Spring Coulee seismic interpretation

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ABSTRACT

Over the past two years, CREWES has recorded three seismic surveys near Cardston in southern Alberta, where the University of Calgary holds the mineral rights to two sections of land. Each survey consisted of multiple seismic lines, the main purpose being to map the sub-surface of the area and secondly to see if there could be hydrocarbon production potential. From nearby producing wells, we have chosen the Mississippian-aged Madison Formation as the primary target and strata of the Lower Cretaceous Mannville Group and Second White Speckled Shale Formation as the secondary targets. This paper gives an overview of the data acquired and summarizes the seismic interpretations.

INTRODUCTION

The University of Calgary acquired the mineral rights to two sections of land in the Spring Coulee area of southern Alberta approximately five years ago. The sections are 14 and 23, T4, R23W4, illustrated in Figure 1. Over the past two years, three seismic surveys have been completed in the area – the January 2008 CREWES, CGGVeritas, Outsource and ARAM survey, the August 2008 University of Calgary field school survey and the August 2009 field school survey (Figure 2). Additional seismic lines were made available from industry for the creation of the time-structure maps.

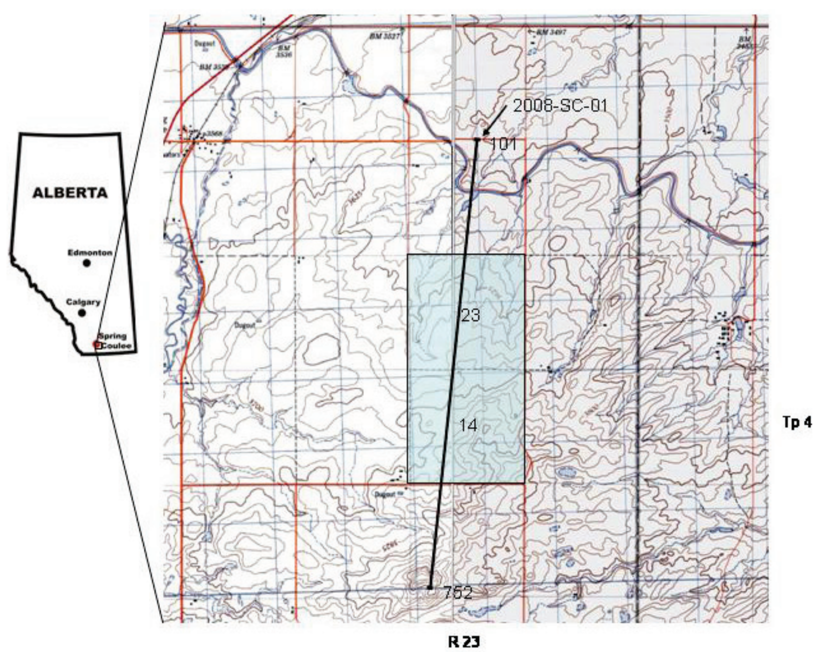

FIG. 1. Map of where Spring Coulee, Alberta is located, the two sections (14 and 23) of land over which the University holds the mineral rights and where the January 2008 seismic survey was located (Bertram et. al., 2008).

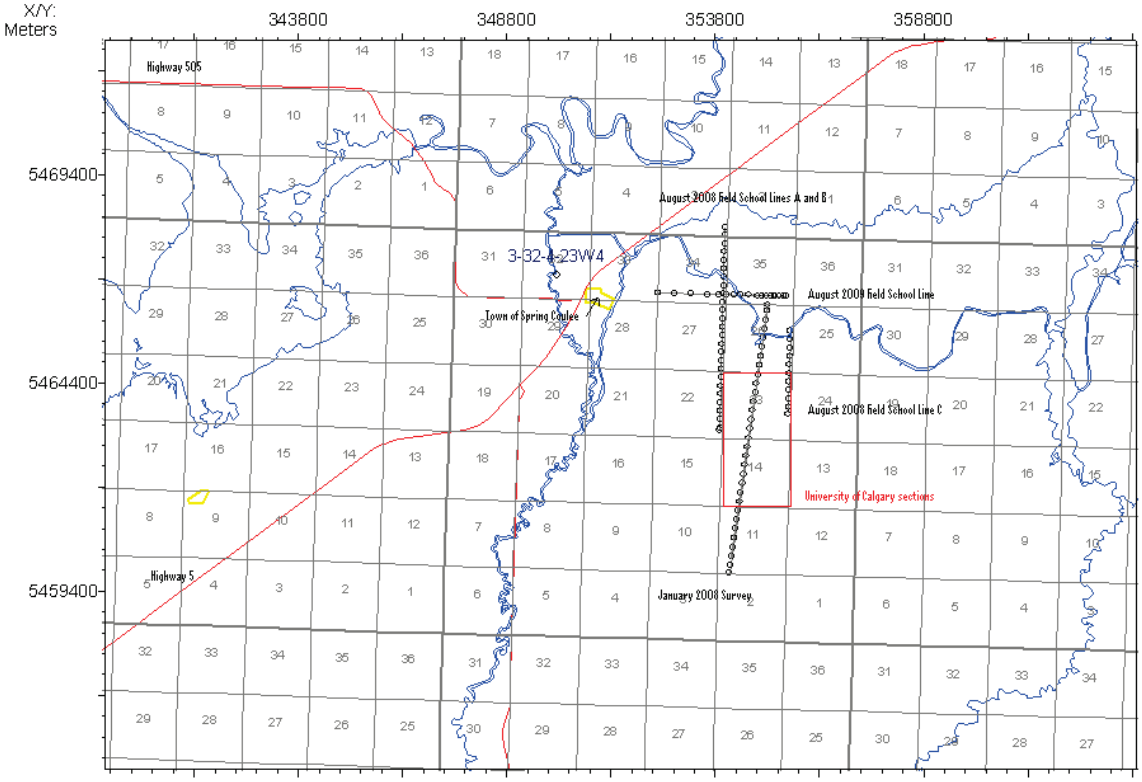

FIG. 2. Base map of CREWES Spring Coulee seismic lines in relation to the University of Calgary's Spring Coulee mineral rights (illustrated by the red box).

