3D Seismic Surveys for Shallow Targets

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Summary

A high-resolution 3D seismic survey was undertaken to map shallow stratigraphy near Calgary, Alberta. The survey was 500m x 300m in area, with shot and receiver lines in an orthogonal geometry using 50m line separation. Shots and geophones were spaced at 10m intervals along source and receiver lines, respectively. The surface source used was an 18,000lb EnviroVibe sweeping over a 10Hz to 180Hz range. The survey yielded excellent reflections with a dominant frequency of 50Hz. One high-amplitude west-dipping reflection, occurring between depths of 250m and 450 m, was mapped over the survey area. The project demonstrates the efficacy of reflection seismic surveys for shallow (100m – 500m) targets.

Introduction

A 3D surface seismic survey was acquired at a site near Priddis, Alberta, about 30 km southwest of the city of Calgary. The purpose of the program was to map shallow stratigraphy and structure to depths of up to 500m, and to investigate shallow aquifers in the study area. 3D seismic surveys are used more typically to map deeper targets, but this program illustrates the usefulness of the method for characterizing shallow targets (such as oilsands deposits).

The survey is located at the eastern edge of the Rocky Mountain foothills in the triangle zone (Lawton et al., 1996), a structural feature where clastic sediments of dominantly Cretaceous age have been wedged into the Rocky Mountain foreland basin. Local topography of the area is controlled by sandstone ridges of the Cretaceous Belly River Formations, which trend in a northwesterly direction, along structural strike. Shales of the Upper Cretaceous Edmonton Formation form the bedrock in the intervening valleys. In the study area, Upper Cretaceous and Tertiary strata dip gently towards the southwest. An aerial photograph of the site is provided in Figure 1, covering a quarter-section of land owned by the University of Calgary and home to the Rothney Astrophysical Observatory (buildings shown near the upper right hand side of the photograph). The 3D seismic survey layout is shown in the southern area, and a 140m deep VSP and logging well was located near the northern access road.

Seismic Survey

The seismic survey was designed to image horizons in the depth range of 100 to 500 m. An orthogonal geometry was employed, with receiver lines oriented north-south and source lines oriented east-west. Shot and receiver lines were 50 m apart and shots and receivers were spaces 10 m apart along their respective lines. Shot lines crossed receiver lines midway between geophones and similarly, receiver lines intersected shot lines midway between shots. This approach to recording optimizes array stacking for surface-wave attenuation (Anstey, 1986). The survey layout and fold plots are shown in Figure 2. One receiver line was recorded with 3C geophones for assessing shallow converted wave data.

