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Campos Synthetic Velocity Model

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Abstract

This study introduces a synthetic velocity model inspired on Campos Basin, Brazil, and its corresponding seismic dataset modeled using the finite difference method. Leveraging the interpretation of a real depth-migrated regional seismic image, the model incorporates key geological complexities characteristic of the basin, including intricate halokinetic structures, depositional onlaps, and listric normal faults. Furthermore, strategically placed reservoirs enhance the dataset's utility for simulating realistic seismic responses. This benchmark dataset is publicly available and offers a platform for testing seismic processing and imaging algorithms in challenging geological environments similar to the Campos Basin.

Introduction

The Campos Basin, located off the southeastern coast of Brazil, is a prolific hydrocarbon province and one of the country's most important oil and gas-producing regions. Despite its significance, seismic imaging in the Campos Basin poses considerable challenges due to its complex geological structures. The presence of extensive salt layers, including salt domes and associated faults, severely complicates seismic wave propagation and imaging accuracy. These issues necessitate the development of reliable seismic models and synthetic datasets to test and improve seismic processing and interpretation tools.

Synthetic seismic data provides a valuable framework for testing and calibrating seismic processing algorithms. In Brazil, for example, studies have focused on creating synthetic data to validate and experiment different methods of seismic processing and to obtain a better image of the geological structures (Lima et al., 2003) and evaluate the effect of converted waves on seismic sections (de Assis Silva Neto et al., 2005). Such works underscore the importance of synthetic datasets in enhancing our understanding of complex geological structures and improving seismic imaging techniques.

In this paper, we present a synthetic velocity model and a modeled seismic dataset derived from a depth-migrated regional seismic line of the Campos Basin. Our objective is to create a robust seismic model tailored for use in seismic processing tools. The synthetic data was generated using the acoustic finite difference method after constructing a velocity model based on the geological interpretation of the depth-migrated regional seismic section 214-RL-175 (Mohriak et al., 1995). The resulting dataset replicates the key structural features of the Campos Basin, including salt cores, rollovers, anticlines, listric normal faults, onlap structures, reservoirs, and more. This work aims to provide a valuable resource for advancing seismic imaging and processing techniques in complex geological settings.

Velocity Model

The velocity model (Figure 1) is heavily inspired by the structural interpretation of the seismic line 214-RL-175. It comprehends the central region of the Campos Basin, within the tectonic compartment represented by Domain I and II (Bizzi et al., 2003). The model contains the main features observed on the real seismic line and incorporates eight strategically placed reservoirs and detailed fault systems to enhance its utility for benchmarking. The complete velocity model comprises 32501 traces, spanning 130004 meters horizontally and 8000 meters in depth, discretized by a 4 by 4 meter grid. The seismic velocities within the model range from 1500 m/s to 5000 m/s.

Seismic Modeling

A synthetic seismic dataset was modeled using the acoustic finite difference method with a second-order (in time) and Eighth-order (in space) centered-grid scheme, a 20 Hz dominant frequency Ricker wavelet and time sampling interval set to 0.0004 s. The spatial grid spacing was set to 4 meters in both directions, ensuring numerical stability and minimizing dispersion. Absorbing boundary conditions were implemented to suppress artificial reflections from the model edges based on Kosloff et al. (1986).

The acquisition geometry consisted of shot gathers spaced at 48-meter intervals at a depth of 8 meters with 2837 shot positions. Receivers were positioned at a depth of 12 meters with a spacing of 24 meters with 355 receivers per shot gather. This configuration yielded minimum and maximum source-receiver offsets of 0 and 8496 meters, respectively. In total, 11000 common midpoint (CMP) locations were obtained with a spacing of 12 meters with a maximum fold of 88 traces. The resulting seismic dataset was then resampled to 0.004 s. Figure 2 shows examples of the Shot and CMP gathers illustrating the seismic response across three distinct regions of the dataset. The complete synthetic dataset is illustrated in Figure 3 through three common-offset panels, revealing all geological features, including the reservoirs.

Conclusions

A velocity model and synthetic seismic dataset of the central Campos Basin was successfully generated using the acoustic finite-difference method, driven by detailed geological interpretation of a depth-migrated seismic line. The resulting velocity model and synthetic seismic data effectively represents the main subsurface structures and illuminate key geological features like halokinetic structures, onlaps, unconformities, and normal faults. The obtained model and dataset provides a robust benchmark for evaluating processing and imaging techniques in complex sedimentary basins. These resources are accessible to the scientific community for research/publication, provided this expanded abstract is cited. Further information and the download repository can be accessed by scanning the QR code on the right.

