Geophysical Research Abstracts
Vol. 20, EGU2018-9035, 2018
EGU General Assembly 2018

Analogue experiments for modeling the storage of silicic magmas in the continental crust

Alexandra Morand, Steve Tait, and Geneviève Brandeis
Institut de Physique du Globe de Paris, Geological Fluids Dynamics, France (moranda@ipgp.fr)

When part of the continental crust melts or a more mafic magma is differentiated, magma with high silica content is produced, which is positively buoyant in the continental crust. Hence, it rises through the crust with two main outcomes: granitic pluton formation or a potentially large and violent eruption. In extreme cases, silicic magmas generate so called super eruptions, and in so-doing form vast calderas. Petrological evidence typically indicates pre-eruptive magma storage at shallow depths ($\leq$ 10 km). The physical mechanisms by which silicic magma stops rising and makes space for itself in the continental crust are not yet well-known, although several hypotheses have been proposed, such as the attainment of a neutral buoyancy level or the existence of a rigidity contrast in the host rocks.

When continental crust undergoes melting its lower part is anomalously hot and so it behaves ductilely. When the light silicic magma rises through the crust it must encounter the barrier represented by the rheology contrast at the ductile-brittle transition. We hypothesize that storage of magma occurs at this transition (the elastic plate resisting the upward progress of the magma), which is expected to be at shallow depths when the crust is very hot as is suggested by different authors in the case of the Uturuncu volcano in Bolivia, the Yellowstone volcano in the USA and the Campi Flegrei volcano in Italy. These examples also show pre-eruptive storage depths which are similar to the brittle-ductile transition depth. We study a physical model in which buoyant magma accumulates beneath an elastic plate and deforms it due to buoyancy forces.

Numerical codes have been developed to compute plate deformations, and laboratory experiments carried out to compare with numerical results. In a square tank of area 1 m^2 and 0,35 m height, a layer of aqueous sugar solution (representing the ductile part of the crust with liquid rheology) is overlain by an elastic plate of gelatin (representing the brittle upper crust). At the bottom of the tank a colored liquid is injected by small injections, which has positive buoyancy in the sugar solution, and for most experiments, is also less dense than the gelatin plate. For each injection the thickness of the liquid accumulation beneath the elastic plate is deduced using a colorimetric technique, while the deformation of the gelatin plate is deduced using a Moiré method. These two measurements are compared with and used to constrain numerical results. The prediction of the calculations is confirmed experimentally and is also applied to the deformation pattern observed at Uturuncu volcano by satellite geodesy.