

Single vibrator, single sweep, 3D seismic acquisition in WCSB

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Summary

During 2013 Talisman performed a successful 3D test of single vibrator, single sweep, technology in the Duvernay play fairway using full size vibrators, and subsequently acquired a similar single vibrator, single sweep, high quality 3D in Eastern Alberta using mini-vibrators. During the latter survey, a successful field test of the slip-sweep technique (Rozemond, 1996) was also performed. Field data from both surveys will be used to simulate and evaluate a variety of slip sweep field efforts. The initial results show that single vibrator, single sweep, technology is viable in the WCSB. This technology can deliver improved spatial sampling, improved signal-to-noise and improved bandwidth when compared to data acquired using traditional multi-vibrator fleets, or even in some cases explosive sources, for little or no increase in acquisition cost.

Introduction

The single vibrator, single sweep, data acquisition technique is now well established in more traditional vibroseis operating areas such as the Middle Eastern deserts (Meunier, 2005; Bouska, 2010). In the Middle East there are usually few surface obstacles for the vibrator trucks, and onshore 3D production levels similar to those of open water marine 3D's are now possible without compromising data quality (Burger et al, 1999; Pecholcs et al, 2010). The use of one sweep per VP is the logical extension of a point made by Cooper in 2002 that *"Higher vibroseis effort should be accomplished by generating more records at frequent source intervals rather than using more sweeps at sparse source intervals"*.

Although the surface conditions in the Western Canada prairies are often less favourable for the efficient operation of multi-vehicle vibrator fleets, with proper planning the efficient execution of single vibrator, single sweep, operations can be achieved. In early 2013 Talisman Energy Inc took advantage of a conventional, proprietary, vibroseis 3D survey in the Duvernay area to test this concept in the Western Canada Sedimentary Basin.

Method

The Duvernay 3D was acquired using 9 vibrators (I/O AVH III and IV, 62,000 lbs Hold-Down Weight), distributed between three fleets, with three vibrators per fleet. The source effort was one sweep per VP using a non-linear, EmphaSeis¹, up-sweep (4-100 Hz, 16 seconds). The VP's were located at 25m intervals along the source lines, and the shot records were recorded both uncorrelated and correlated. At the end of the conventional acquisition, as the recording crew was starting to pick up the geophone spread, ten individual vibrators were deployed to re-acquire about half a day's worth of data along ten adjacent source lines. Each vibrator used exactly the same sweep parameters as before, but with a reduced VP spacing of 8.3 meters along the source line. The 8.3m VP interval resulted in the same total source energy being applied during the test as was used during the conventional production, along the same source lines, and recorded into the same geophones. As for the conventional survey, all the test shot records were recorded both uncorrelated and correlated, and with no temporal overlap.

¹ CGG Trade Mark

Examples

The results from the Duvernay test are shown in Figures 1, 2 and 3. Figure 1 shows a 3D stack taken from the full fold production data volume during an intermediate stage in the processing flow.

