An integrated geological and geophysical analysis of the hydrocarbon potential of the Spring Coulee, Alberta area

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ABSTRACT

The University of Calgary holds the mineral rights to two sections of land in southern Alberta (sections 14 and 23, township 4, range 23 west of the fourth meridian) in the Spring Coulee Area. CREWES was given the opportunity to analyze the hydrocarbon potential of the area. The geological potential of the area was examined, and it was determined that there is a potential to find oil in the structurally high areas of the Madison zone, of Mississippian age, with the possibility of a potential of finding hydrocarbons in younger sand and shale zones, along with deeper carbonates. In January 2008, CREWES, in conjunction with ARAM, Outsource and CGGVeritas shot a 2D-3C seismic survey over the area, looking mainly at the Madison Zone. It was discovered that there are at least two structural highs in the Mississippian zone and more work is being done to model this reservoir. From the information at hand, we have chosen two potential well locations in the south-central portion of section 23 and the north-northwestern side of section 14.

INTRODUCTION

In July of 2004, the University of Calgary hired a new land administrator. Upon searching for the titles for the University of Calgary, he discovered that there were two sections of mineral rights owned by 'The Board of Directors of the University of Calgary'. The land is sections 14 and 23, township 4, range 23, west of the fourth meridian. In the course of a discussion about the University of Calgary's Priddis test site, the administrator mentioned this site. The land is located in southern Alberta - southwest of the town of Magrath and south of the city of Lethbridge, in the Spring Coulee, Alberta area.

A primary target zone in the area is the Mississippian-aged Madison formation. There are multiple secondary sand targets, such as the Sunburst sand, the Sawtooth sand and other younger sand formations. There is also a potential for hydrocarbon production in the deeper Mississippian carbonate and shale formations, such as the Rundle and Banff.

Various large oil and gas companies own the mineral rights in the Spring Coulee area. EnCana and ConocoPhillips are large mineral rights holders in the area to the north and south of the University of Calgary's Spring Coulee land. Figure 1 illustrates the location of the University of Calgary's Spring Coulee land and adjacent land owners.

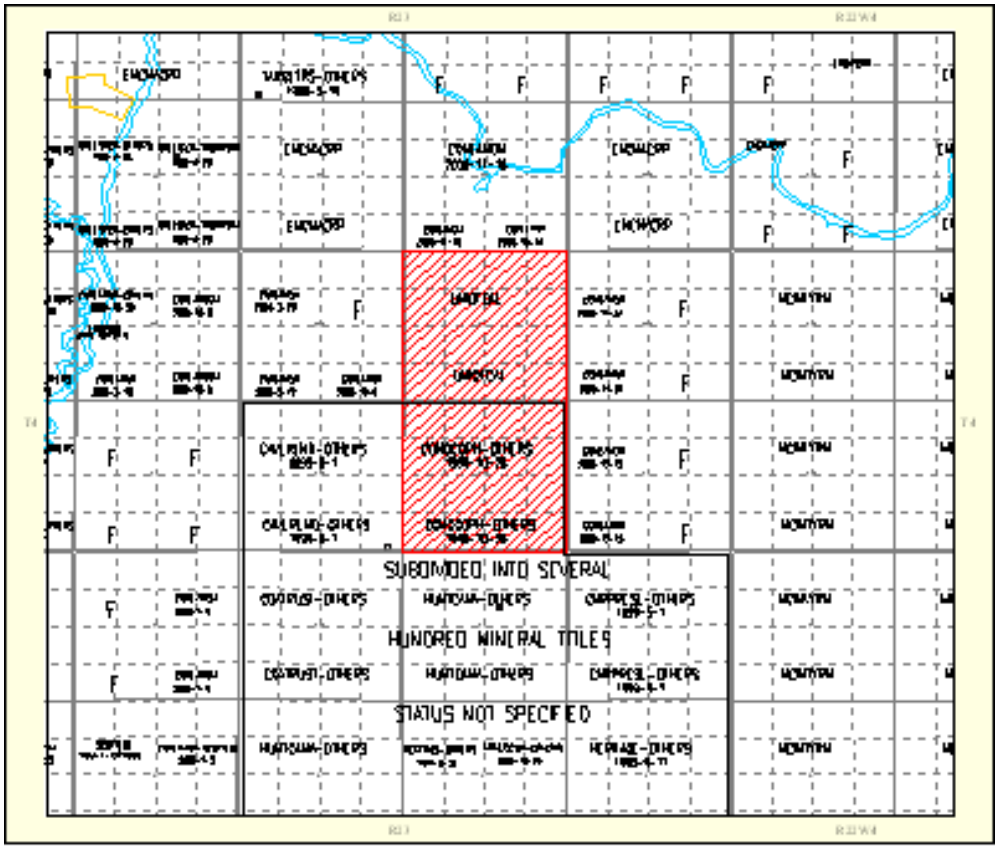

FIG. 1. A land map of the Spring Coulee, Alberta area. The University of Calgary's land is illustrated in the red crosshatch.

REGIONAL PRODUCTION AND GEOLOGY

There are only seven wells in township 4, range 23, and west of the fourth meridian, which indicates that the area is relatively unexplored. The townships to the east and west of the University of Calgary land only have one well each. With so little well information, it is difficult to analyze the hydrocarbon potential of the area, but we can frame a regional picture of the production and geological structure of the area.

Figure 2 illustrates the production of the area.There are two wells that produce hydrocarbons in township 23 and range 4. Well 3-32 produces from the Madison formation, of Mississippian age and well 4-34 produces from the Second White Speckled Shale. To the northeast of the University of Calgary's Spring Coulee land, there is a significant amount of production from the Bow Island and Base of Fish Scale formations.

