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Anelasticity measurement at high pressure and temperature

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Physical property measurements at high pressure and temperature are fundamentally important for understanding the process governing crust and mantle dynamics. When a material includes fluid and/or melt, pressure is necessary to keep fluid geometries and phase relations stable. Because of technical difficulties, most measurements have been carried out for acoustic velocities at pressures below 1 GPa and temperatures below 900C. Acoustic anelastic properties have only rarely measured at high pressure and temperature. Velocities measured by using multianvil press or diamond anvil cell with Brillouin spectroscopy need to be confirmed by acoustic data from a piston cylinder apparatus.

Here we have developed a method to determine accurate attenuation at high hydrostatic pressures and high temperatures. We determined compressional-wave attenuation of a fused quartz to 1185C at 1 GPa. P-wave velocities of a fused quartz have been determined by Aizawa and Ito (2001). A piston-cylinder type apparatus is suited to generate a high hydrostatic pressure that is necessary to make accurate physical property measurements in a pressure vessel. Lithium niobate transducers (6.6 MHz resonant frequency) were used to generate and receive the compressional waves. The received signals were amplified, digitized and averaged by a 1 GHz digital oscilloscope. The signal-to-noise ratios were improved by averaging the amplitude of repeated wave forms. Even at 1185C, we obtained good signal-to-noise ratios for velocity and attenuation measurements. The sample temperature was increased by a graphite heater.

Accurate attenuation coefficients were determined by observing both the first (direct) and second (reflected) arrivals, and taking the spectral ratios of the two arrivals. As the temperature increases, quality factors of not only the sample but also the buffer rods decrease. And properties of transducers may change at high temperature. The unknown extrinsic effects, including reflections, assembly geometries, and frequency characteristics of transducers and instruments being common to both spectra, are cancelled out by taking the ratio of the spectra of first and second arrivals. Measured Q values of a fused quartz rapidly decrease with increasing temperature at 1 GPa. We will discuss the anelastic properties of a fused quartz and related glasses. Although measurements were carried out to 1185C in this study, the platinum rod and other assembly materials can be used to 1400C, that would be a highest temperature achieved in the present method.

Fluids in rock samples will dramatically reduce Q values. We are now planning to perform velocity and anelasticity measurements on rock-fluid systems.

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