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A High Resolution, Low Environmental Impact, Impulsive Seismic Source for the Oil Sands

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Summary

The oil sand resource in Western Canada presents significant technical and environmental challenges to the 3D seismic industry due to its shallow depth. To properly image these shallow zones, there is a need for close spacing of source and receiver lines. This can result in a significant environmental footprint even when using Low Impact Seismic (LIS) techniques to open the lines. As part of its continued experimentation with reduced energy seismic sources, Explor has developed a high-resolution, low-impact, single-person-portable, impulsive seismic source (Patent pending) that is capable of delivering high quality seismic images within the oil sands play fairway without the need for opening LIS source lines. The results from a recent high density 2D line in the Athabasca area are shown in this paper, and it is believed that these results can be extended into the 3D seismic and 4D seismic arenas in a cost effective manner and further optimized by using field-proven techniques such as simultaneous source recording.

Introduction

One of the keys to delivering an increased pre-stack trace density in 2D, 3D and 4D seismic data acquisition is to increase the areal density of the source points. However, conventional seismic source systems involve the use of vehicular access (LIS drills, buggy-mounted impulsive sources, buggy-mounted vibrators), helicopter support (heli-drilling) or some combination of some of these methods. In the case of an oil sands survey, source line spacings for 3D surveys are typically in the 50m – 150m range and the individual cut lines are 2.75 metres wide. In the boreal forest environment, deployment of existing seismic source systems with close line spacing can result in both undesirable environmental impact and high operating cost.

As part of its drive towards delivering increased pre-stack trace density whilst reducing environmental impact, Explor has experimented with a reduced power impulsive energy source that can be easily and rapidly deployed in the field. This source was tested on a 2D line in the Athabasca area in March 2016.

Method

The seismic source is an extension of some ideas developed in the 1980's (Clark, 1984; Varsek, 1985) but brought up to date through the integration of available technology to provide fully autonomous source operations with reliable real-time navigation and accurate source initiation timing. The source is single-person-portable, does not require LIS line preparation in a forest environment, and in certain jurisdictions the regulatory burden is reduced substantially.

Examples

The 2D test line was one kilometre long, and consisted of 200 GSX receiver nodes spaced 5 meters apart with a single 3-component geophone at each station. The receivers were all live for all shots. The line was deployed through the boreal forest along a walking trail with only hand-cutting of tree limbs performed. The line was located approximately 10 km south of Anzac, Alberta, as shown in Figure 1. The seismic source was deployed at one meter intervals, with the relative source/reciver geometry as shown in Figure 2. Each source point was acquired independently, with no shot time overlap.

