Viscoelasticity of the lower mantle from forward modeling of normal modes and solid Earth tides

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Published period dependence of normal modes and solid Earth tides



Seismic absorption band ends (Lekic et al., 2009) at the onset of absorption band for solid Earth tides (Benjamin et al., 2006)

Aim: reconcile the observations with a single viscoelastic model

Experimentally based model of viscoelastic behavior of olivine



Extended Burgers model: high frequency absorption peak followed by broad absorption band with seamless transition to viscous behavior

Faul and Jackson, 2015

Data spanning more than six orders of magnitude in period



 Q_{\oplus}^{-1} 'Earth response function',

not the same as intrinsic Q⁻¹ measured for a material
 calculated with intrinsic Q⁻¹ (P, T, period), including planetary self-gravity and inertia (Lau et al., GJI, 2017)

Sensitivity kernels: Data was selected to have sensitivity kernels as similar as possible to avoid depth corrections



Variation of Q⁻¹ at fixed pressure



Parameter range considered at two fixed pressures: temperature (a), grain size (b), relaxation strength (c) and activation volume (d)

Activation volume shifts high frequency peak the most.

Range of model parameters used in forward calculations



Results: data (black symbols) and calculated Earth response function for a range of parameters as a function of period. Black squares show enlarged data groupings.

Lower panels again show Q-1 at fixed pressure for a range of parameters



Model tests



orange modes were used in original forward modeling
green modes were calculated
with best fitting model parameters
black bars show range of
observations

Thermal boundary layer (TBL) at core-mantle boundary has essentially no effect on calculated response

Summary

- Extended Burgers model with high frequency peak (B) and absorption band (B) is adapted to lower mantle lithology
- Calculation of an Earth response function with extended Burgers model, self gravity and inertia
- Selection of data (modes and tides) with similar depth sensitivity
- Forward modeling of modes and tides for a range of parameters in the Burgers model

Single viscoelastic model can reconcile observed for normal modes a

