Seismic Characterization of Statoil's Leismer Heavy Oil Reservoir

Rainer Tonn
Statoil Canada Ltd., Calgary, Canada
rainer.tonn@statoil.com

Summary

The Lower Cretaceous McMurray formation is prolific heavy oil reservoir. In Statoil's leases (figure 1) about 100 km south of the City of Fort McMurray the bitumen are in a depth of approximately 500 m and SAGD is the appropriate method for production. The cost intensive SAGD operation requires a detailed mapping of the subsurface. This paper discusses two aspects of the geophysical interpretation.

- Depth conversion
- Seismic shale-sand characterization.

Introduction

In 2007 Statoil acquired promising heavy oil acreage in north-east Alberta. The McMurray reservoir in about 500 m depth consists primarily of unconsolidated sands up to 40 m pay thickness and with porosity around 30 %. SAGD (steam assisted gravity drainage) is the production method in this area. In a nutshell, the SAGD technique uses horizontal well pairs to produce the bitumen: the upper horizontal well is for steam injection and the lower well for oil drainage. Compared to "conventional" mining of heavy oil reserves, this method has a much smaller footprint. However, SAGD can be operated efficiently only, if the G&G team is able to image/model/predict the subsurface with high accuracy. The horizontal well pairs must be placed very close to the bottom of the reservoir zone and reservoir barriers like shales must be avoided.

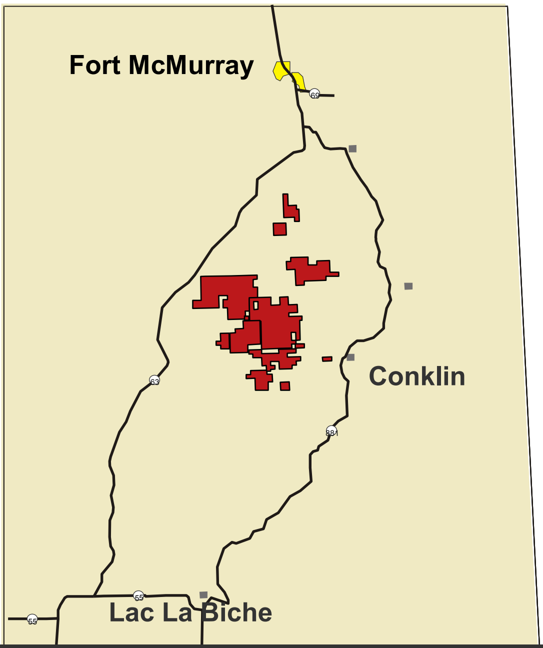

Figure 1: Statoil's leases

Due to the very high well density, the analysis of well data alone allows creating a good starting model of the subsurface. But for the SAGD operation an accurate resolution of the inter-well areas is critical and geophysical mapping becomes important. Two aspects of the geophysical interpretation, i.e. depth conversion and seismic shale-sand characterization, are discussed in this paper.

Depth Conversion

Accurate depth conversion assures that the SAGD well pairs can be placed close to the base of the reservoir allowing an optimal drainage of the reservoir. In an environment with more than 150 wells within the 3D seismic survey or approximately 2 wells/km2, a statistical depth conversion using kriging and simulation techniques becomes the method of choice. The velocities in the study area do not show any depth dependence, but the lateral variation and dependence of local channel or non-channel environments is considerable. In the statistical depth conversion anisotropic variograms with defined direction and range can take care of this challenge. Another advantage of statistical depth conversion is the evaluation of the uncertainty. Simulation results indicated that the depth prediction error to the base reservoir horizon in the densely drilled study area is less than 1.5 m (figures 2 and 3). Crossvalidation examination shows an error of +/- 3.2 m. The velocity field within the reservoir is generated from well logs which are tied to the reservoir base (figure 4). This facilitates a detailed depth imaging of the reservoir heterogeneities.

