Multicomponent seismic survey at Jumpingpound, Alberta

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ABSTRACT

A 5 km long multicomponent seismic line has been recorded by CREWES at Jumpingpound Alberta. The objective is to evaluate multicomponent data in a structural setting. Array and various source tests were also undertaken. The P-wave section shows a clear image of the eastern flank of the triangle zone in the study area. Converted-wave data from the area are currently being processed.

INTRODUCTION

Multicomponent seismic surveys on land have previously been undertaken primarily in areas with little or no structural deformation. Results from many of these surveys have been summarized by Stewart et al. (2002) and many have shown considerable promise for advancing seismic analysis in lithological discrimination, mapping fluid saturants and imaging reservoirs with low P-wave impedance.

In August 2002, CREWES undertook a seismic acquisition program at Jumpingpound, Alberta, about 30 km west of Calgary. The objective of the program was to collect, process and interpret conventional and converted-wave seismic data from an area of moderate geological structure, and to assess the application of multicomponent seismic technology for structural analysis.

PROGRAM

The 5 km long line (Figure 1) was oriented west-to-east and located along a road at the eastern edge of the Rocky Mountain fold and thrust belt. The line crossed the eastern flank of a regional structural trend known as the triangle zone. In this area, blind thrust faults result in complex reflector geometries in the shallow section, with larger-scale duplexes at depth (Lawton et al., 1994). About 15 km to the north of the line, gas is produced from the Jumpingpound gas field. Here, the reservoir is composed of Mississippian-aged carbonates that are carried in the hanging wall of a blind thrust fault. The dominant play along the triangle zone has traditionally been deep carbonate reservoirs, but recently there has also been considerable interest in shallower structural traps within Mesozoic sandstones of the Viking and Cardium formations.

The survey was undertaken for CREWES in conjunction with Veritas Geoservices, using new-generation VectorSeis™ recording equipment. CREWES staff and students constituted the field crew for laying out geophones and cables, and surveying the line. Figure 2 shows a view of field operations along the line. Access was good and topographic variations were less than 30 m. Acquisition parameters for the main survey are presented in Table 1. Symmetric sampling was undertaken with source and receiver intervals both at 15 m, although some shots had to be skipped due to pipeline crossings. The entire 5 km line was live for all shots. VectorSeis technology required that all records had to be recorded uncorrelated and unstacked.

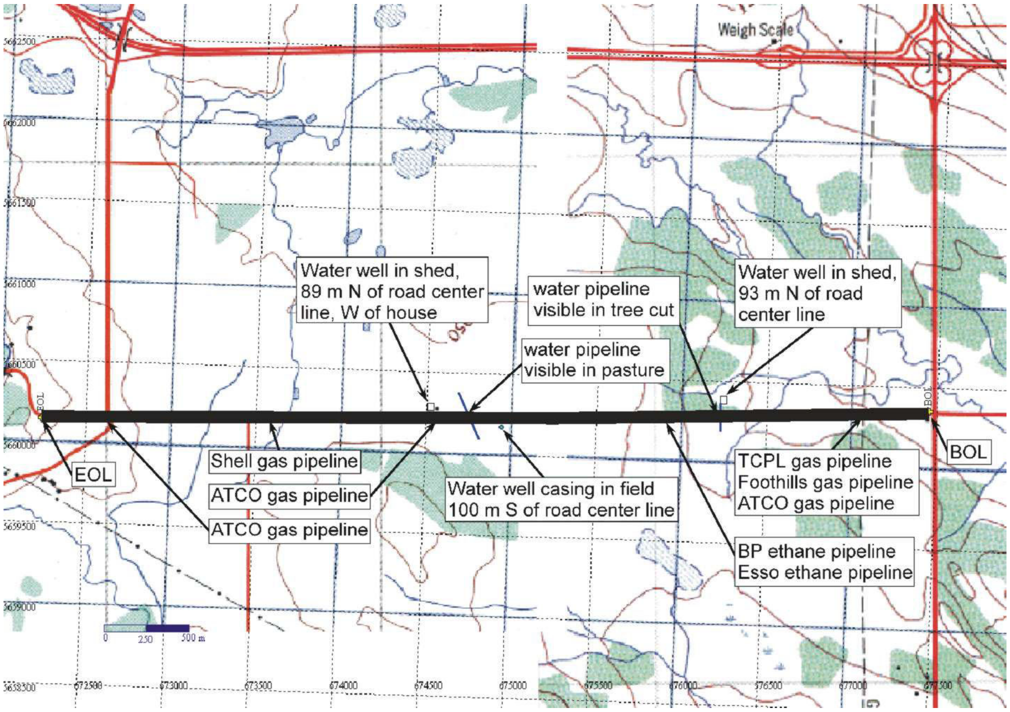

Figure 1. Multicomponent seismic line at Jumpingpound, Alberta. Line is 5 km long.

