Seismic-Wave Attenuation and the Grain-Boundary Sliding Rheology: A Test for the MLD and the LAB.

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The lithosphere-asthenosphere boundary (LAB) and the mid-lithosphere discontinuity (MLD) are both seismic features where seismic wavespeeds drop by 2-10% over a short depth range. Detectable as interfaces that cause Sp and Ps scattering in body-wave coda, the geophysical cause of these seismic features is controversial. Partial melt, frozen melt of hydrous rock, anisotropic twists and physical dispersion from elastically accommodated grain-boundary sliding (EAGBS) have all been cited as causative factors. The EAGBS model predicts a frequency-dependent shear modulus that transitions from "unrelaxed" to "relaxed" rheology in the body-wave frequency band at a depth between 70- and 150-km where temperatures approach, but still are below, the solidus. A key feature of the EAGBS model is a peak in attenuation where velocity reduction occurs, in both depth and in frequency band. If frequency-dependent attenuation exists in a shallow layer of the upper mantle, how would we detect it? We adapt 1-D reflectivity algorithms to compute and compare waveforms from (1) elastic non-dispersive velocities, (2) non-dissipative velocities that exhibit EAGBS physical dispersion, (3) dissipative non-dispersive velocities, and (4) velocities that exhibit both EAGBS dissipation and physical dispersion. Using an Earthscope-derived continental velocity profile with an MLD, we insert physical dispersion directly into the reflectivity computation, and we estimate attenuation as a first-order perturbation. We incorporate the internal-layer boundary conditions of Wu and Chen (2016) to stabilize propagating modes that are trapped in low-velocity layers.

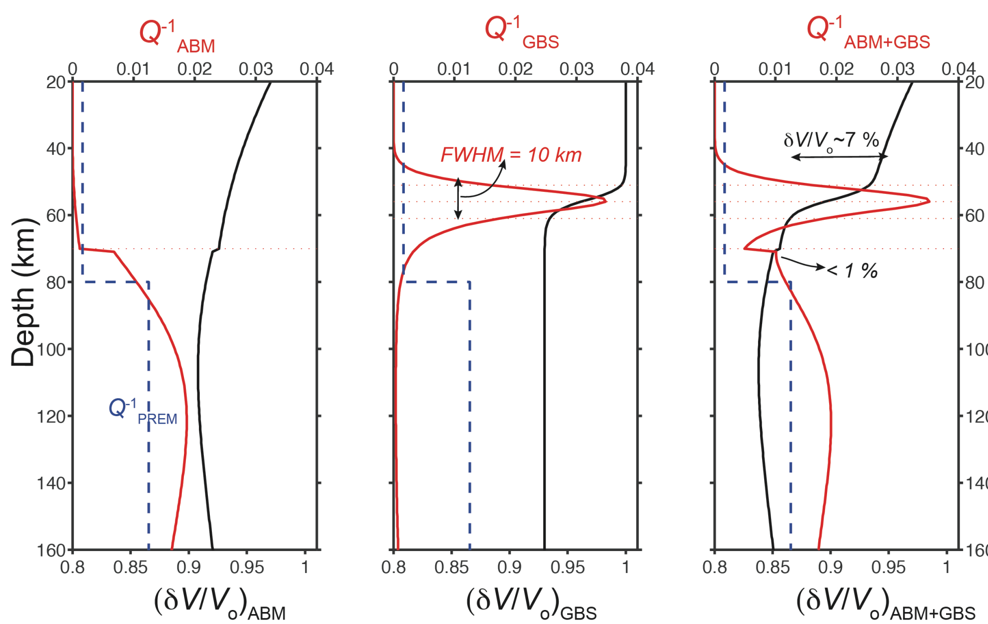

Figure 13 from Olugboji et al (2013): The variation of attenuation, Q^{-1} (red line) and relative velocity reduction $\delta V/V_o$(black line) with depth, for an absorption band model (ABM), an elastically-accommodated grain-boundary sliding (EAGBS) model, and both contributions (ABM+EAGBS). The curves are calculated for a young ocean (t= 45 Ma), using the half-space cooling model. The relative velocity change for the absorption band model is gradual, except around the 70 km dehydration horizon, where the velocity reduction <1 %, due to the change in water content. The relative velocity change due to the grain boundary sliding is much larger, ~7% and is much gradual – over 10 km (measured using the FWHM, full width half maximum, or the broadness of the dissipation peak), this number depends on the parameters of the grain-boundary sliding parameters. The combined contributions (ABM+EAGBS), suggest that at this age, young oceans, the largest contribution to velocity reduction is due to the grain-boundary sliding (<7%), compared to the smaller prediction of <1% from the absorption band model.

Olugboji, T. M., S.-I. Karato, and J. J. Park (2013), Structures of the lithosphere-asthenosphere boundary: mineral physics modeling and seismological signatures, *Geochem. Geophys. Geosyst., 14*, 880-901, doi:10.1002/ggge.20086.

Wu, B., and X. Chen, (2016), Stable, accurate and efficient computation of normal modes for horizontal stratified models, *Geophys. J. Int., 206*, 1281–1300, doi: 10.1093/gji/ggw209.