Land seismic crews: old problems, new ideas

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This paper was prepared for presentation during the 11th International Congress of the Brazilian Geophysical Society held in Salvador, Brazil, August 24-28, 2009.

Abstract

After years of petroleum exploration on land basins, big cities and industries started to appear in regions of oil fields. With this new conjecture in mind, a reformulation of land seismic parameterization is needed. Further more, others difficulties appeared and Petrobras land crews needed to find practical, real-time and efficient solutions. The aim of next sections is to present how a seismic land crew developed good methodologies to overwhelm its field problems in three different areas: parameterization, data quality control (QC) and first break pick.

Introduction

Land seismic exploration is not a new subject in the oil industry. Despite of that, there are many problems that still cause large damage to the final seismic data quality. Parameterization, for example, is one of them. Usually the geophysicist responsible for a seismic project chooses good parameters for perfect sub-surface imaging but forgets that, over the reservoir, could and usually has critical obstacles as rivers, lagoons, farms or even entire cities. Other point of conflict is the confiability of seismic data quality control: seismic processing centers always desire no-error data and it is a complex problem to certify this, as undesired situations can occur even after the simplest data manipulation. With this in mind, it is necessary to analyze any data manipulation using different criteria. An efficient way of controlling this is to create an SPS file from the final SEG-Y data for fold and statistical analysis. At last, it is a fact that, when a seismic processing center asks the land crew to provide first break picks, it becomes one of the most time-expensive processes and a common point of misunderstanding. For these reasons, it is a good idea to provide well-defined methodologies of picking and a seismic data with reasonable first pick visualization. Based on these three majors situation, this paper describes the solutions developed on a land seismic crew.

Field Re-parameterization

Seismic program designers are usually worried about imaging the sub-surface. The aim of a seismic crew is to deliver the designer not only the most trustworthy data but also to guarantee that the field operations follows the project designer instructions as, for example, shot point and record point distance and shot point offsets.

Unfortunately, there can be several obstacles on the surface that can restrain or impede the acquisition as they want. In various cases encountered by the authors, from industries to farms, the most complicated one surely was an entire city located precisely in the middle of a important land survey.

This situation required out-of-the-box field solutions. The first big problem was: as is was impossible to locate shot point inside the limits of the city, the crew did not have the option of “not locate receiver point”. So, it was decided to locate receiver point on the streets. As figure 1 suggests, many geophone coupling test were done to establish the best manner to proceed.

Figure 1: Geophone coupling test. The yellow circle shows a group of geophone coupled directly to earth.

After several data and frequency analysis, the crew decided to couple geophone directly to asphalt with an electric drill. As can be seen in figure 2, the design had to be changed and the receiver lines followed the city’s streets.

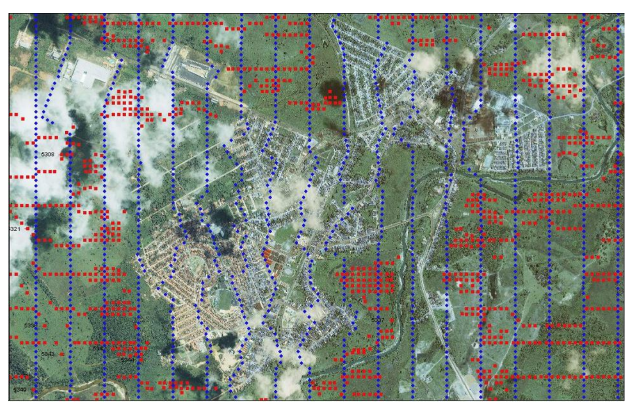

Figure 2: Receiver lines displaced from their original places to follow the streets’ paths.

In figure 3 (a region without shots and geophones) and 4 (a line passing through the city with geophones coupled directly to asphalt) one can see two seismic sections, the first one (figure 3) shows deep and extents regions without information that can reach important seismic events and prejudice static correction. The main reason for this occurs is the lack of near-offset traces caused by extended regions with absence of shots and receivers.

In the other hand, figure 4 shows a better and more complete image of sub-surface. Some blind of information is caused by the lack of shot points, but damage is much less significant and did not reach any important seismic horizon.

It is important to say that a good parameterization plays an important role in field operations. A good choice of parameters, specially the type of survey (orthogonal, swath , brick etc) can help or prejudice the viability of a seismic acquisition. Particullary, in the case of the survey with a city, an orthogonal survey were designed for medium and deep objectives. The characteristic of the project permited the crew to use few receivers lines, with larger intervals between lines without decreasing the fold. Thus, in this manner, the crew could look for streets where the geophones would be coupled to the asphalt.

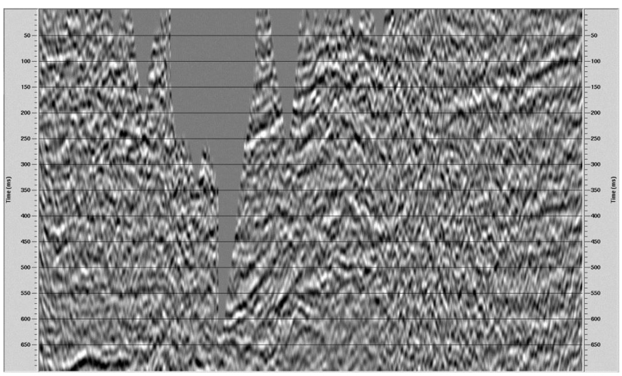

Figura 3: Seismic session in a region without shot and receiver points. The blind region occur in a considerable part of data.