Figure 3 shows a stratigraphic column from Southern Alberta. Of interest in this study was the upper Paleozoic carbonates and Lower Cretaceous clastics of the Mannville Group.

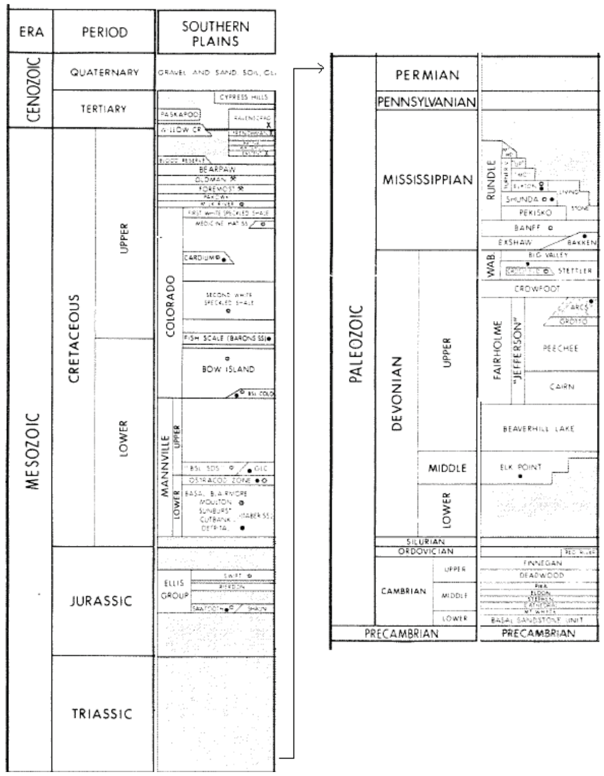

FIG. 3. A table of formations for southern Alberta (AGAT, no date).

METHODS AND SOFTWARE

CREWES processed the seismic data used in the interpretation. The data were imported into the Kingdom Suite software and a synthetic seismogram was computed to tie the seismic data to the formation tops. The 3-32-4-23W4 well was the primary well used for the synthetic seismograms, with three other adjacent wells used to verify the horizon picks. The location of the 3-32 well is shown in Figure 2.

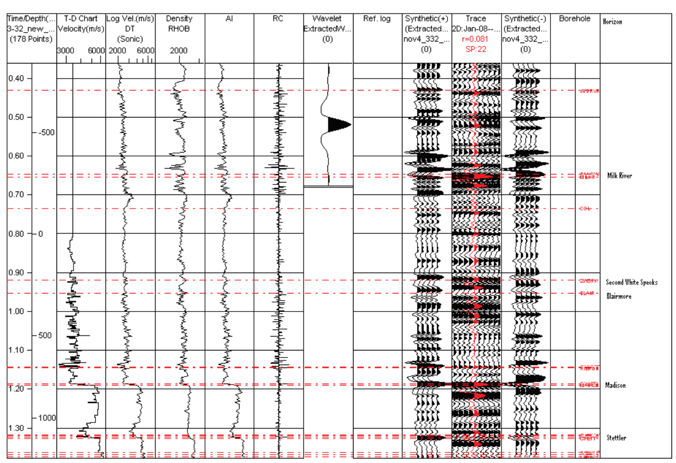

FIG. 4. A synthetic seismogram computed with well 3-32-4-23W4 using a wavelet extracted from the January 2008 DSU seismic line.

A mistie analysis was undertaken between the seismic lines and the data were phase shifted and bulk shifted prior to interpretation. The following horizons were picked on the seismic data: Pre-Cambrian, Stettler, Madison, Second White Speckled Shale, Blairmore and Milk River.

DATA AND LINE INTERPRETATIONS

The University of Calgary acquired three separate seismic surveys in the area. These were recorded in January 2008, August 2008 and August 2009. The locations of all of the seismic lines are shown on Figure 2. The initial January 2008 survey was recorded for data comparison purposes and also to get a structural overview of the subsurface in the parcel of land to which the University of Calgary holds the mineral rights.

The January 2008 survey was recorded by CREWES, CGGVeritas, OutSource and ARAM and consisted of a north-east to south-west seismic line. The sources were dynamite, the University of Calgary's EnviroVibe and CGGVeritas' heavy vibroseis trucks; both Sercel and ARAM recording systems were used. All of the January 2008 survey processed sections are very similar, so the heavy vibroseis, DSU line was chosen as the example for that survey in this report (Figure 5).

