ASSESSING THE METHODOLOGY FOR THE STRUCTURAL MAPPING OF PLANETARY SURFACES.

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Introduction: Photointerpretation of remote sensing data is the standard method used to map tectonic structures on extraterrestrial bodies (ex. [1-2]). At a regional scale, the accuracy or reproducibility of this methodology is not generally considered, but since it is an interpretative task, some degree of subjectivity should exist. Planetary imagery is used, which may also introduce some bias related with illumination constitutions and spatial resolution.

We report the results of a comparison of two photointerpretations with a third dataset obtained semi-automatically (see [3]). The three datasets were compared in order to understand which factors could influence the photointerpretations. At the same time, by using the semi-automatic mapping procedure introduced by [4], we evaluate its accurateness.

We analyzed the Thaumasia Planum region on Mars. It is a region characterized by a complex arrangement of tectonic structures [4-5], ideal to assess tectonic mapping techniques.

Datasets and methodologies: We used two published photointerpretations that analyze the tectonic structures on the Thaumasia Planum region. The first dataset (dataset I), corresponds to the lineaments (representing normal faults and wrinkle ridges) mapped by [5] using a Viking photomosaic at 1:2000000 scale.

We also used the photointerpretation obtained by [6] (dataset II). It is a more detailed analysis produced using several imagery sources: Viking MDIM 2.1 mosaic (231.4 m/pixel), THEMIS infrared daytime mosaic (100 m/pixel) and a HRSC mosaic (50 m/pixel).

Finally, the third dataset (III) was derived from a MOLA DTM with a spatial resolution of ~231m\pixel. All the scarps where automatically extracted from the DTM [4], and were then manually classified using THEMIS, HRSC and CTX for context.

Qualitative comparison: The three datasets are shown in Figure 1. It can be observed the general agreement between the regional distribution of the main sets of wrinkle ridges and normal faults. The major differences between datasets I and II arise from the level of detail and the criteria used to map the tectonic features. Factors such as spatial resolution, illumination conditions, mosaic artifacts and particularly personal style of interpretation can locally influence the results.

Dataset III lineaments are influenced by the quality of the MOLA DTM (figure 3) and the coarse resolution of the MOLA DTM difficult the mapping of small scale structures. Nevertheless, it is clear the higher density of mapped features. When the MOLA data coverage is good, the semi-automatic approach tend to produce a more objective and complete output.

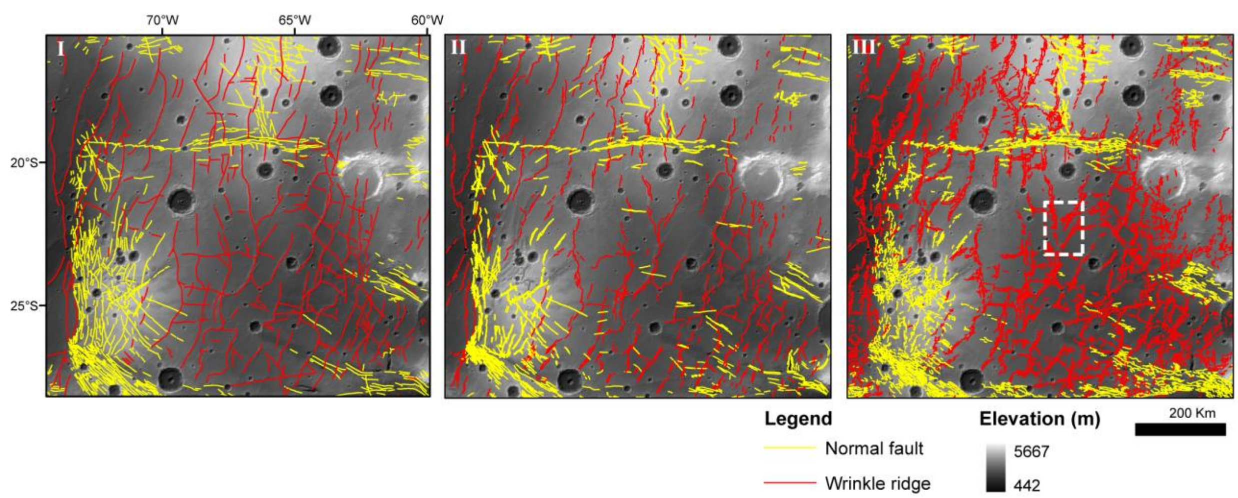

Figure 1 – The three datasets used in this comparison. Note the similar spatial distribution of the tectonic structures in all datasets as well as the larger lineament density for dataset III. The white dashed area mark the region shown in figure 3.