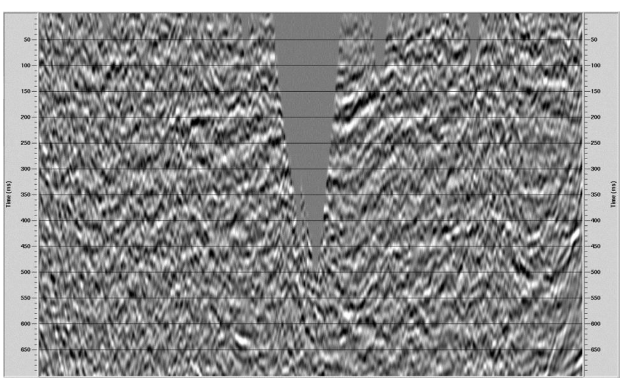

Figura 4: Seismic session in a region with receiver points only. Some blind regions are inevitable, but much more information is recovered.

Seismic Data QC

Every time a survey is placed in complex field situations, the intrinsic data quality is affected by regular daily erros. So, in a survey with lots of shot points and receivers offsets, a good seismic data QC makes itself extremely necessary.

After some tests, the best choice would be generating the SPS file from the final SEG-Y data, apply some statistical methods and visualize it. This type of data control acts as a final and independent inspection that allows enhancement of final seismic data quality because it can identify wrong data manipulation or corrupted data.

With the importance of that in mind, the authors implemented a reliable interface between the pre-processing software and the software used for the data quality control. This increased significantly the confidence in the data delivered to the processing centers.

First Break Picks

There are many reasons for a difficult first break picking, an strictly visual and repetitive procedure. The most common and most difficult to deal surely is the presence of significant noise in the data. Apart this almost unsolvable problem, the use of orthogonal designs rather than parallel ones ends up turning this procedure even more laborious to the field geophysicists.

This occurs mainly because of the higher azimuthal variation the orthogonal design produces and is accentuated by the use of long arrays of sources and receivers.

Besides that, in regions with considerable topographic variation, the energy eventually reaches farther receivers earlier than closer ones as can be seen in figure 5, which complicates the visualization and, consequently, difficults and slows down the picking process.

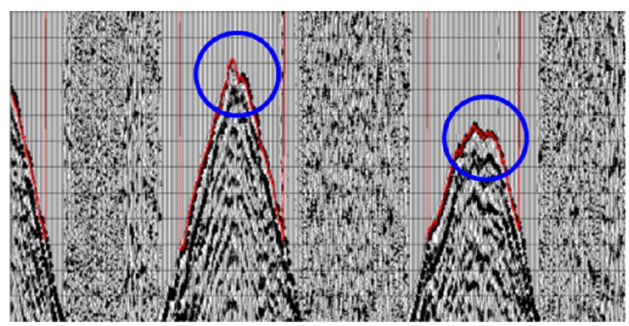

Figure 5: Examples of seismic energy reaching farther receivers earliers than closer ones.

To deal with that, the authors suggested the so-called pre-pick elevation correction (PPEC) in order to attenuate the effects of topography. For that, it´s used the elevation of sources (SE) and receivers (RE) and an estimated velocity (EV) for the low-velocity zone.

$$PPEC=(SE-RE)/EV$$

This correction is applied before the picking process and removed just after that, in order to maintain the data unchanged for the data-processing centers. The results of the correction can be seen in figures 6 and 7 and show the improvement brought by the application of the pre-pick elevation correction.

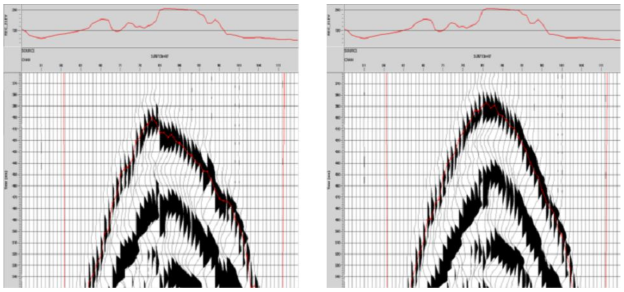

Figure 6: Register before and after the pre-pick elevation correction.

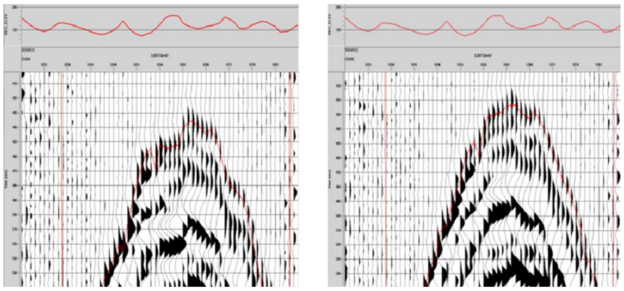

Figure 7: Another register before and after the pre-pick elevation correction.

Conclusions

In this paper, it was showed how a land seismic crew can be able to handle different field challenges. It also suggests that a good survey parameterization involves much more than finding the best sub-surface imaging parameters, but also demands the right choice of survey type for each region. From this point of view, the use of orthogonal design is quite an advance if compared to parallel programs, traditionally used in Brazilian acquisitions in complex regions. With the later, the field crew has much more freedom to offset sources and receivers in the presence of obstacles, not affecting considerably the fold.

Further more, the designer expects the seismic crews to have good ideas in order to solve the field problems. In regions where it is impossible to couple the geophone directly to the ground, the use of electric drill can be fully used in streets. This type of result shows how important is to find out-of-the-box field solutions

For last, as seen in the last section, simple but efficient data manipulation can provoke enhancement of “first break continuity”, resulting in a much more reliable data and more efficiency in future data processing.

Acknowledgments

This work has been supported by Petrobras and its seismic land acquisition crews. The authors make a special thanks to the geophysicists Adriano Lima, Heron Schots, Hugo Miranda, Juliano Binder, Julio Villanueva, Bruno Chaves and Valdir Rocha.

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