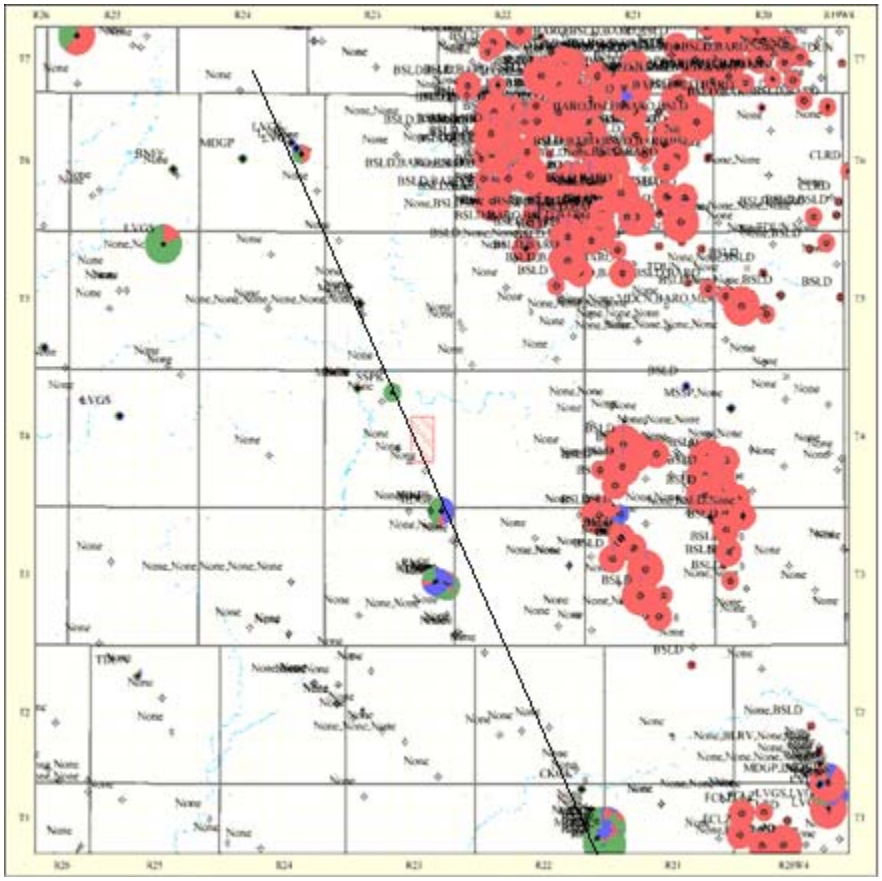

FIG. 2. The regional production of the Spring Coulee, Alberta area, with a general production trend superimposed on the Mississippian-aged producing wells (black line).

There are many defined pools in the Spring Coulee area (Figure 3). There is a Rundle pool just to the south of the Spring Coulee land, and a second farther to the south east. Most of the upper sand production, from formations such as the Bow Island and Base of Fish Scale appears to be to the north east of the Spring Coulee land. As illustrated in the structure map (Figure 4), the higher structure areas are more conducive to Bow Island and Base of Fish Scale Production.

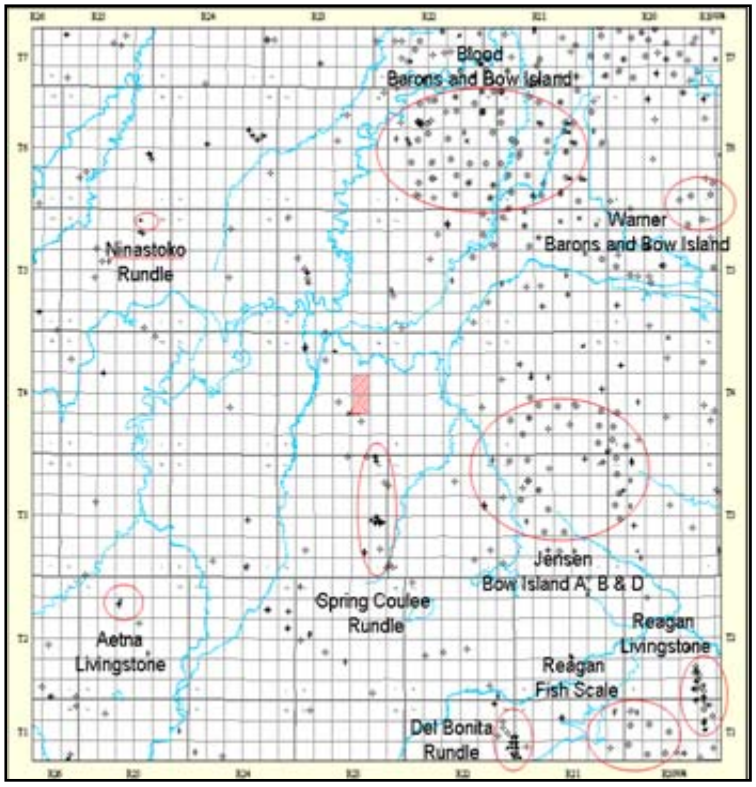

FIG. 3. The government-defined pools in the proximity of the University of Calgary's Spring Coulee land.

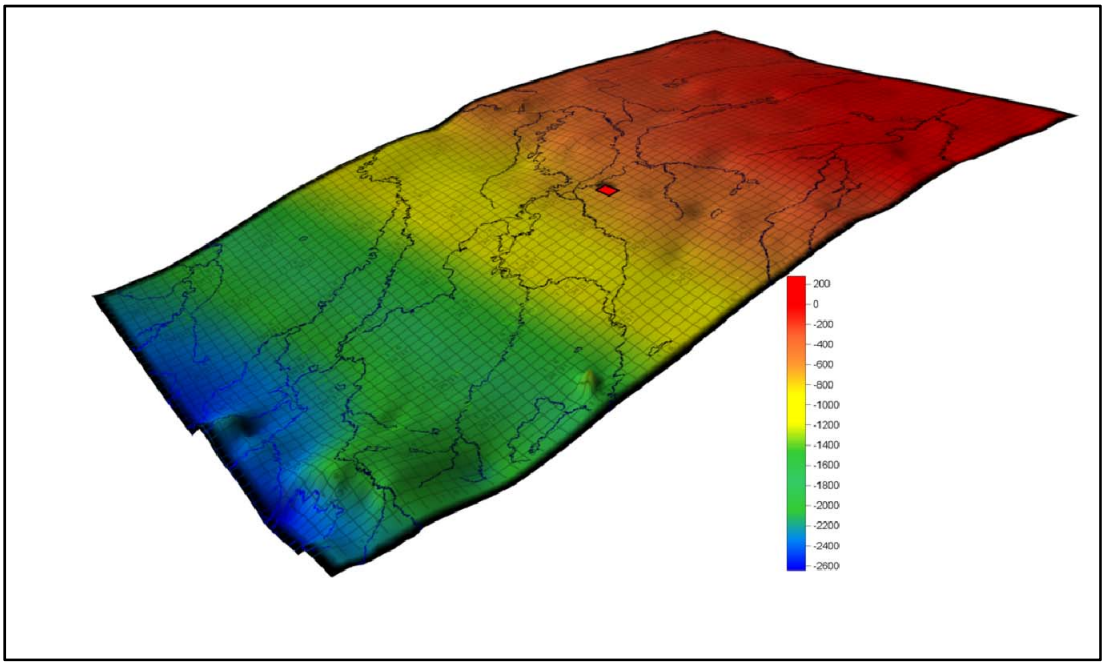

FIG. 4. A sub-sea structure map of the Madison horizon. The Madison formation is structurally high towards the north east and dips to the southwest. The red box illustrates the University of Calgary's Spring Coulee land.

A primary target zone of the CREWES exploration is the Mississippian-aged Madison formation. The Madison formation was deposited on a shallow, tropical, carbonate shelf. The characteristics that make the Madison formation a good reservoir are: dolomitization, fracturing (which enables hydrocarbon migration), and structure from tectonic activity.

