Preliminary multicomponent seismic analysis over the Steen River structure, northern Alberta

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ABSTRACT

In February, 2000, a 6.0 km 3-C seismic line was acquired over the western rim of the Steen River structure in northern Alberta by Gulf Canada Resources Ltd. and the CREWES Project. A dynamite source (1.0 kg at 9 m depth) was recorded by single 10 Hz 3-C geophones offset up to 2820 m. The multicomponent data acquired were very good and were processed to final migration through a sophisticated flow by Sensor Geophysical Ltd. Shallow strata are particularly well imaged by the P-S data as is the pre-Cretaceous unconformity. Deeper, complicated and faulted structure is apparent on both sections but better defined on the P-P data at this point.

INTRODUCTION

The Steen River structure in northern Alberta is the largest known meteorite impact structure in the Western Canadian Sedimentary Basin. The impacting event likely occurred some 90 million years ago and gave rise to a multi-ring structure about 25 km in diameter. Large competent fault blocks of the rim are displaced and rotated. Structural traps exist in the Devonian structures below the preCretaceous unconformity. These structures became resident to migrating hydrocarbons that have become the target of current exploration. To this exploration end, Gulf Canada Resources Ltd. and investigators from the University of Calgary acquired a set of multicomponent reflection and refraction lines. Only the reflection line will be discussed in this paper.

3-C SEISMIC DATA

The 6.0 km multicomponent seismic line was shot in an east-west direction over the western rim of the structure. A dynamite source (1.0 kg at 9 m depth) was recorded by single 10 Hz 3-C geophones offset up to 2820 m. Fastway Exploration Ltd. of Calgary recorded the data. Surface topography in the area slopes toward the southeast (elevations across the line from east to west are from 660 m to 480 m above sea level). However, the predominant subsurface structure dips to the southwest. An aerial view of the line and area, plus the seismic layout are shown in Figure 1. Note that the 3-C seismic line was shot with three seismic cables – one cable for each component. Example shot gathers for both the vertical and radial channels are shown in Figures 2 and 3. We notice, what appears to be, a long offset refraction (location 301) in Figure 2 that may be from the pre-Cretaceous unconformity. Furthermore, we see back scatter at location 181, perhaps from an out-of-the-plane reflector. We observe coherent P-S reflections on the radial channel, but note that they have considerable high-frequency static shifts across the spread. We also see an S-wave refraction at a slightly higher velocity than the ground role (evident on vertical and radial channels). Similar features are observed on vertical and radial traces in Figures 4 and 5.

Figure 1. Areal view of the 3-C seismic line at Steen River, northern Alberta on the left with a view down the line on the right. Note the three cables that were used for the 3-C seismic recording.

