Just stop that racket! – a Canadian oilsand case history

Sylvestre Charles, Suncor Energy Inc. and Anna Leslie, CGG

Summary

In this case history, we illustrate the importance of identifying the various noises that may affect the seismic data during recording. This information can be used for better planning of future 3D surveys to improve noise mitigation strategies.

Introduction

A 24km^2 vibroseis 3D seismic survey was acquired during the winter of 2015 as the baseline for a future commercial SAGD scheme in the Athabasca oil sands, Alberta. The McMurray reservoir is at a shallow depth i.e. approximately 150m, and the internal stratigraphic architecture is very complex. The base of the reservoir lies upon Devonian carbonates that are deformed due to deeper evaporite dissolution. To capture the geological complexity, one needs to record a very high-resolution survey with a bandwidth that has an upper frequency of at least 200Hz and a lower frequency in the 4 to 5Hz range. To do so, we used a single sensor - single vibrator – single sweep ping-pong approach. The sweep parameters were optimized with a high-resolution 2D test line. To ensure the broad spectrum is not affected by spatial aliasing and to capture the heterogeneities that are present in the near surface, one has to rely on dense seismic acquisition parameters with short shot and receiver spacing as well as close source line and receiver line spacing.

Improved sampling of both signal and noise resulted in superior seismic imaging. However, we were faced with two additional difficulties: the first one, common to most oil sands, is because of the interference of the strongest portion of the ground roll with the near offset reflection data. The second is related to the presence of common noises in seismic data that are much more difficult to attenuate especially at shallow times and near offsets, as all components (P & S reflections/refractions and ground roll) of the wavefield overlap.

Noise attenuation

Even if both signal and noise are adequately sampled and all of the characteristics of the noise are known, noise and signal will not be perfectly separated at processing. There will always be a bit of signal alteration in the removal process as well as a bit of noise that will leak through. Cascading effects in the data processing workflows will make matters worse. In other parts of the world, increasing the trace density has produced very nice results at both pre and post stack (Winter et al 2014). In this case history, due to already tight geometry and the cost constraints of line clearing, the cost of doing this is prohibitive. Therefore reducing the amount of noise in the raw record is critical if one wants to improve the quality of the subsurface image, enhance our ability to better characterize the reservoir and reduce overall project turnaround times.

Unfortunately, in the absence of proper mitigation strategies for specific noises, these issues could be overlooked during recording and their causes can be poorly documented.

Examples

In active mine sites, like the oil sands, blasting is often a daily activity. This blast energy noise interferes with the signal on the seismic record. Careful communication between mine operations and seismic operations need to be in place to avoid this type of interference. On cabled spreads, this type of noise is quite easy to identify. When using cableless systems, the real-time noise will be much harder to pick up, and must be monitored through anticipated blast time, which can cause some down time if there are delays in blasting. The acquisition crew for this survey did a very good job of not recording during mine blasts. In fact, there were only two instances out of more than 80000 shots of blast records interfering on VP data (these were void records that had been reshot). We can see the effect of the mine blast 12km away (*Fig 1*). Although not often investigated, the blast energy can tell us interesting information about the survey area.

Roadways can produce large cones of noise on shot records, especially in the oilsands where large 3rd party vehicles are always present, and this type of noise is difficult to remove. We can see on the uncorrelated data that this noise would present more of a problem on a dynamite program if using a small charge size and a re-shoot is not an option.

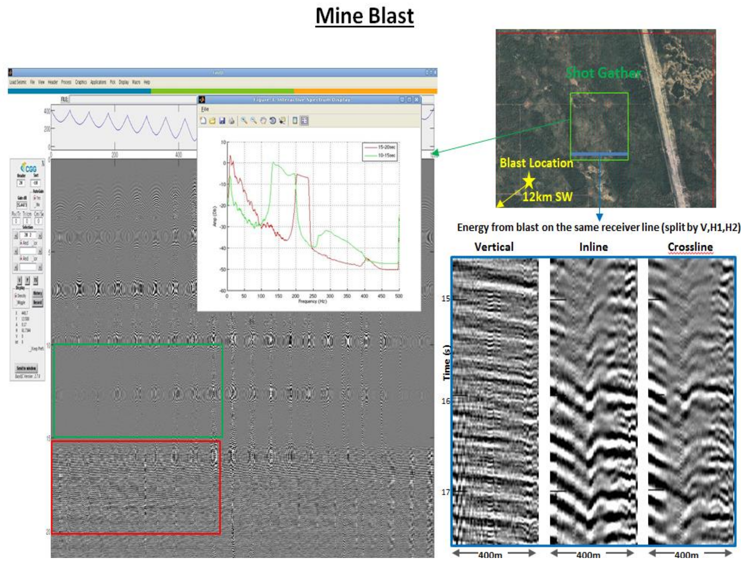

Figure 1: *Blast from a mine caught on the last 7 seconds of the record. Increase in low frequency energy by 20dB. On the right, the energy arriving at one receiver line, but split into different components shows a definate change in characterics, perhaps due to different ground conditions across the receiver line.*

Operationally, moving equipment on the spread often creates the largest source of noise during acquisition. In many cases, helicopters are used to move equipment from the front to the back of the spread. While very efficient operationally, the noise produced does affect the spread especially when geometry is so tight, it can saturate quite a number of sensors with noise. The noise negatively impacts data quality within at least a 100m radius of the helicopter.

Although the noise from helicopters, vehicles and snowmobiles will mostly stack out because of its intermittent nature, it can require some extra time during processing if it is prevalent, and it can adversely affect early parts of the processing such as first break picking if not dealt with effectively. For further analysis and also for future planning, it is worth requesting the GPS tracks of all equipment moving in the field before, during and after recording from the geophysical contractor and subcontractors (line clearing, surveying, seismic drilling, etc).

