First Common Offset Vector Processing Workflow applied in Recôncavo basin

Fernando Silva, Guilherme Vasconcellos, Manoel Gontijo and Marco Schinelli. Petrobras UO-BA.

Abstract

Acquisition of Wide Azimuth seismic surveys represents a growing trend in oil industry. This acquisition strategy enables not only to optimize the illumination of complex structures, but the reservoir characterization with analysis of seismic attributes variations as a function of offset, and azimuth. However the processing of those surveys requires the application of specific workflow, different from the conventional one used for data with narrows azimuths.

In 2009, Petrobras acquired a new orthogonal, wide azimuth 3D survey covering Araçás, Fazenda Boa Esperança and Mandacaru onshore fields (Figure 1), where a previous slant 3D was already available. Despite the good result obtained by new acquisition, it needed to be submitted to an appropriate workflow for wide azimuth data, known as COV - Common Offset Vector, to evaluate if such a technique could further improve the results already obtained by the new 3D.

With that purpose Petrobras contracted third services to reprocess the new 3D using the COV technique.

The obtained improvements confirmed the effectiveness and importance of COV workflow for wide azimuth data. The company is now preparing to internally develop the codes and expertize to extend the wide azimuth processing technology to other areas.

Introduction

The COV technique takes advantage basically of the reorganization of seismic data in each unit cell, considering not only the distribution of offsets, but also the source-receiver azimuth (Figure 2). Thus, several processing steps such as interpolation, migration or velocity analysis benefit from the organization in cells more appropriate than those used in conventional workflow, where the traces are grouped with the same offset, but mixing together different source-receiver azimuths.

Seismic surveys using narrow azimuths, such as those from marine streamer acquisition using a small number of cables, or slant geometries in land acquisition (small angle between shooting and receiver lines), can not be processed using COV technique, because the azimuth diversity on each bin is very small. By the other side, for wide azimuth surveys, the regular organization and sorting of traces in each cell by offset and secondarly by source-receiver azimuth, is important for several processes whose spatial aperture can gather information from different azimuths.

Nowadays, the processing with COV technique becomes very important due to the increasing application of acquisition techniques designed to provide wide azimuth sampling, as achieved by orthogonal surveys on land acquisitions or OBCs in marine areas, among others. Therefore it is imperative that the processing companies may improve their processing workflow to take full advantage of all the benefits permitted by wide azimuth acquisitions.

Methodology

- *Regularization and Interpolation:*

This step is critical to land seismic surveys acquired over production areas, where the impact associated with production infrastructure and operational obstacles is very high, especially on near offsets. For overcome this problem it was used a process that helps with the identification of coverage losses through many different domains (like source-receiver offset or common azimuth, both in traditional or COV organization), which also allows to evaluate the fold variation on inline and crossline directions (Figure 3). Such review helps to accurately define the next interpolation steps and parameters for COV cell construction used on KPSTM migration.

Inline Offset Range: -3250m to 3250m x 500m

Xline Offset Range: -1950m to 1950m x 650m

- *Filters to coherent noise and spikes attenuation:*

Corresponds to the application of radial filters to coherent noise attenuation, such as ground roll, applied on shot and receiver domains. The data had already static correction applied, and two additional stages of residual statics: Correlation and Max power (pilot based) statics.

- *Spike decon and surface consistent gain:*

Applied on common shot, and receiver gathers.

- *Noise attenuation and interpolation in cross spread domain:*

Both processes operate more effectively in this domain, by grouping together spatially similar traces. The cross spreads volumetric organization allows the application of 3D filters in different domains (FK, Tau-P, etc.).

- *Time migration:*

Seven different velocity field estimates were used for time migration. The first two were isotropic, and the last five used VTI anisotropy. The various iterations for velocity improvement were important due to low signal to noise ratio, in areas with low fold and lack of near offsets, and multiples contamination.

Parameters used on each interaction:

- Interaction 1 (Isotropic):

Initial velocity model created with stack velocities, merged with post stack migration velocities. Converted to interval velocities, smoothed, and converted back to RMS velocity;

Aperture: 1 Km;

Dip: 30^0

Maximum frequency: 45 Hz;

Offsets range: 100-4000m x 100m;

Automatic process to apply residual move-out on selected inlines.

