Multi-Attribute Solutions Help Reduce Risk in a Complex Geological Environment in Brazil

aspentech | Case Study

> "The workflow used in this study was both efficient and accurate. We have since used it successfully in three other pre-salt carbonate fields."

Carlos Jesus , Geophysicist, MSc, Petrogal

CHALLENGE

Mapping carbonate mounds in the Brazilian pre-salt fields is a major challenge for geoscientists. It is difficult to identify and delineate features using only seismic data because of the complexity of the seismic image generated.

SOLUTION

AspenTech solutions were used in every step of the workflow, combining hybrid spectral decomposition with curvature and coherence geometrical attributes, in order to provide useful geological information and generate a seismic facies classification.

VALUE CREATED

- Good reservoir quality carbonate mounds were identified efficiently within the complex geological environment of the Brazilian pre-salt zone.
- The technology helped the customer reduce risk by avoiding drilling in non-productive areas in several pre-salt carbonate fields.
- This workflow has been successfully applied in three other pre-salt carbonate fields.

Overview

Brazil has been producing oil from pre-salt carbonate reservoirs for over 10 years. These reservoirs have reached an incredible output of 2.96 million barrels of oil equivalent per day, representing close to 75% of the country's daily production (3.97 million barrels) and demonstrating the importance of these reservoirs to Brazil. However, it is tremendously challenging to map and characterize carbonate reservoirs, given their considerable spatial heterogeneity, complex pore systems and often ambiguous seismic responses.

Seismic attenuation can greatly affect the quality of seismic signals perpetuated at great depths. Consequently, mapping carbonate mounds in the Brazilian pre-salt fields, which lie at depths of 5,000 - 6,000 meters, and below an approximately 2,000-meter thick layer of salt, is a major challenge for geoscientists. This is due to low seismic illumination and low amplitude anomalies, low impedance, and high fault and fracture density that are characteristic of these geological environments. It is difficult to identify and delineate such features in these fields using only seismic data because of the complexity of the seismic image generated, and the absence of impedance contrast between the reservoir and adjacent sealing facies.

AspenTech Workflow Efficiently Identifies Good Reservoir Quality Carbonate Mounds

To resolve this issue, a workflow was proposed that would combine hybrid spectral decomposition (HSD) with curvature and coherence geometrical attributes (Figure 1). These attributes were able to provide useful geological information, and were used to generate a seismic facies classification for identifying good quality reservoirs in carbonate mounds (Figure 2).

AspenTech solutions were used in every step of the workflow: Aspen Echos™ for amplitude gain and structure-oriented filter; Aspen SeisEarth™ for interpretation of the top and base of the reservoir, mapping and attribute generation; Stratimagic™* for seismic classification; and VoxelGeo™* for mound geobody extraction.

**Now integrated into Aspen SeisEarth.*

To begin with, the seismic data was preconditioned using structural oriented filtering (SOF) to remove background noise and preserve fault edges. The SOF volume was then used to generate the curvature attribute. To improve overall vertical resolution, image enhancement was applied to the SOF volume to calculate a coherence cube, facilitating better identification of the faulted and fractured character of these mounds. HSD was applied to the SOF volume to identify low amplitude zones, which correspond to areas of good porosity (Figure 3). All of these seismic attributes were then combined to classify the seismic facies. This allowed the user to distinguish the most important facies representing good reservoir quality carbonate mounds, and to extract a geobody that could be used as spatial control for porosity distribution in reservoir modeling.

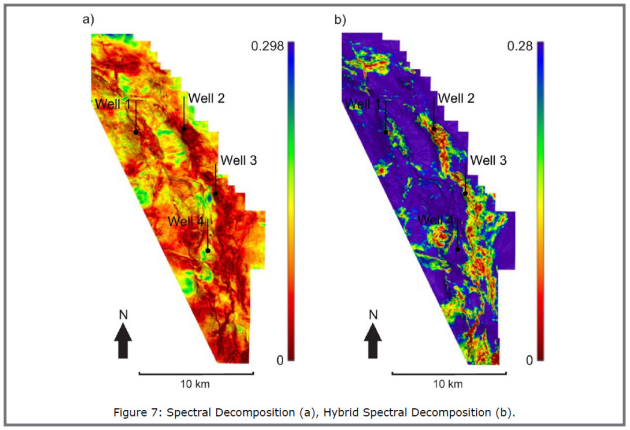

Figure 1. Spectral decomposition (a), hybrid spectral decomposition (b).

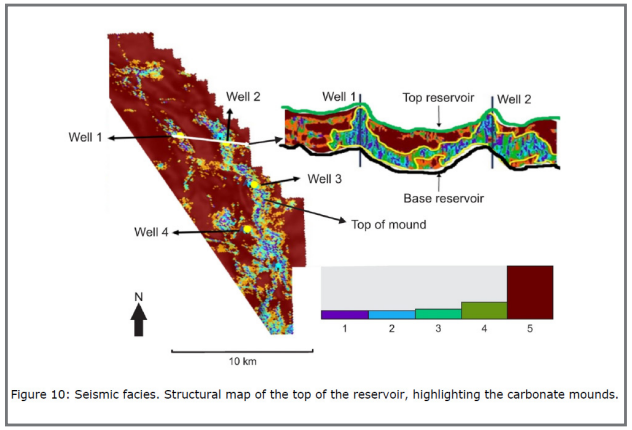

Figure 2. Seismic facies. Structural map of the top of the reservoir, highlighting the carbonate mounds.

