Unsupervised Seismic Interpretation in the Santos Sul Area, Southern Brazil, Using Seisnetics AI Engine

Abstract Summary

This study demonstrates the application of Seisnetics' unsupervised interpretation technology to a broadband 3D seismic dataset spanning approximately 12,400 km² in the Northern Pelotas Basin. The method employs genetic algorithms to automatically extract geological features such as horizons and faults from complex stratigraphic and structural environments. This approach significantly reduces interpretation bias and manual labor, accelerating early-phase basin screening and enabling more efficient regional assessments in frontier exploration areas. The 3D seismic survey used in this study is named Santos Sul 3D, a designation chosen to facilitate geographic reference, as the area lies immediately south of the Santos Basin. The data was acquired at a critical time for the industry, amid intensified efforts to discover hydrocarbon resources analogous to those recently found offshore Namibia with its two Walvis and Orange Basins considered conjugate margin analogs to Brazil's Pelotas Basin. Both processing and depth model building were conducted using a high-end workflow, designed to support interpretation, rigorous quality assurance, and more informed decision-making. These efforts resulted in a high-quality dataset well suited for identifying exploration opportunities.

Method and/or Theory

Seisnetics treats seismic interpretation as a problem of data segmentation, where the seismic volume is broken into coherent populations of waveform segments. The core of this method is a genetic algorithm (GA) that simulates biological evolution to extract seismic horizons and faults.

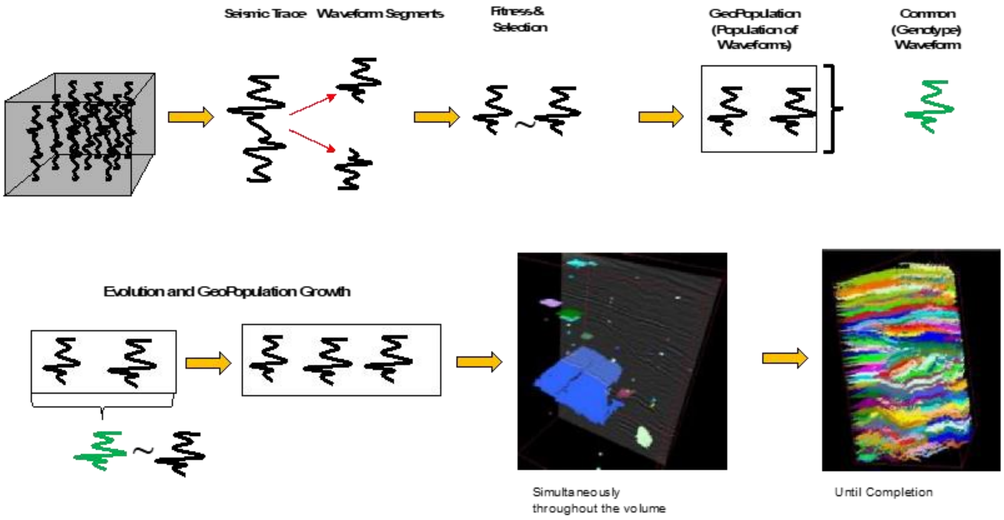

Figure 1: Seisnetics' segmentation principle explained.

Each seismic trace is represented by a "chromosome" consisting of waveform attributes such as amplitude, dip, and continuity. These are grouped into "genetic populations" or horizons by evaluating waveform similarity (fitness). Through multiple generations, sub-populations evolve, maximizing **intra-**population similarity and minimizing **inter-**population similarity.

The fitness attribute, unique to Seisnetics, serves as a quantitative indicator of waveform similarity within each extracted horizon. It enables interpreters to rapidly assess the internal consistency of geo-objects and to identify regions of waveform variability that may correspond to depositional heterogeneity, lithological changes, or structural complexity.

Results

The interpreted 3D seismic dataset spans 12,400 km² and was acquired using GeoStreamerTM technology, incorporating long offsets and tight trace spacing to maximize resolution. To enhance subsurface imaging, modern processing workflows including source de-blending, de-ghosting, and Full Waveform Inversion (FWI) were applied. Seisnetics then processed the dataset using its unsupervised interpretation technology, automatically generating thousands of horizon surfaces (geo-populations) that can be queried on demand to quickly identify zones of interest. In addition, the workflow produced high-resolution attribute maps including fitness, dip, amplitude, and continuity and extracted fault polygons and planes where structurally relevant, offering a comprehensive and datapoint-rich interpretation environment.

