Submission code: J40KARVGNL

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Exploring the Aram Block with 3D OBN Seismic Data: A Breakthrough in Brazilian Offshore Pre-Salt

Matheus Barbosa (PETROBRAS), José Eduardo Rodrigues (Petrobras), JOSÉ CLÁUVER DE AGUIAR JÚNIOR (PETROBRAS)

Exploring the Aram Block with 3D OBN Seismic Data: A Breakthrough in Brazilian Offshore Pre-Salt

Abstract

When exploring deep reservoirs under a complex overburden, long-offset, full-azimuth ocean-bottom nodes (OBN) emerge as the most effective seismic acquisition technique to ensure superior imaging and velocity model building (VMB). Based on this premise, the Aram 3D OBN data represent the first case of an OBN acquisition and processing focused on an exploratory area in Brazil. A comparison between legacy streamer data and OBN data reveals the expected potential of OBN data to uplift the image on Aram block. Noteworthy improvements include enhanced delineation of the salt topography and overhangs without human interpretation at the VMB stage, greater detail in the structure of the deeper features (faults, rifts and basement), higher resolution and focalization of pre-salt reservoir, and more accurate definition of igneous rocks. All these highlights are due to the transformative potential of OBN technology to explore complex geological settings in Brazil's offshore basins.

Introduction

Located in the Santos Basin (Figure 1), the Aram block is an important asset for the exploration of the remaining potential of the Brazilian Pre-Salt. It was acquired in March 2020 during the 6th bidding round of the Brazilian National Agency for Petroleum, Natural Gas and Biofuels (ANP), under the regime of production sharing, with Pre-Sal Petróleo S.A. (PPSA) as the manager. The complex geological setting in the the Aram block (deep minibasins, highly structured salt, complex salt topography with overhangs and intrusive igneous rocks) poses challenges on the seismic imaging of deep targets. These challenges require the application of state-of-the-art seismic data acquisition and processing technologies to build a velocity model that accounts for all subsurface complexities and to achieve robust seismic imaging.

Although commonly used in production development scenarios, in the case of Aram, 3D OBN data was acquired during the exploratory phase, aiming to ensure better data quality from the start of oil field exploration. The purpose of this work is to highlight the unquestionable and profitable benefit of OBN data for exploration in this case.

Materials and method

The ocean-bottom node dataset comprises an area of approximately $1,013$ km^2 and was deployed on a $500m \times 500m$ regular spacing grid, and shots on a $50m \times 50m$ carpet grid. This design yielded rich azimuth data coverage with offsets as long as 32.5 km, as it can be seen in the rose diagram in Figure 1, providing an excellent yet cost-effective solution dataset on for a regional survey (Mei et al., 2019; Vigh et al., 2023).

