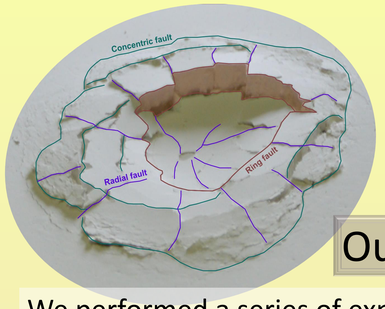
Chaotic caldera collapse: a new interpretation for the origin of chaotic terrains on Mars



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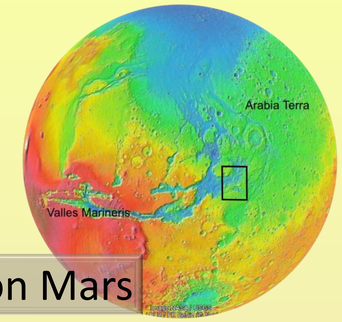
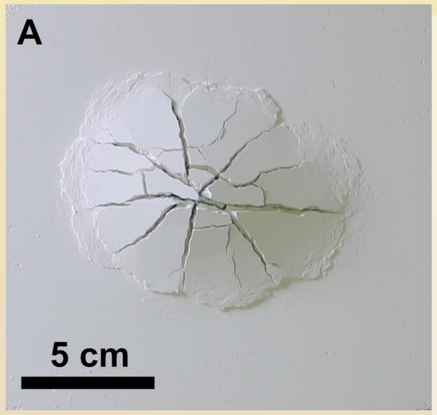


Our analogue experiment

We performed a series of experiments (Fig. 1) using different setups to test the hypothesis that the peculiar features of chaotic terrains on Mars could have been formed by a particular type of caldera collapse known as *piecemeal* or *chaotic (Branney & Kokelaar, 1994; Moore & Kokelaar, 1998; Roche et al., 2000; Scandone, 1990; Troll et al., 2002).* An analogue magma chamber, where a polyglicerine imitating the magma was repeatedly intruded and extruded, was positioned under K-feldspatic sands simulating the brittle crust. Here the resulting structures formed on the analogue brittle crust after two cycles of inflation and deflation:

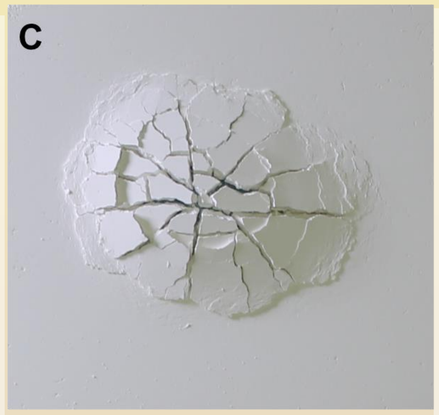


(A) 1° inflation:

- ✓ Concentric thrust faults
- ✓ Radial faults irradiating from the center

(B) 1° deflation

- ✓ Formation of the ring fault
- ✓ Thrusts are reactivated as normal faults
- ✓ Concentric faults



(C) 2° inflation:

- ✓ Development of further radial and concentric faults (their intersection forms the polygonal blocks)
- ✓ The top is already collapsed, with a minor inflation

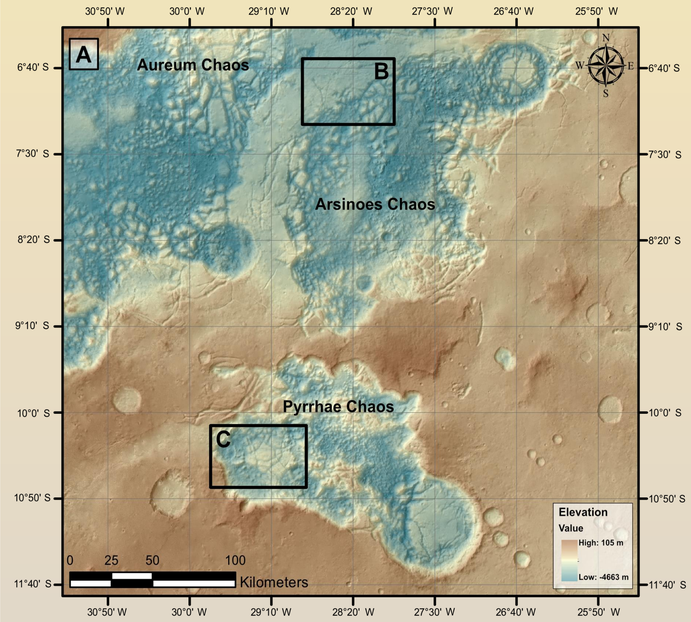
(D) 2° deflation:

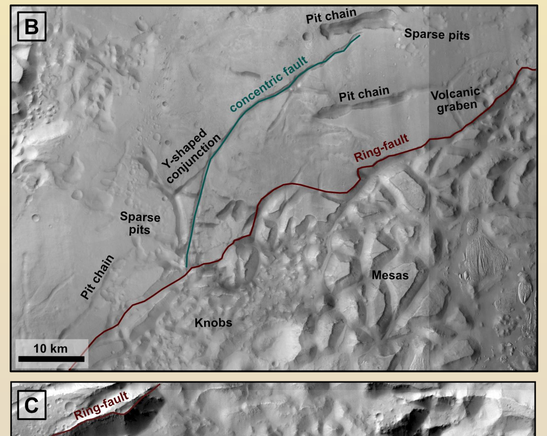
- ✓ The caldera floor is collapsed broken into polygonal blocks.
- ✓ The subsidence of the ring fault increased within the 2° cycle.

Fig. 1: the two cycles of inflation and deflation are described from A to D.

Comparison with chaotic terrains on Mars

The resulting structures formed on the analogue brittle crust resemble strongly the faults disrupting the basaltic bedrock of chaotic terrains on Mars. The analogue magma chamber of the experiment was set based on the characteristics of Arsinoes Chaos (Fig. 2), but most of the features are recurrent also in the other chaotic terrains.
Our experiment demonstrated that this process alone can explain already the enigmatic characteristics of chaotic terrains. Other factors (e.g. criosphere melting, groundwater overpressure) might have contributed causing further distruption and a more complex geological setting.





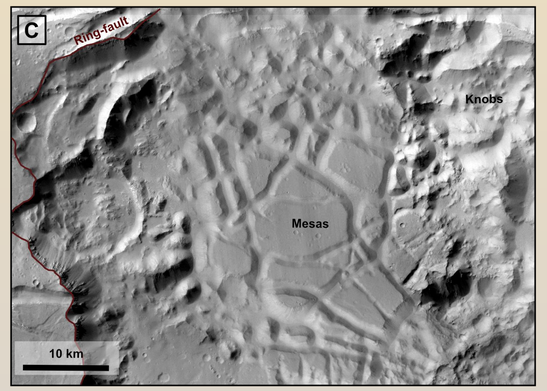


Fig. 2: The structures occurring within chaotic terrains (and particularly our case of study Arsinoes - Pyrrhae Chaos) fit very well with our experiment: a depressed basin bordered by a ring fault, polygonal blocks formed by the intersection of radial and concentric faults, and a caldera floor that is disrupted following the polygonal pattern.
A) Blended MOLA-HRSC DEM; B) and C) CTX mosaic by (Dickson et al., 2018)

References
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