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Relationships between grabens and calderas in the Solar System

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Abstract

Extensional stress regimes in planetary bodies have been found to be a widespread mechanism driving many processes of magma ascent through the crust, often resulting in accumulation and sub-surface magma chambers (through inflation, vertical stacking of sills, floor subsidence, and other processes). After being emptied by eruptive activity or withdrawal of magma at depth, the roof of such a chambers may eventually collapse, forming a volcanic caldera. In this research we explore the relationship between grabens, a structural expression of the local tectonic environment limited by normal faults that acts to accommodate extension within the crust, and the formation of calderas.

Here we focus on two Solar System examples, Nili Patera (Mars) and Masaya Volcano (Earth). Both volcanoes are situated on top of one of the limiting faults of a graben, possess outer caldera-bounding ring faults partially covered by lava flows that flowed from eruptive centers within the caldera, and have cinder cones associated with their inner ring faults. These similarities, given the fact that the environments where the calderas have developed are substantially different (in Mars plate tectonics and the presence of a hydrothermal system are absent), render them particularly useful in terms of comparative studies.

Using remotely measurable physical characteristics such as the diameter of inner and outer caldera ring faults, the area covered by fractures related to the collapse of the caldera floor, the amount of subsidence, etc; we compare and contrast calderas that are either associated or not associated with graben, expanding some of the existing planetary caldera databases [3]. We consider the depth to the magma chamber for each case based on statistical analysis of other caldera constructs and previous analogue modeling studies [1], [2], [4]. Finally, we will use the information acquired to undertake a more detailed regional structural study of both calderas, emphasizing the effect of the local graben on their shape (roundness and ellipticity), orientation (relation between striking direction of the graben and caldera elongation), type of activity through time, and local structural framework.

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