PhD Course in *Models and Methods for Materials and Environmental Sciences* - Cycle XXXVIII
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Volatile distribution in Earth's mantle heterogeneities: implications for the global mantle convection

The presence of compositional heterogeneities in the Earth's mantle has long been debated. In the last decades, several studies speculated on the presence of heterogeneities as the cause of isotopic and compositional variabilities in Mid Ocean Ridge Basalts (MORB) possibly due to assimilation of melts derived from source components with lower melting temperatures than the surrounding mantle. These components are introduced into the mantle by subduction zone processes, and subsequently folded and stretched by mantle convective motions. The heterogeneous mantle assemblage that formed once rising below Mid Ocean Ridges (MOR) undergoes decompression partial melting, forming magmas that carry the chemical signatures of the lithological heterogeneities. Magmas originated from different depths and lithologies in the mantle are often mixed together on their way up, hampering the possibility to recognize the geochemical signatures of single components. Regions of the MOR system where melts are created but not mixed are needed to identify these components. One possibility to test this hypothesis is to study ridge regions where mantle temperatures are lower-than-normal. The resulting lower degree of melting allows the extraction of volatile-rich melts from the low-solidus heterogeneities present in the mantle, giving us insights and better understanding of their composition. Investigating abundance and isotope ratios of volatile species from fresh glass samples, could tell us more about the mantle convective mechanisms and the nature of mantle heterogeneities.

During this PhD program basaltic glasses from the Equatorial Atlantic (Romanche and St. Paul multiple fracture zone system) collected during the SMARTIES 2019 expedition, will be analyzed alongside with a set of basaltic glasses recovered from the eastern smooth-seafloor region of the Southwest Indian Ridge. I will determine the volatile absolute concentrations and the isotopic compositions of these glasses, as well as their major, trace, and radiogenic compositions. As novel approach, I will study boron isotopes to define the nature of mantle heterogeneities and exclude late hydrothermal alteration processes. In addition, the analysis of exsolved sulfide droplets will help understanding sulfur solubility and its strong dependence from the FeO and TiO_2 concentrations. Trace elements and radiogenic Isotope compositions analyses will be carried out at CIGS-UNIMORE using LC-MS/MS triple-quadrupole and High Resolution Multi Collector Inductively Coupled Plasma Mass Spectrometry (HR-MC-ICPMS) respectively and in collaboration with Prof. Stracke in Münster (Germany). Volatile abundances, boron isotopes and sulfide inclusions analyses will be carried out at the Woods Hole Oceanographic Institution using Secondary Ion Mass Spectrometry (SIMS), in collaboration with Drs. Glenn Gaetani and Brian Monteleone.

This project will allow a deeper understanding of the volatiles' distribution in the Earth's mantle and its contribution to the global mantle convection system, which ultimately defines the global volatile cycle of our planet. Disentangling the contribution of different types of heterogeneities is crucial to define their impact on the whole mantle volatile budget and degassing behavior. This goal can be achieved by crossing volatile content with the radiogenic isotopic signature of the analyzed magmatic series. The precise definition of the composition of mantle heterogeneity with its age and provenance and specific volatile content will define strict constraints on mantle convection, times of recycling and distribution of the volatiles within the Earth. This has important implications for long-term climatic series, chemical evolution of the oceans and mantle viscosity.