Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG59-14 Room:106 Time:May 28 11:15-11:30

Elasticity, anelasticity, and viscosity of a polycrystalline material at near-solidus temperatures

YAMAUCHI, Hatsuki[1*] ; TAKEI, Yasuko[1]

[1]Earthquake Research Institute, The University of Tokyo

For a quantitative interpretation of seismic structures in the earth's interior, understanding of rock anelasticity over a broad frequency range is needed. There are high-Q^{-1} and low-V regions in the upper mantle. To interpret them, it is important to understand effects of melt on anelasticity.

Anelasticity of mantle rock or rock analogue at seismic frequencies have been measured intensively. We use polycrystalline aggregates of organic "borneol" as rock analogue to accurately measure the anelastic properties over a broad frequency range. A sample made from borneol + diphenylamine binary system partially melts at T_m = 43 ℃ and its equilibrium microstructure is quite similar to that of olivine + basalt system.

Using these samples, forced oscillation tests have been performed to measure anelasticity as a function of frequency f, temperature T, grain size d, and melt fraction ϕ. McCarthy et al. (2011) showed that polycrystal anelasticity follows the Maxwell frequency (f_M) scaling, by demonstrating that all attenuation spectra Q^{-1}(f) obtained under various experimental conditions collapse onto a single master curve $Q^{-1}(f/f_M)$. However, this result was obtained from the data at $f/f_M < 10^5$, which is lower than the seismic frequencies normalized to f_M in the upper mantle ($10^6 \leq f/f_M \leq 10^9$). Recently, Takei et al. (2014) measured Q^{-1} of rock analogue up to $f/f_M \sim 10^8$ and showed that the Maxwell frequency scaling is not fully applicable to $f/f_M > 10^4$. They showed that the deviation from the master curve increases with increasing homologous temperature T/T_m (T_m: solidus temperature) and/or grain size. Based on their results, they speculated that at near-solidus temperatures high Q^{-1} and low V can occur even without melt. However, their data were limited to $T/T_m \leq 0.93$. Data at $T/T_m > 0.93$ are needed to examine the detailed behavior at the onset of melting.

In this study, we prepared 4 samples made from borneol + diphenylamine binary eutectic system with different grain sizes and melt fractions. Anelasticity of these samples was measured at near-solidus temperatures ($0.88 \leq T/T_m \leq 1.01$). In order to clarify the mechanism of anelasticity, mechanical data over a broad frequency range are needed. Therefore, in addition to forced oscillation tests, ultrasonic tests and creep tests were conducted to measure elasticity and viscosity at the same temperature conditions.

The samples were pre-annealed at supersolidus temperatures to prevent the rapid grain growth at the onset of melting. This improvement enabled us to measure elasticity, anelasticity, and viscosity at near-solidus temperatures and examine how these properties behave at the onset of melting. We found that although the ultrasonic velocities are discontinuously reduced by the poroelastic effect of melt, anelasticity and viscosity changed continuously with temperature even at the onset of melting. Based on these data, an empirical formula of the relaxation spectrum X was obtained as a function of nondimensional variables f/f_M and T/T_m. A preliminary appreciation of the formula to the upper mantle suggests that high Q^{-1} and low V can occur at near-solidus temperatures even without melt. It also suggests that seismic attenuation changes continuously even at the onset of melting, whereas seismic velocity changes discontinuously due to the poroelastic effect of melt.

In this study, the temperature dependence of anelasticity could be captured at near-solidus temperatures, but dependences on the grain size and melt fraction couldn't be captured. This is because the samples that experienced partial melting show various hysteresis effects, and the hysteresis effects masked these effects. Our next step is to investigate effects of grain size and melt fraction on anelasticity by using samples that do not experience partial melting and hence are free from the hysteresis effects.

Keywords: anelasticity, seismic attenuation, melt