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Crustal folds alter local stress fields as demonstrated by magma sheet – fold interactions in the Central Andes

Matías Clunes[1], John Browning[1,2,3], José Cembrano[1,2], Carlos Marquardt[3], and Agust Gudmundsson[4]

[1]Department of Structural and Geotechnical Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile (mclunes@uc.cl)

[2]Andean Geothermal Centre of Excellence (CEGA), Universidad de Chile, Santiago, Chile

[3]Department of Mining Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile

[4]Royal Holloway University of London, Department of Earth Sciences, Egham TW20 0EX, United Kingdom

For magma chambers to form or volcanic eruptions to occur magma must propagate through the crust as dikes, inclined sheets and sills. The vast majority of models that investigate magma paths assume the crust to be either homogeneous or horizontally layered, often composed of rocks of contrasting mechanical properties. In subduction regions that have experienced orogenesis, like the Andes, the crust has been deformed over several million years, resulting in rock layers that are commonly folded and steeply dipping. The assumption of homogeneous properties or horizontal layering then does not capture all of the potential magma path crustal interactions. Here we tackle this problem by determining the effect of a crust made of steeply inclined layers in which sills and inclined sheets are emplaced. We combine field observations from a sill emplaced in the core of an anticlinal fold at El Juncal in the Chilean Central Andes, such as lithologies, sill and fold limbs attitude, sill length and layers and sill thickness, with a suite of finite element method models to explore the mechanical interactions between inclined layers and magma paths. Our results demonstrate that the properties of the host rock layers as well as the contacts between the layers and the crustal geometry all play an important role on magma propagation and emplacement at shallow levels. Sill propagation and emplacement through heterogeneous and anisotropic crustal segments changes the crustal stress field promoting sill arrest, deflection or propagation. Specifically, sills are more likely to be deflected when encountering shallow dipping layers rather than steeply dipping layers of a fold. Mechanically weak contacts encourage sill deflection due to the related rotation of the maximum principal compressive stress and this effect is attenuated when the fold layers are more steeply dipping. This processes may change the amount and style of surface deformation recorded, with significant implications for monitoring of active volcanoes.