The effect of source noise and dipping structure on the Jumpingpound 3C-2D data

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ABSTRACT

A five kilometer long 3C-2D seismic line was acquired by CREWES near Jumpingpound (west of Calgary, Alberta) in 2002. The migrated vertical component stack shows a clear image of the eastern flank of the triangle zone in the study area. The radial component shot gathers are quite noisy, but coherent reflections can be identified on the migrated stack. The vertical and radial component stacks compare well, and it should be possible to conduct a joint interpretation study.

ACQUISITION

CREWES conducted a multicomponent seismic survey in late August 2002 near the Jumpingpound and Wildcat gas fields, 30 km west of Calgary (Figure 1). The source and receiver interval were both 15 m. The source was 3x44000 lb Hemivibes. The sweep was 8-120 Hz over 12 s, with four sweeps per vibe point. All receivers (VectorSeis^{TM}) were live for every shot, with a maximum source-receiver offset of 5000 m (Lawton et al., 2002). Although elevation differences along the line are minimal, the subsurface is known to be structurally complex, as the line is situated above the eastern flank of the triangle zone along the eastern edge of the Rocky Mountain fold and thrust belt (Lawton et. al, 2002).

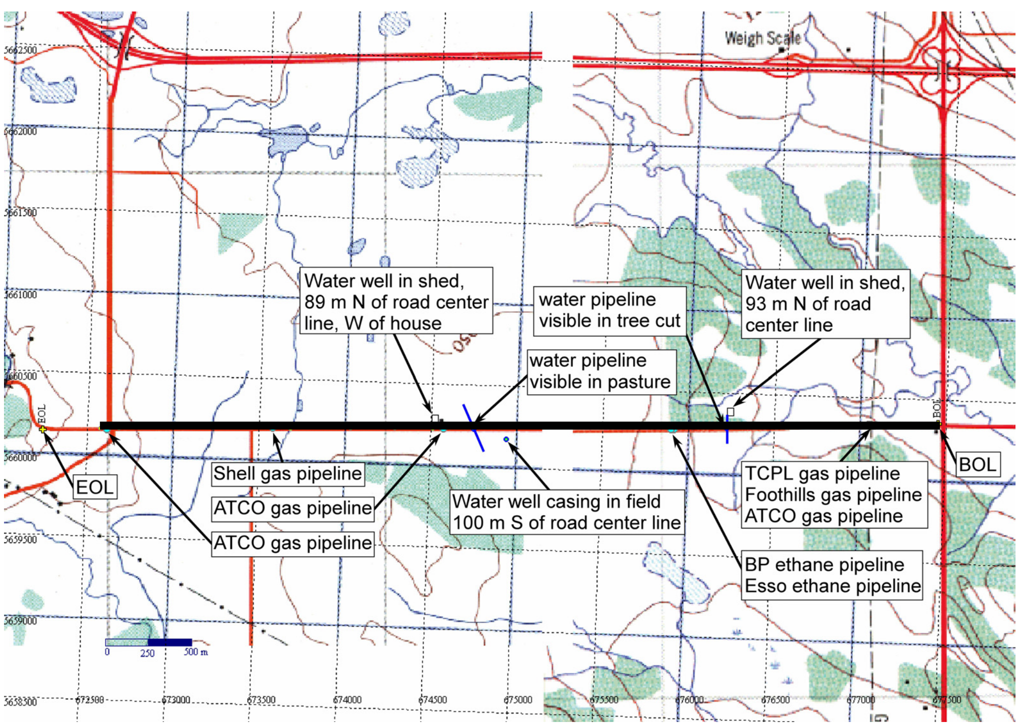

FIG. 1. Multicomponent seismic line at Jumpingpound, Alberta. The line is 5 km long The Trans-Canada highway runs west-east across the top of the figure (from Lawton et al., 2002)..

PROCESSING

Before processing the data, shot gathers for each of the three components were carefully examined. It was found that, while the vertical component is of good quality, the horizontal components have a low signal/noise ratio (Figures 2a-2c).

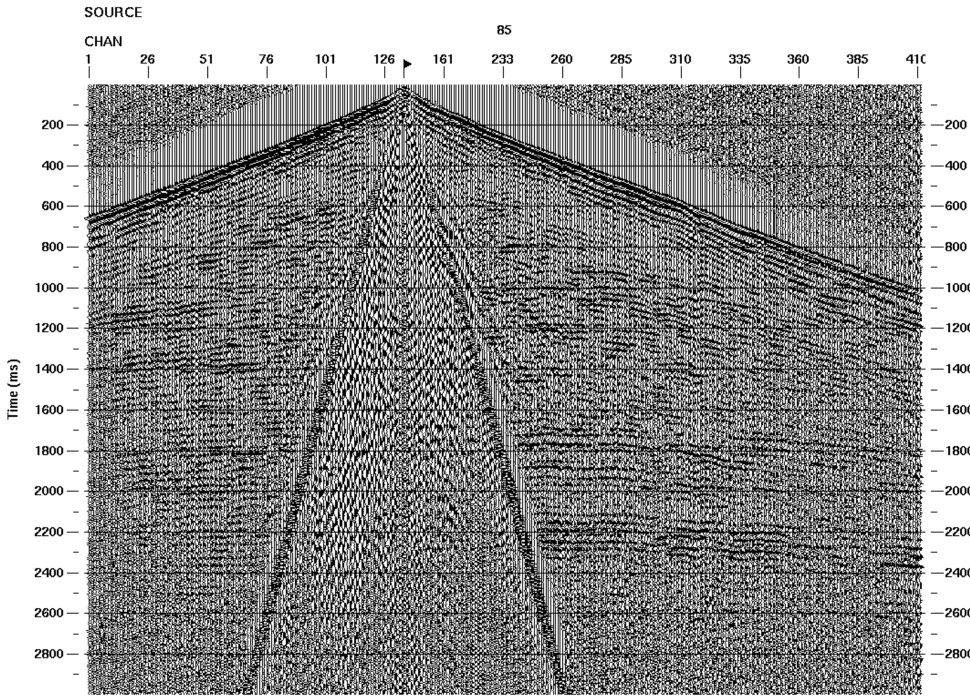

FIG. 2a. Vertical component shot gather for source 85.