Figure 2. Field operations along the Jumpingpound seismic line.

Table 1. Acquisition parameters for main Jumpingpound seismic survey

Source	3 x 44000 lb Hemivibes
Sweep	8 – 120 Hz over 12 seconds
Stacks	4 per VP
Receivers	VectorSeis Gold 3C
Receiver interval	15 m (5 m over 450 m along central part of the line)
VP interval (nominal)	15 m
Offsets	Up to 5 km

In addition to the main survey, several other acquisition experiments were also undertaken. In the central part of the line, the receiver interval was reduced to 5 m over an aperture 450 m long. One objective was to test post-acquisition receiver array-forming with vibrator sources for multicomponent seismic surveys. In addition, an auxiliary seismic program was conducted along this high resolution spread, to evaluate the performance of a single minivibe vibrator source for high-resolution, shallow acquisition. This survey was undertaken as a precursor to a coalbed-methane 4D seismic program planned by CREWES for later this year. The source interval along the high-resolution spread was 15m, and this spread was live for all shots.

The line was positionally-surveyed using differential, single-frequency global positioning system (GPS) surveying equipment. These measurements yielded positional accuracies of approximately 80cm. Though adequate for the 15m interval station positions, the GPS based measurements were judged inadequate for the high-resolution (5m interval) portion of the spread. A total station (an automated theodolite) was used to more accurately measure those positions.

The program took 2 days to complete, in somewhat wet and soggy conditions, but it was an interesting and useful learning experience for CREWES personnel.

RESULTS

Initial processing of the vertical component of the data is currently being undertaken by Veritas. Because of the manner in which the data had to be recorded in the field, the initial flow consisted of geometric rotation of the data into X, Y and Z components, followed by correlation and stack of common shots. At various times during the survey, there was traffic noise on the spread, thus both a vertical stack as well as a diversity stack of the data were done. Examples of stacked shot gathers of the vertical component are shown in Figures 3 and 4 respectively, and an improvement in noise reduction through diversity stacking is evident in Figure 4. Coherent reflections are visible across the record, with basement events at about 2400ms. The apparent change in time-dip of the first arrivals across the central part of Figures 3 and 4 corresponds with the location of the high-resolution spread over which the receiver interval was reduced to 5 m, compared with 15 m elsewhere.

