Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

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In the mantle wedges near subduction zones, seismic high attenuation $Q^{-1} > 0.01$ (or low $Q < 100$) is observed (e.g., Abers et al., 2014, G^3). Partial melting is generally considered as the main cause, but it is still difficult to interpret quantitatively how much melt exist there or how high temperature is. Although poroelastic effect of melt can be estimated theoretically (e.g., Takei, 2002, *JGR*), anelastic effect of melt is poorly understood. Recently, we experimentally captured that, when melt fraction is larger than 1%, anelastic relaxation of polycrystalline material is significantly enhanced by melt (Yamauchi and Takei, 2016, *JGR*). However, accurate measurement of the effect of melt on anelasticity is difficult, because a rapid grain growth occurs at the onset of melting, obscuring the effect of melt. In this study, we develop a new method to prepare samples suitable for the measurement of melt effect, perform the measurement, and establish a model of rock anelasticity applicable to the mantle both at subsolidus and supersolidus temperatures.

We use polycrystalline aggregates made from borneol + diphenylamine binary eutectic system (eutectic or solidus temperature T_m = 316 K) as a partially molten rock analogue. This system has an equilibrium microstructure similar to that of olivine + basalt system (Takei, 2000, *JGR*). Samples used in this study have a few wt% diphenylamine. Above T_m, all diphenylamine grains disappear into the melt phase. In Yamauchi and Takei (2016), to prevent the rapid growth of borneol grains during the mechanical tests at supersolidus temperatures, testing samples were pre-annealed at the supersolidus temperature ($T/T_m \simeq 1.03$), cooled, and again partially molten to measure the melt effect without grain growth. In this previous experiment, quenched melt network remained even at $T/T_m < 1$. Therefore, the effect of microstructural change at $T/T_m = 1$ from dispersed diphenylamine grains to a connected melt network could not be examined. We have to improve the sample preparation method to clarify the effect of melt-network formation so that we can detect the existence/nonexistence of melt in the upper mantle by using the seismic data.

In this study, after partially melting a sample at supersolidus temperature ($T/T_m \simeq 1.03$) for grain growth, we kept the sample at just below the solidus ($T/T_m \simeq 0.99$) to promote the growth of diphenylamine grains from the quenched melt network. After 50-80 days, we successfully obtained a sample which is composed of large borneol grains and dispersed diphenylamine grains. We prepared two samples with melt fractions 4.5% and 3.7%. We will prepare an additional sample with different melt fraction. Using these samples, accurate measurements of elasticity at 1 MHz, anelasticity at 10^2-10^{-4} Hz, and viscosity will be performed at various temperatures from below to above the solidus temperature (T/T_m = 0.89 to 1.01). Data at $T/T_m < 1$ can be used to reproduce the subsolidus effect (due to grain-boundary premelting) captured in Yamauchi and Takei (2016). Data at $T/T_m \geqq 1$ can be used to clarify the melt effect. In the presentation, we will show these mechanical data and discuss seismological implications inferred from them.

Keywords: anelasticity, seismic high attenuation, partial melting, the effect of melt, melt network

