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Geodynamic Evolution of Wrinkle Ridges and Rate of Crustal Shortening on Lunae Planum, Mars

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Abstract

Preliminary results of the crustal shortening analyses and geochronological stratigraphy of the Lunae Planum are presented. They indicate a wrinkle ridges refer an age distribution from ∼3.7 Ga to ∼3.0 Ga, with surfaces getting younger towards the East. Our observations are in accordance with earlier observations of greater shortening amounts towards the West (in older ridges) and the age distribution of wrinkle ridges suggests a 700 Ma time interval for the proposed ∼1110 m horizontal shortening at a deformation rate of $1.59E^{+02}$ cm/Ma for compressional deformation on the Lunae Planum.

1. Introduction

The Lunae Planum is a unique plain extending up to Acidalia Planitia, which contains the basalt lava flows formed by the Tharsis volcanism. The topography of this area descends from west to east, from 800 m to -750 m.

Wrinkle ridges are probably one of the most common, but least understood, types of planetary structures on terrestrial planets. These structures indicate the surface deformation of the Martian crust formed by folding and thrust faulting [1]. Despite the interpretation of the morphology, deformations and geodynamic importance of many wrinkled ridges, different conceptual, kinematic and mechanical models applied in previous studies [2]. However, the age relation and formation processes of these structures in the Lunae Planum region are still not clear.

The purpose of this study is to understand main mechanism of the wrinkle ridges, chronological order of geomorphological structures and determine the timing and duration of the crustal shortening of Lunae Planum.

2. Methods

The Lunae Planum (15°N 67.5°W) covers a basin of 900 square kilometers, lies north of the Valles Marineris, a well-known rifting system on Mars. The unique coverage of high-resolution image data, especially HRSC (12.5 m / pixel), CTX (6 m / pixel) and HiRISE (0.3 m / pixel), allows the detailed mapping and analysis of wrinkle ridge structures. The high-resolution digital elevation model was processed by using ISIS3 (The Integrated System for Imagers and Spectrometers) and AMES Pipeline to get the exhaustive profiles along to wrinkle ridges for further mapping in ArcGIS. The crater size-frequency distribution (CSFD) and buffer crater counting (BCC) method were preferred to the obtained absolute age of the wrinkle ridges and geomorphological structures on the Lunae Planum.

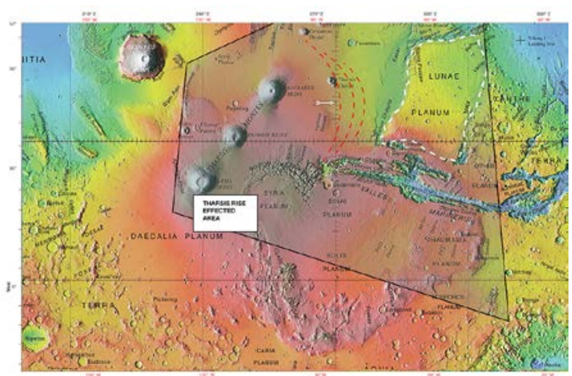

Figure 1: Geographic map of the Tharsis Rise with research area Lunae Planum basin.

3. Results and Discussion

The formation of wrinkles ridges is widely discussed and different tectonic mechanisms are suggested to explain their origin. Our analysis is based on determining the amount of total shortening and calculating an absolute age for wrinkle ridges by using crater-size frequency distribution and buffer crater counting methods. Age determination analysis were indicated that the BCC method according to the asymmetric structures of wrinkle ridges represented absolute age with higher accuracy. Thus, wrinkle ridges cumulated in three groups according to age and geodynamic periods, these structures were classified and dated using the buffer crater counting (BCC) method [3].

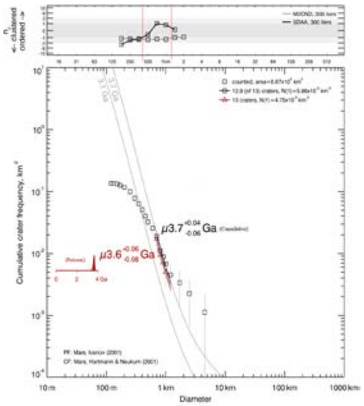

Figure 2: The highest absolute age of wrinkle ridges derived from buffer crater counting method.

BCC measurements of wrinkle ridges refer an age distribution from ~3.7 Ga to ~3.0 Ga, with surfaces getting younger towards the East (Fig 2). Respectively, wrinkle ridges formed between ~3.6 Ga to ~3.3 Ga years in the west, ~3.3 Ga to ~3.2 Ga in the middle and ~3.2 Ga to ~3.0 Ga in the east group. More than 50 wrinkle ridges were examined in detail for obtaining the elevation offset, width and total relief (Fig 4). [5].

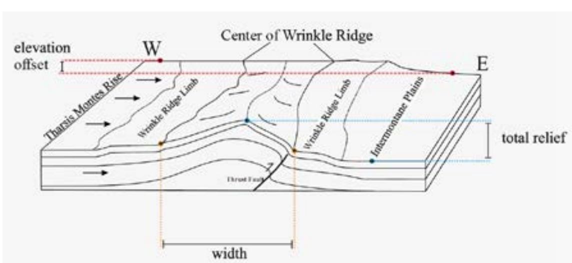

Figure 2: Schematic reconstruction of the wrinkle ridge parameters for calculating shortening by faulting and folding.

The width corresponds to the distance of the two lowest points across the wrinkle ridge, where the slope angles reach minimum; the limit between wrinkle ridge limb and intermontane plain (Fig. 3). The total relief is measured by taking the difference between the elevation of the lowest flat and the highest point of the ridge. The elevation difference between the two plains across the ridge corresponds to the elevation offset value (Fig. 3). The age distribution of wrinkle ridges suggests a 600 Ma time interval for the proposed ~1110 m horizontal shortening at a deformation rate of $1.59E^{+02}$ cm/Ma for compressional deformation on the Lunae Planum.

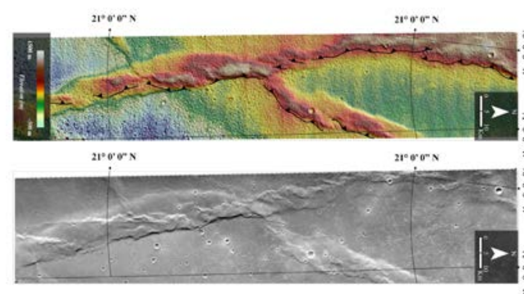

Figure 4: Schematic reconstruction of the wrinkle ridge parameters for calculating shortening by faulting and folding.

Acknowledgements

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