MANUAL AND AUTOMATIC LINEAMENT MAPPING: COMPARING RESULTS.

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Introduction: Mapping geologic/geomorphologic features from remote sensing data by visual interpretation is a time consuming task. Spatial and spectral resolutions, sensor characteristics and illumination conditions are some of the factors that can lead to a biased interpretation. Interpreter personal skills and experience will also condition the reproducibility of the final results [1].

Several methodologies have been proposed for the automation of mapping procedures on Mars, focusing on different morphological features (craters [2, 3], drainage networks [4] or terrain morphology [5]) and using different datasets. A method for tectonic lineament extraction using MOLA DTMs was previously outlined [6, 7]. In this work we will qualitatively compare the results obtained from the automatic mapping approach and from a traditional tectonic lineament mapping.

Data and methodology: The study area corresponds to the eastern margin of the Thaumasia plateau and the same detailed structural mapping presented in [8] is used in this comparison.

The automatic mapping procedure utilizes a 256 pix/º DEM (~232 m/pix). Gaps between MOLA profiles were filled using the natural neighbour interpolation technique [9]. In [6, 7] we have applied the wavelet transform for the segmentation of lineaments performing the analysis at one chosen scale. The multiscale method that we will use in this work is more robust and less user-dependent.

A 1-D continuous wavelet transform is performed in four scan directions. Local maxima lines of the wavelet transform are tracked across scale and several parameters are extracted in order to characterize the topographic discontinuities [10].

The maximum scale at which the modulus-maxima lines are identified and the scale of occurrence of the general maxima are some of the extracted parameters [11]. These parameters allow the spatial location and hierarchisation of the topographic discontinuities [10]. The decay of the wavelet transform along the local maxima line is used to estimate the Hölder exponent of the discontinuities and allows the discrimination between sharp and smooth discontinuities [10].

The wavelet scale information is weighed with a morphological multiscale gradient [12]. An hysteresis threshold is then applied and the resulting binary matrix is vectorised after the application of a sequence of morphological operators [6, 7]. The vectorisation is followed by a shape analysis in order to split the lineaments into uniform striking segments [13]. The segments are then merged using an angular and distance tolerance factor.

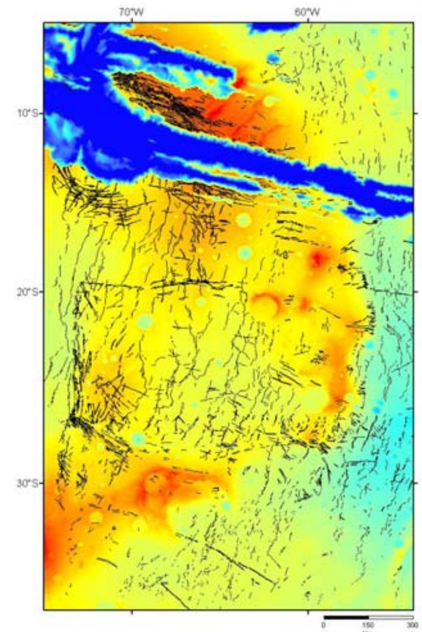

Figure 1. Manually extracted tectonic lineaments superimposed on MOLA altimetry [8].

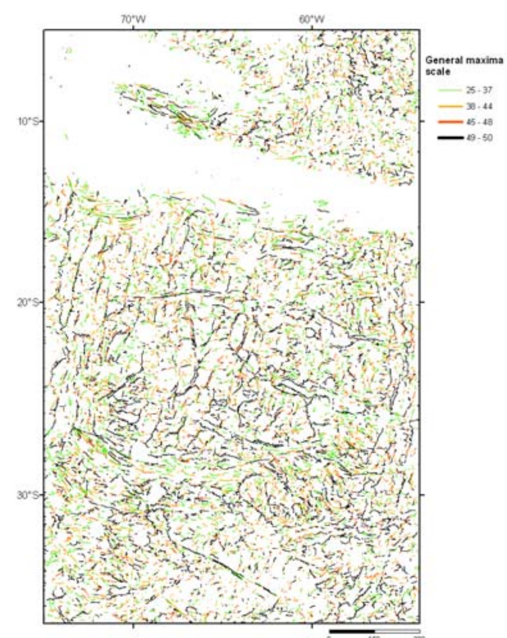

Figure 2. Lineaments extracted automatically. The colour code corresponds to the wavelet transform general maxima scale.

