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Can high rates of passive volcanic gas emissions induce reservoir depressurization at Ambrym volcano (Vanuatu)?

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Satellite-based UV spectrometers can constrain sulphur dioxide (SO_2) fluxes at passively degassing volcanoes over decadal time scales. From 2005 to 2015, more than 15 volcanoes had mean passive SO_2 fluxes greater than 1 kiloton per day. Although the processes responsible for such high emission rates are not clearly established, this study aims to investigate the impact of strong degassing on the pressurization state of volcanic systems and the resulting ground deformation. One possible result of high degassing rates is the depressurization of the region where the melt releasing gas is stored, which may result in subsidence at the Earth's surface. Passive degassing may depressurize pathways between deep and shallow magma storage regions, resulting in magma ascent and possibly eruption.

A lumped-parameter model developed by Girona et al., 2014 couples the mass loss by passive degassing with reservoir depressurization in an open volcanic system. However, this model has yet to be tested using real measurements of gas emissions and ground deformation. In our study, we focus on Ambrym volcano, the past decade's top passive emitter of volcanic SO_2, which exhibits intriguing long-term subsidence patterns and no obvious pressurization preceding eruptive periods. We compare subsidence rates measured by InSAR to the system's average daily SO_2 flux, focusing on a subsidence episode spanning 2015 to 2017 that is not clearly linked to magma removal from the system. Using realistic input parameters for Ambrym's system constrained by petrology and gas geochemistry, a range of reservoir volumes and conduit radii are explored. Large reservoir volumes (greater than 30 km^3) and large conduit radii (greater than 300 m) are consistent with depressurization rates obtained from geodetic modelling of InSAR measurements using the Boundary Element method. By comparing these values of reservoir volume and conduit radius with those estimated from geodesy, gas geochemistry, and seismology, we test the applicability and discuss uncertainties of the aforementioned lumped-parameter physical model to interpret the long-term subsidence at Ambrym volcano as a result of sustained passive degassing.