C04 Seismic Source Comparison

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Summary

3 seismic source types, vibrators, explosives and weight drop are compared. A seismic wavelet is estimated for each source. The wavelets are normalized using specific source parameters: mass for the explosives, mass and heights for the weight drop, Peak force and sweep rate for the vibrators. The observed amplitude levels are compared to the input energy.

Introduction

The primary objective of a recent seismic source test was to select a source for a seismic survey. In processing these tests, particular attention was paid to amplitudes and signal to noise ratio. A specific procedure for comparing impulsive and vibratory amplitudes was developed.

Seismic Sources

The following sources were used and analyzed:
Weight drop: 20 tons from 20 m on one single location. The results show a very repeatable image.
Explosive: 5 charges: 5, 10, 16, 20 and 35 kg in various locations at depths between 15 and 18 m
Vibrator: 2 types Nomad 90 (peak force 400 kN) and M22 (133 kN) with various sweeps on various locations.
It is easy to evaluate the energy spent by the vibrator engine between 5 and 25 Hz while shaking a 1Hz/s sweep: 300 kW * 20 s = 6 MJ. Likewise the potential energy of the drop is 20m*20T*9.81 = 4 MJ. In other words we should expect similar S/N from the vibrator and from the weight drop

Signal estimate

Figure 1 represents a weight drop record. No clear reflections can be seen. Consequently the signal estimate consists in the average of flattened first arrival in a given offset range as shown on the figure. The same offset range was used for all SP. Vibrator data were correlated using an operator with the same phase spectrum as the pilot and with an amplitude spectrum of 1 in the sweep frequency range. This procedure preserves original amplitudes.

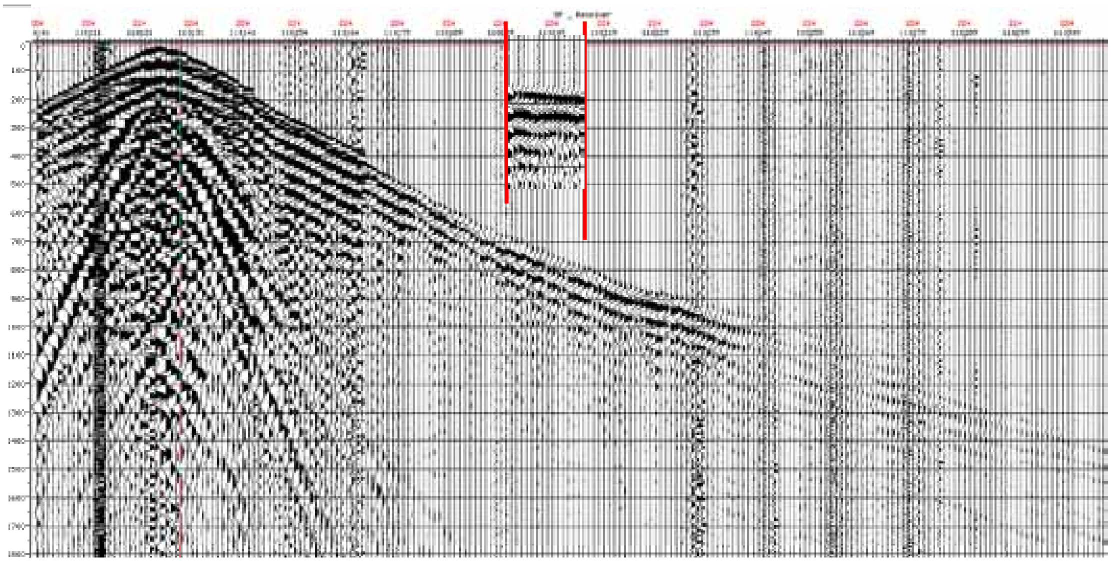

Figure 1 *Weight drop record – Signal estimate (average of flattened first arrival in a given offset.*

Amplitude spectra of wavelets were computed and normalized using the following formulas:

Weight drop: A(m,h) = Ao(1kg, 1m)* $(m*h)^{0.5}$ (not applied, only one mass and one height)

Vibrator : A(Pf, Ns, Sr) = Ao(1kN, 1sweep, 1s/Hz) * Pf* $(Ns*Sr)^{0.5}$

Explosives: A(m) = Ao(1kg) * $(m)^{1.2}$

Note that vibrators normalization uses theoretical parameters while the exponent used for explosives normalization is purely empirical.

