Reservoir Characterization Using Converted-Wave Seismic Data: Case Study from Lower Cretaceous McMurray Formation, Athabasca Oil Sands

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Abstract

Oil sand is unconsolidated sand, which contains bitumen and water. The oil-sand reservoirs are very heterogeneous at every scale and contain highly viscous oil (viscosity higher than 10,000 cp) which at the reservoir conditions cannot flow to a wellbore.

The Lower Cretaceous McMurray Formation reservoir used in this study is located in the Athabasca basin, of the Northern Alberta, Canada. High-resolution multicomponent 3D seismic data, along with cores and wells data were processed using the most advanced workflows in order to image the reservoir heterogeneity. These workflows include petrophysical analysis, joint PP-PS inversion and neural network analysis.

Three deterministic inversions using (1) only PP seismic, (2) PP and PS poststack seismic, and (3) PP and PS prestack seismic are analysed and compared. The joint PP-PS inversion of the prestack seismic data produces the best estimates of P-impedance, S-Impedance and density, allowing for excellent reservoir characterization of the Athabasca oil sands reservoir.

Neural network analysis is used to enhance the resolution of the elastic properties estimated from joint PP-PS prestack inversion, and to estimate petrophysical and engineering properties such as porosity, resistivity and saturation. In all neural network analyses, we find that the most significant seismic attributes include converted-wave information.

Some of the results of this study are: (1) converted-wave seismic data have a major role in oilsands reservoir characterization; (2) estimated density seismic volume shows a good separation of the two bitumen sands, vaguely identified on the similar volume obtained only from PP prestack inversion; (3) P-wave velocity seismic attribute allows mapping of the McMurray top which otherwise is very difficult based only on the PSTM stack; (3) estimated resistivity seismic volume allows not only to differentiate the reservoir from the non-reservoir but also bitumen sand from water sand.

Understanding the reservoir heterogeneity will have a significant impact on thermal recovery of the bitumen-saturated sands.