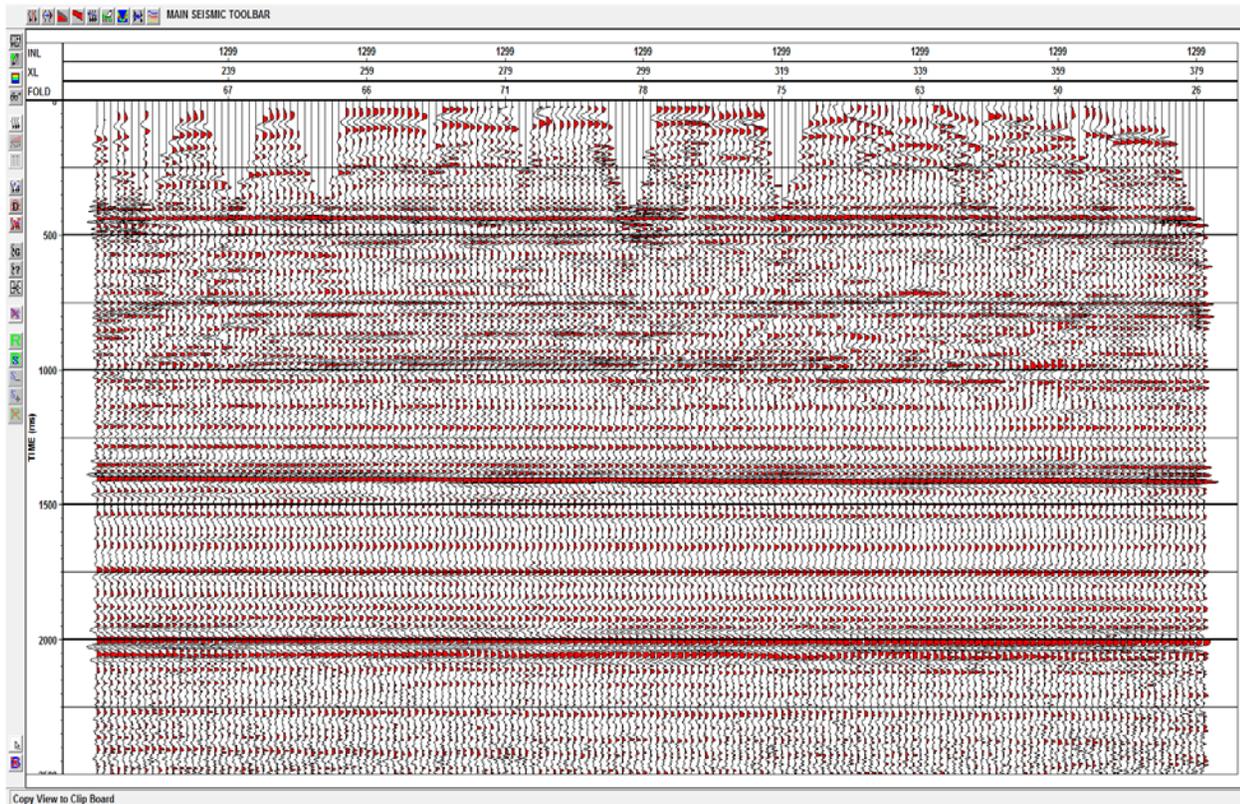


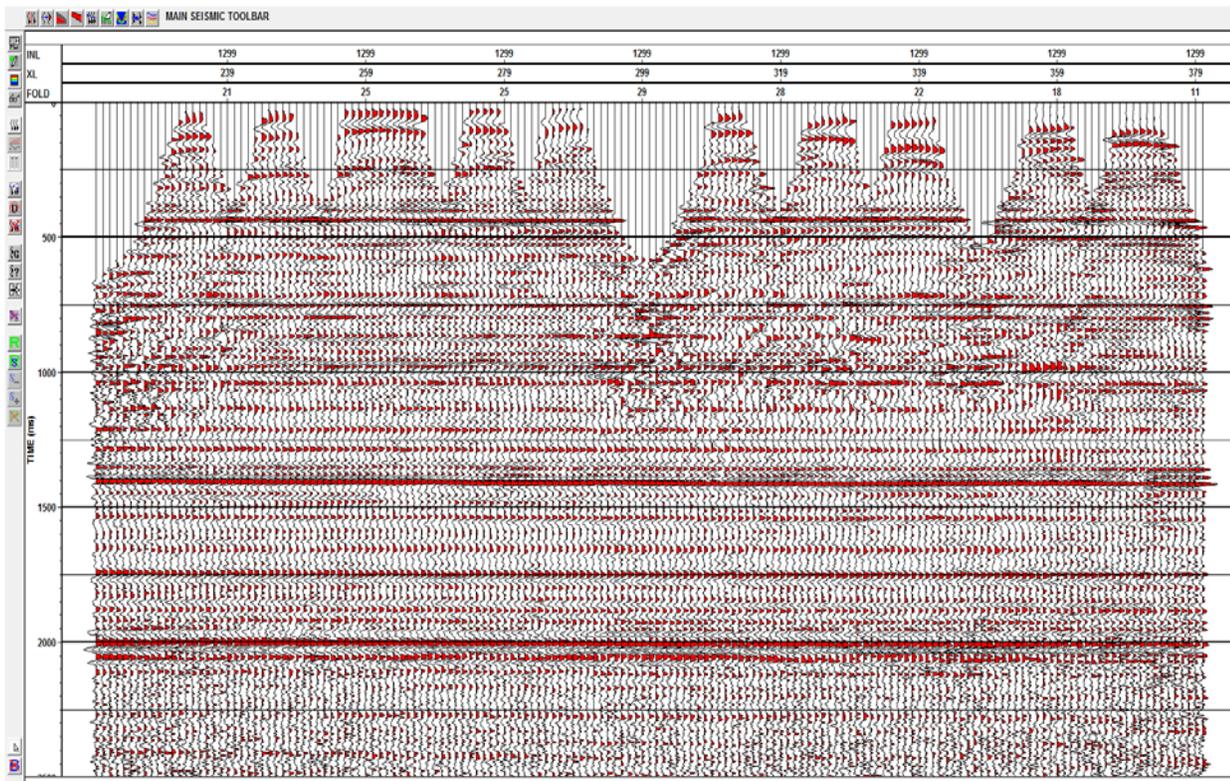
Figure 1 - Full fold 3D stack - production data (3 vibrators per fleet, 1 sweep per VP at 25m)