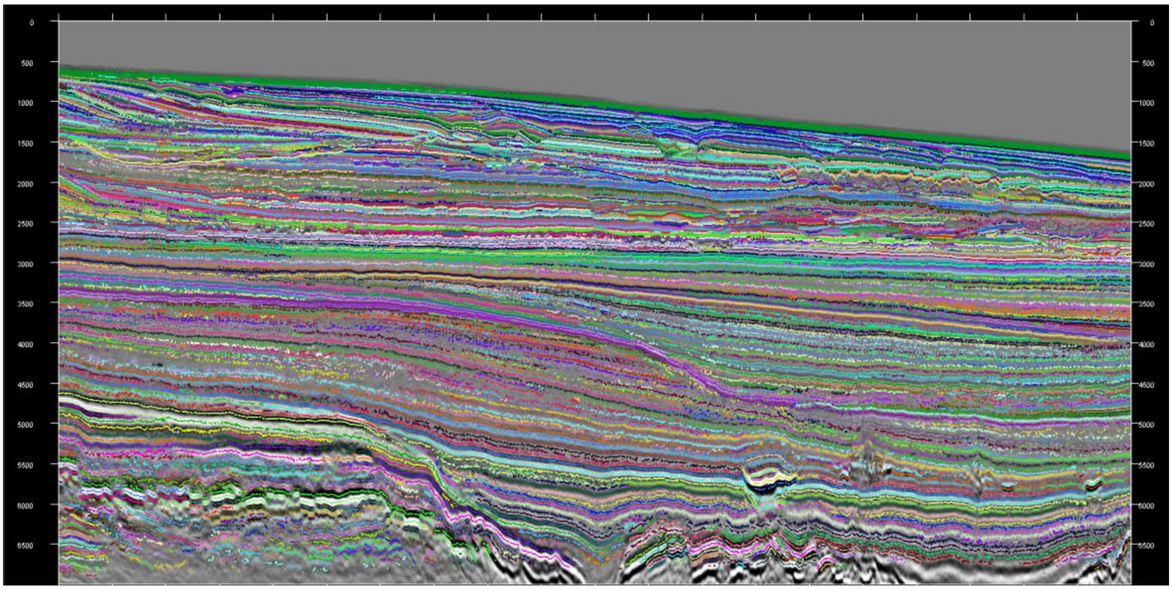

Figure 2: Inline showing all the surfaces extracted in monochrome, revealing the structure and different geometries within the basin.

The output reveals major stratigraphic features such as the structures basement, then Basin lows filled with the Cretaceous source rock followed by localized volcanic intrusions as in the process of the basin fill so in later stages of passive accumulation, possible Mass Trasport Complexes (MTCs) in the late Cretaceous (Fig.3) and throughout Tertiary section.

Santonian volcanic intrusions related to the Santos Cluster magmatic event were identified with high precision (Fig.4). In the example below, we show how the fitness attribute reveals the precise contours of volcanic intrusions at the bottom of the dataset (rounded red shapes in the East).

Additionally, the interpretation reveals a series of pockmarks within the Tertiary section, along with two distinct erosional canyon incisions trending NW-SE, features that reflect dynamic sedimentary processes and possible fluid migration pathways (Fig. 5).

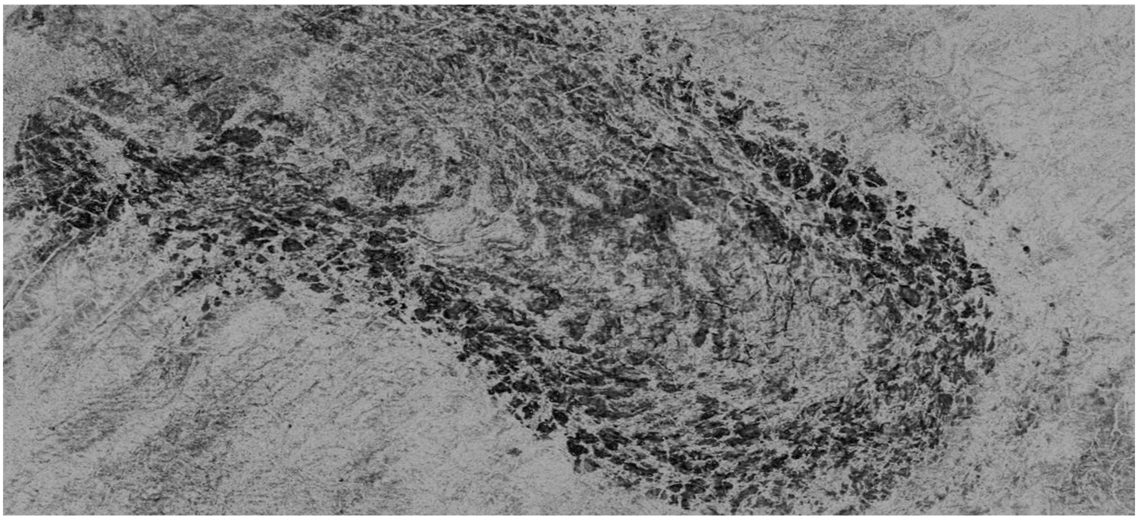

Figure 3: Example of amplitude extraction from the mapped Mass Transport Complex (MTCs).

