



An experimental study of the volcano-sagging to volcano-spreading transition

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Volcanoes on Earth and other planets undergo gravitational deformation on a variety of timescales. Two end-member modes of gravity-driven deformation are volcano sagging (or volcano flexure) and volcano spreading. It has been long known that the mechanical and geometric properties of the basement rocks below the volcano strongly influence such gravitational deformation modes. One key mechanical property is the presence of a zone or layer that is sufficiently widespread and that has an effective viscosity low enough to produce ductile behavior in response to the load of the overlying volcanic edifice. Key geometric properties include the ratios between (1) volcano height and ductile basement thickness and (2) volcano height and brittle basement thickness. Despite such longstanding knowledge, a thorough parametric exploration of these properties has hitherto not been carried out experimentally. Consequently, the circumstances under which one gravitational deformation mode transitions to the other (i.e. the recently proposed spreading-sagging continuum) is imprecisely defined. To address this issue, we conducted a series of scaled analogue experiments involving a sand-plaster cone overlying a simple basement structure that comprises a single sand-plaster (brittle) layer and a single silicone (ductile) layer. By systematically varying the above-mentioned geometric ratios, we comprehensively define the transition from volcano-spreading through to volcano-sagging for a simple conically-loaded two-layer basement system. These results form a more robust experimental basis for distinguishing and interpreting the structural and morphological features of volcanoes subject to combined gravitational deformation processes, as observed in the field or in remote sensing data.