Acknowledgments

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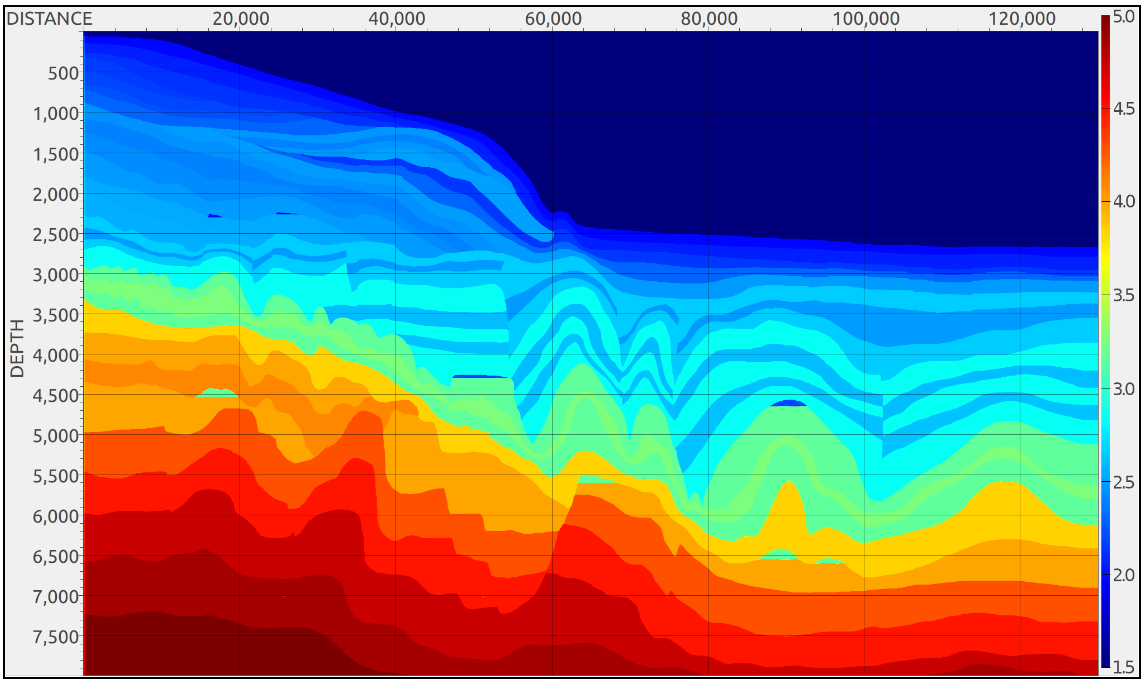

Figure 1: Depth velocity model of the Campos Basin, based on key tectono-sedimentary sequences, highlighting halokinetic features in the deep-water region.

