Successful Application of Accelerated Weight Drop on VSP Acquisition

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Abstract

The utilization of Vibrators or dynamite sources in onshore borehole seismic acquisitions is very uncommon in Brazil. Because of rough relief and dense vegetation in most of Brazilian basins, Vibrators are seldom used in the country, and the use of dynamite requires not only seismic crews to be available in order to perform the service, but also an environmental permit. For those reasons much of onshore VSP acquisitions in Brazil are usually done using airguns installed in pits specially built for those operations. A research program supported by Petrobras in a partnership with Federal University of Bahia proposed some experiments to evaluate the value of accelerated weight drop as complementary source for onshore seismic acquisition. As a secondary benefit, with the support of Schlumberger and taking advantage of twelve receivers installed in a production well for a microseismic monitoring operation in Miranga field, Northeast Brazil, a simple experiment was carried out in order to evaluate the efficiency of this impact source on VSP operations.

Introduction

AWD - Accelerated Weight Drop Source - AWD Source is a surface “impact” type seismic energy source. The energy produced by the AWD can vary from 10 to more than 100 K-joules and is derived from a large hardened steel hammer mass (458 lbs in the model used here) that impacts a ground coupled base plate. The first Impact sources were proposed by the half of last century. Much of the insuccess of the first drop weight sources was related with the hammers low velocity, using just gravity as propulsion.

Mechanically, these new AWD use a hydraulic system to lift the hammer mass to a “mass loaded” position. After loaded, a nitrogen gas charged cylinder and piston assembly applies a downward force on the hammer mass. The pressure applied to the hammer mass goes from a minimum of 500 up to 2000 PSI (Figure 1). When released, the hammer mass is propelled at high velocity to impact the base plate. The Digipulse AWD AF 450 used in this experiment is vehicle mounted over a Ford 1717 truck, and primarily designed for use on seismic exploration surveys

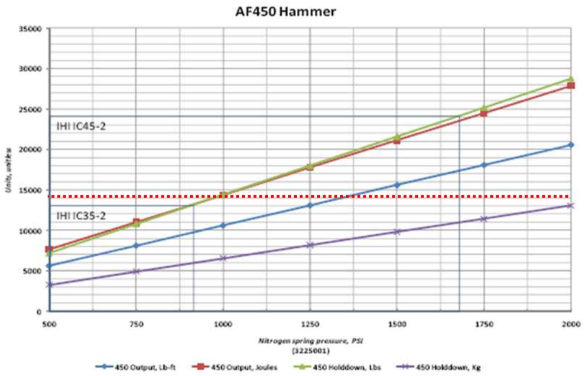


Figure 1. Spring pressure and energy produced.

Figure 2. The AWD AF-450 – Accelerated Weight Drop source used in the experiment.

VSP acquisition

As mentioned before, the number, spacing and position of the string of 3C geophones was designed for the microseismic monitoring of a stimulation process. The twelve 3-C receivers used in the experiment were anchored over the 969 -1299m depth interval, with 30m spacing. Before the microseismic survey the AWD source fired five times close to the wellhead, without gun time break control due to problems with the radio system of AWD unit.

As seen on Figure 3 the obtained repeatability was very high, dispensing any NRMS calculation. This regularity on source signature is a very valuable characteristic for VSP sources because usually shots need to be repeated in a vertical sum pattern to improve the SNR.

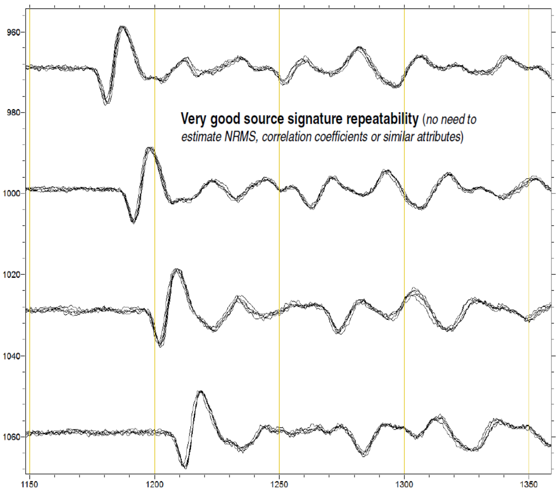
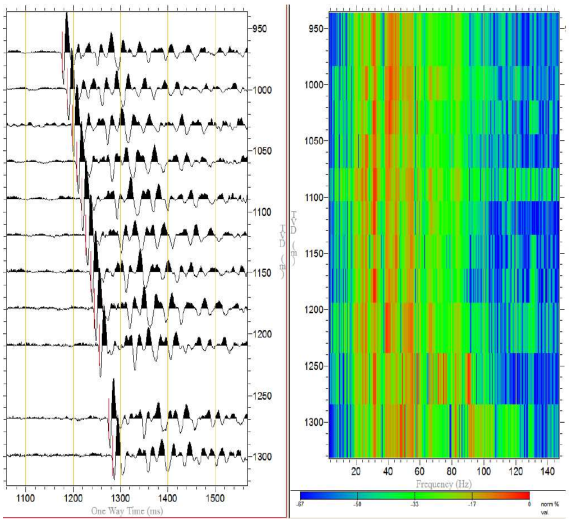


Figure 3. Group of superimposed shots (5) with the source occupying the same position, showing very high repeatability.

