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Numerical Modeling of Magma Transport In Distributed Volcanic Fields: A Case Study of the Springerville Volcanic Field, Arizona, USA

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Numerical modeling is an efficient way to understand the interaction between magmatic systems and surrounding structures on a variety of scales. Here we use a finite difference model to simulate long term average magma migration leading to the development of distributed volcanic fields. According to the ergodic hypothesis, the viscous flow of a fluid in a porous media (Darcy's Law) is statistically equivalent to full field scale magma migration averaged over geological time through the crust. The location and flux from the magma source region are boundary conditions of the model. Changes in the model permeability, associated with changes in the bulk properties of the lithosphere, can simulate preferential magma migration paths and alter the estimated magma flux at the surface. The simulated surface flux can be validated using the observed spatial intensity map of the volcanic field computed using vent location data. Our results show that for several volcanic fields in the western U.S. the modeled permeability necessary to reproduce the observed vent distribution is not uniform. Changes in model permeability correlate with crustal structure, which is determined from long-wavelength gravity anomalies, geologic models, and related tectonic data. We suggest that in some distributed volcanic fields large-scale crustal structures, such as inherited tectonic block boundaries, influence magma ascent and the pattern of volcanic eruptions. Probabilistic models of volcanic hazard for distributed volcanic fields can be improved by identifying crustal structures and assessing their impact on volcano distribution with the use of numerical models.