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Structural modeling of thrust faults in the Amenthes Region, Mars

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Abstract

The study of lobate scarps provides information about the process of thrust faulting that generates these structures, which is related to the lithospheric characteristics at the time of formation. The 3D modeling of Amenthes Rupes fault system generates a global vision of this largely studied structure, constraining the listric fault geometries and the fault propagation fold morphologies. A maximum horizontal slip of ~5.5 km has been measured and two different depths of faulting have been obtained, probably indicating complexities in the mechanical behavior of the Martian crust.

1. Introduction

Lobate scarps are structural landforms present in planetary surfaces considered as the topographic expression of large thrust faults. The depth of faulting of these large compressive structures on Mars is interpreted to coincide with the brittle-ductile transition (BDT) at the time of formation, so its study provides insights into the lithospheric structure and mechanical behavior [e.g. 1, 2].

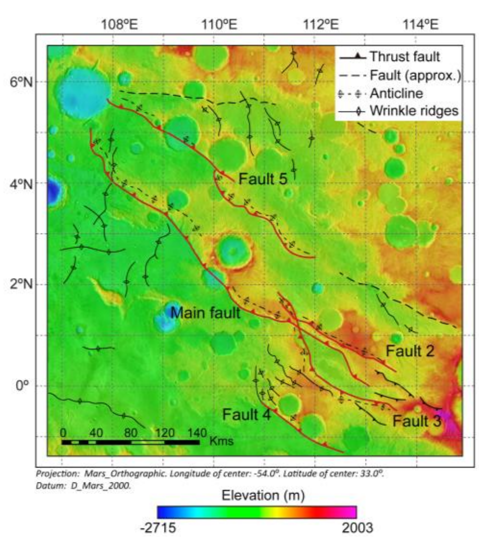

Figure 1: Structural map of the studied region over the original MOLA surface.

Amenthes Rupes has been largely studied and modeled due to its large size and location [1, 2, 3, 4]. This lobate scarp is part of a thrust fault set located in the Amenthes Region, in the Martian highlands near the dichotomy boundary [5]. The 3D modeling of the 5 thrust faults present in the area (figure 1) provides information about the faulting structural pattern and the characteristics of the lithosphere when they formed (3.7 Ga ago [4]).

2. Methodology

A combination of trishear and fault parallel flow algorithms in a 3D modeling using MOVE^{TM} software has been applied to obtain the information about the structure of Amenthes Rupes fault population. This 3D modeling has provided good results when modeling large mountain ranges on the Earth and Ogygis Rupes lobate scarp on Mars [e.g. 6, 7, 8], allowing to model the fault propagation fold generated by the thrust fault slip under a lobate scarp.

The slip of the hanging wall over the footwall is defined by the fault parallel flow algorithm, where the material moves along paths parallel to the fault surface, while the characteristics of the folding ahead of the propagating thrust fault are determined by trishear parameters, defining the fault propagation fold that forms the lobate scarp.

3. Summary and Conclusions

The 3D forward model has been obtained by iteratively changing the fault parameters minimizing the elevation difference between the original MOLA surface and the model topography. The fault parameters obtained by 3D forward modeling include the fault geometries, the slip distribution, the fault propagation folding and their variations along the strike for each of the studied faults.

The listric geometry obtained for the 5 modeled faults implies that these faults decrease its dip angle until being horizontal when reach its depth-to-detachment. This observation, together with the slip distribution obtained for each fault allows to calculate the horizontal slip affecting the area, which presents a maximum value of ~5.5km (figure 2).

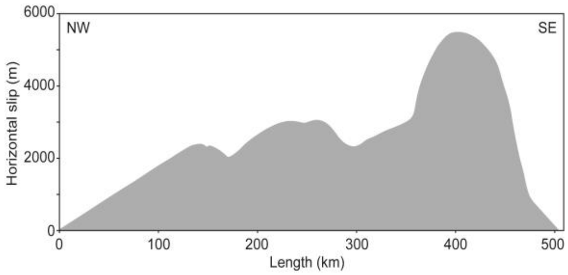

Figure 2: Total horizontal slip distribution represented in a lengthwise profile orthogonal to the general slip direction of the analyzed faults.

The depth of faulting shown by minor faults (9-11 km) could indicate internal mechanical discontinuities in the crust. This depth of faulting is clearly differentiated from the depth where the largest faults root (19-24 km), which agrees with the depth of the BDT of the Late Noachian-Early Hesperian calculated in previous lobate scarps works [e.g. 1, 2, 3, 4, 9, 10].

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