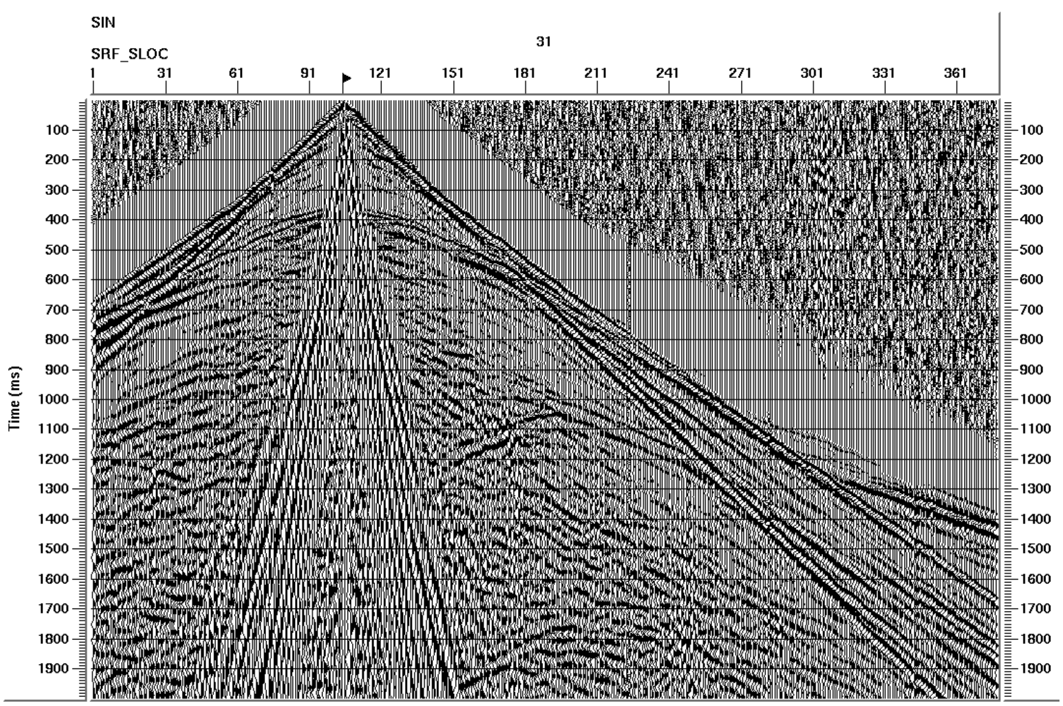

Figure 2. Vertical component shot record.

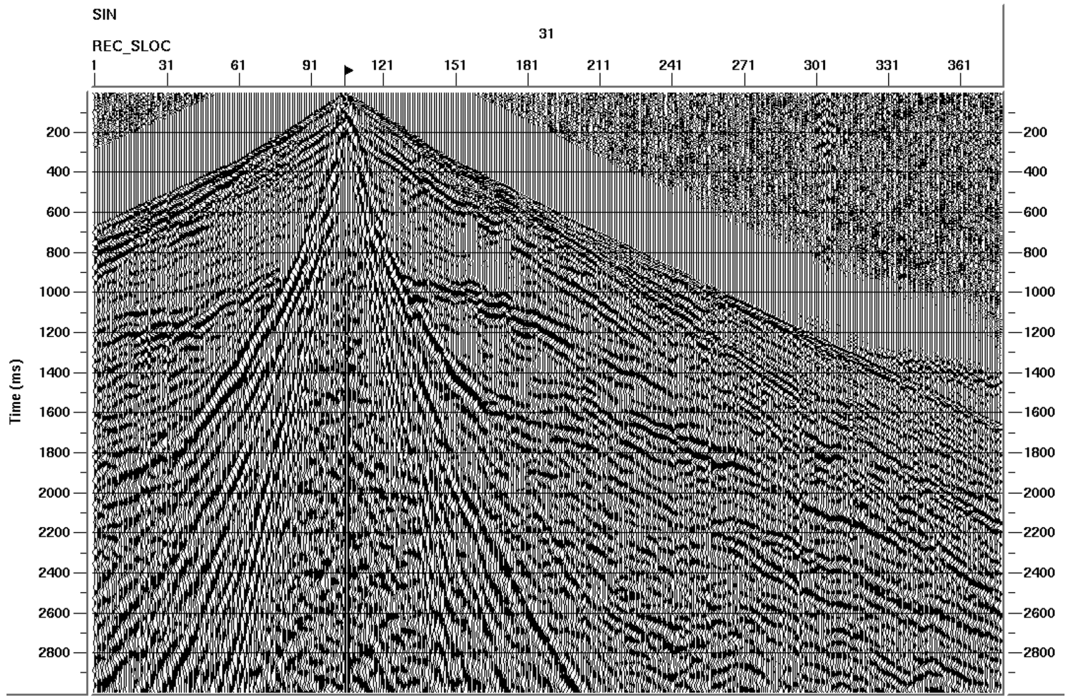

Figure 3. Radial component shot record.