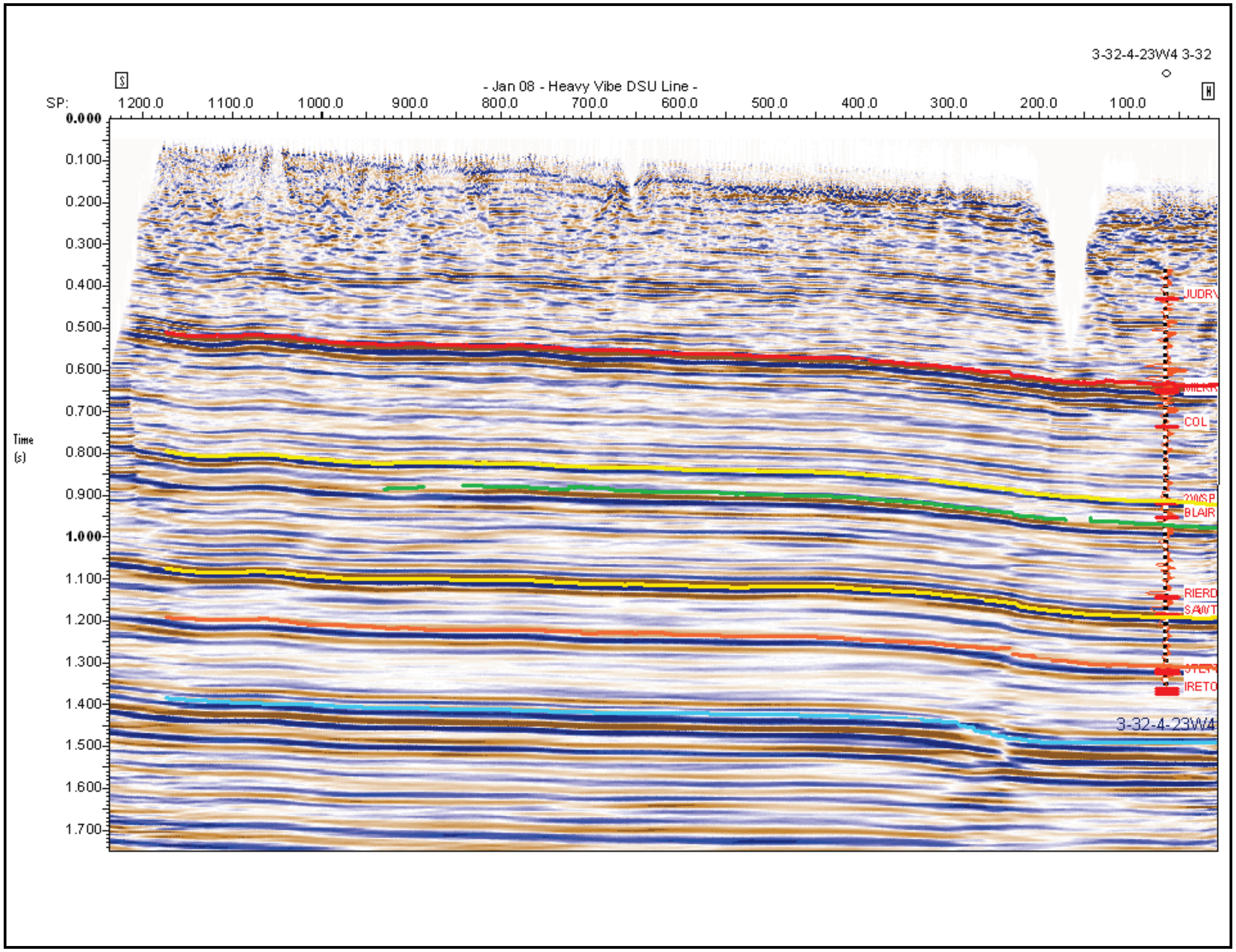

FIG. 5. The heavy vibroseis, DSU January 2008 survey line illustrating the horizon picks.

The August 2008 field school survey consisted of three seismic lines in two locations. The lines are called Field School A, B (Figure 6) and C (Figure 7); Field School A and B were shot in the same location, thus line B will be used as the example. The Field School 2008 lines were oriented in a north-south direction and were approximately 3 km long.

