determining sense of motion and fault location is partially guided by the model presented in Siwabessy et al. (2021) [8] (Fig. 3A). Fault line segments are color-coded according to which of the seven identified trends they belong. Stereonet diagrams were made assuming an arbitrary 90° dip for display purposes and show trend orientations in the region (Fig. 3B). Crosscutting relationships are determined according to the stratigraphic column and correlation chart for the nearby and slightly overlapping region of Bathys Planum (Fig. 3C, 4).

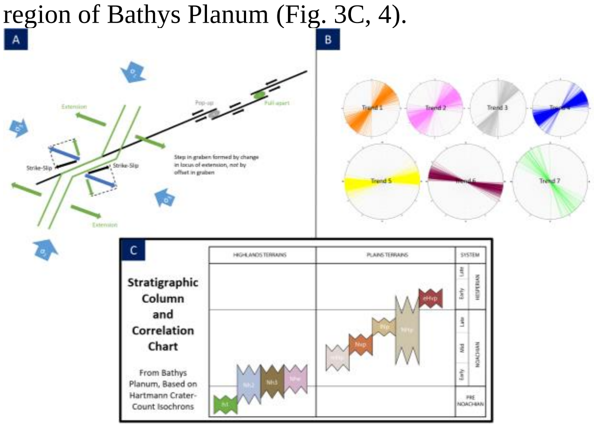

Figure 3: Subfigure A: A model presented in Siwabessy et al. (2021) [8] describing the interaction between pre-existing crosscutting structural weaknesses, which have been reactivated as strike-slip faults, and the grabens radial to the Stage 1 Claritas and Stage 3 Pavonis tectonic centers of Anderson et al. (2001) [3]. Subfigure B: Stereonet diagrams assuming a 90° dip for display purposes showing regional fault trend orientations. Subfigure C: Stratigraphic column and correlation chart for units mapped in the Bathys Planum map region. Youngest inferred emplacement ages are approximately placed according to interpreted basement ages from crater counting statistics results for nearby rock units mapped in Bathys Planum in a prior project. The geologic time scale is after Tanaka and Hartmann (2012) [9].

Results with Interpretation: Seven fault trends were mapped, including the two trends of Tharsis-driven grabens running through Bathys Planum and to the southwest. The two youngest trends identified are the normal faults forming the graben radial to the Stage 1 Claritas and Stage 3 Pavonis tectonic centers [2]. These graben-forming faults do not crosscut the early-Hesperian age eHvp volcanic unit of Bathys Planum, but they do crosscut the next oldest unit, the Noachian to early-Hesperian age NHp plains unit along with all other geologic units within this region. This constrains the lower age of any structure in this region to the early-Hesperian at the youngest. Fault trends four and five crosscut eHvp as well as NHp and are at least intersected, if not crosscut by all other trends. However, the fact that the remaining fault trends (three, six and seven) do not crosscut either of the eHvp or NHp plains units places trends four and five as the next oldest after the graben-forming faults. It is these two trends which exhibit the highest concentration of easily identifiable pop-up ridges and pull-apart basins in addition to the few clear examples of truly offset crater rims (Fig. 1). Offset crater rim examples suggest a left-lateral slip sense for these two trends.

The remaining fault trends, three, six, and seven are older than the above, as they do not crosscut any of the plains units, however their relationships cannot be further determined except that they are younger than the likely Noachian age highland material they crosscut. In addition, there are no obvious alignments with any known cause of regional stress.

Similar to the graben zig-zags, other landscape features such as channel-forms, fluvial or otherwise, linear ridges, and linear slopes are also commonly zig-zagged, however they appear to step to the right instead in a right-lateral sense in an east-west direction throughout this mountain range, suggesting possible strike-slip motion along faults in this orientation.

Conclusion: the fact that the grabens are zig zagged, but not truly offset suggests a similar reactivation of pre-existing faults by the two graben sets as in Bathys Planum [2, 8]. The additional evidence of zig-zagging landforms outside the boundaries of either graben set further suggests a region influenced by a series of strike-slip faults.

References: [1] Karasözen, E. et al. (2016). *JGR*, 121(6), 916–943. [2] Anderson, R. C. et al. (2020). *LPI Contributions*, 2357, 7020. [3] Schultz, R. A. & K. L. Tanaka. (1994). *JGR: Planets* 99(E4). [4] Anderson, R. C. et al. (2001). *JGR*, 106(E9): 20563-20585. [5] Anderson, R. C. et al. (2019b). *USGS*. [6] Malin, M. C. et al. (2007). *JGR: Planets*. [7] Christensen, P. R. et al. (2004). *SSR*, 110: 85-130. [8] Siwabessy, A. G. et al. (2021). [9] Tanaka, K. L. & W. K. Hartmann. (2012). In The Geologic Time Scale, eds. F. M. Gradstein et al. 275-298.