Using Seismic Tomography to Estimate the Magnitude of Lateral Variation in Effective Mantle Viscosity

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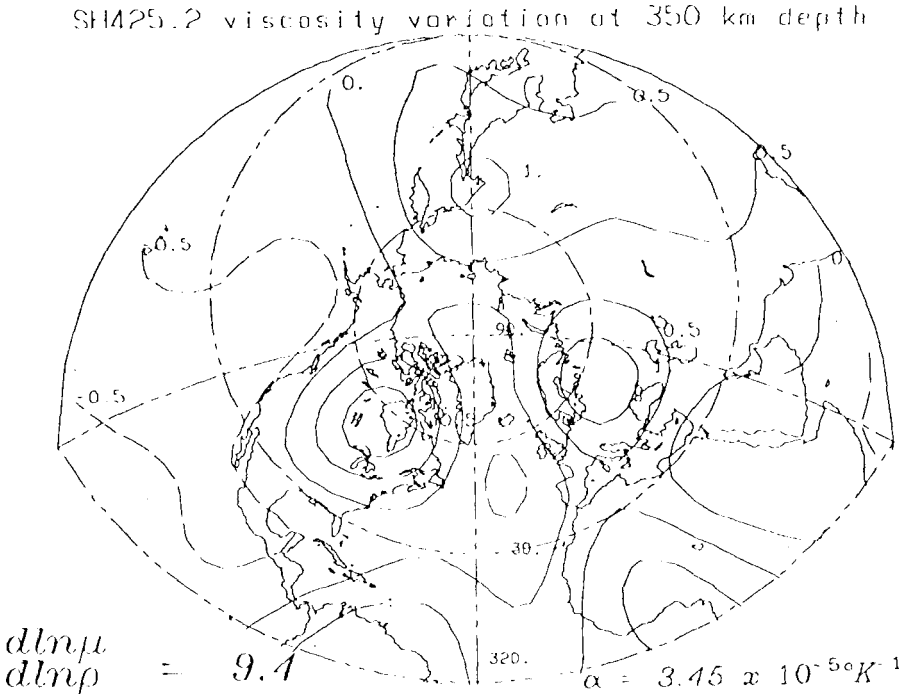
Recent tomographic views of mantle v_S are used to estimate corresponding lateral variations in effective viscosity under the assumption that temperature fluctuations, δT, about spherically symmetric mean values, $T_o(r)$, are the sole source of shear wave velocity anomalies. Empirical velocity-density relations and estimates of the depth-dependence of the coefficient of thermal expansion allow an estimate of δT to be calculated from the lateral structure of v_S. Creep laws are used to convert δT into predictions of lateral variations in viscosity. We find that the ratio of local to spherically symmetric viscosity, $\Delta\eta(r,\theta,\lambda) \equiv \eta(r,\theta,\lambda)/\eta_o(r)$, varies, peak-to peak, by one to four orders of magnitude, depending upon the choice of thermodynamic parameters. A typical result is shown in the figure below. Here contour intervals are 0.5 $\log_{10}\Delta\eta(r,\theta,\lambda)$.



One obvious consequence of large lateral structure in viscosity is the potential for corrupting any simple extraction of an "average" viscosity value for the mantle from post-glacial rebound models. Note that both Fennoscandia and Laurentide provinces lie over viscosity highs. A second, less obvious, consequence of large viscosity fluctuations is that these affect mantle attenuation and dispersion at very low frequency and long wavelength (tides and Chandler wobble). A composite viscoelastic model is used to fit the entire spectrum from seismic frequencies to the 18.6 year tide. Soft inclusions in a hard matrix provide the required response at tidal frequencies while a spectrum of dislocation mechanisms in both phases control response in the seismic band, exactly as in previous layered single phase models.

1. 1994 Spring Meeting
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4. T
5. (a) T041 Lat. Var. Viscosity
   (b) 5144 Wave atten.
   8160 Rheology of the lithosph. and mantle
6. O
7. 5%
8. 70.00 U.S. check enclosed
9. C
10. None
11. Yes