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Elastic Properties of Oil Sands

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Heavy oil and bitumen have become tremendously important resources for us in this decade. Properties of them significantly differ from conventional oil. They are characterized by several features; higher viscosity, higher density, higher seismic attenuation, higher velocity dispersive, and so on (Han et al., 2006; Batzle et al., 2006; Mochinaga et al. 2006).

The SAGD method is one of the most effective methods for producing the bitumen in Canada. It makes the bitumen flowable by heating it with injected steam and reducing its viscosity. The steam movement is highly influenced by complex substructure in the reservoir. The time-lapse seismic survey is expected to be powerful for monitoring the three-dimensional steam movement. However, there remain the difficulties of how to make quantitative interpretation of the time-lapse data because there is no model of relating seismic velocities of bitumen-saturated sediments (oil sands) directly with reservoir parameters (temperature, pressure, and saturation).

We measured and analyzed ultrasonic velocities of the oil sands acquired from the SAGD operation area and then obtained a relation of the velocities with temperature and pressure individually. We investigated validity of the Gassmann equation for predicting velocity changes. Consequently, we concluded that the Gassmann equation can be applicable at temperatures greater than 80 degrees Celsius. We combined the laboratory measurement results to obtain a sequential rock physic model that can predict velocity changes induced by steam injection. We finally predicted elastic property changes during the steam injection according to the model. P-wave velocity is a relatively all-around player for distinguishing the steam fronts, while S-wave velocity can be used only for distinguishing the gentle-warmed area.