Attenuation in the Oceanic Lithosphere and Asthenosphere: Results from Arrays of Ocean Bottom Seismometers

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Using Rayleigh waves, we have measured shear attenuation beneath 4 arrays of ocean-bottom seismometers: MELT and GLIMPSE near the East Pacific Rise; PLATE on 150-160 Ma seafloor in the western Pacific, and the Cascadia Initiative deployments on the Juan de Fuca plate in seafloor 0-10 Ma old. In addition, we measured attenuation of P waves in the 1-15 Hz band beneath PLATE using body waves from intermediate and deep focus earthquakes. For Rayleigh waves, we employed the two-plane-wave technique to account for multi-path interference arising from velocity heterogeneities outside the arrays, the Born approximation to account for focusing and defocusing within the study areas, and station corrections to account for site response and errors in instrument response. Rayleigh wave attenuation coefficients extend from periods of 20 s up to 143 s for Juan de Fuca. The Juan de Fuca area is slightly more attenuating than seafloor of similar age near the East Pacific Rise. Beneath Juan de Fuca, the minimum shear quality factor Q is found centered at about 80 km, just below the expected dry solidus. Q averaged over the well-resolved depth range of 70 to 110 km is 45-50. The existence of the maximum attenuation below the dry solidus beneath young seafloor points to the role of melt removal and consequent dehydration in altering the composition and melting temperature of the mantle. A component of convective downwelling is needed to explain both the rapid increase in shear wave velocity away from the ridge and the attenuation pattern. Comparison of the attenuation of low frequency surface waves with high frequency body waves indicates that intrinsic attenuation is frequency dependent, but that the usually assumed power law form is unlikely to persist throughout the seismic frequency band.

Keywords: Attenuation, Oceanic Lithosphere and Asthenosphere