Imaging the Oceanic Lithosphere-Asthenosphere System beneath 155 Ma Western Pacific Seafloor Using S-to-p Receiver Functions

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The structure of the oceanic lithosphere-asthenosphere system is key to deciphering the creation and evolution of tectonic plates. In this study, we probe the lithosphere-asthenosphere system beneath 155 Ma western Pacific seafloor using teleseismic converted body waves recorded by the PLATE project ocean-bottom-seismometers. Within the lithosphere, the binned S-to-p (Sp) receiver functions imply a significant velocity decrease at depths of 33-50 km as a mid-lithospheric discontinuity. We tested multiple models for this boundary and found that the best explanation is the velocity contrast between background mantle and trapped, crystallized, volatile-rich partial melt, for example dolomite from carbonated melt and garnet granulite from basaltic melt. These melts possibly originate from deeper asthenospheric melting beneath the flanks of spreading centers, and are carried away from the ridge along with cooling lithosphere. Below the mid-lithospheric discontinuity, a lithosphere-asthenosphere boundary is detected at depths of 82-100 km with peak amplitudes at ~90 km. Waveform modeling points to a ~10.5% shear velocity drop over several km across the lithosphere-asthenosphere boundary. In simple cooling models, temperature changes alone are too gradual to produce a distinct lithosphere-asthenosphere boundary phase, indicating that an additional mechanism is required to sharpen the velocity gradient, such as a small amount of partial melt that is distributed throughout an asthenospheric layer from the base of the seismic lithosphere to a depth of ~ 120 km, as marked by a positive Sp phase.