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Characterization of heterogeneity and wave propagation in partially frozen brines

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Often, the loss mechanisms responsible for seismic attenuation are unclear and controversial. In terms of a plausible mechanism for attenuation in ice-brine coexisting systems, we must consider the physical interactions between pore fluid and ice. We used partially frozen brine as a solid-liquid coexistence system to investigate attenuation phenomena. Ultrasonic wave transmission measurements on ice-brine coexisting system were conducted in order to examine the influence of unfrozen brine in the pore microstructure on ultrasonic waves. During the growth of ice from brine, salt cannot be incorporated into the ice crystals. As the ice freezes, the salt is rejected as concentrated brine, thus successively lowering the freezing point of the remaining fluid. Some of this brine drains out through channels as the ice grows, but much of the brine remains trapped between ice crystals. In this system, the amount of unfrozen brine can be controlled by varying the temperature. We quantitatively estimated attenuation in a frequency range of 350-600 kHz by considering different distances between the source and receiver transducers. The attenuation results measured from our experimental data are not entirely due to the intrinsic properties of the ice-brine coexisting system; a component of attenuation due to scattering effects is also included in the estimate. The level of scattering attenuation is related to the magnitude heterogeneity of acoustic impedance between ice and unfrozen brine. If the wavelength of seismic wave is much longer than the scale length of heterogeneity in an ice-brine coexisting system, the system is considered to be homogeneous material. We investigated the microstructural evolution of brine inclusions in granular and columnar ice through MRI (Magnetic Resonance Imaging) measurements. The scattering effect might be dominant at the temperature where the pore dimension is largest, and decrease with decreasing temperature. To isolate intrinsic attenuation from total attenuation, scattering attenuation must be estimated from the information of the microstructure of an ice-brine coexisting system. We condected observations of the pore microstructure of an ice-brine coexisting system to estimate the component of scattering attenuation.