Elastic Wave Velocity Model Analyses for Gas-Hydrate Bearing Sediments

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Understanding gas-hydrate concentration and distribution effects on seismic wave velocities of the gas-hydrate bearing sediment is important for using seismic exploration technique to identify the gas-hydrate bearing zones and evaluate gas-hydrate concentration. Usually, a gas-hydrate formation is considered to be a multiphase porous elastic medium. At certain formation conditions, it contains solid substrates, gas-hydrates and free water that are filled in formation pores. In our work, a random medium model is proposed for full elastic wave modeling, in which the gas-hydrates and water are supposed to be filled in the medium pores, forming an inhomogeneous medium. Therefore, the gas-hydrate bearing formation is assumed to consist of three kinds of elastic media. The first is a fluid, i. e., water, and the second is a solid, the gas-hydrate, while the third is also a solid, the solid substrate. In order to simulate a multiphase porous elastic medium, i.e., the gas-hydrate bearing sediment, the total fraction for water and gas-hydrate is equal to the formation porosity.

A random number function is used to generate random distribution models for the three components with a certain fraction of water, gas-hydrate and solid substrate. Various gas-hydrate concentration models are generated and the elastic wave propagation is simulated using our high-order staggered finite-difference method to investigate gas-hydrate concentration and distribution effects on elastic wave field and velocities. Through these studies, elastic wave field in various random models are given and compressional velocities for various random models with various frequencies are estimated from calculated synthetic waveforms.

Our numerical modeling analyses show that, the compressional wave velocities are strongly affected by, in addition to the solid substrate, source centre frequency, gas-hydrate concentration. Also, elastic wave velocities obtained using the time-average equation, the Gassmann model, the Biot-Gassmann model, and the LCA model are compared.