Husky Heavy Oil VSP

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Abstract

CREWES was a participant in a walk-away vertical seismic profile (VSP) test near Cold Lake. Two-hundred and twenty-two VectorSeis accelerometers were deployed in a well at a nominal two meter spacing. Fourteen source points were acquired with dynamite and the University of Calgary's EnviroVibe source without moving the string of accelerometers in the well. *P-S* wavefields are observed on the radial and transverse components, and *S-S* wavefields are visible on the vertical, radial and transverse components for most shots. Higher amplitude down-going S-waves were generated from the vibrator source compared to dynamite. Three methods to perform automated component rotation are tested, and shown to give similar results, which are consistent between both source types. *P-P* and *P-S* brute corridor stacks are produced and compared to synthetic seismograms.

Acquisition

Fourteen source points were acquired twice, once with dynamite and once with EnviroVibe. Acquisition parameters are listed in table 1.

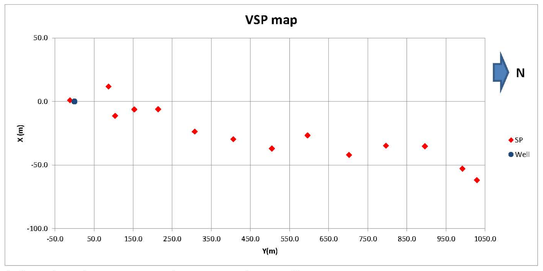

FIG 1. A map of the shot locations relative to the well.

Table 1: Acquisition Parameters

Dynamite	0.125 kg.	9 m depth.	
EnviroVibe	10-300 Hz over 20 s.	Linear. One sweep per vibe point.	100 ms start taper, 1000 ms end taper.
Receivers	VectorSeis.	222 X3C sensors at nominal 2 m spacing Depth range 60-500 m.	Magnetically attached to inside of steel casing.
Borehole	562 m TD.	Vertical.	No fluids in borehole.
Record	1 ms sample rate.	3 s trace length.	

The Data

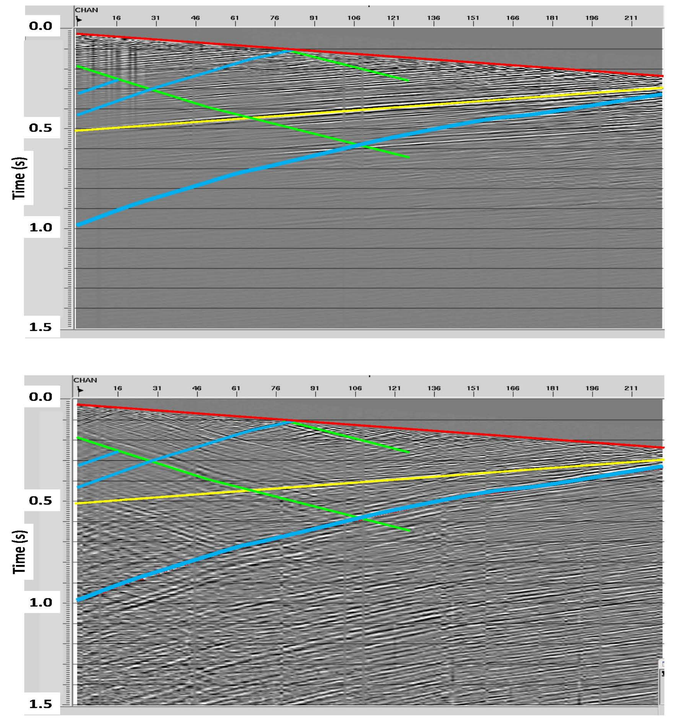

FIG. 2. Vertical (a) and radial (b) components for dynamite source point 1, after removal of down-going P (red line). Yellow denotes up-going P, green is down-going S, and cyan is up-going S.

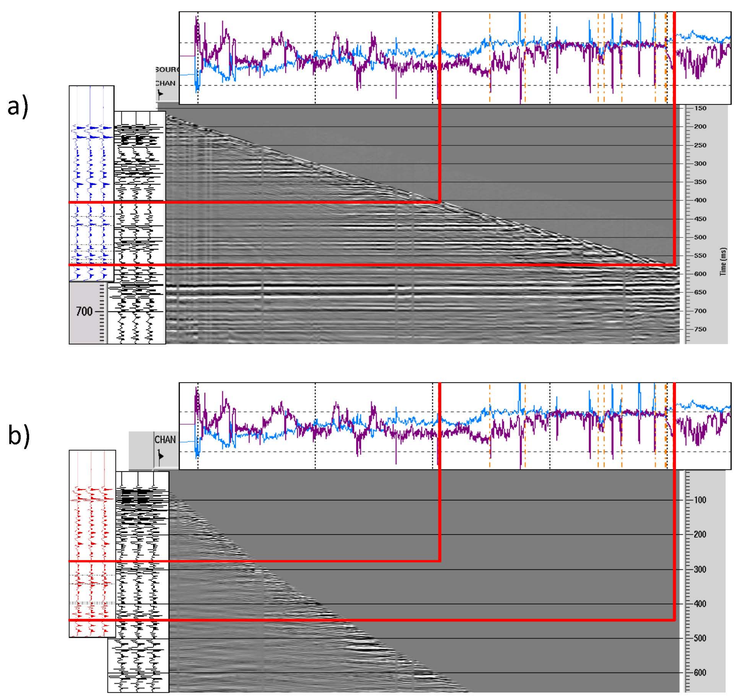

FIG. 3 Dynamite, vertical (a) and radial (b) components. Blue and red traces are P-P and P-S synthetic seismograms (repeated 3x), black traces are corridor stacks (repeated 3x), grayscale seismic data is up-going P (a) and up-going S (b), purple and cyan curves are the density and P-sonic logs from a nearby well. Vertical scale is one-way P-travel time. Horizontal scale is depth.

The wavefield separation was done by first flattening the data on the first-break picks and then median filtering to enhance the down-going P wave. This result was then subtracted from the flattened data to remove the down-going P wave.

P-P and *P-S* corridor stacks were produced by flattening the data on the up-going P and S reflections respectively. Top and bottom mutes were applied before the gathers were stacked. An *f-k* filter was applied to the S wavefield to reject all dipping events.

Future Work and Discussion

This data set can be used to estimate seismic attenuation (Q). Both Q_p and Q_s can be measured. Three different methods of Q estimation will be explored, namely, analytic signal method, spectral ratio method, and match filter method. The match filter method (Cheng and Margrave) is derived in a similar style as spectral ratio method (Bath, 1974). Q estimates from these methods can be compared to each other, and to the analytic signal method, which is best when true amplitudes are recorded (Tonn, 1991). Finally Q_p and Q_s can be compared through the empirical equation (Udias, 1999):

$$Q_s = \frac{4Q_p}{3(\frac{V_s}{V_p})} \qquad (1)$$

Up-going converted wave shear energy is clearly present on the radial component after component rotation, and can be used to create a *P-S* corridor stack for the near-zero-offset dynamite shot, which should have the least chance of success for this process. Source generated down-going shear waves can be seen on the vertical, radial and transverse components. Up-going *S-S* reflections can also be seen.

This is a high-quality, very rich dataset, that will afford many opportunities for future research. To date, no true amplitude recovery, deconvolution, or filtering has been applied to the data. The walk-away VSP has not yet been processed to an image via VSP-CDP transform.

Acknowledgements

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