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Another perspective on a new exploratory frontier: The evolution of seismic data availability in the Pelotas Basin, Brazil

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Abstract

This work presents an important part of the recent evolution of seismic survey history conducted in the Pelotas Basin, which aimed to corroborate with the studies of siliciclastic plays that positions it as an new exploratory frontier. It highlights the importance of acquiring and processing 3D seismic data with the application of robust technologies capable of reducing exploratory risk through improved seismic imaging and the construction of a detailed velocity model, ensuring better characterization and understanding of the sedimentary record in the basin. Through the comparison between the technical aspects of 2D seismic lines and sections of the available 3D seismic data, it is observed that the latter is capable of providing a new perspective on the recurring clastic deposits in the area, especially in terms of the spatial correlation between these events. Improvements in the structure framework, seismic resolution, and the signal-to-noise ratio (S/N) have already been noticed.

Introduction

In the oil and gas industry, new exploratory frontiers are usually surrounded by uncertainties and challenges that, when properly addressed, can reveal promising potential for hydrocarbon discoveries. Economic, strategic, or technological aspects directly impact exploratory dynamics in these areas and may delay or accelerate this process. However, it is the acquisition and processing of new data, within favorable geological and economic contexts, that can establish a strategic guideline and foster technological innovation, aiming to de-risking exploratory activities and enabling the execution of a project such as the exploration of a new frontier.

Located in the southernmost portion of the Brazilian passive margin, the Pelotas Basin covers approximately $347,000\ km^2$ in offshore areas. It is bounded to the north by the Florianópolis High, where it borders the Santos Basin, and crosses the geographic boundaries between Brazil and Uruguay up to the Polônio High, which separates it from the Punta del Este Basin (Bueno et al., 2007). Its exploratory history dates back to the mid-20th century, when the first of four major cycles of seismic surveys and well drilling began in the area. This exploratory activity spans from the onshore portion of the Pelotas Basin, through the shallow water region of the continental shelf, and extends into deep and ultra-deep waters (ANP, 2022).

From the fourth and most recent research cycle, the deep-water portion were systematically studied through the acquisition and processing of a regular 2D seismic grid (Figure 1). Linked to the significant discoveries made in the Outeniqua (South Africa) and Orange (Namibia) Basins, these systematic studies have brought the Pelotas Basin back into focus. In its extensive drift-phase sedimentary record deposited over rift-phase volcanic rocks (Stica et al., 2014), the exploratory plays are possibly associated with the vast Cretaceous and Tertiary clastic deposits, similar to those found in the conjugate sedimentary basins.

After decades of working on 2D regional seismic lines, only 3D seismic data acquired and processed with new technology could enhance the imaging quality and characterization of exploratory plays in this area. In this sense, this work aims to demonstrate the evolution of the available seismic data in the southern portion of the Pelotas Basin.