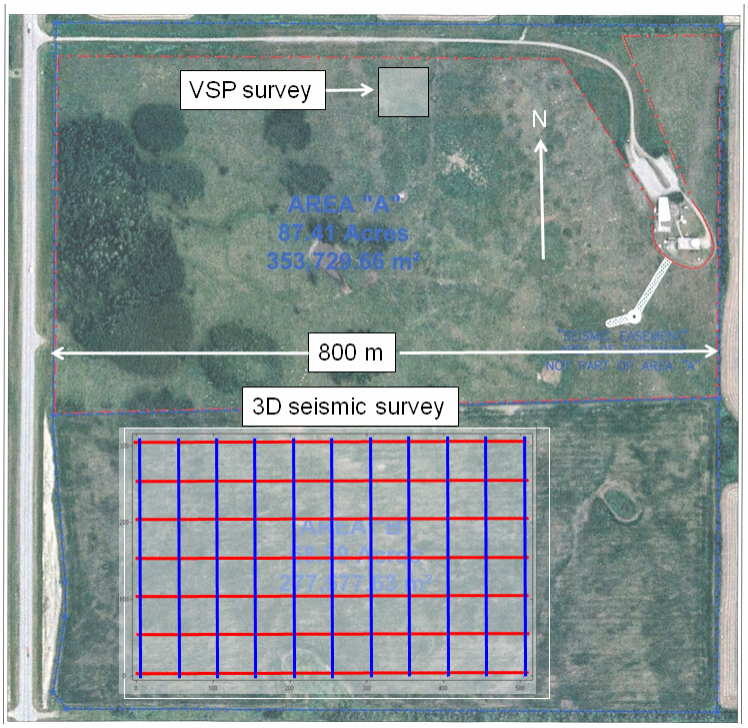

Figure1: Priddis shallow 3D seismic survey

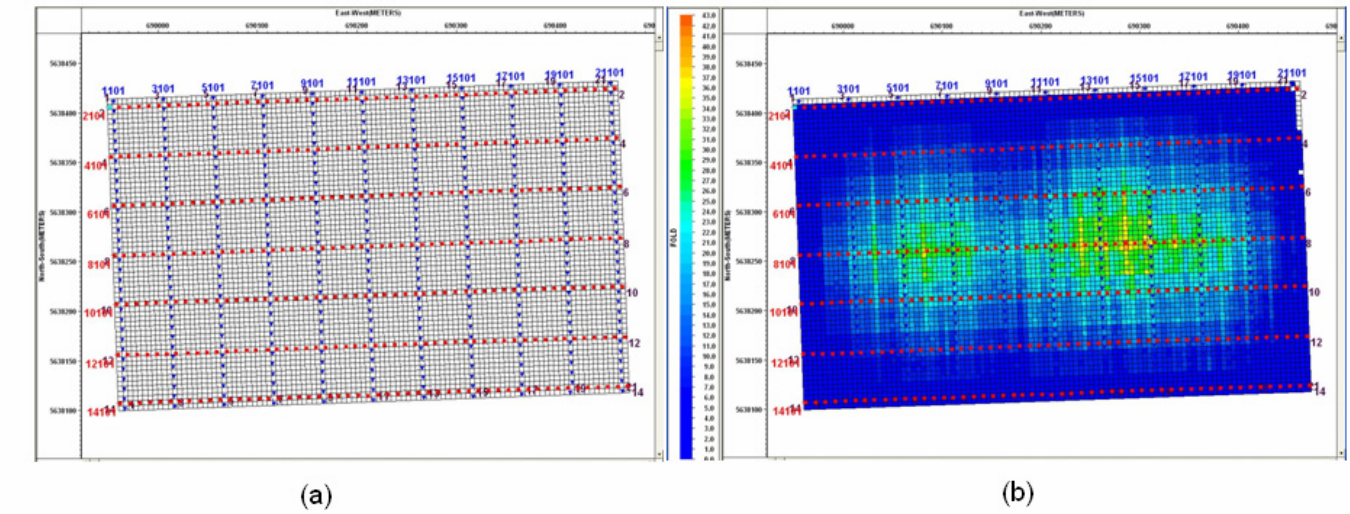

Figure 2: (a) geometry and (b) fold plots for Priddis high-resolution 3D survey

Results

An example of a correlated shot gather (with AGC scaling) is displayed in Figure 3a. Clear first arrivals are visible, but surface and airwaves dominate the record at later times. However, after application of a 40-60-140-180 Hz bandpass filter, clear reflections are observed between 250 ms and 500 ms (Figure 3b).

Initial processing of the data through to a brute stack has been completed and an example of cross-line section is shown in Figures 4. Figure 5 is an isometric view of vertical and horizontal slices from the data volume. Most prominent in these displays is a series of west-dipping reflections between 100 ms and 400 ms, corresponding to approximate depths of 250m to 450m. The high-amplitude event between 200 ms and 300 ms is interpreted to correspond to a thick, competent sandstone that may be a regional aquifer.

