Subject offered for a contract starting october 2019

SUBJECT TITTLE: The key role of two-phase flows (bubbles within viscous magma) in driving eruptions: Insights from 1) analysis of joined measurements of infrasound, seismicity and SO2 flux at Stromboli (Italy) and Soufrière of Guadeloupe and 2) study of bubble clusters with using fluid mechanics laboratory experiments.

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IPGP- Dynamique des Fluides Geologiques

Financing: Doctoral contract with or without assignment

For more information go to http://ed560.ipgp.fr, section: Offres de these (PhD offer), You must apply on the Doctoral School website

Presentation of the subject: (1 or 2 pages)

The crucial role of the gas, in driving volcanic eruptions at depth and at surface, is now widely recognised. The viscous magma is displaced by the nearby bubbles (diameter from microns to several meters) in various ways (2-phase flows), depending on the type of volcanic activity, i.e. explosive, effusive or persistent at open-vents volcanoes.

Firstly, open-vents volcanoes, often presenting series of Strombolian explosions of various intensities, i.e. a quasi-regular series of large quasi-cylindrical bubbles breaking at the surface, are responding, although with a delay, to any changes in the degassing pattern within a shallow magma reservoir. Hence, they are providing a quasi-direct route to phenomena occuring at depth, where eruptions are initiated. Open-vents volcanoes display a persistent volcanic activity, although of variable intensity. The question, that we which to address in this phD is how and why periods of enhanced activity, often dangerous, are produced. Long-times series at open-vents volcanoes, such as at Stromboli (Italy), could therefore be key measurements to unravel physical processes at the origin of eruptions and be crucial for monitoring. Continuous infrasonic records (sound waves <20 Hz) will be used to estimate the gas volume expelled at the vent, both during explosions and between explosions, but also at depth, providing the use of an appropriate model of 2-phase flows patterns in conduit and reservoir. Seismic records, when available, can be used to separate the depth of origin of

Taylor bubbles, hence their process of formation, where SO2 flux, when available can give information on the passive degassing.

Additional key informations can be obtained from performing laboratory experiments in fluid mechanics, in which the key physical features of some eruptive patterns can be reproduced and modelled. One aspect to better understand the eruptive behaviour of volcanoes, is to reproduce in the analog volcano the formation of bubble clusters in the conduit and constrain how and why they may coalesce, i.e. forming a single large gas pocket, during rise.

The first aspect of this phD will consist in analysing the long-time series of infrasonic and seismic signals recorded close to Stromboli volcano (Italy), using our existing automatic codes, written in Matlab. These records will be interpreted to understand the temporal evolution of the eruptive activity (gas volume and strength of explosions) and the changes in degassing patterns. These data will be combined with other available records, such as seismic and SO2 flux measurements, when available.

The second aspect of this phD will use the experimental facilities of the fluid mechanics laboratory to mimic 2-phase flows (small bubbles in viscous fluids) in an analog volcano. The formation of bubble clusters, produced by a stable foam accumulated at the top of a large reservoir and spreading into a small central uppermost conduit (an initial condition most analogous to eruptive conditions with a bubbly flow produced on the annulus at the base of the conduit) and their coalescence in the conduit, if and when it occurs, will be characterised and modeled in order to explain extremely different volcanic regimes found at basaltic volcanoes. Finding the conditions for the transitions between the various regimes in the conduit and the characteristic diameter of bubble clusters will be a key to understand the eruptive patterns and their changes.

The third aspect of this phD will be devoted to understand the current degassing of the fumarolles of Soufrière of Guadeloupe and look for precursory signals of impending eruption, which can be phreatic, phreato-magmatic ou magmatic. This volcano had slowly started its period of unrest in 1992 and now the activity is reaching very significant levels of activity. The acoustic measurements at Soufrière will be used to quantify the amount of degassing at the various fumarollic vents and look for precursory signs of enhanced activity.

The core of the phD (currently set at 2 years1/2) consists in analysing infrasound at Stromboli and Soufriere of Guadeloupe, combining it to other joined measurements (seismicity, SO2 flux). A touch of laboratory fluid mechanics experiments (currently set at 6 months) will reinforce our understanding of eruptive regimes at basaltic volcanoes. The partition between data analysis and laboratory experiments can be adapted depending on the main interests of the phD student and on the results.

Requirement of phD: an interest in physical volcanology with basic knowledge of physic and use of softwares (matlab will be used but very similar to Python).