Where is the post-perovskite at the base of the mantle?
Apply machine learning methods to detect layer D''

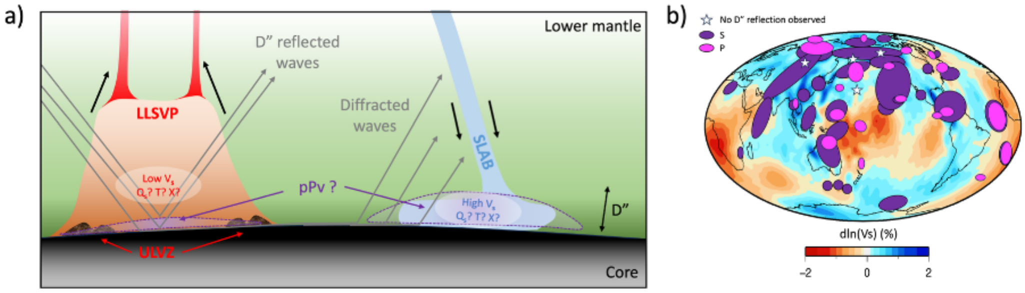
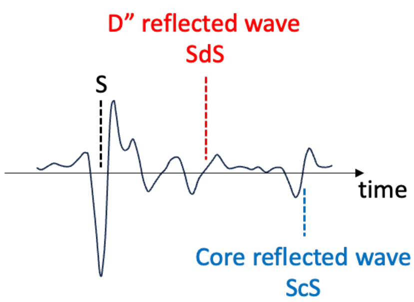


Figure: (a) (a) Schematical sketch of lower mantle key structures such as D", LLSVPs, ULVZs. Constraining Vs and Q_s^{-1} will bring key constraints on temperature (T) and mineralogy (X, presence of pPv). (b) Reported detections of the D" discontinuity with P (pink circles) and S (purple circles) data and no D" detection (white stars) (reproduced from Jackson & Thomas (2021)) on top of the tomographic model SEISGLOB2 (Durand et al., 2017) plotted at 2800 km depth.

Supervisor(s):The internship will take place at the Laboratoire de Géologie de Lyon (LGL-TPE) under the supervision of **Stéphanie Durand (stephanie.durand@ens-lyon.fr)**.

Suitable formation level & prerequisite: The trainee should have a solid background in geosciences or computer science or machine learning techniques. He or she should be familiar with python and Fortran.

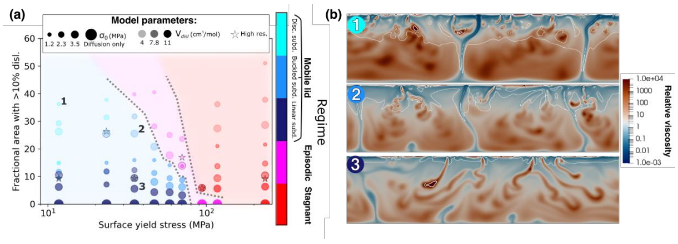
Keywords: neural networks, signal processing, lower mantle, post-perovskite, D'' layer



The D" region (Figure 1a) corresponds to the lowermost few hundred kilometers of the Earth's mantle. This specific layer was identified as early as the 1950s (Bullen, 1950). It was characterized in the 1980's by its long wavelength structures, typically over 1000 km. But seismic imaging has improved considerably, revealing the D" region complexity and making it increasingly enigmatic. The D" region became a symmetrical analog of the lithosphere as being a thermal and/or chemical boundary located at the base of the mantle. The D" layer is mainly interpreted as the consequence of a phase transition from Bridgmanite (Bdm) to post-perovskite (pPv). However, this layer is not always detected which may reveal, besides coverage problems, 3D variations in temperature or/and composition (Figure 1b), due to the properties of the Bdm phase transition (high Clapeyron slope and transition pressure dependence on composition). Because of its deep location, it remains challenging to study, which has hampered a global exploration to date. Its worldwide distribution, topography and origin are still actively debated. Is there a pPv layer globally present at the base of the mantle remains, 35 years after the first D" observation, an open question?
Answering this question requires a global mapping of small-scale D" structures. The aim of this internship is to develop an algorithm that automatically detects D" reflected waves (SdS) on individual seismograms and to apply it to a global dataset. D" reflected waves are expected to arrive just before core reflected waves (ScS), so we will seek for ScS precursors. Based on existing datasets (Durand et al., 2019) as well as synthetic seismograms the aim is to train a CNN to achieve the detection.