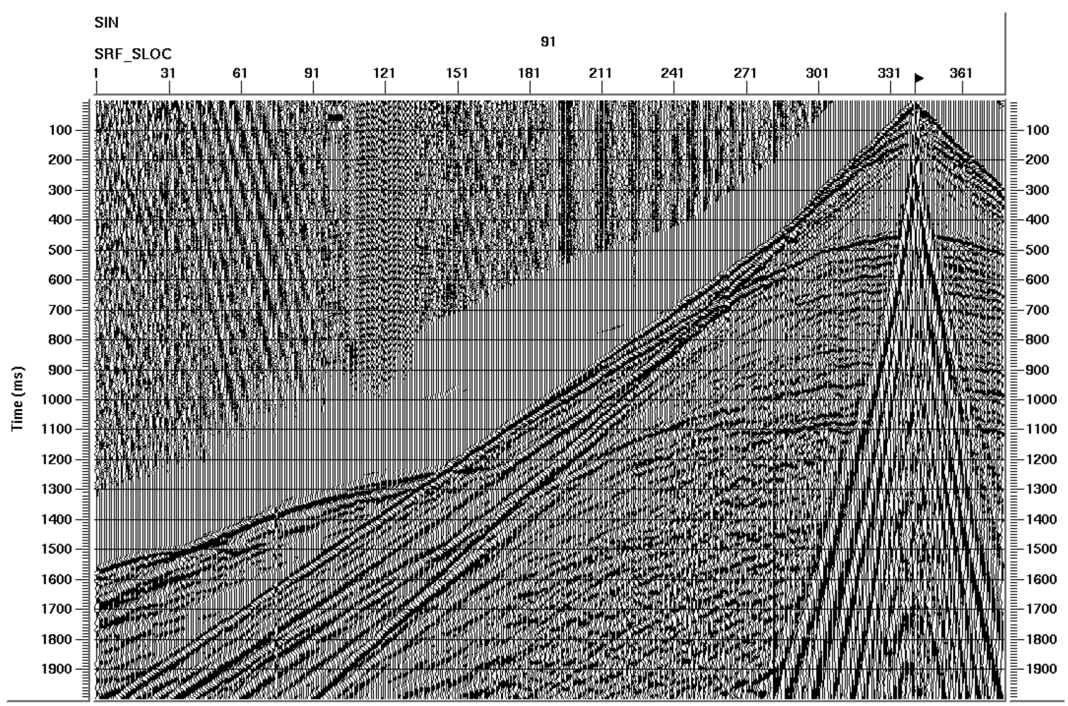

Figure 4. Vertical component shot record.

