Processing and analysis of data recorded from a buried permanent seismic source

Tyler W. Spackman*, Don C. Lawton
twspackm@ucalgary.ca

ABSTRACT

- GPUSA permanent seismic sources were installed and tested in September 2018
- Application of Gabor deconvolution mitigates "ringy" character in recorded VSP data
- Datasets are comparable to those acquired with Vibroseis

INTRODUCTION

In September 2018, permanent seismic sources were installed and tested at the Containment and Monitoring Institute Field Research Station (CaMI.FRS) in Newell County, Alberta. Three different sources were tested: two surface sources (FIG. 1) and one source cemented in a borehole (FIG. 2). The sources operate by rotating an eccentric mass in a circle, and the coupling between the rotation axle and the ground causes seismic waves to propagate. Simultaneously using two masses allows for the control of wave type (i.e. compressional or shear).

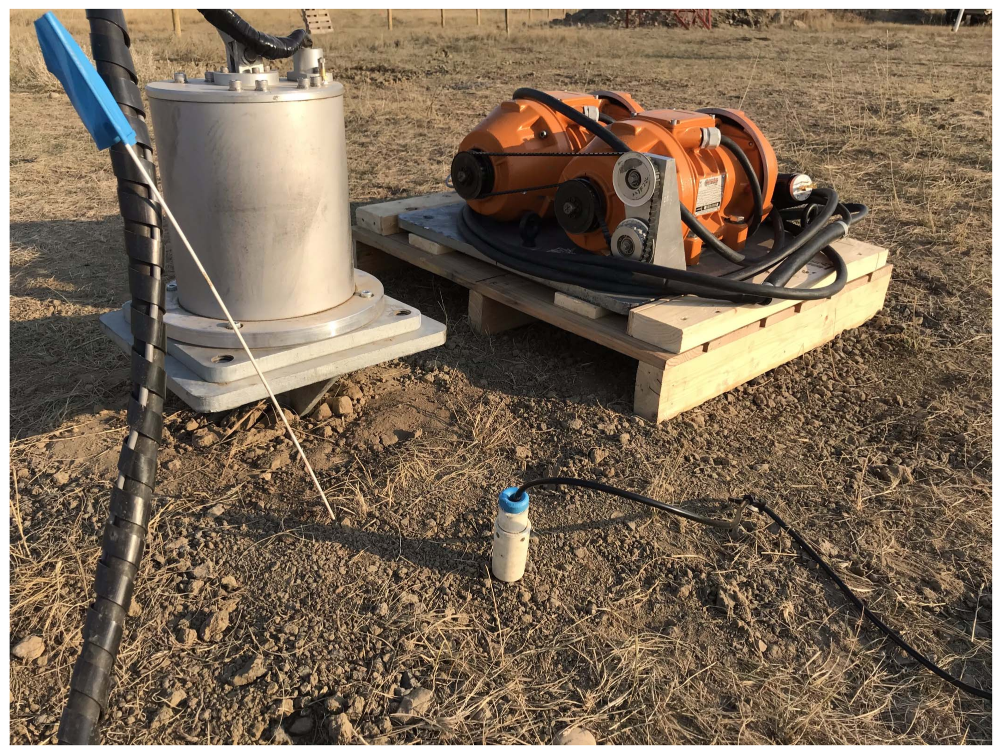

FIG. 1: GPUSA surface linear vibrators with geophone for scale. Rotation axes for these sources are horizontal.

FIG. 2: GPUSA borehole linear vibrator prior to installation. Rotation axis for this source is vertical.

PERMANENT SOURCE DATA

As the eccentric mass has a fixed orbital radius, the amplitude spectrum of permanent source data has a quadratic dependence on the angular frequency, ω (FIG. 3).