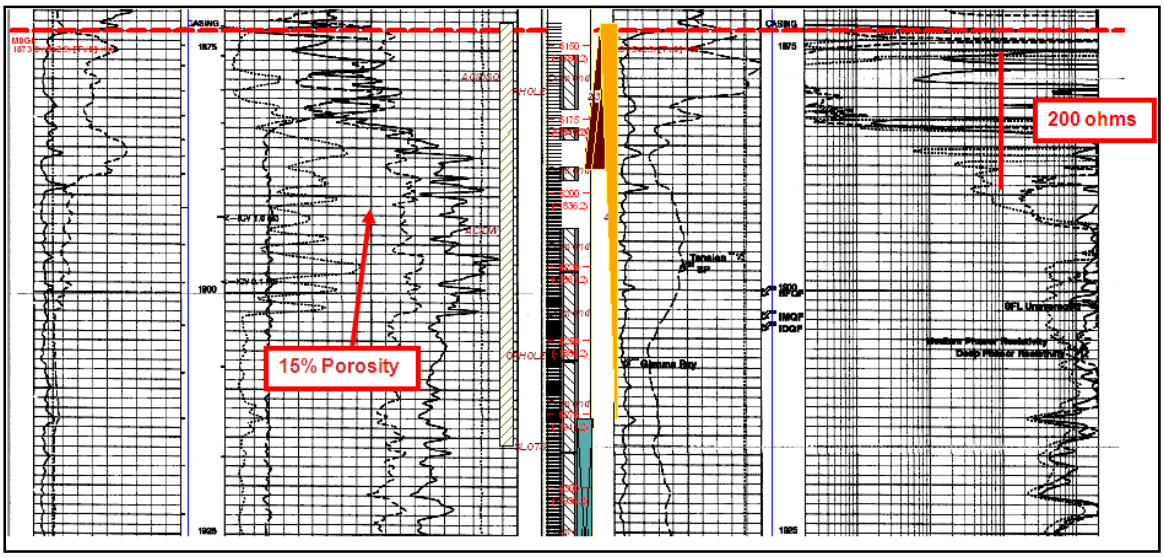

FIG. 5. The Mississippian (Madison) horizon in well 11-13-3-23W4, which is located one township south of Spring Coulee, Alberta. The zone has a porosity of approximately 15% and a varying resistivity of approximately 200 ohms.

REGIONAL SEISMIC DATA

The Lithoprobe seismic processing facility at the University of Calgary has seismic data across Western Canada and one of their lines runs from west to east, just north of the University of Calgary's Spring Coulee land. The Lithoprobe Southern Alberta Lithosphere Transect (SALT) 30 line (Figure 6) illustrates the deep basement structures.

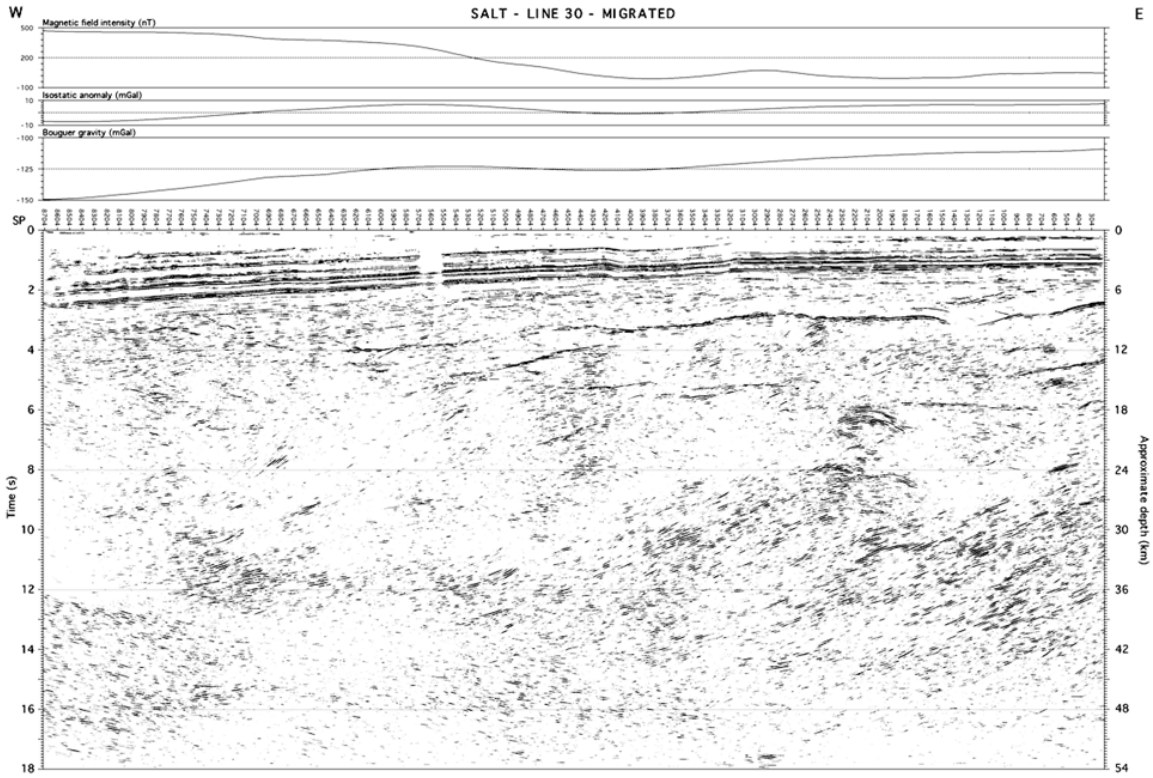

FIG. 6. The University of Calgary's Lithoprobe Seismic processing facility's southern Alberta lithosphere transect (SALT) 30 line.

Paukert (1980), undertook an integrated geoscience study in the Carmangay, Alberta area. The seismic data from Paukert's thesis (Figure 7) was used as a quality control and for comparison of horizons to the Spring Coulee data.

