Seismic Inversion for Horizontal Well Planning in Western Saskatchewan

Case Caulfield, Marina Feroci**, Kevin Yakiwchuk* - (*True Energy Inc., **Fugro-Jason)*

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Introduction

A normal incidence inversion was completed over a Cretaceous age McLaren channel sandstone in an area of Western Saskatchewan. Although several vertical and horizontal wells had successfully produced 11 deg API oil from the channel, important geologic and geophysical issues complicated the seismic interpretation and horizontal well planning. Conventional seismic interpretation, using primarily drape and amplitude maps, could map the general extent of the channel sands, but could not easily examine the interior of the sand package or distinguish rapid lateral facies changes. It was felt that a successful inversion would improve horizontal trajectory planning and ultimately increase production from the field.

The main objectives of the inversion included: 1) Delineate shale breaks within the sandstones; 2) Improve depth mapping of the top and bottom of the sandstone; 3) Evaluate and map abrupt lateral changes in the depositional patterns of the sandstones; 4) Using a depth-converted impedance image, estimate total oil column to judge whether the oil/water contact is sufficiently below the planned trajectory to support adequate oil production. All of these issues were vital in the planning of potential horizontal well trajectories.

The success of the inversion was in a large part due to the high frequency content of the data and good P-wave impedance separation between the regional sand-shale package and the productive McLaren sandstone.

Methodology and Results

CSSI inversion was used to transform the input seismic data to pseudo acoustic impedance logs at each CMP. The input seismic is modeled as the convolution of an estimated wavelet and a reflection coefficient series representing the geology. A unique set of user-specifiable constraints guides the variation of impedances in a geologic way both vertically and laterally. The algorithm is also flexible, quickly adapting to different geologic scenarios - delta, reef, channel, etc. The low frequencies in the inversion are extracted from a 3D geologic model constructed for the project. The model is defined by the interpreted horizons and a framework spreadsheet and is populated by well log impedance. Between the wells, the logs are interpolated, respecting layer thickening and thinning, fault boundaries and the input stratigraphy.

Figure 1 compares the increased resolution obtainable with inversion (in colour) relative to the seismic (wiggle traces). A section through 3 of the wells used for the inversion is shown. The impedance logs from the wells are superimposed (in colour), along with the Gamma Ray (in blue). Rock property analysis showed that channel sands have lower impedance than the surrounding shale, and the characteristic impedance values for sands in this area is around $6 \cdot e^{6}$ $kg/m^{3} \cdot m/s$. The shale break between channel sands in well 121-16 (from GR log) is clearly visible in the Inversion (red colour), while it is almost impossible to detect from the seismic traces (compare with seismic signature at 141-16 well, where there is no shale).

Ultimately, the inversion aided in identifying an unexploited portion of the field which was penetrated by two horizontal wells, now producing upwards of 150 BOP/day. Figure 2 shows one of the new horizontal wells superimposed on the inversion. The channel sands, with low impedance values, are shown in orange-yellow colour. The productive sands, as predicted by the inversion results, were successfully encountered at a lower level then the previously known productive sands.

Figure 1

Absolute P-Impedance

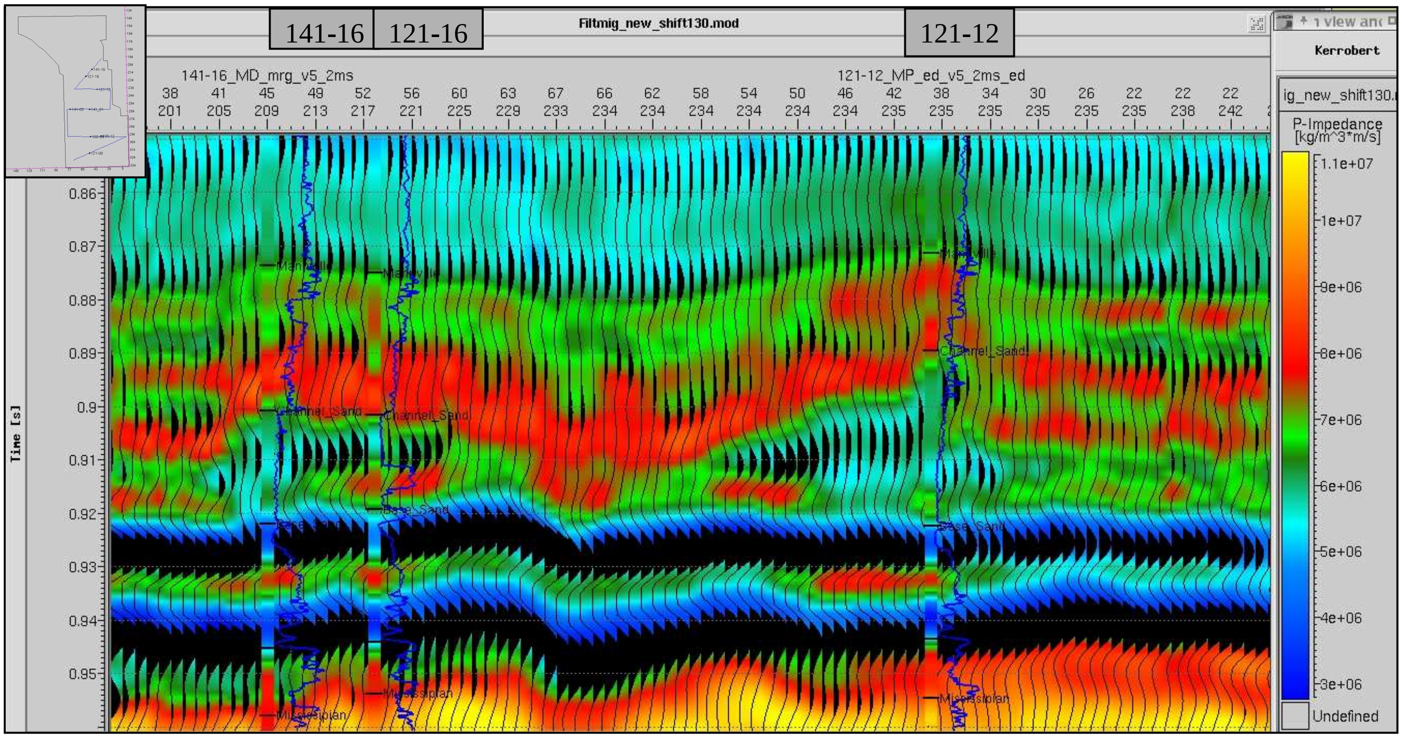

Figure 2