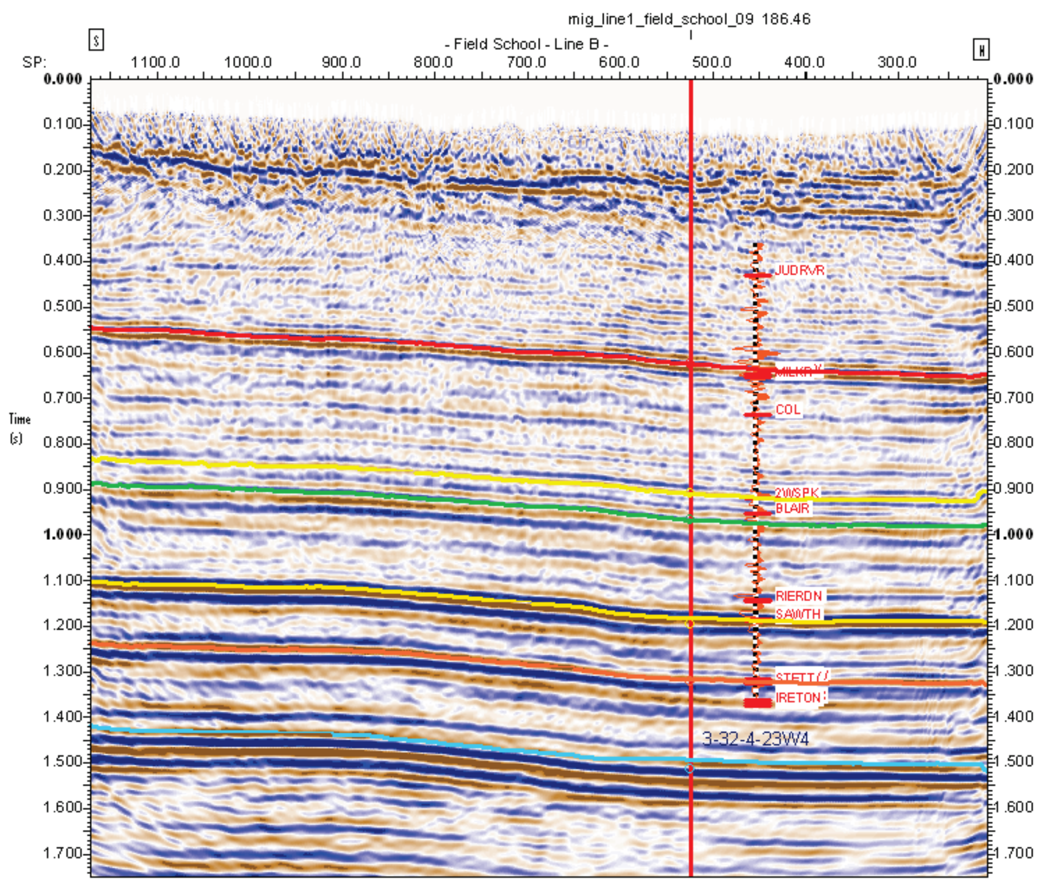

FIG. 6. Line B of the August 2008 Field School Survey. This line is oriented in a north-south direction (north to the right in this figure). Note the intersection between the 2008 and 2009 field school lines, illustrated by the red line.

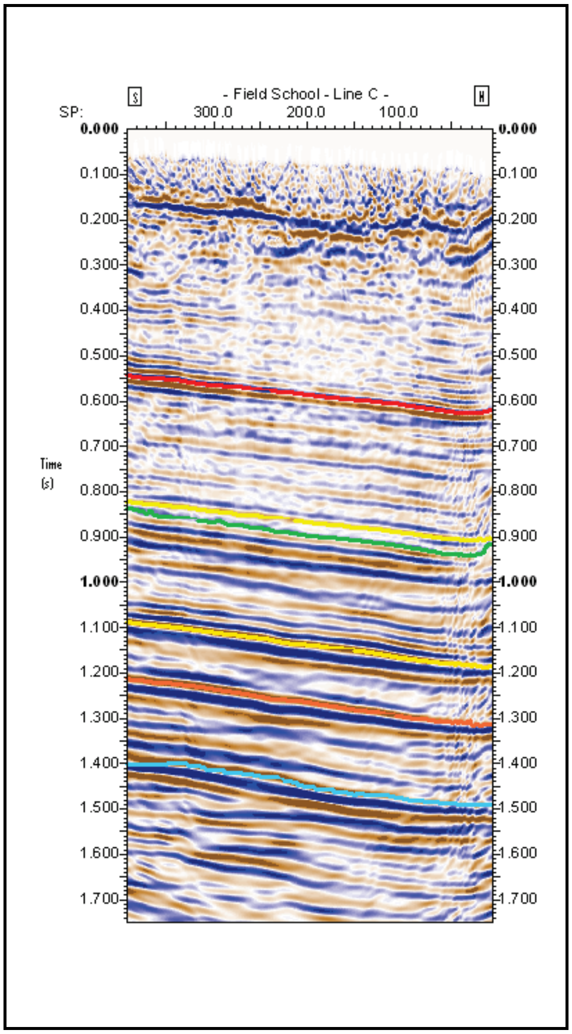

FIG. 7. Line C of the August 2008 Field School Survey with horizons picked.

The August 2009 field school survey (Figure 8) consisted of one seismic line oriented in an east-west direction along a township road immediately to the north of the University of Calgary's Spring Coulee land. This was recorded as a multicomponent seismic line and is reported on by Lawton et al. (this volume).

MAP INTERPRETATION

This horizons picked on the seismic sections were contoured to create time-structure maps. The maps were also augmented by horizon picks from available industry seismic data. Figure 9 displays the Pre-Cambrian time structure, with a normal fault interpreted that offsets the basement and Paleozoic strata with the downthrown side to the east. The fault displacement decreases to the north.

Figure 10 shows the time-structure at the Madison Fm and is an attenuated version of the basement map. The interpreted fault is shown on this map. Figure 11 shows the time structure of the Second White Speckled Shale pick and this shows gentle drape over the deeper fault, suggesting differential compaction across the fault, or slight reactivation during the lower Cretaceous.

