Structure and the Topography of the Transition Zone

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Transition zone plays an important, but not completely clear role in the Earth's dynamics. It is still a subject of the debate how strong a barrier it is for the flow in the mantle. For the most part, two end members are being considered; whole mantle flow and layered flow. In recent years, the paradigm of whole mantle flow has been strongly favored. Yet there are many indications that, at least in the subduction zones, the flux across the 670 km discontinuity is severely impeded. We are approaching the problem from two directions. First, we investigate whether a model of lateral heterogeneities in shear velocity that allows a discontinuous change in the pattern of lateral variations shows a substantial difference in the power spectrum above in below the discontinuity. We find a very significant change at 670 km, but not across the 400 km discontinuity. We do not find strong evidence for discontinuities either at 1000 or 1800 km depth. Second, we use the travel dimes of $S400S$ and $S660S$ precursors to study the topography of these discontinuities and measure directly the differential travel times of $S400S - S660S$ to obtain a more accurate estimate of the transition zone thickness. We find that there is significant relief on both boundaries, on the order of ± 20 km and that a similar topography is observed in the transition zone thickness, with the large wavelength thickening under the subduction zones of the Western and Eastern Pacific and thinning under the Pacific and Indian Oceans. The South Atlantic is anomalous with a thicker than average transition zone. We find that the topographies of the 400 km and 660 km discontinuities are de-correlated, in the sense of the gravest spherical harmonic terms, implying different origin of their lateral variations. In summary, we find that the 670 km discontinuity represents a significant barrier to the whole mantle flow and that at least a part of the flow and mixing of the subducted material.