A series of statistical parameters derived from the processing are collected and associated with each lineament. Parameters such as terrain slope and aspect, length and azimuth are also computed.

Since we are only interested in the study of tectonic related scarps, crater scarps that are also identified must be suppressed. This is attempted using a "craterness" index that is automatically generated by a crater recognition algorithm [6].

Results: The described method is efficient for scarp extraction from the MOLA data (fig. 2 and 3). Not all the identified scarps have a tectonic origin. Crater rims and crater ejecta blankets are also marked as well as scarps associated with Vallis Marineris trough. Regions of the DTM with wide interpolated areas tend to produce artefacts and lineament continuity is seriously affected in these areas. A set of classification rules is applied using the extracted statistical parameters. This allows the suppression of a great number of crater rims and meaningless lineaments. Crater ejecta blanket scarps are more difficult to remove automatically (fig. 3).

In figure 2 lineament colours represent the value of the maximum scale of the wavelet general maxima. This is an interesting parameter for the hierarchisation of the scarps since it could be related with the DTM "local frequency" [11]. The extracted statistical parameters should be in the future integrated on a lineament supervised classification scheme.

Discussion and conclusion: The lineament map obtained automatically (fig. 2) has a higher and more uniform lineament density. Some crater rims are still visible since the crater identification algorithm fails to identify degraded craters [6].

All the main tectonic structures identified manually are also present in figure 2. Graben and wrinkle ridge scarps are accurately identified and in some cases new minor structures are correctly recognized in the Thaumasia highlands (fig. 3).

Transcurrent structures clearly stand out from figure 2. Extensive E-W shear corridors are visible (20º and 28º South). The lineaments associated with these corridors possess in some cases high values of general maxima scale which reflects the importance of shear strain in the tectonic evolution of this Mars province.

The proposed method prove to be efficient on the mapping and characterization of lineaments at a regional scale. A more detailed and quantitative comparison must be accomplished. The application of this methodology on HRSC DTMs will allow a more accurate characterization of tectonic features on the surface of Mars.

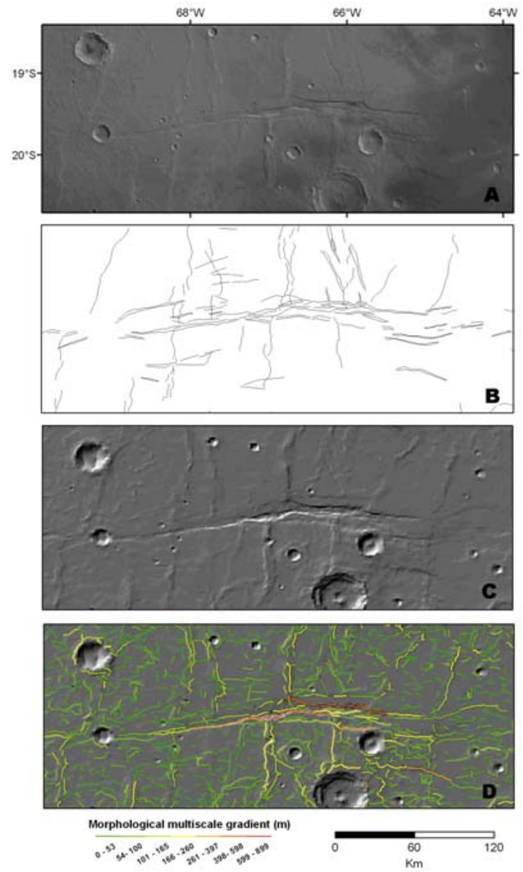

Figure 3. A) HRSC image of an area presenting wrinkle-ridges and strike-slip faults. B) The manual mapped lineaments. C) MOLA shaded relief. D) Automatically mapped lineaments. The colours symbolize the median value of the morphological multiscale gradient. This is a measure of the altitude difference between the top and base of the scarps. Note that crater exterior borders and crater ejecta blanket are still present nevertheless some new minor scarps are correctly identified.

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