Undershooting in the recovery of the coverage affected by operational obstacles in a 3D Seismic Survey

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Abstract

There is a great difference between the developed (pre-plot) and the executed (post-plot) projects in seismic data acquisition processes. There are many possible causes for these differences: cities, buildings, roads, oil pipelines, etc. One way to minimize the negative effects of the impossibility to perform a recording at a shot point is to use the Undershooting method. This method enables the acquisition of information regarding the common midpoint (CMP), and can be used depending on the relation between the offset and the objective depth at that point.

Introduction

The use of the undershooting technique in order to regain the desired coverage in areas of big operational obstacle becomes more and more common in seismic acquisition processes (SBGF, 2008). Using the data of a table of safety distances we establish which SPs of a seismic acquisition can be allocated and detonated in the field. When it is not possible to reduce the mass of the charge, whether due to low signal-to-noise ratio (S/N) or due to the objective depth, we can use this method so that we do not lose completely the information of these SPs. This method is based on the CMP model, that is, for each given point in space, there are many source-receptor pairs which sample its subsurface. In figure 1, the point **P** would be sampled by the wave emitted through detonation of the SP1 and registered at the G4 receiver, but due to some operational obstacle this shot point cannot be detonated. We can recover this information by changing the shot point to the SP2 position and receiving the signal at the G6 receiver. One limitation of this method is the linear relation between the offset and the objective depth which we intend to sample (Cordsen, 2000). For shallow objectives, we cannot use offsets which are too long, because in spite of sampling the unitary cell, we would lose the desired information.

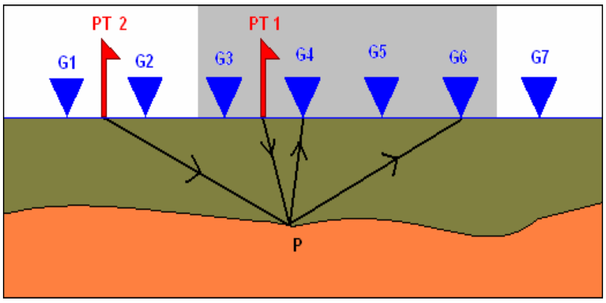

Figure 1 – Undershooting process. Point **P** is in a restricted área (gray) and can be sampled by the source-receiver pair (PT_2, G_6). PT_1 cannot be detonated due to some operational obstacle.

Case Study

In the year of 2008 the PETROBRAS Seismic Team 0026 performed the acquisition of the seismic data of the 3D_CP_EMBASAMENTO program. The location of the Project can be seen in figure 2. Within the limits of this 3D survey there are many operational obstacles, three of which are cities: Carmópolis, Rosário do Catete and Maruim.

Figure 2 – Location of the 3D_CP_EMBASAMENTO

The project was planned with a total of 60 *swaths*, each of which composed by 4 shot lines and 8 receiver lines.

The main field parameters of this Project can be seen on table 1.

Recording	
Recording instrument	Aram-Áires
Number of Channels	640
Recording time	4.0 s
Source	
Source type	Power Gel
Shot interval (IPT)	120 m
Source array	L3x1/20m, 1Kg per hole
Source depth	3.0 to 4.0 m
Receiver	
Type	SM-24
Station interval	30 m
Receiver array	L6x1/25m
Bin	
Bin Dx	15.0 m
Bin Dy	30.0 m
Nominal Fold	40
Traces per Km^2	77083 traces/Km^2

Table 1 – Acquisition parameters

The detonation sequence is described next: the swath is initialized with an incomplete spread; the first SP of the first shot line is detonated with 41 channels on, 40 of which in front and one behind of the shot point. Then the other first SPs of the other swath shot lines are detonated, thus concluding the first detonation sequence of 4 shots. After each detonation sequence the spread increases 4 stations until it is filled with 80 stations (1185 – 15 – 0 - 15 – 1185). From this point on, the whole spread is moved four stations at each detonation sequence and when the device touches the last station, at the limit of the program, the number of active stations ahead is reduced in a similar way to the initial process. At the change of swath, the rolling of four receiver lines occurs. Figure 3.a shows the recording device of swath 02. Thus, the project was planned with a uniform coverage of 40 samples per unitary cell. At the pre-plot of this project a density of 132 SPs/Km² was expected, as shown in figure 3.b.

We use the *Undershooting* method in order to recover the information regarding the areas of Rosário do Catete and Maruim cities. Two different approaches were made: increasing the density of shot point next to the city of Rosário do Catete, as shown in figure 3.c and altering the detonation script at the surroundings of Maruim city, as shown in figure 3.d, allowing the data acquisition and recovering the desired coverage in many points. In both cases, the geophones were also installed within the urban areas, allowing a better sampling of the cells. To such purpose, the devices were put on the sidewalks and squares, as seen in figure 4, and this process was only possible through the engagement of the workforce assigned to gather permission (e.g. to enter private property) and the topography team, which were present during the whole recording process in the affected areas.