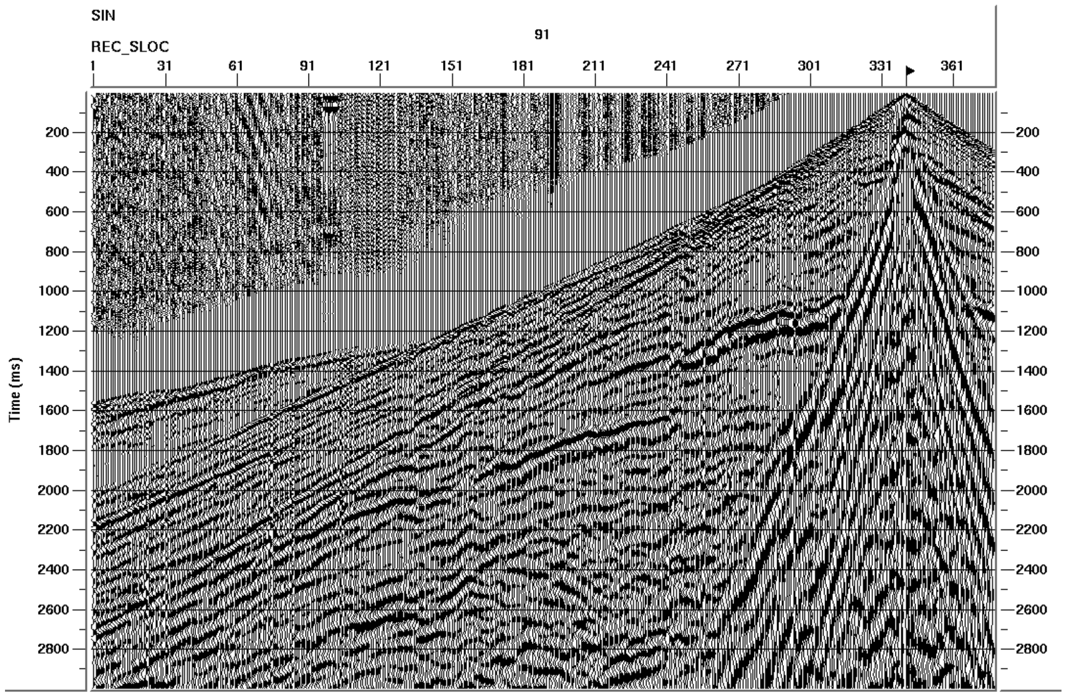

Figure 5. Radial component shot record

3-C PROCESSING RESULTS

The 3-C data were processed through a flow which included: geometry and edit for all three components. The vertical channel data were then processed with steps that included: surface consistent deconvolution, spectral whitening, statics (refraction,

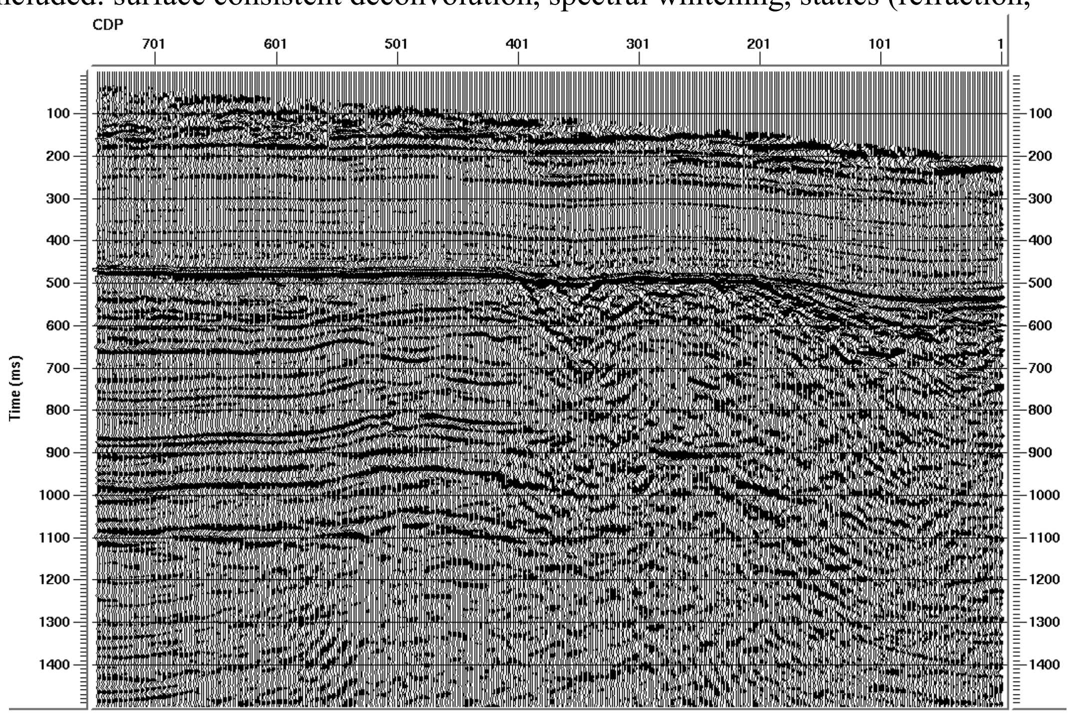

Figure 6. Migrated P-wave DMO stack.

residual, and trim), velocity analysis, gain, filtering, time-variant scaling, stack (DMO), and migration. The results are shown in Figure 6. A pre-stack migration is shown in Figure 7. The pre-stack migration may show some better details of the