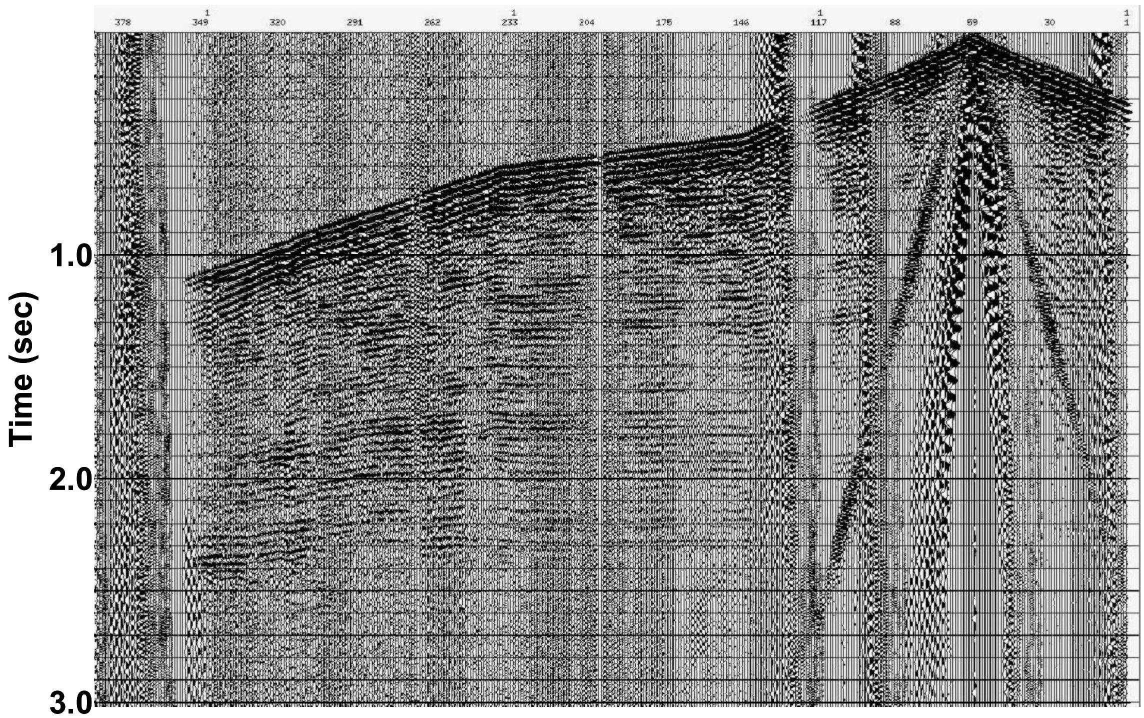

Figure 3. Raw shot gather, vertical component, after correlation and vertical stack (AGC applied).

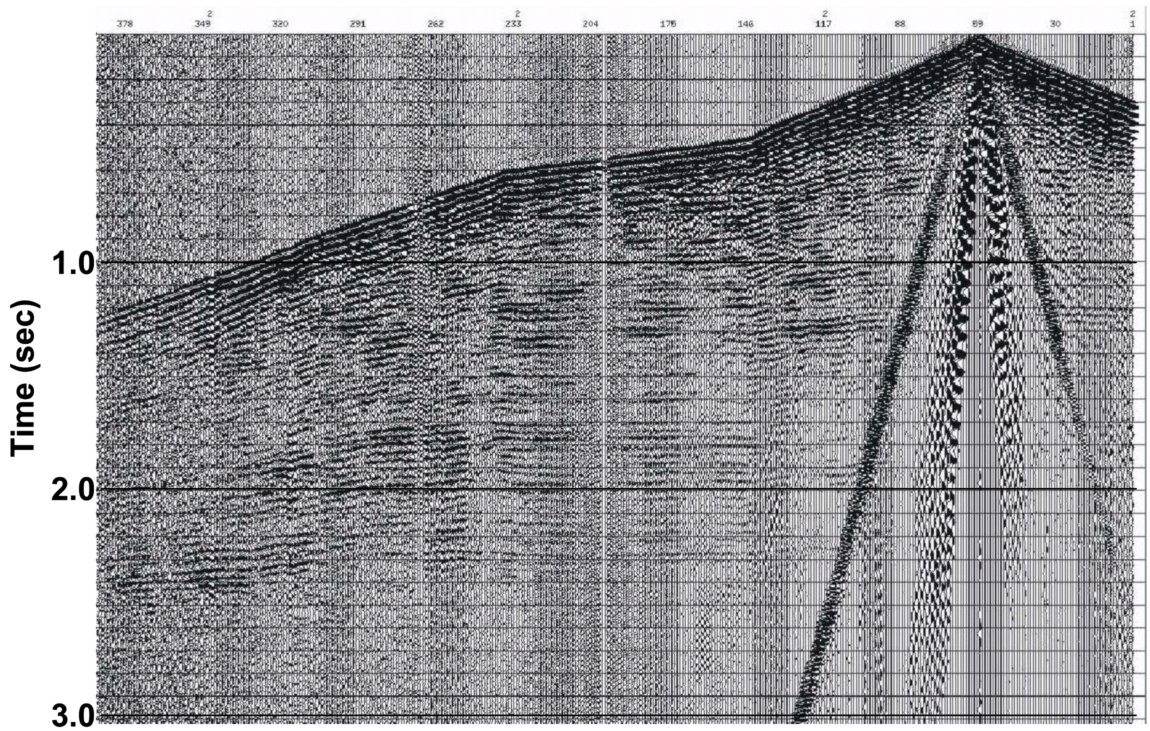

Figure 4. Raw shot gather, vertical component, after correlation and diversity stack (AGC applied).

The data have taken through a initial P-wave processing flow, including prestack noise attenuation, spectral whitening and residual statics. A brute stack of diversity-stacked shots is displayed in Figure 5, and the stack after 3 iterations of velocity analysis as well as spectral whitening, is shown in Figure 6.

