ÉCOLE DOCTORALE SCIENCES DE LA TERRE

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TITRE du SUJET : Timescales of reservoir and degassing processes : Application to Dominica (Lesser Antilles Arc).

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Large pumiceous events may have dramatic effect not only due to the magma volume involved but also because of their related consequences (tephra dispersal, climatic effect) that can affect the environment across various temporal and space scales. However, the processes leading to these eruptions remain poorly constrained. Dominica Island, located in the central part of the Lesser Antilles arc, bears evidences of such volcanic events. The main event is called the Roseau Tuff, with ~58 km^3 of magma emitted, which is 1.5 to 2 orders of magnitude larger than the largest eruptions in the arc. This eruption is similar in volume to that of the Tambora volcano (Indonesia, 1815), about 50 km^3 of magma equivalent DRE, and the Minoan eruption of Santorini volcano, about 60 km^3 of magma. The emitted products extend further than Dominica itself as air-fall tephra from this eruption are identified offshore in piston cores several hundred kilometers from the island and as thick turbidite deposits are evidenced in the Grenada basin. Dominica is thus characterized by infrequent large eruptions whereas in the same period of time, several small pumiceous eruptions occurred on Montagne Pelée (Martinique), St Lucia and Soufrière (Guadeloupe) which involved, as most recent eruptions of the arc, low volumes of magma, generally < 1 km^3. Whereas most islands contain only one active volcano, Dominica has also the particularity to count 4 active volcanoes. Considering the neighboring islands of Guadeloupe and Martinique half of the active volcanoes are located in the central part of the arc which represents only 1/5 of its total length. So raises the question of the origin of such large volumes of magma in the central part of the Lesser Antilles arc and of their eruption in a short period of time.

The objectives of the PhD are to understand the conditions of storage and emission of large volumes of pumiceous magma in the central part of the Lesser Antilles Arc. It is motivated by the volcanic hazards associated to these large events, by the likely geothermal energy potential associated to the magma source/reservoir of these large volume eruptions but also by fundamental questions about the assembly of magma and the growth of such large reservoirs in the crust (timescales and dynamic) and the processes leading to the eruptions of large magma volumes and their consequences. Some results of the PhD will be useful to define the linked geothermal systems through a research approach that could be applied in whatever similar volcanic context.

The PhD is thus focused on the reservoir and conduit processes. Precisely, the student will investigate long term processes in the magma chamber(s), such as crystallization and differentiation, as well as short term processes prior to eruptions (degassing, mixing, re-equilibration). The behavior of the magma inside magma chamber is strongly dependent on replenishment-mixing-differentiation cycles which may be at least partially registered in melt inclusions and even bulk rock compositions. Timescales of magma accumulation in the crustal reservoirs and the related processes such as crystallization and associated differentiation can now be determined precisely. Diffusion modelling of zoning patterns in minerals and glasses provide relatively short timescales corresponding to the mobilization of the magma. This part of the PhD will be performed in collaboration with D. Morgan (Leeds, UK), who developed this method of investigation. Degassing processes in the conduit will also be studied by a comparative geochemical and textural analysis (microcrystallinity and vesicularity) of the different eruptive products all along the eruptions. Eruptive style of H_2O-rich silicic magmas varies from effusive (lava dome) to highly explosive (plinian) eruptions. H_2O degassing constitutes the main engine of these eruptions. The role of pre-eruptive conditions, in particular the H_2O saturation pertained to the reservoir prior eruption, on the eruptive dynamic is clearly evidenced. Then, in the conduit, during ascent, correlation between the evolution of the volatile phase and the rheology of the melt (vesicularity, microcrystallinity, viscosity) allows a better understanding of the eruptive dynamic and of the shift in eruptive style. It is only recently that some important issues such as the degassing processes generating large eruptions with both fallout phase and voluminous pyroclastic flow, the processes responsible for the emplacement and welding of the pyroclastic flow or the importance of over-flow with respect to a sustained eruptive column have been raised.

The data will provide a model for the large pumice eruption in Dominica. Comparison will be established with smaller eruptions which occurred along the arc (Martinique and Guadeloupe) but also with other large eruptions in the world (Campanian ignimbrite, Campi Flegrei; Minoean eruption, Santorini; Tambora, Indonesia) for which studies are carried and new data will be published.