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Constraints on thin layers with high-attenuation and low-velocities in the mantle

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We propose a new methodology based on Ps receiver functions to constrain anelasticity in thin seismically attenuating layers. At low incidence angle and due to partitioning of seismic energy, the effect of anelasticity is to increase the amplitude of the seismic pulse converted at the top of the attenuating layer, and to decrease the amplitude of the pulse converted at the bottom of the layer. We theoretically demonstrate this principle, and verify it with numerical simulation of wave-propagation in spherical Earth's models. We show that the elastic and anelastic contributions to seismic velocities have different effects on the amplitudes, hence allowing the separation of both contributions in narrow sub-horizontal regions of the Earth. We discuss here the potential application in characterizing a thin (∼10s km) low-seismic velocity zone on top of the olivine to wadsleyite $(Mg,Fe)_2SiO_4$ phase transition in the uppermost mantle transition zone (∼410 km depth) [1]. This zone has several possible origins, including dehydration-induced partial melting [2] or softening at the early stage of transformation due to the presence of an intermediate spinelloid phase [3]. We show how upscaling the results of laboratory experiments [2, 4] may help in alleviating the trade-off between elastic and anelastic contributions to seismic velocities, and inferring what is the physical mechanism at the origin of attenuation. Finally, we extract the elastic and anelastic contributions to a low-velocity zone observed atop the 410-km discontinuity below the dense Transportable Array seismic network in the western US [5].

References:

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