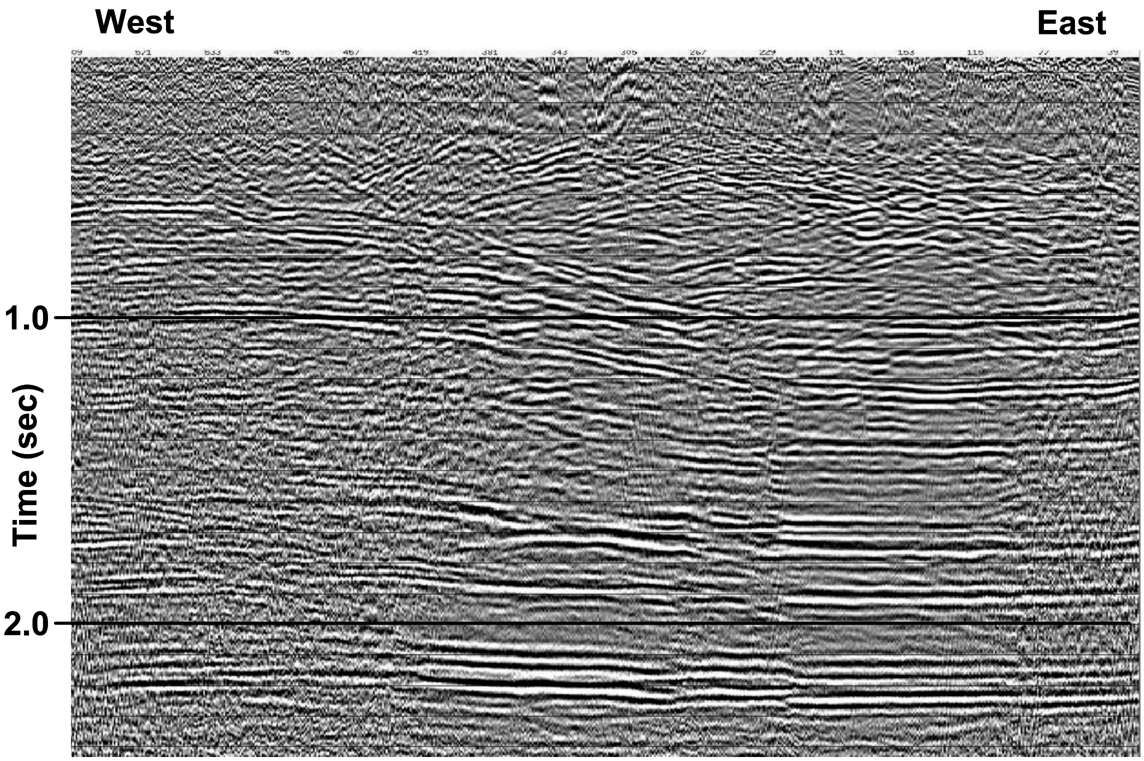

Figure 5. Brute stack, vertical component, of Jumpingpound seismic line.

A post-stack phase-shift migrated section, using 100% stacking velocities, is displayed in Figure 7. In this section, the eastern flank of the triangle zone is clearly evidenced by the eastward dips of reflectors between 600 ms and 1700 ms. This structure is interpreted to be caused by crustal wedging of sediments into the foreland basin succession along horizontal detachments, and appears similar to other seismic data from the Jumpingpound area discussed by Slotboom et al. (1996). However, in this example, there appears to be several levels of detachment, resulting in tectonic thickening of overlying strata to form a broad anticline in the western half of the section. Of particular interest is the high amplitude event at about 1700 ms that is interpreted to be the reflection from the top of the Mississippian carbonates. This event shows displacement on a backthrust, with a clear hangingwall cutoff near the west end of the line.

At early traveltimes in Figure 7 (< 700 ms), reflections are highly disrupted. This reflection pattern is interpreted to be caused by intense penetrative strain resulting from shallow tectonic wedging in Upper Cretaceous and Lower Paleocene sediments. A more detailed interpretation will be undertaken once data processing has been completed.