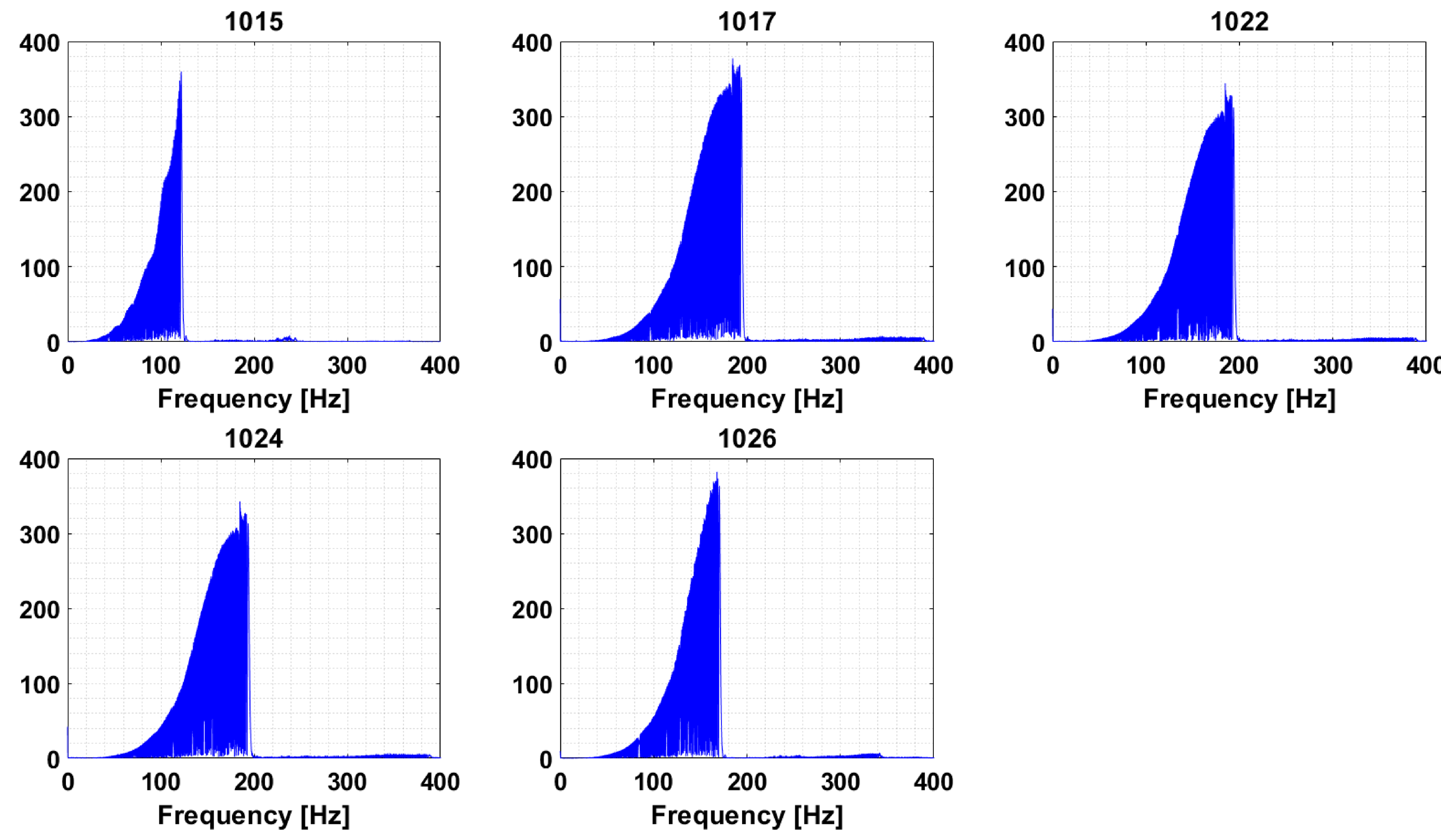

FIG. 3: Amplitude spectra for pilot trace (nearest geophone) for five test sweeps of GPUSA borehole linear vibrator.

Data from the borehole linear vibrator, correlated with the geophone trace immediately adjacent to the source borehole, is extremely ringy in character (FIG. 4). This could be due to the ω^2 relationship described previously.