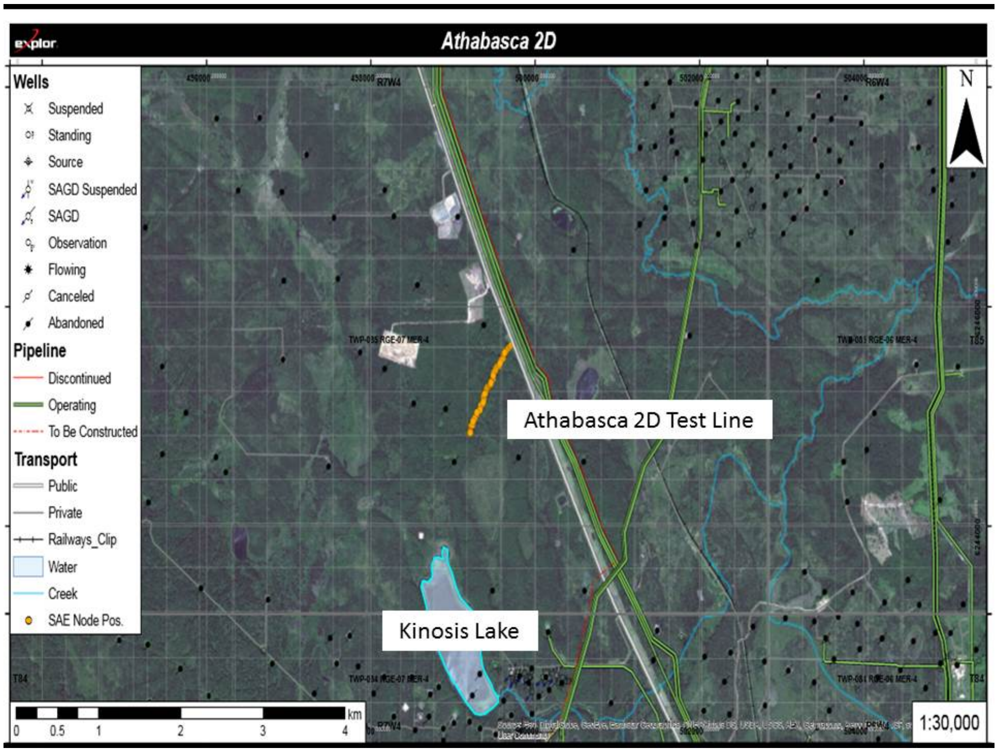

Figure 1 Athabasca High Density 2D Test Line Location

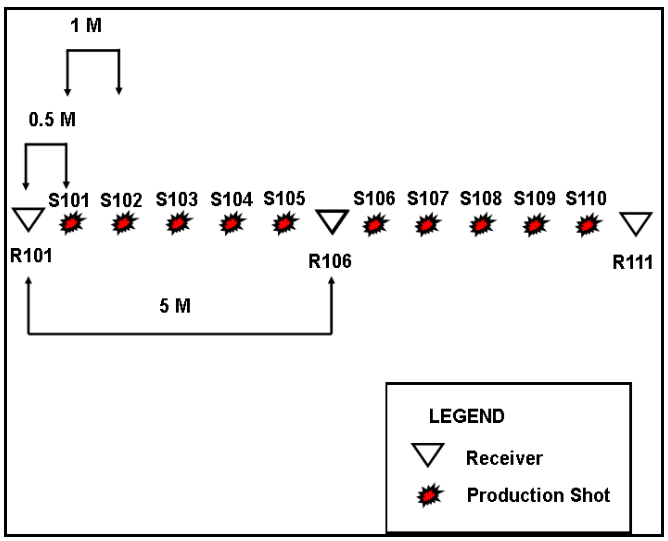

Figure 2 Source-Receiver Geometry

Two different source options were tested, with approximately half the shots being taken with each type. A typical shot record from each source type is shown in Figure 3, with Source A delivering a superior signal-to-noise ratio per shot to that from Source B. However, it is interesting to note that separate CMP stacking of the two shot types shows remarkably similar energy penetration, reflection continuity and frequency content for each of the two source types, despite the apparently poorer quality of the Source B shots.

The data were processed by two data processing companies. Firstly a "fast-track" processing was performed so that Explor could evaluate the latent data quality. The final section from this processing effort showed that the test location included a significant surface anomally in the center of the line – interpreted to be a Quaternary channel – but also established that reflection data had been recovered through to the intra-Devonian section. The data set was then subjected to a more detailed processing flow that was AVO compliant and included pre-stack time migration. The final section from the AVO compliant processing effort is shown as Figure 4, with the Top Paleozoic reflection occuring at approximately 400 msecs two-way travel time, based on information from adjacent wells. Figure 4 shows that the new, low-powered, seismic source successfully images geology within the upper part of the Devonian section.

