Reprocessing the 1999 Blackfoot 3C-3D seismic data and anisotropy analysis for the radial component

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ABSTRACT

The 1999 Blackfoot 3C-3D data was reprocessed and an f-x spectral analysis was carried out. The results show that the data of the natural bin size (40m x 80m) in the MEGA survey still have good frequency spectra and good resolution in time and in space. The anisotropy analysis was also carried out for the radial component of the 1999 seismic. No obvious anisotropy was found in this data.

INTRODUCTION

In 1999, a 3C-3D seismic survey was conducted by PanCanadian Petroleum Ltd. over the Blackfoot field located near Strathmore, Alberta, Canada. The seismic survey in 1999 is shown in Figure 1. This survey covered an area of 8 square kilometres (2 x 4 km), which was smaller than the area in the 1995 seismic survey. The shot interval was 160 m and the receiver interval was 80 m. Another difference between these two surveys is that in the 1995 seismic survey, conventional 3C geophones were used, and the VectorSeis^{TM} 3C digital geophones were used in the 1999 seismic survey.

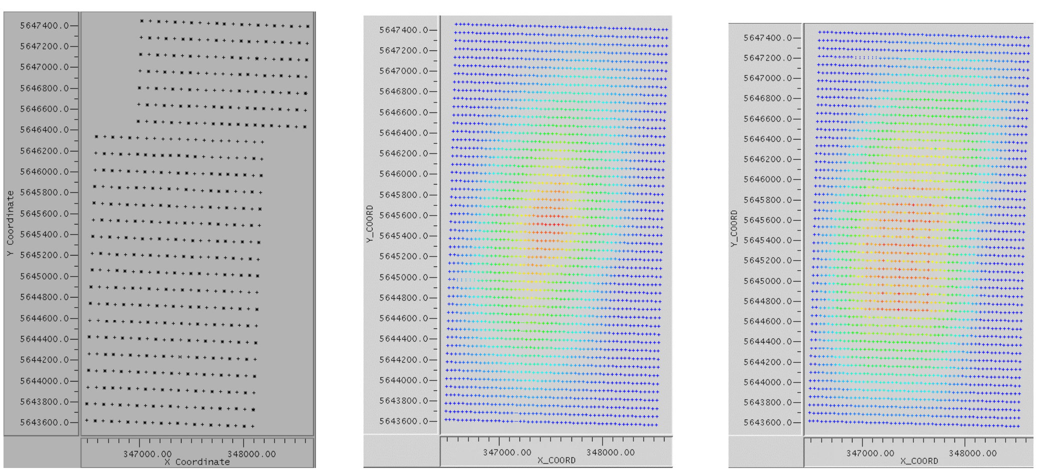

FIG. 1. The 1999 Blackfoot 3C-3D seismic survey is on the left. The CDP folds for the vertical component are in the middle. The CDP folds of the radial component are on the right (V_P/V_S=2.2 for ACP binning).

RESULTS

The 1995 and 1999 seismic surveys were conducted with different acquisition parameters. The source and receiver intervals were both 60 m for the 1995 seismic survey; while the source interval was 160 m and the receiver interval 80 m [the Mega-bin technique (Goodway and Tessman, 2001)], for the 1999 seismic survey.

VectorSeis™ 3C digital geophones were also used for the 1999 survey. The vertical component data was processed using the natural bin size (80 x 40 m), and the radial component was processed using $V_P/V_S = 2.2$. All processing for both the vertical and radial components was conventional, but it should be noted that the processing parameters were very similar to those used in processing the 1995 data.

Hand statics for the radial component were applied twice. It was difficult to pick up a horizon in the common receiver stacked section on the first time stack with the P-S stacking velocities estimated from the final velocities of the vertical component (upper panel of Figure 2). After the first round of hand-statics corrections, velocity analysis was conducted, then using the new velocity functions with the first round of hand-statics corrections for receivers, the second common receiver stack was obtained. After picking a horizon again, the second round of hand-statics corrections was finished. The final receiver stack is shown in the lower panel of Figure 2.