The need for a QC geophysicist in the field

Field quality control is one aspect of the acquisition that is not often incorporated within acquisition surveys in Alberta. Due to the size and duration of surveys, the type of quality control often included on international crews is more likely assigned to the realms of data processing. On the client side, it is rare to see a detailed field acquisition report in which all issues associated with recording have been documented: too often it consists entirely of operational statistics and HSE reports. While the importance of these data cannot be minimized, from a geophysical processing point of view, the reports are often lacking in geophysical information that could help in the upstream processing, and down the road, reprocessing of data.

The benefits of checking the data during the acquisition has the added benefit for processing. Geometry corrections can be made with more certainty if caught and confirmed in the field, saving time during processing. Checks that correlate data quality with vibrator attribute (Vibroseis Attributes

Processing Support: VAPS) data and geophysical attributes can be linked in the field in a way that is often overlooked once the data arrives at the processing center. Checking the data quality, signal verification and signal to noise quality can aid both acquisition and processing by highlighting areas that could be problematic.

In this case history, vibrator control issues were identified and the vibrator drive level needed adjustment several times. Without having the ability to analyze the potential root causes of this problem, there would have been no other option but constantly adjusting the drive level or setting it to a fix number with potentially disastrous results. Providing real-time feedback to the client about these issues while optimizing crew productivity turn out to be critical to the success of this project.

Vibrator attributes

During acquisition, the recording crew will analyze the vibrator attributes files for daily tracking of different parameters measured during each sweep. This file is often used to identify any potential vibrator problems and is an important measure of vibrator performance. As described in Janiszewski (2009) the file can be interrogated for many uses during the acquisition. The information is used extensively by the acquisition crew, and passed on with the deliverables to both clients and processing centers.

During this survey the VAPS files were investigated to see if there was some correlation with ground condition differences within the survey area. By mapping the VAPS over a satellite image, aerial photography or LiDAR images the changes in ground conditions were monitored more closely with the data quality and vibrator performance. The best correlation was with the stiffness (see figure2). By correlating the VAPS with these maps, changes in vibrator performance can be anticipated, and this can avoid downtime during acquisition.

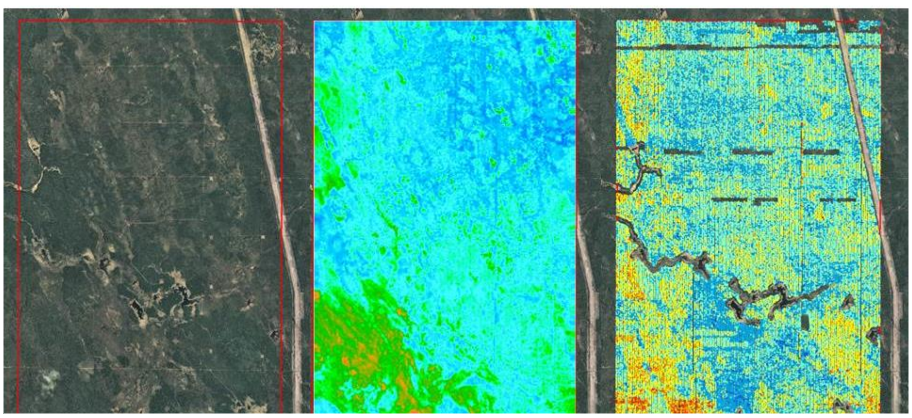

Figure 2: *A comparison between aerial photography, shot statics and stifness / viscosity from the VAPS*.

Cableless vs Cable system

With the recent advances in technology, cableless systems are becoming more prevalent (Alphonso, 2015). While these systems offer many advances in productivity, the ability to observe the noise level on the full spread is not always possible, and this has been one of the main concerns during acquisition. Basically not all nodal systems are equal in their functionalities and some are worse than others in that matter. The advantages of detecting the environmental noise in real-time on a cabled system does allow the observer the ability to time the acquisition to miss any environmental or acquisition related noise, and reshoot badly affected VPs almost immediately. Cableless systems rely more on crew communications and good planning to avoid too much of this noise on the active spread during acquisition. This is especially the case for very shallow targets where noise can infiltrate the signal on one side of the spread.

Conclusions

Increased pressure from the business side to extract more value out of the seismic data is no longer limited to getting a higher resolution image of the subsurface. The characterization of the subsurface has become equally important, where both amplitude versus angle and amplitude versus azimuth need to be taken into account. The broadening of the seismic bandwidth with the associated tightening of the acquisition parameters will naturally increase trace density and therefore the signal to noise ratio. However, budget constraints, schedule and sometimes the environmental footprint of such tight surveys will be the limiting factors to the increase in trace density. Noises during recording should not be overlooked and taken into account during the planning of these surveys so that an acceptable compromise can be made between data quality and crew productivity.

No matter how much planning comes into the acquisition of a particular survey, there will always be unforeseeable difficulties in the field. We see the role of QC geophysicists as critical to be able to perform the required analyses in the field to the benefits of the seismic contractor and the client so that they can both make informed decisions. This information can also contribute to the writing of a more detailed and relevant field acquisition report.

As cableless recording systems are becoming more prevalent, the inability of some of these to harvest and view shot records in quasi-real-time for immediate analysis limits the ability to monitor the real-time noise in the field. The need to plan and communicate information in the field during operations such as helicopter movement over active shooting spreads will be more important with traditional cable systems. Having mitigation plans in place for environmental noise, such as wind monitoring, shooting at night when necessary, and standby guidelines will be of paramount importance with this type of acquisition. This will mean more of a partnership between acquisition contractor and client to ensure recording production can be optimized while balanced with the need for improved data quality through reduced noise.

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