Crooked-line seismic data processing at Castle-mountain

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ABSTRACT

As part of the 2006 geophysics field school, a ~6.5 km long crooked-line seismic survey was conducted. Two different types of receivers were used, analog single component geophones and digital multicomponent VectorSeis®. This report details the processing results for the analog geophones. The data have been processed as a crooked-line up to a final post-stack phase-shift migrated section. The results are very encouraging. A preliminary interpretation shows that the migrated section is geologically reasonable, in the sense that it can be compared to existing geologic cross-sections. Crooked-line processing of the multicomponent data is in progress.

INTRODUCTION

A ~6.5 km long crooked-line (maximum curvature 25 degrees) 2D seismic survey was undertaken for the University of Calgary 2006 geophysics field school (Stewart et al., 2006). Two recording systems were used simultaneously: The University of Calgary's ARAM system, and a VectorSeis® system from Kinetex, Inc. Analog geophones were planted in the ditch on the east and digital on the west side of the road. The acquisition parameters are listed in Table 1. This report details crooked-line processing of the geophone data.

The survey was acquired along a gravel road that follows the West Castle River (Figure 1; CDP bin center locations exported from ProMAX). As such, the near surface is comprised of glacial and river sediments. The line crosses the Lewis Thrust at CDP 801, which carries Proterozoic Purcell Supergroup rocks, primarily argillite, limestone and dolomite in the hanging wall over Cretaceous clastics in the footwall (Norris, 1993).

Processing

Figures 2 and 3 show a sample shot record from near the south end of the line. There is quite strong ground roll present in the data, but some reflections can clearly be seen in the shot gather from 500-1300 ms.

Receiver spacing was 5 m for the analog geophones, which would normally imply a 2.5 m CDP bin spacing. However, for future comparison to the VectorSeis® data and increased fold, we used 5x100 m CDP bins (Figure 4). The resulting CDP fold (Figure 5) peaks at 220 fold, but on average is about 190 fold along the central portion of the line.

The results of conventional P-P processing, including post-stack phase-shift migration, can be seen in Figure 6, which also shows the locations of some of the major structures, transferred from Figure 1.

