

Oil Sands Reservoir Characterization A Case Study at Nexen/Opti Long Lake

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Introduction

The Athabasca oil sands contain more than a trillion barrels of oil within the Cretaceous McMurray Formation of northeastern Alberta. The McMurray Formation is generally considered to be a compound estuarine valley system characterised by multiple cuts and fills. It is bounded below by Devonian rocks at the pre-Cretaceous unconformity and above by the widespread transgressive marine shales and sands of the Wabiscaw Formation. In the Long Lake area, it is 60 to 100 m thick, with net pays of greater than 40m. Still, its complexity is legendary. Stacked channel deposition exhibits a high degree of reservoir variability both vertically and laterally making lithological predictability difficult.

Traditionally, at least 8 and often many more vertical wells per square mile are drilled and cored to obtain enough data to be confident in defining a SAGD¹ project area. Even then, significant variations occur between wells. 3D seismic data has been used successfully in the past mainly to define the base of the zone of interest (there is a strong reflector at the Cretaceous-Devonian boundary), and the gross thickness of the interval. Various attempts have been made to decipher the internal composition of the channelled interval with limited success.

Objective

In this paper, I describe the method, application and results of a technique of quantitatively extracting and classifying elastic rock properties from seismic data. The extraction process uses AVO (amplitude vs offset) analysis to separate the compressional (P-wave) and shear (S-wave) components of the seismic data. The resulting components are then used to calculate physical rock properties such as shear rigidity (μ) and incompressibility (λ)². It is common knowledge among oil sands geoscientists that the density log through the McMurray Formation shows a strong correlation to the gamma ray log and is therefore a good lithology indicator. Recent work directed at determining facies from seismic relies on an estimate of density from the seismic data. In the process I describe, I also incorporate an estimate of density obtained from seismic using a neural-network approach³.

Wireline logs directly (or indirectly) measure P-wave velocity, S-wave velocity and density. Integrating this data with core and log analysis the λ and μ properties are calculated and assigned lithologies and fluid properties-. Detailed quality assessment and cross-plot analysis is carried out to assign empirical limits and guidelines for lithology and fluid discrimination based on

the measured rock physics properties. The determined relationships are then used to calibrate and classify the seismically-derived properties. The result is a seismic volume transformed to a detailed lithological characterization of the reservoir within the zone of interest. Drilling results are shown to validate and quantify the success of the method.

Applying this technique over a project area allows more confident mapping of the channels and the reservoir quality and continuity within the channels. A few of the potential benefits in oil sands areas include fewer vertical wells required to define the resource area, and more confidently placed horizontal wells for optimal production.

References

1. Steam Assisted Gravity Drainage – visit <http://www.nexeninc.com> to find more details on this process.
2. Goodway, W., Chen, T., and Downton, J., 1997, Improved AVO fluid detection and lithology discrimination using Lamé petrophysical parameters; “ $\Lambda\rho$ ”, “ $\mu\rho$ ” and “ λ/μ fluid stack”, from P and S inversions: 1997, 67th Annual International Meeting., SEG Expanded Abstracts, p183-186.
3. Dumitrescu, C., Weston Bellman, L., and Williams, A., 2005, Delineating Productive Reservoir in the Canadian Oil Sands using Neural Networks Approach, CSEG Technical Abstracts.