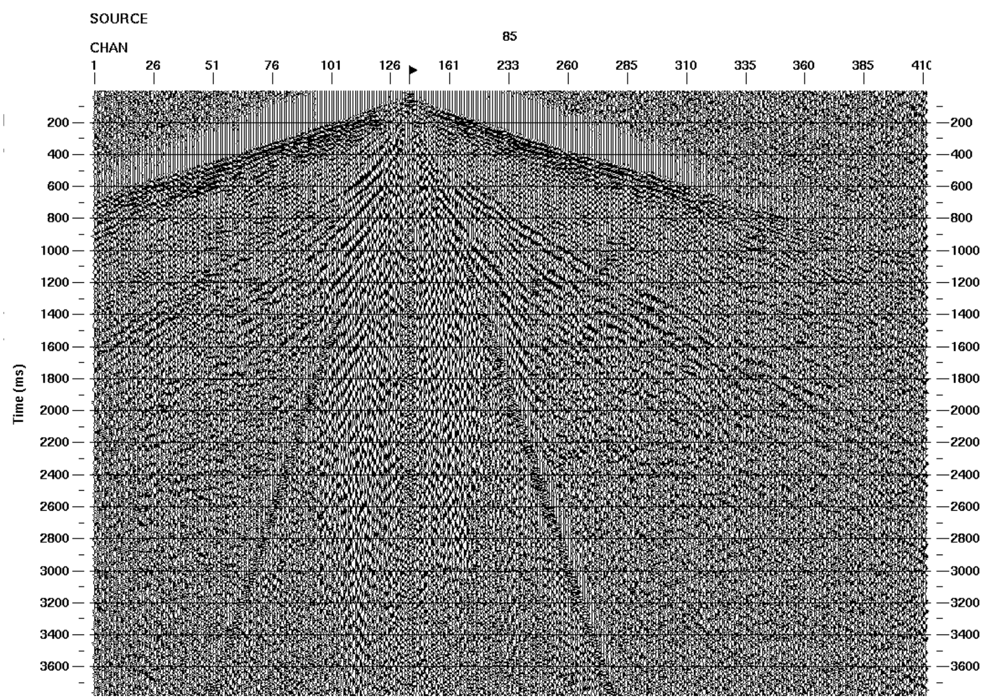

FIG. 2b. Radial component shot gather for source 85.

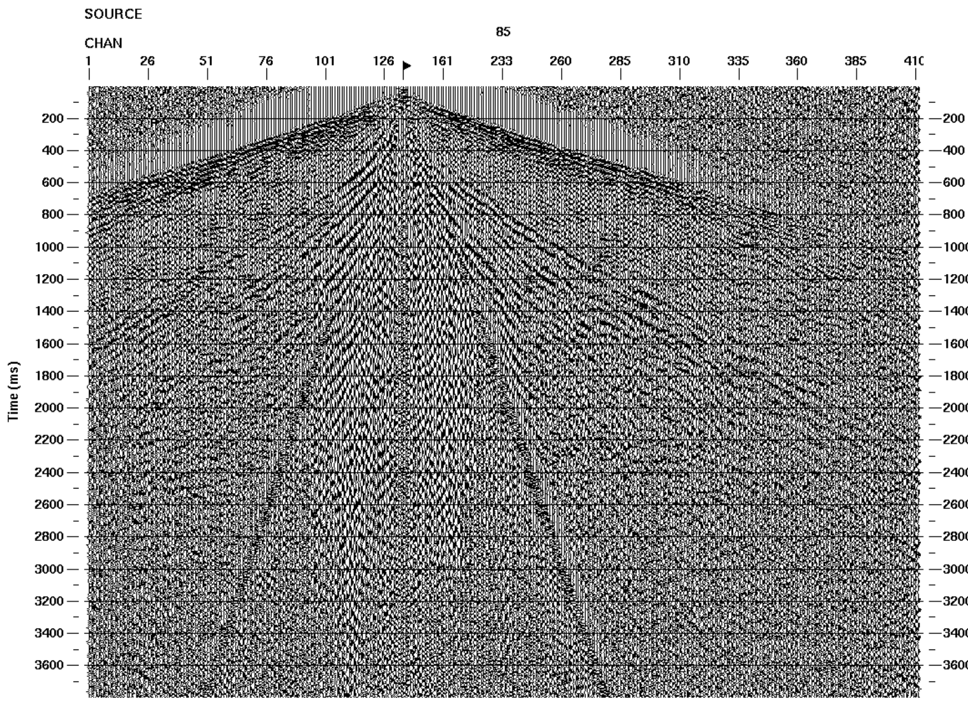

FIG. 2c. Transverse component shot gather for source 85.

