Exploring Earth's interior structure and dynamics beneath the Australasian tectonic plate

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The mantle is characterised by convecting material, consisting of hot upwelling plumes, and cold downgoing slabs. The upper and mantle is dominated by various discontinuous jumps in material properties, caused by mineral phase transitions as pressure and temperature increase with depth, and other compositional changes. The major global discontinuities are located at 410 and 660-km depth, bounding the "mantle transition zone" (MTZ). Their depth and strength depent on temperature and composition. They can also affect mantle convection, and downgoing slabs (such as that associated with the Tonga trench) are observed to become stuck at the 660-km transition. Seismic models show that both up and downwelling mantle flow is also deflected in the mid-mantle. However, the causative mechanisms remain debated.

A recent global study of the mid-mantle discontinuities shows multiple regional reflectors from 800 to 1300 km depth. These reflectors display a strong correlation to up and downwelling material (Figure 1), and suggest the presence of significant heterogeneity, but the relationship to both composition and deflection of flow remains an unanswered problem. Further studies show that the 660-km transition is typically undetected in some types of seismic waves, only becoming visible for very high temperatures. The relationship between the visibility of the 660 and the deeper features is unconstrained.

While Australia is relatively seismically inactive, the plate boundaries display a range of stages of slab stagnation, making it an ideal natural laboratory. The aim is to combine observations from seismic waves which interact with mantle discontinuities with mineral physics modelling, in order to map the structures, thermochemistry, and dynamics beneath the region. The output will improve our understanding of the link between seismic discontinuities and deflection of convecting material.

Multiple projects are available. Students with a computational background are encouraged to apply.

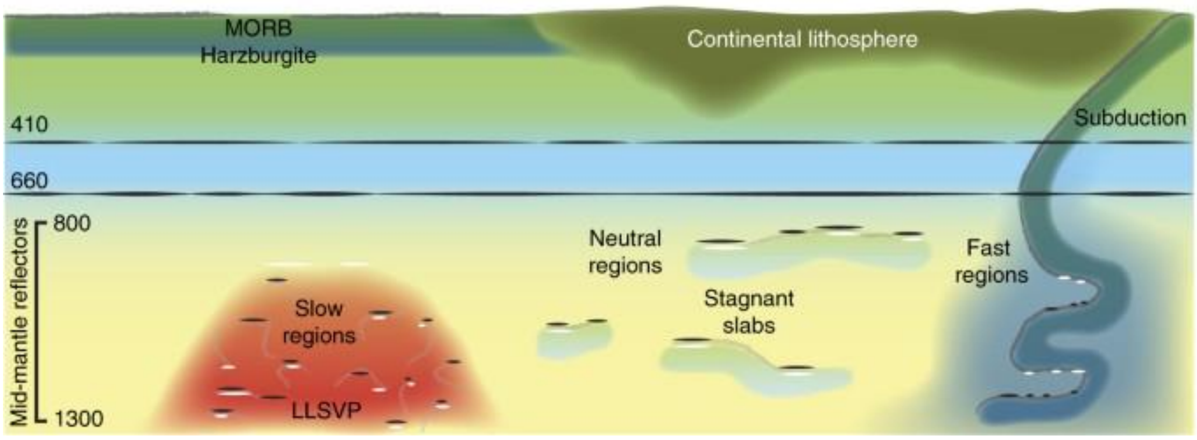

Figure 1. Interpretation of reflectors in the mid-mantle. Potential sub-horizontal mid-mantle reflectors are denoted black (positive impedance) and white (negative impedance) and grouped by seismic domains: (1) Fast, cold downwelling regions (blue), with heterogeneities that are predominantly too small and variable to be resolved by SS precursors. (2) Slow, hot upwelling regions (red). (3) Neutral regions (yellow), perhaps with compositionally or texturally distinct material (lighter yellow). Slabs may stagnate above these features, generating shallow reflections for the neutral domains.