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The study of the relationship between Pit chains and grabens and their role in the formation of Rift systems and Troughs in Noctis Labyrinthus

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Abstract

Pit chains commonly occur along a bounding fault, allowing to infer a genetic relationship between grabens and pits. In this work we propose a comprehensive model for the formation of pit chains , the complex sequence of rift system and troughs in Noctis Labyrinthus. Like other previous authors, we confirm that a volcano-tectonic activity is the main process controlling the generation of such interesting and intricate structures in the studied area. We analyzed the geometrical properties and the maximum displacement as a function of fault length and cumulative frequency of fault length distribution for 499 mapped faults, which reveal the host lithology of the faults and the arrangement of rocks in of the crust and the lithosphere.

We finally suggest a model where a relative sequence of events responsible for the formation and development of the scalloped network of troughs in Noctis Labyrinthus (Mège et al.,2003).In this model, the magma propagates from depth to the surface by exploiting a network of interconnected fractures, and as a consequence, this magma inflation generates the formation of dike-induced grabens and pit chain on the surface.

Introduction

Noctis Labyrinthus is one of the enigmatic area in the surface of Mars.This area is made up by a complex inter-connected network of canyons and branched extensional faults and grabens **Fig.1**.These particular features of unknown origin, make Noctis Labyrinthus an interesting target to understand the possible factors that control the formation of these complex grid of troughs and infer the possible fault system evolution. We performed a detailed qualitative and quantitative study of these faults system through the study of their geometrical properties and surface morphology in order to understand their mechanical evolution and variations over different scales of length, the mechanisms of growth and the related stress field. We measured the maximum displacement as a function of faults length. The D_{max}/L diagram provides slightly different results according to the fault type, since this ratio change from normal, thrust, and strike slip faults, so it provides information about the possible nature of the faults in the selected area (Seog Kim et al., 2005). The cumulative frequency plot **Fig.3** was used to infer the scaling law of the fault system and faults growth, determine the lithology of the faulted rocks, the arrangement of materials in the subsurface and also the vertical confinement of faults vs. penetration of the brittle crust (Sornette.,2009; Torabi and Berg., 2011;Sornette et al., 1993; Cowie et al., 1991).

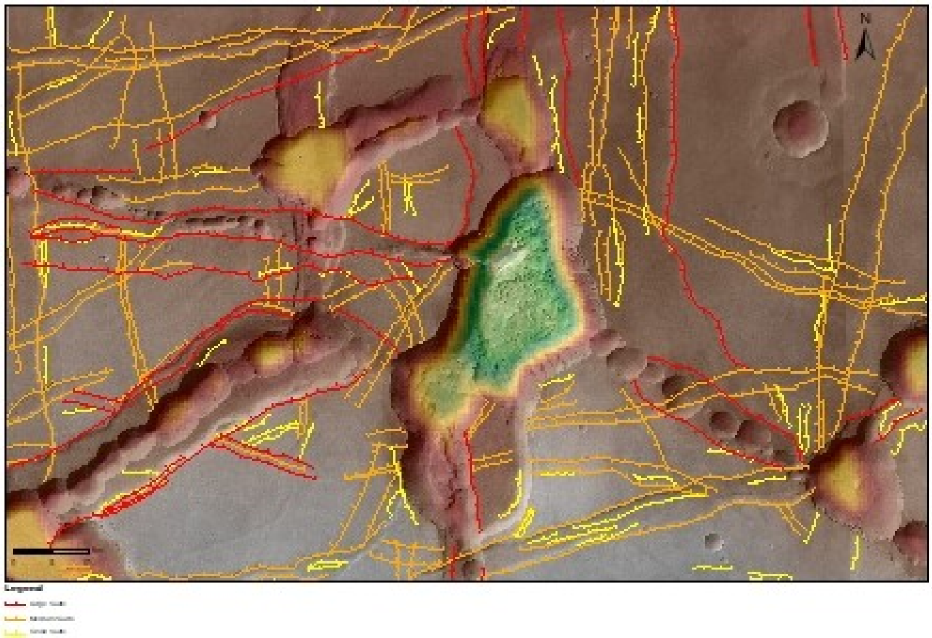

Fig.1. Surface interconnection between faults and pit chains, which follow a linear trend. Faults sizes and colors are labeled on the graph.