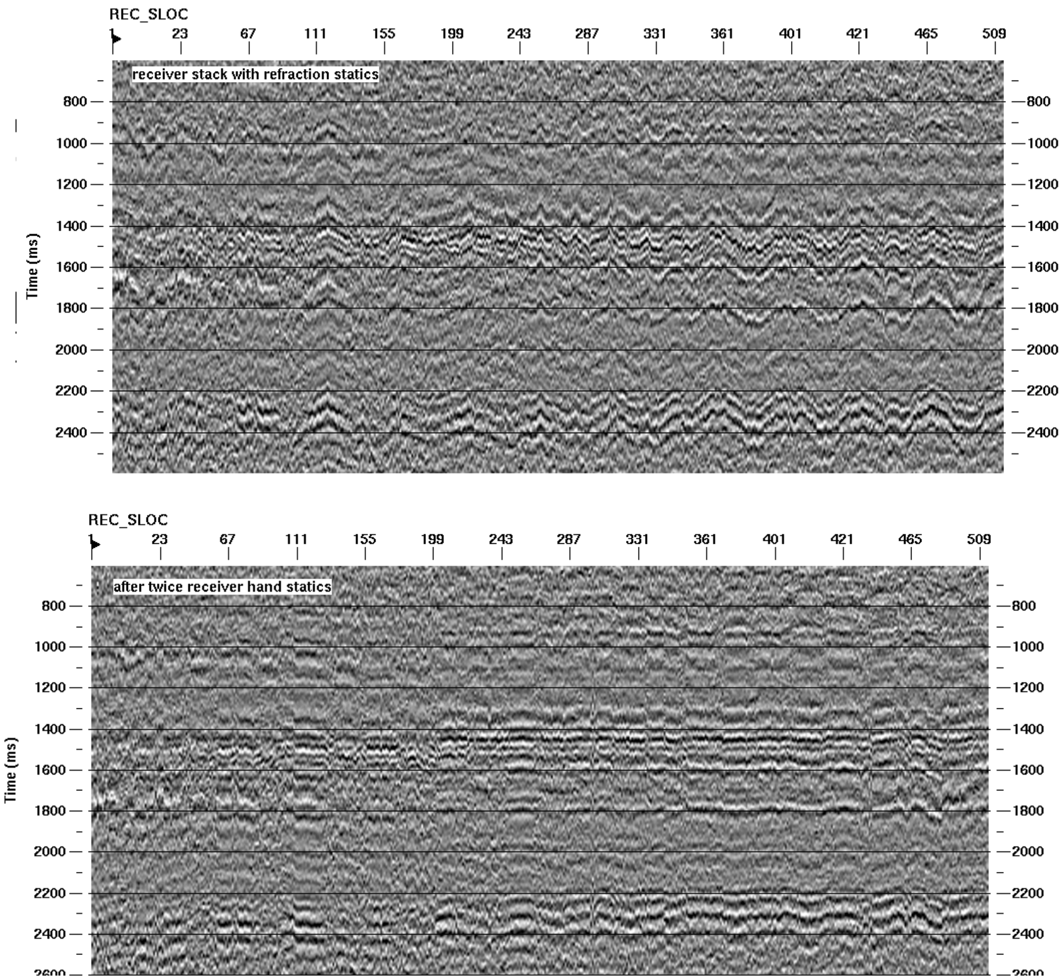

FIG. 2. The upper panel shows the receiver stack after shot statics and doubled receiver statics of the vertical component are applied to the radial component. The lower panel shows the final receiver stack after two passes of hand statics.

The migrated section for the vertical component is shown in the left panel of Figure 3. The migrated section for the radial component is shown on the right, with the radial component compressed by 1/1.6 (V_P/V_S = 2.2). Good matches for the main events can be seen in Figure 3. This suggests that the processing of the vertical and radial components was consistent.

The natural bin size for the 1995 3C-3D survey was 30 x 30 m. In order to compare the results from the 1999 seismic data with the results of the 1995 data, the migrated sections for both the vertical and radial components of 1999 data sets were re-gridded to 30 x 30 m, using a sinc function to interpolate the post-stack sections.

As shown in Figure 4 these three migrated sections compare very well. The migrated section of the vertical component of 1999 is on the left, the migrated section of the vertical component of 1995 is in the middle and the migrated section of the radial component of 1999 is on the right.

