SH Velocity and Compositional Models Near the 660-km Discontinuity Beneath South America

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The IRIS PASSCAL experiments have supplied the seismology community with high quality, freely available and spatially dense datasets. The high quality broadband seismic data recorded in two PASSCAL experiments in South America (BANJO and BLSP) provide us with an opportunity to investigate the upper mantle seismic structure beneath South America. The dense observations also minimize the effects of lateral seismic heterogeneities on the seismic results. We constrain SH-wave velocity structures near the 660-km discontinuity beneath South America using triplicated phases near the discontinuity recorded in the epicentral distance range of 10° - 30° for a deep event. The seismic data suggest that the velocity gradient above the 660-km discontinuity is larger than that of Preliminary Earth Reference Model (PREM), while the velocity jump and the velocity gradient below the 660-km discontinuity across the discontinuity are the same as PREM. The large velocity gradient above the 660-km discontinuity requires existence of the ilmenite phase in the bottom of the transition zone; the velocity jump across the discontinuity can be explained by the presence of more garnet above the discontinuity than in the pyrolite model; and the high velocity gradient in the top of the lower mantle can be explained by the gradual transformation of garnet to prevoskite persisting to a greater depth. Such a mineralogical model may be explained by an aluminum content of 3.4% in the top of the lower mantle and a low temperature and/or low Al content in the bottom of the transition zone beneath South America.

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(a) Great circle paths from the seismic event (star, 1994/11/04, evdp = 597 km) to stations (triangles), with the green segments indicating the portions that the CD branch travels below the 660-km discontinuity. (b) Ray paths of the triplications near the 660-km discontinuity for a source depth of 597 km. The AB branch is the direct SH wave propagating above the discontinuity; the BC branch is the reflection off the discontinuity; and the CD branch is the seismic wave traveling below the discontinuity. (c-d) Comparisons of observed tangential displacements for the seismic waves sampling the transition zone beneath South America (event in (a)) (black traces) and synthetic waveforms (gray traces) calculated using (c) PREM and (d) our best fitting model, along with predicted travel time curves of the three branches of the seismic phases (dashed lines). (e) The best fitting SH velocity models based on the seismic data (red) and a mineralogical model (blue), along with PREM (black) as reference. (Since the best fitting SH velocity models based on the seismic data and a mineralogical model are very close, the prediction of the best fitting mineralogical model is shifted a little to make it distinguishable.)