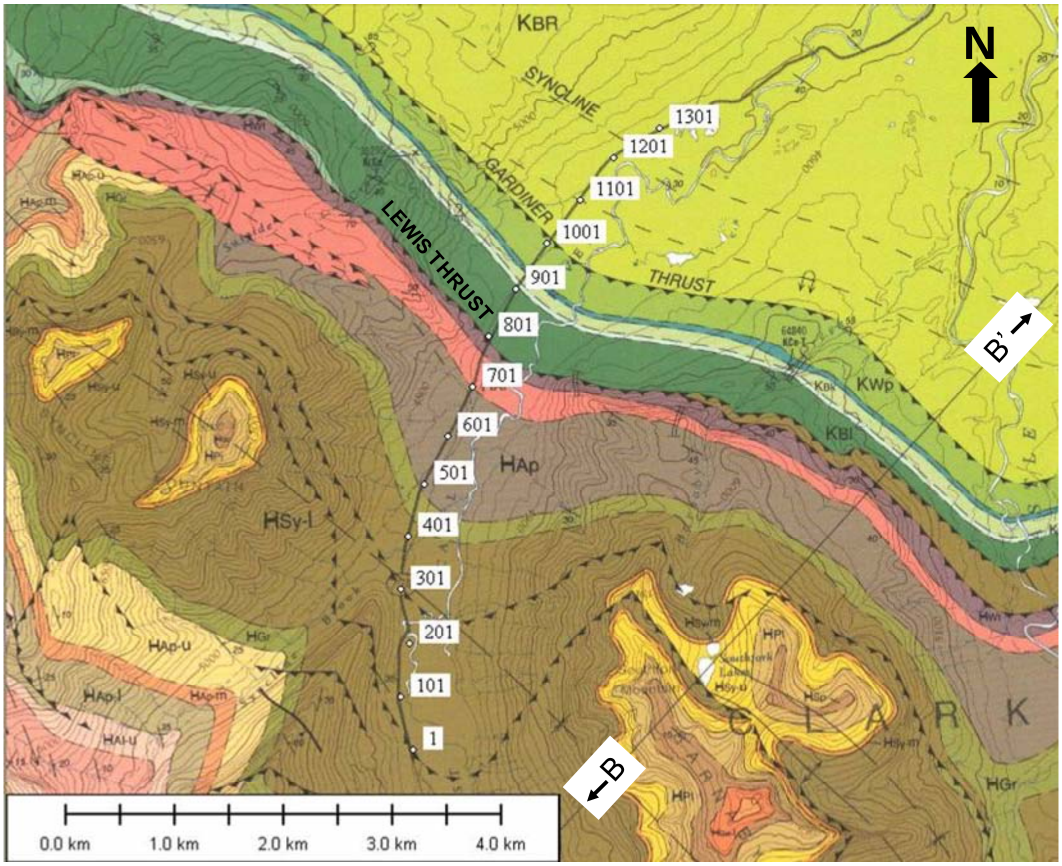


FIG. 1. Part of geology map (Norris, 1993) with every hundredth CDP location posted. Seismic survey crosses the Akamina syncline (CDP 301), Lewis thrust (801), Gardiner thrust (1001) and Lost Creek syncline (1250). Cretaceous rocks are northeast of the Lewis thrust (green), Proterozoic rocks are southeast.

Table 1. Acquisition parameters.

Recording System (University)	ARAM
Recording System (Kinetex)	I/O
Source	Single vertical vibrator (IVI EnviroVibe)
Source Array	Stationary at 5 m VP interval, 4 sweeps per VP. Diversity stacked in the field.
Sweep	8-120 Hz over 16 s with 4 s listen time
Sample Rate	1 ms
Receivers (University)	I/O SM24 10Hz single component at 5 m spacing. 400 live channels per shot; rolling spread.
Receivers (Kinetex)	I/O VectorSeis 3C MEMS at 10 m spacing. All receivers live for all shots.
Receiver Array	Single sensor per station.