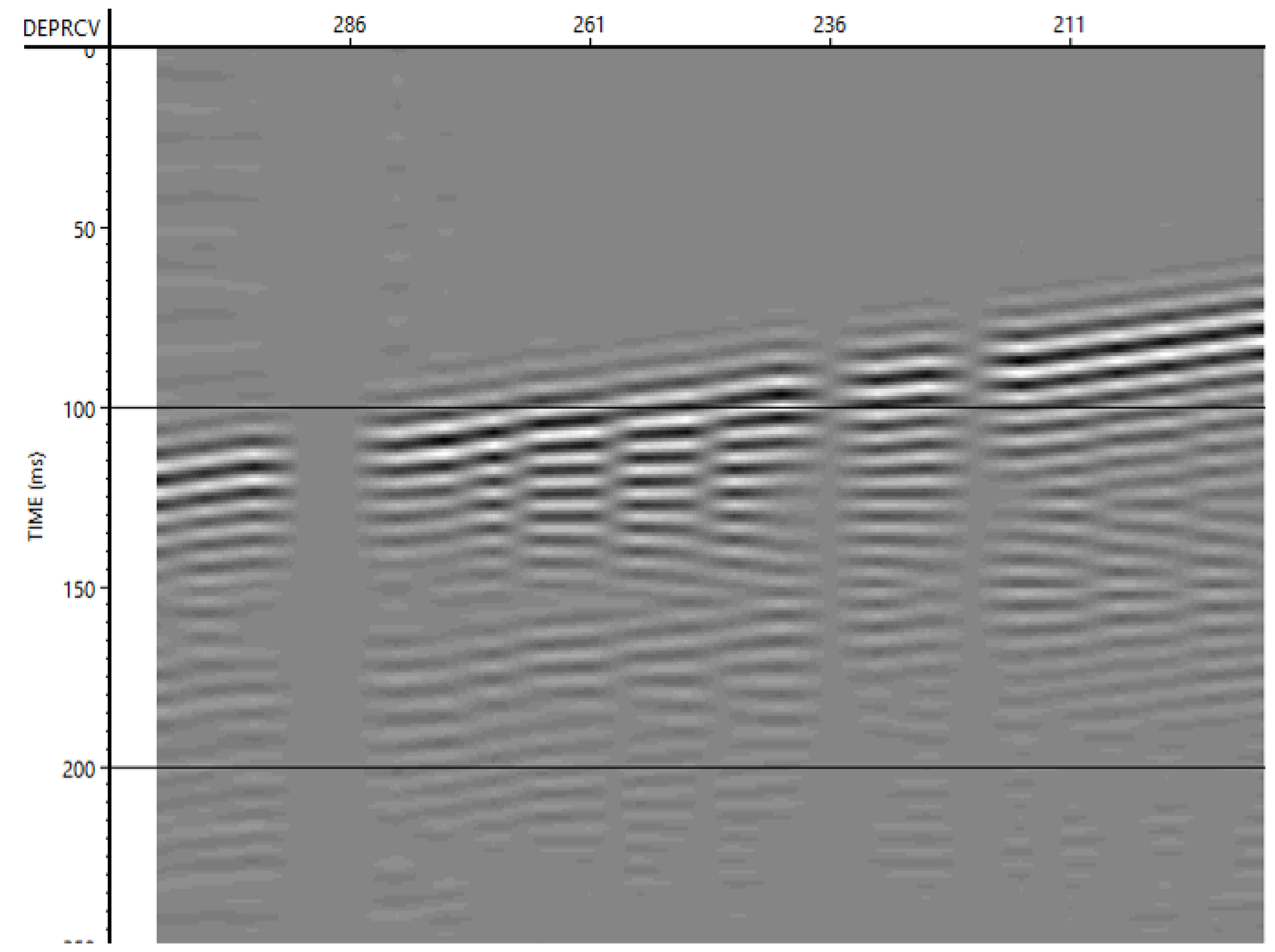

FIG. 4: Raw VSP data from borehole linear vibrator source. Data correlated with surface geophone nearest source location. Sweep is 0-175 Hz for 25 sec. Symmetric downsweep.