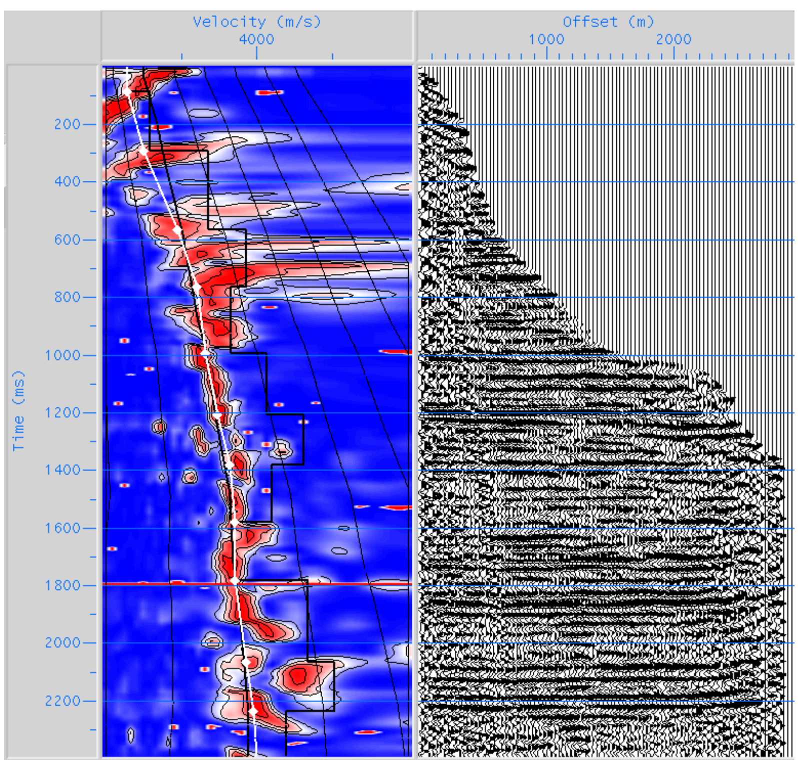

FIG. 3a. Supergather for CDP 386. Maximum offset is ~2850 m.

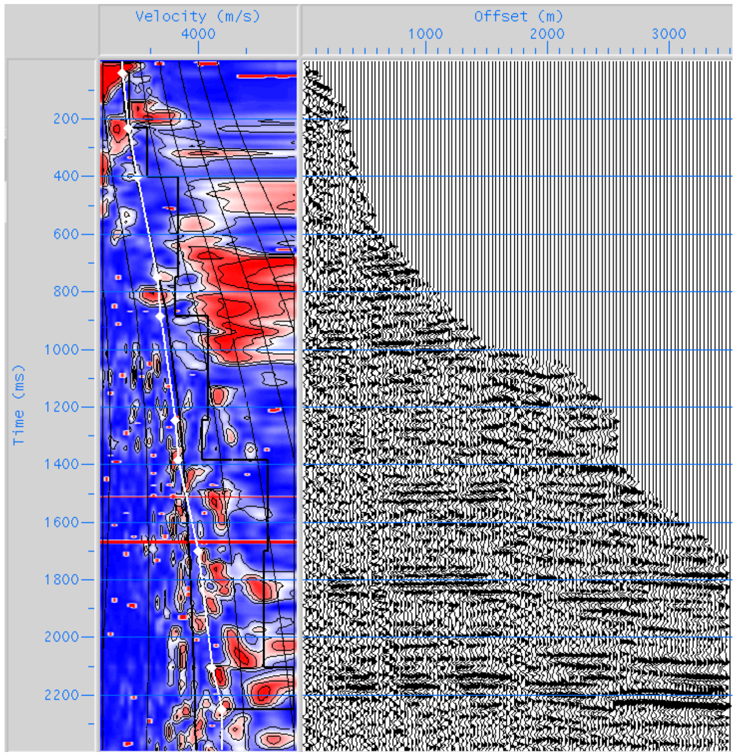

FIG. 3b. Supergather for CDP 658. Maximum offset is ~3500 m.

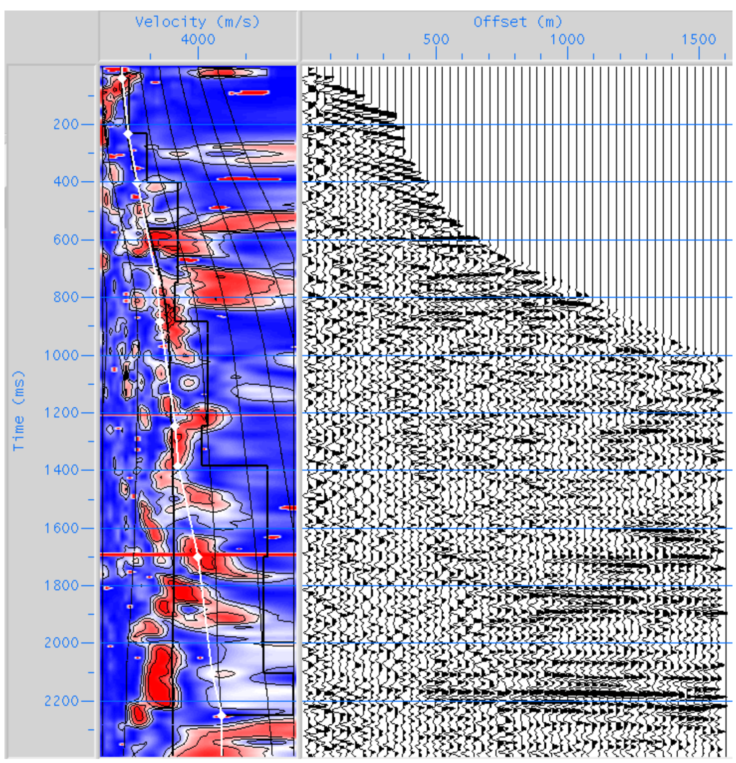

FIG. 3c. Supergather for CDP 800. Maximum offset is ~1600 m.