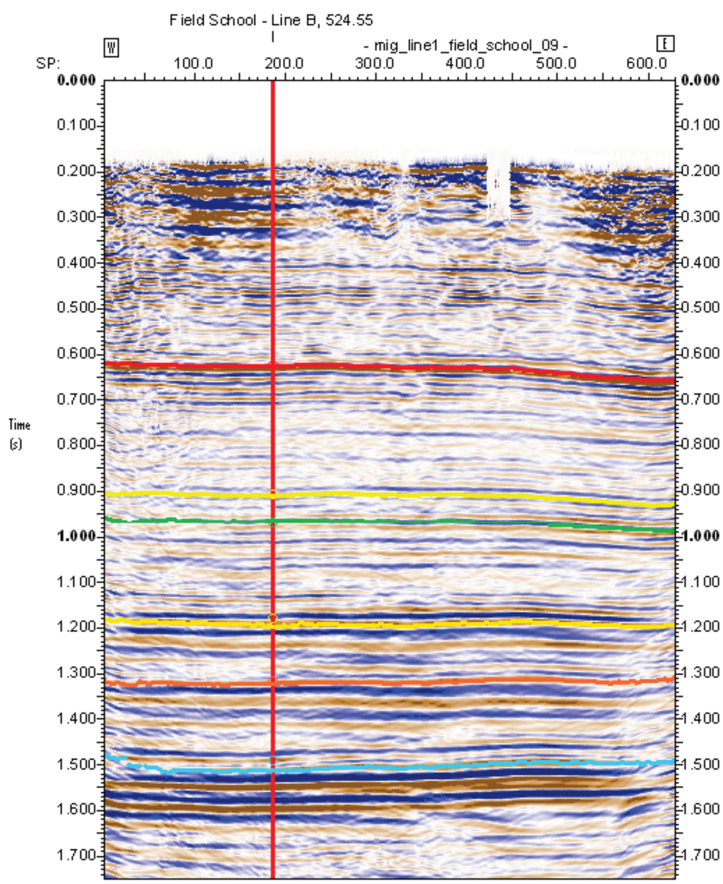

FIG. 8. The August 2009 Field School Line oriented in an east-west direction to the north of the University of Calgary's Spring Coulee land. Note the intersection of the 2009 and 2008 (lines A and B) field school data, shown with the red line.

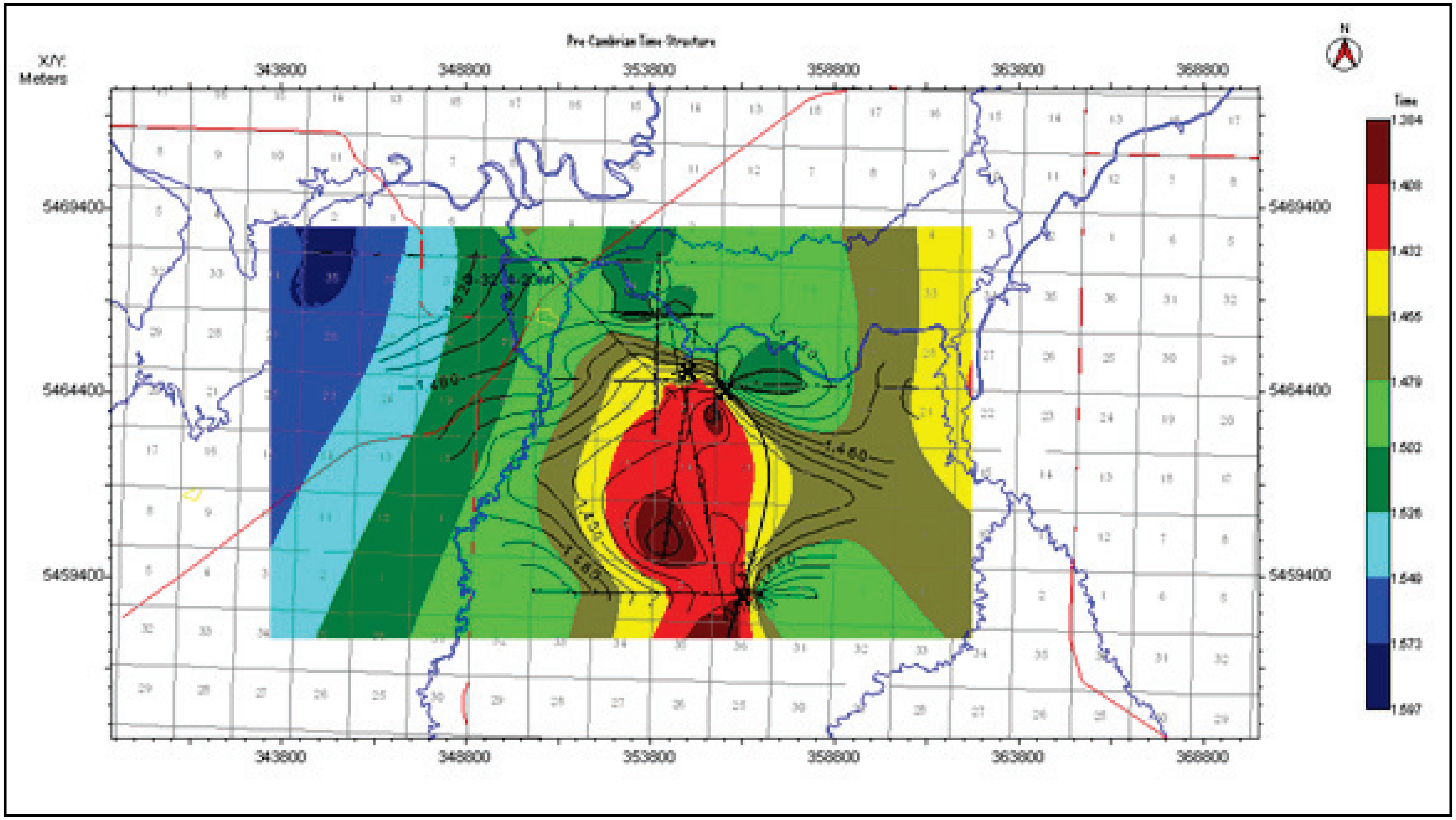

FIG. 9. Pre-Cambrian time-structure map, derived from the horizon picks on the seismic sections, illustrating a fault (the thick black line and the ‘x’ on the seismic lines a fault is interpreted).

