Waveform Search for the Innermost Inner Core[1]

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Waveforms of the PKIKP seismic phase in the distance range 150° to 180° are analyzed for evidence of an inner-most inner core of the type proposed by Ishii and Dziewonski[2] to account for an abrupt change in elastic anisotropy near radius 300 km inferred from observed travel times of PKIKP. Seismograms synthesized in models having a discontinuity at 300 km radius in the inner core (Figures 1-3), however, exhibit focused diffractions around the innermost sphere at antipodal range that are inconsistent with observed PKIKP waveforms (Figures 5). Successful models have either a transition in elastic properties spread over a depth interval greater than 100 km or an innermost sphere that exceeds 450 km radius (Figure 4). Evidence of a sharp discontinuity in the lower to mid-inner core is sparse in existing global seismic data. Some examples can be found of PKIKP complexity near 161° and 164-165° (Figure 5), consistent with a triplication created by a 475 km radius discontinuity. An abrupt change in either viscoelastic or scattering attenuation at this radius is also observed in PKIKP waveforms (Figure 6), suggesting the existence of an innermost sphere with small, regionally uniform, seismic attenuation[3]. In contrast to the relatively uniform innermost inner core, a 0 to 100 km thick region at the top of the inner core exhibits strong lateral variation in seismic attenuation, suggesting lateral variations in the processes of solidification, flow and recrystallzation at the inner core/outer core boundary. Analogous to the evidence for an abrupt fabric change in the uppermost inner core, the evidence for an innermost inner core may represent another fabric change. This change may simply signify the end stage of solidification, flow and recrystallization, resulting in the highest ordering and largest grain sizes of intrinsically anisotropic crystals.

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[2] *PEPI*, 140, 203-217, 2003.

[3] *JGR*, 107(B12), 10.1029/2002JB0011795 and 10.1029/2002JB1796.

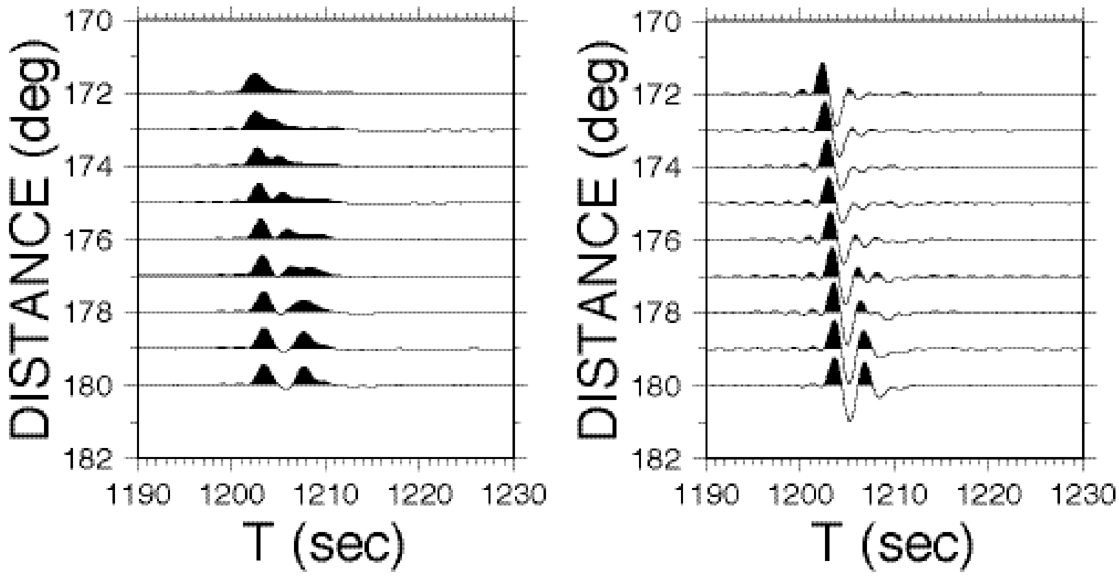

Figure 1. Displacement (left) and velocity (right) seismograms of PKIKP waveforms synthesized in an Earth having a discontinuity at 300 km radius in the inner core with a 4% postive increase in P velocity, corresponding to the velocity increases predicted by the Ishii and Dziewonski model for PKIKP rays oriented along polar and equatorial directions w.r.t. to the rotational axis. Note the constructive interference at the antipode of waves diffracting around the boundary of the discontinuity from opposite azimuths.