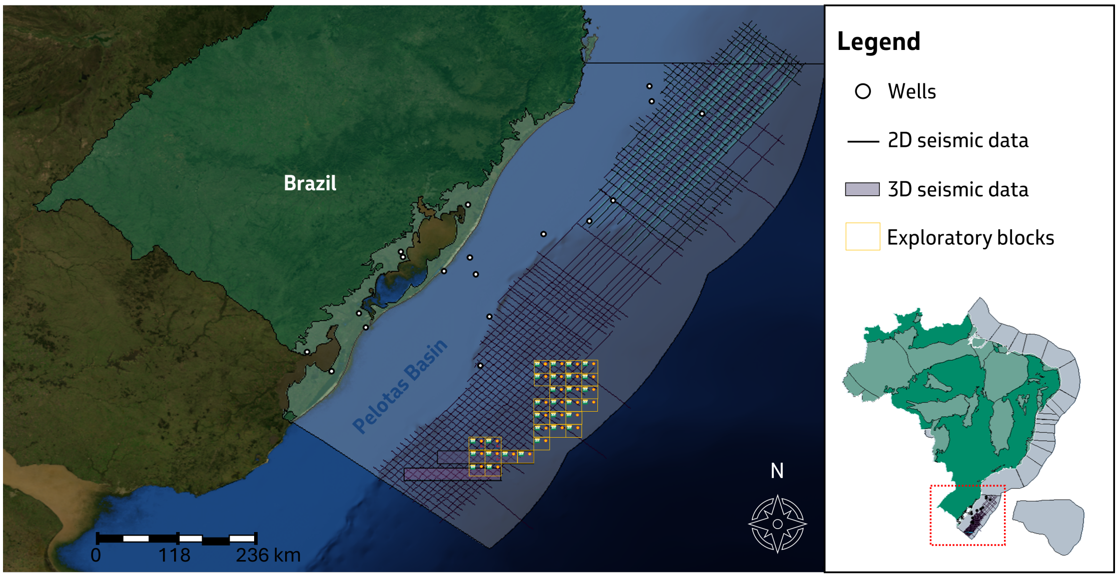

Figure 1: Location map of the Pelotas Basin indicating the exploratory blocks acquired by Petrobras in 2024, the position of 2D seismic lines, the very first 3D seismic volume available on the area, and drilled wells in the region. The presented 2D seismic lines are not the total amount of 2D seismic data available, but only the most recently reprocessed.

Materials and method

The 2D seismic lines in Figure 1 are part of a towed streamer dataset acquired at different times and reprocessed in 2021, sparsely covering almost the entire deepwater and ultra-deepwater portion of the Pelotas Basin. Together, they comprise 123 dip and strike seismic sections with a total survey length of approximately $28,857\ km$. Although employing best practices and efficient algorithms for seismic data processing, such as multi-domain noise attenuation, static corrections, de-multiple, among other techniques, the very nature of 2D seismic data imposes limitations on subsurface information in terms of azimuth, offsets, and illumination. Furthermore, it introduces a degree of uncertainty that may lead to ambiguous interpretations.

On the other hand, the seismic survey area where the 3D data was collected encompasses approximately $2,768.36\ km^2$ and offers higher quality both for seismic imaging and for the anisotropic velocity model building. The major enhancements on the de-bubble, de-ghosting, and surface related multiple attenuation stages ensures the reliability and accuracy of the processed seismic data. Besides that, a robust workflow associating full waveform inversion (FWI) and tomographic inversion performs greatly to assure detailed properties models.

In this work, we will perform a comparison between seismic sections from 2D and 3D seismic data, highlighting technical aspects that demonstrate the evolution of data availability and quality in this strategically important region for the country.

Results

We compare the results of seismic data processing from different acquisition types (2D x 3D) using a 2D KPSDM seismic section and an arbitrary inline from the 3D KPosTM. Thus, it is possible to establish a direct comparison between the data, as the section positions are coincident. Despite the 2D KPSDM data presents a good S/N, noises such as residual multiple energy and migration artifacts are issues that could be better addressed. On the other hand, the presented 3D KPosTM data is in a preliminary stage of processing. This fast-track processing sequence is an expedite strategies that simplify steps in order to anticipate the interpreter's initial impressions on the data. Figure 2a illustrates the limitations of the 2D data in providing a clear structural definition, as faults and fractures are poorly imaged and lack sufficient detail. Additionally, when compared to the 3D section (Figure 2b), the lower seismic resolution of the 2D data becomes evident, particularly in the ability to discriminate between geological layers. The 3D data not only enhances the visualization of structural features, such as faults and fractures, but also offers superior clarity in identifying and distinguishing the interfaces between layers, highlighting its significant advantage for subsurface characterization.

