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Rift-zone dyke injection triggered by transient flank slip events: evidence from volcano-tectonic seismicity

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Rift-zone dyke injection at basaltic volcanoes is often preceded by weeks to years of accelerating rates of volcano-tectonic (VT) earthquakes located in the edifice surrounding the shallow magma storage system. The spatiotemporal patterns of earthquakes associated with these events are consistent with an active dyke injection mechanism, where the approach is controlled by the material failure of the edifice driven by over-pressured magma. However, at Kilauea volcano, Hawaii, between 1959 and 1983, many dyke injection events are not preceded by such accelerations. Instead, the onset of these passive dyke injections is frequently accompanied by transient increases in the rate of small (M2-4) VT earthquakes located within the mobile flank of the volcano. Flank earthquake hypocenters may be separated from the location of the dyke or other known magma reservoirs by tens of kilometers. Importantly, the patterns of these flank VT earthquake swarms closely match those observed to accompany recent episodes of transient aseismic flank slip at Kilauea, identified in continuous GPS measurements and referred to as “silent” or “slow” earthquakes. Similar patterns are observed in the seismicity accompanying dyke injection at Mt Etna, Sicily. As a consequence, we argue that the stress changes resulting from transient flank slip are a plausible trigger for both dyke injection and the flank VT earthquake swarms associated with passive events. These findings highlight the interaction between the magmatic system and flank instability at basaltic volcanoes, and consequently the importance for understanding the processes involved in flank deformation for improving eruption forecasts.