COMPARATIVE ANALYSIS OF FAULT SCARPS MORPHOMETRIC PARAMETERS ON MARS. David A. Vaz[1,2], Mauro G. Spagnuolo[3]; Simone Silvestro[4], [1]Center for Geophysics, University of Coimbra, Observatório Astronómico da Universidade de Coimbra, Almas de Freire, 3040-004 Coimbra, Portugal (vaz.david@gmail.com), [2]CERENA, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal, [3]IDEAN, UBA-CONICET Ciudad de Bs. As., Argentina, [4]Carl Sagan Center, SETI Institute, 189 North Bernardo Avenue, Suite 100, Mountain View (CA), 94043, USA.

Introduction: Normal faults scarps are abundant features on Mars surface and their present-day morphology reflects the initial fault geometry and posterior degradation processes. Our aim is to better understand these two factors using high resolution imagery and topography.

We present a comparative analysis of two morphometric parameters (scarp slope angle and height) on two different areas. The faults in the first area are located in the Claritas Fossae rift (figure 1) and were formed during Noachian to Late Hesperian times [1]. The second area is located in the Phlegethon Catena region (figure 2) and the age of faulting is younger, probably Late Hesperian to Late Amazonian [2]. The importance of the slope/height relation is that it can be used to model scarp degradation and to perform morphological dating of fault scarps [e.g. 3, 4].

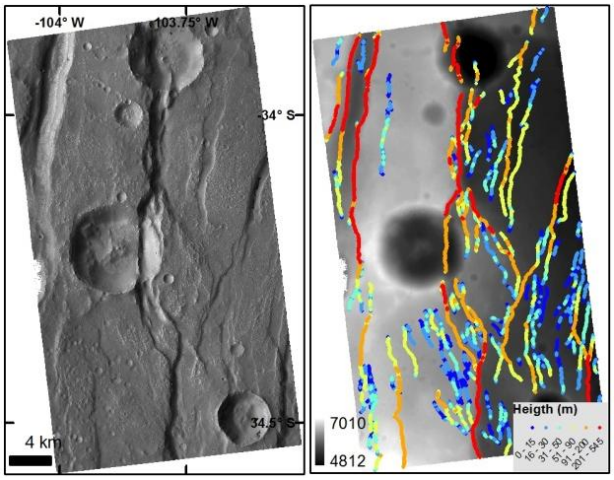

Figure 1 – Claritas Fossae study area CTX orthoimage (left) and DTM (right); the fault scarps height is overlaid on the DTM. Note the good agreement between the structures automatically mapped from the DTM and the CTX image.

Datasets and methodologies: Two DTMs and the associated orthoimages have been built from two CTX stereopairs by using ISIS in combination with the NASA Ames Stereo Pipeline stereogrammetry software [5].

We have automatically mapped the scarps using the same procedure introduced in [6] and that was later validated using MOLA data [7]. To avoid the manual segmentation/classification of the faults scarps, we have implemented a supervised classification scheme using artificial neural networks (combining object-based morphometric descriptors computed from the DTM with several image textural descriptors). The overall classification accuracy was ~90%, but a final inspection and correction was performed in order to assure the best possible results.

As shown in [6], besides the correct recognition of the fault scarps, this technique allows a complete and effortless morphometric analysis of the topographic discontinuities. In this report, we focused on two parameters which were automatically derived from the DTMs: scarps height (vertical throw) and slope angle (see figures 1 and 2).

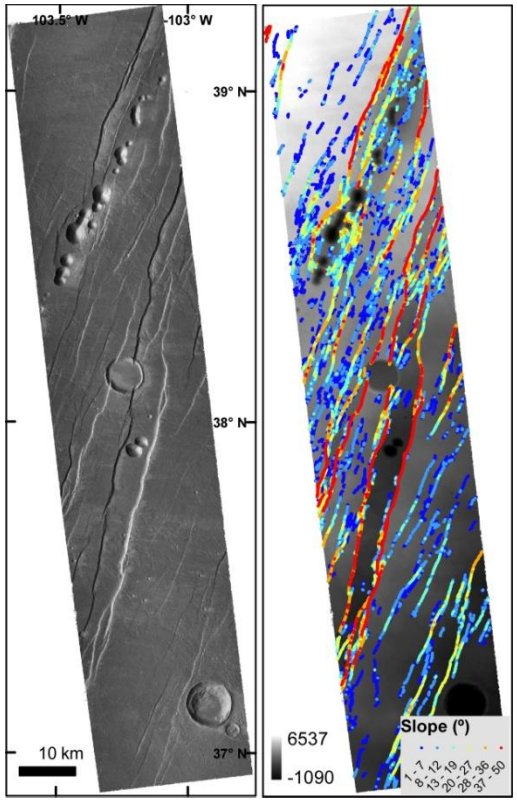

Figure 2 – Phlegethon Catena study area CTX orthoimage (left) and DTM (right); the slope angles computed across the fault scarps are overlaid on the DTM and correspond to the scarps maximum slopes. Some pit chain craters are visible in the floor of the grabens.

