geoconvention
Calgary • Canada • May 7-11 2018

Enhance Reservoir Characterization at Narrows Lake Oil-sands Project by Using 3-Component Seismic

Weimin Zhang
Cenovus Energy Inc.
Carmen C. Dumitrescu
Terra-IQ Ltd.

Summary

This paper presents an analysis of various seismic inversions (deterministic and stochastic) to better understand the reservoir in the Cenovus Energy's planned Narrows Lake Thermal Project. The goal was to use quantitative interpretation of the 3-component (3C) seismic survey to better characterize the reservoir heterogeneity by detecting lithology changes and mapping the rich pay, non-rich pay and mudstone with special attention for the interval defined by the reservoir top and the reservoir base. This also provides a baseline image for future time-lapse evaluation of the steam movement in the SAGD (Steam Assisted Gravity Drainage) and/or Solvent Assisted Processes(SAP). The earth model will be built by using global and soft constraints generated from seismic analyses.

After extensive tests of various inversions, elastic properties from joint PP-PS prestack inversion provided the best correlations with over 100 wells available within the survey. Density inversion from 3C3D seismic data better separates pay from non-pay zone within the McMurray formation than previosuly used acoustic impedance. The elastic parameters estimated from inversion were further used in neural network analysis to derive total porosity, shale volume and resistivity seismic volumes.

The enhanced seismic reservoir characterization from 3C3D seismic data will reduce the number of Strat wells in the development area. As a result, the costs will be lower and there will be less impact on the environment . Our analyses of reservoir heterogeneities will contribute significantly to the accurate planning of future horizonal wells, which will make better reservoir performance under thermal operations. This methology could be applied to future development phases in Narrows Lake and other oil-sands projects.

Introduction

Cenovus Energy's Narrows Lake planned Thermal Project located just north of Christina Lake, 170 km South of Fort McMurray, Alberta, will use SAGD and/or SAP technologies to recover bitumen from the Lower Cretaceous McMurray Formation.

3C3D seismic was shot in March 2017 as a baseline, with 100 m source line and 60 m receiver line. Dynamite was the source in 9 m drill holes with a 250 g charge. Receiver interval is 20 m and shot interval is 40 m, producing CDP bins of 10 m x 10 m with a usable fold of 20-25 at offsets of 400 m (equivalent to reservoir depth). PP seismic data processing includes AVO compliant workflow for noise and multiple attenuation, 5D interpolation (COV domain) and prestack Kirchhoff time migration. Key PS processing processes are: layers PS splitting correction, 5D interpolation (COV domain) and prestack Kirchhoff time migration.

Method

Seismic inversion is recognized as a valuable technique to extract information about the geological properties of the reservoir. At the first level of classification, inversion methods could be poststack (developed in the 1970s) or prestack (developed in the 1980s and 1990s). Common industry practice is to use deterministic prestack inversion of the PP seismic and more recently of the PP and PS seismic data when available. Quantitative interpretation in a similar oil-sands reservoir situated a couple of Townships south of Narrows Lake project proved the benefits of using multi-component seismic inversion (Dumitrescu et al, 2014) in identifying two layers of sand which were not separated by the PP prestack seismic inversion. However, big progress was made, in the recent years, on the stchastic (or geostatistic) method. Each of these methods use different assumptions and have different limitations.

For this first inversion project in the Narrows Lake area we have tested the following inversions (using the same low-frequency model):

1. Deterministic poststack seismic inversion of the PP PSTM stack for impedance
2. Deterministic separate poststack inversion of the AVO P- and S-wave impedance reflectivity for P- and S-impedance
3. Deterministic simultaneous prestack PP seismic inversion for P- and S-impedance and Density
4. Deterministic joint PP-PS prestack seismic inversion for P- and S-impedance and Density
5. Geostatistic prestack PP seismic inversion for P- and S-impedance

In this paper, both simultaneous prestack PP seismic inversion and joint PP-PS prestack seismic inversion use background relationships in a logarithmic domain (Hampson and Russell, 2013), between P-impedance, S-impedance and density component of the low frequency model.

The inverted elastic properties seismic volumes were further used in neural network analysis to estimate total porosity, shale volume, resistivity seismic volumes.

Conclusions

Various seismic inversions (deterministic and stochastic) were tested to better understand the Narrows Lake oil-sands reservoir. Density inversion from 3C3D seismic data much better separates pay from non-pay zone and characterize the reservoir.

Seismically derived elastic properties from joint PP-PS prestack inversion were further used in neural network analysis to estimate total porosity, shale volume and resistivity seismic volumes.

Finally, the oil-sands reservoir was characterized in terms of seismic facies (rich-pay, non-rich pay and mudstone) which were defined based on geological facies.

All of which helped to more accurately characterize the reservoir and better predict reservoir performance under thermal operations.

Acknowledgements

Greg MacNeil, Ann O'Byrne, Will Chiang, Evan Talbot, James Newsome and Logan Popko at Cenovus Energy

Draga Talinga at Terra-IQ

Tobin Marchand and Eric Senetza at Key Seismic

References

Dumitrescu, C. C., Larson, G., Mayer, F. and Talinga, D., 2014, Reservoir characterization using converted-wave seismic data: Case study from Lower Cretatceous McMurray Formation, Athabasca Oil Sands; Geoconvention 2014

Hampson, D., and B. Russell, 2013, Joint simultaneous inversion of PP and PS angle gathers: CSEG Recorder, June, 32–39.