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Flank instability and internal deformation on volcanic islands: An experimental study of the coupling between gravitational spreading and rift-zone intrusion

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Volcanic islands are often structurally unstable and subject to various forms of deformation and mass wasting. Although the character of flank deformation and flank instability is similar on many islands, details of the structural expression, the fault geometry and size of landslides significantly differ. Flank instability is thought to be related to two principal mechanisms, which are gravitational spreading and forceful dike intrusions into a rift-zone. In this paper we experimentally investigate structures typical for volcanic spreading and rift-zone intrusion, in order to better understand the interplay of these two mechanisms. In a sand-box we reproduce unstable and deforming volcanic edifices and herein systematically study structures developing during (i) pure spreading, (ii) pure rift-zone intrusion, and (iii) spreading combined with rift-zone intrusion. We recorded the experiments with a digital camera and measured deformation by applying a pixel correlation technique. This enables us to obtain high resolution spatial data coverage, locate faults and measure their submillimeter displacements. The end-member models show that typical spreading structures are listric normal faults, whereas typical rift-zone intrusion structures are a graben above the intrusion plus a sub-horizontal detachment depending of the intrusion depth. However, coupling the spreading and rift-zone intrusion mechanisms leads to an interaction of the developed faults; some are hindered while others are further encouraged. While the end-members encourage wedge internal faulting, their combination discourages this type of faulting and hence may even stabilize volcanic flanks. We apply this understanding to Hawaii and Reunion in an attempt to better identify the main mechanism of flank instability, flank faulting and sector collapses.