Depth Conversion Methodology using a Stochastic Velocity Model for the McMurray Formation

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Summary

Depth conversion of seismic trace data is a key part of planning for SAGD well production. Even small errors of 2-3 metres are significant when placing horizontal well bores near the base of the reservoir zone. Intra-zone reflections within the McMurray can represent reservoir changes in facies and fluid content. Reservoir and fluid heterogeneity can have a large effect on interval velocities within the McMurray. The laterally changing reservoir and fluid zones are not easily interpreted across the entire project. Traditional layer cake depth conversion tools require a series of layers for building up the velocity information. The layer surfaces, which are tied to well tops, have a good tie in the depth domain, since the velocity is computed as an average for the layer. However, intra-zone reflections may be due to changes in interval velocity that are not well represented by the overall average zone value. This can lead to miss-ties of intra-zone events when compared to synthetic seismograms.

By using a stochastic velocity model instead of an average zone velocity, we are able to incorporate some of the intra-zone velocity changes and get an improved tie for intra-zone reflections in the McMurray formation when compared to the a layer cake depth conversion based on zone interval velocities. The results are also compared to a pre-stack depth migrated volume.

Introduction

When planning a SAGD operation, the positioning of the horizontal well pairs is critical. The injecting and producing well pair is placed near the base of the reservoir zone and needs to avoid a structural contact of bitumen over water while minimizing stranded pay. 3D seismic data is shot and interpreted to guide the positioning of the SAGD pairs. Accurate depth conversion of the seismic data is required for the ideal positioning of the horizontal well pairs.

SAGD development areas have abundant data control through the extensive core holes that are drilled to characterize the reservoir. Even with this extensive well control, infill wells and horizontals often encounter events a few metres from the expected depths due to reservoir and fluid heterogeneity. Depth conversion of the time seismic is often performed using layer cake velocity models where the velocities for each zone are extracted from the time/depth relationships (TDR) of the core holes. The time/depth relationships are generated through the tying of synthetic seismograms. Pre-stack depth migration (PSDM) processing is another depth conversion tool. PSDM has the advantage of being able to focus the seismic events which post processing depth conversion is not able to do. Data is added each drilling season with new core holes and producing pairs themselves. As a result of the continuing data acquisition, the interpreter requires an easily updatable, reproducible and quick depth conversion technique that can be applied as the new tie positions are received.

Traditionally depth conversion using the TDR data set will extract interval or average velocity functions from the TDR and use these to assign velocity surfaces to key zones for depth conversion. Well tops in the core holes are used to calibrate the velocities and/or resultant depth surfaces to the known depths. This layered velocity model is then used to convert the seismic trace data to depth. While the resultant depth converted volume ties well at the calibrated surfaces defining the zones of the model, events internal to the zones do not always appear to tie the logs as they should.

This paper looks at a depth conversion technique using a stochastic velocity model determined from the well TDRs. Localized velocity changes due to fluids or reservoir can be incorporated. This technique allows more “velocity structure” to be incorporated into the velocities of the zones. The results are compared with more traditional depth conversion techniques.

Method

The same data set of TDR information from synthetic ties is used to create a velocity model that not only varies laterally around the layers, but has a fit tighter to the TDR data vertically within the layers. The following steps are used to create a stochastic velocity model from the TDR data set.

1. Compute the average velocity from the Time/Depth relationships for the wells
2. Create a 3-dimensional cellular grid over the zones of interest using the key surfaces to guide the layering in the model.
3. Distribute the average velocity data through the 3-dimensional cellular grid using geostatistical techniques.
4. Produce a velocity model for depth conversion from the time surfaces, well tops and 3-dimensional velocity distribution.

The resultant velocity model is used for depth conversion of the seismic trace data. The results are compared with depth conversion from a layer cake model and the pre-stack depth migration. Synthetic seismograms in the depth domain are compared with the depth converted traces to investigate the tie of the intra-zone reflections with the synthetic response.

