Field observations and numerical models of a Pleistocene-Holocene feeder dyke swarm associated with a fissure complex to the east of the Tatara-San Pedro-Pellado complex, Southern Volcanic Zone, Chile

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Abstract

Magma is transported through the lithosphere as dykes which, during periods of unrest, may feed eruptions at the surface. The propagation path of dykes is influenced by the crustal stress field and can be disturbed by crustal heterogeneities such as contrasting rock units or faults. Moreover, as dykes propagate, they themselves influence the surrounding stress field through processes of stress transfer, crustal deformation and seismic failure. The result is the formation of arrested dykes, as well as contrasting strike and dip angles and dyke segmentation. Here, we study the mechanisms of dyke injection and the role played in modifying the stress field and potential propagation paths of later dyke injections. To do this we combine field data from an eroded and well-exposed shallow feeder dyke swarm with a suite of two-dimensional FEM numerical models. We mapped 35 dyke segments over a similar to 1 km long dyke swarm exposed similar to 5 km to the East of Pellado Volcano, in the Tatara-San Pedro-Pellado (TSPP) volcanic complex, Southern Volcanic Zone of the Andes. Detailed mapping of the swarm elucidates two preferential strike orientations, one similar to N80 degrees E and the other similar to N60 degrees E. Our numerical models simulate both the TSPP volcanic complex and the studied dyke swarm as zones of either magmatic excess pressure or as a rigid inclusion. The crustal segment hosting the volcanic complex and dykes is modelled using an elastic domain subjected to regional compression in select model cases. Model outputs provide the stress and strain fields resulting from the different geometries and applied boundary loads. The model results indicate that individual dyke injections can locally rotate the principal stresses such as to influence the range of orientations over which later dykes will form. The orientation of sigma(1) at the dyke tip ranges over 60 degrees (+/- 30 degrees either side of the dyke tip) indicating that the strike orientation of later dykes will fall within this range. The effect of adding a bulk regional compression is to locally increase the magnitude of favorably oriented tensile stresses in the bedrock but to reduce the range of sigma(1) orientations to 40 degrees (+/-

20 degrees). This implies that under a far-field transpressive stress regime, as is common in Andean settings, regional dyke swarms will tend to maintain their strike orientation parallel to the regional bulk stress. These results should be accounted for when studying periods of volcanic unrest in order to discern the location and orientation of potential fissure eruptions in active volcanic areas such as the Southern Volcanic Zone of the Andes.

Palabras clave

Palabras clave de autor: Dyke propagation paths; Southern Volcanic Zone; Numerical modelling; Fissure eruptions; Arc volcanism; Transpressional convergence

KeyWords Plus:MIXED BINGHAM DISTRIBUTION; STRIKE-SLIP-FAULT; DIKE PROPAGATION; MAGMA-CHAMBER; CENTRAL ANDES; EVOLUTION; EMPLACEMENT; TECTONICS; PALEOSTRESS; SEISMICITY

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