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2D Acoustic Seismic Modeling Based on Land Seismic in the Resende Basin, Brazil

Cassimiro Carvalho (GISIS/UFF), Guilherme Lenz (GISIS/UFF), Felipe Costa (GISIS/UFF), Marcos Lopes (GISIS/UFF), Marco Cetale (GISIS/UFF)

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Abstract Summary

This study presents the construction of a 2D synthetic acoustic seismic model based on real data acquired in the Resende Basin (RJ), with the objective of evaluating its capacity to simulate the observed seismic response. Using interpretations of a land seismic line, a layered acoustic velocity model was created, which was then modeled and processed. The results show that, despite the simplifications, the model reproduces the main seismic features, evidencing its potential in terms of the quality of resolution of synthetic data when compared to real terrestrial data.

Introduction

Seismic modeling is a powerful tool for understanding subsurface wave propagation and validating geophysical interpretations. It is especially relevant and useful in onshore surveys, where real data present higher levels of noise, which makes data analysis and interpretation difficult. This study uses a land seismic acquisition registered in the Resende Basin in the Rio de Janeiro state, to build synthetic models based on parameters extracted from the field acquisition, with the aim of evaluating the capacity of these models to reproduce geological features identified in the observed data.The application of synthetic models in this context allows isolating and testing the effects of different velocities in the medium, contributing to the understanding of the limitations and potential of the seismic response in controlled scenarios. By comparing the simulated results with the real data, it is possible to identify the responses of the physical representation in the model and analyze the complexity of the geological environments of the studied region, which is evidenced in studies of Ramos et al. (2006), which demonstrates several geological analyses where it is possible to determine different interpretations of the Basin. In addition, this approach helps in adjusting interpretations and in developing more assertive strategies for the processing and analysis of terrestrial seismic data.

Methodology

From the interpretation of a 2D land seismic line acquired in the Resende Basin by the Seismic Imaging and Seismic Inversion Group (GISIS) of the Fluminense Federal University (UFF), horizons and depth and velocity information were extracted and used to construct a simplified geological velocity model. This model was structured in five layers based on the interpretation of seven horizons and was implemented in a programming script to apply the previously extracted information. The model reaches depths of up to 500 meters, with velocities ranging from 2200 m/s to 3500 m/s (Figure 1). The 2D acoustic seismic modeling was performed using *Seiswave 2D* Seismic Imaging and Seismic Inversion Group (2024), adopting the same geometry as the field acquisition: an 832-meter line with 72 geophones spaced regularly every 8 meters. A total of 91 shooting points were used, distributed among the geophones and also at the ends of the line, in order to ensure adequate coverage along the entire profile and increase the resolution of the edges. The synthetic data generated were processed in *Echos* Aspen Technology, Inc. (2024), allowing comparison between the seismograms and stacked sections with the real data.

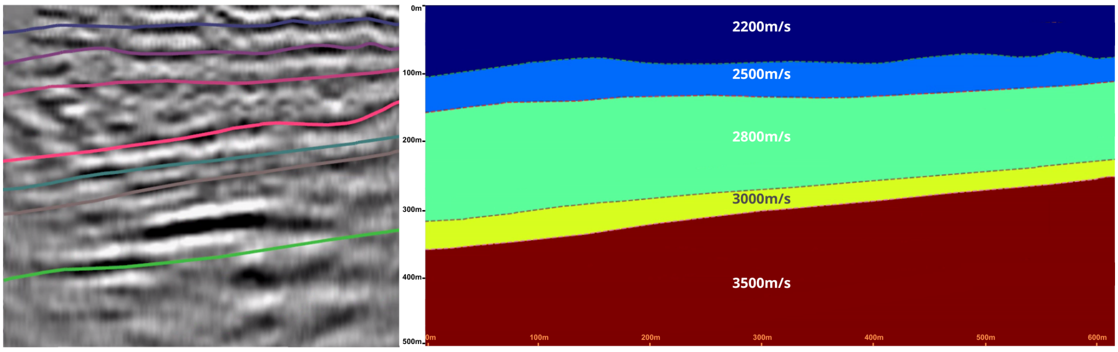

Figure 1: On the left, seismic session with extracted horizons for modeling. On the right, velocity model created from the horizons.

Results

In the comparative analysis between the seismograms (Figure 2), the synthetic data revealed four of the main predicted reflectors that were used in the synthetic model, with good continuity and coherence in the seismic responses. However, the field data presented intense presence of surface noise, especially ground roll, which made it difficult to visualize the other events.