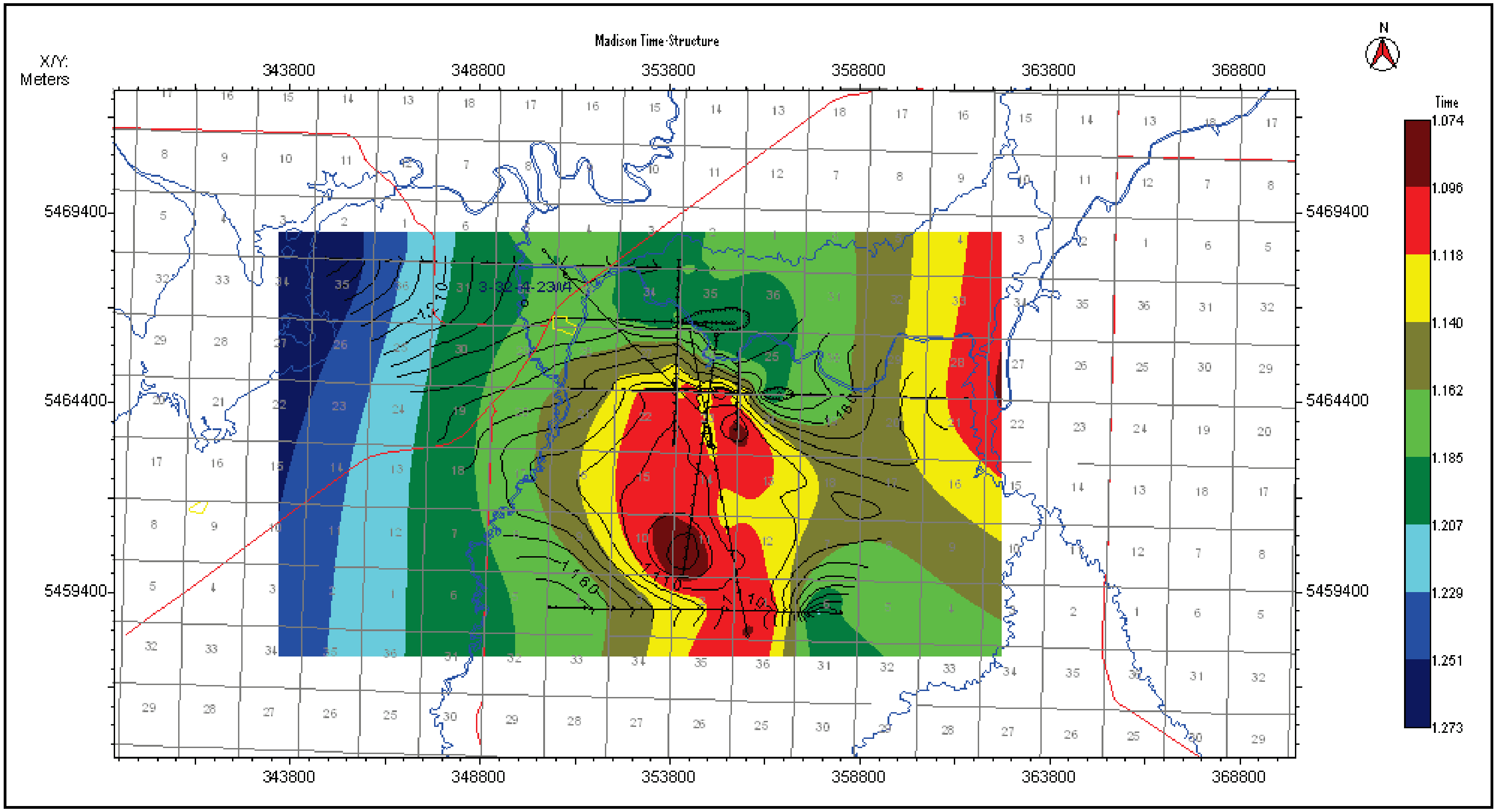

FIG. 10. The Madison (Mississippian) time-structure map, derived from the seismic horizon picks, illustrating a fault to the east of the University of Calgary's Spring Coulee land.

