Geophysical Research Abstracts
Vol. 12, EGU2010-5683-1, 2010
EGU General Assembly 2010

Elastic and inelastic properties of Earth analogue materials determined from forced oscillation experiments

Christine McCarthy (1), Yasuko Takei (1), Takehiko Hiraga (1), and Kazuhiro Fujisawa (2)

(1) University of Tokyo, Earthquake Research Institute, Tokyo, Japan (mccarthy@eri.u-tokyo.ac.jp), (2) Japan Patent Office, Tokyo, Japan

Recent seismological studies provide three-dimensional and highly resolved Q structure of the upper mantle. Interpretation of seismic data for thermodynamic state and dynamics, however, is still difficult because the influence on velocity and attenuation by wave frequency, temperature, grain size and/or the presence of melt is still poorly understood. Laboratory experiments are thus needed to investigate these influences and to understand the physical processes by which wave absorption at seismic frequencies occurs. The high temperatures and pressures needed to recreate mantle conditions, however, make experimental studies difficult and limit the range of conditions that can be explored.

To avoid these complications, we employ an organic binary system as an analogue to geologic materials. With a eutectic melting temperature (T_E = 316 K) just above room temperature (at ambient pressure), borneol-diphenylamine has been found to provide an attractive chemical analogue to study the influence of melt, obviating the difficulties associated with high-temperature, high-pressure experimentation. Borneol-diphenylamine exhibits a moderate and controllable dihedral angle (40° at 316 K) that provides an equilibrium melt-geometry very similar to that of the olivine + basalt system [*Takei*, 2000]. In order to isolate the effect of melt from those of temperature and grain size, we first seek to characterize these effects on the response of the pure solid phase (borneol; T_m = 478K). Very fine-grained samples are prepared by cold-milling of borneol crystals. Controlled grain growth during subsequent annealing yields specimens with desired grain sizes. Our custom-fabricated, forced-oscillation apparatus measures phase lag (Q^{-1}) and Young's modulus (E) separately with great precision over a broad range of frequencies (10 – 10^{-4} Hz). Although both anelastic and viscous responses are included in this frequency range, they can be separated by using Q^{-1} and E obtained independently. The purely anelastic response is described by the relaxation strength spectrum.

The remarkable results that we have obtained so far are as follows: (1) The relaxation spectrum for pure borneol (at T/T_m = 0.64) displays a power law relationship, i.e. $Q^{-1} \propto f^{-m}$ (where m is between 1/6 and 1/4) over several decades in frequency and over a range of grain sizes, consistent with the so-called high-temperature background; (2) Additionally, we observe a negative grain size dependence of attenuation at low frequencies (<0.1Hz), but see no such dependence at high frequency (>1Hz). Although such a transition to a grain-size independent regime was not observed in previous studies performed in limited frequency ranges [e.g. *Jackson et al.* 2002], its existence is quite reasonable, since the unrelaxed modulus measured by ultrasonic frequency does not depend on grain size. Understanding the physics of this transition is needed to extrapolate this result to mantle conditions. Our initial results indicate that both our approach and apparatus are successful at obtaining high quality data over a much broader range of frequency space than previously possible.

Jackson, I. J.D. Fitz Gerald, U. H. Faul, and B.H. Tan (2002) Grain-size-sensitive seismic wave attenuation in polycrystalline olivine, *J. Geophys. Res.* 107:B12.

Takei, Yasuko (2000) Acoustic properties of partially molten media studied on a simple binary system with a controllable dihedral angle, *J. Geophys. Res.*, 105:B7, 16,665-16,682.