To apply : Please send a CV, a covering letter to stephanie.durand@ens-lyon.fr

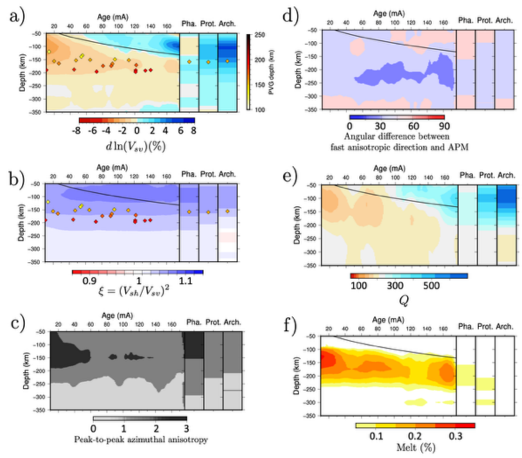
Investigation of the rheological and seismological properties of Earth's asthenosphere.



Supervisor(s):The internship will take place at the Laboratoire de Géologie de Lyon (LGL-TPE) under the supervision of **Maëlis Arnould (maelis.arnould@univ-lyon1.fr) and Stéphanie Durand (stephanie.durand@ens-lyon.fr).**

Suitable formation level & prerequisite: The trainee should have a solid background in geosciences or computer science. He or she should be familiar with python and Fortran. The trainee will be required to work on cluster environments under UniX.

Keywords: Seismic anisotropy, attenuation, asthenosphere, mantle rheology, numerical modeling, mantle convection



Abstract:
The asthenosphere, located at the interface between the lithosphere and the rest of the mantle, plays a key role in Earth's internal geodynamics. However, its nature, dynamics and geometry remain poorly constrained at present, limiting our understanding of the rheology and dynamics of the Earth's mantle, as well as the couplings between the lithosphere and the mantle. Seismological observables can provide information on the rheology of this layer: the low seismic velocities and high seismic attenuation of the asthenosphere would suggest the presence of partial melting, the high seismic anisotropy would show the existence of dislocation creep at the origin of the preferential orientation of olivine crystals, and variations in seismic attenuation could reveal the evolution of grain size in the asthenosphere. Combining these seismological observations on asthenospheric rheology with geodynamic models of mantle convection would allow us to better constrain asthenospheric rheology, and to better understand its dynamics and its role in plate tectonic motions.

The aim of this research internship is to jointly exploit seismological observables (velocities, anisotropy and attenuation) and geodynamic models of mantle convection with plate tectonics to explore the effects of different rheologies (linear or composite, with or without grain size evolution, with or without partial melting in the asthenosphere) on seismological characteristics and the dynamic consequences that such rheologies would produce. We propose to use the StagYY code (Tackley et al., 2000), which allows to run fully-dynamic 2D numerical models of whole-mantle convection with plate tectonics and a complex rheology (Arnould et al., 2023, Manjón Cabeza-Córdoba et al., *in rev.*) in order to explore the effects of the amount of dislocation creep, of grain-size evolution, and of parameterized partial melt in such models, on the development of seismic anisotropy and attenuation. We will then be able to make quantitative comparisons between the spatial distribution of observed anisotropy and attenuation in the Earth's asthenosphere and the seismic properties predicted from geodynamic models, with the goal to better constrain Earth's asthenosphere rheology, and ultimately its dynamics.

Practical information: Internship gratification provided by INSU AAP project.

To apply : Please send a CV, a covering letter and possibly the names of referees we could contact : maelis.arnould@univ-lyon1.fr, stephanie.durand@ens-lyon.fr