Where in the earth are the low frequencies?
Comparison of sources at Hussar

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Introduction

One of the long-term ***goals*** of reflection ***seismology*** is to produce images of the subsurface, whose traces resemble ***ideal well logs***, accurately representing ***acoustic impedance as a function of depth***. Full-waveform inversion is the processing/interpretation method used to approach this goal; but its success depends largely upon the bandwidth of the recorded seismic reflection data, especially at the low end of the spectrum. In 2011, CREWES conducted a field experiment in the Hussar area, whose objective was to compare various combinations of sources and receivers with respect to the relative amounts of ***low-frequency reflection energy*** recorded with each combination. Because every seismic source inevitably generates ***surface waves*** in addition to desired ***body waves***, it can be difficult to determine what portion of the low-frequency source energy actually contributes to low-frequencies in the reflection spectrum. ***We compare the three sources*** used in the Hussar experiment (buried dynamite, Eagle Failing y2400 vibrator, and INOVA 364 vibrator) by separating the coherent noise from single shot gathers. ***We then compare the Low-frequency spectra of raw shot, noise estimate, and de-noised shot for each of the sources***, to see how the energy is partitioned.

Results

Figures 1a-1f show the ***raw shot gather***, ***most significant noise component***, and ***de-noised shot gather***, as well as the ***spectra*** for each, as recorded on the vertical component of Vectorseis 3C accelerometers with the ***buried dynamite source***. All data were integrated before analysis.

Figures 2a-2f show the ***raw shot gather***, ***most significant noise component***, and ***de-noised shot gather***, as well as corresponding ***spectra***, as recorded on the vertical component of Vectorseis 3C accelerometers for the ***Eagle Failing y2400 Vibrator***. Source point is the same as for the dynamite shot in Figure 1.

Figures 3a-3f show the ***raw shot gather***, ***most significant noise component***, and ***de-noised shot gather***, as well as corresponding ***spectra***, as recorded on the vertical component of Vectorseis 3C accelerometers for the ***INOVA 364 Vibrator***. Source point is the same as for the dynamite shot in Figure 1.

Conclusions

- ***Dynamite*** source appears to impart ***more low-frequency*** energy into ***reflections***.
- ***Vibroseis*** sources appear to put ***more*** of their ***low frequency*** energy into ***surface waves***.
- ***Dominant frequency*** of ***dynamite*** data was ***higher*** (20Hz) ***than*** that of ***Vibroseis*** (14Hz).
- Integration 'drift' noise affects the lowest frequency range for all sources.
- At ***this source point***, ***INOVA vibrator*** data may have slightly greater S/N than y2400 data, but at ***other source points***, the ***y2400 vibrator*** data have the edge.