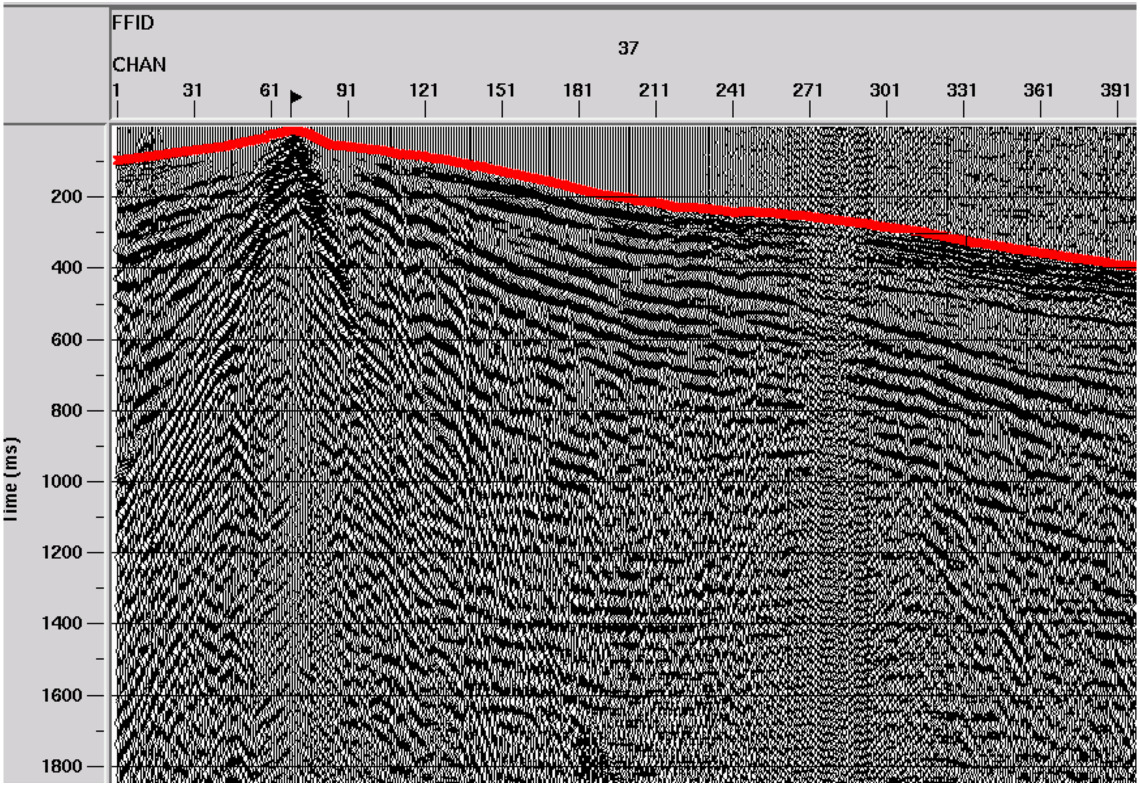


FIG. 2. Example shot gather from near the south end of the line. Good reflectivity can be seen down to 1400 ms. The noise at channels 271-301 is due to a diesel generator on the recording truck.

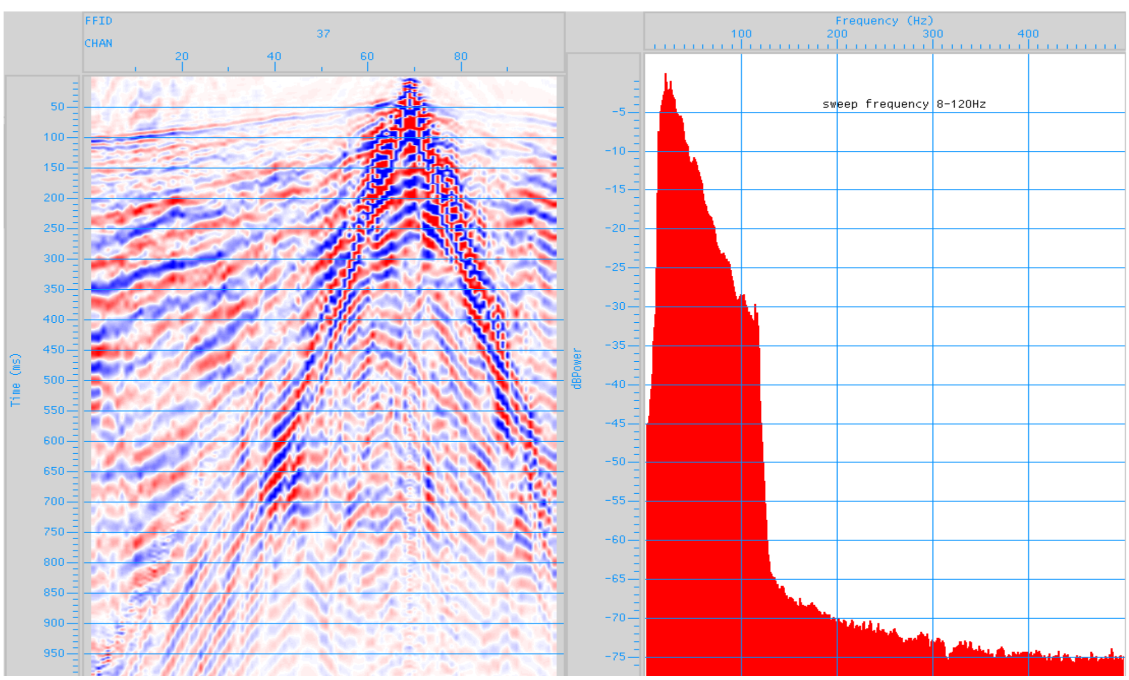


FIG. 3. Spectral analysis for shot gather shown in Figure 2.

a) b)