The signal to noise ratio and frequency content were high as shown on Figure 4, despite this characteristic depends much on base plate coupling with soil what may recommend some shots around the wellhead to choose the best place in terms of best coupling



During the survey some additional shots with small offsets from wellhead were carried out, with good results but that won't be evaluated in this analysis because we are considering future tests with some more control on source offset.

Processing

Due to the lack of gun time break during the continuous recording of all shots, these were first spliced and then aligned using the first-break times of the first shot as a reference.

A SNR~16 was obtained after stacking 5 shots at 1.3 km depth. Figure 5 shows the enhanced downgoing waves and the residual upgoing wavefield, which shows very coherent reflectors. These were further enhanced by standard VSP processing, including 8-95 Hz deterministic zero-phase deconvolution and velocity filtering. The final corridor stack is shown in Figure 6.

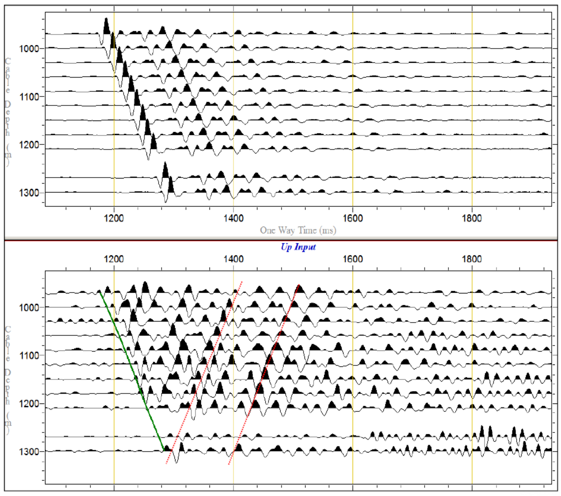


Figure 5. Zero offset VSP processing showing upgoing wavefield and some reflections.

Results and Conclusions

This was an exciting opportunity to evaluate the efficiency of the AWD source on VSP operations and the preliminary results were very encouraging. Down to the depths tested (1300 m), the AWD source seems to be perfectly valid for simple Checkshots and also for Zero-offset VSP surveys, provided the geology is not too complex and reflectivity response is fair to good.

Despite that a direct source comparison was not available in the receiver well, in a Schlumberger Confidential recent VSP onshore Bahia with a 250 in3 G-Gun fired at 2.5 m depth and 1750 psi inside a 4.5 m deep pit, the SNR at 1300 m depth was about 4 to 5 times larger than in this test with the AWD source. But more shots per stack than 5 can be used to further improve the SNR of the impact source.

The time synchronization between the downhole and surface acquisition systems needs to be tested, including

GPS time stamping. Optimal data processing workflows (using maximum coherency stacking, etc) are being evaluated. Finally, another acquisition test is recommended in a deeper well, using another seismic source for comparison.

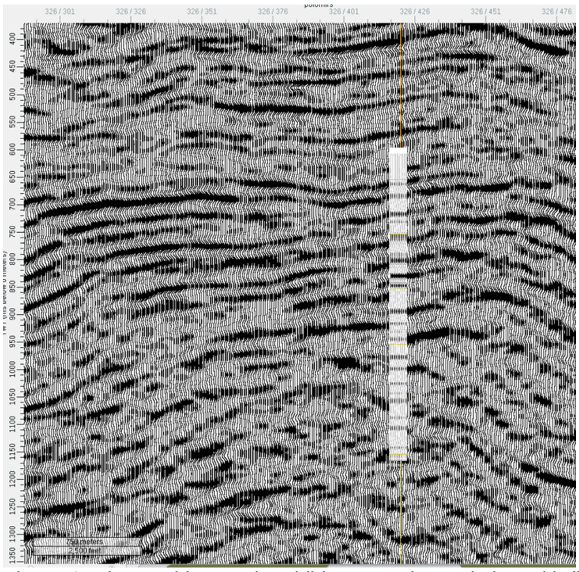


Figure 6. The corridor stack exhibits a good correlation with line extracted from 3D surface seismic.

Acknowledgments

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