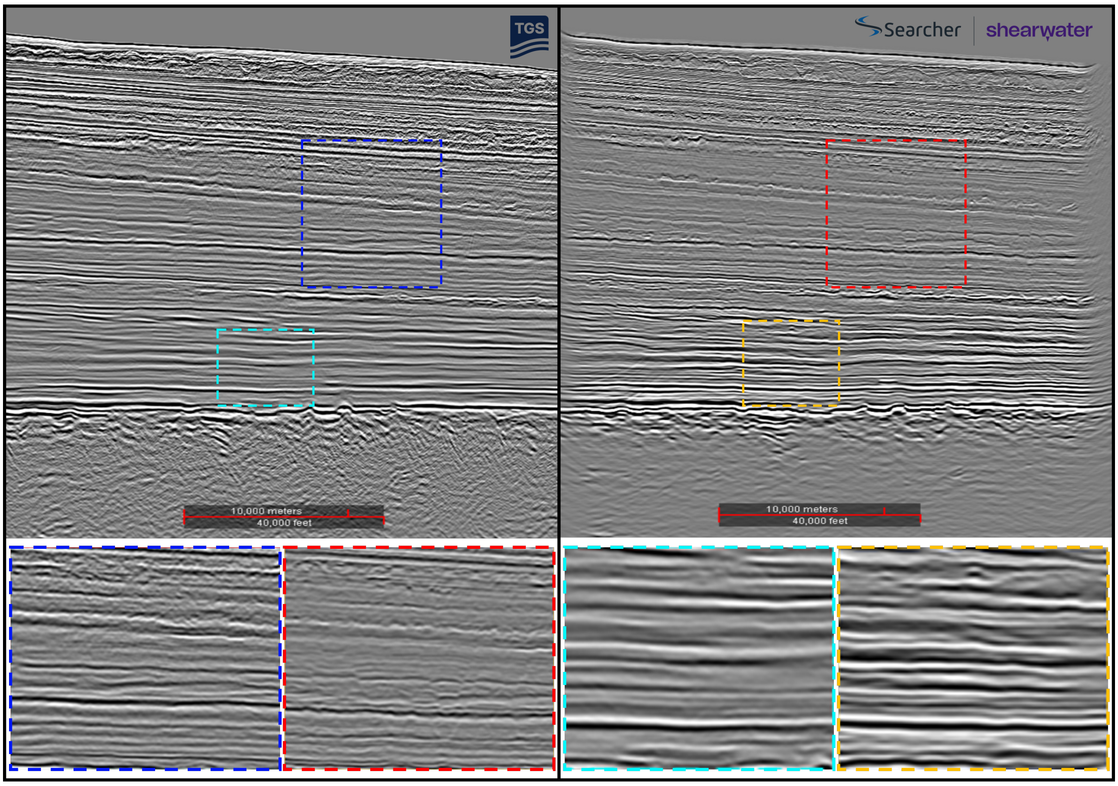

Figure 2: Inline section of the (a) 2D and (b) 3D seismic datasets. The seismic sections share the geographical coordinates, although the 2D line extends NW to SE.

Beyond the substantially increased spatial sampling and the possibility of obtaining a better lateral correlation between geological features, the 3D seismic amplitude (Figure 2) shows improvements on numerous technical aspects, such as the fault and fractures imaging and the general uplift on the image observed through the high-resolution well-solved reflectors either shallow and deep parts of the data.

Conclusions

Seismic data acquisition in 2D and 3D serves distinct purposes and offers different levels of subsurface understanding, each with its own set of advantages and limitations. While 2D data has historically been the cornerstone of initial exploration efforts in Pelotas Basin, providing a cost-effective means to map large-scale geological structures and identify potential hydrocarbon plays, 3D seismic data represents a significant technological advancement, offering a more detailed and accurate depiction of the subsurface

From the comparison, it can be seen that this extensive 3D seismic survey is expected to deliver essential insights into the geological framework of the Pelotas Basin. Even considering a basic but consistent processing, The data has proven to be impactful. Even though its full potential is yet to be unveiled through robust processing of the full-track sequence, it has already contributed to interpretation and enriched the geoscientific knowledge accumulated about the region.

The increasing 3D seismic data availability will shed light on the connection between the conjugate margins of the Pelotas Basin and the Orange Basin, greatly mitigating exploration risks and unlocking a completely new frontier for exploration.

Acknowledgments

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