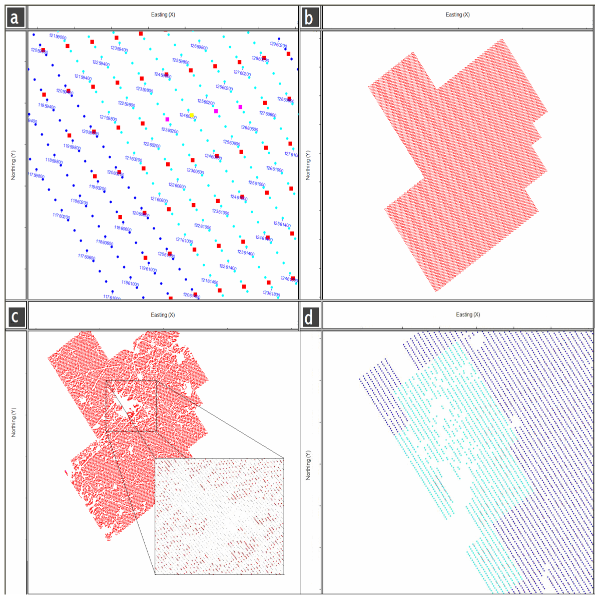

Figure 3 – **a)** Recording device: The receivers are represented in blue, the SPs in red. In light blue the active stations, in pink the detonation sequence. **b)** Project pre-plot 132 SPs/Km^2. **c)** Project post-plot high density of shots in Rosário do Catete (detail). **d)** Change of the detonation script within the urban perimeter of Maurim; additional channels were activated to increase the coverage.

Figure 4 – Recording of data in the city of Rosário do Catete: **a** – Seismographic cables; **b** – Communication boxes; **c** e **d** – Geophone arrays; **e** – Cables.

Results

During the execution of this Project, 94,14% of the total predicted recordings (figure 3.b) were made (figure 3.c) and 94,02% were validated by the pre-processing of the ES-0026. 2,70% of the total recordings were programmed for the area of the two obstacles described above, which is equivalent to 5,04% of the valid traces. 55% of the recordings were recovered by the undershooting method and 69% of the number of traces proposed for the area were recorded. Figure 5 shows the expected and achieved coverages in the two areas. With this method, we managed to reduce the number of cells which would not be covered within the city of Maruim. The great difference between the expected (planned) and the obtained (executed) results in the city of Rosário do Catete is due to the expressive growth of the city, since the planning was made based on a georeferenced map database which is partially outdated and thus incompatible with the actual local situation. We can say that this problem is predictable and common considering the actual scenario of growth of the cities in the countryside of Brazil, which turns the undershooting method into a very useful tool to deal with such scenarios.

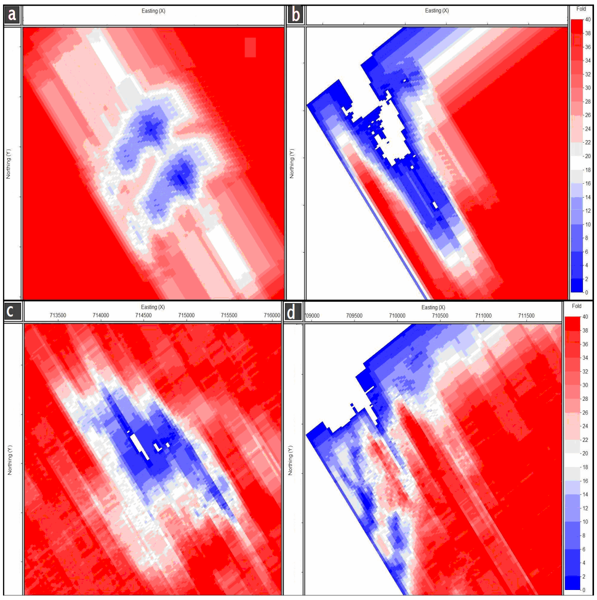

Figure 5 – Expected coverage in the pre-plot in: **a** – Rosário do Catete; **b** – Maruim and the real coverage **c -** Rosário do Catete; **d** – Maruim.

The images in figure 6 show the near offsets of the pre – plot and post-plot obtained at this two areas, with a mean value of 500m.

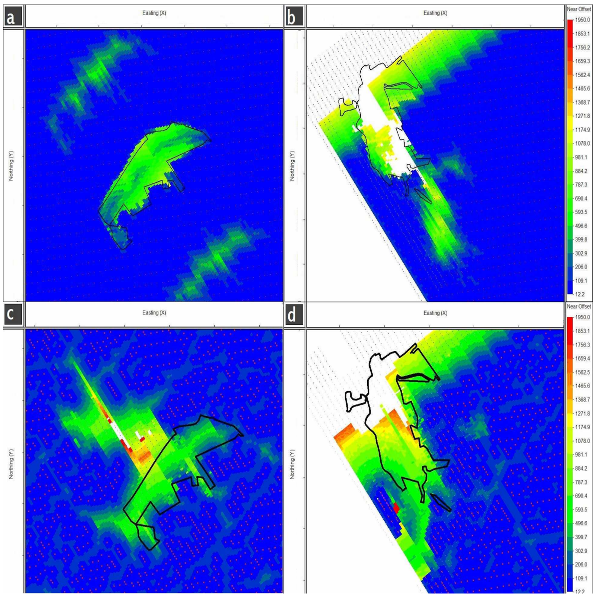

Figure 6 – **a)** *Pre-Plot* of the *Near offset* in the area of Rosário do Catete **b)** Maruim **c)** Post-Plot of the near offset in the area of Rosário do Catete. **d)** Maruim (City contours retrieved from the Petrobras Geodesy database).

Conclusions

As we can observe in figure 5, the difference in the coverage of a 3D survey due to extensive operational obstacles can be reduced by using the undershooting method. This method has, as advantage, a low operational cost. We must observe the desired objective depths and evaluate the possibility of allocating the new shotpoints at the allowed positions.

Acknowledgements

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References

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