Time-lapse 3D seismic monitoring in the Athabasca oil sands development area in Canada

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Time-lapse 3D seismic monitoring study was conducted in the Japan Canada Oil Sands Limited (JACOS) Hangingstone steam-assisted gravity drainage (SAGD) operation area, Alberta, Canada. The objective of the study was to delineate the steam affected zone with the 3D seismic data acquired at different production stages.

The oil sands reservoirs in the Hangingstone area occur in the Lower Cretaceous McMurray formation and are approximately 300m deep. Sedimentary environments of the McMurray formation are considered as fluvial to upper-estuarine channel fill deposits. The oil sands reservoirs were formed as the vertically stacked incised valley fill sands and their distribution is very complex both vertically and horizontally.

The time-lapse surveys were acquired in February, 2002 and in March, 2006. Detailed 3D geological models for reservoir characterization were constructed by integrating the first 3D seismic (baseline survey) and well data. These 3D models were used for optimizing the deployment of the new SAGD well pairs. The second 3D survey (monitoring survey) was conducted in the northern part of the baseline survey, where active SAGD wells exist. Repeatability is important for the time-lapse survey and the 3D seismic data were recorded with almost the same field acquisition parameters.

The data sets of both the baseline survey and the monitoring survey were processed with similar processing flows and parameters at the same time for the seismic monitoring study. Large differences in seismic character within the reservoir and time delays below the reservoir were clearly observed around the active SAGD well pairs.

In order to evaluate seismic responses changes of the time-lapse surveys, synthetic seismic data was simulated under various reservoir conditions in the SAGD process. The results of the seismic modeling gave us useful information about the P-wave velocity dependency on temperature, pore pressure and pore fluid change in the oil sands reservoir. From the seismic modeling study, the differences of the seismic responses between the time-lapse seismic volumes were interpreted as phenomena caused by P-wave velocity decrease of the oil sands layers due to the steam-injection.

As a result of the study, the time-lapse seismic data in the field show distinct seismic response changes around the SAGD well pairs in the reservoir zone due to the steam injection. The time-lapse seismic monitoring and the seismic modeling are very useful to investigate the rock property changes of the interwell reservoir sands in the field.