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Experimental modelling of ground deformation associated with shallow magma intrusions

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Active volcanoes experience ground deformation as a response to the dynamics of underground magmatic systems. The analysis of ground deformation patterns may provide important constraints on the dynamics and shape of the underlying volcanic plumbing systems. Nevertheless, these analyses usually take into account simplistic shapes (sphere, dykes, sills) and the results cannot be verified as the modelled systems are buried. In this contribution, I will present new results from experimental models of magma intrusion, in which both the evolution of ground deformation during intrusion and the shape of the underlying intrusion are monitored in 3D. The models consisted of a molten vegetable oil, simulating low viscosity magma, injected into cohesive fine-grained silica flour, simulating the brittle upper crust; oil injection resulted is sheet intrusions (dykes, sills and cone sheets). The initial topography in the models was flat. While the oil was intruding, the surface of the models slightly lifted up to form a smooth relief, which was mapped through time. After an initial symmetrical development, the uplifted area developed asymmetrically; at the end of the experiments, the oil always erupted at the steepest edge of the uplifted area. After the experiment, the oil solidified, the intrusion was excavated and the shape of its top surface mapped. The comparison between the uplifted zone and the underlying intrusions showed that (1) the complex shapes of the uplifted areas reflected the complex shapes of the underlying intrusions, (2) the time evolution of the uplifted zone was correlated with the evolution of the underlying intrusion, and (3) the early asymmetrical evolution of the uplifted areas can be used to predict the location of the eruption of the oil. The experimental results also suggest that complex intrusion shapes (inclined sheet, cone sheet, complex sill) may have to be considered more systematically in analyses of ground deformation patterns on volcanoes.