DATA PROCESSING

To attempt to mitigate the ringy character, several deconvolution methods were tested. Gabor deconvolution appeared to have the most success and was applied to the borehole linear vibrator data. Compared with data acquired with the same receivers and a Vibroseis source (FIG. 5), the borehole linear vibrator data exhibits a clearer upgoing wavefield, downgoing wavefield, and first breaks.

The resultant corridor stacks are similar in character, showing the same major reflectors, and agree with synthetic seismograms derived from FRS well logs. The injection interval is identifiable on both sections at approximately 250 ms. The quality of the borehole linear vibrator corridor stack encourages the further use of permanent seismic source in geophysical monitoring.

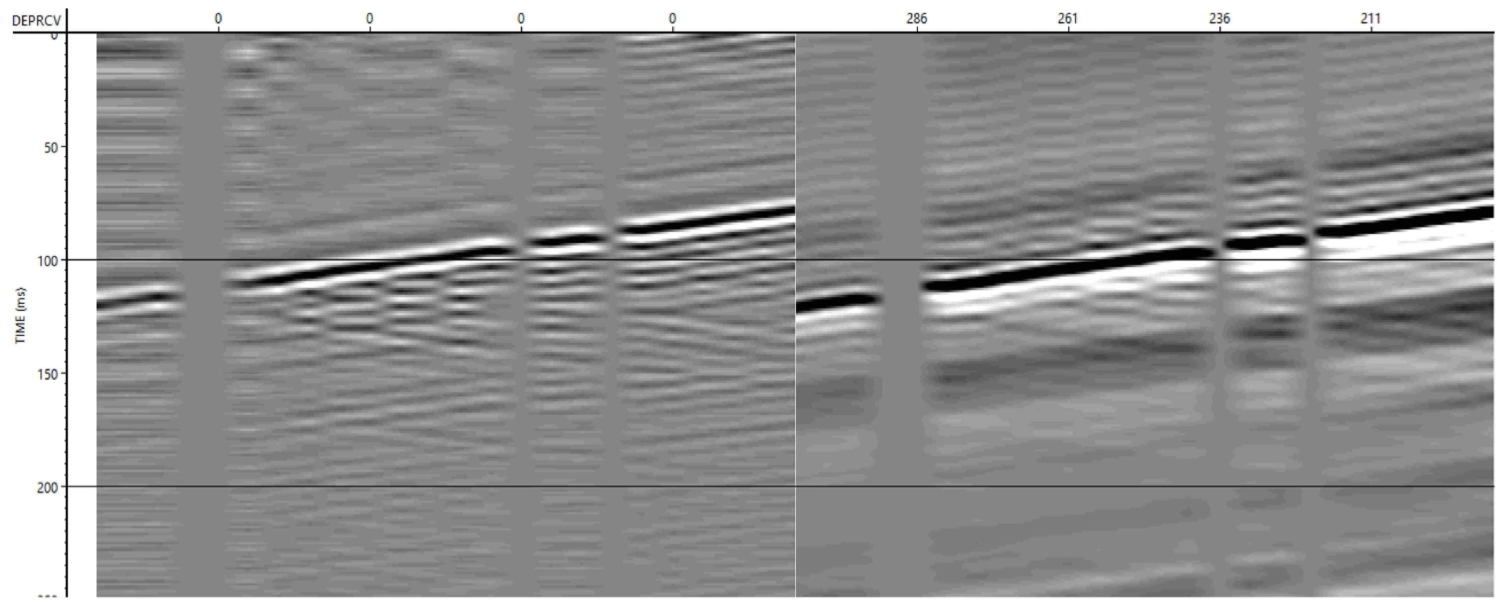

FIG. 5: VSP data from borehole linear vibrator (left) and Vibroseis (right) with Gabor deconvolution applied.

