SEISMIC EVIDENCE FOR ACCUMULATED OCEANIC CRUST ABOVE THE 660-KM DISCONTINUITY BENEATH SOUTHERN AFRICA

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High-pressure assemblages of subducted oceanic crust are denser than the normal upper mantle but less dense than the uppermost lower mantle [Ringwood, 1991; Hirose et al., 1999]. Thus subducted oceanic crust may accumulate at the base of the upper mantle. Direct observational evidence for this hypothesis, however, remains elusive. We present an analysis of a negative-polarity shear wave converted from compressional wave at a seismic discontinuity near 570 - 600 km depth beneath southern Africa. The negative polarity of the converted phase indicates a ~2.2 ± 0.2% S-velocity decrease with depth at the seismic discontinuity. This velocity reduction is associated, however, with a low velocity contrast at the 660-km discontinuity. The exsolution of Ca-perovskite in former oceanic crust at depth greater than 600 km and the associated small volume fraction of ringwoodite are plausible explanations for the apparent paradox between the negative velocity discontinuity and the low velocity contrast at the 660-km discontinuity.


Figure 1. (a) Locations of broadband seismic stations (triangles) and the profile of the receiver function stacks (line). Circles with a radius of 2 outline two of the overlapping patches used in stacking. (b) Waveforms of the stacked receiver functions along the profile in (a) and their 95% confidence limits determined by bootstrap. Arrow marks the arrival of the negative-polarity phase. An nth root (n=2) stacking process is used to enhance coherent phases and suppress random noise. (c) A comparison of the receiver functions stacked along Pds moveout curves (solid lines) and reverberation moveout curves (dotted lines). Every other trace in (b) is shown for legibility. (d) Waveforms of two linearly stacked receiver functions from the two patches outlined in (a) and their 95% confidence limits. The bottom trace corresponds to the patch near the center of the array. The scale of the vertical axis is relative to the amplitude of P wave on the vertical component. The top trace has been shifted upwards by 0.05.

Figure 2. (a) Two possible scenarios may cause a negative-polarity P-to-S conversion near 590 km depth: a uniform reduction in velocity at the base of the upper mantle (dashed line) and a velocity reduction near 590 km followed by a greater than normal velocity gradient (dotted line). The reference shear velocity structure (solid line) is a modified iasp91 model with a smaller velocity contrast at the 660-km discontinuity to provide a better fit to the observed P660s amplitude. (b) The top traces are the synthetic receiver functions for the three velocity models in (a). Line styles match those in (a). Arrow marks the converted phase from the velocity reduction near 590 km depth. The waveform of a linearly stacked receiver function from the center patch in Figure 1a and its 95% confidence limit are shown for comparison. The top traces are shifted upwards by 0.05.