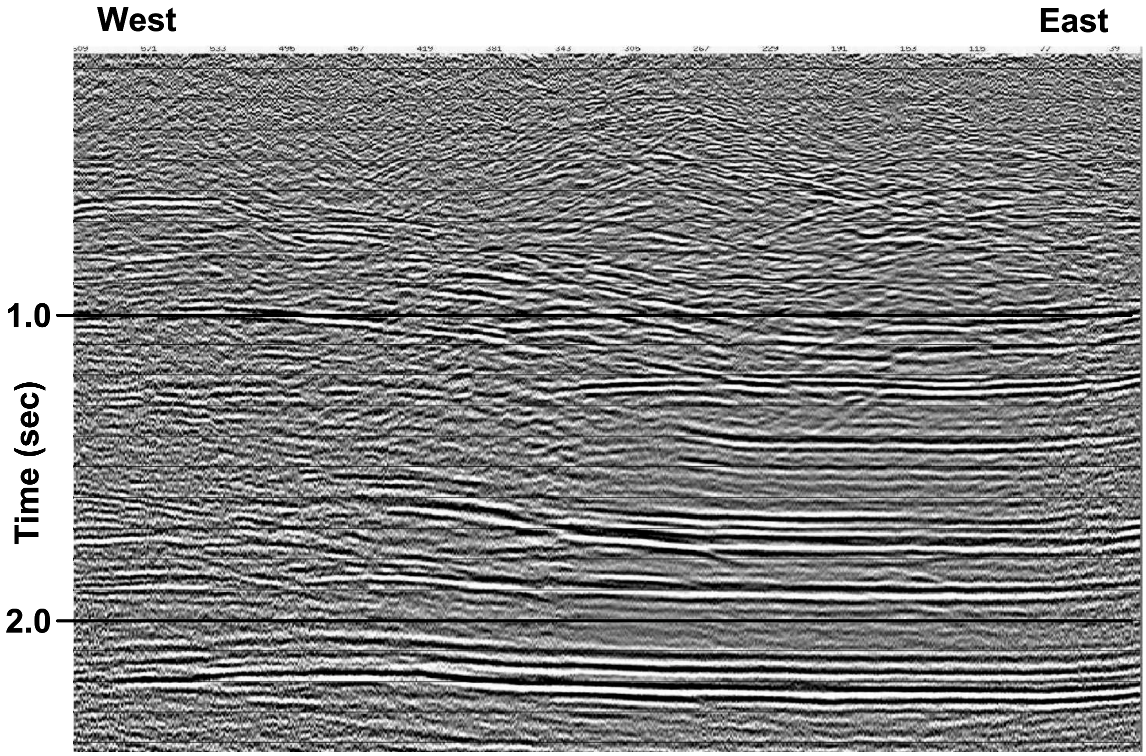

Figure 6. Brute stack, vertical component, Jumpingpound seismic line after prestack noise attenuation

