

Topographic and Structural Effects on Dike Propagation and Eruption

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Abstract

We have modelled magma flow in a dike rising in a crack whose strike runs from a highland or ridge to an adjacent lowland to determine the effect of topography on the flow, using a 3D hydromechanical code, FLAC3D (<http://www.itascacg.com>). The aperture, a , is calculated as a variable in a sheet of zones of fixed width d during the simulation as a function of model deformation. The permeability tensor of each zone is adjusted at each time step in response to the pressure in the cell according to the relationship

$$k_{ij} = \delta_{ij} \frac{a^3}{12\mu d}, \quad (1)$$

which is obtained by equating the flow through the layer of permeable zones from Darcy's law with Poiseuille's law under the same gradient. The fluid viscosity is μ , and the crack width is a . We found a distinct tendency for the flow to be diverted away from the highland end of the strike toward the lowland. For the 4-km long strike length we modelled, eruption was offset between 500 and 1250 m toward the lowland from the center of the strike length. Separation of the geometric effect of the topography from the topographic overburden effect on lateral confining stresses at the crack indicates that both contribute to the effect. Although this analysis explains a tendency for volcanic eruptions to occur in low lands, it does not preclude eruptions on highlands. If the strike on the dike is parallel to the length of a ridge, the effect described here will not operate. Another possibility is that the strike length of a dike may be so short that its strike does not extend far beyond the edge of the ridge. A separate simulation used a 2D discrete element code, UDEC (<http://www.itascacg.com>) to investigate the interaction of magma in a vertical dike with normal faults and stratigraphy. We found that steeper faults are more easily intruded and that, as the magma rises to within a few hundred meters of the surface, sills are intruded into stratigraphic discontinuities in the hanging wall but not into the foot wall. The particular configurations modelled mimic topography and structure around the proposed nuclear waste repository at Yucca Mountain, Nevada, USA, so that the results relate to the volcanic hazard at the site. Field observations at nearby Paiute Ridge indicate behavior of Tertiary basalts intruding rhyolite tuffs similar to that in our UDEC models.

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