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Experimental study of anelasticity of a polycrystalline material for seismological application

TAKEI, Yasuko[1*] ; YAMAUCHI, Hatsuki[1] ; KARASAWA, Fumiya[2]

[1]Earthquake Research Institute, Univ. of Tokyo, [2]Yahoo, Japan

Rock anelasticity causes dispersion and attenuation of seismic waves. Therefore, for the quantitative interpretation of seismic low velocity and/or low Q regions in the upper mantle, understanding of rock anelasticity is necessary. However, due to the difficulty of forced-oscillation experiment under high-temperature ($>1000^{o}$C) and small strain ($<$10ˆ-6) conditions, systematic data on rock anaelasticity, needed for the understanding of underlying mechanisms, have not been obtained adequately. To address this lack of data, data from rock analogue (polycrystalline organic borneol) will be of merit. Our recent result published in McCarthy et al (2001) has shown that anelasticity of polycrystalline materials is subject to the Maxwell frequency scaling: Q = Q(f/fm). However, the applicability of this scaling to the seismic dispersion and attenuation has not been guaranteed because experimentally testing frequencies normalized to the Maxwell frequency fm of the laboratory samples are usually much lower than the seismic range in the upper mantle ($10^6 <$ f/fm $< 10^9$). In this study, by using borneol as an analogue to mantle rock, we measured anelasticity up to higher normalized frequencies (0.1 $<$ f/fm $< 10^8$), and examined the applicability of the Maxwell frequency scaling to these new data. The obtained data show that the Maxwell frequency scaling is no more applicable to higher normalized frequencies than f/fm = 10^4, where attenuation spectra plotted as functions of f/fm scatter significantly by temperature, grain size, and impurity. Especially, a small amount of impurity (diphenylamine) significantly enhanced the anelastic relaxation. The addition of dyphenylamine to borneol significantly lowers the melting temperature from Tm=477 K to Tm=316 K. From these results, we have speculated that the enhancement of anelasticity with impurity and/or temperature might be scaled by T/Tm. If this speculation is true and can be generalized to the other polycrystalline materials, it will give a crucial insight for the underlying mechanism. Because T/Tm is close to one in the upper mantle and it is important to investigate the detailed behavior of anelasticity near T/Tm=1.

Keywords: anelasticity, polycrystalline material