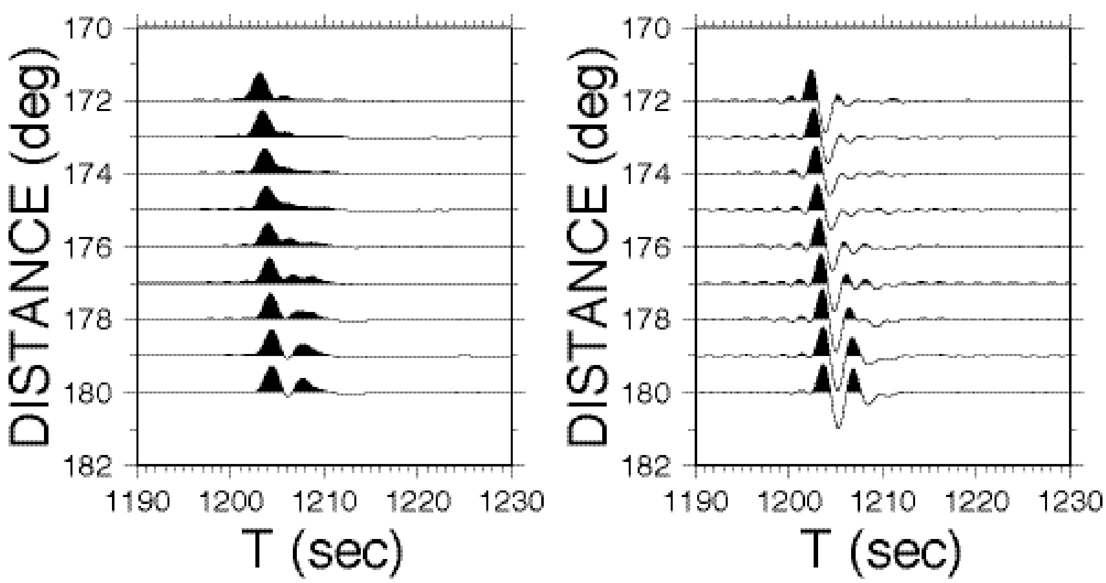

Figure 2. Same as Figure 1 but for a 2% positive velocity increase in P velocity at 300 km radius in the inner core.