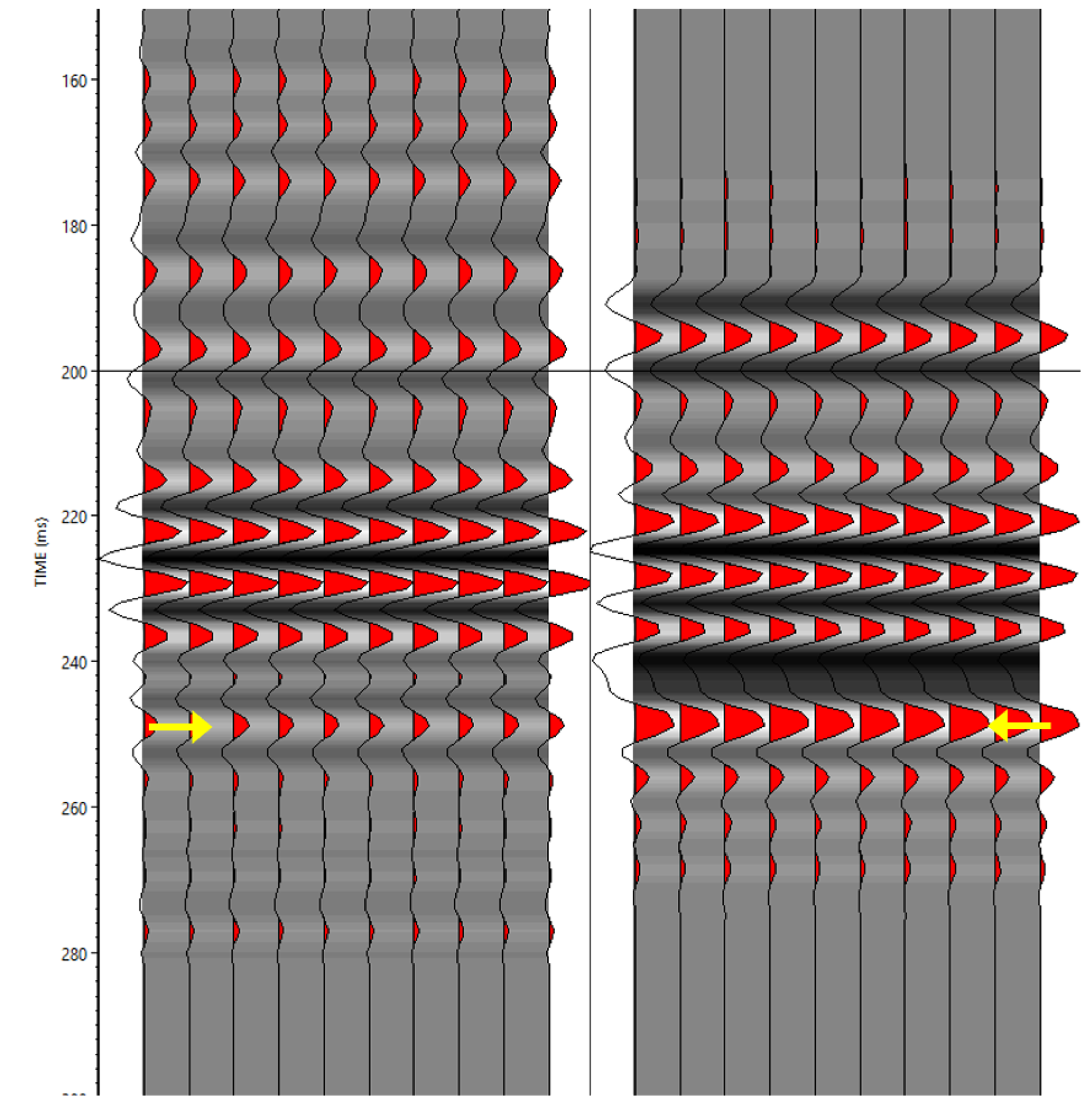

FIG. 6: Corridor stacks for borehole linear vibrator (left) and Vibroseis (right) VSP data. Injection interval highlighted by arrows.