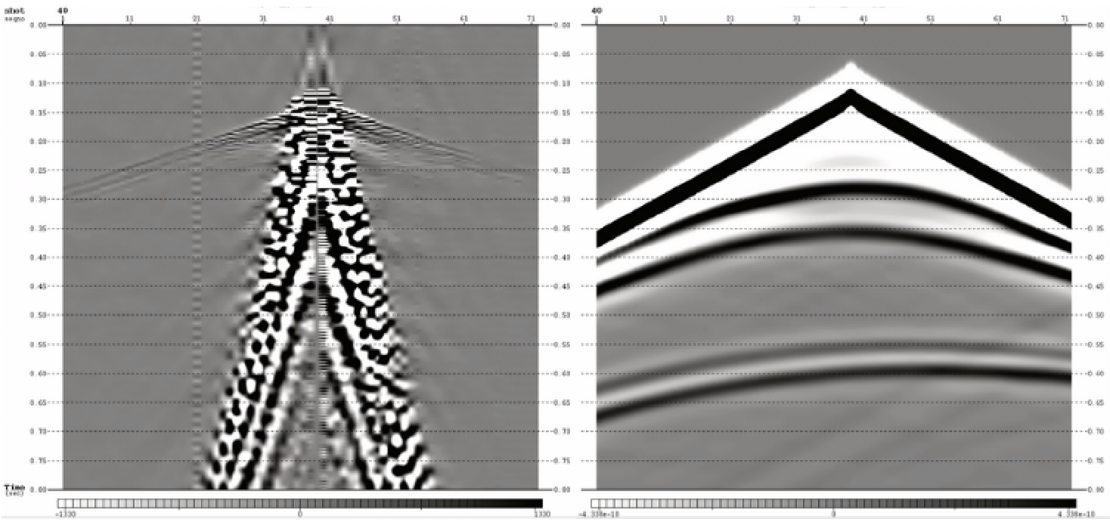

Figure 2: Comparison between field data (left) and synthetic data (right).

In the comparison between the stacked sections (Figure 3), the presence of the 4 main reflectors relating to the synthetic model with 5 layers was highlighted. It is possible to observe that the reflection arrival times were preserved, indicating general consistency in the positioning of the interfaces and their respective depths. The observed differences are attributed to the absence of common effects in real terrestrial data, such as low velocity zones (LZ), ground roll, and local variations, parameters that were not included in the model.

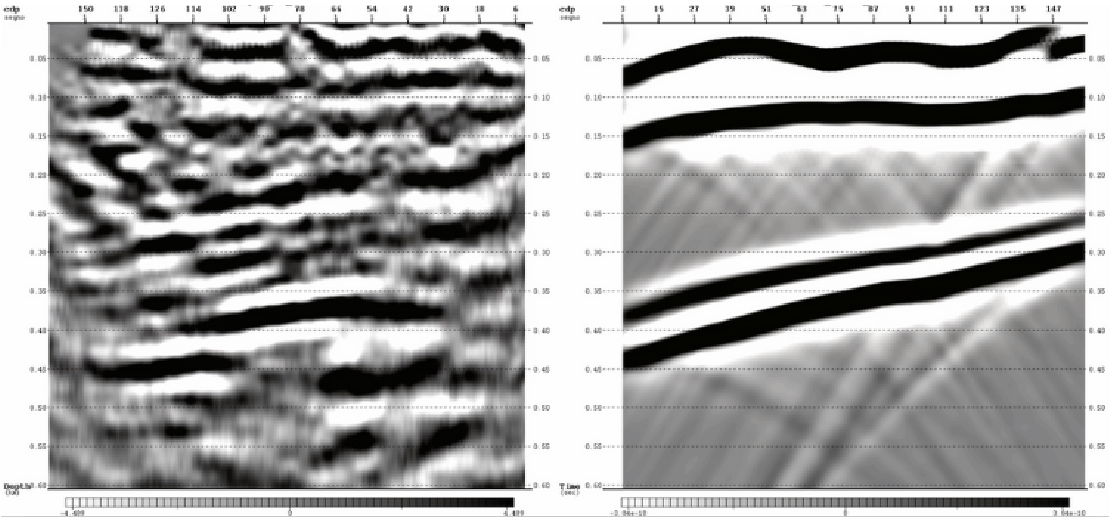

Figure 3: On the left, stacked real seismic section with 0.6 seconds of recording. On the right, stacked synthetic seismic section with 0.6 seconds of recording.

Conclusions

The results demonstrate that the synthetic model, even in its acoustic and simplified form, was able to partially reproduce the seismic response observed in the real acquisition. The presence of noise and the complexity of shallow terrestrial data impose important limitations on direct modeling, highlighting the need for more robust adjustments to adequately represent such conditions. This work represents an initial effort in the development of a more realistic model, which will be refined in the future by incorporating typical effects of terrestrial data, in addition to elastic parameters and well logging information.

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