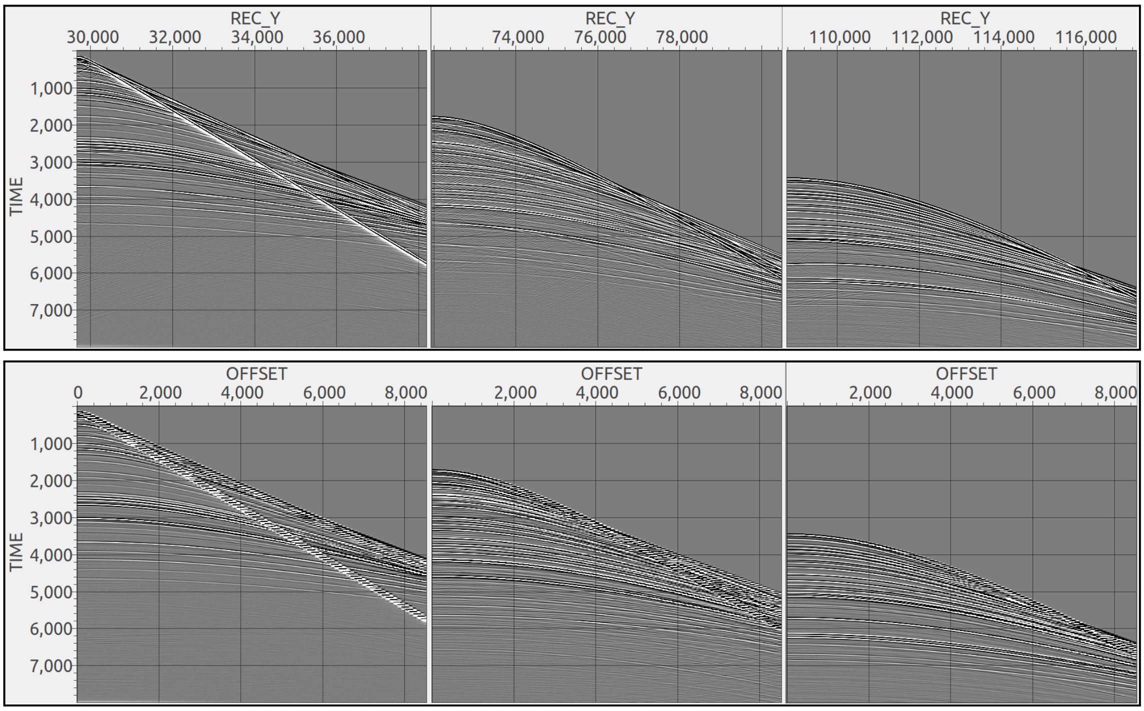

Figure 2: Top: Shot gathers at positions 29688 m (left), 71976 m (middle), and 108792 m (right). Bottom: CMP gathers at indices 1000 (left), 4500 (middle), and 7700 (right). The direct water wave has been removed from these gathers by modeling and subtracting the water layer response.

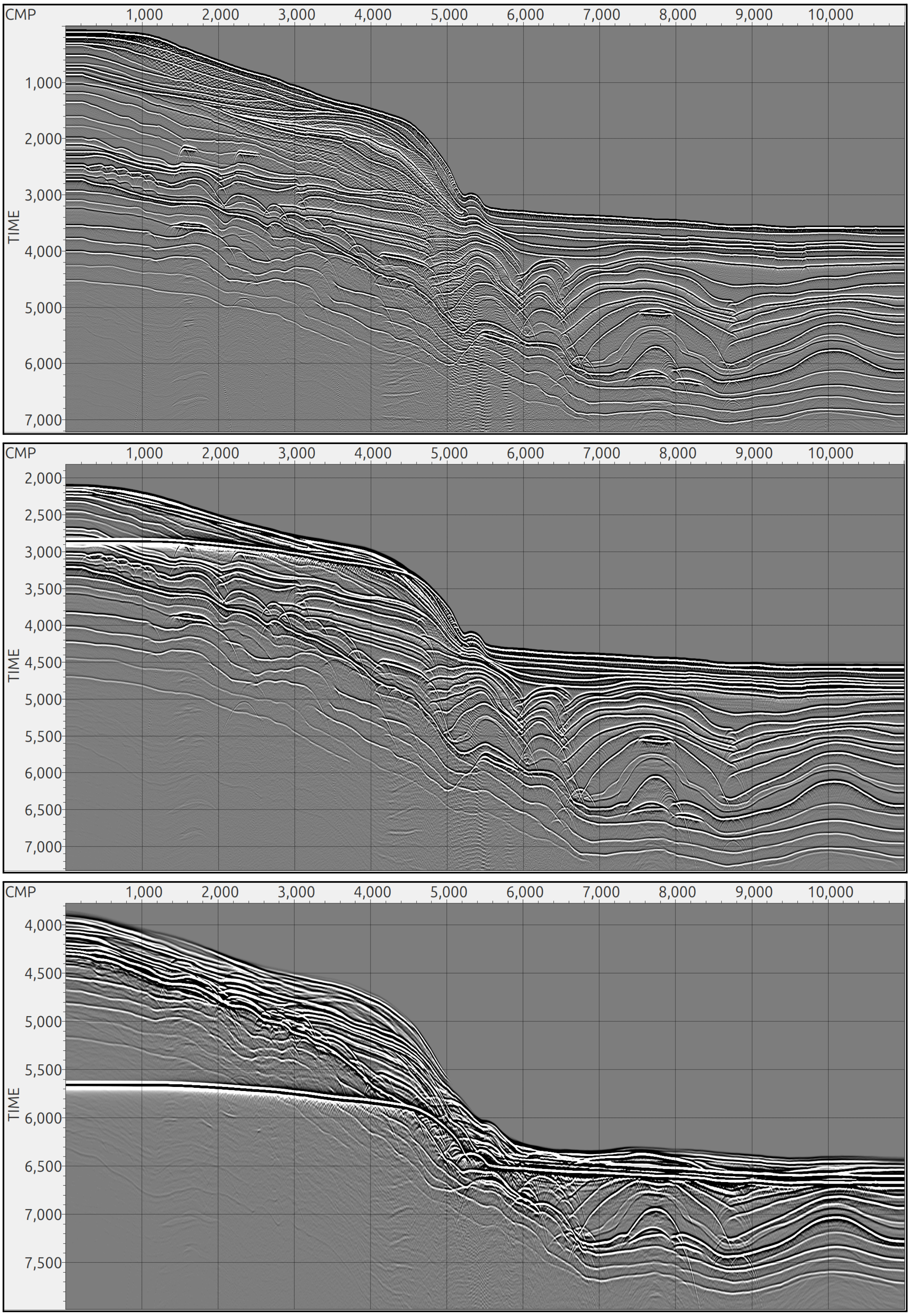

Figure 3: Constant offset panels at offsets 0 m (top), 4200 m (middle), and 8400 m (bottom).