Caldera ring-faulting during the 2015 Ambrym dike intrusion and the search for the missing deflation source

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During dike intrusions, co-eruptive surface displacements have shown discrepancies between the magma volume evacuating a volcano's reservoir and the magma volume injected into the dike. In some cases, the intruded volume can be up to 5 times greater than that of the reservoir volume loss. Such differences are explained by shape effects of a stiff ellipsoidal reservoir compared to a compliant crack, in combination with magma compressibility. As a result, co-eruptive surface displacements do not always provide unambiguous insights into the volcano's plumbing system, leaving lingering questions regarding the reservoir's depth, geometry and size.

On February 21st, 2015 at Ambrym volcano (Vanuatu), a dike intrusion produced up to 2 meters of line-of-sight shortening (co-eruptive uplift), as measured by InSAR, SAR correlation, and Multiple Aperture Interferometry (MAI). Using a 3-D Mixed Boundary Element (BE) forward model, combined with a Monte Carlo neighbourhood inversion algorithm, we solve for the dike overpressure and geometry that produces the best-fitting surface deformation. However, this pressure source alone cannot explain a portion of the co-eruptive uplift. The residual deformation is instead modelled by caldera ring-faulting. Using the BE forward model, the stress change imposed by the opening dike on a passive, frictionless fracture (fault) is explored. We find that the dike opening clamps the fault, resulting in reverse slip, as opposed to observed normal faulting. Including a deflating pressure source beneath Ambrym's caldera allows for producing up to 30 cm of normal fault slip at the surface. At Ambrym, the existence of a deflating reservoir and coeval ring-faulting was confirmed with InSAR measurements during a large-scale rift zone intrusion in 2018.

The 2015 co-eruptive surface displacements at Ambrym can be modelled by a dike and a normal fault, but the missing deflation source is only identified once taking into account the mechanical interactions between the pressure sources and the caldera ring fault. In volcanic systems, especially those with an interplay between dike migration, reservoir deflation, and ring-faulting, the stress change induced by multiple sources should be considered in order to improve conceptual models of the volcano's plumbing system.

Keywords: Volcanology, spatial geodesy