Offset effects can be seen on the supergathers (Figures 3a-3c). On the east side of the line, reflections between 600 and 1000 ms are not visible at offsets less than 200 m, but reflections at 1000 to 2200 ms can be seen at all offsets (Figure 3a). At CDP 685 (centre of black box, Figures 4a-4d), there are no obvious reflections above 600 ms. Reflections between 600 and 1000 ms are not seen for offsets less than 100 m. Events between 1000 and 1800 ms are not present at near offsets, and are also weak near 800 m offset due to source noise (Figure 3b). On the west side, there is no sign of reflections at offsets less than 400 m, other than the basement reflection at 2200 ms (faintly, Figure 3c). The overall decrease in near-offset reflection quality from east-west as we move towards the core of the triangle zone implies that the offset effects described here are not due solely to source noise, but are likely also a result of increasingly complex near-surface geology.

The vertical component data were processed conventionally. After elevation statics, refraction statics, residual statics, trim statics, several iterations of velocity analysis, surface consistent deconvolution, and spectral whitening, preliminary results were obtained. The stacks shown in Figures 4a-4e were migrated using a poststack Kirchhoff time migration. East-dipping reflections interpreted to be the eastern flank of the triangle zone can be clearly seen between 600 and 1700 ms (similar to results shown by Lawton et al, 2002).

To examine the effect of source generated noise on stack quality, a number of source-receiver offset ranges were tested; 0-3500 m, 200-3500 m, 300-3500 m, and 400-3500 m are shown here (Figures 4a-4d). When an offset range of 0-3500 m is used, a very noisy stack is obtained (Figure 4a). Near-horizontal reflections between CDPs 240 and 520 (right half of Figures 4a-4d) are more clearly imaged if near-offsets (0-200 m) are not included. Further improvement can be seen as more offsets are excluded. For example, the reflection at 1000 ms becomes more continuous (Figures 4b-4d). Interestingly, west-dipping reflections between 600 and 900 ms (right half of Figures 4b-4d) which are not obvious on Figure 4a, become apparent as near offsets are removed. On the west side of the line an east-dipping reflection appears in the image if offsets less than 300 m are not used (black box, Figures 4a-4d). This reflection also becomes more continuous as the offset range is restricted. No clear events exist above this reflection. This may be due to increased structural complexity in the near-surface at this position on the line.

Finally, positive and negative source-receiver offsets were compared (Figures 5a and 5b). By inspection, the positive-offset stack images the shallow section better than the negative-offset stack.

The radial component data was also processed conventionally (see Lu and Hall (2003) for processing flow), with a *Vp/Vs* ratio of 2.2. Since the data is quite noisy, an f-k filter was applied to the stacked section before Kirchhoff post-stack time migration was performed (Figure 6a). The transverse component was processed with the same processing flow, except the polarity of traces with a negative source-receiver offset was not reversed (Figure 6b).

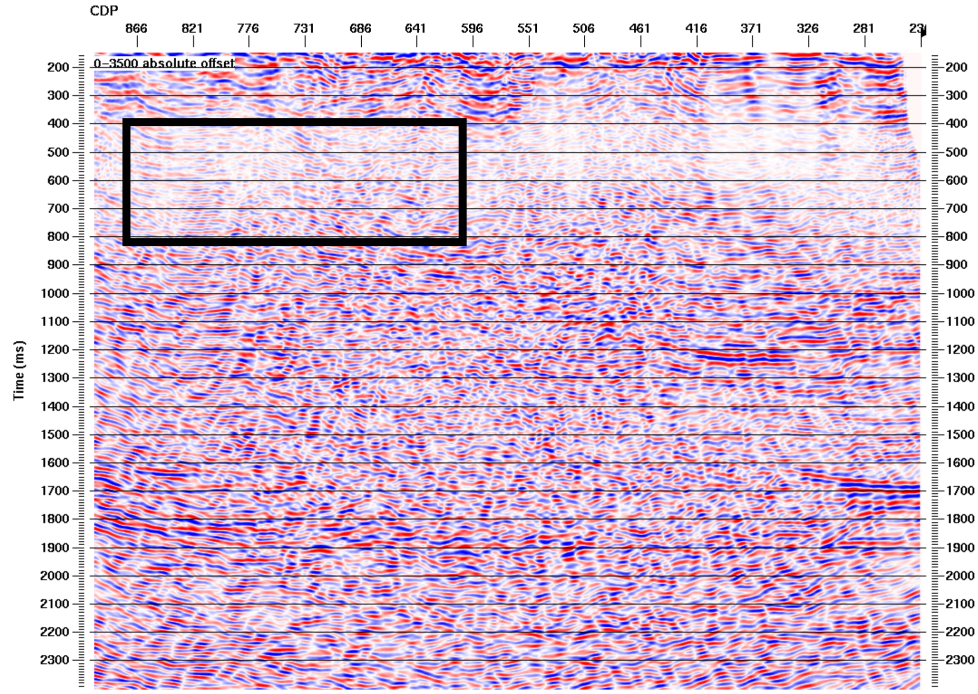

FIG. 4a. Migrated vertical component stack with source-receiver absolute offsets limited to 0-3500 m. East is towards the right.

