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Towards a refinement of the D-L fault scale relationship for Mercury using MESSENGER topography

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1. Introduction

Terrestrial faults show that the maximum displacement along the fault plane (*D)* scales with the plan-view length of the fault (*L)* [e.g., 1]. Particularly, it has been proposed that the latter relationship can be simplified to a linear relationship

$$D=\gamma L \quad (1)$$

where γ is a constant depending on the lithology and overall tectonic context [1]. The linear relationship seems to be also applicable for planetary faults [e.g. 2, 3] and it is one of the few tools commonly used for estimating fault shortening and thus the amount of global planetary contraction for Mercury [4-7]. The ratio of D to L (i.e. γ) strongly affects the resulting estimates of shortening, therefore, the accuracy of γ is fundamental for quantitative tectonic studies based on (1). The coverage and resolution of topographic datasets are crucial for calculating γ. Prior to the MESSENGER mission, γ for Mercury's lobate scarps and wrinkle ridges were defined using the topography obtained from Mariner 10 images and radar observations from Arecibo [e.g. 4, 5]. Here we present preliminary results of a refinement of γ based on a survey of compressional tectonic structure throughout 30% of the Mercury's surface using topography derived from MESSENGER data. Our preliminary results suggest that γ values derived and used in previous studies [5-7] were likely overestimated and could have then resulted in a overestimation of fault shortening and global planetary contraction.

2. Data and methods

We use all the publicly released data available through the Planetary Data System archive. These include imagery from Mariner 10 and MESSENGER MDIS camera, and stereo-derived and laser altimeter topography derived from MDIS and MLA MESSENGER data, respectively. We focus on a region covering about 30% of planet's surface. Using Geographic Information System (GIS) spatial analysis and statistics routines we digitize tectonic structures as vectorial features and subsequently derive quantitative parameters for each of them. Particularly, displacement (D) measurements were obtained assuming that the height (h) of the lobate scarp (measured accross topographic profiles orthogonal to the fault trace) entirely reflects the amount of slip along the fault plane (Fig. 1). With this assumption, after measuring *h* the displacement can be obtained by

$$D = h/\sin \theta \quad (2)$$

where θ is the fault dip angle. Subsequently, D has been computed using (2) for three different fault angles θ: 25°, 30°, and 35°, based on the indications from fault mechanics and terrestrial analogues. Finally for each of the latter angles γ has been derived from the linear fit of the D-L data.

3. Preliminary results

To date, a total of 227 topographic profiles have been investigated across 25 lobate scarps and 12 wrinkle ridges, while previous γ values were based on 8 lobate scarps and 7 wrinkle ridges and using a single topographic profile per feature [e.g. 4-6]. The ratio between the measured features reflects directly the spacing of the DTM, with lobate scarps being more likely to be measured (due to their larger overall size), while the wrinkle ridges are less likely to be measured with the current MDIS DTM spacing. Our measurements point to γ value ranging from 4.6 to 5.9 x 10^{-3} (for θ = 25° and 35°, respectively) and 5.3 x 10^{-3} (for θ = 30°) for lobate scarps; whereas previously determined γ values range from ~6.0 to ~8.1 x 10^{-3} with 6.9 x 10^{-3} for $\theta = 30°$ [4-6].

6. Summary and future works

We are using topography derived from MESSENGER data to derive the ratio of D to L (i.e. γ) for Mercury's compressional structures. The latter value is fundamental for estimating fault shortening based on (1). Our preliminary results suggest that previous γ values could be overestimated. This overestimation could have been propagated to estimates of Mercury's global contraction and radius decrease [4-7]. Our results should be confirmed and integrated by further observations over significant portions of the planet using stereo-derived topography from MESSENGER orbital phases and the data that will be provided by SIMBIOSYS camera system of the BepiColombo mission.

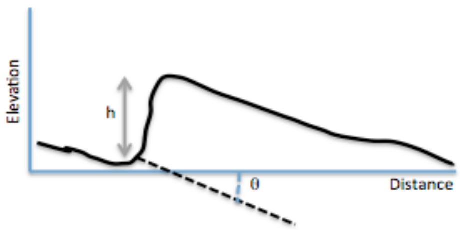

Figure 1: (a) sketch topographic profile across a lobate scarps and its geometric parameters.

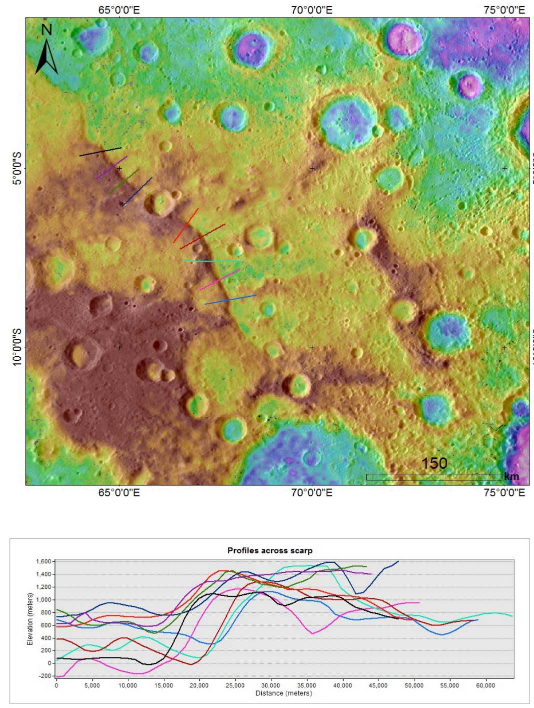

Figure 2: (top) topographic map of a lobate scarp and location of the topographic profiles (color lines) investigated for measuring D along the fault trace; (bottom) a series of topographic profiles across the same lobate scarps as in the top panel.

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