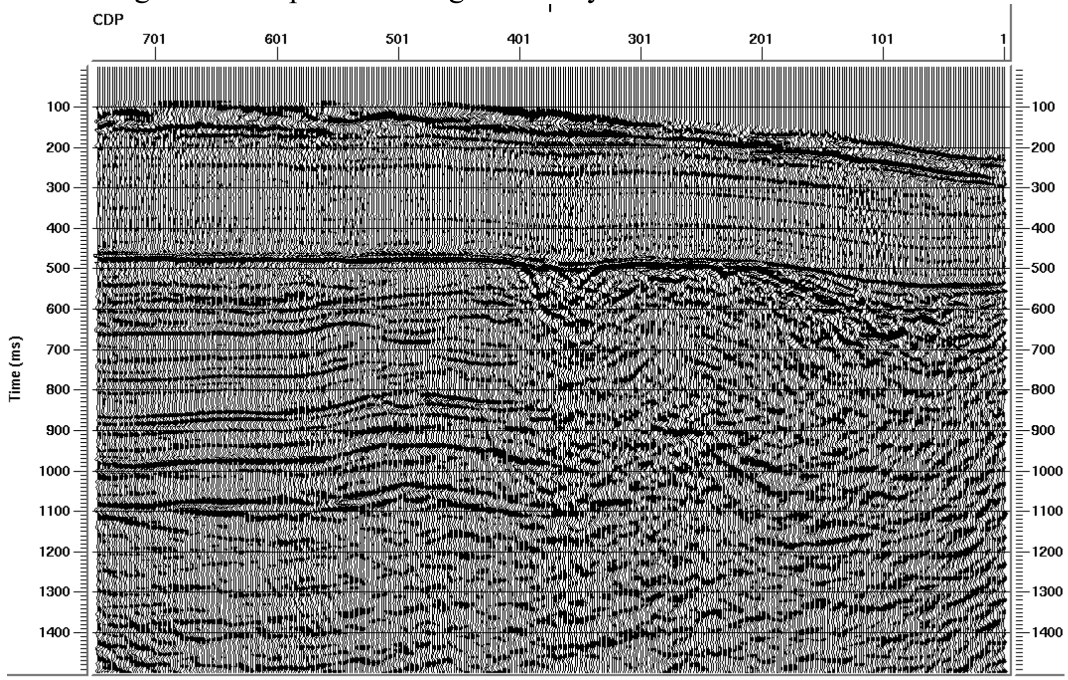

Figure 7. P-wave prestack migration

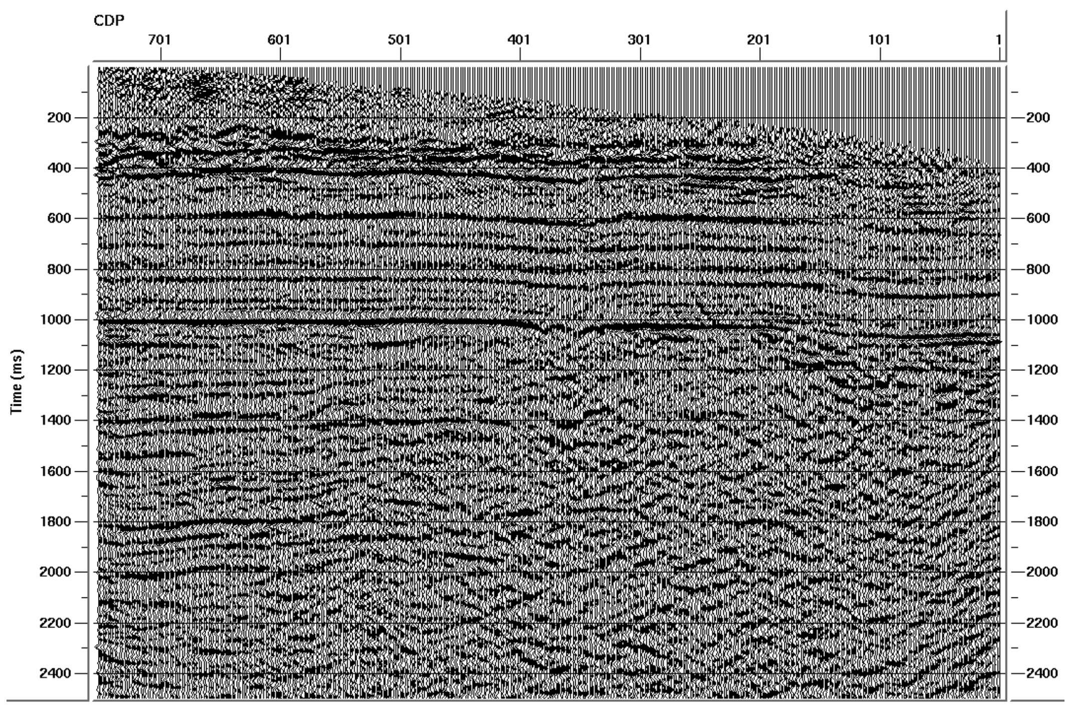

Figure 8. Converted-wave migrated DMO stack.

faulted topography. The corresponding converted-wave processing includes trailing spread polarity reversal, S-wave refraction statics, f-k filtering, depth-variant stacking or DMO, and migration (Figure 8). We once again see the increased detail in the near surface (to 1000 ms) and unconformity surface at 1000 ms. The migrated section in Figure 9, without DMO, appears to better define the unconformity surface.