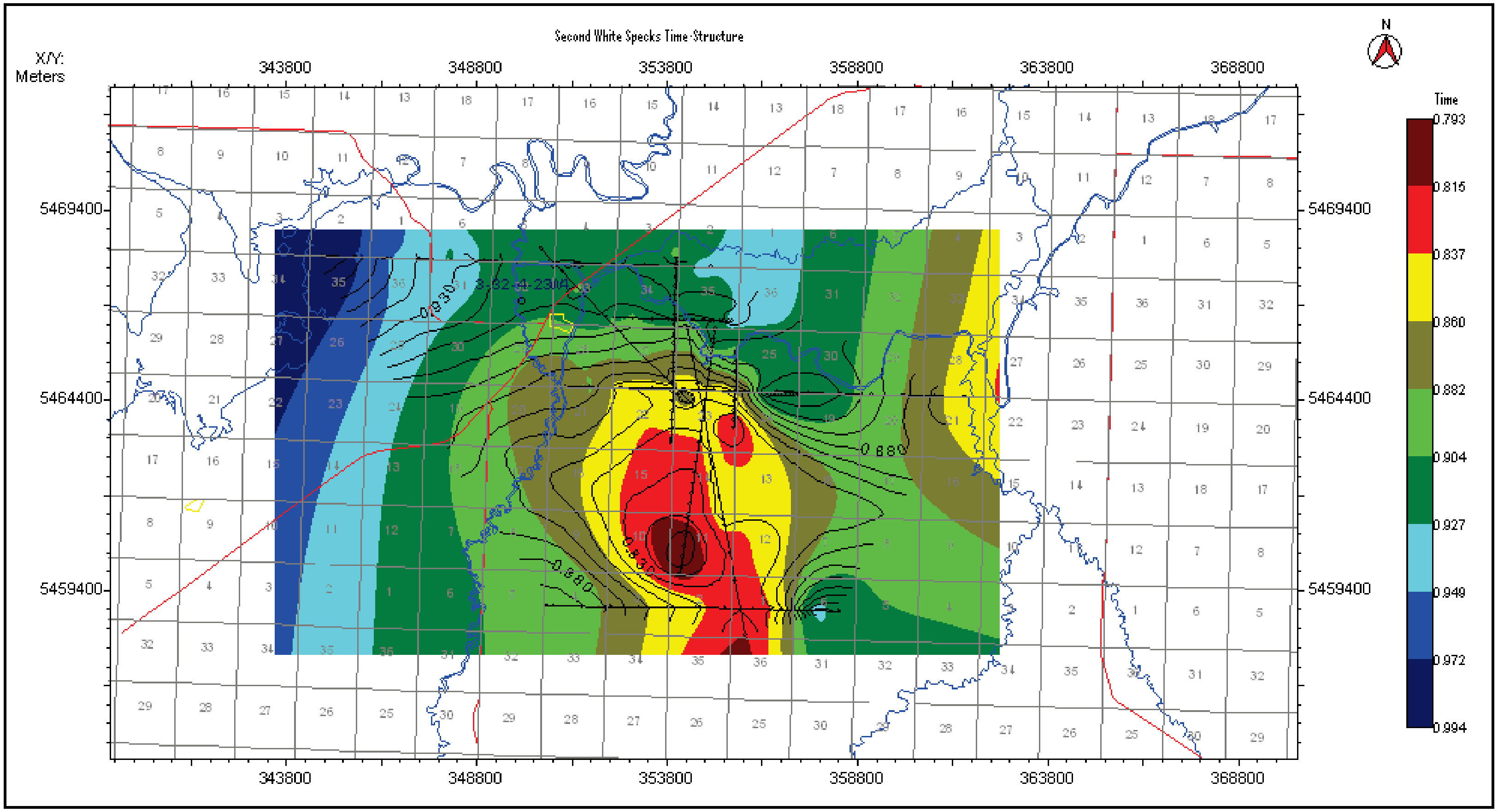

FIG. 11. The Second White Specks time-structure map, derived from the seismic horizon picks.

Figure 12 shows the January 2008 seismic line flattened on the Madison horizon. This figure shows that faulting started in the early Paleozoic and continued into the low Cretaceous. The fault may serve as a hydrocarbon trapping mechanism for migrating oil and gas. We expected to see evidence of a fault in the 2009 Field School survey, but the throw of the fault had reduced significantly to the north. We suspect that this may be evidence that there is more then one fault in the area, and may be a linear fault system.

