Subject offered for a contract starting October 2014

**SUBJECT TITLE:**

# Upper mantle signature of a mantle plume beneath an active hotspot. Example of La Réunion.


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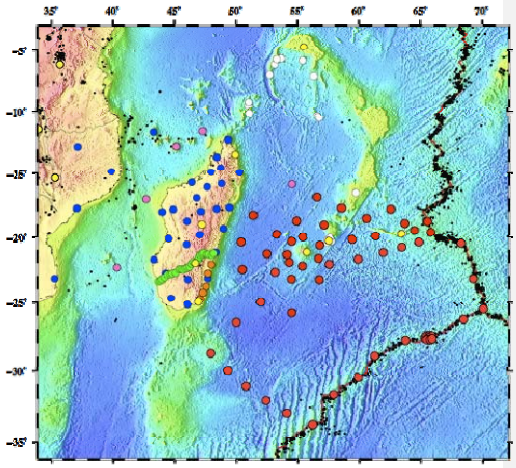
Financing: Doctoral contract with or without assignment

*For more information go to http://ed109.ipgp.fr, section: Offres de these ( PhD offer), You must apply on the Doctoral School website*

Presentation of the subject: (1 or 2 pages)

The RHUM-RUM project (Réunion Hotspot and Upper Mantle – Réunions Unterer Mantel) carried by the Institut de Physique du Globe de Paris, the GéoSciences Réunion laboratory at the University of La Réunion and the department of geophysics at Munich University aims at imaging the whole mantle from the crust to the core in order to detect the possible presence of a mantle plume beneath La Réunion hotspot, to characterize its geometry, its dynamics and its interaction with the moving plates.

To achieve this objective, a large number of terrestrial and ocean-bottom seismic stations have been deployed in the SW Indian Ocean during the period 2011-2014. By using these data, we propose in this thesis to tackle the following scientific questions:



Map of the seismic stations in the SW Indian Ocean. Red dots: RHUM-RUM OBS deployed in 2012 - 2013. Orange dots: INSU-SISMOB stations installed in Madagascar (2012-2014). Pink dots: stations installed in the Eparses Islands (2011-2014). Yellow dots: permanent Geoscope, Geofon and IRIS stations. Blue dots: US project MACOMO (PI, M. Wyssession). Green dots: Project GFZ (PI F. Tillmann). Black points: natural seismicity (1990-2010, Mb> 4.0).

- i) the structure and geometry of the plume in the upper mantle and its location relative to La Réunion and Mauritius islands,

- ii) the structure of the crust and the lithosphere, and the evaluation of its possible thermo-mechanical thinning by the plume,

- iii) the sublithospheric spreading of the plume, including the role of the preexisting structures (fracture zones, paleo-ridges), of the geometry of the lithosphere-asthenosphere boundary, of the plate motion and of the bathymetric anomalies,

- iv) the relation between La Réunion hotspot and the Central Indian ridge, and particularly a possible asthenospheric channel linking both, beneath the Rodrigues ridge.

Mis en forme : Anglais (Royaume-Uni)

**Methodology**

In order to provide answers to these questions, we propose to analyze body waves through receiver functions and shear-wave splitting analyses.

*Receiver functions: Moho depth and lithosphere – asthenosphere boundary (LAB)*

If seismic tomography is a powerful tool to image the deep Earth structures, it poorly constrains the depth of the interfaces such as the Moho and the LAB. In the frame of the proposed thesis, we propose to map the crustal thicknesses beneath the RHUM-RUM stations by using the receiver function techniques that uses *P*-to-*s* (*Ps*) converted phases [1]. The base of the lithosphere will be characterized by receiver functions using *S*-to-*p* (*Sp*) conversions. These analyses should allow detecting and characterizing two possible signatures induced by a rising plume feeding a hotspot: the presence of **magmatic underplating** beneath the crust and the **thermo-mechanical erosion** of the base of the lithosphere. Such signatures were suggested beneath Hawaii and Cape Verde and also quantified by numerical models.

*Seismic anisotropy: mapping of the upper mantle flow*

Active and/or fossil **upper mantle flow** can be mapped through anisotropy by measuring the splitting of the teleseismic shear waves. The PhD student will be in charge of characterizing the seismic anisotropy beneath the RHUM-RUM terrestrial and ocean-bottom seismic stations in order to precise the regional upper mantle flow pattern [2]. These observations will be discussed in view of the **plate motion**, of the mantle convection pattern issued from geodynamic modeling, of the **asthenospheric plume spreading** models, of the LAB geometry, of the geometry of the fracture zones and of the bathymetric anomalies. Anisotropy mapping will also be used to detect and characterize a possible **asthenospheric channel** that could link the active hotspot to the Central Indian ridge, explaining some morphological, geophysical and geochemical features of this area.

**Thesis location:**

The work will take place primarily at the University of La Réunion, in the laboratoire GéoSciences Réunion that is part of the "Géologie des systèmes volcaniques" team of IPGP.

G. Barruol, DR CNRS is the P.I. of the RHUM-RUM project, funded by the ANR for the period 2012-2015.

**Collaborations :**

The thesis student will be fully involved in the French-German RHUM-RUM project and will require interacting with the other scientific partners:

- the seismology group in Frankfurt (G. Rümpker, I. Wölbern) and in Canberra (H. Tkalčić and B.L.N. Kennett) for the receiver functions,
- the seismology groups in Munich and Oxford (K. Sigloch and H. Igel) in charge of the body-wave whole-mantle tomography,
- the seismology group at IPGP (E. Stutzmann, J.-P. Montagner, A. Mazullo) in charge of the surface wave anisotropic tomography,
- the numerical and analog modeling groups (A. Tommasi, D. Arcay, C. Thoraval in Géosciences Montpellier, C. Farnetani at IPGP and A. Davaille in FAST Orsay) to compare the seismic observations to modeling,
- the Marine Geosciences group at IPGP (J. Dyment, C. Deplus) in charge of the bathymetric, gravimetric and magnetic analyses.

• More details on the RHUM-RUM project : http://www.rhum-rum.net

*Few references*

[1] Fontaine F.R., Tkalčić H., and B. L. N. Kennett, 2013, Imaging crustal structure variation across southeastern Australia, *Tectonophysics*, 582, 112-125, doi:10.1016/j.tecto.2012.09.031.

[2] Barruol G., and Fontaine F.R., 2013, Mantle flow beneath La Réunion hotspot track from *SKS* splitting, *Earth and Planetary Science Letters*, 362, 108-121, doi:10.1016/j.epsl.2012.11.017.