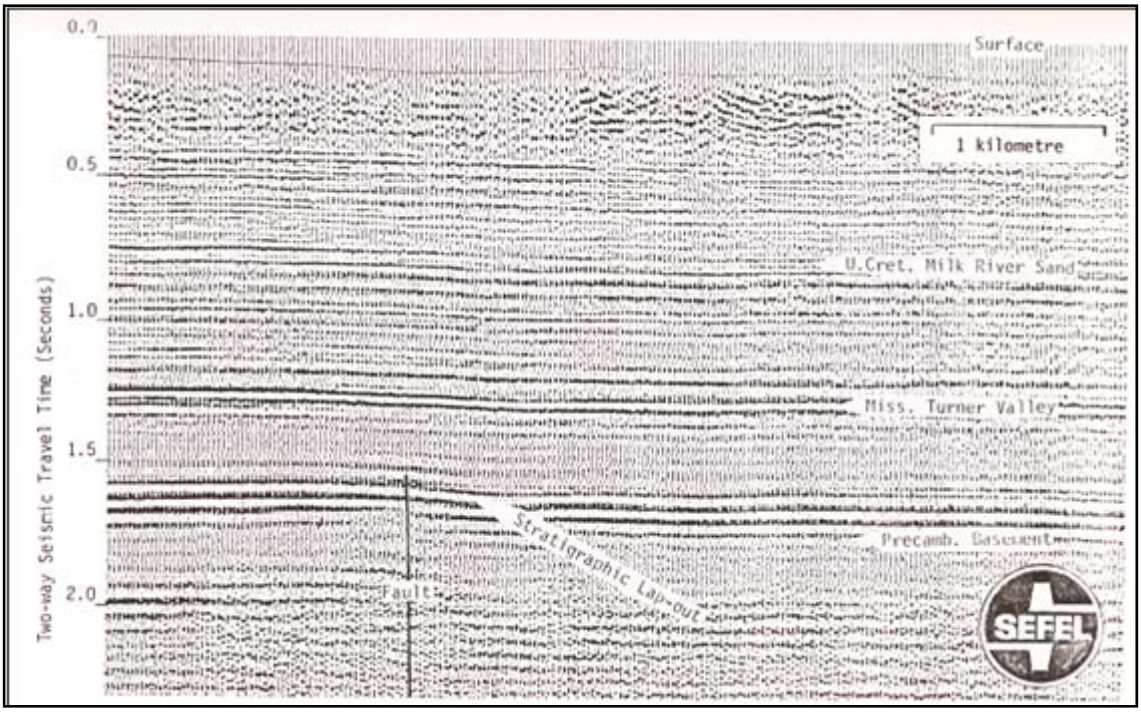

FIG. 7. Regional seismic data from north of the Spring Coulee in the Carmangay, Alberta area (Paukert, 1980).

JANUARY 2008 CREWES SEISMIC SURVEY

The January 2008 CREWES Seismic Survey consisted of dynamite, mini-vibroseis and heavy vibroseis sources and both the ARAM and Sercel recording systems. The survey consisted of an approximately four kilometer long line, from the northeast to the southwest. The Outsource survey plan is illustrated in figure 8. The topography of the area is shown in Figure 9, with the light grey line illustrating the January 2008 CREWES seismic line and the dark grey lines indicating the donated EnCana Corporation lines.

Figures 10-14 illustrate the interpreted P-wave results from the January 2008 survey. The synthetic on the right-hand side of Figures 10-14 is the 3-32 well, located approximately four miles to the northwest of the University of Calgary's Spring Coulee land. This is the closest deep well (deeper then the Madison) in the proximity of the study area.

The mini-vibroseis P-wave section is aligned with the mini-vibroseis shear wave section in Figure 15. Further work is being done to register the dynamite and heavy vibroseis sections.

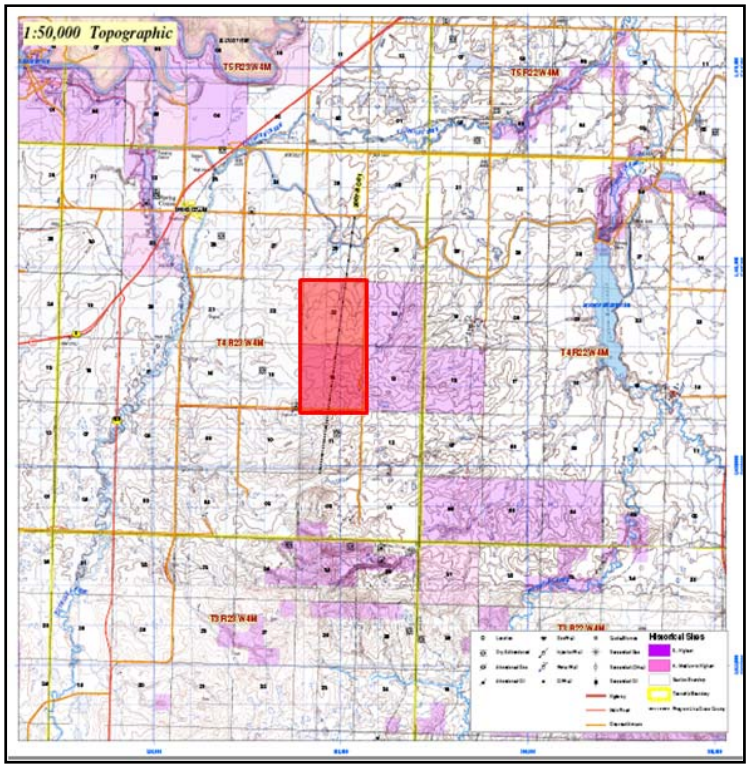

FIG. 8. The Outsource seismic survey plan for the January 2008 CREWES survey. Sections 14 and 23, township 4, range 23 and west of the fourth meridian are illustrated by the red box and the survey line is indicated by the NE-SW trending line over the two sections.

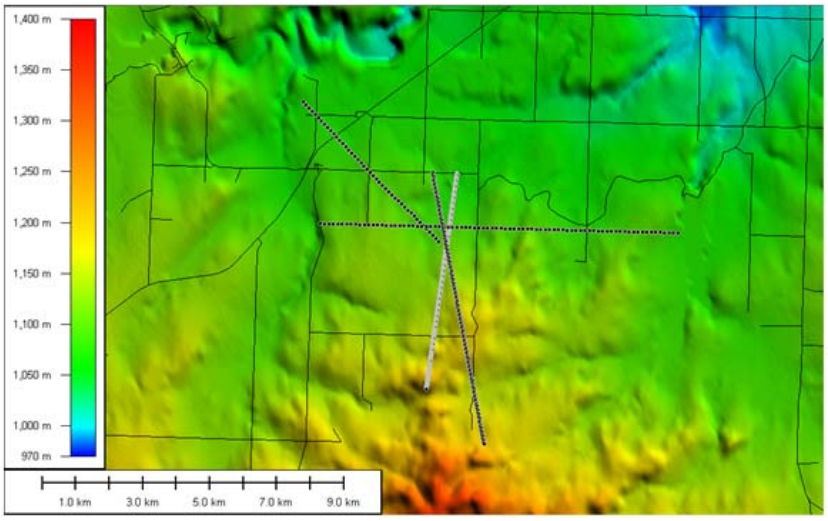

FIG. 9. A topographic map of the Spring Coulee, Alberta area. The 2008 CREWES seismic survey is illustrated by the light gray line. The donated EnCana Corporation data is denoted by the three dark gray lines. Map created by Kevin Hall, CREWES.

