A new look and an old source

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2004 CSEG National Convention

Introduction

In this paper we examine the performance and operation of a controllable, surface referenced weight drop system, which has the capability of generating very high amplitude but manageable impacts. The source is compared to conventional dynamite, and the potential benefits are demonstrated.

Background

Seismic surveys conducted using weight drop sources have been used for many years, but have fallen out of favor recently. Two years ago we examined the potential for high impact energy sources, where a weight was dropped from a high altitude. While it was possible to generate high energy source points, and good seismic records with this method, there were understandable concerns about safety in a continuous production environment, particularly in areas where there is significant oil field infrastructure (pipelines), We have subsequently worked to evaluate the potential of surface referenced weight drop systems, and having used available systems for exploration activity in the 2002/2003 winter season, have identified a number of potential improvements that could be implemented. The problems that these types of source have had in the past have been the lack of control of the source, and the reliability and repeatability of source timing. With these problems in mind a new source development effort was undertaken by Polaris Explorer Ltd. and Apache. We have examined a new source unit (the "Explorer 860") and used it to acquire a significant area of 3D seismic. The new source has the capability of generating a very large surface impact, with a very high degree of repeatability, but is also controllable so that the impact effort can be reduced if required. This control can help minimize ground roll generation and improve the resultant seismic data. In this paper we show comparison of data collected with dynamite with this new weight drop system, and demonstrate the benefit of a dynamically controllable source.

System Description

The system tested uses a hydraulic system to raise and lower a weight of just over 2600 lbs. Plumbed into the top of the hydraulic cylinder is a nitrogen gas charged accumulator. The pressure in the accumulator can be adjusted, and this pressure controls the force acting on the top of the mass when released. The weight is released under pressure to drive onto a base plate of similar mass. The weight can be raised up to 24". By manipulating the stroke length and the volume of oil vented in the down stroke of the hydraulic system, a library of individually unique force outputs can be stored in the system memory and called up when required depending on the requirements of a particular area. Because the system timing is very accurate, multiple units can be used at the same time if higher impact energy is required. This is not possible with conventional systems where the timing accuracy would not permit multiple unit operation. Gimballing at the base plate ensures that the mass always hits the base plate perpendicularly even if the base plate is deployed on uneven ground. GPS units synchronized with the system enable an accurate source position to be determined for each source point. The entire system is mounted on the back of a maneuverable buggy in a way that allows the base plate to be deployed so that the weight of the buggy holds the base plate on the ground prior to generation of a shot.

Figure 1: Surface weight drop unit.

Weight Drop Tests

The system was tested to measure peak output force and timing. Testing suggested accuracy of timing to sub microsecond levels, with highest force configuration, which was determined to have a peak impact of greater than 650,000 lb. However, there was significant apparent timing delay from the first to subsequent impacts. The seismic returns from the first impact at a particular location always had longer travel time than subsequent impacts at the same location. This was caused by compaction of the ground under the base plate when the unit was first fired at any location.

Deployment of the units in the field showed that once the base plate was “bedded in”, the repeatability from one “drop” to another was very good, and shots could be vertically stacked if required. However, it was found that for the exploration objectives in the area of the test, there was no requirement for vertical stacking, as a single “thump” produced excellent seismic returns with good signal to noise at the objective levels. Tests were conducted to examine the effect of variation of the activation force. The bottom limit to activation force is effectively a freefall of the mass. The best seismic records were produced when the activation force was less than the peak force.

Test Results

Figures 1 and 2 show a comparison between a shot using the weight drop source at maximum impulse, and another shot at the same location using 65% impulse. It is clear that much of the ground roll associated with the larger impact is reduced and that the overall signal to noise is enhanced, when using less than the maximum impulse energy.