- Interaction 2 (isotropic):

Eta Scan (Tested on selected lines). Range of values: 1-14%;

Manual velocity picking.

- Interaction 3 (VTI):

Automated velocity update.

- Interaction 4 (VTI):

Velocity automatic update - conditioned to the trend of higher values to avoid influence of reverberations.

- Interaction 5 (VTI):

Alfa Scan and model update;

Velocity automatic update - conditioned by the information from Alfa scan interpretation.

- Interaction 6 (VTI):

Final input data (after all the conditioning steps);

Test to OVT binning parameters definition;

Tested the combination of different parameters;

- Interaction 7 (VTI on OVT domain):

4 Km aperture;

Dip ranges limited by a time variant function:

Time (ms)	Dip (degrees)
0	30
200	30
800	45
2000	60
3000	30

Maximum frequency - 70 Hz;

OVT: Offsets Inline: 250m to 3250m x 500m (reciprocity' principle)

Offsets Crossline: -1950m to 1950m x 650m .

- *Steps after time migration:*

After the final migration it was applied the following processing sequence:

AZIM – Analysis and residual azimuth correction function (least squares to best fit the surface that represents the azimuthal variations);

Final mute

Stack;

Kthresh3D

Inverse Q

Rogain;

Segy Output

- *Depth migration:*

The first isotropic Kirchhoff depth migration didn't produce good results in terms of amplitude regularization, and particularly in fault planes imaging, that were noticeably more visible in the time migration. Various attempts to improve the velocity field, including with use of anisotropy and tomography, persisted in the production of unsatisfactory result. Alternatively, it was decided to migrate with the RTM algorithm, that was able to correct the deficiencies observed in the Kirchoff migration, producing superior results (Figure 4).

This is the sequence used to depth migration:

Pre conditioning of input gathers;

Final conditioning of input gathers;

Initial velocity model derived from sonic logs;

Initial Kirchhoff PSDM ;

TTI Kirchhoff PSDM;

TTI Tomography;

New Stack Scan interaction;

Final PSDM migration;

TTI OVT Kirchhoff PSDM;

Final TTI RTM.

Results

From the point of view of supplying a better support to the seismic interpretation of Araças field, this reprocessing improved the quality of seismic data, resulting in higher signal to noise ratio and better definition of structural behavior of main reservoirs under the 3D area. Thanks to that result it has been used for the development process of a new accumulation found on a low block of Araças field and identification of new opportunities in neighbor areas. The sections shown on figure 5 compare the result of conventional processing with the COV workflow (time migrated sections).

From the perspective of understanding the differential of reprocessing with the new COV workflow it is difficult to precisely quantify its impact, though noticeable, considering that other resources were used in this workflow, that had no direct connection with the vector organization (surface consistent equalization processes or anisotropic parameter estimation) and possibly could also have been used during the legacy processing.

It is evident that specific strategies for interpolation of missing traces, or estimation of velocity using the COV organization are important to orthogonal surveys such as Araçás 3D, and if not used, may waste most of the illumination benefits obtained with orthogonal acquisitions.

Conclusions

This project was successful because the results characterized the importance of COV processing technique to wide azimuth data. It is easy to prove that the strategies of vector processing are becoming more efficient and accessible, because of the increasing use of different techniques to land and marine wide azimuth seismic acquisition.

Aknowledgments

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References

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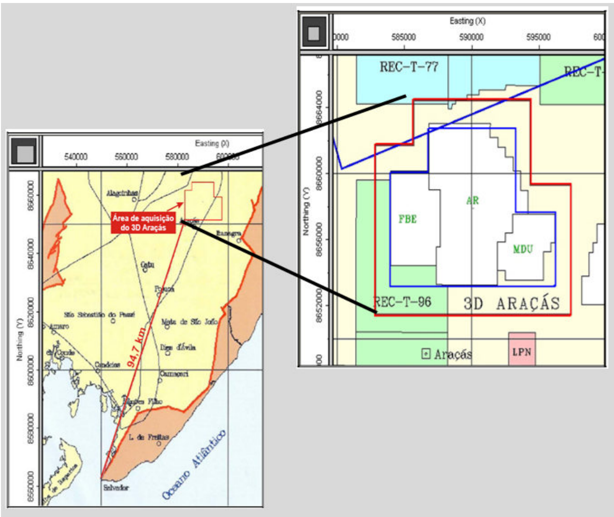

Fig. 1 – Araças Field location and 3D limits.