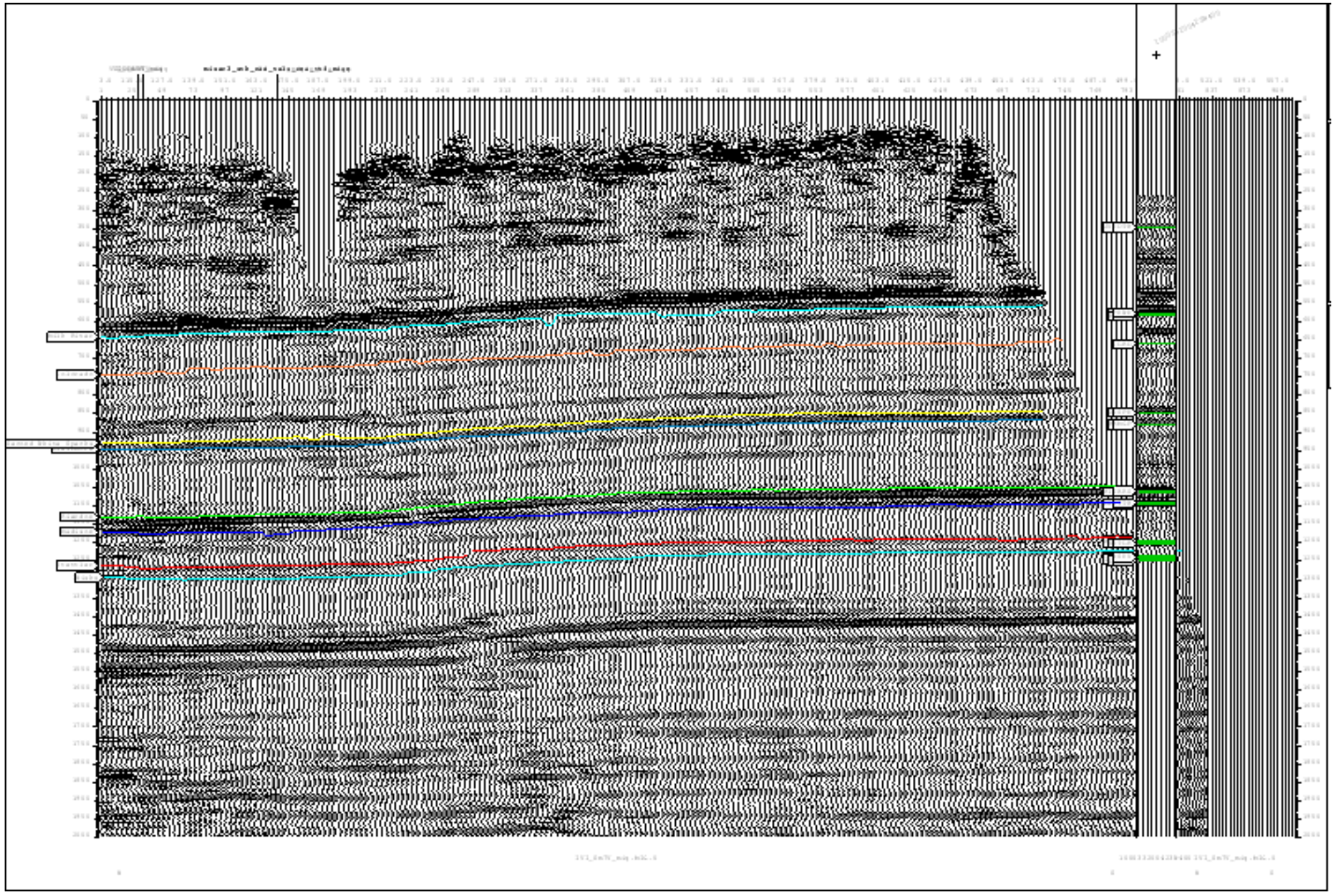

FIG. 10. The CREWES mini-vibroseis section with formation horizons picked. The dark blue line is the Mississippian-aged Madison formation. Note the possible fault, transcending up to the drainage ditch (top left). The data was processed by Han-Xing Lu of CREWES.

