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Morpho-structural criteria for the identification of volcano deformation processes from analogue modeling

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The morphology of volcanoes provides important information about edifice evolution. Volcanoes can deform by gravitational instability and intrusions. This deformation can compromise volcano structural stability, promoting flank collapse even at dormant edifices. Identification of past/active deformation processes is therefore important not only for the understanding of volcano evolution but also for volcanic hazards. Both deformation due to the flank spreading of a volcano over its weak core and due to the intrusion of a cryptodome in the volcano edifice can produce faulting and changes in the morphology of volcano flanks. These morpho-structural changes in the volcano open the possibility to identify potential deformed and unstable volcanoes using remote sensing techniques and DEMs. We have used analogue models of flank spreading and intrusion processes to make progress in the morpho-structural identification of deformation features which can provide criteria for distinguishing processes. We have geometrically and mechanically scaled two different sets of experiments using a sand-plaster mixture for volcano materials, silicone putty for weak core rocks and Golden Syrup for magma intrusions. For monitoring changes in the volcano morphology we have used a Kinect sensor (Microsoft), which provides us vertical displacements of volcano flanks several times per second with a 1 mm precision. We have synchronized the Kinect sensor with a digital camera for monitoring the spatio-temporal evolution of tectonic structures together with morphology. All experiments produce asymmetrical changes in volcano morphology, developing convex-concave geometries in the deformed flank. However, the spatial relationships of structures with changes in volcano flank curvature are different for the two processes, as noted by previous authors. The morphometric tools developed for analyzing volcano topography allow us to identify intrusion processes due to volcano volume increase. We have compared the results of our experiments with known examples of deformed volcanoes due to intrusions (eg., St Helens) and flank spreading (eg. Casita) and we confirmed that the criteria developed from modeling works well in the natural cases. We consider that further experiments are necessary to fully explore the capacity of application of morphometric tools to analogue modeling of volcano deformation processes, since our first results show a promising research avenue for the remote identification and evaluation of volcano deformation processes in remote volcanoes worldwide.