Development of the cyclic-deformation apparatus: an approach to the attenuation of seismic waves in the solid-liquid composites

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Seismic wave attenuation is an indicator of temperature and/or liquid content in the Earth interior. We developed a cyclic deformation apparatus to measure the anelastic properties of partially molten samples in the frequency range from 10 mHz to 1 kHz. The characteristics of the apparatus are summarized as follows.

(1) A cyclic uniaxial load is applied to an analogue partially molten sample, while the stress and strain of the sample are measured. A multilayer piezoelectric actuator is used as a loading system. Strain amplitude should be as small as 10^-5, so that the data are not affected by crack opening and sample non-linearity. A laser displacement meter with a resolution of 10^-8 m is used to measure the displacement of the sample (about 10^-6 m). Stress (30 kPa) is measured by the load cell.

(2) Q^-1 is estimated using a phase lag between stress and strain. Resonant frequencies of the sample and the apparatus should be much higher than the frequency of cyclic deformation (10 mHz to 1 kHz), so that the phase lag between stress and strain can be directly related to the sample anelasticity.

(3) Mechanical coupling between the sample and the apparatus is important to avoid the frictional energy dissipation. In the present apparatus, a constant uniaxial load is applied to the sample in addition to the cyclic load used for the anelasticity measurement.

(4) A binary eutectic system of organic materials (eutectic temperature=43^oC) is used as a partially molten rock analogue. The dihedral angle is controlled in the range from 35^O to 17^O, close to that of rock + melt systems [Takei, 2000]. The Young modulus of the sample is about 3 GPa. The experiments are conducted within a constant temperature chamber.