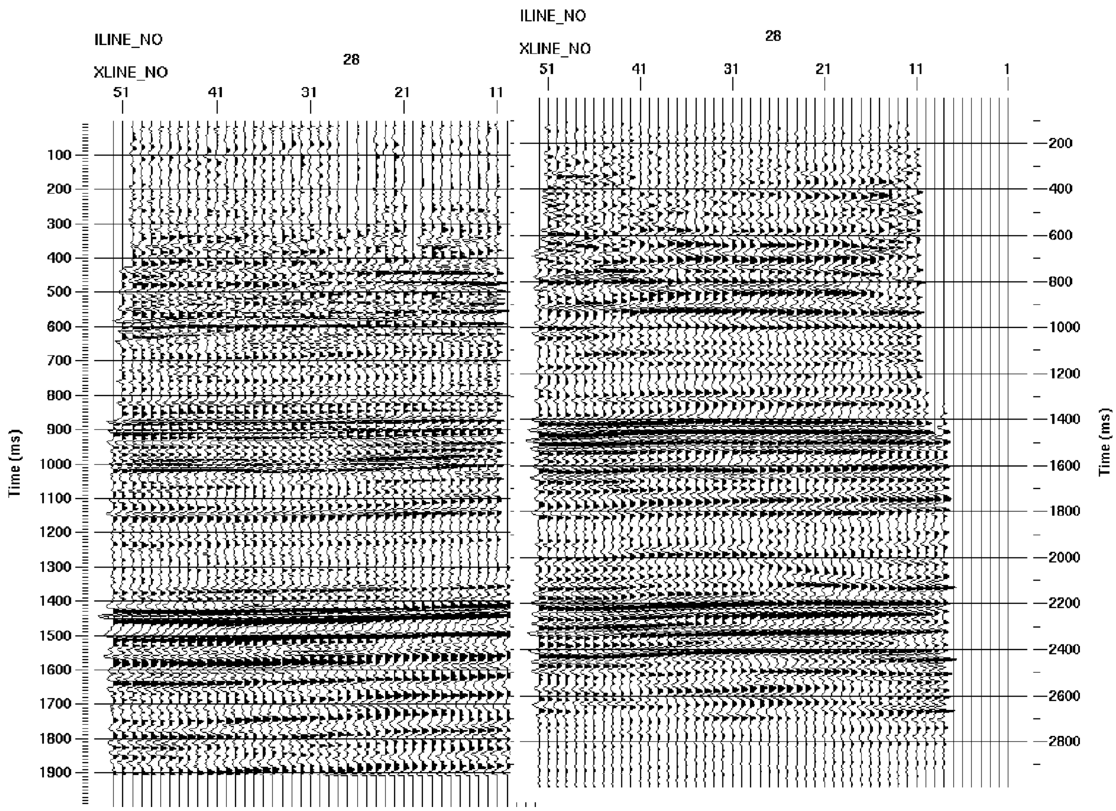

FIG. 3. The migrated section for the vertical component is on the left; the migrated section for the radial component is on the right. The bin size for the vertical component is 80 x 40 m, and the V_P/V_S ratio for ACP binning is 2.2.

