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A new approach to broadband low impact seismic data acquisition in the Boreal forest.

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Summary

Resource development companies operating in the Canadian oil sands face the significant challenge of reducing the surface footprint of their operations. While in situ projects are not as impactful as surface mining operations, an estimated 97 percent of the oil sands that will be recovered will involve in situ methods. On average 50 percent of land disturbance results from current exploration methods to delineate oil and gas reserves as well as regulations to demonstrate cap rock integrity (COSIA Challenge, 2021). The application of distributed source array geometries with broadband low impact source types and nodal receivers that combined are capable of recording over 6 octaves of bandwidth are a path forward to providing data sets that meet the technical, safety and environmental goals for seismic data acquisition in Canada's Boreal forest.

Background

Canada's heavy oil region poses several technical, operational, and environmental challenges for seismic data acquisition. There's a growing concern regarding the ecological impacts of seismic operations, more specifically, line clearance. The region is somewhat unique in that the targets are relatively shallow, 100 to 900 meters, which complicates data acquisition on several fronts. Imaging these shallow targets requires tight source and receiver line spacings which traditionally have been cleared. Although more recent low impact seismic (LIS) methods have been employed to reduce the amount of line clearance by a narrowing cut line widths from ~8 meters to ~2.75 meters for the source lines and ~1.75 meters for the receiver lines, the improved imaging required to delineate reserves and comply with governmental regulations has necessitated 3D and 4D acquisition geometries which have offset many of the gains realized through current LIS methods. From an operational perspective the lines provide an efficient network allowing the crew to move throughout the project in a predictable cost-efficient manner including during significant weather events. In addition, this line network provides evacuation routes if required by an HSE incident. The conundrum is obvious, how do we reduce line clearance while meeting our technical and operational objectives in a safe and efficient manner.

Design Considerations

The benefits of acquiring broadband seismic data are well documented with respect to the wavelet, low-frequency texture, ease, and accuracy of interpretation, AVO and inversion (Denis, 2013). When evaluating methods to meet the environmental needs of acquiring seismic data in the Boreal forest we need to consider several items such as signal strength, signal bandwidth and sampling (spatial and temporal) and how they relate to meeting our objective of acquiring a high density broadband data set. When considering a source, the primary factors are related to its physical size, the output signal bandwidth, and the signal strength. With respect to the recording system, considerations should be given to the ease and efficiency of deployment and data management, the operating specifications (power consumption, memory and temperature limitations), and its recording specifications (frequency response, sampling capabilities, noise floor and spurious frequency considerations). Lastly, we need to look at the source and receiver grid or geometry and how we can reduce line clearance while considering both the source and recording system advantages and limitations with respect to meeting the technical and regulatory requirements.

At first glance, if we were to apply conventional or "typical" 3D design methodologies to this problem, there's an obvious disconnect between a reduction in line clearance and our ability to deliver a broadband data set rich in low frequency. One approach might be to utilize small "portable" sources, unfortunately these are typically band limited with respect to very low frequencies (<5Hz) and by nature have low signal or energy output. It is difficult to overcome the former however we can mitigate the latter by increasing the number of source locations either by tightening the group interval or the line intervals or both. This can be problematic if we need to do any line clearance. If no cutting is required, we need to be mindful of the limitations or the efficiency of moving a portable source through the forest especially during and after severe weather events, for example heavy snowfall. Additionally, there may be concerns regarding potential HSE incidents and an efficient means of worker extraction. On the receiver side, the market has seen a significant offering of new nodal or cableless recording systems in the last 5 years which are ideally suited to reduced line clearance. As mentioned earlier we need to be mindful of the systems' technical specifications given our goal of recording ≥6 octaves of bandwidth and considering that the shallow nature of the play typically returns frequencies above 150Hz and in some cases above 200Hz.

A New Approach

A new method to satisfy the environmental objectives without compromising the imaging requirements involves the novel approach of utilizing a multi-gridded multi-source-type geometry (Bell et al., 2015). The advantage of this approach is that a larger very low frequency high energy source type such as onSEIS™ (figure 1), which is designed for narrow line access, can be sampled more sparsely with a much larger grid or line spacing. Smaller lower energy high frequency portable sources are sampled more frequently on a tighter line grid and do not require line clearance. Units such as onSEIS™ have the advantage of being synchronizable to improve energy output for deeper targets. Additionally, they are impulsive with a reset time of 6 seconds so deploying multiple units has the advantage of a very rapid data acquisition scheme. With no changes to current LIS methods other than the use of onSEIS™, line clearance would be reduced by over 30 percent. The combination of multiple source types on the gridded geometry can significantly improve this number while delivering a high-density broadband data set in a cost-effective manner.

IHI IC35 Narrow		
Type	Synchronized Electromagnetic Impulsive	
Propulsion	Tracked Carrier	
Energy	Strong	
Octaves	+6	
Weight	15,650kg	(12,500lbs)
Length	4m	(13' 2")
Width	1.5m	(5')

Figure 1: onSEIS^{TM} Synchronized Electromagnetic Source

References

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Denis, M., Brem, V., Pradalie, F., and Moinet, F. (2013). Is broadband land seismic as good as marine broadband: SEG Technical Program Expanded Abstracts September 2013, 141-145.