Kinetics of the magmatic processes and plumbing system evolution (mush stability, eruption triggering). The example of the Chaîne des Puys volcanic province (France).

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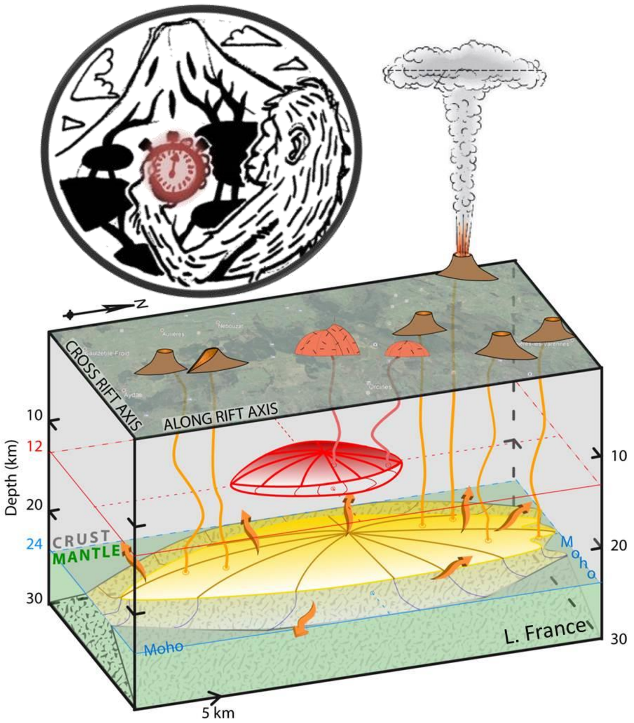
Application dead-line: 7th of July 2022

PhD project:

Magmatic processes and associated volcanoes and eruptions are associated with important societal issues including risk management, climate change, or the genesis of ore deposits. Quantifying the spatiotemporal evolution of magmatic systems is therefore essential if we are to fully understand these complex processes. The evolution of a magmatic system is governed by the organization of its plumbing system, the location of the melt and its transfer into the system, and, importantly, the kinetics that govern these processes, which has become a burning issue in recent years (e.g., Saunders et al., 2012; Cashman et al., 2017; Budd et al., 2017; Karakas et al., 2017; Cooper, 2017). The key timescales of magmatism can be characterized with the lifetime of crystal mushes at depth ($\mathbf{d_1}$), and the time required to destabilize the system and to transfer the magma to the surface and eventual eruption ($\mathbf{d_2}$). Recent studies suggest that the magma mushes could be stable for thousands of years (Rubin et al., 2017; Szymanowski et al., 2017), and that its destabilization leading to eruption occurs over weeks (Viccaro et al., 2016) to decades (Druitt et al., 2012). The ascent of magmas to the surface usually takes hours to days (e.g., Demouchy et al., 2006; Sigmundsson et al., 2015).

Diffusion chronometry (aka geospeedometery) has been extensively used in the last decades to provide quantitative constraints of the kinetics and timescales of magmatic processes (e.g., Costa et al., 2020). It is based on the temporal relaxation of chemical or isotopic heterogeneities in minerals created by a range of magmatic processes, on our capability to measure such chemical and/or isotope variations through profiles in minerals, and on the application of diffusion coefficients and models. One challenge of diffusion chronometry is the distinction between chemical gradients that are purely due to diffusion from those created during crystal growth (e.g., Gordeychik et al., 2020). The different diffusivities of isotopes (e.g., Li, Mg, Fe) has shown that it may be possible to distinguish between these processes and thus to obtain more robust time constrains based on chemical zoning in minerals (e.g. Dohmen et al., 2017).

The aim of this PhD project will be **to quantify the times of magma-mush longevity (d_1) and its remobilization towards the surface (d_2) in a continental rift environment.** The targeted area is the Chaîne des Puys (metropolitan France) that is characterized by ~90 monogenic volcanoes (maars, cones, and domes) that erupted between ~90 and 6.7 ky close to the present location of Clermont-Ferrand (a metropolitan area with >470,000 inhabitants). Relying on diffusion chronometry, the PhD has three objectives: (1) to provide constraints on the timescales of the mid-crust mushy reservoir stability (**d_1**), (2) to put constraints on the kinetics of reservoir destabilization and associated eruption triggering (**d_2**) for mafic magmas stored in deep crustal reservoirs (yellow in Figure), and (3) contrast these results with those of felsic magmas stored in mid-crustal reservoirs (red in Figure).



<u>Figure:</u> Schematic view of the plumbing system architecture of the Chaîne des Puys volcanic system (metropolitan France; derived from France et al., 2016; MACAK project). Mafic volcanoes may be fed by a deep-crustal reservoir, and acidic eruptions by a mid-crust reservoir.

PhD organization & candidates:

The PhD candidate will be mainly hosted in CRPG (Nancy, France), and will spend several journeys to IPGP (Paris, France). Sampling field campaigns will be conducted over the PhD project. The PhD candidate will have access to the exceptional analytical facilities of CRPG-lab (SEM, EBSD, EPMA, SIMS...).

We are looking for candidates with a very strong academic and scientific record. The candidates will ideally have validated an Earth Sciences Master degree, and have an expertise in igneous petrology, in situ analytical techniques, and numerical modelling. Strong candidates with exceptional skills in modelling will also be considered.

<u>REFERENCES:</u>

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