AAPG Annual Convention
Salt Lake City, Utah
May 11-14, 2003

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Rock Physics for Gas Hydrate Reservoir Characterization

Enormous amounts of methane gas hydrate are present in sediments under the world's oceans as well as in on-shore sediments in the Arctic. These hydrates are a potential future energy resource. The most well-developed geophysical tool for exploring large volumes of the subsurface where gas hydrate is found is seismic reflection profiling. However, to characterize a natural gas hydrate reservoir with seismic data, we must be able to relate the elastic properties of the sediment to the volume of gas hydrate present. One way of achieving this goal is through rock physics effective-medium modeling. It appears that the effective elastic moduli of sediments strongly depend not only on the volume of hydrate but also on its position within the pore space. We offer a first-principle-based effective medium model for the elastic-wave velocity in unconsolidated, high-porosity ocean-bottom sediments with gas hydrates. The elastic constants of the dry-sediment frame depend on porosity, elastic moduli of the solid phase, and effective pressure. To account for the effect of gas hydrate on sediment elastic moduli we assume that hydrate becomes part of the solid phase thus modifying the porosity and elasticity of the frame. The model is applied to real sonic and seismic data and helps accurately quantify the concentration of methane hydrate in the pore space as well as free gas quantity below the hydrated zone.