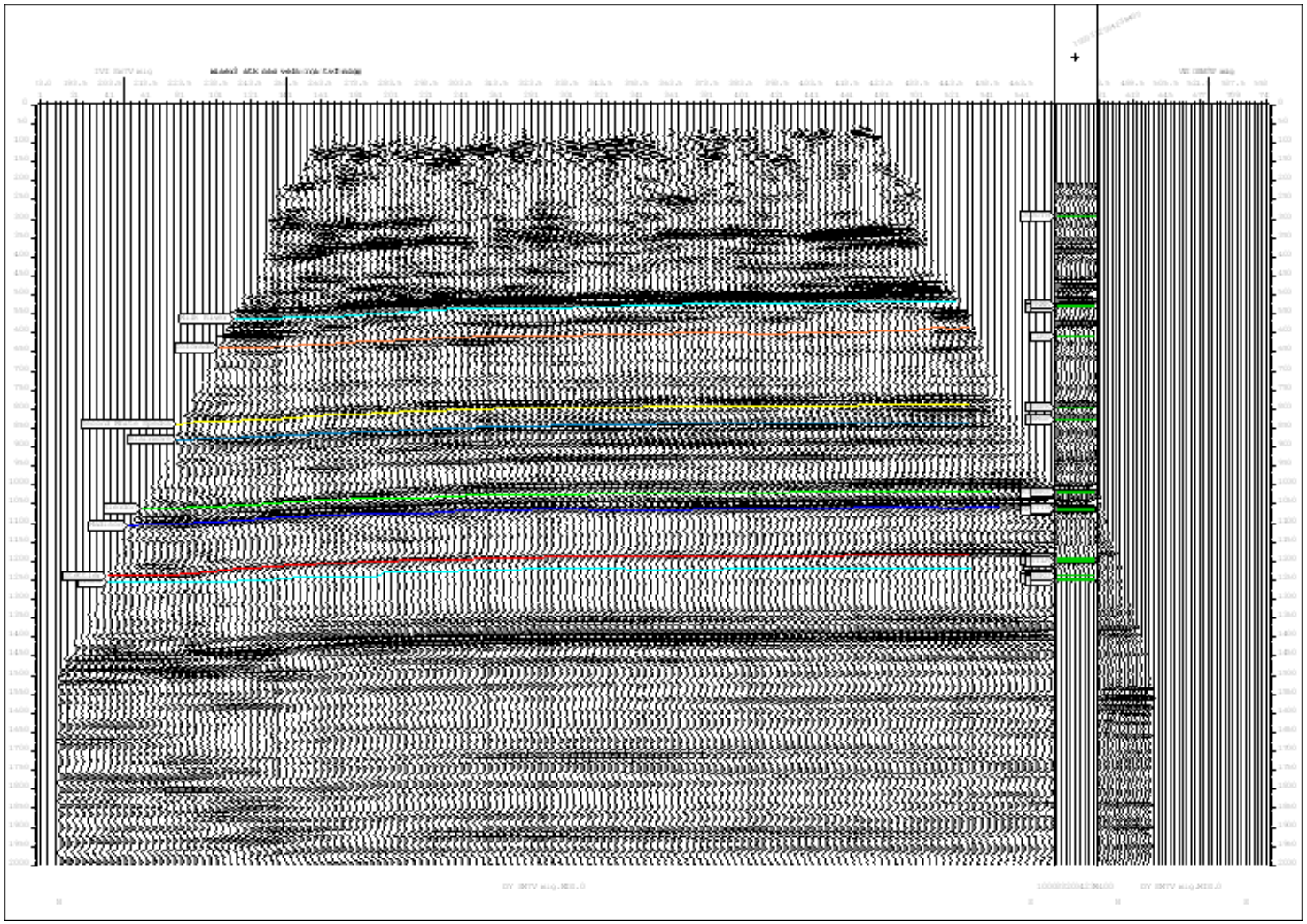

FIG. 11. The CREWES Spring Coulee dynamite seismic section. This line is shorter, thus we do not see the drainage ditch or the fault. The data was processed by Han-Xing Lu of CREWES.

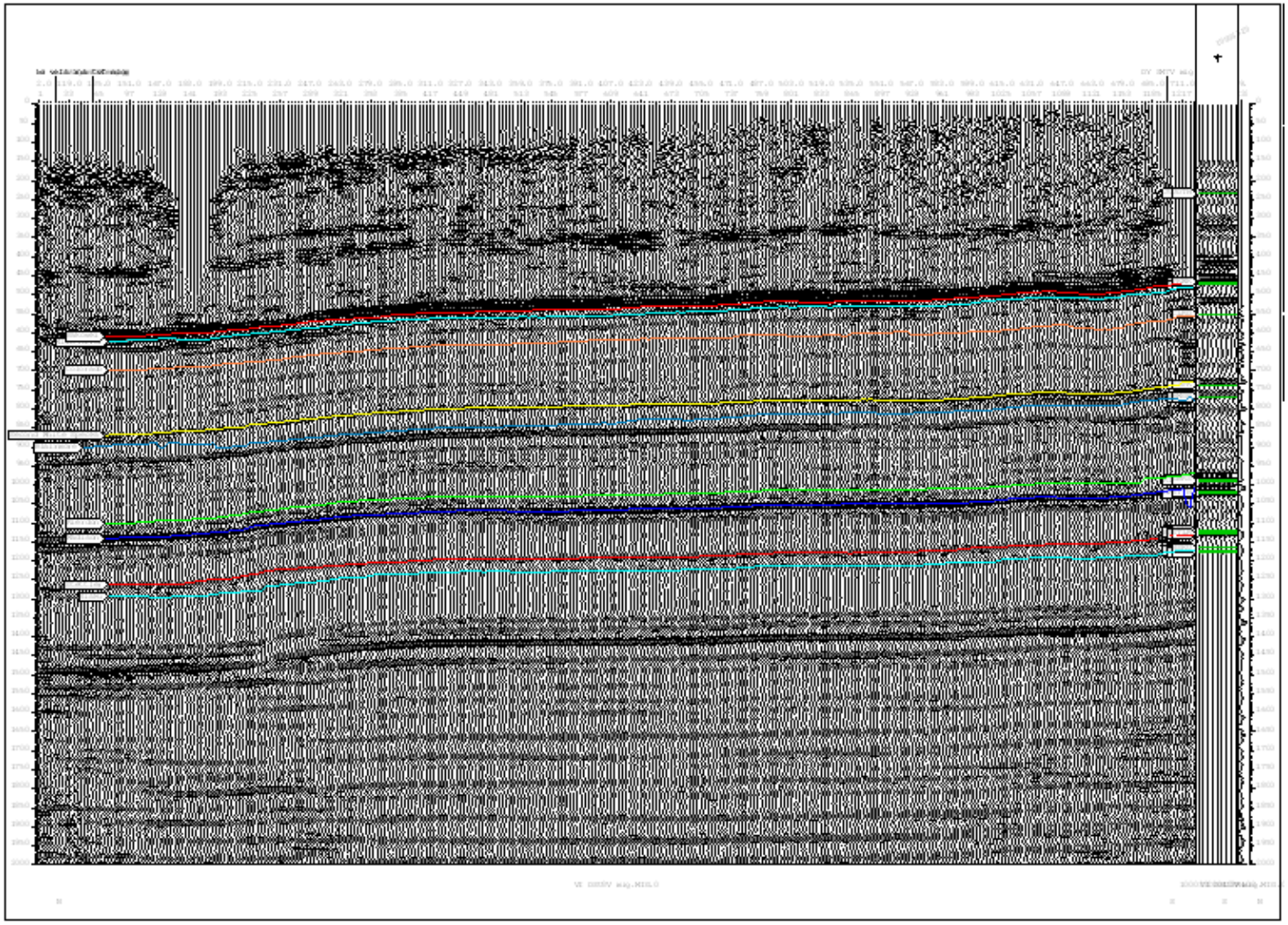

FIG.12. The Spring Coulee heavy vibroseis section, recorded with the Sercel system. The data was processed by Han-Xing Lu of CREWES.