Figure 2 shows the 3D stack of the single vibrator, single sweep, test data along the same section profile as Figure 1, while Figure 3 shows the 3D stack of only those production shots that coincide with the Figure 2 test data. All three stacks have the same processing flow, the same static corrections, and the same stacking velocities.

It is interesting to note that below 2 seconds the stack of the single vibrator, single sweep, test data (Figure 2) shows an improved signal-to-noise ratio when compared to the stack of the equivalent production data (Figure 3). This improvement is most likely due to the superior ambient noise cancellation of the higher fold test data (up to 30 fold) compared to the equivalent production data (up to 10 fold). This observation supports Cooper's comment, cited above.

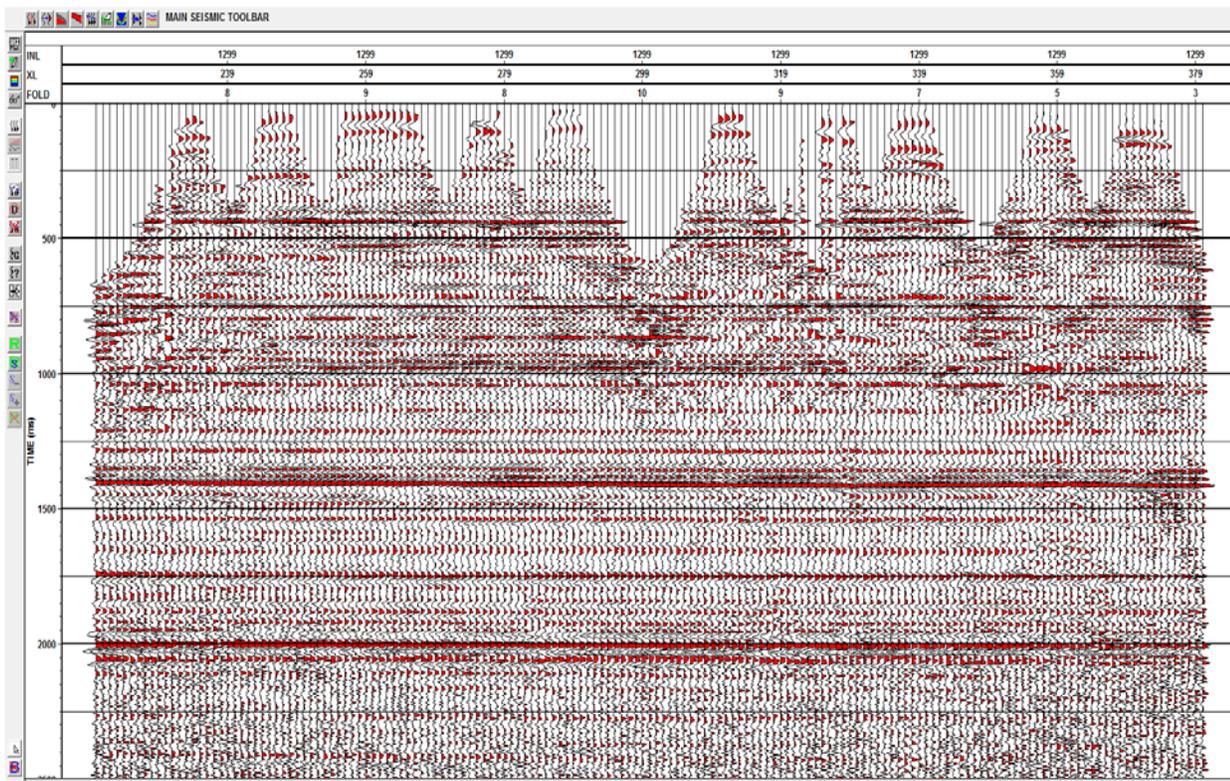
Following the Duvernay test, a full production 3D survey was designed in Eastern Alberta using the single vibrator, single sweep, source technology but using mini-vibrators (15,000 lbs HDW, 27 second linear up-sweep, 6-100 Hz) and a cable-less, nodal, recording system. Preliminary processing has shown high data quality, with the reflection frequency response covering the full sweep range up to 100 Hz. This frequency response exceeds that seen in two adjacent 3D surveys, acquired using a conventional, deep hole, explosive source. A representative, unprocessed, receiver gather from this survey is shown in Figure 4. At the end of the Eastern Alberta survey, the crew recorded a large volume of single vibrator, single sweep, test data using the slip-sweep methodology.