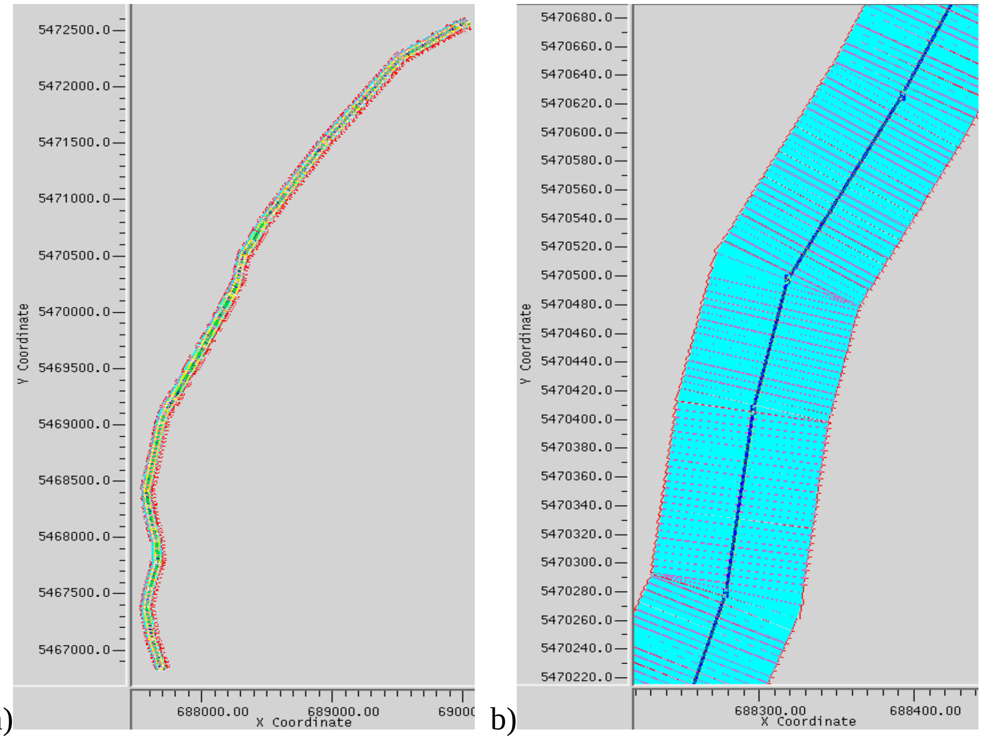


FIG. 4. Crooked-line CDP binning for the Castle mountain survey (a) and a close-up (b) showing detail of some of the corner bins.