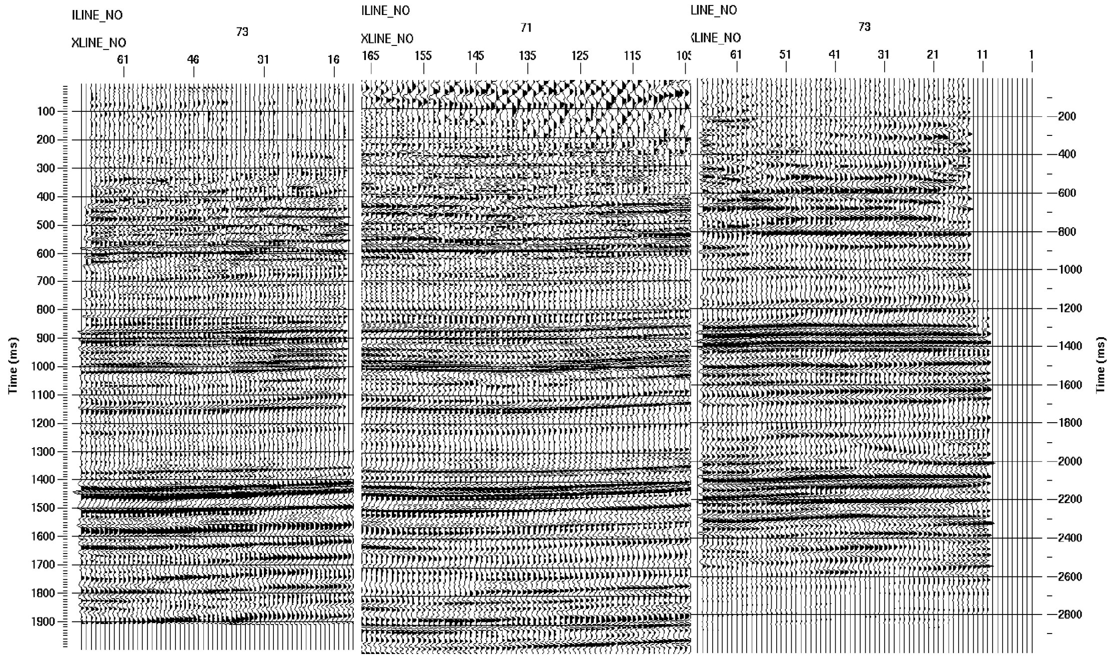

FIG. 4. The re-gridded migrated section of the vertical component of the 1999 data is on the left, the migrated section of the 1995 is in the middle and the migrated section of the radial component of the 1999 data is on the right.

The radial component of the Blackfoot 3C-3D 1999 dataset was processed under the assumption of isotropy. In a layered anisotropic medium, the conversion point location is controlled by the effective velocity ratio γ_{eff} (Thomsen, 1999). In an anisotropic layer the conversion point of P-S reflection is closer to the source-receiver midpoint than in a single isotropic layer. When the data is processed under the assumption of isotropy, the far-offset traces may be misplaced with respect to the near-offset traces during the CCP (common conversion point) stack. Thus, it may be important to take anisotropy into account in converted-wave processing.

A test for anisotropy in the 1999 radial component of the seismic data was conducted, using different values of the effective V_P/V_S ratio γ_{eff} (0.5−1.2) in the 3D CCP stack. No obvious anisotropic effects were found in this data, but for different effective V_P/V_S ratios, slightly different images still can be seen. The seismic section in the window 1.4 -1.8s (the zone of interest in the Glauconitic channel) of in-line 28 (the location of production well 0808) is shown in Figure 5 using different effective V_P/V_S ratios. The most coherent image of the channel was obtained using the effective V_P/V_S ratio γ_{eff} =0.9. It does mean that there is anisotropy, but it is very weak. If the best image appears when γ_{eff} =1.0, then there is no anisotropy in the medium.