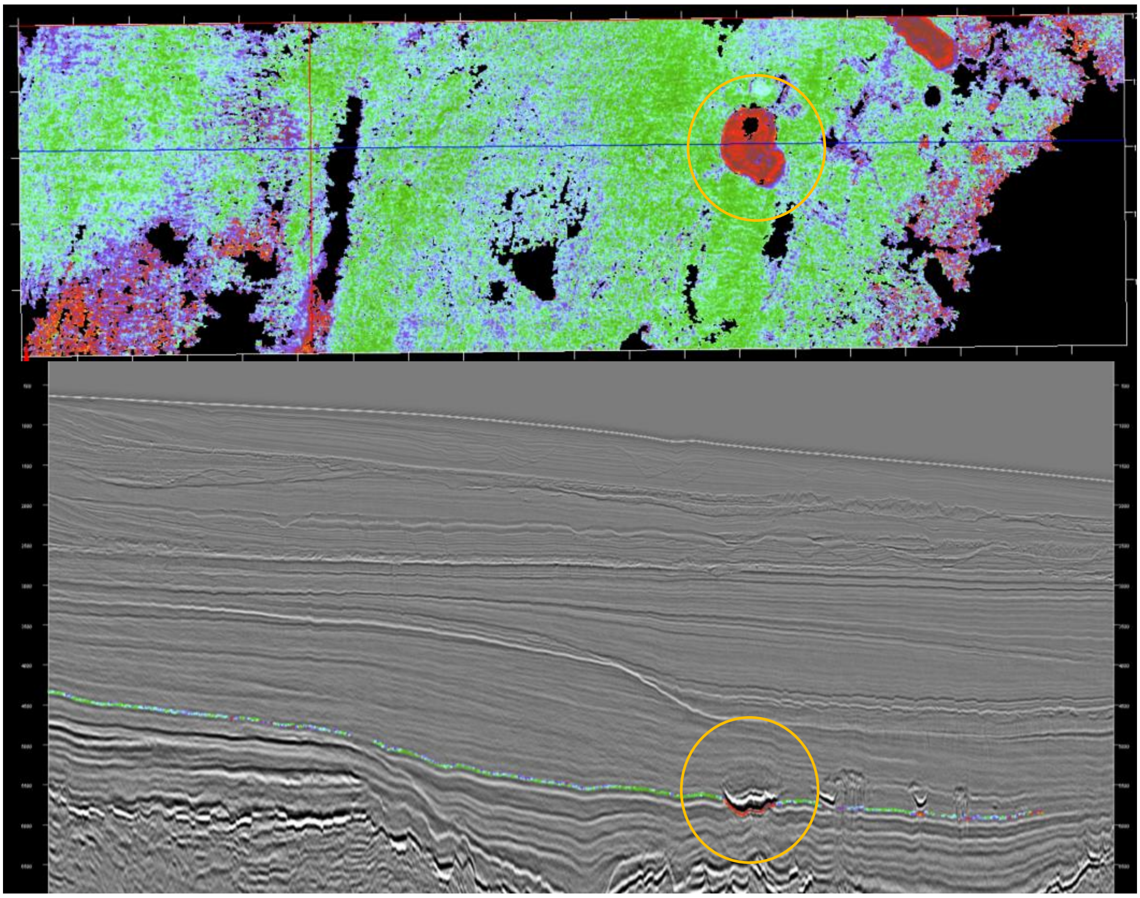

Figure 4: Example of feature by displaying the fitness attribute (top picture, top view of the surface using the fitness attribute): volcanic intrusion appearing in red color along the surface.

Figure 5: Example of pockmarks identified in the Tertiary section. The image also shows two distinctive erosional canyon incisions elongated in NW-SE direction.

Conclusions

The Santos Sul 3D multi-client program is a strategically important exploration project designed to greatly improve insights into the petroleum system of the frontier area. This state-of-the-art dataset has the potential to reshape the understanding of regional geological plays, providing a critical resource for reducing exploration risk in both the Southern Santos and Northern Pelotas Basins. Leveraging high trace density broadband acquisition and advanced depth model building through FWI processing, the program is focused on delivering a dataset tailored to the needs of modern exploration.

This case study validates the applicability of Seisnetics for unsupervised seismic interpretation in underexplored regions like Santos Sul. The AI-driven workflow bypasses manual picking and delivers interpretable volumes within days rather than months. The ability to automatically extract and classify geo-objects using waveform similarity and genetic algorithms introduces significant advantages in speed, scalability, and consistency. The insights obtained offer valuable support for early-phase exploration, stratigraphic compartmentalization studies, and regional de-risking.

Acknowledgments

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