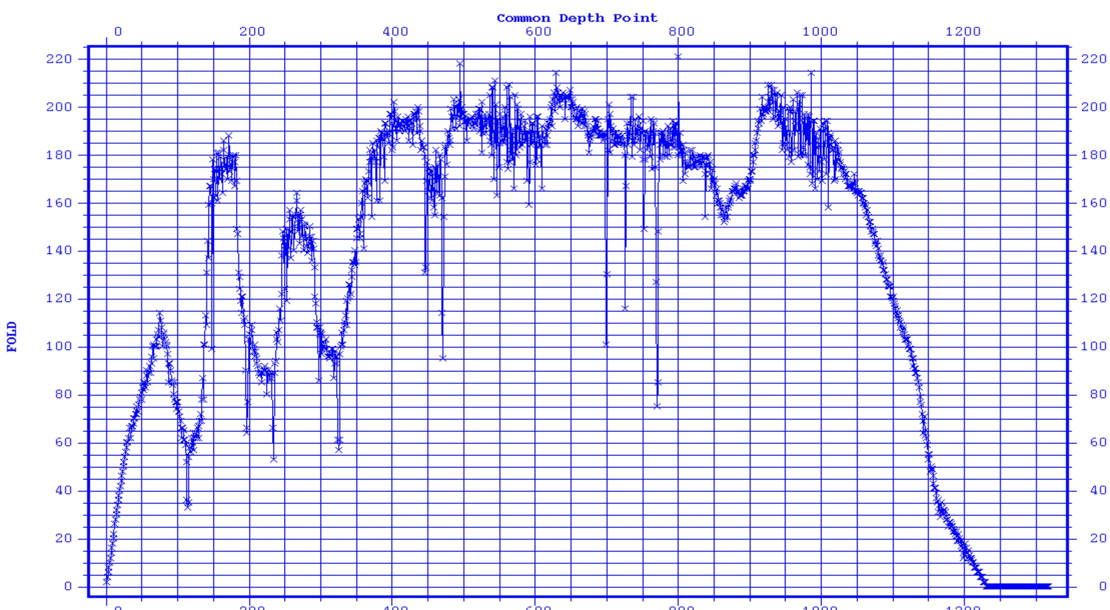
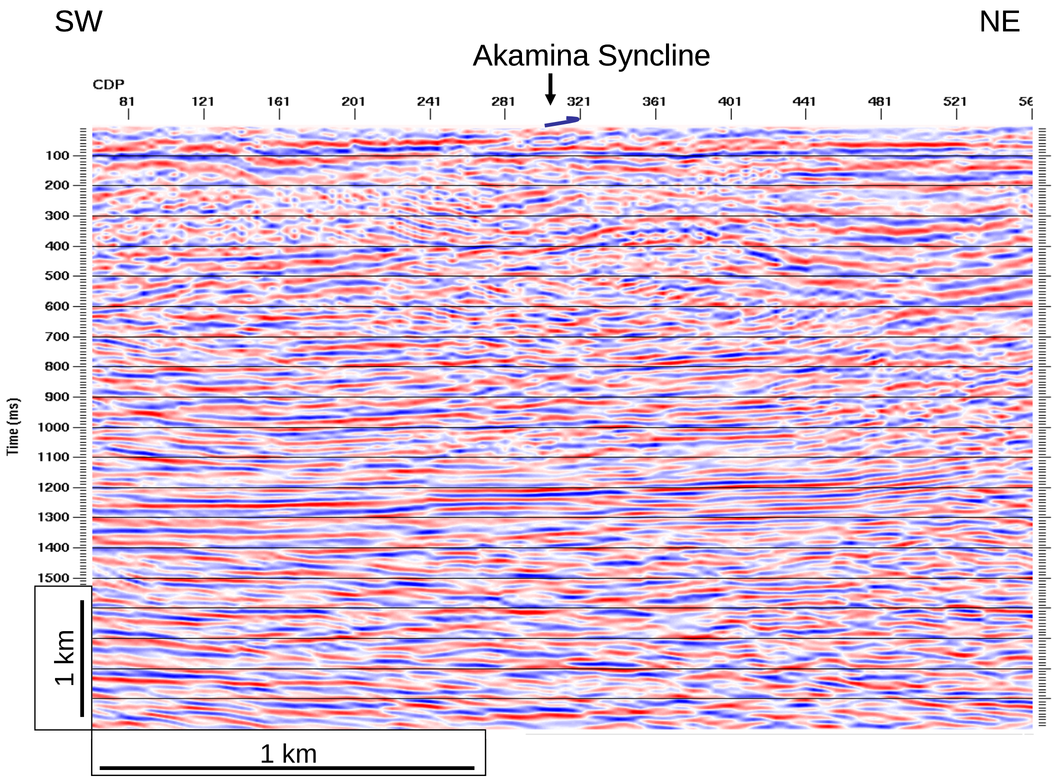
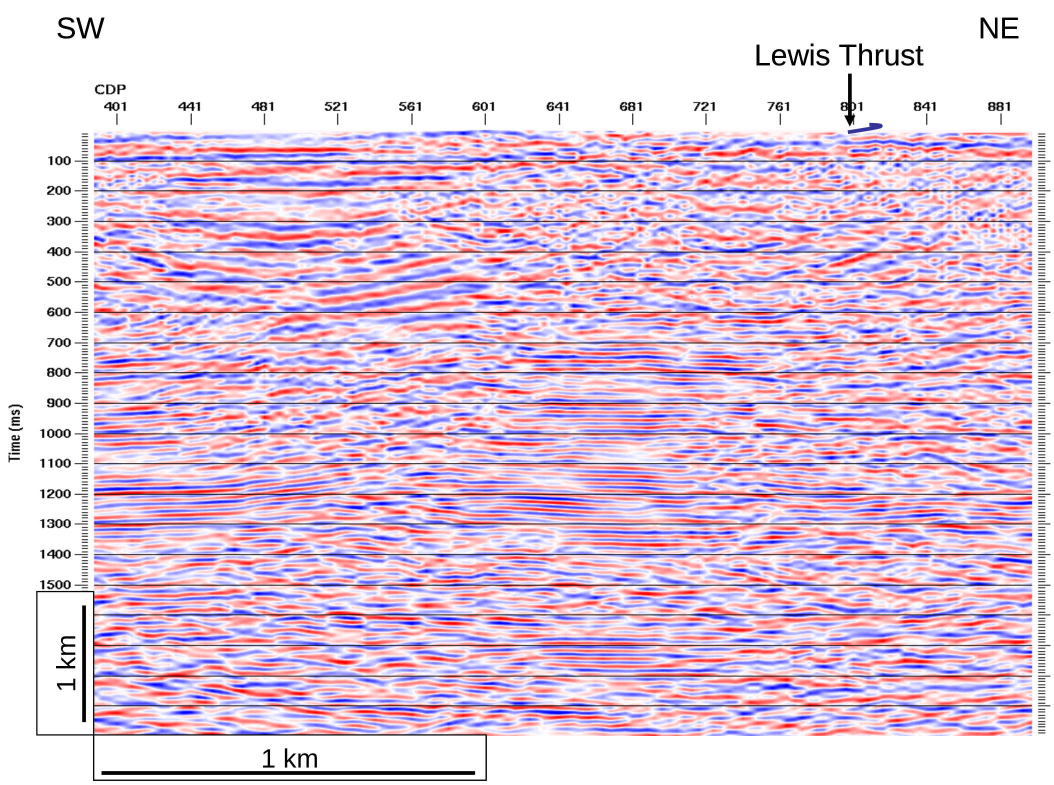


