Subject offered for a contract starting october 2016

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Financing: Doctoral contract with or without teaching assignment

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Formation and Instability of Silicic Magma Reservoirs in the Continental Crust

We propose to study the physical processes by which silicic magmas accumulate in the upper crust to form magma reservoirs that can either remain there to form granitic intrusions or become unstable and erupt. Many silicic magmas are often interpreted on petrologic and geochemical grounds to be formed by partial melting of the continental crust. It is also commonly observed that silicic magmas are erupted from reservoirs that are situated in the shallow crust – from depths on the order of 10km. or less, whereas the most likely site of partial melting based on physical modelling is the lower crust. The goal of this project is to understand the processes involved in the transport of magma from the lower to the upper crust and, more particularly what causes silicic magma to accumulate at a particular depth in the upper crust, in other words what physical processes underly the formation of shallow crustal magma chambers. Correct modelling of these processes should lead to understanding of what determines the shape of these reservoirs, how shape may or may not vary as a function of magma volume, and over what time scale does magma accumulation and storage take place. The very large silicic eruptions that are known to have occurred in the geologic past indicate that volumes on the order o 1000 km^3 can be involved. Because the density of silicic magmas is less than that of the surrounding lower crust, and because their viscosity is high, such magmas are likely to be transported from the lower to the upper crust as diapirs of partially molten rock. One goal of the thesis will be to study what may happen when rising silicic magma encounters the upper crust which is rheologically stiffer. To a first approximation, the lower crust – upper crust boundary may be treated as a ductile-fragile transition that occurs over some vertical thickness. The magma will tend to spread horizontally, but also to deform the rheologic boundary because of its buoyancy. The latter effect will eventually inhibit spreading and cause magma to pond at the boundary. Once this static ponding condition is reached, if supply continues, the accumulation of more magma will enhance the deformation. Eventually buoyancy may be sufficient to fracture the overlying crust and trigger eruption. During large volcanic eruptions, a caldera structure often forms during emptying of the magma reservoir. A second goal of this project is to study how the instability of magma reservoirs during eruption can lead to the formation of a caldera. The objective is to study the deformation of the upper crust due to magma accumulation and its storage and/or eruption by devising laboratory experiments with materials chosen to represent the different geologic units. We will study the processes of magma accumulation and the generation of magma chamber shapes by deformation of the surrounding crust and attempt to determine conditions under which fracturing of the fragile layer and hence eruption may be expected to occur. We will analyse the results of the laboratory experiments in terms of the physics of the system to understand the relevant scales in order to apply the results of the laboratory experiments to natural magmatic / volcanic systems. We hope to contribute important results relevant to large volcanic eruptions and a physical framework that can be used to understand the petrologic and structural observations on silicic magma systems in the continental crust. The work will be carried out in the Geological Fluid Dynamics research group at IPG Paris which has a long experience of physical modelling of this type.