1. Data and methods

In our work, as a basemap, we used two orthoimages H3210_0000 and H3221_0000 from High Resolution Stereo Camera (HRSC) on board Mars Express, bearing a resolution of 12.5 m/pixel and for the surface topography, we utilized an individual Digital Elevation Model (DEM) from Mars Orbiter Laser Altimeter (MOLA) on board Mars Global Surveyor, with resolution of ~460 m/pixel. With these data sets, we made all morphometric measurements required for characterizing the faults and the grabens systems, analyzing faults distribution using rose diagrams, measuring faults lengths and the maximum vertical displacement of faults population and carry out a D_{Max} Vs. L diagram and a cumulative frequency plot by input data in Origin software. Afterward, we studied the relationship of those fractures in terms of the formation and evolution of Pit chains and troughs.

2. Discussion and Conclusion

Noctis Labyrinhus is a framework of intricate rifts systems and branched faults, that have coalesced together to form an interconnected topography characterized by large troughs and canyons, driven by an invariant extensional stress field. Fault grow and develop at the same way but at different scales (Schultz et al., 2000; Turabi and Berg., 2011).

Crustal-Scale linkage in localized faulting zone is responsible for the formation of rift segment border by a pre-existing fracture (Soliva and Schultz., 2008). So far, only a few locations on Mars, where the D_{Max}/L relationship has been measured. In our work, the nonlinear distribution in the **Fig.2** might be explained by the presence of small size fractures, with different depths, which could be one of reasons that affect the large distribution of measurements in the Displacement-Length diagram (Turabi and Berg., 2011), or alternatively, it could be linked to the brittle crust thickness that control the displacement and the length of faults as in the terrestrial analogues faults systems (Soliva and Schultz., 2008; Schultz and Fossen.,2002; Soliva et al., 2005; Comie., 1998).

