Thermal modelling of magma fluxes and the petrological evolution of magmatic systems

GREGOR WEBER, GUY SIMPSON, LUCA CARICCHI

Department of Earth Sciences, University of Geneva, Rue des Maraîchers 13, 1205 Geneva (gregor.weber@ungie.ch)

Chemical variations in genetically related rock suits hold clues to the architecture, dynamics and temporal evolution of magmatic plumbing systems that ultimately feed volcanic eruptions. Magma fluxes in the Earth's crust are anticipated to modulate the rock chemistry record, as pulsed injections of fresh magma impact the construction, thermo-chemical evolution and pressurization of subvolcanic reservoirs. The resulting compositional diversity and temporal trends in the abundance of magmatic rocks reflects the interplay between thermal evolution of magmatic systems and differentiation processes. In this respect, it is interesting that while some systems sample magmas covering a wide spectrum of geochemical compositions, other volcanoes produce magmas with rather monotonous chemistry through time. Such different behavior could reflect different stages of thermal maturation, differences in magmatic processes or a combination of both.

We use thermal modelling coupled with published experimental phase equilibria to explore the influence of magma fluxes on the chemical diversity of erupted magmas. Magma intrusion with different injections rates (0.01 to 0.1 km^3/yr) is modelled at various crustal depth (1 GPa to 0.2 GPa) for which experimental phase-equilibria are available. We compute the temporal evolution of the chemistry of eruptible magma (sum of magma with <50 vol.% crystals and all the interstitial melt) to quantify the probability that an eruption samples magma with a given composition during the lifespan of the magmatic system. The calculations show that specific injection rates at a given depth result in characteristic sets of eruptible magma chemistry in space and time. Interestingly, reservoirs fed by low average magma flux become more mafic with time, while high rate of magma input leads to more evolved chemistries with time. We compare the modelling results with the geochemical record of different magmatic systems in arc settings. Our results provide insights into the link between chemistry of erupted magma and the long-term thermal evolution of magma reservoirs.