Shear attenuation and anelastic mechanisms in the central Pacific upper mantle

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We determine the mantle attenuation (1/Q) structure beneath 70 Myr seafloor in the central Pacific. We use long-period (33-100 sec) Rayleigh waves recorded by the NoMelt array of broadband ocean-bottom seismometers. After the removal of tilt and compliance noise, we are able to measure Rayleigh wave phase and amplitude for 125 earthquakes. The compliance correction for ocean wave pressure on the seafloor is particularly important for improving signal-to-noise at periods longer than 55 sec. Attenuation and azimuthally anisotropic phase velocity in the study area are determined by approximating the wavefield as the interference of two plane waves. We find that the amplitude decay of Rayleigh waves across the NoMelt array can be adequately explained using a two-layer model: in the shallow layer, in the deeper layer, and a transition depth at 70 km, although the sharpness of the transition is not well resolved by the Rayleigh wave data. Notably, observed in the NoMelt lithosphere is significantly higher than values in this area from global attenuation models. When compared with lithospheric measured at higher frequency (~3 Hz), the frequency dependence of attenuation is very slight, revising previous interpretations. The effect of anelasticity on shear velocity (V_S) is estimated from the ratio of observed velocity to the predicted anharmonic value. We use laboratory-based parameters to predict attenuation and velocity-dispersion spectra that result from the superposition of a weakly frequency dependent high-temperature background and an absorption peak. We test a large range of frequencies for the position of the absorption peak (f_e) and determine, at each depth, which values of f_e predict and V_S that can fit the NoMelt and V_S values simultaneously. We show that between depths of 60 and 80 km the seismic models require an increase in f_e by at least 3-4 orders of magnitude. Under the assumption that the absorption peak is caused by elastically accommodated grain-boundary sliding, this increase in f_e reflects a decrease in grain-boundary viscosity of 3-4 orders of magnitude. A likely explanation is an increase in the water content of the mantle, with the base of the dehydrated lid located at ~70-km depth.

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