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Fault Populations on Alba Mons, Mars, and their Age Relationships to Volcanic, Fluvial, and Glacial Processes

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Abstract

We map the cross-cutting relationships between faults, valley networks, and (volcanic) flows on Alba Mons to infer the temporal sequences of the major processes that influenced the area. Preliminary mapping on the northwestern flank suggests that lava flows predate the valley networks, and the faults postdate both the flows and the fluvial valleys. We also mapped individual fault segments for future quantitative fault population analysis.

1. Introduction

Alba Mons is a large, low-relief volcano with a planform extent of 1015 km × 1150 km exceeding that of Olympus Mons but with only ~6 km relief and extremely low flanks slopes (~1°) [1]. Alba Mons has a summit caldera complex, extensive lava flow fields on its flanks and in the surrounding plains [2], and prominent sets of graben (e.g., Tantalus and Alba Fossae) that extend from south of the volcano around its flanks and into the northern plains [3,4]. A series of dendritic valley networks [5] is found on Alba Mons' flanks; coupled with the volcano's low relief, the valley networks have been interpreted to indicate pyroclastic deposits at the base of the volcano, suggesting that Alba Mons may be a transitional form from the ancient highland paterae to the prominent shield volcanoes of the Tharsis region [6].

This study is part of a larger project that will result in two formal USGS geologic maps of Alba Mons` summit region and its western flank [7]. Here we focus on two specific questions: 1) What are the quantitative properties of the fault populations such as their length distribution and the displacement-length ratio? 2) What are the relative ages of lava flows, channels, and tectonic features (e.g., graben, ridges, and pit crater chains) on the upper flanks of Alba Mons?

2. Methods and data

Images with ~5m/pixel resolution taken by the Context Camera (CTX) on the Mars Reconnaissance Orbiter (MRO) were used for the mapping, and images (~0.5m/pixel resolution) of a few selected sites from the High Resolution Imaging Science Experiment (HiRISE) were used for cross-evaluation of small-scale features. The test mapping area is located on the northwestern flank of Alba Mons extending over 44.5-46.5°N and 112-114°W. It was selected due to the presence of all three features of interest, i.e., valley networks, faults, and lava flows. Figure 1 shows some examples of identified cross-cutting relationships where the contact points are marked accordingly.

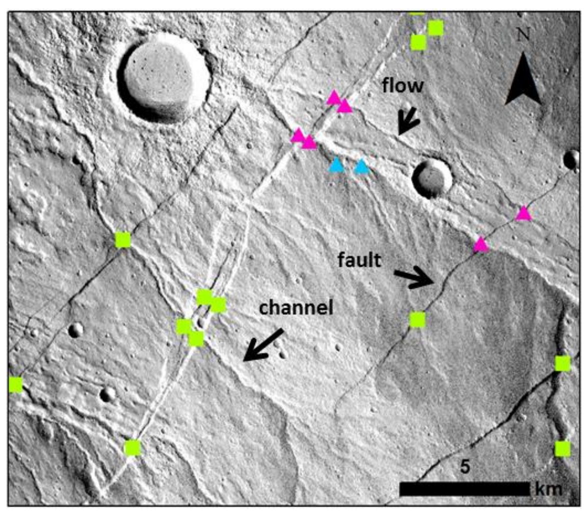

Figure 1: CTX image showing examples of mapped cross-cutting relationships. See Fig. 2 for legend.

3. Preliminary results

The numerous faults in the test area are part of the larger concentric graben sets surrounding the summit region and appear to be the youngest of the three

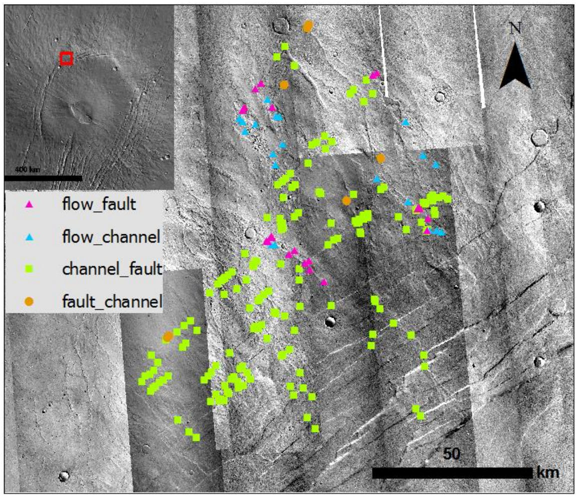

Figure 2: Cross-cutting relationships mapped in the test area. * The first item in the legend name is older, e.g. flow_fault = the flow is older than the fault.

types of landforms. Numerous channels predate faults. Lava flows are less abundant, but where unambiguously identified, they appear older than both faults and valley networks (Fig. 2). This result agrees with previous mapping [2, 8]. Identification of the relationships was in some cases complicated by crater ejecta, as well as what we assume to be the ice-rich latitude-dependent mantle that is known to be ubiquitous in mid-latitudes [e.g., 9]. HiRISE images show that the topographic expression of geomorphological features is somewhat subdued, especially when observed at very small scale, which resembles "blanketing" by an extensive mantle deposit. In some cases it is hard to distinguish the type of flows, which may be either lava or debris flows.

4. Discussion and conclusions

Preliminary results from one test region suggest that the volcanic activity ceased on this part of Alba Mons before the onset of the extensive fluvial activity. This along with the preferential formation of channels on the northern flank of Alba Mons are suggested by [2] to be evidence for the accumulation of friable ice-rich material during high obliquity periods. As to the pyroclastic origin of the deposits proposed by [6], this age sequence would require a late pyroclastic activity that might have occurred after the effusive flows were emplaced. Mapping of a larger area where more lava flows are present is planned before we can conclusively confirm the sequence of geological processes.

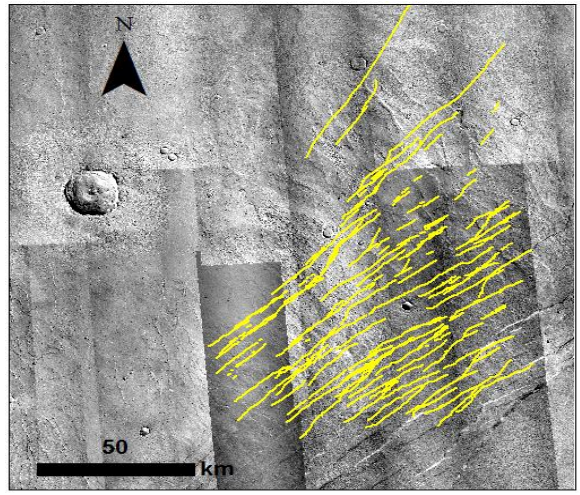

Fig. 3: Individual fault segments, often in en echelon patterns. Base map is same CTX image mosaic as in Fig. 2.

The young relative age of the mapped faults suggests that the majority of them correspond to the stage III faulting event [10], which is part of a complex sequence of tectonic activity that lasted from Noachian to Late Amazonian. The faults appear extremely pristine and well-preserved when compared to other faults on Mars, supporting the notion of a relatively recent formation. We plan to extend the detailed mapping of the faults at small scales to obtain a representative sample of quantitative fault length distribution. This can be useful for estimating the strains acting on the area to constrain formation models of the prominent graben systems surrounding Alba Mons.

References

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