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

Sam Poppe[1], Eoghan Holohan[2], Matthieu Kervyn[1], Audray Delcamp[1], Paul Byrne[3], Ben van Wyk de Vries[4]

[1]Vrije Universiteit Brussel, Belgium, [2]GFZ Potsdam, Germany, [3]Carnegie Institut Washington, USA, [4]Laboratoire Magmas et Volcans, France

E-mail: delcampa@tcd.ie

Volcanoes on Earth and other planets undergo gravitational deformation on a variety of timescales. Two end-member modes of gravity-driven deformation are volcanic sagging (or volcani flexure) and volcano spreading. It is widely known and accepted that the mechanical and geometric properties of the basement rocks below the volcano strongly influence such gravitational deformation modes. One key parameter allowing deformation is the presence of a zone or a 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 controlling deformation behavior 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 aboce-mentionned geometric ratios, we comprehensively define the transition from volcano-spreading to volcano-sagging for a simple conically-loaded two-layer basement system. 3D displacement veolocities of the model surface are documented and allow to track and quantify the deformation. These results form a robust experimental base 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.