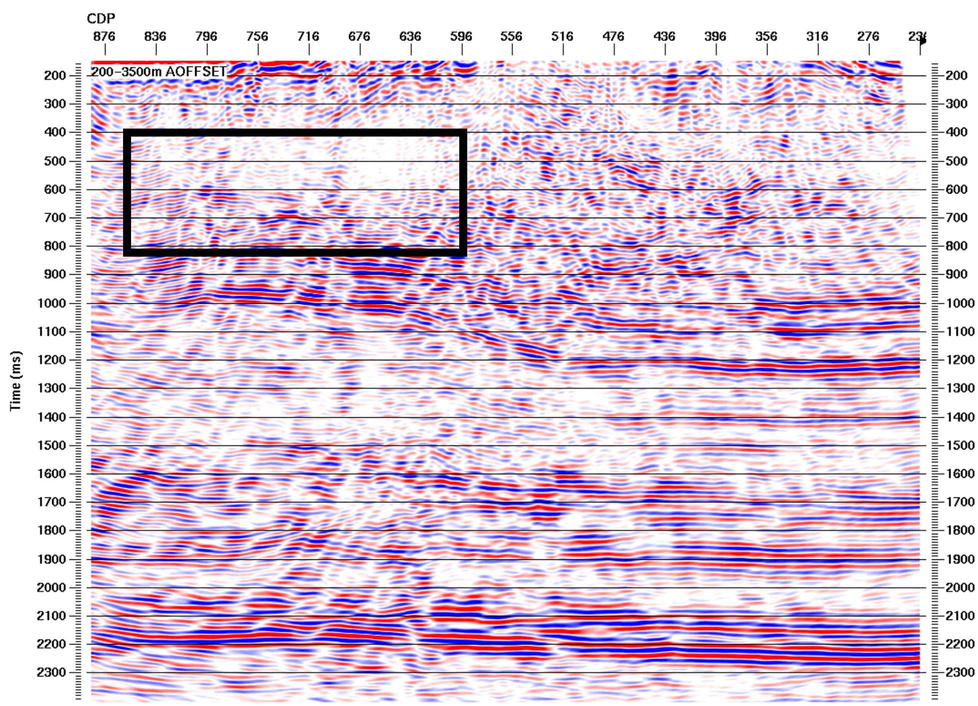

FIG. 4b. Migrated vertical component stack with source-receiver absolute offsets limited to 200-3500 m. East is towards the right.

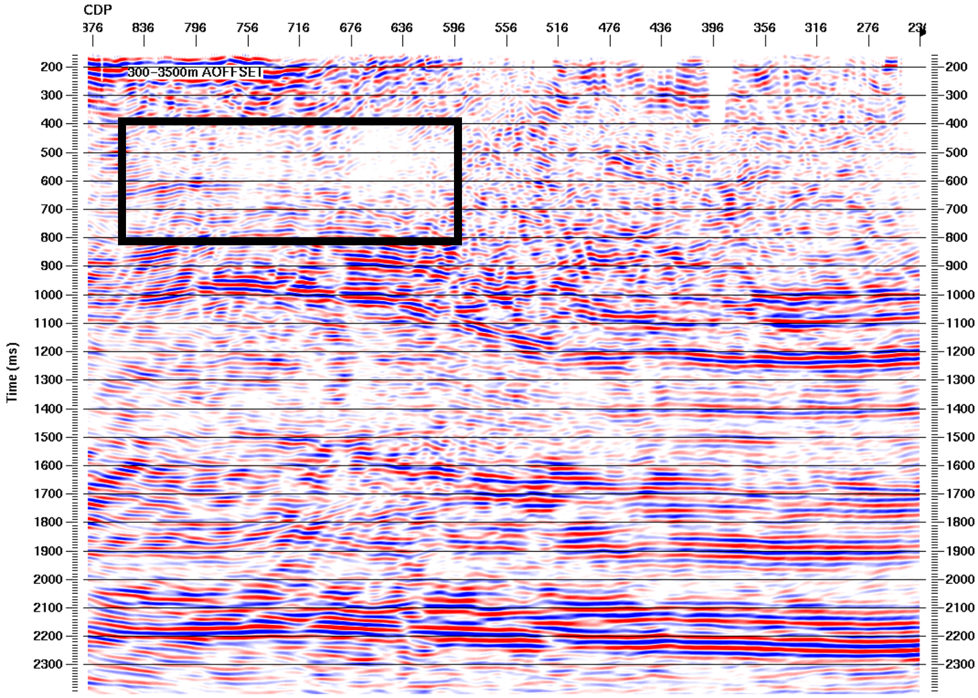

FIG. 4c. Migrated vertical component stack with source-receiver absolute offsets limited to 300-3500 m. East is towards the right.