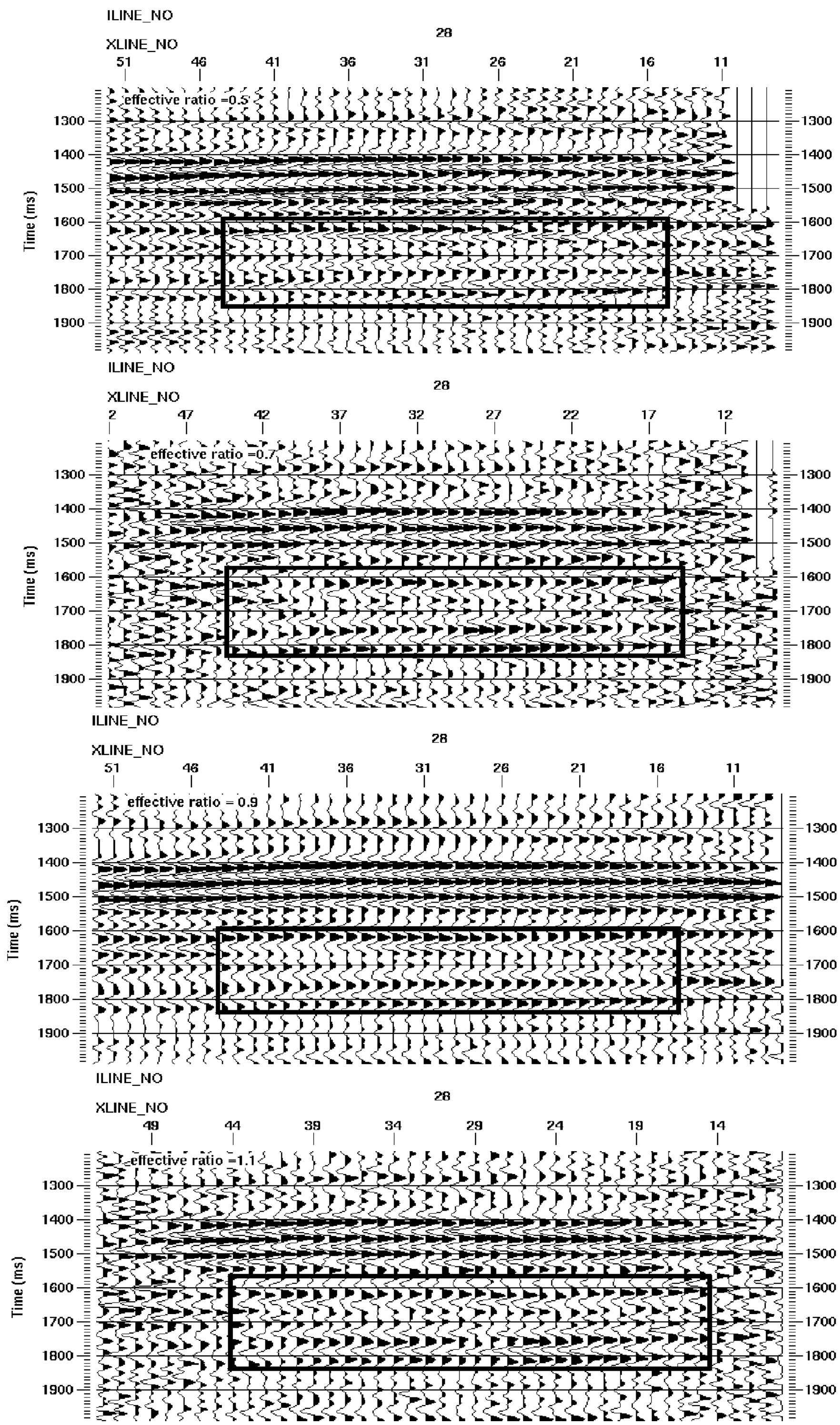

FIG. 5. The migrated sections of the radial component of Blackfoot 3C-3D data for different effective ratios (γ_{eff}), with 0.5, 0.7, 0.9, and 1.1, describing the upper to the lower panels respectively. The black solid square is the zone of the interest (Glauconitic channel)

