Determination of Intrinsic Attenuation in the Oceanic Lithosphere-Asthenosphere System

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Quantitative characterization of the physical properties of the oceanic lithosphere-asthenosphere system (LAS) is indispensable to our understanding of plate tectonics. P and S waves traveling through the oceanic LAS are known to have an anomalous feature of long lasting high frequency waves. A large number recordings of the 2011 Tohoku earthquake aftershocks by broadband ocean bottom seismometer arrays deployed in the NW Pacific provided an unprecedented opportunity to quantitatively separate the intrinsic (anelastic) and extrinsic (scattering) attenuation effects on seismic wave propagation in the pure-oceanic paths and to directly infer thermo-mechanical properties of the oceanic LAS.

For this end, we simulated energy transportation of higher frequency seismic waves (~3 Hz) in scattering media and compared the simulated and observed envelopes. The envelopes observed in the NW Pacific are characterized by larger amplitudes especially in S and quasi-exponential amplitude decay with distance. We showed that such features can be explained if and only if we have high intrinsic Q in the lithosphere and low intrinsic Q in the asthenosphere.

The strong intrinsic attenuation in the asthenosphere obtained in this study (~3 Hz) is comparable to that constrained at lower frequency (~100 s) by surface waves and suggests frequency-independent anelasticity, while that in the lithosphere is frequency dependent. This difference in frequency dependence indicates that the strong and broad peak dissipation recently observed in the laboratory exists only in the asthenosphere and sheds new light on what distinguishes the asthenosphere from the lithosphere.

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