Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-10 Room:203 Time:May 21 16:45-17:00

2D elastic full-waveform inversion for estimating fluid distribution in hydrocarbon reservoir

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Seismic full-waveform inversion (FWI) method has been used to estimate subsurface velocity structure. FWI directly utilizes observed waveforms that could include information on the properties of subsurface materials. In seismic time-lapse surveys, we observe the difference between waveforms as a function of time for the change such as fluid alteration. Residual waveforms between the observed before and after a certain time interval are used to estimate the changes in the fluid distribution in terms of seismic velocities in FWI method.

In contrast to the previous FWI applications, our research focuses directly on the properties in the hydrocarbon reservoir in order to estimate the fluid distribution and alteration. We simulate the wave propagation based on the Biot theory that includes the effects of fluid in porous media. The simulation model is composed of a block of sandstone saturated with water and gas. We assume a transition zone around the fluid contact, whose vertical profile of the saturation rate varies gradually in time in this zone. Since the P-wave velocity distribution shows little change during the movement of fluid contact in our model, we focus on the S-wave velocity distribution with an elastic FWI method. The waveforms of the P-S converted contribute to the inversion of S-wave velocity distribution, although those of the direct P could distort the results. The separation of the P-S converted waves from the acquired could be a possible scheme for the estimation of S-wave velocity distribution.