Results

Vibrator normalization is very efficient as can be seen on fig.2. Remaining discrepancies are in the zone in which the start frequencies are different. This normalization makes amplitude and signal to noise ratio predictions possible. Moreover, it allows actual source comparison.

1 kg of explosives (at depths between 15 and 18m) produces roughly the same amplitude as
A 90000-lbs vibrator with a 1-Hz/s sweep and as
A 20-m drop of a 20-ton weight (see figure 3)

This is consistent with initial expectation.

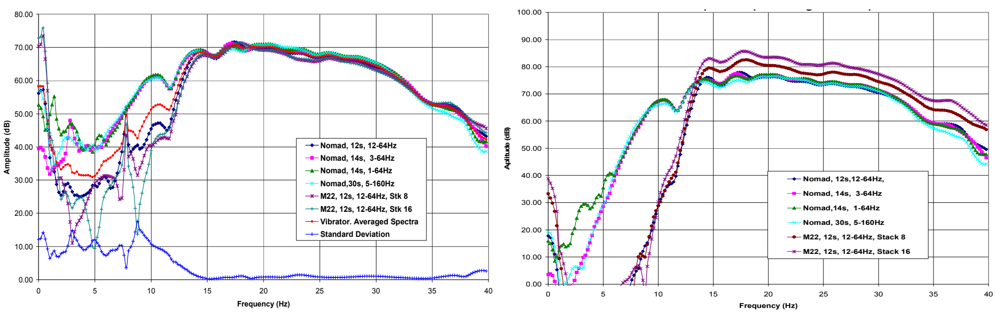

Figure 2 *Amplitude spectra of Vibroseis data before and after normalization.*

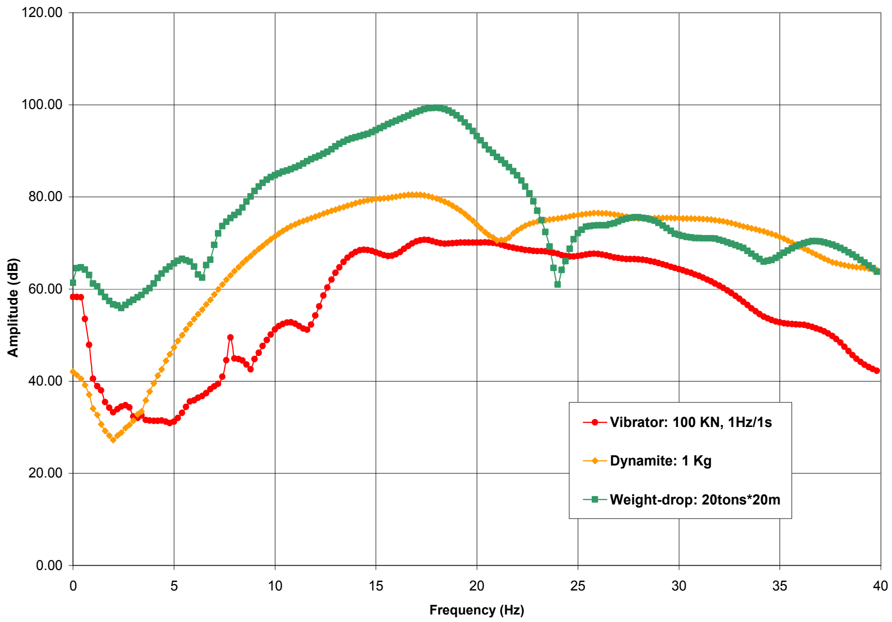

Figure 3 *Amplitude spectra of*
Vibroseis data (100 kN, 1 Hz/s),
Explosive data (1kg) and
Weight-drop data (20 tons 20m).