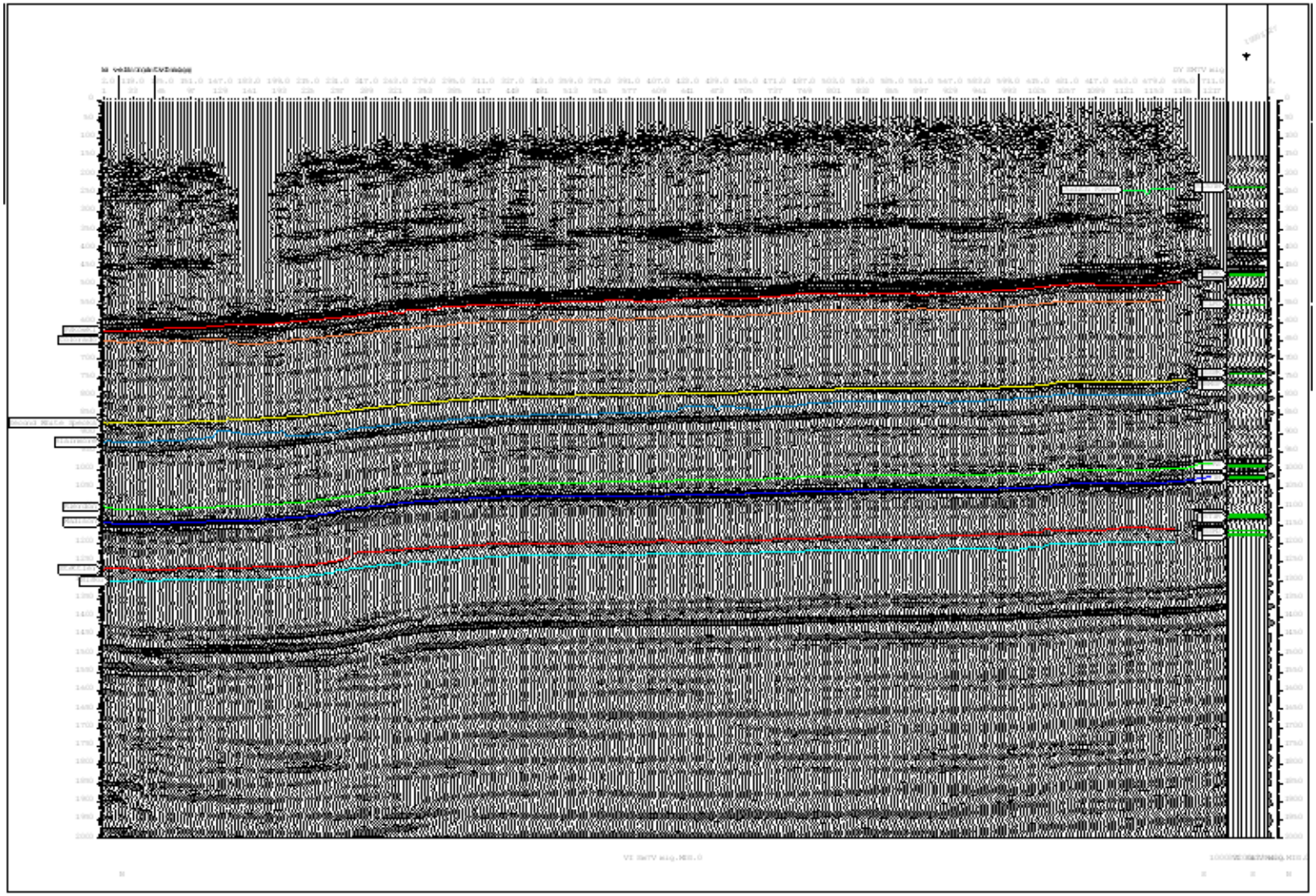

FIG.13. The Spring Coulee heavy vibroseis section, recorded with the ARAM system. The data was processed by Han-Xing Lu of CREWES.

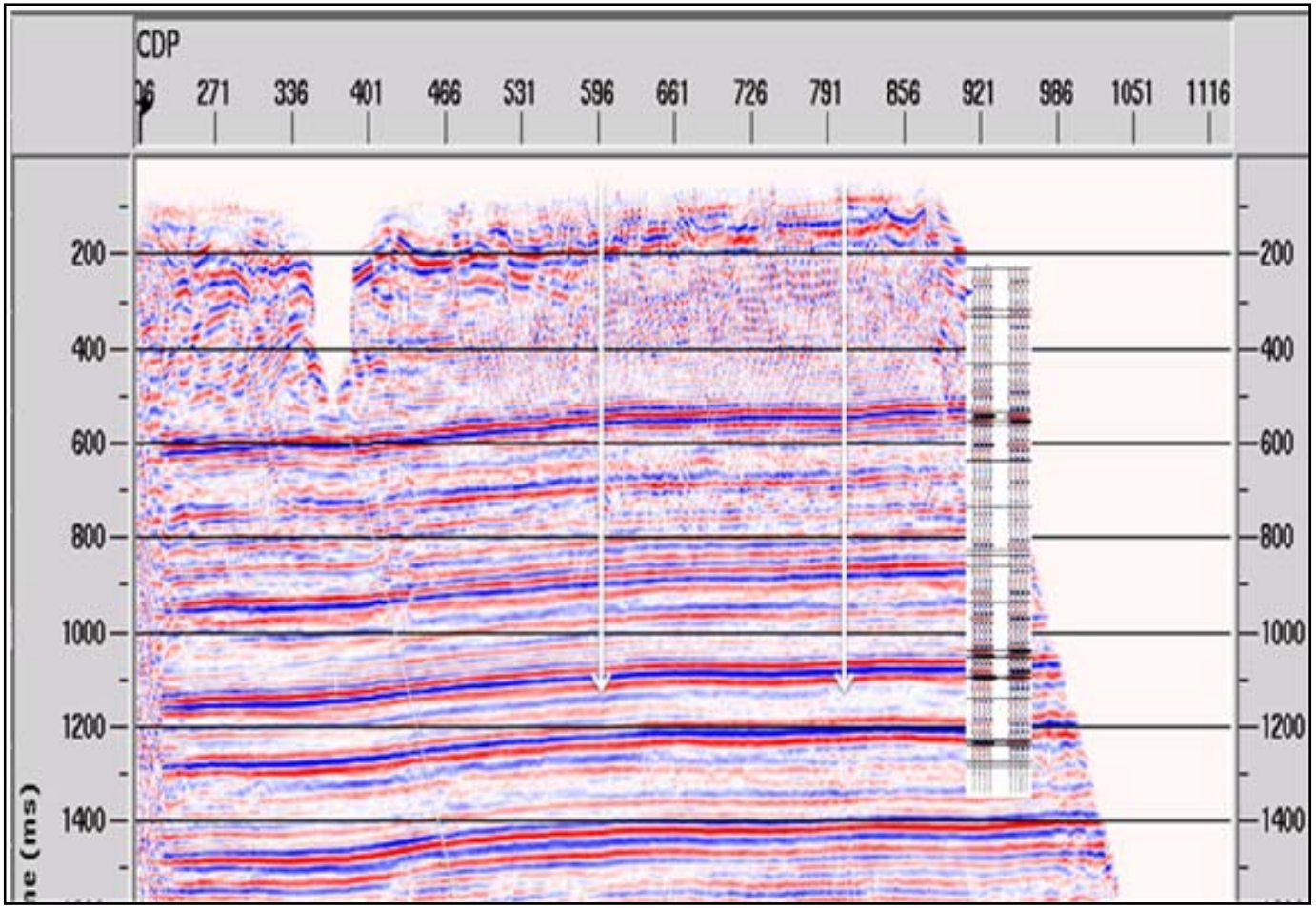

FIG.14. The Spring Coulee mini-vibroseis section with two potential well locations, illustrated by the white arrows. The data was processed by Han-Xing Lu of CREWES.