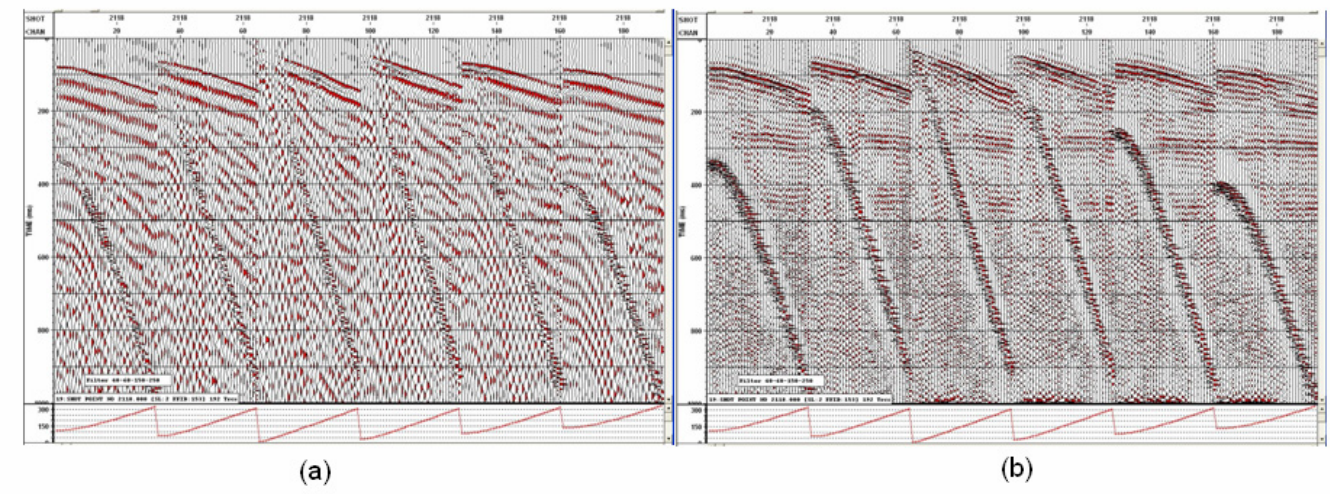

Figure 3: (a) raw shot gather (with agc) and (b) filtered shot gather (40-60-140-180 Hz bandpass)

