Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Thermochemical heterogeneities in the deep Earth's mantle

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Summary:

Seismic tomography and analytical geochemistry provide clear evidences that the deep mantle is constituted of different reservoirs. Major ones are -the so-called "mean mantle", -the subducted slabs, -the large low-shear-velocity provinces (LLSVP) and -the small ultra-low velocity zones (ULVZ). Both LLSVP and ULVZ are at the contact with the core, however, the LLSVP extend vertically up to ~1000 km. High-resolution seismic imaging is also detecting hot plumes that are rising up through the mantle until they eventually induce intraplate volcanism.

This PhD work will be dedicated to the interpretation of the LLSVP and ULVZ and more generally to the thermochemical structure of the lowermost mantle. This subject remains largely controversial for several reasons: (i) The comparison between the 1D seismic profiles (such as PREM) and the elastic properties of minerals suggests a larger fraction of the major mineral, the $(Mg,Fe)(Si,Al)O_3$ bridgmanite, with increasing the mantle depths [1]. However, the coexistence of a bridgmanitic lowermost mantle and a peridotitic upper-mantle is incompatible with large-scale mantle convection, which should mix the mean-mantle efficiently, as shown by all geodynamical models. (ii) It was proposed that LLSVP were formed by major mantle overturns early in the Earth's history, which would have brought large volumes of magmas to the lowermost mantle [2]. Still, the seismic properties of LLSVP are not compatible a basaltic composition [3]. (iii) The nature of the ULVZ received interpretations as divergent from each other as -a chemical reaction with the core, -the graveyard for subducted basalt, -the relic of a basal magma ocean...

New experiments will be performed to refine our knowledge on the mineralogy and composition of the LLSVP and ULVZ. We will also try to understand the mechanism yielding to the generation of hot-plumes. With the laser-heated diamond anvil cell (LH-DAC), we will reproduce the conditions of pressure and temperature prevailing in the entire lower mantle and synthesize samples representative to the conditions of the primitive Earth's, when the different reservoirs segregated from each other, as well the conditions of the present-day Earth.

The recovered samples will be analyzed using the last generation of high-resolution scanning electron microscope coupled with a focused ion beam for their preparation (FIBSEM). Synchrotron-based techniques of X-ray diffraction and X-ray fluorescence are also available, as well as various types of mass spectrometries.

Reference cited

1 Murakami et al. *Nature* **485**, 90, (2012)
2 Ballmer et al. *Geochem., Geophys., Geosyst.* **18**, 2785, (2017)
3 Vilella et al. *Earth Planet. Sci. Lett.* **554**, 116685, (2021)