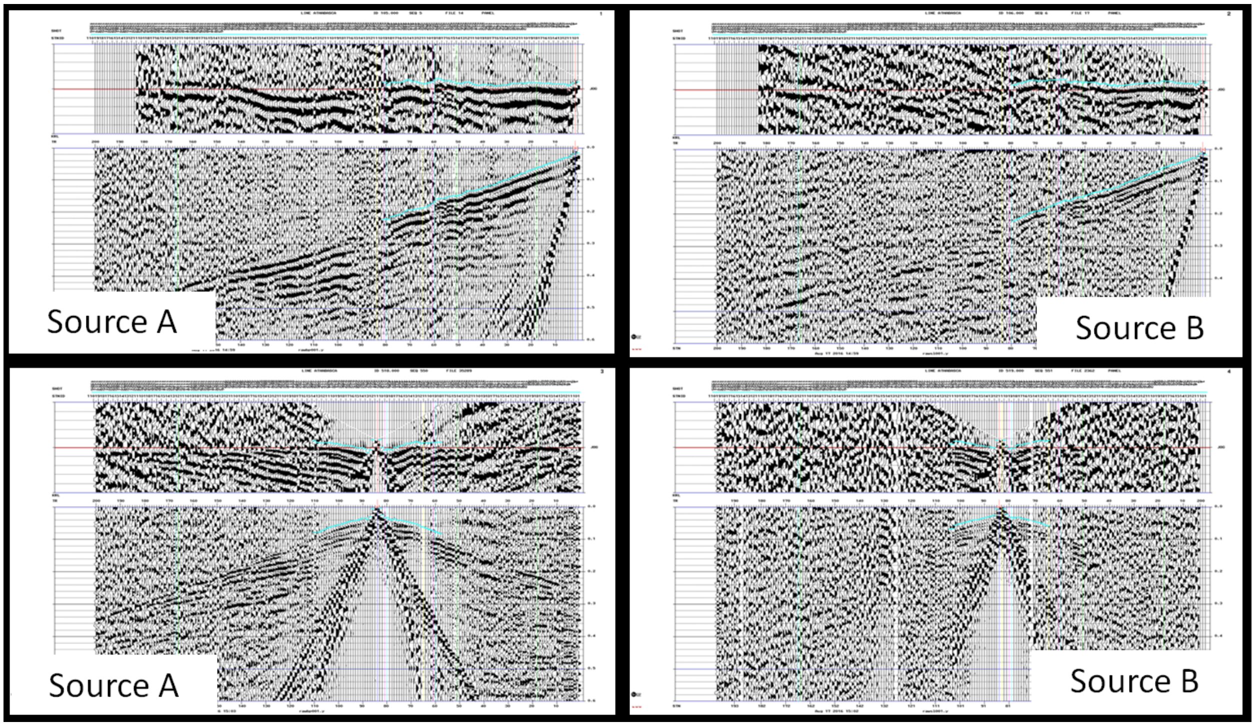

Figure 3 Two typical adjacent shot records from Source Option A and Source Option B

