Tomographic proxies for the presence of post-Perovskite in Earth’s lowermost mantle

**Overview**

Convective processes, which remove heat from the Earth’s deep interior, drive plate tectonics at the surface and sustain our protective magnetic field. To model these convective processes and to understand the thermal evolution of the Earth, it is crucial to have robust estimates of present-day temperatures in the Earth. Such estimates are typically obtained using observations of sharp jumps in seismic velocities, interpreted to arise due to changes in the crystal structure of mantle minerals. By combining seismic observations of such mineralogical phase transitions with expected depths based on mineral physics experiments and calculations, we obtain much-needed estimates of temperatures in the deep Earth.

Seismic observations of phase transitions are however sparse due to heterogenous seismic data coverage, especially in the deep mantle where the transition of bridgmanite (Br) to post-perovskite (pPv) is inferred as explanation for jumps in seismic velocity (Figure 1). Consequently, we only have a very patchy image of where the phase boundary may occur, limiting our ability to constrain lateral variations in temperature and heat flow across the core-mantle boundary. Our interpretations are further complicated by the fact that the properties and stability field of pPv as estimated from mineral physics remains uncertain.

In this project, we aim to investigate instead to what extent different aspects of global seismic tomography can be used as proxy for the phase transition of bridgmanite to post-perovskite. Proxies of interest include the vertical gradients in seismic velocity and the ratio and correlations between different seismic velocities, as well as the mapping of velocity structure to temperature. By investigating both high-resolution synthetic tomography models and existing tomography models based on data, we will ascertain under which conditions different proxies work and be able to provide recommendations as to what improvements are required in seismic tomography to utilise particular proxies in practice.

**Methodology**

To investigate the accuracy of different proxies, we will firstly construct synthetic seismic tomography models. These will be based on available geodynamic mantle circulation models, with the temperatures converted to seismic velocities using mineral physics data for different mantle compositions. Different proxies for the phase transition will be computed based on the seismic velocities, which can be compared to the true occurrence of the pPv phase we have assumed. Subsequently, the accuracy of the proxies in existing tomography models based on data will be investigated by taking the limited resolution of seismic tomography into account. By investigating a wide range of mantle compositions, mantle
dynamic scenarios and seismic tomography models, we will be able to assess to what extent the proposed proxies work and what may need to change in order to make them work. Similar workflows may also be applied to other phase transitions in the mantle to obtain further insights into mantle temperatures.

**Timeline**

**Year 1:** Doctoral training courses, literature review, familiarising with mineral physics data, geodynamic models and seismic tomography.

**Years 2 and 3:** Development of workflow for different proxies, testing of proxies in high-resolution synthetic tomography models, tomographic filtering high-resolution models, testing of proxies in filtered models, investigations of different mantle compositions and phase boundary possibilities.

**Year 4:** Data integration, thesis completion, writing of papers for international journals and presentation of results at international conferences.

**Training & Skills**

The supervisory team in Oxford are leaders in global seismic tomography, multi-disciplinary interpretations of mantle structure and experimental mineral physics. The successful candidate will join the vibrant seismology group at the University of Oxford, and benefit from interactions with existing PhD students, postdocs and faculty who work on similar topics.

In this multidisciplinary project, the PhD student will receive training in analysis and compilations of mineral physics data, geodynamic simulations and global tomographic inversions of seismic data. In addition, they will be mentored on how to prepare scientific results at (inter)national conferences, how to write manuscripts for publication in international journals and how to communicate their science to a general audience.

In addition to the training in these transferable skills and research skills, the student will be provided with advice on funding applications and career support.

**References & Further Reading**


**Further Information**

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