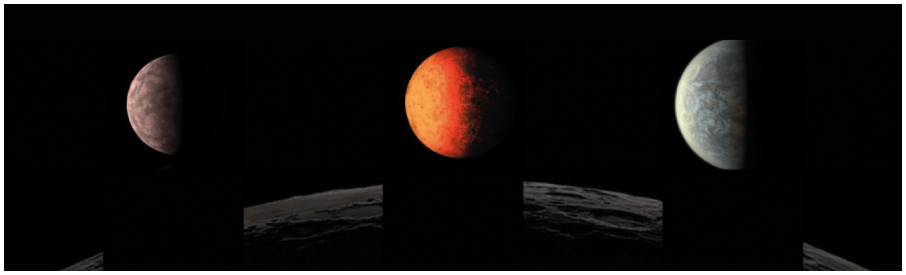

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The DAGGER project: Modelling magma propagation on Earth versus Mars

Friday 24 October 2025 18:00 (1 hour)

On Earth, intrusions of dykes in the shallow crust can induce graben formation. Graben and fracture features are also seen in the Tharsis volcanic province on Mars and are proposed to form through similar mechanisms. 'Marsquake'clusters were detected below Cerberus Fossae, one such graben and fracture system, by the InSight mission seismometer between 2019 and 2022. To generate these marsquakes, two plausible scenarios include: (1) the emplacement of a magma dyke segment, or (2) relaxation of the host rock around previously intruded dyke segments that contract when cooling. However, as on Earth, the subsurface magma processes cannot be directly observed. Most analytical and numerical models simplify magma-induced deformation to linearly elastic and assume a fully intact host rock. This does not account for inelastic deformation processes or the reduced bulk crustal rock strength linked to heavily fractured crust, which is particularly pertinent to Mars.

The DAGGER project will pioneer a two-dimensional (2D) numerical model using the Discrete Element Method (DEM) to simulate a dyke intrusion in shallow planetary crust, assessing the inelastic deformation including fracturing, and also test a three-dimensional (3D) approach. Field campaigns to eastern Iceland are used to collect drone imagery for photogrammetry and geological measurements, scanline data on fractures around intrusions in different host rocks, and host rock samples to determine bulk rock strength in the laboratory that will serve to calibrate the numerical models. The model will first be applied to simulate conditions analogue to Earth, then to Mars, allowing testing of different magma-induced marsquake mechanisms. Furthermore, our approach will improve the upscaling of intact rock sample strengths to crustal scale bulk rock strengths, and contribute to more robust modelling and interpretation of volcanic plumbing systems and their ground deformation on rocky planetary bodies.

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