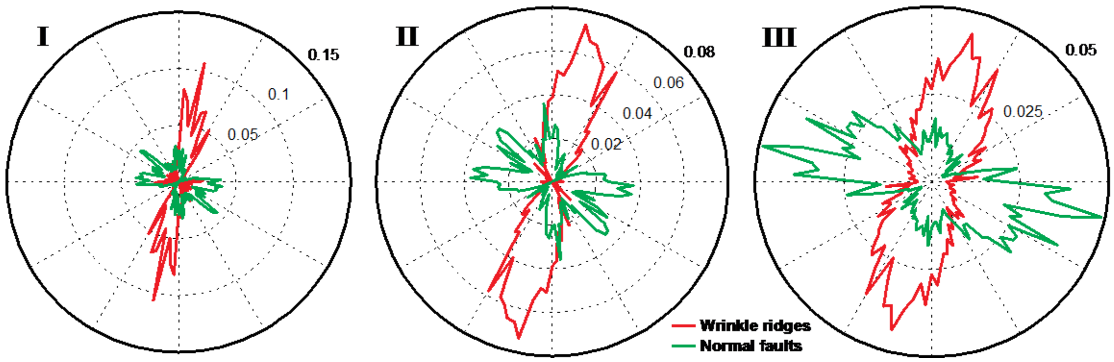

Figure 2 – Length-weigthed circular distributions. Dataset III circular distribution was corrected for MOLA directional bias using the method described in [3]. The same directional modes can be recognized on the three datasets, but presenting distinct relative frequencies.

Quantitative comparison: We have employed confusion matrices to compare the consistency of mapped lineaments between datasets. We have estimated accuracy rates of 72-82% between datasets I and II, while lower rates were found for the I-III and II-III cases (74-76% and 67-66% respectively). This difference can be partially justified by the higher ratio of unique recognitions in dataset III (features in dataset III that are not present in the other datasets). This is certainly related not only to the positive identification of new tectonic features, but also to the more complete mapping of the morphologies (see figure 3 for an example).

Line density is the parameter that presents a higher variation between datasets. We link this fact with the different spatial resolution of used datasets as well as to the personal style of the interpreters.

Length-weighted circular histograms were used to compare the main trends of the two types of tectonic structures. The preferential North-South trend of the MOLA tracks produces a directional bias, which would influence the results obtained from the semi-automatic method. This bias cause an underestimation of the East-West structures, but can be corrected by using the circular distribution of crater scarps as reference (see [3] for details).

The same directional modes can be recognized for the three datasets (figure 2). The main difference is the relative strength of each mode in dataset III. For the wrinkle ridges, a 6° interval is enough to include the mean azimuths computed for the datasets. A higher dispersion exists for the normal faults case (all mean azimuths are comprised in a 12º interval). If we recall that 10º bins are commonly used for plotting circular distributions of tectonic lineaments, we conclude that the obtained mean trends are coincident.

Conclusion: From this comparative analysis we conclude that: 1) regional surveys such as the one typified by dataset I are able to produce the same valid results as more detailed analysis (dataset II), this is only true in terms of spatial distribution and directional statistics, lineaments densities are highly influenced by scale of analysis; 2) different datasets and different illumination conditions can locally influence the interpretations; 3) we have demonstrated that the semi-automatic mapping procedure is capable of producing results comparable to photointerpretations, with the main disadvantages arising from the characteristics of the input MOLA data, allowing at the same time a full morphometric characterization of the tectonic scarps [4].

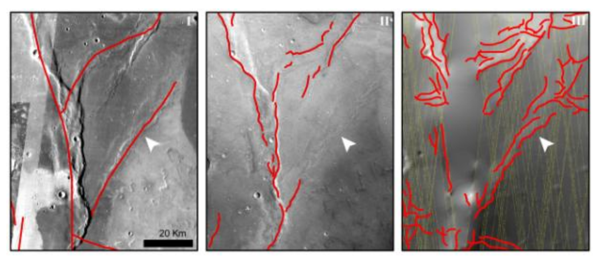

Figure 3 – Example of mapped wrinkle ridges (see figure 1 for location). Lineaments are overlaid on THEMIS IR imagery, HRSC and MOLA shaded relief (from left to right). Differences in interpretative style are observable between dataset I and II. Note how the different illumination conditions mask or enhance some of the scarps. In dataset III, MOLA data gaps (MOLA tracks in yellow) influence the mapping results. Despite this, wrinkle ridges are mapped in a more complete form, with the correct mapping of both bounding scarps.

References: [1] Montgomery D. R., et al. (2009) *Geol. Soc. Am. Bull.*, 121, 117-133. [2] Di Achille G., et al. (2012) *Icarus,* 221, 456-460. [3] Vaz D. A., et al. (2012) *Comput. Geosci.*, 48, 162-172. [4] Vaz D. A. (2011) *Planet. Space Sci.,* 59, 1210-1221. [5] Dohm J. M. and K. L. Tanaka (1999) *Planet. Space Sci.,* 47, 411-431.[6] Borraccini F., et al. (2007) *J. Geophys. Res,* 112.