

MORPHO-TECTONIC EVALUATION OF DORSA-GEIKI WRINKLE RIDGE USING TERRAIN MAPPING CAMERA-2 ONBOARD CHANDRYAAN-2. A.S. Arya^{1*}, Abhik Kundu², Arup Roychowdhury¹, Amitabh¹, Sumit Pai¹, Dipayan Dasgupta², R. P. Rajasekhar¹, Vishnu Patel¹, Ankush Kumar¹, K. Suresh¹, Ajay Prashar¹, Joyita Thapa², S Gomathi³, Vijaysree³, ¹Space Applications Centre, Indian Space Research Organisation (ISRO), Ahmedabad-380015, India, ²Asutosh College, Kolkata, ³U. 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° to 4° S and 53.25 to 53.75° 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), representing 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 wrinkle ridge. The analysis shows maximum principal stress (σ_1) lies along NE-SW oriented horizontally

whereas the minimum principal stress (σ_3) 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

parallel and orthogonal to Dorsa Geiki (DG), occurring outside the Dorsa. The vertical offset of the DG versus crustal shortening show moderate relationship, however there is no significant relationship between the vertical offset versus un-deformed original length of crust. These relations need further investigation . This research note presents a brisk preliminary analysis of low sun-angle TMC-2 data. The analysis will continue to evolve further and get refined.

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References: [1] Marshak, S., & Mitra, G. (1988). Basic Methods of Structural Geology: Prentice Hill. Engelwood Cliffs, New Jersey [2] Golombek M.P, Plescia J.B & Franklin B.J (1991) Faulting and Folding in the formation of Wrinkle Ridges . Proc of Planetary & Lunar Sciences, Vol-21, pp 679-693, 1991 [3] Anderson, E. M. (1951). The dynamics of faulting. Hafner Pub. Co.

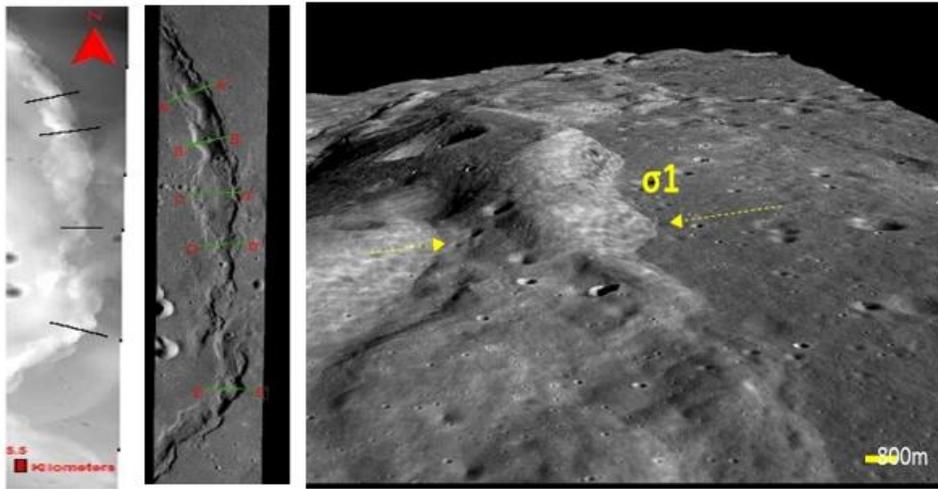


Figure 1 : DEM (L) & Orthoimage (Centre) of Dorsa Geiki (R) showing the location of profile sections (Line). Three dimensional perspective view of a part of Dorsa Geiki (R)

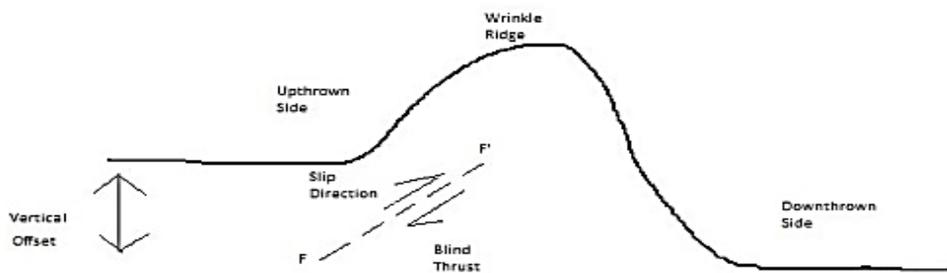


Figure 3: Schematic of the morpho-structural set-up of Dorsa Geiki . perspective view of a part of Dorsa Geiki (R).

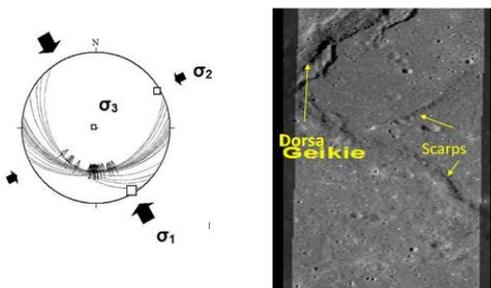


Figure 2: Orientations of maximum principal stresses σ_1 (L) responsible for formation of the Dorsa Geiki and the other stress field resulting in orthogonal scarps/ridges outside the Dorsa Geiki (R).

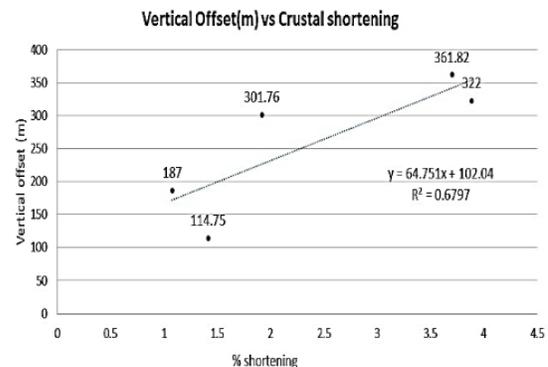


Figure 4: Scatter plot of Vertical offset versus crustal Shortening (%).