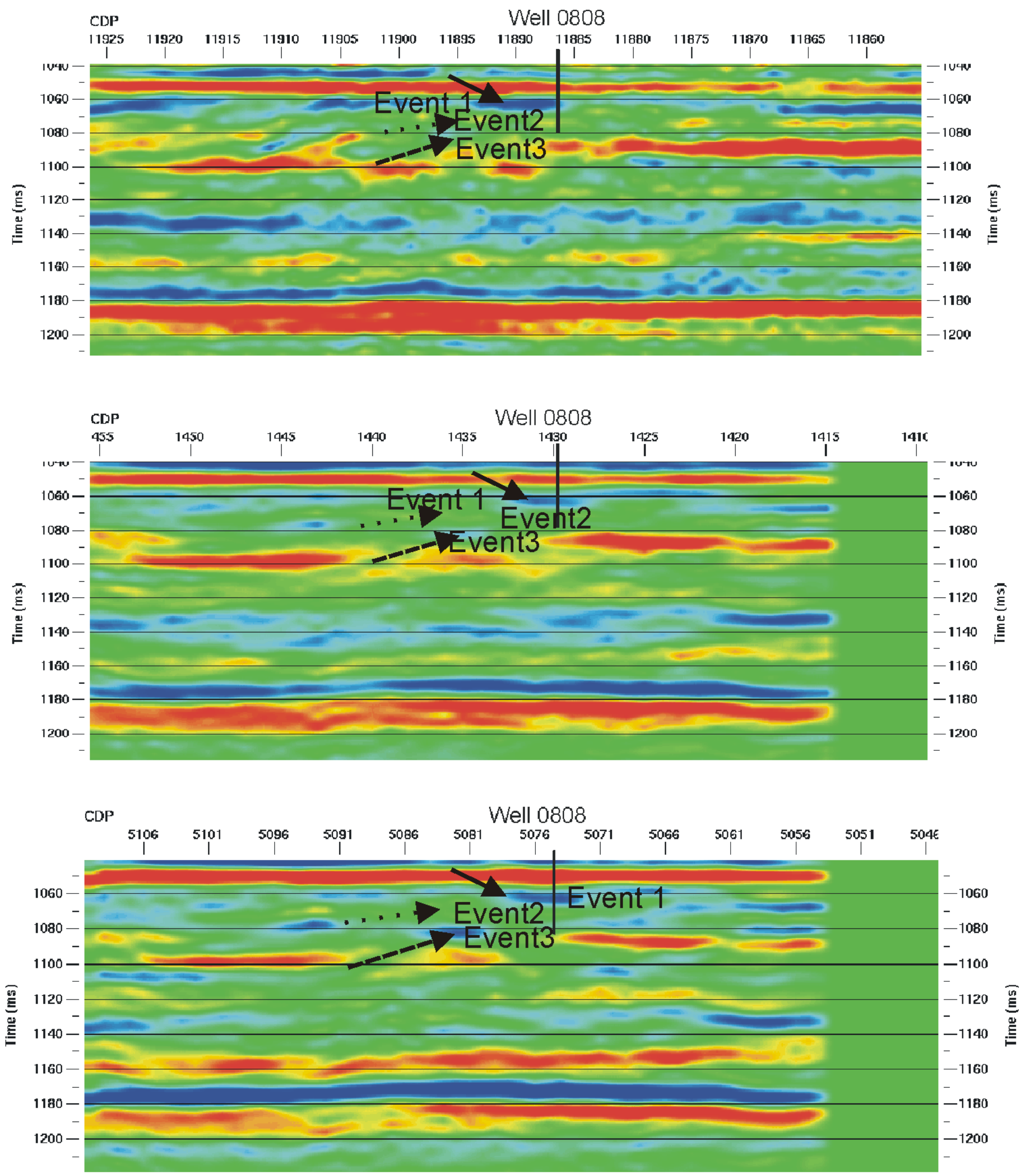

FIG. 6 This figure displays three migrated sections of the same location. The upper panel is the 1995 data (inline71), the middle panel is the 1999 original data and the lower panel is the 1999 re-gridded data. The Lower Manville formation was flattened to 1050 ms. The location of the production well 0808 is shown by a vertical solid line. Event 1 (trough) is the Upper channel, event 2 (trough) is the Lower channel and event 3 (peak) is the intermediate event.

The Blackfoot field encompasses a Glauconitic incised valley system. The upper and lower channels consist of mainly porous quartz sandstones, while the middle channel consists of relatively dense lithic sandstones. Oil is the primary hydrocarbon, although gas is also found in the Upper channel and whenever it comes out of solution. The channel can be seen in Figure 6, where the Lower Mannville was flattened to 1050 ms in the 1995 data (upper panel), the 1999 original migrated section (middle panel), and the 1999 regridded section (lower panel). These three in-lines are at the same location, so that the Lower Mannville and Mississippian formations show the same patterns in all cases. The zone of interest is the Glauconitic channel zone between the Lower Mannville and Mississippian that is shown in Figure 6. The upper channel can be seen at around 1058-1060 ms, and the lower channel at about 1068-1070 ms in the in-lines. In the 1995 seismic section between the upper lower channels (events 1 and 3) a peak (event 2) can be seen clearly, but in the 1999 sections, both original and re-gridded, the peaks (event 2) were very weak and cannot be seen. From Figure 6 we see higher spatial resolution in the 1995 data than in the 1999 data because of the smaller natural bin size in the 1995 data.