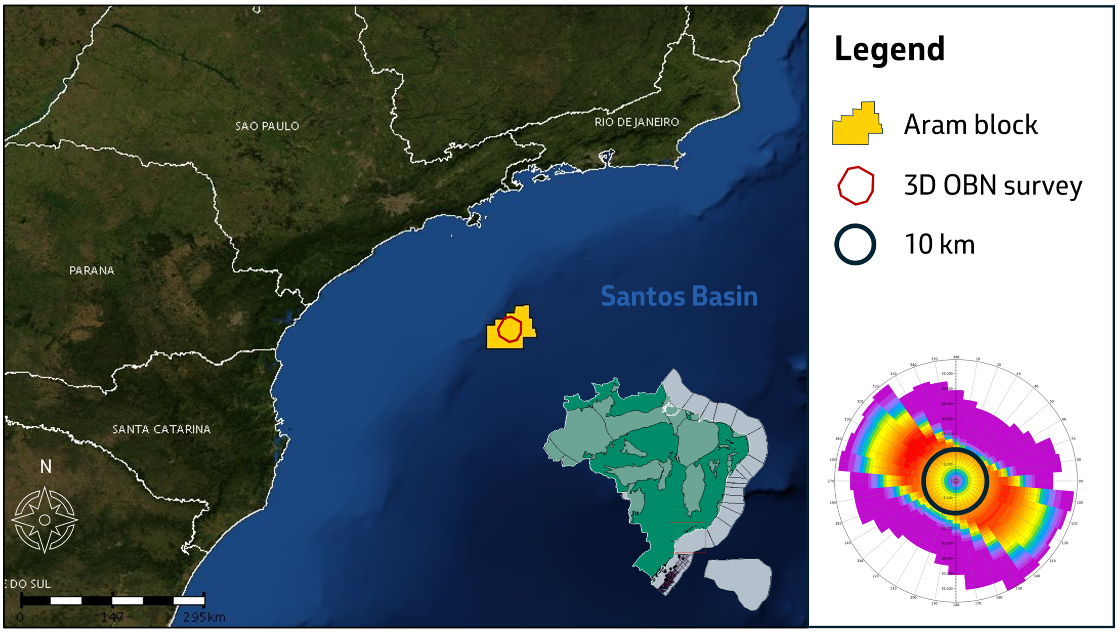

Figure 1: Location map of the Aram block and the 3D OBN survey.

Focusing the analysis in the benefits of a rich azimuth data, we compare a legacy narrow-azimuth streamer data to the 3D full-azimuth ocean-bottom node dataset in two different scenarios. The first one encompass a fast-track project, in which the time processing and VMB are accomplished by an expedited strategy and simplified steps, although they still use cutting-edge technologies for multiple and noise attenuation, migration, and FWI. The second comparison reveals the full potential of the 3D OBN data, through a full-track sequence using the most advanced algorithms to 3D de-ghosting, near-field hydrophone directional de-signature, and 3D de-multiple strategy for time processing. For the VMB workflow, the model was derived by an acoustic FWI using all waveforms (diving waves and reflections) and offsets from hydrophone data and tomography iterations interleaved with subsequent iterations of FWI, starting from low frequencies and progressing up to 15 Hz.

Results

The comparison between the results of seismic data processing from different acquisition types (streamer x OBN) is illustrated below through slices of the seismic data and velocity models and through RMS amplitude maps. First we compare the streamer LSRTM 60 Hz data with two versions of the 3D OBN RTM 45 Hz data: one coming from the fast-track sequence and other from the full-track sequence described in the previous section. Figure 2 presents this comparison in an inline section, where we can also see the respective P-wave velocities. Another comparison was made using RMS amplitude maps. RMS amplitudes were computed in a pre-salt window of 400 m length and top defined by the base of the salt (Figure 3).

From Figure 2a-c it is interesting to notice the improvement on the base of salt image (better focus, balanced amplitude and simpler structure), the definition of details on the structure of the basement and the overall uplift on the image of the reflections under the base of salt. Another important aspect is the delineation of the intra-salt igneous rocks e salt topography. Figures 2d-f show the evolution in quality of the velocity models. The improvement on the resolution of the models in the whole sedimentary section (post-salt, intra-salt, and below salt layer) is clear in the OBN data, as well as the more geological aspect of the velocity features.

