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Correlation between chaotic terrains and impact craters on Mars

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Abstract

We present the result of a statistical analysis of chaotic terrains around Xanthe Terra. For 50 objects we measure the diameter and the maximum and minimum depth. The difference between the two measured depths represents the minimum collapse achieved by each chaotic terrain. The correlation between maximum depth vs diameter of chaotic terrains is statistically similar to the same relation for impact craters. Much more statistically similar is the relation between the minimum collapse and the diameter compared to crater depth vs diameter relation of impact crater. This result suggests that chaotic terrains are likely formed on older impact craters after the collapse of sediment filling the craters. This interpretation agrees with a buried sub-ice lake scenario, proposed to explain the evolution of martian chaotic terrains.

1. Introduction

Chaotic terrains on Mars present some unsolved characteristics, such as the high collapse achieved in the chaos basins, the highly fractured terrains and the occurrence of outflow channels. Although different scenarios have been proposed to explain the evolution of chaotic terrains, their general application to all martian chaos is difficult and inconclusive. For this reason, an evaluation of common morphometric characteristic of chaotic terrains urgently needs. In this contribution we present the results of a statistical analysis performed on 50 chaotic objects around Xanthe Terra (Fig. 1). For each object we measure the diameter and the maximum and minimum depth respect to the surrounding non-collapsed area. We also measure the maximum collapse as the difference between the maximum and minimum depth. Data are measured from HRSC images and, for the parts with incomplete HRSC mosaic, from MOLA images. We obtain the morphometric parameters from the average between data of 2 perpendicular cross sections across each chaotic terrain and data from a Triangulated Irregular Network.

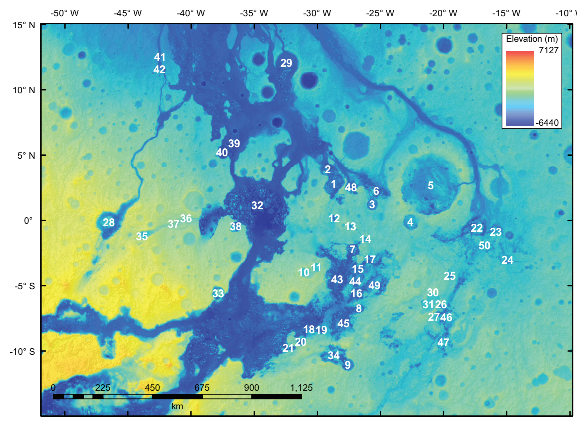

Figure 1: Location of mapped objects. MOLA mosaic dataset.

2. Results

The most part of the measured objects has a maximum depth greater than 1.2 km (Fig. 2a). The latter represents the maximum collapse achievable by complete pore-space closure of 20 km depth cryosphere after groundwater release, with a depth-porosity relation suggested by [1]. This indicates that the groundwater outflow process is not responsible for the high collapse observed in the most part of the chaotic terrains. Only 5 objects (not reported in figure 2) have a maximum depth greater than the pristine depth of impact crater, calculated from 4 different diameter vs depth relations. Furthermore, the relation between diameter and maximum depth is statistically similar to the relation between diameter and pristine depth of impact craters (Fig. 2a). This similarity is much more significant when the minimum collapse achieved by chaotic terrains is taken into account vs diameter. In fact, the difference in slope between chaos and crater relations is less than the statistical interpolation error (Fig. 2b).

The high collapse shown by the most part of the chaotic terrains and strong correlation between diameter vs collapse relation and the same relation for pris-

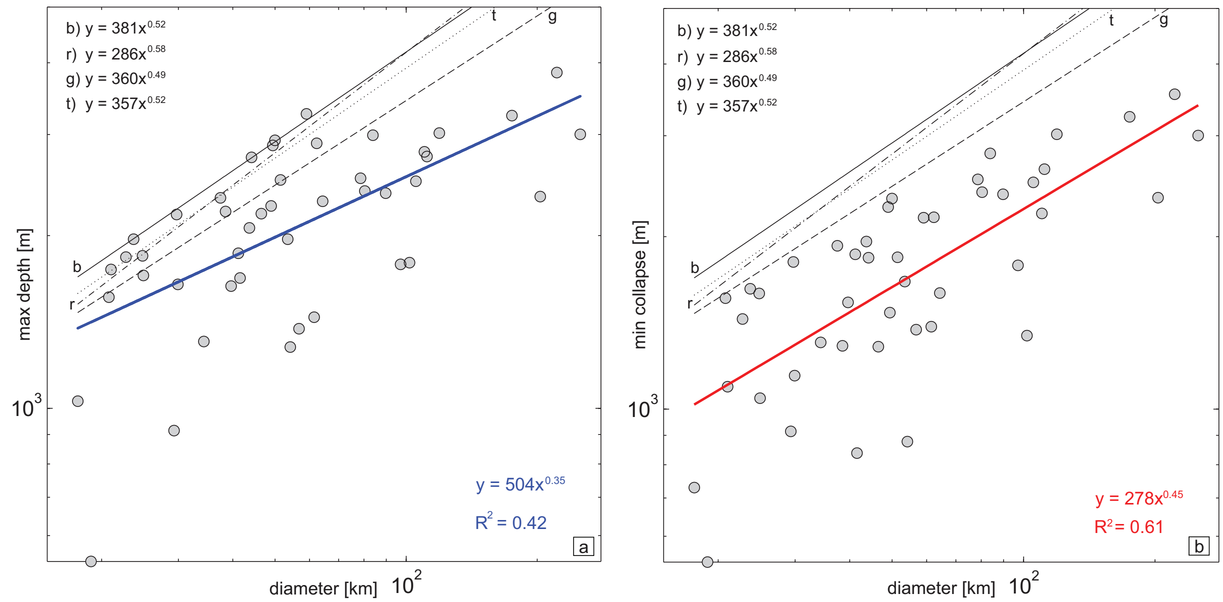

Figure 2: Maximum depth (a) and minimum collapse (b) of mapped objects compared to their diameter. The correlation curves (blue and red) are parallel to depth vs diameter curves referred to pristine craters obtained from 4 different models (black lines).

tine crater suggest that they can be formed on older impact craters, after the collapse of sediment partially filling the craters. Of the four major processes proposed to explain the evolution of the chaotic terrains, only the buried sub-ice lake scenario seems to match the results of this statistical analysis. The scenario starts with the partial filling of the crater by water ice and the subsequent burial under a thick overburden sequence. The buried ice unit starts melting as a result of the thermal insulation by the overburden in combination with the planetary heat loss, creating a subsurface lake. When the melt layer reaches a remarkable thickness the overburden collapses, resulting in massive expulsion of liquid water to the surface [2, 3]. This scenario can explain the high collapse of chaotic terrains, the similarity with impact craters and the shifting between the chaos collapses and the pristine crater depths relative to the same diameter (Fig. 2b). The latter can be explained by the partial filling of crater by sediments. Magma cryosphere scenario can only explain the high collapse but not the strong correlation between chaos and impact craters, while gas-hydrated and aquifer scenarios disagree with both observations [3].

3. Conclusions

The strong correlation between the collapse achieved by the chaotic terrains and the pristine depth of impact crater suggests that chaotic terrains are formed on older impact craters, after the collapse of sediment filling the craters. This interpretation agrees with a buried sub-ice lake scenario proposed to explain the evolution of martian chaotic terrains. This is a non-climatic mechanism able to produce even large volume of liquid water on Mars.

References

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