Title of the thesis: Bedrock influence on maar fragmentation mechanisms

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Summary:
Maars, small volcanic edifices in which the crater floor lies below the pre-eruptive surface, are formed by explosive eruptions, but the associated eruptive mechanisms have long been a subject of debate. For more than forty years, maar volcanism has been interpreted to result from explosive interaction between ascending magma and an external water source. Alternatively, some authors have argued that fragmentation in some silica-undersaturated magmas may have been due to exsolution of CO_2 by decompression. Both mechanisms may also alternately operate in the same edifice.

In this project, we aim at quantifying the modes of fragmentation at a series of quaternary basaltic maars located on different geological substratum, namely soft sediments, crystalline basement and coral reefs. The objective will be to contrast the two types of fragmentation: magmatic versus phreatomagmatic, and to understand how the substratum can modulate their occurrence and intensity, as well as the feeding system and eruption dynamics during the associated event. In terms of structures, the study will be from top to bottom, and for quantification from macroscopic to microscopic. Morphological parameters of each **edifice** considered will be used to quantify the energy of eruptions. For each maar, the **deposits** will be studied in terms of stratigraphy and sedimentology to characterize the mode of emplacement (fallout, PDC, ballistic) and fragmentation. **Grain size** and **componentry** analyses of the deposits will inform on the energy, type and mode of fragmentation. To support or discard the importance of external water in enhancing the explosive character, **morphology** and **texture** of selected ash grain sizes will be conducted using SEM and/or tomographic analyses (in case of tubular or fibrous particles).

Since the rheological properties are affected by magma composition, particle morphology and texture are too. Therefore, the geochemistry of magmas will also be studied, as well as its potential variation through time. Whenever possible, **whole rock major/trace element geochemical analyses** will be performed on large juvenile, homogeneous, fresh fragments, in parallel with the composition of the **groundmass** (which is more directly relevant to magma

rheology in a magma fragmentation context). In cases where the quality and/or amount of material is not suitable for such bulk analyses, the chemical composition will be evaluated, and its possible evolution traced, through mineral and glass compositions instead (via electronic microprobe and LA ICP-MS measurements). Furthermore, **mineral compositions** will be used as a **barometer** to retrieve the magma storage depth. Finally, to confirm or discard deep active magma-CO_2 interaction and/or shallow passive water interaction, the **volatiles** (H_2O and CO_2) will be measured in selected glass samples (via Raman spectroscopy).

To test how the substratum can modulate the formation of a magmatic diatreme-maar versus a phreatomagmatic maar system, three examples will be selected. The first is the mafic maar of Kaweni, on the eastern coast of Grande Terre (Mayotte). This volcano is the westernmost subaerial expression of a 60 km long WNW-ESE volcanic ridge, whose opposite eastern subaqueous end is the site of an exceptionally long-lasting and voluminous volcano-tectonic event that began in May 2018. Younger than 150 ky, this maar lies on an ancient coral reef and hosts the capital of Mayotte. Of similar age and dimension is the mafic maar of Clermont-Chamalières, in and on which the city of Clermont-Ferrand has been built. This maar, lying on the Oligo-Miocene sediments of the Limagne and the most recent fluvial deposits of the River Tiretaine, is exceptional, with the opening phase deposits (which are usually not exposed) being well preserved within several caves beneath the city. Finally, the last candidate is the younger (54 ky) maar of Beaunit. Belonging to the Chaîne des Puys and lying on the Paleozoic basement of the French Massif Central, its well-exposed deposits, the presence of granite inclusions in the first, ash-dominated part of the sequence, and the presence of mantle xenoliths, in the final strombolian dominated sequence, make this maar a perfect candidate to quantify fragmentation variations within a single edifice.