Results and discussion: Figures 1 and 2 show the mapped faults scarps on the two study areas. Note the good agreement between the structures visible in the images and the lineaments that mark the fault scarps middle points (which were mapped directly from the DTMs). Since this mapping technique allows a complete morphometric analysis of the faults scarps, its application on different areas has the potential to highlight differences in the degradation states of the fault scarps.

The resultant average height/slope curves (see figure 3) are similar to the curves predicted by diffusive scarp degradation models [e.g. 8, 9]. This suggests that the morphological dating of fault scarps on Mars may be possible (as previously proposed by [4]).

The extracted morphometric parameters are correlated but significant differences exist between the two areas. In Phlegeton Catena the slope angles reach 40º while in Claritas Fossae the averaged maximum slopes only attain an angle of 30º. This morphometric difference seems to indicate a higher degree of degradation for the Claritas Fossae scarps. Assuming identical initial fault geometries and similar degradation rates through time at the two sites, we speculate that this morphometric difference is a product of the different faulting ages. This possibility is in agreement with the different faulting ages derived from crater counts and stratigraphic relations, which give older ages of faulting for the Claritas Fossae region.

Apart from these preliminary interpretations, the data shown in figure 3 allows a comparative scarp degradation modeling that can be used on Mars to investigate and quantify the degradation processes that shaped the fault scarps.

Conclusion: We present a systematic methodological plan to survey the morphological proprieties of normal faults scarps on Mars. It relies in the application of a set of mapping techniques that enable the automatic extraction of several morphometric parameters directly from the DTMs.

By testing this methodology in two distinct areas we have found different slope/height relations that indicate important morphological differences. Assuming a similar initial geometry for the fault scarps, the results suggest a higher relative degree of degradation for the Claritas Fossae region.

Our morphometric measurements foresee the application of diffusive scarp degradation models that can provide parameterization for: 1) degradation rates; 2) relative age of faulting and 3) faulting geometry on Martian rifts.

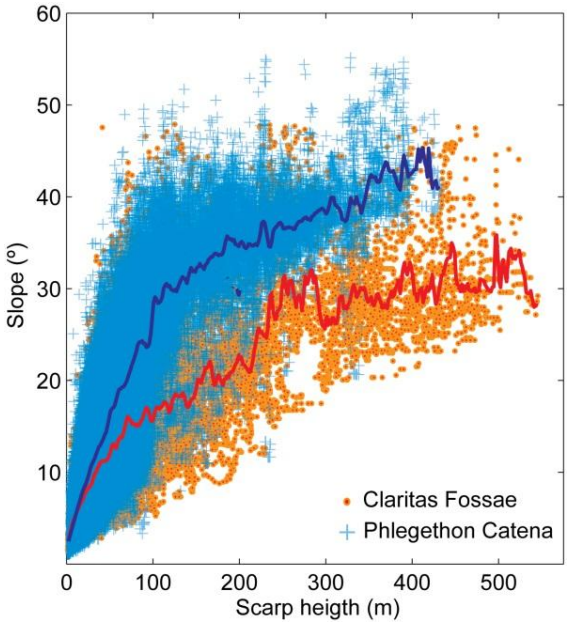

Figure 3 – Slope *vs.* height plot showing the relation between the parameters for the two sites. Moving average curves are also shown. Phlegethon Catena fault scarps present higher slopes, also note the reduction of the curves gradients for increasing scarp heights.

References: [1] Dohm J. M. and K. L. Tanaka (1999) *Planet. Space Sci.*, 47, 411-431.[2] Tanaka K. L. (1990) LPSC XX, 515-523.[3] Hanks T. C., et al. (1984) *J. Geophys. Res*, 89, 5771-5790.[4] Wilkins S. J., et al. (2001) LPSC XXXI, 1254.[5] Moratto Z. M., et al. (2010) LPSC XLI, 2364.[6] Vaz D. A. (2011) *Planet. Space Sci.*, 59, 1210-1221.[7] Vaz D. A., et al. (2012) *Comput. Geosci.*, 48, 162-172.[8] Hanks T. C. and D. J. Andrews (1989) *J Geophys Res-Solid*, 94, 565-573.[9] Pelletier J. D., et al. (2006) *Geomorphology*, 74, 257-270.

Acknowledgements: This work was supported by FCT (Fundação para a Ciência e a Tecnologia) with the grant FRH/BPD/72371/2010 and the contract PEst-OE/CTE/UI0611/2012-CGUC. Simone Silvestro is supported by a grant from the NASA Mars Data Analysis Program (NNH09ZDA001N).