FIG. 5. CDP fold for 5x100 m bins; ARAM data.

a)

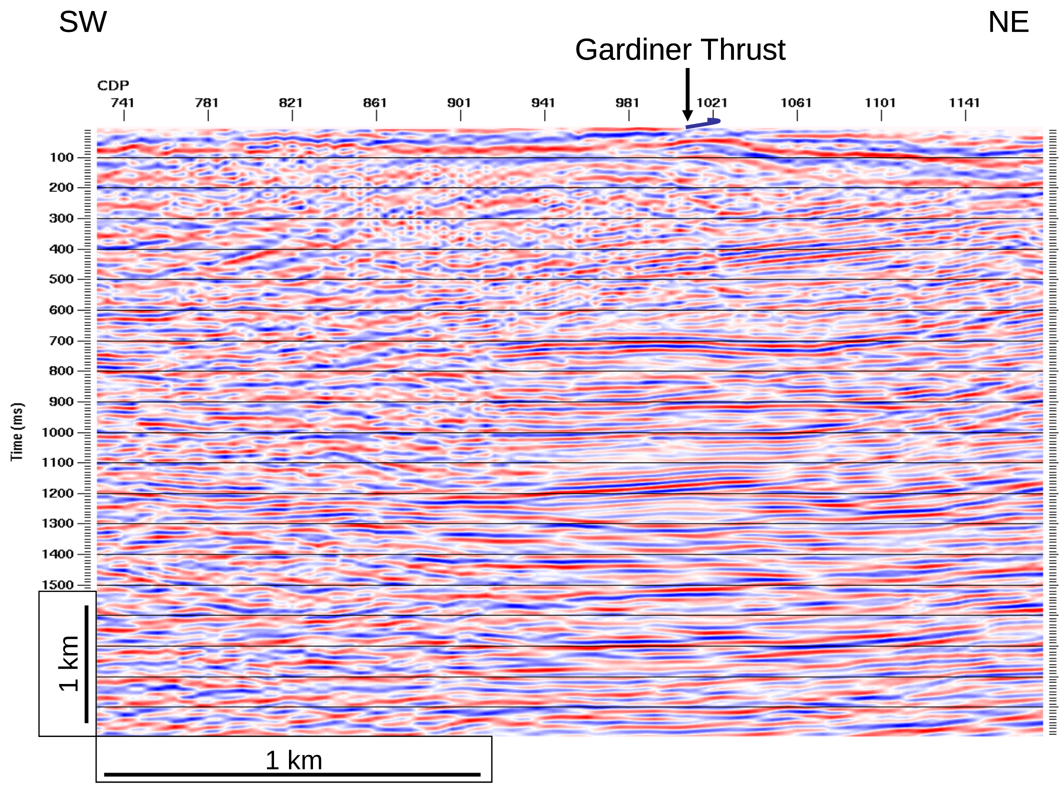


a)