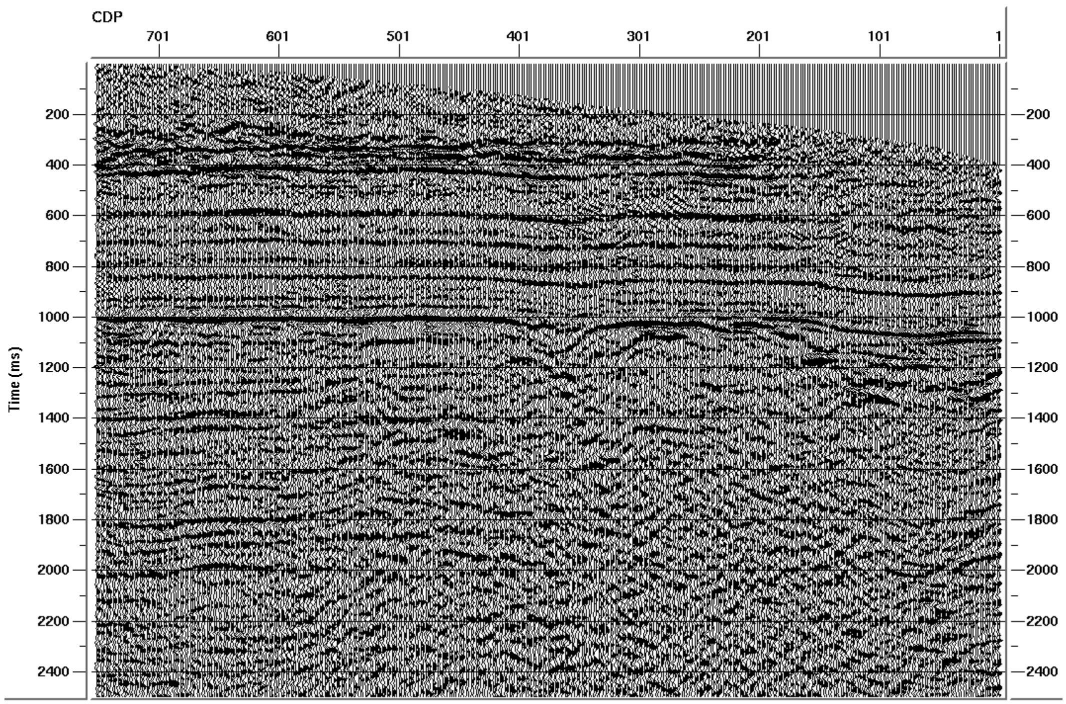

Figure 9. Converted-wave post-stack migration.

CONCLUSIONS

This paper provides a preliminary display of 3-C data acquired over the Steen River structure in northern Alberta. High-quality P-P and P-S sections have been developed that show significant detail in the shallow section as well as on the pre-Cretaceous unconformity. Some structural detail is apparent in the heavily faulted region beneath the unconformity.

ACKNOWLEDGEMENTS

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