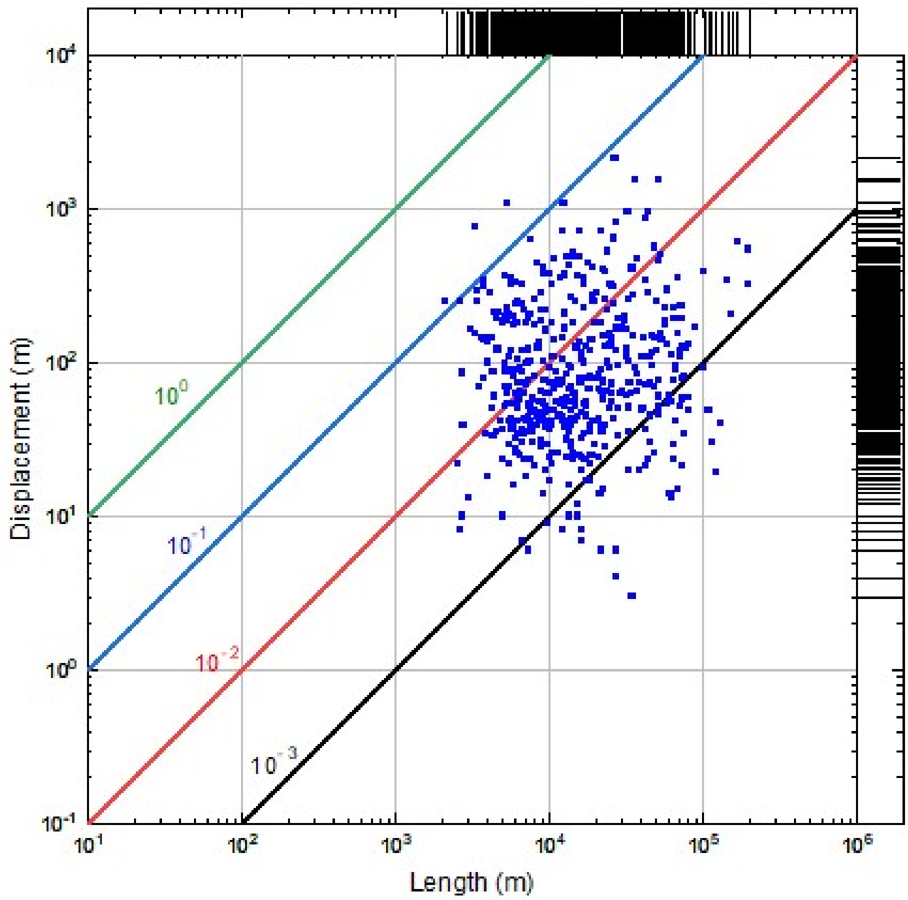

Fig.2. D_{Max} /L diagram of faults studied in this work, shows a large scattering of values. The different D_{Max} /L limits are plotted in various lines with different colors. Topographic offsets was measured along single MOLA tracks.

The cumulative frequency Vs. Length of fault population values grows in exponential fit **Fig.3** of size distribution, mainly reflecting the presence of layered sequence of massive basalt (R.Soliva and R.Schultz., 2008).

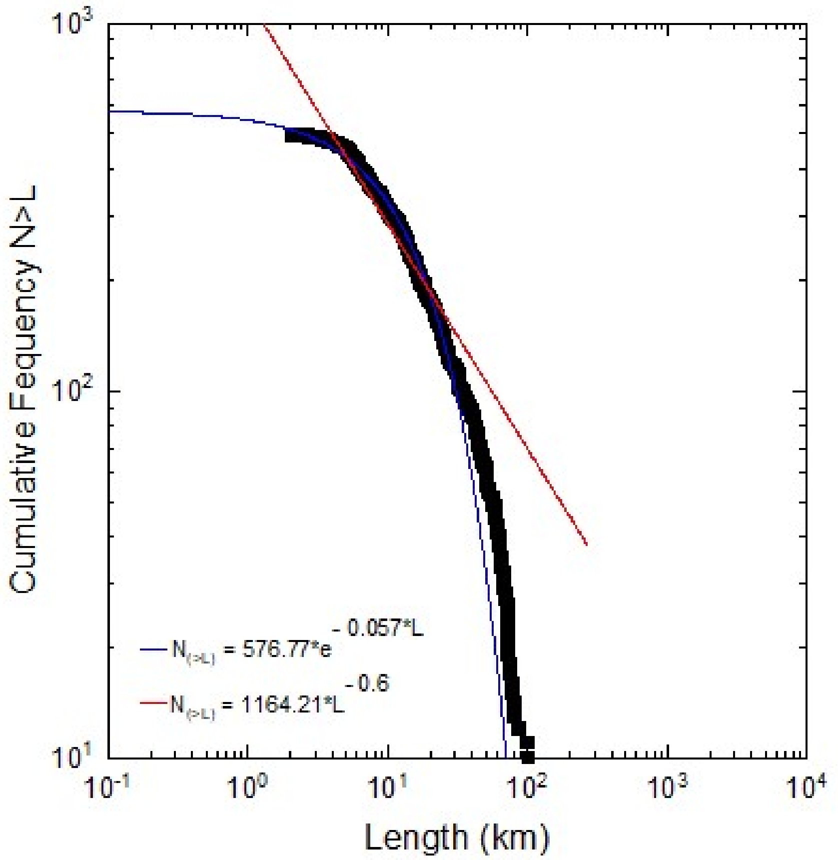

Fig.3. The cumulative size distribution of the fault length population with Exponential and Power Law fits. On the diagram, the Exponential function fits the most with the main trend.

Furthermore,We classified pit chains as a morphological features of volcanic collapse generated by pressure drop above dikes (Mège and Masson., 1996; Liu and wilson., 1998; Scott et al., 2000; Mège and Masson., 1996; Wilson and Head., 2002; Ernst et al., 2001; Mège et al.,2003).Dikes play an important role to connect the surface to the magmatic source. The magma chamber at depth continuously generate flow that will be transported later to the upper levels through the dikes (Mège et al.,2003). This procedure will produce a stress in the dike tip, followed by deflation causing the collapsing of the surface, where there is a graben already formed. This sequence of events is responsible for the generation of the pit chain.We are suggesting a model based on a coupled physical processes of an early extension, visible on the surface by a forked grid of faults and grabens and a magma plumbing.

Acknowledgements

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