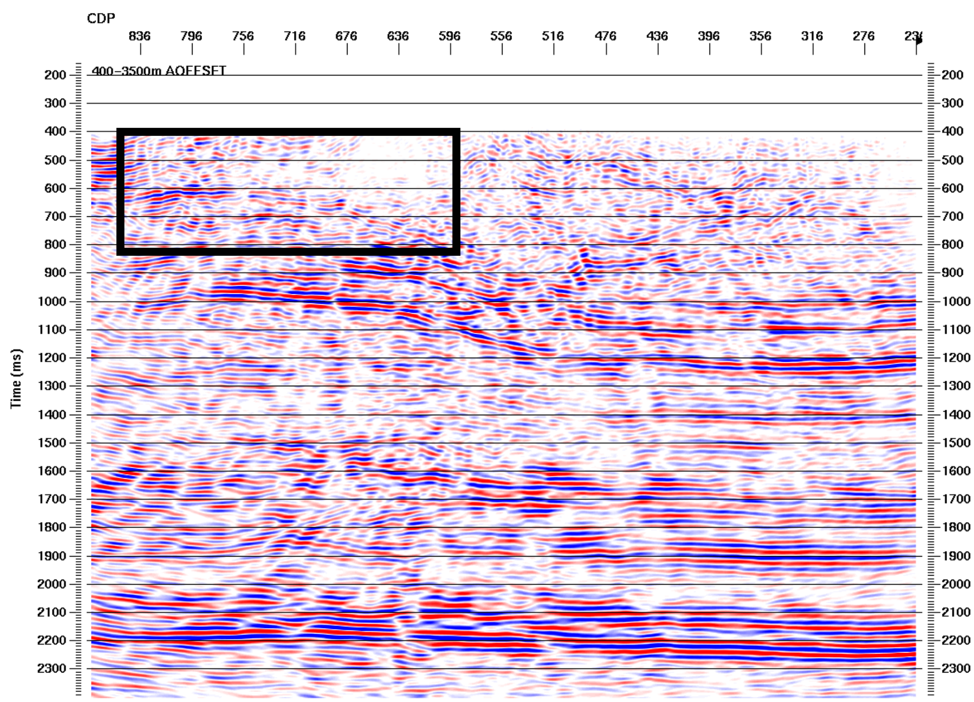

FIG. 4d. Migrated vertical component stack with source-receiver absolute offsets limited to 400-3500 m. East is towards the right.

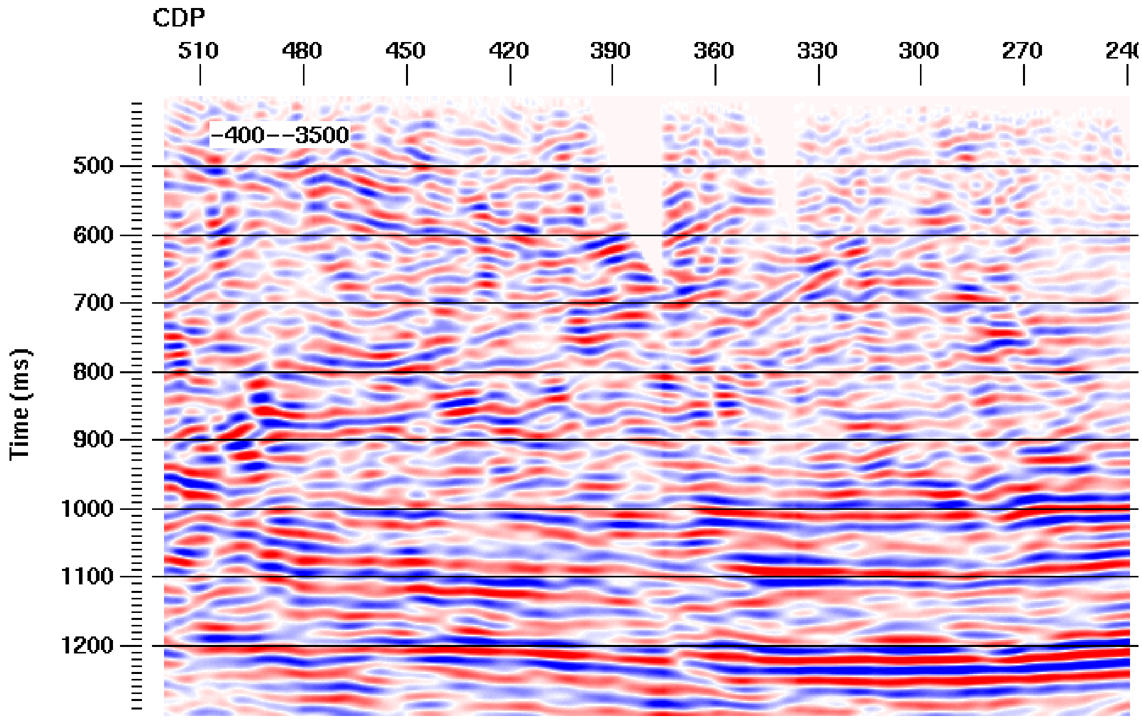

FIG. 5a. Migrated vertical component stack for source-receiver offsets of -3500 to -400 m.