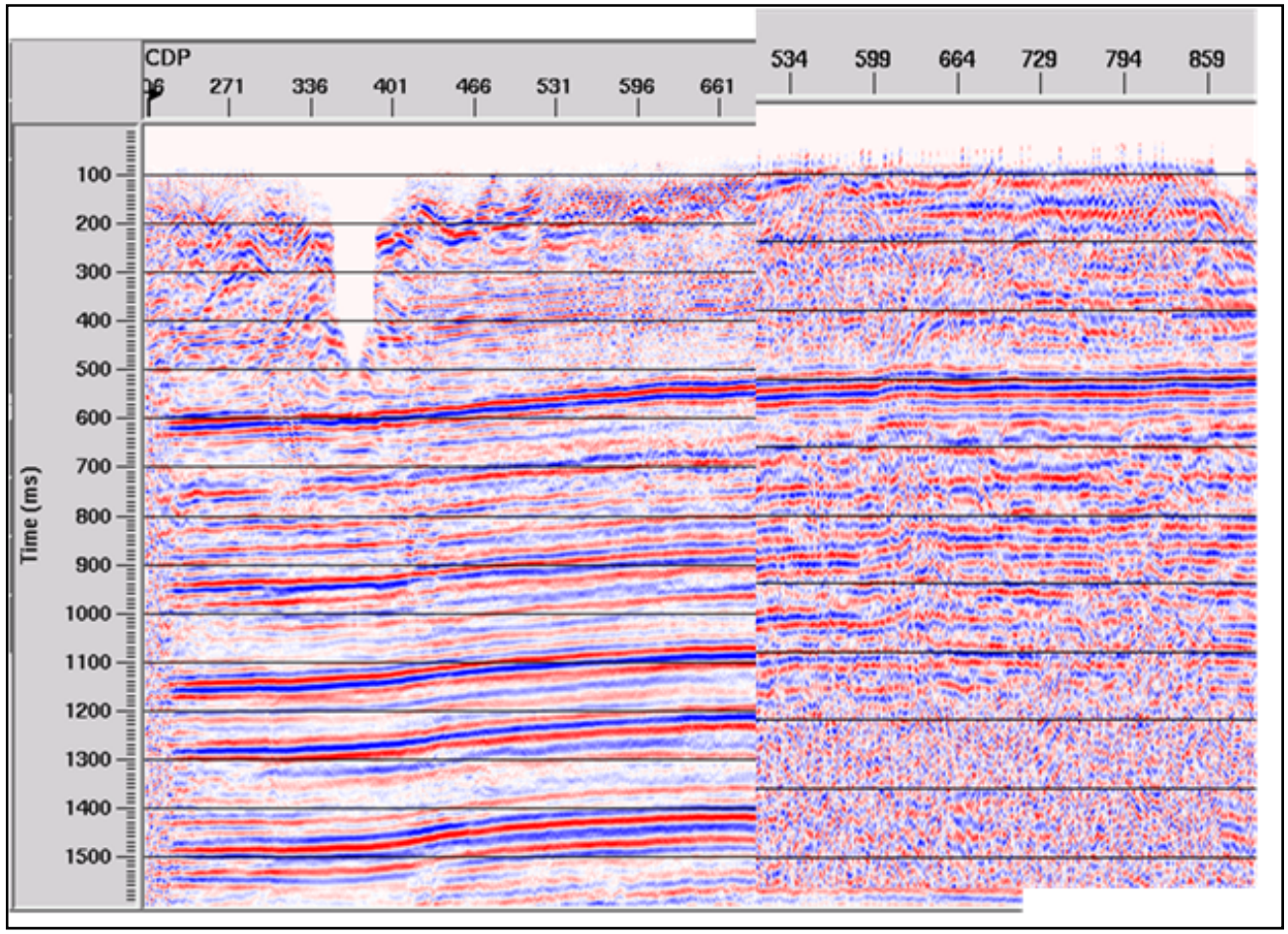

FIG.15. Han-Xing Lu's comparison of the mini-vibroseis P-wave and shear wave sections. The Vp/Vs ratio used is 1.9.

As stated in the regional geology section of this paper, the primary hydrocarbon target zone is the Mississippian-aged Madison formation. The targets are defined seismically by slight highs in the horizon. Figure 13 illustrates the two potential well locations that have been picked based on highs in the Madison formation. The location farther to the left is the preferred location, as it is closer to the fault – which would be a source of hydrocarbons due to migration.

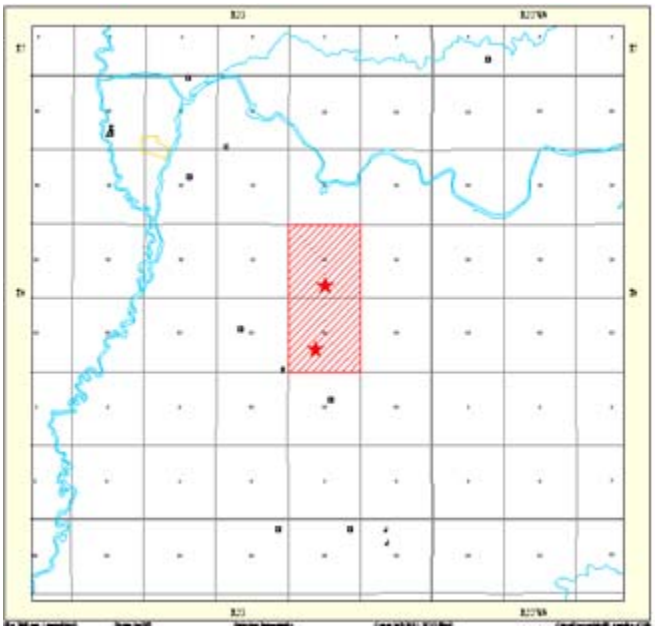

FIG.16. The two potential well locations (red stars) from the seismic data (Figure 13) transposed onto the land map.

CONCLUSIONS

The Spring Coulee, Alberta area is relatively unexplored terrain; there are very few wells in each township and township 4, range 23, west of the 4th meridian is no exception. There are many producing zones in the area and thus there is great potential within the land to which the University of Calgary owns the mineral rights.

There is an abundance of Bow Island and Base of Fish Scale production to the northeast of the Spring Coulee land, which is structurally higher than the University of Calgary's land. The Madison carbonate is the primary hydrocarbon target zone. There are multiple secondary target zones, including the Milk River sands, the Colorado shales, the Second White Speckled Shale, Sawtooth and Sunburst sands, the other Mississippian targets: the Rundle, the Banff and the Devonian Nisku and Leduc carbonates.

The data from the January 2008 seismic survey has given us an immense amount of information and we have identified two potential well locations (Figure 16). Work is still being done on this project to identify and analyze secondary targets and to interpret the shear wave data.

ACKNOWLEDGEMENTS

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REFERENCES

Paukert, G.W., 1982, Geophysical Study of Precambrian Basement Fault Structure and Related Cretaceous Stratigraphic Variation in Southern Alberta: University of Calgary Master of Science Thesis.