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Key Points:

- Broadband recordings of *S-P* conversions allow for constraining compositional properties of deep Earth materials
- Stishovite is present in subducted eclogite and contributes to shear velocity softening
- Fragments of subducted oceanic crust are entrained in mantle flow and can be preserved at depths approaching 2,000 km

Supporting Information:

- Figure S1
- Supporting Information S1

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Estimate of the Rigidity of Eclogite in the Lower Mantle From Waveform Modeling of Broadband *S*-to-*P* Wave Conversions

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Abstract Broadband USArray recordings of the 21 July 2007 western Brazil earthquake (M_w=6.0; depth = 633 km) include high-amplitude signals about 40 s, 75 s, and 100 s after the *P* wave arrival. They are consistent with *S* wave to *P* wave conversions in the mantle beneath northwestern South America. The signal at 100 s, denoted as $S_{1750}P$, has the highest amplitude and is formed at 1,750 km depth based on slant-stacking and semblance analysis. Waveform modeling using axisymmetric, finite difference synthetics indicates that $S_{1750}P$ is generated by a 10 km thick heterogeneity, presumably a fragment of subducted mid-ocean ridge basalt in the lower mantle. The negative polarity of $S_{1750}P$ is a robust observation and constrains the shear velocity anomaly δV_S of the heterogeneity to be negative. The amplitude of $S_{1750}P$ indicates that δV_S is in the range from −1.6% to −12.4%. The large uncertainty in δV_S is due to the large variability in the recorded $S_{1750}P$ amplitude and simplifications in the modeling of $S_{1750}P$ waveforms. The lower end of our estimate for δV_S is consistent with ab initio calculations by Tsuchiya (2011), who estimated that δV_S of eclogite at lower mantle pressure is between 0 and −2% due to shear softening from the poststishovite phase transition.

1. Introduction

While seismic tomography has mapped the penetration of subducting lithosphere into the lower mantle on scales > 100 km (e.g., Fukao et al., 2001; Grand et al., 1997), array recordings of reflected or converted phases indicate that fine-scale (10–100 km) structure is present in the deep mantle (e.g., Kaneshima, 2016; Shearer, 2007). *S*-to-*P* conversions at depth *x*, denoted as S_xP, are excellent probes for detecting layering or localized heterogeneity in the lower mantle beneath deep-focus earthquakes. These shear wave conversions have been used to map small-scale seismic structure beneath the Marianas (e.g., Kaneshima & Helffrich, 1998), Tonga (e.g., Kaneshima, 2013; Li & Yuen, 2014; Yang & He, 2015), Indonesia (e.g., Kaneshima & Helffrich, 1994; Niu & Kawakatsu, 1997; Vanacore et al., 2006; Vinnik et al., 1998), South America (e.g., Castle & van der Hilst, 2003; Kaneshima & Helffrich, 2010), and northeast China (Niu, 2014). Kaneshima and Helffrich (1999) interpreted these small-scale, deep-mantle heterogeneities as fragments of subducted oceanic crust.

We inspected Transportable Array (TA) and Canadian National Seismic Network (CNSN) waveforms from 41 deep-focus (>300 km) earthquakes in South America since 2007. We detected high-amplitude S_xP conversions only in recordings of the 21 July 2007 M_w = 6.0 (latitude = 8.1°S; longitude = 71.3°W; depth = 633 km) western Brazil earthquake (the Brazil earthquake from hereon). The Brazil earthquake had a dip-slip source mechanism with optimal downward radiation of *SV*-polarized shear waves. The absence of clear *S-P* conversions in waveform data from other events is likely due to the unique focal mechanism of the Brazil earthquake.

Previous studies have modeled the amplitude and polarity of S_xP conversions (e.g., Kaneshima & Helffrich, 1999; Niu, 2014; Vinnik et al., 1998). In this paper we analyze broadband regional network waveforms by 2-D finite difference modeling at periods longer than 2 s. The broadband recording of $S_{1750}P$ at stations from the TA and CNSN elucidates the signal polarity and amplitude. By forward waveform modeling, we put constraints on the thickness and the shear velocity of the anomalous structure in the deep mantle responsible for generating $S_{1750}P$.