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The impact of data resolution and magmatic resurfacing events on understanding fault growth behaviour in the volcanic regions of Iceland and Mars

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Abstract

We show a comparative study of fault behaviour in the volcanic regions of Krafla, Iceland and Alba Patera, Mars. The study highlights the importance of both data resolution and magmatic resurfacing in controlling any comparison between fault behaviour in potentially analogous regions both on a single planet and across the Solar system.

1. Introduction

Despite differences in the tectonic settings on Mars and Earth, comparative studies of normal faulting behaviour on these two planets could be one of the routes to understanding parameters, such as surface gravity and lithospheric strength, which control variations in crustal processes across planetary bodies [1]. Comparisons can be made between the distribution of Terran maximum displacement/length (D_{max}/L) relationship of faults and those measured on Mars [7]. However, usefully extracting values controlling differences in fault growth behaviour relies not only on being able to constrain the effects of differences in data resolution but also in understanding variations in tectonic settings on Earth. In this study we have compared D_{max}/L measurements made at a range of resolutions on Earth at the actively rifting, Krafla volcanic zone, NE Iceland [2,5] and on Mars in the region of fault systems in the northern region of Alba Patera [3,6,7].

2. Method

For the Krafla faults, we created a 0.5 m resolution digital elevation model (DEM) of the area from airborne LiDAR, additionally downsampling to create 10 m and 30 m DEMs. From these we measured three major fault systems, as single faults at 30 m resolution, and all component faults at 10 m and 0.5 m resolution. For the Martian faults we measured fault systems as single faults using ~460 m resolution Mars Orbiter Laser Altimeter (MOLA) data and as component faults using ~6 m resolution Context Camera (CTX) stereographic image data from the Mars Reconnaissance Orbiter (MRO). Examples are shown in figure 1.

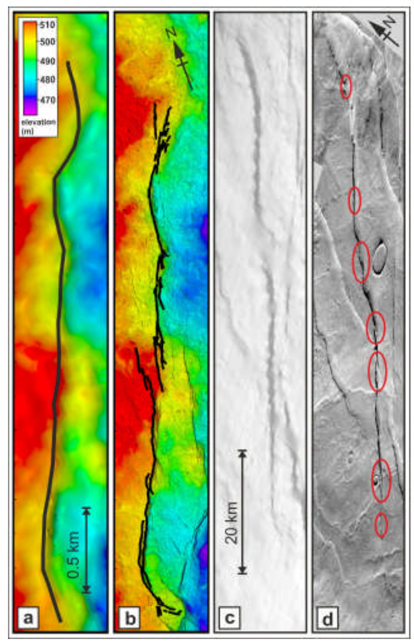

Figure 1. Showing a single fault system in Krafla (a) and Alba Patera (b), using 30 m resolution LiDAR and 360 m resolution MOLA data respectively. The corresponding segmented faults shown using 0.5 m resolution LiDAR and 6 m resolution CTX data.

To allow comparative measures between the magmatically resurfaced regions of Alba Patera and similar regions on Earth, we used the 0.5 m resolution to measure the displacement/length profiles of 775 faults in a magmatically resurfaced area of Krafla to develop a model of fault growth through resurfaced layers, with lengths ranging from 10s to 1000s of metres.

3. Results

The D_{max}/L data for an example fault system from Krafla and Alba Patera are shown in figure 2 (a and b respectively). For the Krafla data, all fault systems measured shown a similar distribution, with single faults in low resolution showing a low D_{max}/L and a spread of segmented faults in the high resolution data that sit at the top end of the Terran D_{max}/L distribution. A similar result can be seen with the Martian fault data when compared with the published Martian distribution. Additionally, the high resolution data is observed to be within the Terran published distribution.

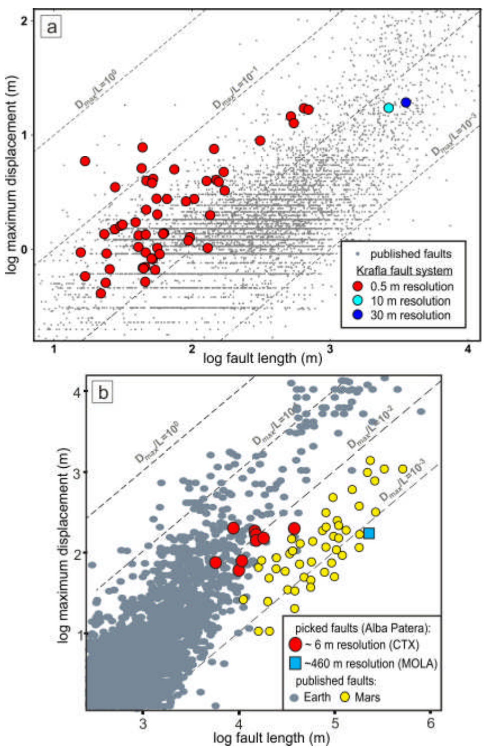

Figure 2. Example Dmax/L data for a single (a) Krafla and (b) Alba Patera fault system. Published fault data: Terran (grey) as shown in [1], and Martian (yellow), as shown in [7]

4. Summary and Conclusions

Potential limitations in understanding fault segmentation and the effectiveness of direct comparison of fault behaviour, both between locations on Earth and between fault populations on different planets and moons, can be controlled by the resolution of the data being used. Additionally, we observe that, in a magmatically resurfaced region, continued fault growth may result in a lower D_{max} across the fault system (measured as a single fault in low resolution data) as the fault re-establishes through a segmented system of faults at the surface. In attempting to understand and quantify parameters that act as key controls to differences in behaviour across planetary bodies, influences such as varying data resolution and magmatic resurfacing must be considered.

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