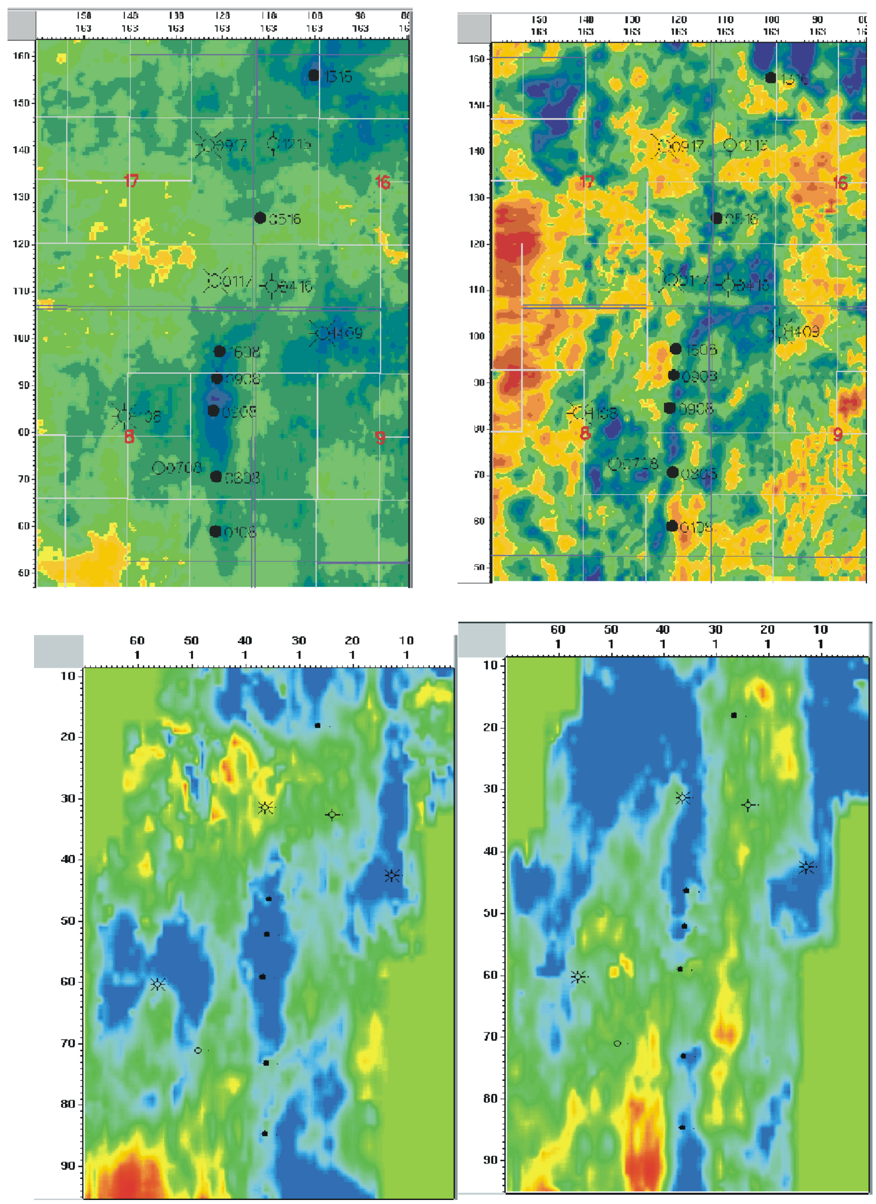

FIG. 7. The time slice of the upper channel is on the left, and the time slice of the lower channel is on the right. Top panels are for 1995 data and the lower panels are for 1999 data. The Lower Manville was flattened to 1050ms in the vertical component of the 1995 and 1999 dataset.

The time slices of the 1995 (upper panels) and 1999 (lower panels) for the upper and lower channels are shown in Figure 7. The Lower Mannville was flattened to 1050ms. The Glauconitic channel system extends from south to north through the Blackfoot area and is approximately 1560m below the surface. This is evident from the negative amplitude anomalies (blue/dark) that show a trend through the producing oil wells. The upper channel anomalies indicate a wide channel, while the lower channel is relatively narrow.

CONCLUSIONS AND DISCUSSION

The results from 1999 VectorSeis™ seismic data acquired using the Mega-bin technique are comparable to those obtained from conventional coil geophones in the 1995 seismic survey.

In the time slices from the Lower Manville (flattened to 1050 ms) to Mississippian formation (1090 ms), the upper channel is at 1058 ms and the lower channel is at 1068 ms, which is the productive zone. From Figure 6 a difference is observed between the 1995 and 1999 datasets. In the 1995 seismic data between the upper and lower channels, there is a positive amplitude event (event 2). This peak corresponds to a non-porous lithic formation that is a permeability barrier between the upper and lower channels. In the 1999 dataset no such positive amplitude event is present, or is at least very weak. There are two possible explanations for this difference. One is that the spatial resolution for the 1999 data is lower than for the 1995 dataset. Another possibility is that after four years of production, something has changed, causing the velocity structure to change as well.

In a related paper an f-x analysis (Lu and Margrave, 2001) is performed on these two datasets and demonstrates that processing was good and that the frequency content in these two datasets is comparable.

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