# Displacement-Length Ratios and Contractional Strains of Wrinkle Ridges in Thaumasia Minor and Solis Planum, Mars

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Statistical analyses of the planetary tectonic structures such as faults, joints and dikes are established means to comprehend stress-strain conditions throughout the history of planetary bodies. The geometric properties of the tectonic structures have been used by earlier workers to infer the rudimentary mechanical controls that helped in their origin and evolution [1]. Studies confirm that within the fault on terrestrial and planetary surfaces the maximum displacement ($D_{max}$) is proportional to its length (L). The $D_{max}$-L ratios are therefore utilized to delineate an average long-term equilibrium stress field [2, 3]. Wrinkle ridges, formed above to blind thrust faults, are compressional structures found abundantly on Mars [4]. Wrinkle Ridges in Thaumasia Minor and Solis Planum were studied using MOLA/HRSC Blended DEMs. Topographic profiles, across trends, were extracted for each wrinkle ridge near their midpoints [cf. 2] to evaluate their height and maximum displacement ($D_{max}$). Displacement and length values of the wrinkle ridges were plotted on a graph. The $D_{max}$-L ratios ($\gamma$) for wrinkle ridges of both the regions are calculated by a linear fit method [cf. 2, 5]. The $\gamma$ value of ridges in Thaumasia Minor was found to be ($2 \times 10^{-3}$) while that in Solis Planum is found to be ($1.2 \times 10^{-3}$). The contractional strains ($\varepsilon$) in Thaumasia Minor and Solis Planum are estimated to be ˜0.14% and ˜0.1% respectively (fault plane dip $\theta$ is assumed to be 25°). These estimated values indicate that the Thaumasia Minor is more affected by compressional tectonics than the adjacent Solis planum.

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**MORPHO-TECTONIC EVALUATION OF DORSA-GEIKI WRINKLE RIDGE USING TERRAIN MAPPING CAMERA-2 ONBOARD CHANDRYAAN-2.** A.S. Arya[1*], Abhik Kundu[2], Arup Roychowdhury[1], Amitabh[1], Sumit Pai[1], Dipayan Dasgupta[2], R. P. Rajasekhar[1], Vishnu Patel[1], Ankush Kumar[1], K. Suresh[1], Ajay Prashar [1], Joyita Thapa[2], S Gomathi[3], Vijaysree[3], [1]Space Applications Centre, Indian Space Research Organisation (ISRO), Ahmedabad-380015, India, [2] Asutosh College, Kolkata, [3]U. R. Rao Satellite Centre, ISRO, Bengaluru – 560017, India. (*arya_as@sac.isro.gov.in).

**Introduction:** Terrain Mapping Camera-2 (TMC-2) onboard Chandryaan-2 mission is a panchromatic high resolution (5 meter) stereo imaging instrument, capable of generating 3D images of the Lunar surface. TMC-2 (15th October 2019) imaged Lunar surface over Mare Fecunditatis from an altitude of ~100 kms. with a low sun-angle which highlights the subtle topographic variations thus enabling mapping of low elevations landforms. One of the important lunar tectonic feature is Dorsa Geiki (DG), an arcuate wrinkle ridge, about 220 kms (1 $^{O}$ to 4 $^{O}$ S and 53.25 to 53.75$^{O}$ E ) long that has low elevation scarps/ridges, in and around. Wrinkle ridges are believed to be created by crustal deformation due to compressive forces. In this study we tried to carry out a brisk preliminary analysis for reconstructing the morpho-tectonic set up of this wrinkle ridge and analyse its stress and strain conditions using TMC-2 ortho-images and the Digital Elevation model (DEM).

**Methodology & Results**: Five profiles have been taken across this wrinkle ridge in i.e. AA', BB' , CC', DD' , EE' (Fig. 1). The folded profiles are restored to estimate the longitudinal strain (in this case the shortening of the surface due to thrust faulting and concomitant wrinkle ridge formation) following line-and-length cross-section balancing method [1] using the said data to derive various morphometric parameters (Table-1). The horizontal distance of the profiles representing deformed crust across the ridge (L1) ranges from 5917.13 m to 7821.3 m whereas the length of the curve over the profile (L2) varies from 5553.9m to 7933.63 m representing the length of the pre-deformed crust over DG. The ΔL (L2 –L1), repsenting crustal shortening , varies from 63.66 m to 227.65 m. The Vertical offset between both the sides of the wrinkle ridges across the profiles varies from 114.75 m to 361.82 m.

The total accumulated average strain across the DG varies from 1.07 % to 3.88 % which is conformal with the average total accumulated strain of Lunar wrinkle ridges - 0.26 % to 3.6 % [2].

The geographical trends of the straight domains along the axis of the wrinkle ridges are utilized to reveal the palaeostress orientations, following Anderson's Theory of faulting [3] responsible for formation of the winkle ridge. The analysis shows maximum principal stress (σ1) lies along NE-SW oriented horizontally whereas the minimum principal stress (σ3) lies vertically (Fig.2). There are some NE-SW trending scarps/ridges outside the Dorsa Geiki running parallel as well as orthogonal to the Dorsa Geiki. This is also indicative of the two principal directions of stresses in this Mare region that may have probably resulted in creating these orthogonal scarps/ridges outside the Dorsa. An attempt has been made to re-construct the morpho-tectonic set-up of the Dorsa Geiki (Fig.3) which indicates that there is a downthrow towards the eastern side of the ridge indicating a vertical offset of 361.82 m caused by a westward dipping candidate blind thrust fault (F-F). In order to understand the relationship between the quantum of downthrow of the eastern block with the amount of crustal shortening a scatter plot has been generated (Fig. 4) which show a moderate relationship.

| Wrinkle ridge Profile | L1 (m) | L2 (m) | ΔL(L2-L1)m | % shortening | Vertical Offset (m) |
|---|---|---|---|---|---|
| AA | 5917.13 | 6144.78 | 227.65 | 3.7048 | 361.82 |
| BB | 5942.65 | 6058.93 | 116.28 | 1.9192 | 301.76 |
| CC | 7821.3 | 7933.63 | 112.33 | 1.4159 | 114.75 |
| DD | 5982.88 | 5919.22 | 63.66 | 1.0754 | 187 |
| EE | 5338.06 | 5553.9 | 215.84 | 3.8863 | 322 |

Table 1: The morphometric parameters of the Dorsa Geiki derived from the ortho-image and DEM.

**Conclusion:** It may be concluded that Terrain Mapping Camera -2 on board Chandryaan 2 has given high resolution and high quality DEM to carry out morpho-tectonic analysis of Dorsa Geiki wrinkle ridge which indicates that there is westward dipping blind thrust that results in the crustal shortening across the ridge and a total accumulated strain of about 1.0 to 3.9 %, which is conformal with the average total accumulated strain of Lunar wrinkle ridges. The estimated principal stress regimen shows NE-SW trend which is also possibly the cause of some scarps/ridges