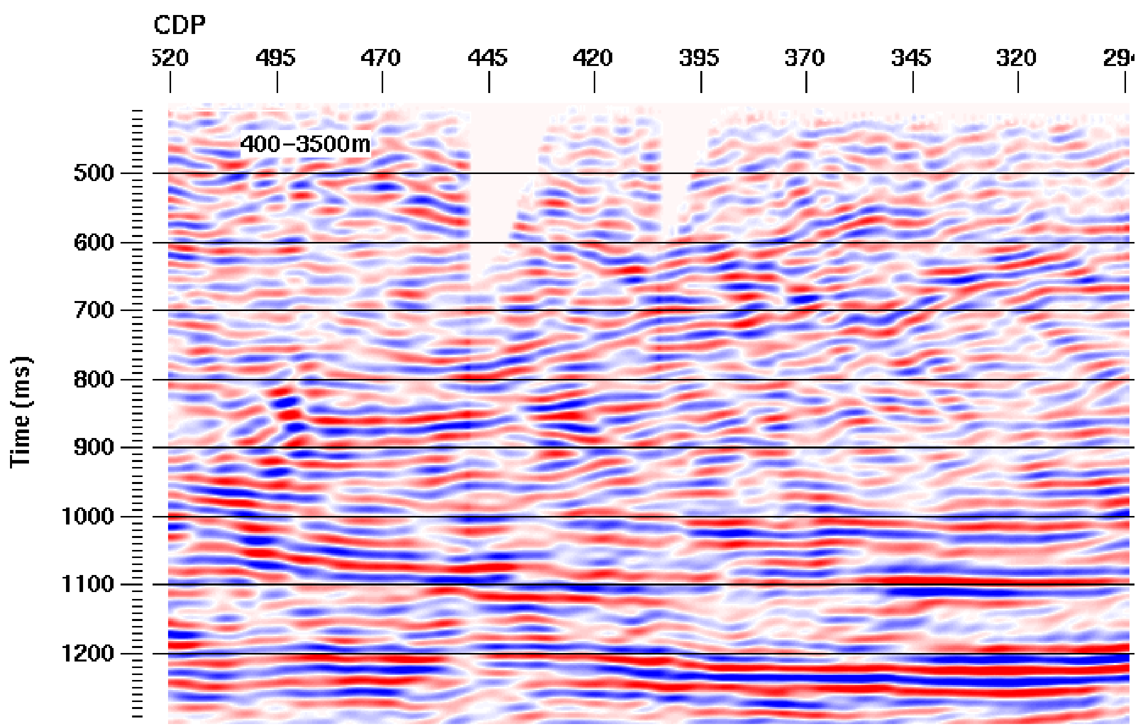

FIG. 5b. Migrated vertical component stack for source-receiver offsets of 400 to 3500 m.

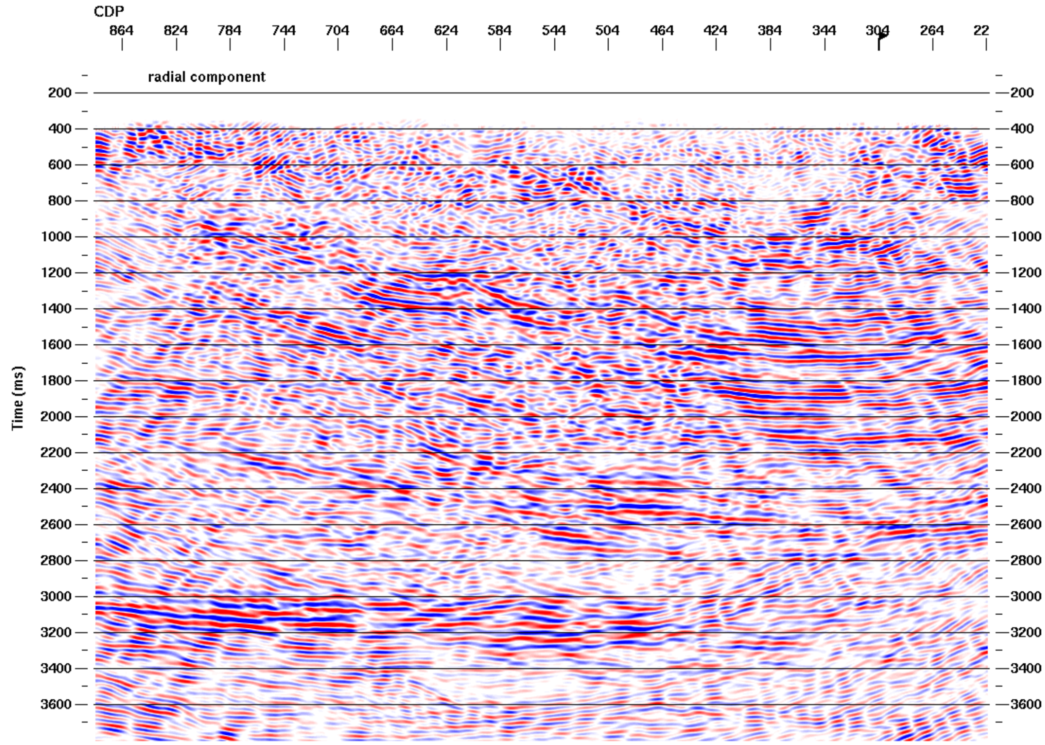

FIG. 6a. Migrated radial component stack.