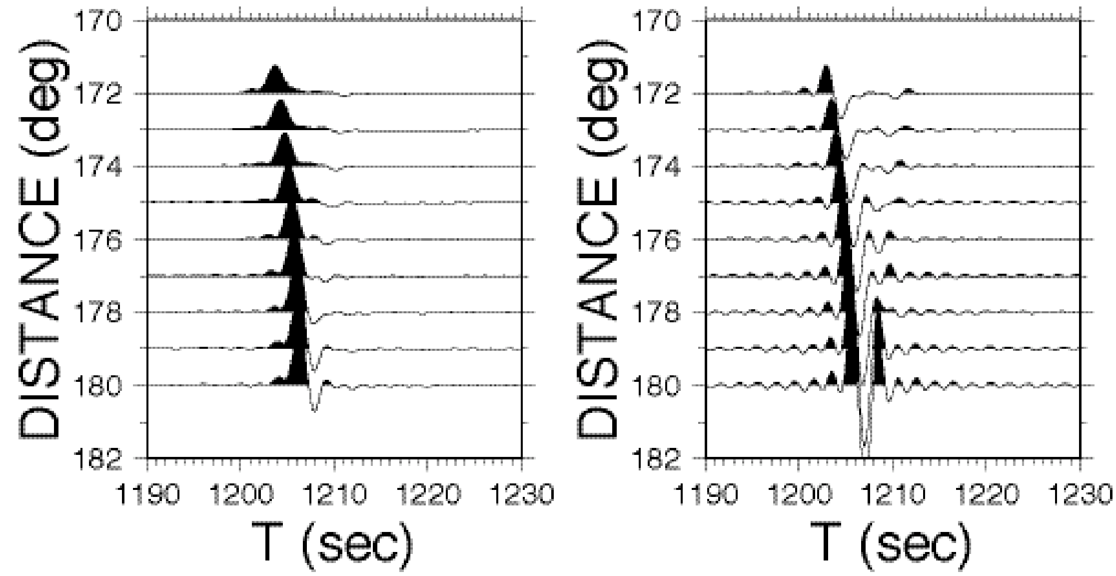

Figure 3. Displacement (left) and velocity (right) synthetic seismograms for a negative 2% velocity decrease at 300 km radius of the inner core, corresponding the velocity decrease predicted by the Ishii and Dziwonski model of the inner core at PKIKP ray orientations intermediate (45) w.r.t. to the pole of rotation. Note: the strong amplitude increase in the velocity seismograms due to the effect of exiting a shadow zone starting near 170^{o}.

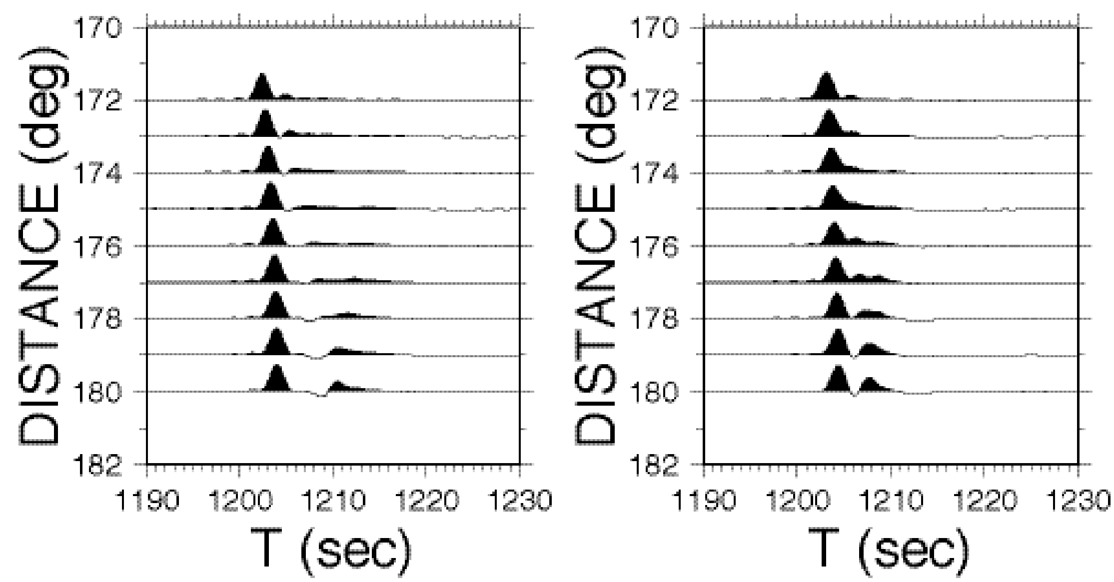

Figure 4. A comparison of displacement synthetics for a positve 2% discontinuity at 400 km (left) versus 300 km depth (right) in the inner core. Note the strong sensitivity of antipodal synthetics on the radius of innermost-inner core discontinuity.