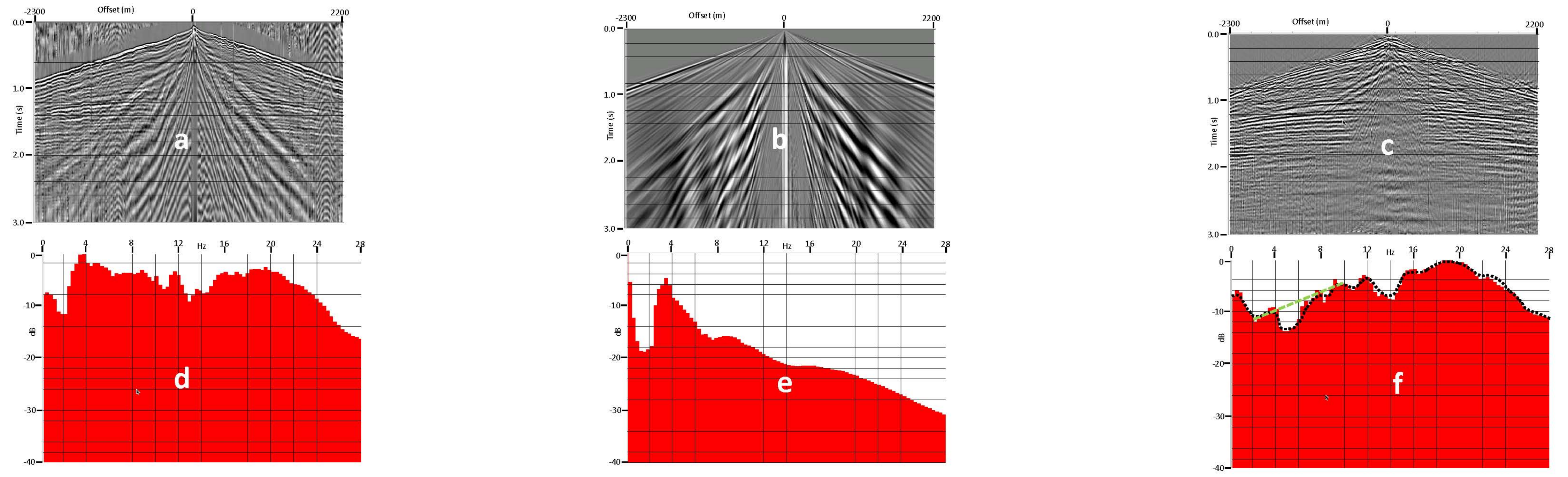

FIG. 1. a) Raw vertical component Vectorseis shot gather for dynamite source at source point 347. b) Most significant coherent noise component from shot gather in a). c) Shot gather in a) after de-noising. d) Power spectrum of raw shot gather in a). e) Power spectrum of most significant coherent noise component. Note strong peak at 4Hz as well as the peak near DC, which is likely due to 'drift' introduced by integrating the accelerometer data. f) Power spectrum of the de-noised shot gather in c). Predominant frequency is about 20Hz. Peak at around 1Hz is likely remnant integration 'drift' noise.