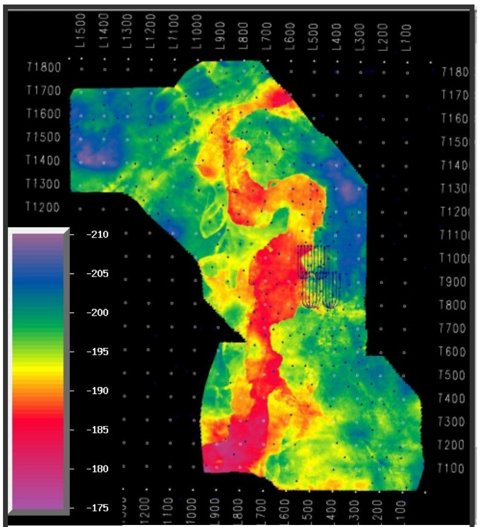

Figure 2: Devonian MSL Depth

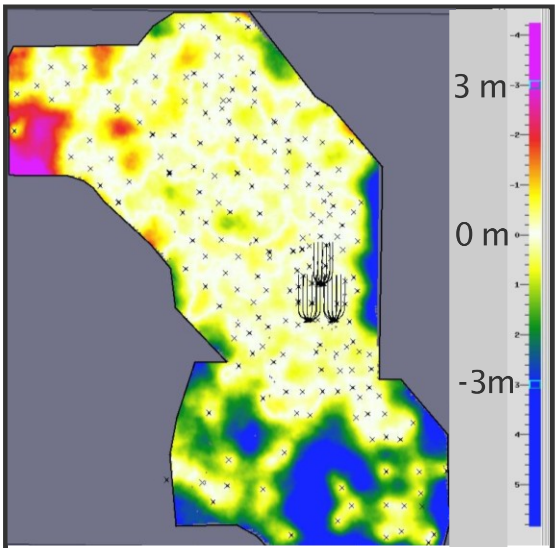

Figure 3: Simulated Average Residual Depth

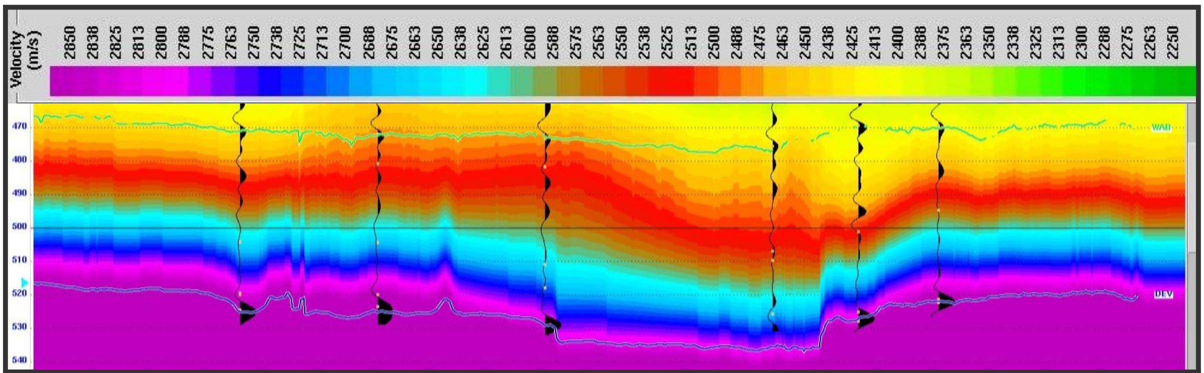

Figure 4: P-velocity field within the Reservoir

Seismic Shale-Sand Characterization

Even thin shale/mud layers can impede the drainage of the SAGD process. Therefore, the mapping of reservoir heterogeneities is critical. Seismic attributes can be correlated to sand

and shale. However, no single seismic attribute is sensitive enough to distinguish safely between sand and shale. A limited set of input attributes which are combined in a neural network approach delivers reliable results for the sand-shale interpretation. In particular attributes derived from a simultaneous pre-stack inversion are key to a successful seismic inversion to geological parameters. Since the training of the neural network can be done on only approximately 10% of the well data base, the remaining 90 % are potential candidates for true blind tests. These blind tests are the critical verification of the methodology.
The resulting volumes allow a visualization of the sand/shale distribution in the reservoir. Figure 5 shows two seismic sections inverted to gamma ray and intersecting a training well and a true blind test well.

