How to Forecast the Fate of Vertically Propagating Dike from Geodetic Data

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Dike propagation is ubiquitous in volcanoes, especially those with mafic magma. Vertically propagating dike leads to a fissure eruption if it reaches the surface. However, it does not always reach the surface but is arrested on the way to the surface. This study investigates how to forecast whether a propagating dike reaches the surface or is arrested from geodetic data which records surface deformation due to the dike propagation.

A vertically propagating dike is arrested mainly for three reasons: 1) solidification of magma, 2) lack of buoyancy to drive magma upward, and 3) insufficient intrusion volume. We discuss how the dike propagation associated with the 1997 and 1998 seismic swarm off the Izu Penisula, Japan, and the 2015 failed eruption of Sakurajima volcano, Japan, arrested by incorporating geodetic data and insights gained from analogue experiments and theoretical considerations.

Our investigation indicates that the dikes intrusions associated with the 1997 and 1998 seismic swarm off the Izu Peninsula are arrested by magma solidification, lack of buoyancy, or both. On the other hand, the 2015 dike intrusion in Sakurajima volcano is likely caused by the lack of buoyancy, insufficient intrusion volume, or both.

Geodetic data well constrain the volume of the intruded magma but does not constrain the shape of the dike very well. In other words, some of the parameters required to forecast the fate of the intruded dike are not well constrained solely from geodetic data. Therefore, it is crucial to employ not only geodetic data but also other data, such as earthquake locations, to better understand the state of the dike and forecast whether the intruded dike results in an eruption.

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