Active diapiric ascent of silicic magma beneath the Bolivian Altiplano

Rodrigo del Potro[1], Mikel Diez[1], Cyril Muller[1], Jon Blundy[1], Antonio Camacho[2], Joachim Gottsmann[1]

[1]University of Bristol, United Kingdom, [2]Instituto de Geociencias (CSIC-UCM), Spain

E-mail: r.delpotro@bristol.ac.uk

Transport of large volumes of silicic magma drives the evolution of the Earth's continental crust and the dynamics of the largest magnitude volcanic eruptions on the planet. In partially molten source regions within the continental crust, melt segregates, accumulates and initiates its ascent to shallower crustal levels where it emplaces as plutons. However, the structural connection between a distributed configuration of melt-filled pores in the source and these plutons is still a highly debated open problem. The two end-members embodying this connection are dykes and diapiric structures. In recent years dyking has been favoured over diapirism, with the latter being essentially disregarded as a viable mechanism for magma ascent. Herein we show, for the first time, geophysical evidence constrained by petrological and geological observations, and consistent with mechanical considerations, of the on-going diapiric ascent of granitic magma through the hot, continental, mid-upper crust of the Central Andes.

The thickened continental crust of the Central Andes hosts the Altiplano-Puna Magma Body (APMB), the largest known active continental mid-crustal zone of partial melt. Directly above it, the Altiplano-Puna Volcanic Complex (APVC) is the largest Neogene ignimbrite province with a total erupted volume of >12000 km3, generated mostly in episodic, supervolcanic eruptions during a flare-up event. Current signs of unrest are evidenced by a long wavelength, monotonic ground uplift and a peripheral subsidence centred on Uturuncu volcano, which was initially detected by InSAR. We have expanded the time of observation by re-measuring existing geodetic levelling lines, and show that the rate of deformation has been fairly constant for at least 45 years. The depth of the source of deformation coincides with the top of the APMB, which makes the APMB-APVC system an ideal setting to study the ascent and emplacement of silicic magma in an active environment. Our primary data set is a new high-resolution Bouguer Anomaly over the APMB. Inversion of these data using petrological and geological constraints provides evidence for the presence of vertically elongated, partially molten granitic bodies massively rooted at the top of the APMB. The geometry of the anomalies precludes the presence of dykes, in favour of massive structures. We argue that our observations, together with the ground deformation pattern, the shallow brittle-ductile transition zone, high heat-flux and perturbed geotherm suggest that high power input and locally favourable tectonics in the APMB-APVC provide an adequate setting for the current diapiric ascent of silicic magmas in the mid-upper crust. We explore this hypothesis using a thermo-mechanical model of a gravitationally unstable dacitic sill overlain by felsic crust, with the perturbed geotherm of the APMB-APVC system. Our results show diapirs that rise 10 km from the source, and account for the gravity and ground deformation observations.