Examples

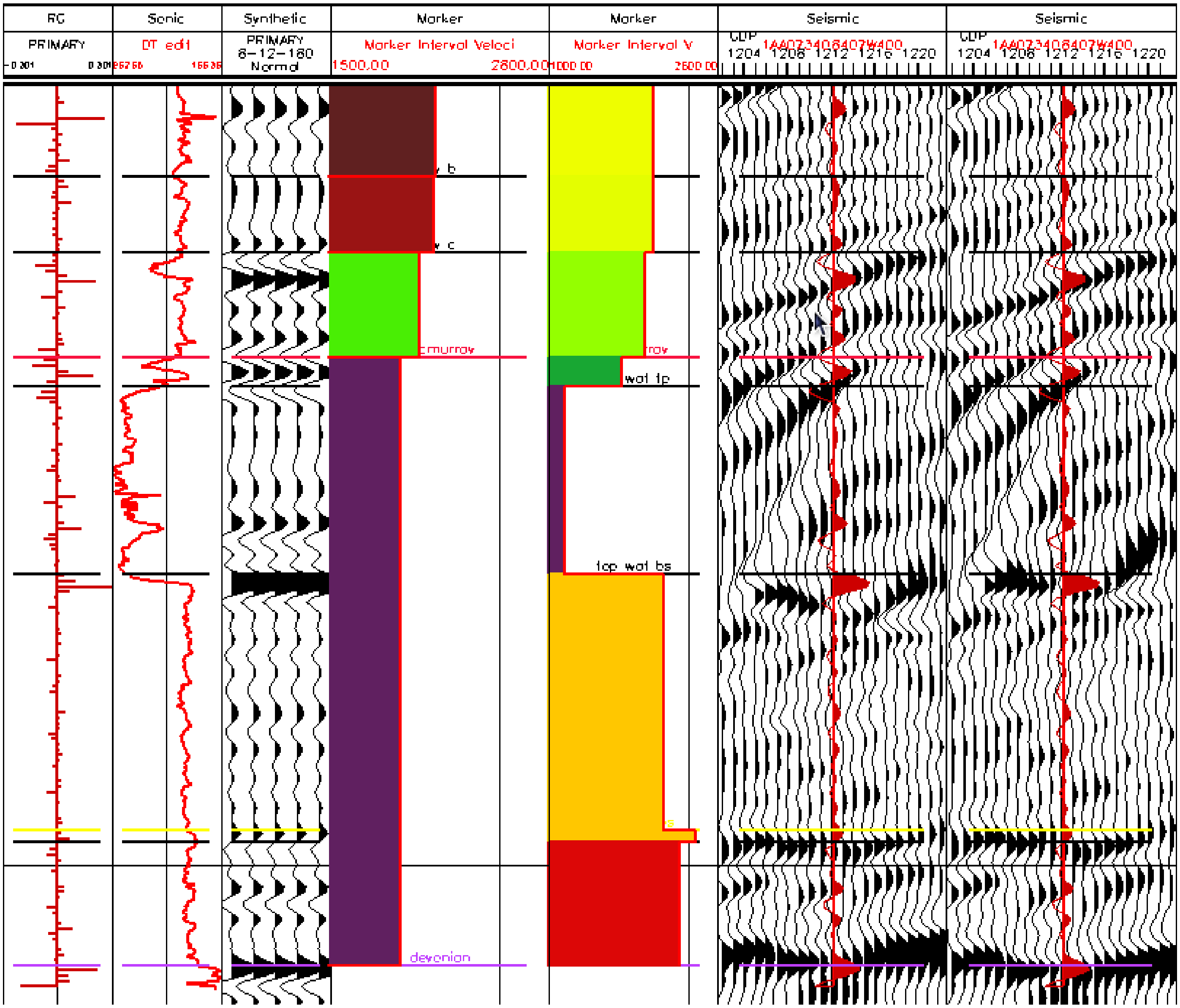

Figure 1: Example synthetic seismogram tie in the depth domain. The 4th track shows the interval velocities if the major correlation events are used to define the layer cake velocities. The 5th track shows how the interval velocities can change within the McMurray zone due to the upper wet gas zone. The stochastic velocity model attempts to capture these intra-zone velocity changes. The left and right seismic panels show the depth conversion results based on a zoned layer cake velocity model and based on stochastic velocity model respectively. Notice the improved tie in the right panel at the base of the wet gas zone (top_wat_bs marker).

Conclusions

A more accurate velocity model for general depth conversion can be achieved by building a stochastic cellular velocity that incorporates both vertical and lateral velocity variations.