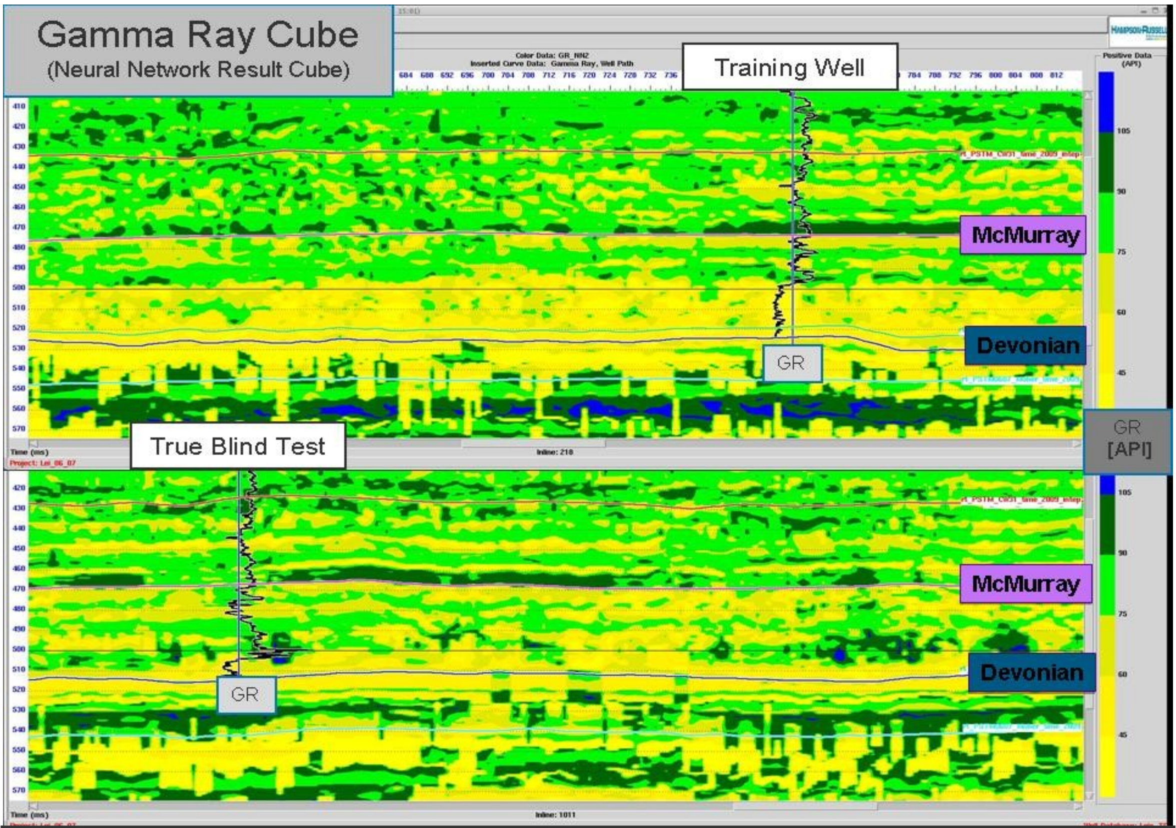

Figure 5: Gamma Ray Section intersecting training well and blind test

Conclusions

High quality 3 D seismic allows for reliable structural and stratigraphic mapping of the McMurray reservoir in Statoil's Leismer license. Statistical depth conversion not only achieves high depth prognosis accuracy but also provides the tools for an estimation of the depth prediction uncertainty. A neural network analysis of multi seismic attributes enables the interpreter to map the boundaries of the reservoir and to identify thin shale layer, which could impede the SAGD drainage process.

Acknowledgments

I want to thank Statoil Canada for the permission to publish the paper.