Figure 1: 100% effort

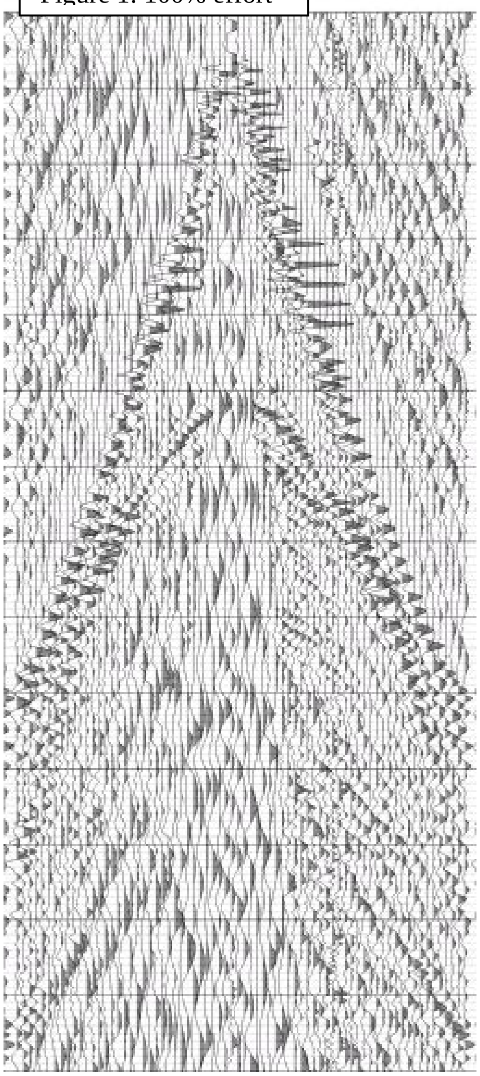
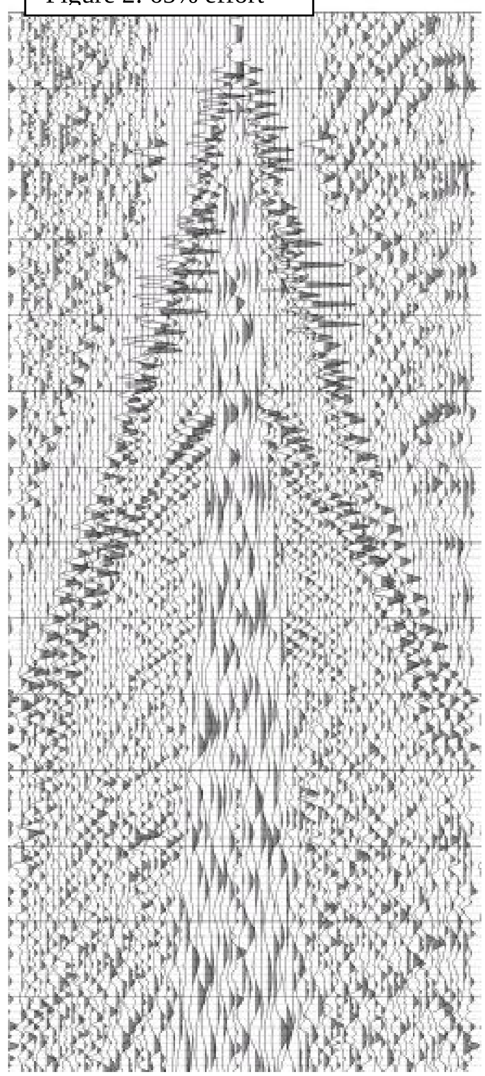


Figure 2: 65% effort



Comparison with individual dynamite records suggests that Signal to Noise ratio is at least as good as conventional dynamite source records in this area, and detailed comparison will be made in the paper.

As part of the testing sequence, individual “thumps” were recorded separately, but each location was thumped several times. This permitted evaluation of the summation of energy from several thumps at the same location, as well as comparison of different shots and stack sections. Figure 4 shows a 2D stack line produced within 1.5 hours of completion of shooting. This line is the stack of a series of shots using only the second “thump” at each source location, using 100% effort at each source location. The data has been though preliminary processing in the field, but already shows excellent continuity and reflection strength at the target depths. The comparison data on the right of figure 4 is a dynamite line extracted from final processing of an adjacent 3D survey shot earlier. This line is in the same area, but is not in exactly the same location as the 2D test line. The improvement from the thumper data is evident.