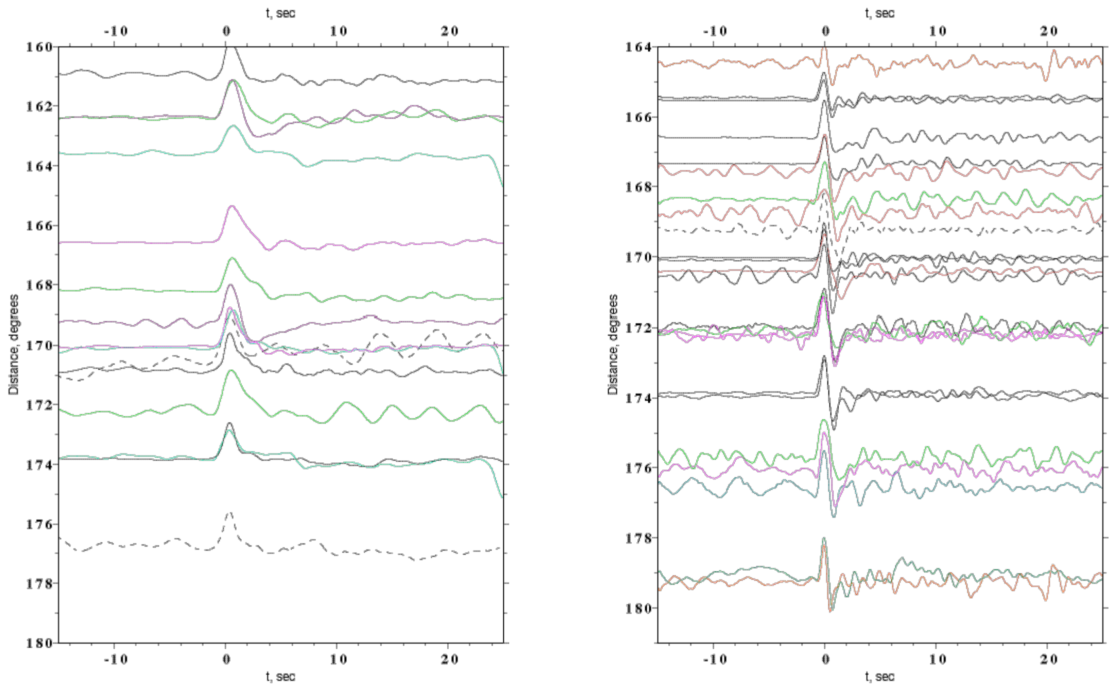

Figure 5. Displacement (left) and velocity (right) observed seismograms from deep focus events along the South American subduction zone recorded by stations in Asia and the Arctic, corresponding to orientations w.r.t. to the rotational axis that would exhibit a velocity increase in the innermost inner core model of Ishii and Dziewonski. Near antipodal recordings are inconsistent with a sharp discontinuity at 300 km depth. Some waveform complexity near 164 to 166, however, are consistent with velocity increase at radius 450 km.

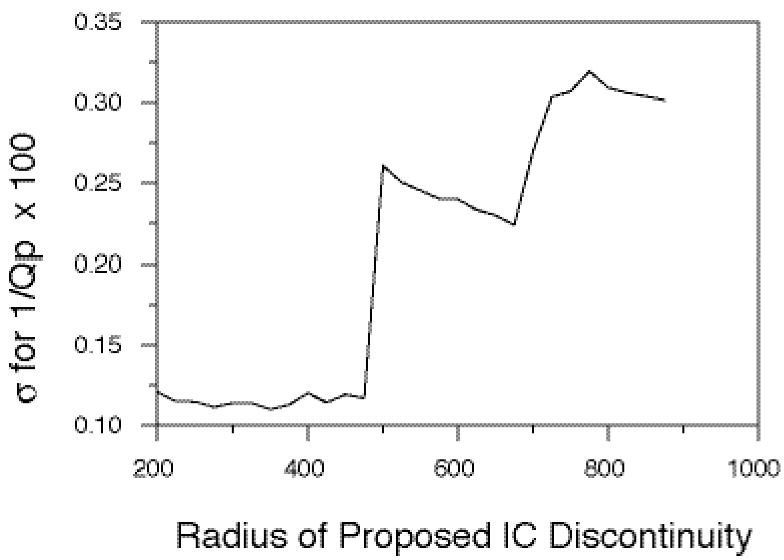

Figure 6. Standard deviation of seismic attenuation in an innermost inner core having a boundary at a varying radius, calculated from results of Xu and Cormier (2003). Note: an innermost inner core boundary at 475 km bounds a region having low attenuation (high Q) with small lateral variability.