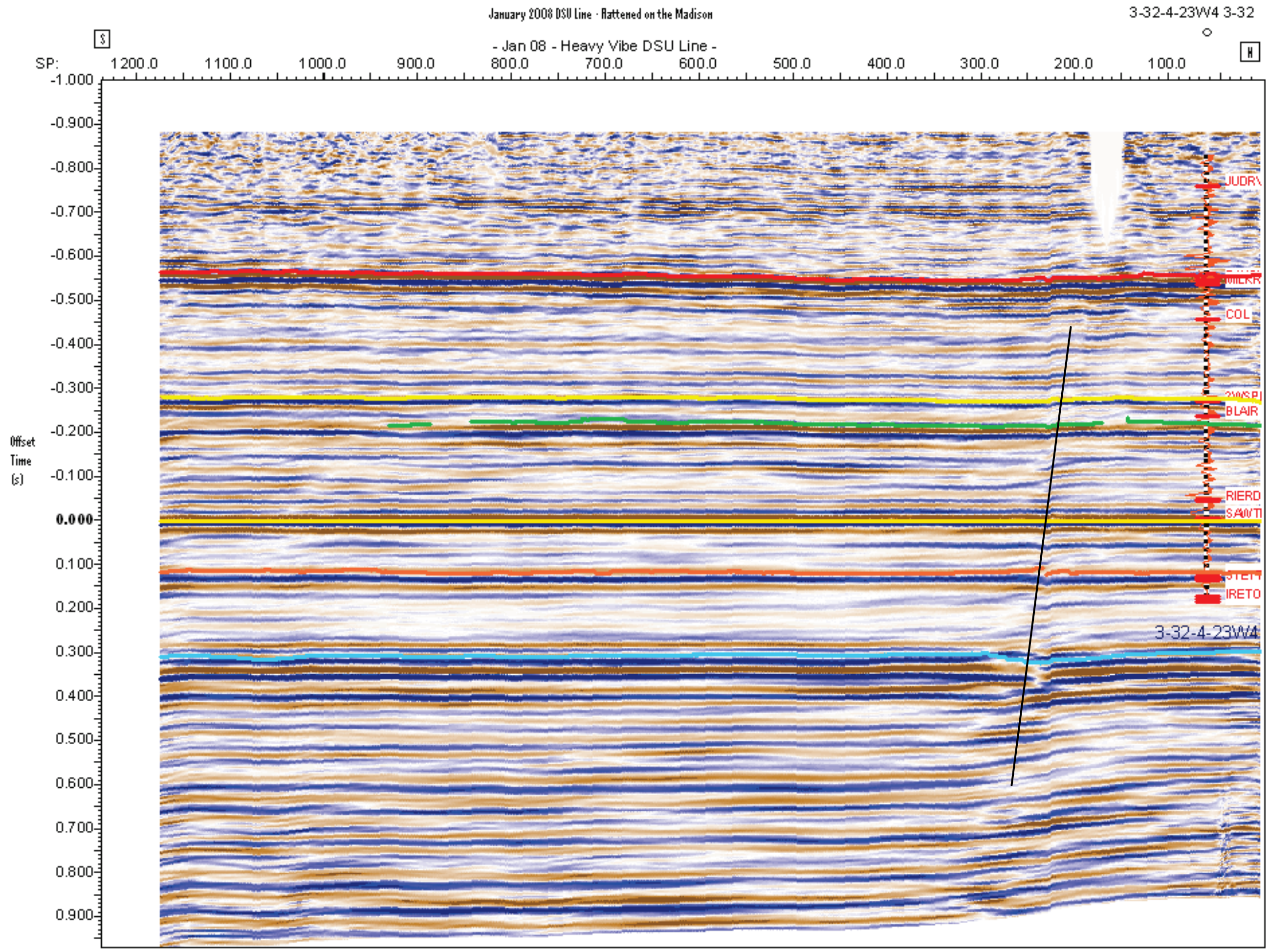

FIG. 12. The January 2008 Heavy Vibe DSU Line flattened on the Madison (yellow) horizon and displaying offset time on the y-axis. The fault is illustrated with the black line.

The area of Spring Coulee has many different producing formations and it is hypothesized that the faulting systems in the area may be a mechanism of trapping. Figure 13 (Ostridge and Stewart, 2008) illustrates the wells in the area that are producing. The bulk of the gas production comes from the Bow Island and Base of Fish Scales formations and is located to the north-northwest of the present study area. Ostridge and Stewart (2008) illustrated that there may be a linear producing trend from north-east to south-west across the Spring Coulee area. It is possible that production is just to the west of the fault and follows an arch on the upthrown side of the fault.

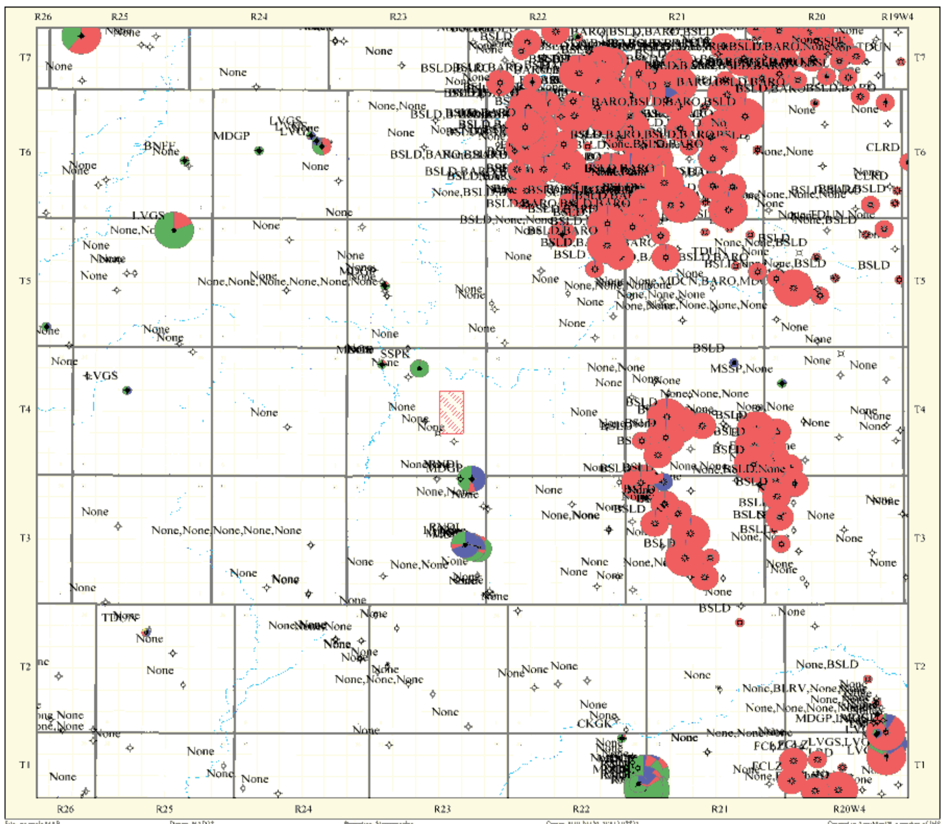

FIG. 13. Map of producing wells in the Spring Coulee area (Ostridge and Stewart, 2008).

CONCLUSIONS

CREWES has obtained multiple seismic lines in the Spring Coulee, Alberta area land with the goal of analyzing the subsurface. There are structural complexities in the area due to basement-related faulting which may induce a hydrocarbon trapping mechanism in Cretaceous strata.

FUTURE WORK

The propagation of faults in the Spring Coulee area is very interesting and mystifying; future work includes mapping of these faults to determine hydrocarbon trapping mechanisms.

Since we originally hypothesized that the fault system propagated from south to north, and the 2009 field school data discounted this hypothesis, a seismic line shot to the east of the 2009 line would be desirable. This would help us to indicate if we have two separate faults or if our fault changes trend to the north. This could be completed in the 2010 field school.

ACKNOWLEDGEMENTS

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