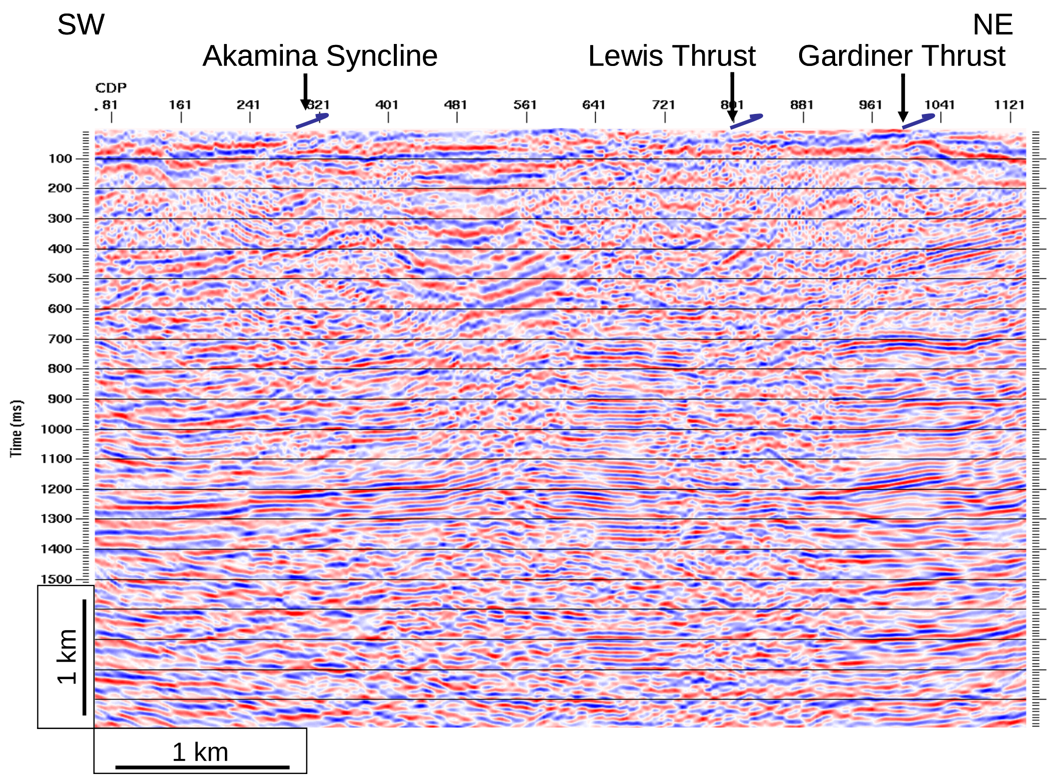


b).

FIG. 6. Caption on next page.



c).



d)

FIG. 6. Final post-stack phase-shift migrated sections. Figures 6a (SW), 6b and 6c (NE) show close-ups with a horizontal exaggeration of about 3.2:1; Figure d shows the entire section with a horizontal exaggeration of about 1.5:1. Time to depth conversion assumes 5000 m/s.

INTERPRETATION

A full interpretation has not been done, but Figure 7 shows a comparison of the migrated section to a geologic cross-section (B-B', Figure 1). Everything above the Lewis thrust is Proterozoic. Cretaceous clastics are shown in green, and Jurassic clastics with thin beds of limestone are shown in blue. It seems reasonable to interpret SW dipping breaks in the near surface reflections near CDPS 301 and 1001as being due to a thrust fault near the Akamina syncline location (cf. Figure 1) and the Gardiner thrust. Surprisingly, the Lewis thrust is less obvious. It also seems reasonable to interpret the prominent discontinuous band of reflections that appear across the entire section at about 1200-1300 ms as a combination of the Coleman thrust and Jurassic thin-bedded limestones. There is a hint of an anticline (CDPs 321-401 and 200-500 ms) that is interpreted as a hanging wall anticline above the Lewis thrust. In general, the Proterozoic part of the migrated section appears to have lower frequency content than the rest of the section (Cretaceous-Jurassic).