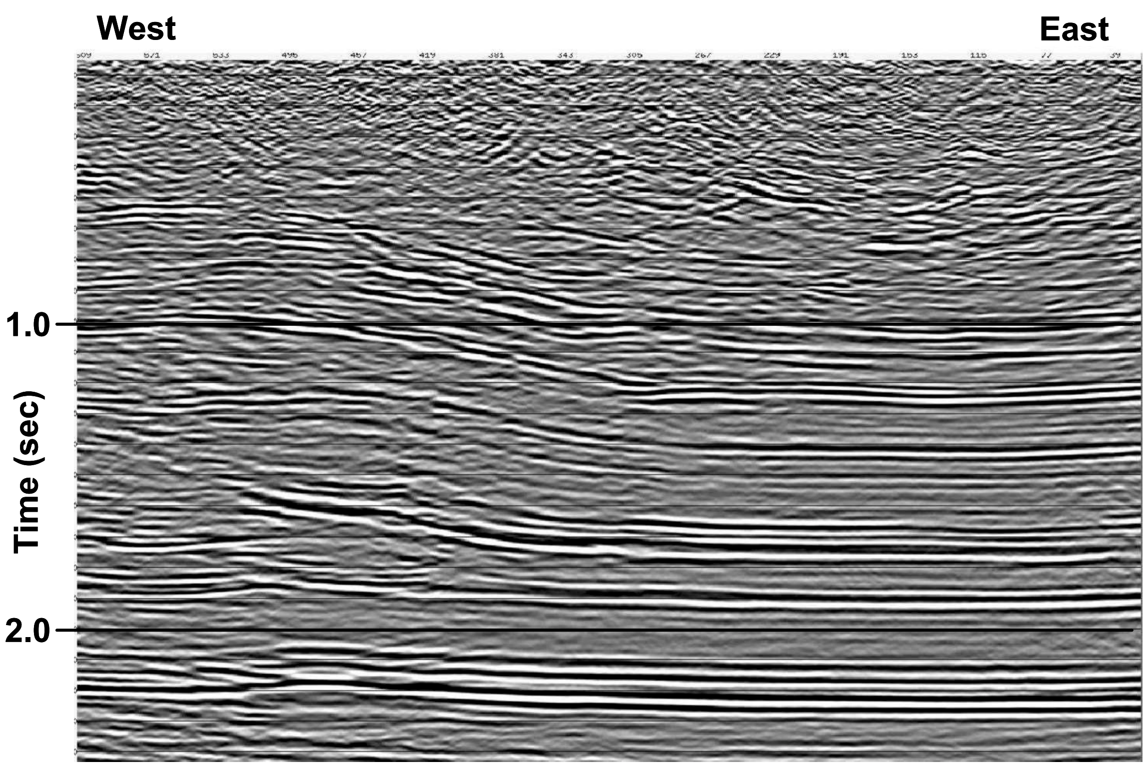

Figure 7. Migrated stack, vertical component, Jumpingpound seismic line.

Processing of the horizontal component data has also been initiated. Figure 8 shows a display of the diversity-stacked radial component of the same shot as illustrated in Figure 3. The data are noisy but some weak reflections are visible at about 1200 ms.

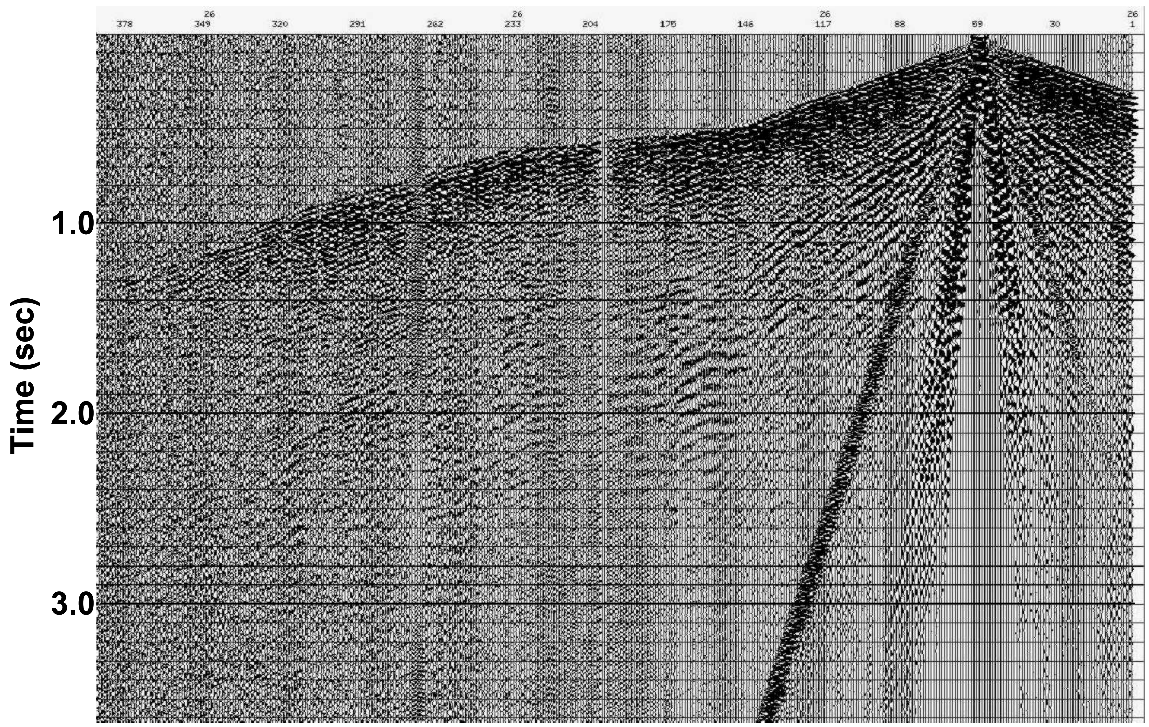

Figure 8. Raw shot gather, radial component, after correlation and diversity stack (AGC applied).

DISCUSSION

The data collected along the Jumpingpound line will yield important results about the efficacy of converted-wave data in areas of moderate geological structure. Good-quality P-wave data were obtained. The converted-wave appear to be quite noisy and processing will likely be challenging. Useful results are also anticipated from the high-resolution spread over the next months.

ACKNOWLEDGEMENTS

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