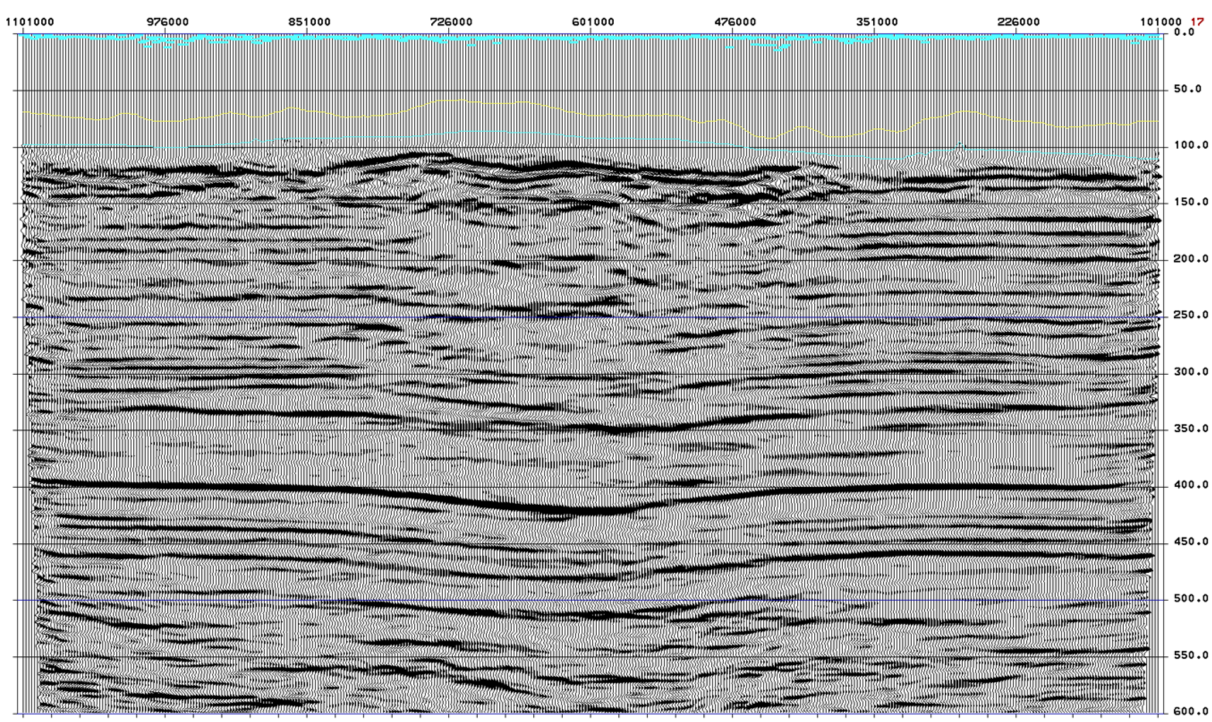

Figure 4 Final AVO compliant pre-stack time migrated section

A “quick look” PS section was also produced and this showed that PS reflection data had been recovered from the target section, but to date this work has not been taken any further.

A velocity analysis panel is included as Figure 5, and this shows the pre-stack quality of the data after noise reduction and two passes of residual statics and velocity picking.

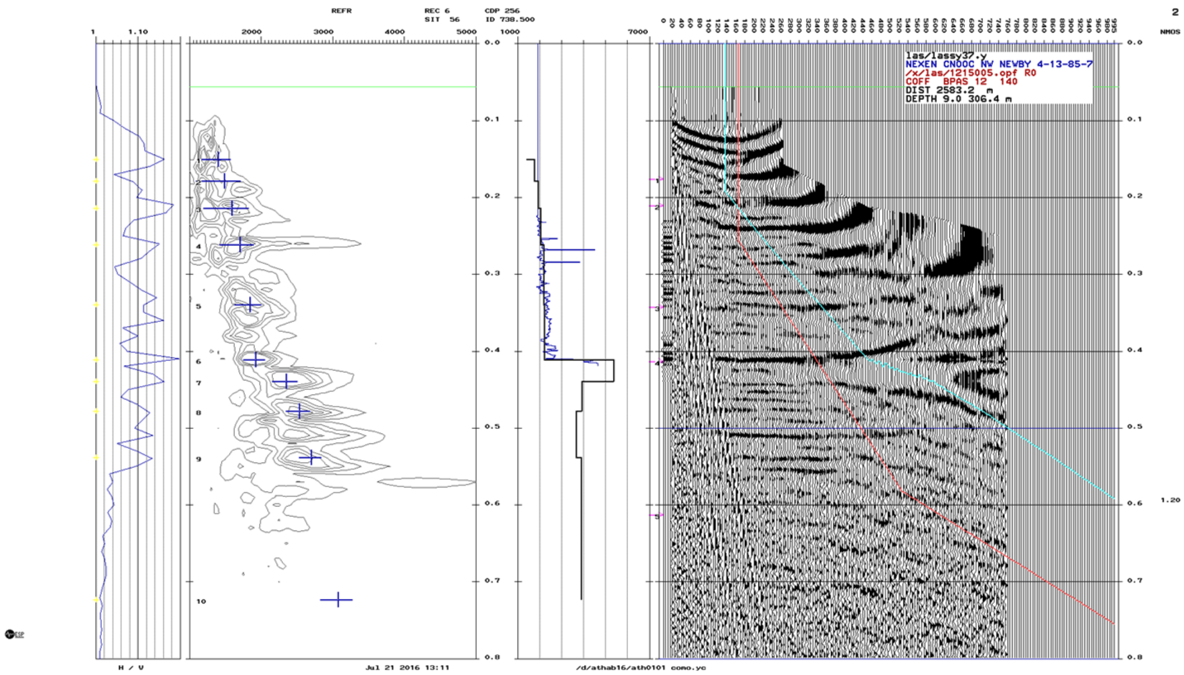

Figure 5 A typical velocity analysis panel from the high resolution 2D test line

Conclusions

The new, low power, seismic source delivers sufficient signal to penetrate through the full oil sands stratigraphy and into the Paleozoic economic basement, without the need for opening LIS source lines. The principle of acquiring a greatly increased pre-stack trace density using a highly portable, relatively low powered, source with resultant improvement of spatial sampling has proven to be effective. We believe that this principle can be extended to 3D and 4D seismic surveys within the oil sands play fairway and may be applicable for other shallow geological imaging objectives. We now plan to deploy multiple units of this source across 3D surveys using field proven simultaneous source techniques to allow for the acquisition of a high source density in an operationally efficient manner (Abma, 2015).

Acknowledgements

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References

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