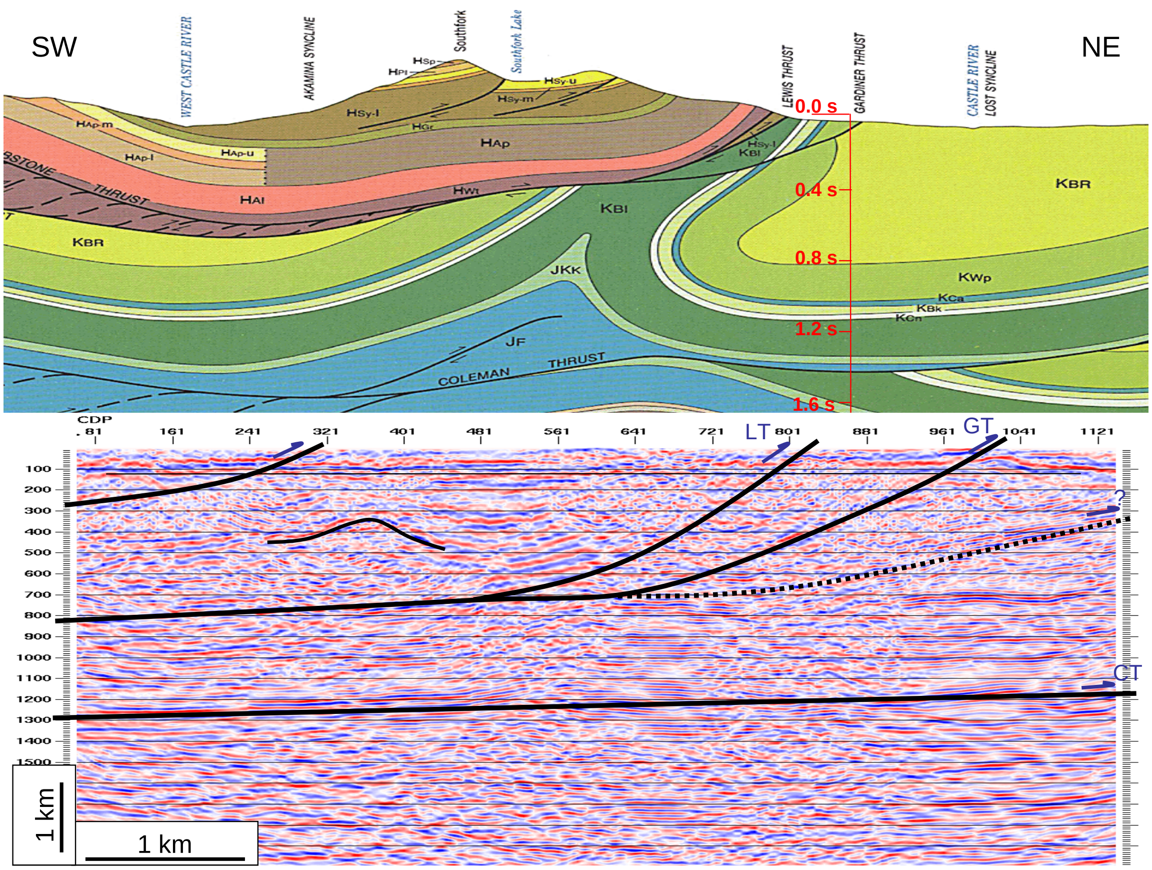


FIG. 7. Comparison of part of B-B' cross-section (top; Norris, 1993) to migrated section. LT = Lewis Thrust, GT = Gardiner Thrust; CT = Coleman Thrust. Section tied to cross-section at Akamina syncline and Lewis thrust. Horizontal exaggeration 1.5:1. Measured dips at the surface near the seismic line are 30-50 degrees (Norris, 1993).

DISCUSSION AND FUTURE WORK

It is possible to get seismic energy down to at least 3.5-4.0 km depth with a single IVI EnviroVibe in a structurally complex area. We are able to process the resulting data to a migrated section that appears to be geologically reasonable. The results are very encouraging, and a more formal interpretation is warranted, especially after the radial component results have been processed. Currently, a ProMAX module for crooked-line asymptotic conversion point (ACP) binning is in the debugging stage.

ACKNOWLEDGEMENTS

The authors would like to thank NSERC (Natural Sciences and Engineering Research Council of Canada) and all CREWES sponsors. We would also like to thank Henry Bland for making survey file and other colleagues for their help and support. Finally, we would like to thank Landmark Graphics and Hampson-Russell for the use of donated software.

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Norris, D.K., 1993, Geology and structure cross-sections, Beaver Mines (West Half), Alberta-British Columbia; Geological Survey of Canada, Map 1838A, scale 1:50,000.

Stewart, R.R., Wong, J., Hall, K. W., Bertram, M.B., Bland, H.C., Lawton, D.C., Gallant, E.V., 2006, The West Castle multicomponent seismic surveys: An overview: CREWES Research Report **18**.