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Numerical simulation of wave propagation in the media based on MRI measurement of partially frozen brines

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We used partially frozen brine as a solid-liquid coexistence system to investigate attenuation phenomena in laboratory experiments. Attenuation results measured from 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. In this paper, to isolate intrinsic attenuation from total attenuation, scattering attenuation is estimated based on synthetic data generated from the information of the microstructure of an ice-brine coexisting system by conducting Magnetic Resonance Imaging (MRI) measurements. There are, to our knowledge, few laboratory measurements of attenuation that take account for the effect of scattering attenuation. We obtained a series of two-dimensional apparent diffusion coefficient (ADC) maps of the ice-brine coexisting system using diffusion-weighted magnetic resonance imaging (DW-MRI) technique at temperature of ?5 degree C to find strongly heterogeneous spatial distribution of unfrozen brine. We constructed a synthetic seismic data set propagating through two-dimensional media based on ADC maps and generated synthetic data with a second-order finite difference scheme for the two-dimensional acoustic and elastic wave equation. Each pixel in MR images has a 16-bit gray scale depth. Velocities of P- and S-wave are assigned to each pixel by assuming that high diffusivity is water and low diffusivity is ice and the velocity and density values are linearly interpolated between water and ice. We estimated ultrasonic scattering attenuation in such a system by using the centroid frequency shift method, assuming that the quality factor (Q-value) is independent of frequency.