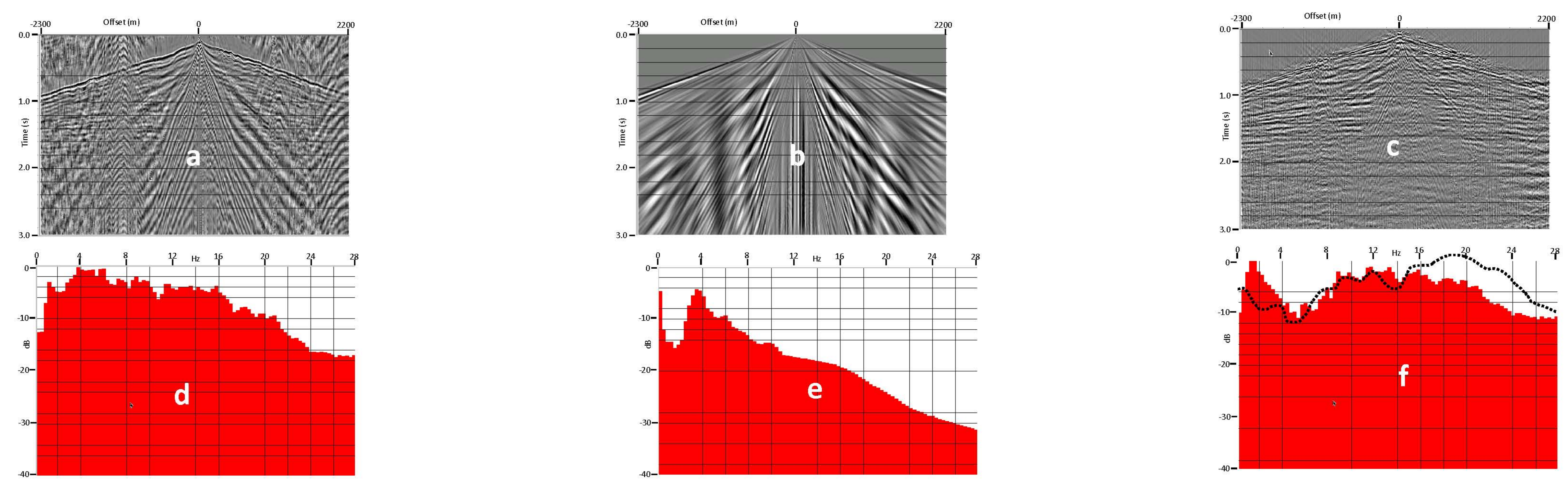

FIG. 2. a) Raw vertical component Vectorseis shot gather for Eagle Failing y2400 vibrator at source point 347. b) Most significant coherent noise component from shot gather in a). c) Shot gather in a) after de-noising. d) Power spectrum of raw shot gather in a). e) Power spectrum of most significant coherent noise component. Note strong peak at 4Hz as well as the peak near DC, which is likely due to 'drift' introduced by integrating the accelerometer data. f) Power spectrum of the de-noised shot gather in c). Predominant frequency is about 14Hz. Peak at around 1Hz is likely remnant 'drift' noise. Note that this remnant noise is stronger relative to the predominant frequency than that in Figure 1f. The dynamite power spectrum from Figure 1f is represented by the dashed line.

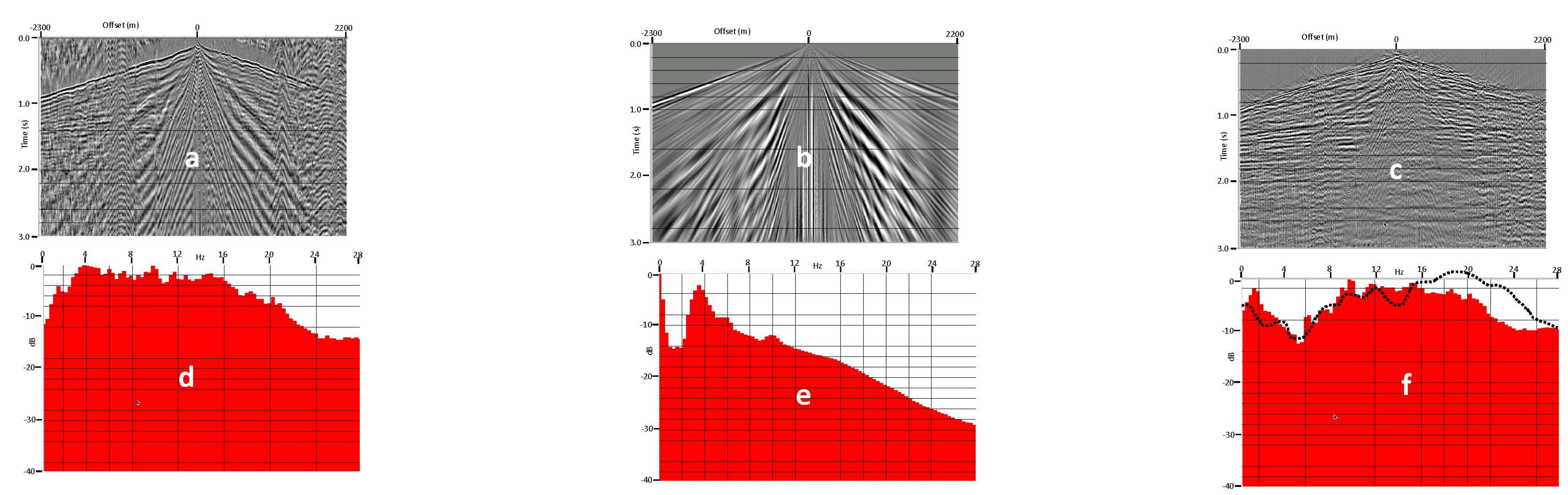

FIG. 3. a) Raw vertical component Vectorseis shot gather for INOVA 364 vibrator at source point 347. b) Most significant coherent noise component from shot gather in a). c) Shot gather in a) after de-noising. d) Power spectrum of raw shot gather in a). e) Power spectrum of most significant coherent noise component. Note strong peak at 4Hz as well as the peak near DC, which is likely due to 'drift' introduced by integrating the accelerometer data. f) Power spectrum of the de-noised shot gather in c). Predominant frequency is about 14Hz. Peak at around 1Hz is likely remnant 'drift' noise. Note that this remnant noise is stronger relative to the predominant frequency than that in Figure 1f. The dynamite power spectrum from Figure 1f is represented by the dashed line.