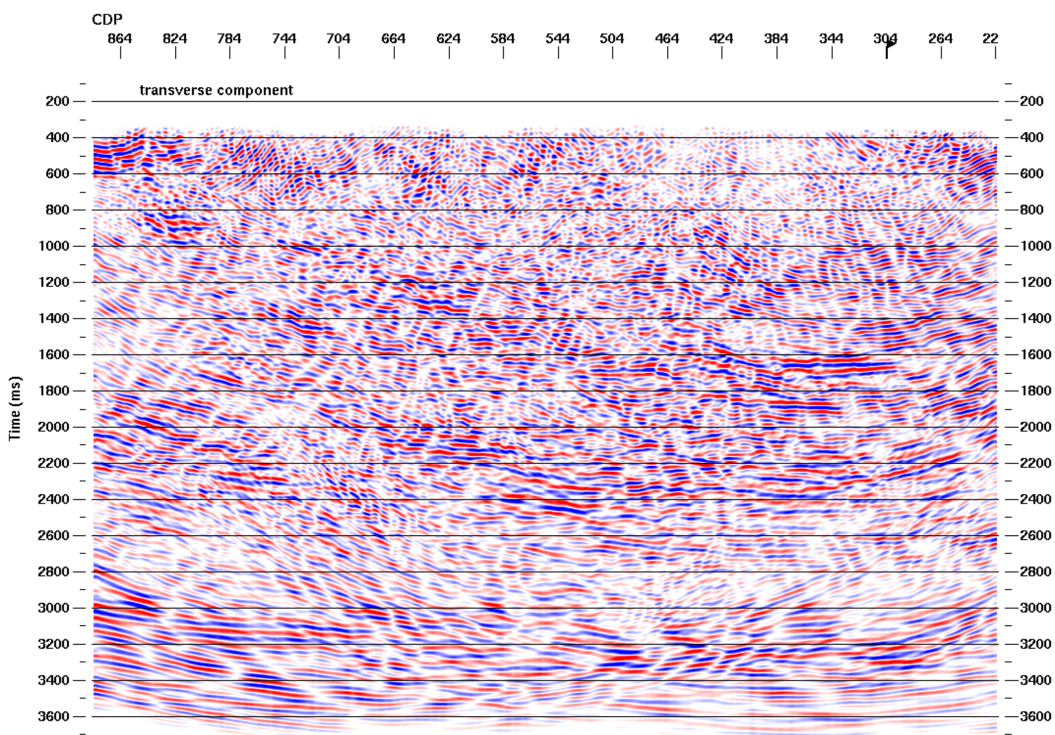

FIG. 6b. Migrated transverse component stack.

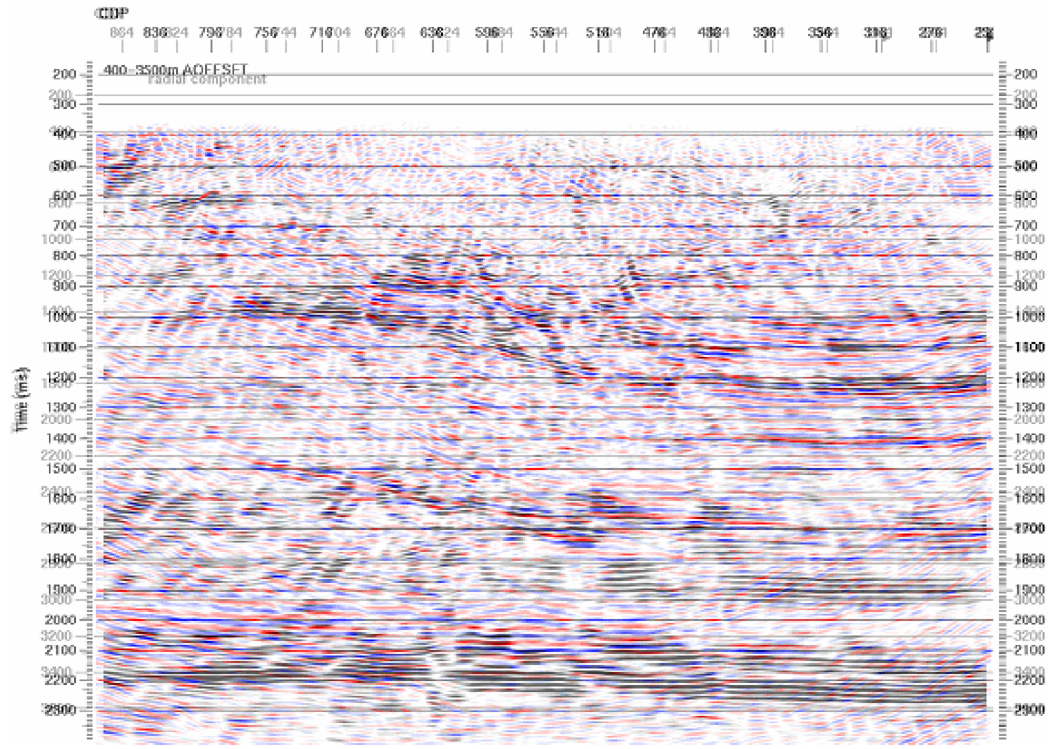

FIG. 7. Comparison of migrated radial (colour) and vertical component (black) stacks.

The radial section is noisy, but coherent reflections (eastward-dipping events in the west and flat events in the east, good basement reflection) can be seen in the final section (Figure 6a). The transverse stack is noisier than the radial, as expected. Because of unbalanced amplitudes in the stack, the migrated sections have a lot of migration noise. Even so, these initial results are encouraging. In order to check the radial component results, the migrated vertical stack was superimposed on the radial (400-2500 m offsets for both, Figure 7). The time scale of the radial stack was stretched by a factor of 1.6 for this comparison. The close match between major reflections on the two stacks leads us to trust the results of the radial processing.

CONCLUSIONS

East-dipping structures of the eastern flank of the triangle zone in the Jumpingpound area and underlying near-horizontal basement, have been successfully imaged for both vertical and radial component data. The range of source-receiver offsets used for stacking must be carefully chosen in this area. In general, reflections are not seen on the vertical data for offsets less than 100 m on the east end of the line, and for offsets less than 400 m on the west end. This is partly due to source noise, but is likely also related to increasingly complex geological structures (including increasing dips) as the line moves (from east to west) towards the core of the triangle zone.

FUTURE WORK

More filter testing needs to be done on the radial component data in order to produce a more interpretable stack. Also, offset dependant data quality issues should be investigated for the radial component.

ACKNOWLEDGEMENTS

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REFERENCES

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