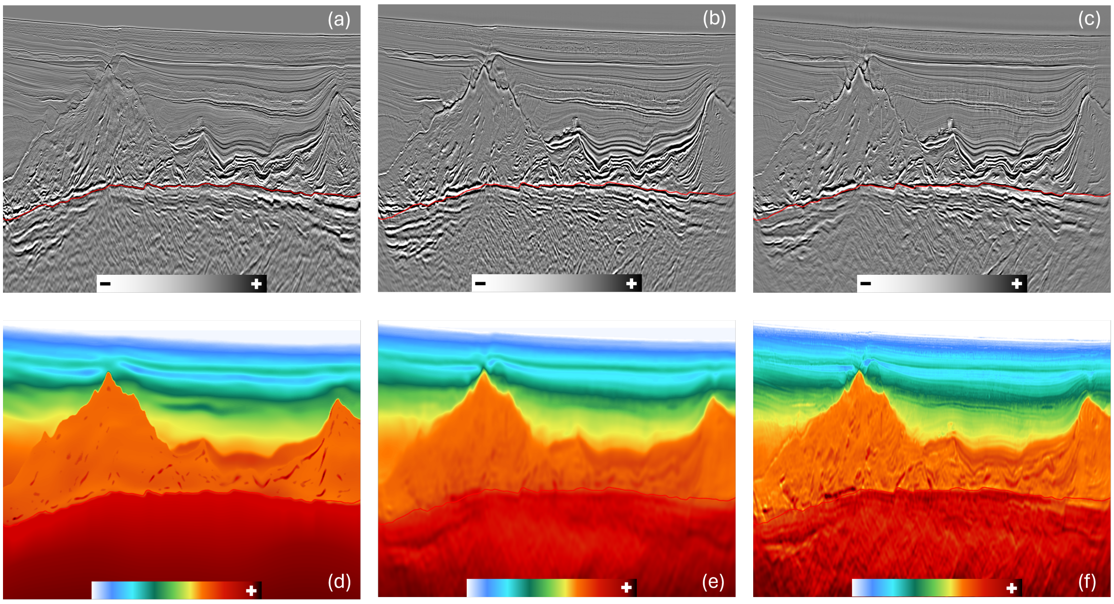

Figure 2: Inline section view - (a) LSRTM 60 Hz streamer data, (b) 3D OBN RTM 45 Hz fast-track data, (c) 3D OBN RTM 45 Hz full-track data, and their respective P-wave velocity models (d-f). The red horizon is the base of salt interpreted on the legacy streamer data.

The RMS amplitude maps in a pre-salt window (Figure 3) provides good insights about how the seismic energy is distributed in the reservoir region due to propagation in the complex overburden. Here we can see the real impact of the OBN data (full azimuth acquisition) when compared with the streamer data (narrow azimuth acquisition), even considering a poorer processed OBN data as the one from the fast-track sequence. On the OBN RMS maps we can see more realistic amplitude distribution and more homogeneous illumination.

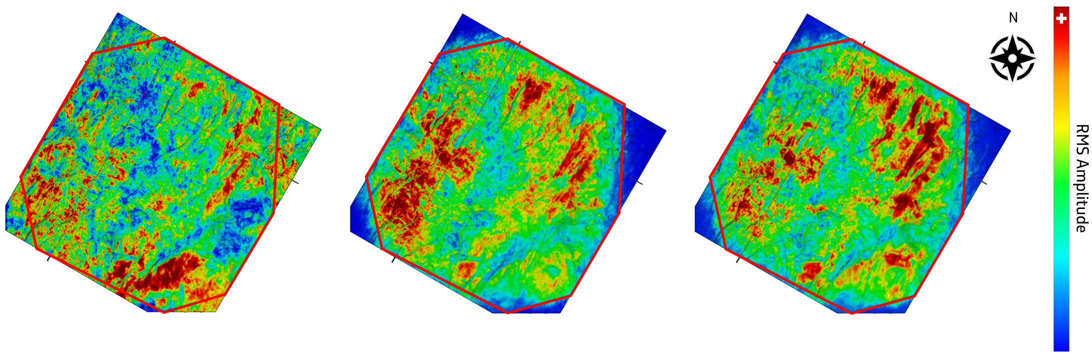

Figure 3: RMS amplitude maps from the (a) legacy streamer, (b) 3D OBN fast-track, and (c) 3D OBN full-track data.

Conclusions

Exploration of oil fields in complex areas can benefit from the increase of the seismic image quality arising from the use of OBN data from the start of the exploration project. The results seen for the Aram block show that a better characterization of the reservoir can be achieved at an early stage of the exploration phase of an oil field. As expected, using long-offset, full-azimuthal OBN data as input to FWI has delivered an improved velocity model and a high-quality image helping de-risking seismic exploration.

The OBN acquisition in Aram block is an evidence that OBN acquisition can be justifiable even at the exploration phase, delivering high quality information that certainly will optimize the development plan of this field.

Acknowledgments

We would like to thank CNODC Brasil Petróleo e Gás Ltda and Petróleo Pré-Sal SA (PPSA) for agreeing to the submission of this work. We also thank TGS processing team for their efforts in this project.

References

Mei, J., Z. Zhang, F. Lin, R. Huang, P. Wang, and C. Mifflin, 2019, Sparse nodes for velocity: Learnings from atlantis obn full-waveform inversion test: SEG International Exposition and Annual Meeting, SEG, D043S125R004.

Vigh, D., J. Xu, X. Cheng, and K. Glaccum, 2023, Sparse-node acquisition for data fitting velocity model building: Geophysical Prospecting, **71**, 1540–1550.