The next step in the process is to evaluate the acquired slip sweep test data from the Eastern Alberta survey, and also to use the raw, individual, uncorrelated, field records from both surveys to simulate a variety of slip sweep efforts in the processing center (Thacker et al, 2000).



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Figure 2 - Single vibrator, single sweep, 3D stack (Single vibrator, 1 sweep per VP at 8.3m)



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Figure 3 - Production shots equivalent to Figure 2 (3 vibrators per fleet, 1 sweep per VP at 25m)

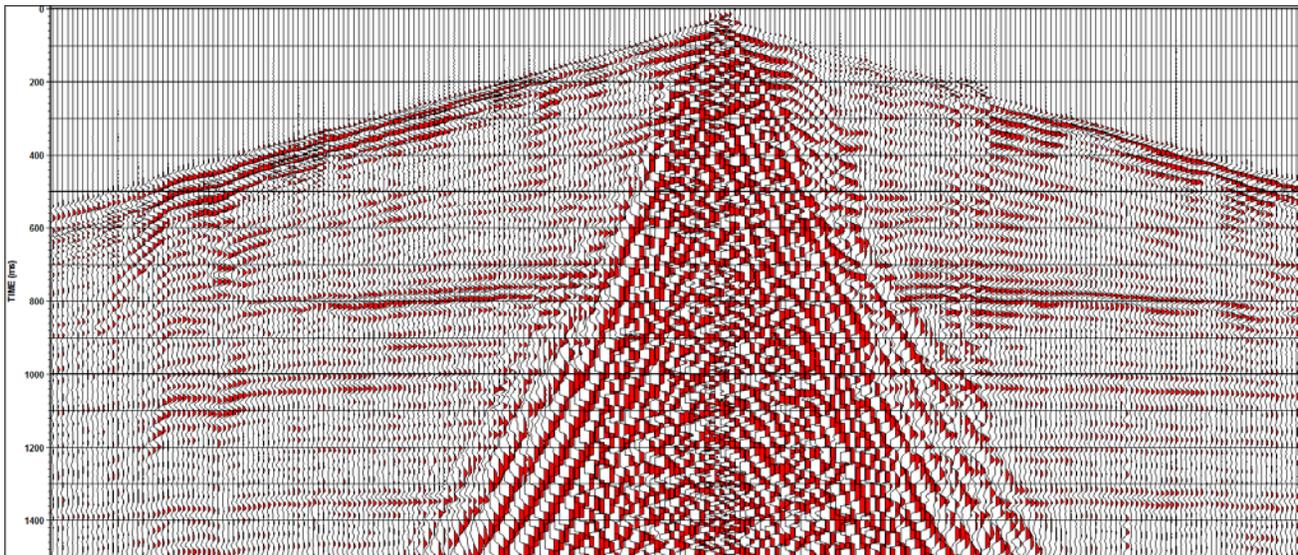


Figure 4 - Receiver gather, Eastern Alberta – Mini-vibrator, single sweep per VP (T^2 gain function only)

Conclusions

The Duvernay test shows that a single sweep from a single vibrator provides sufficient reflection energy to allow the data processors to image the complete sedimentary section in the WCSB with no loss in data quality. The same conclusion can be drawn from the mini-vibrator results from Eastern Alberta. Based on worldwide industry experience, it is anticipated that slip-sweep simulation will prove successful in both cases, and will therefore provide a sound operational basis for the cost-effective acquisition of single vibrator, single sweep, 3D seismic data in the WCSB.

Wherever Vibroseis is viable in the WCSB, the use of single vibrator, single sweep plus slip sweep will deliver improved spatial sampling, an increased trace density and an increased trace diversity, thereby resulting in an increased final data quality that may surpass that obtained from multi-vibrator fleets or even, in some cases, from explosive sources. The uplift in trace density, trace diversity and data quality, will also be beneficial for seismic inversion and rock property extraction in the pre-stack domain.

In closing, Talisman acknowledges that this approach is already being used by some operators in Northern Alberta. The intent of this paper is to provide some published case histories that can support its wider acceptance and application across the WCSB.

Acknowledgements

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