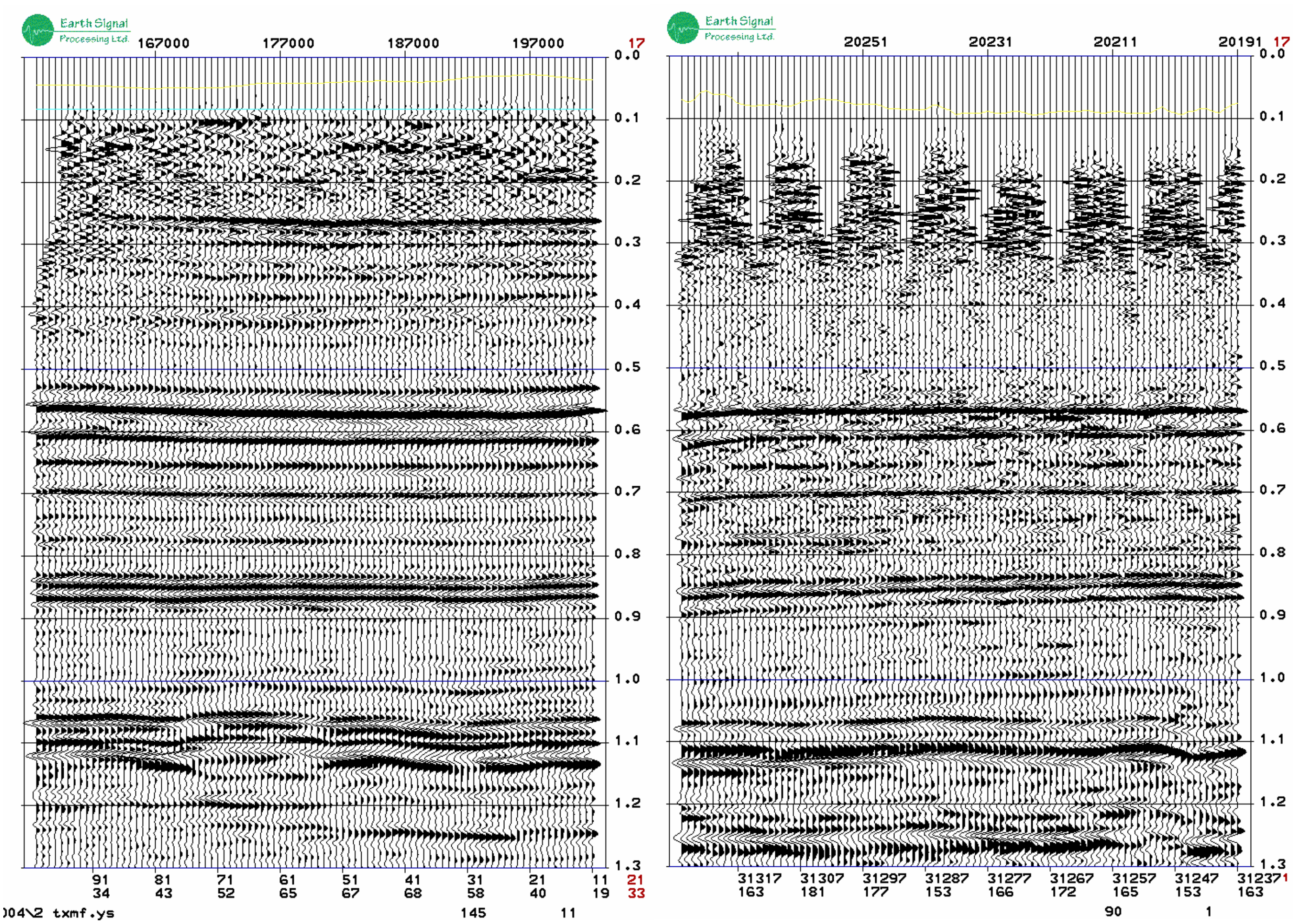


Figure 4: Stack section. Weight drop (left) and dynamite (right)

A comment on Operation efficiency and cost

When designing a 3D dynamite survey, the cost of drilling holes can become a critical factor in the overall design of the survey. This effectively places a limit on the shot line interval, and the shot interval down a line. When using the surface weight drop system, shots can be taken very rapidly, and with more than one unit active it is possible to achieve levels of shot production which are likely to be much higher than achievable with dynamite. In this case the limiting factor to operational efficiency moves away from the shots, and recording is limited by the number of receivers that have to be moved on a regular basis. If the operation is limited by receiver moves, then the number of shots can be increased (with surface weight drop) without any increase in cost of operations. It is therefore possible to increase the effective fold of 3D seismic using surface weight drop systems by decreasing the shot interval along the shot line without detriment to the efficiency of the crew, or cost of the operation. This further has the potential to improve the quality of the final seismic data.

Environmental Impact potential

Seismic exploration in some areas of Canada is not possible without some impact to the local environment. Over the course of many years, continuing seismic activity can lead to problems in obtaining further permits and permissions because of the effects on the environment of older seismic activity. Shot and receiver lines for 2D and 3D seismic exploration. It would of course be desirable if the width and number of these lines could be reduced while still performing adequate seismic exploration. The surface weight drop system is highly maneuverable, and can be driven down relatively narrow cut lines (which do not have to be straight). Additionally there is very little surface damage from the source, and no requirement to drill into the subsurface. Figure 5 shows a surface location after completion of the source point. While some compaction of the surfaced is evident, there will be little or no long term damage to the surface as a result of seismic acquisition. This is likely to find favor with landowners in other parts of Canada, particularly on farm land where permitting for dynamite is difficult. The attraction of an alternative which only requires a pass of a tractor is obvious.

Figure 5: Ground after source activation.

Conclusions

Acquisition in forested areas of Canada can be both expensive and difficult to permit. Part of the hope for the development of this new source technique is that it may lead to easier permitting procedure through a more “environmentally friendly” technique when compared to conventional dynamite acquisition. In fact the development of an accurately controllable weight drop source with very high impact energy has led to recording seismic data which is of better quality that traditional dynamite, and considerably cheaper. The flexibility of the source means that source locations, density of source points and source effort can be changed dynamically, leading to better custom seismic solutions to local problems. While most of the design and development work associated with this project was performed by Polaris Explorer Ltd, the cost burden associated with development of the new source was offset by Apache. This model of co-operation between a contractor and oil company is likely to be the only way that future innovations in seismic acquisition will be possible.

References

Monk, D.J. 2002, Seismic with a Thump: Presented at the CSEG meeting 2002.