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Seismological observations of mantle discontinuities, and their mineral physical interpretation

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Seismological studies on mantle discontinuities have been succesful in observing the transition zone discontinuities at 410 and 660 km depth, as well as discontinuities in the lower mantle at a whole range of depths. The characteristics of discontinuities place important constraints on the style of mantle convection in the Earth. Here, we study mantle discontinuities using large collections of stacked PP precursors, SS precursors and receiver functions. Such stacks show clear reflections from the transition zone discontinuities and provide a means of investigating hypotheses about the mineral physical nature of discontinuities in the Earth's mantle.

The 410 km discontinuity is observed in all data types and is characterised by a simple single peak. The 660 km discontinuity, however, shows a much more complex structure. It had been apparently absent in previous studies of PP precursors, posing major problems for models of mantle composition. We reported, for the first time (see Deuss *et al.* 2006), that the 660 km discontinuity can be seen in PP precursors, SS precursors as well as receiver functions. Our observations reveal a very complicated global structure with single and double reflections ranging in depth from 640 to 720 km. A weaker and possibly non-global discontinuity at approximately 520 km depth is also present in SS and PP precursors, but does not show up consistently in receiver functions. We find that this 520 km discontinuity is split in certain regions, while in other regions one discontinuity is observed.

These observations are explained by the presence of multiple phase transitions on a global scale in the transition zone. Pyrolite and piclogite mantle models contain a mixture of olivine and garnet. The phase transitions of olivine and garnet explain the seismic observations of double peaks (or splitting) at the 520 and 660 km discontinuities. Computations of reflection amplitudes for different mantle models show that our observations are consistent with a pyrolite composition. We conclude that transition zone discontinuities cannot be interpreted in terms of olivine phase transitions only and we imply that phase transformations in the garnet components are of major importance for understanding the structure of the Earth's mantle and its convective state.

Our three data types also support evidende for reflections from lower mantle discontinuities, the most consistent ones being at approximately 800 and 1150 km depth. Discontinuities at 1100-1220 km have been proposed before by some regional studies and would be consistent with tomographic models, particularly in subduction zone areas.