Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Exploration of crustal differentiation: a multi scale etrogeochemical study

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Summary :

In the post-Archean times, the continental crust is dominated by granitoids and it is accepted that there is a relationship between granite production and crustal growth, however, this link is still difficult to quantify. To overcome this difficulty, we need to evaluate the precise crust/mantle component of the granites sources, and the genetic link between lower crustal rocks and upper crustal granitic plutons. Previous studies have focussed on whole rock and zircons but their interpretation are still highly debated. The goal of this project is to study partially melted rocks from the lower crust, granites and enclaves within them to explore and better constrain crustal evolution processes which control the formation of the continental crust.

To succeed, this project will use recent analytical developments at the mineral scale on REE-bearing minerals (apatite, titanite, monazite, allanite, zircon). The results obtained at the mineral scale (<600 microns) will be compared to whole rock analyses in order to study potential isotopic disequilibrium during partial melting and/or hybridization of magmas. These results will then be integrated in a more general context at the outcrop scale (few meters) and then at the crustal section scale (few kms). This project requires fieldwork in key locations where middle and lower crust granites and partially melted rocks are accessible. In these locations, a variety of granitoids (calk-alkaline and peraluminous) and partially melted lower and middle crust samples (granulite and amphibolite) will be carefully sampled. The studied localities represent exceptional Hercynian deep crustal roots and display direct field evidence of hybridization of granitoid via the incorporation of partially melted granulite to granitoid bodies.

The PhD position will be conducted at the Laboratoire Magmas et Volcans (LMV) in Clermont-Ferrand, France. The appointment is for three years and will preferentially start on October 1st, 2021. Candidates should have a strong interest in petrology and geochemistry. A first experience using in-situ analytical techniques (microprobe, LA-ICP-MS) and/or in clean lab and with mass spectrometry techniques is preferable.

Methods : This work will require (i) sampling during two field seasons in collaboration with Antonio Langone (Pavia, Italy), (ii) a detailed metamorphic and magmatic petrological study of the different lithologies, (iii) the use of imaging and various in-situ analyses : SEM to identify the different phases, microprobe for major and minor elements analyses, LA-ICP-MS for trace elements analyses, (LA)-MC-ICP-MS for isotopes analyses (iv) the use of clean lab chemistry.

[1]Bruand E., Fowler M., Storey C., Laurent O., Antoine C., Guitreau M., Heilimo E., Nebel O. (2020). Accessory mineral constraints on crustal evolution: elemental fingerprints for magma discrimination. *Geochemical Perspectives Letters* vol.13, p.712, DOI:10.7185/geochemlet.2006 .

[2]Doucelance R., Bruand E., Matte S., Bosq C., Auclair D., Gannoun A.M. (2020). In-situ determination of Nd isotope ratios in apatite by LA-MC-ICPMS:Challenges and limitations. *Chemical Geology* vol.550, p.119740, DOI:10.1016/j.chemgeo.2020.119740 .

[3]Gasser, D., Bruand, E., Rubatto, D., Stüwe, K. (2014) The behaviour of monazite from greenschist facies phyllites to anatectic gneisses: an example from the Chugach Metamorphic Complex, southern Alaska. *Lithos, 134-35*, 108-122.