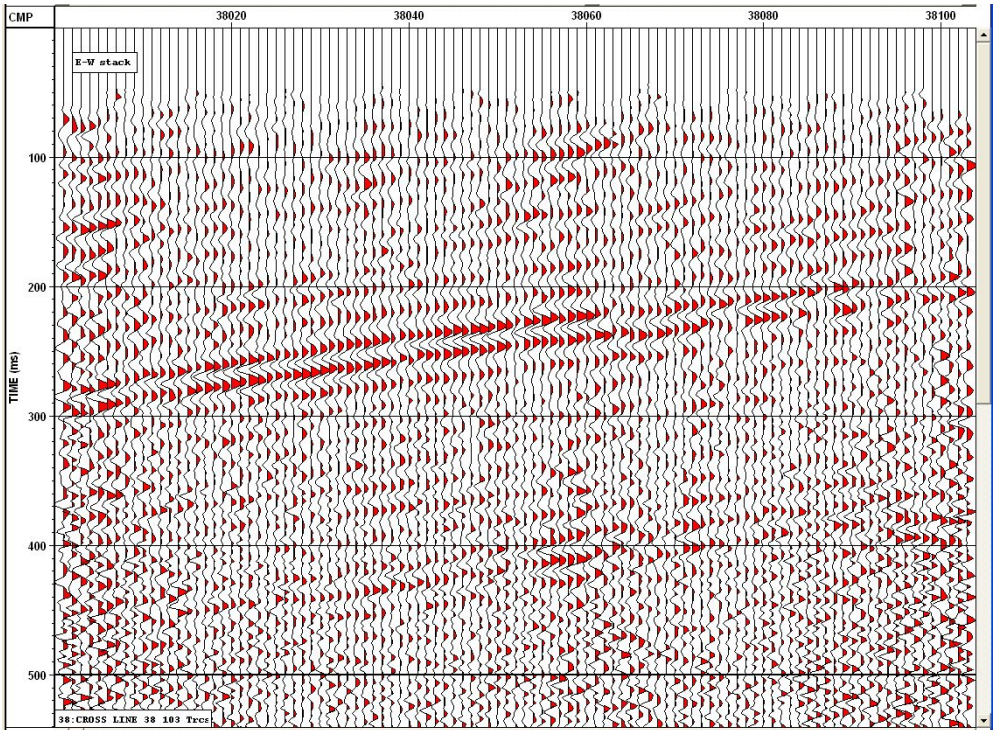

Figure 4: Cross-line section from a brute stack of the 3D volume

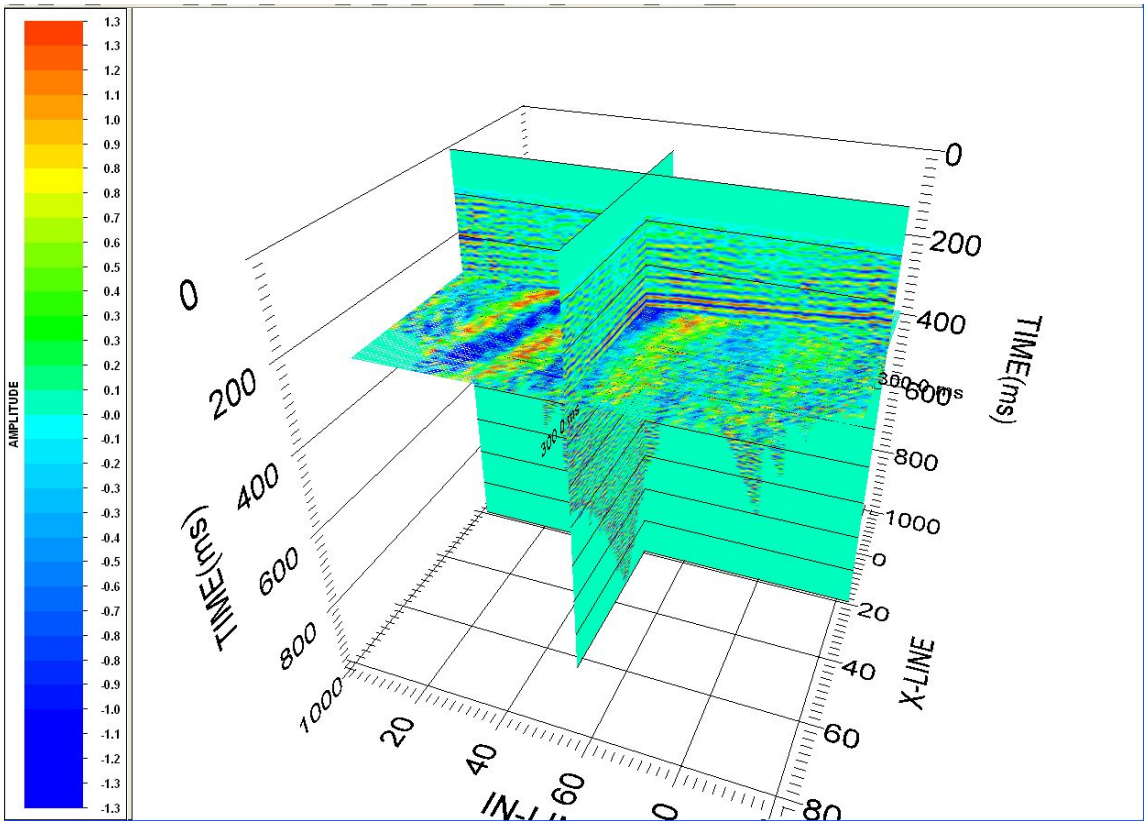

Figure 5: Brute stack 3D seismic volume

Conclusions

The results of the survey illustrate the opportunity that 3D seismic surveys provide for mapping shallow reflectors and the acquisition geometry needed to image them. Applications include mapping the distribution of shallow aquifers, delineating shallow coals and investigating oilsands deposits.

Acknowledgements

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References

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