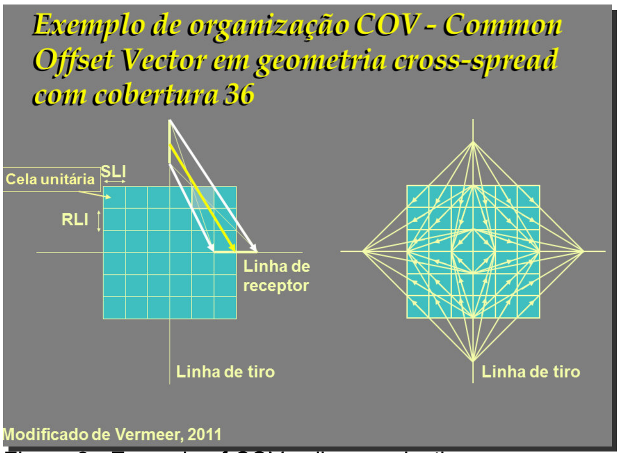

Figure 2 - Example of COV cells organization.

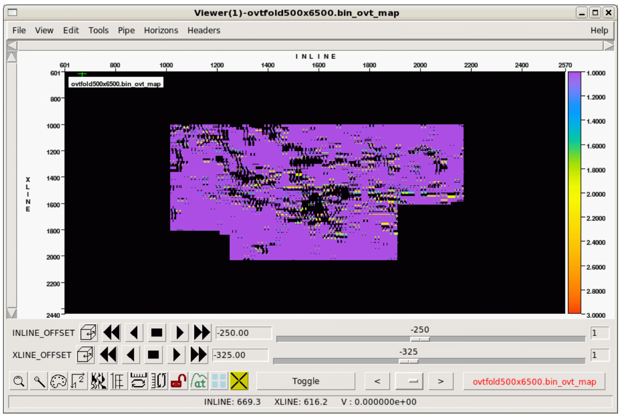

Fig. 3 – Screen capture of module used for analysis of fold losses in various domains.

Migration Algorithm Comparisons – Xline 1619

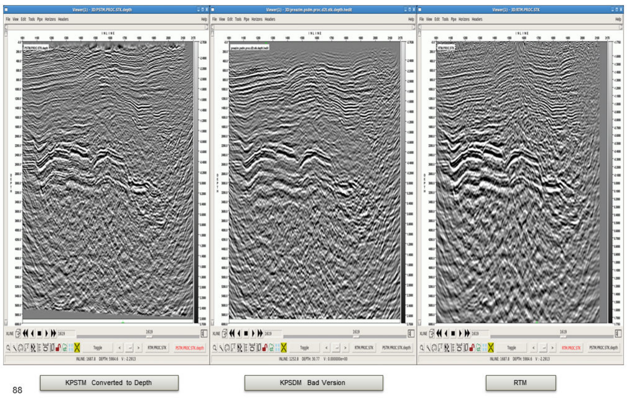

Fig. 4 – Kirchoff PSTM migration (left), Kirchoff PSDM Kirchoff (center) and RTM – XL 1619 (right).

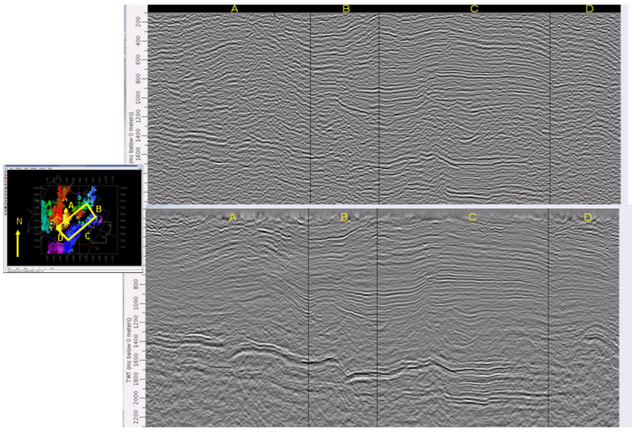

Fig. 5 – Arbitrary section from conventional processing (above) and COV workflow.(bellow).