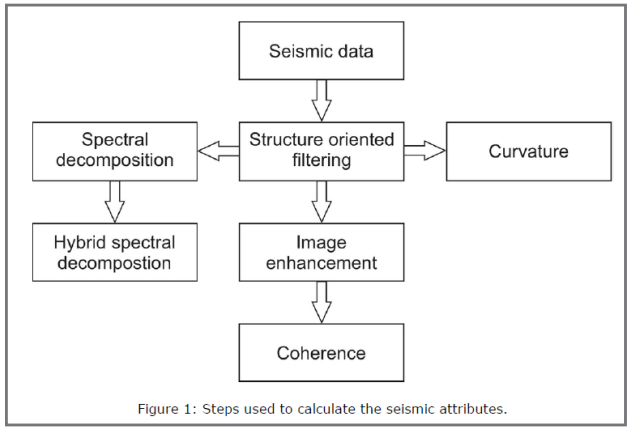

Figure 3. Steps used to calculate seismic attributes.

Results

Geometric attributes (curvature and coherence) (Figure 4) were used to identify zones with a high density of faults and fractures, typical of carbonate mounds, for the seismic facies classification. Five seismic facies classes were chosen. Facies 1-3 were identified as carbonate mounds with high porosity and a high density of fractures, meaning the best reservoirs. Facies 4 and 5 were considered to be non-reservoirs in terms of their quality. The extracted geobody in facies 1-3 was classified as good reservoir quality carbonate mounds. Wells 2 and 3 are in this geobody, whereas wells 1 and 4 are in an area not identified as a carbonate mound, corroborating the well log response (Figure 5).

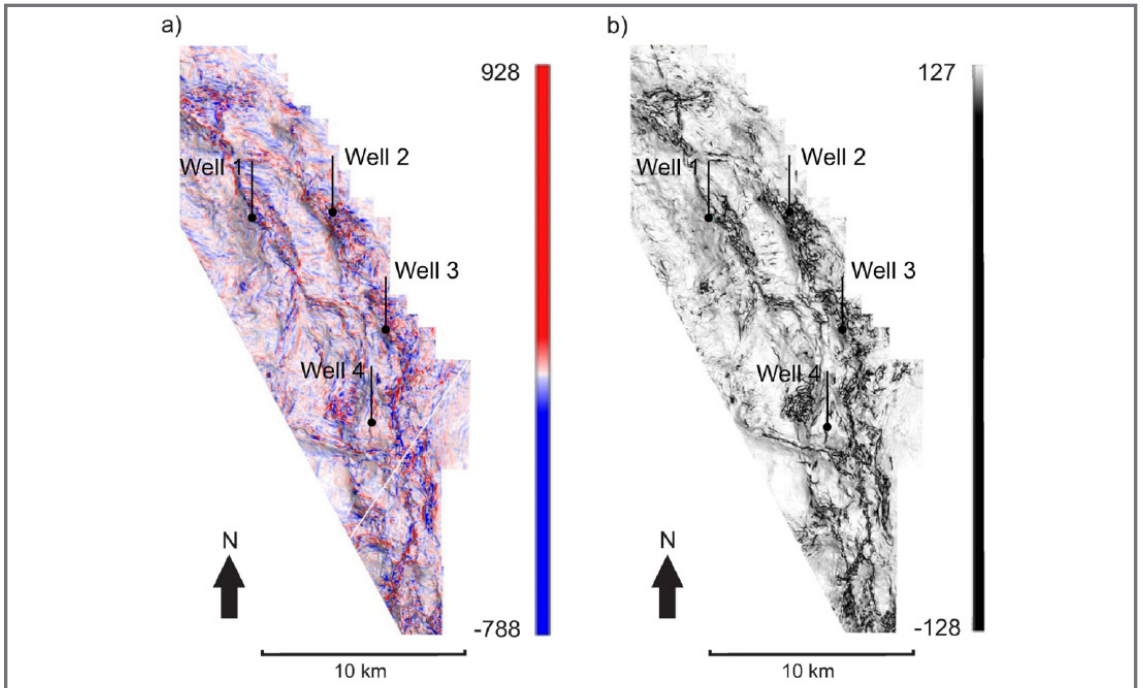

Figure 9: Curvature (a) and coherence (b) attributes applied to the structural map of the top of the reservoir, revealing faults and fracture zones around the wells.

Figure 4. Curvature (a) and coherence (b) attributes applied to the structural map of the top of the reservoir.

Conclusion

The workflow efficiently identified good reservoir quality carbonate mounds in a complex environment. The coherence and curvature attributes were useful tools for identifying faults and fracture zones, whose high densities represent one of the most important characteristics of carbonate mounds. Since low seismic amplitude is also a typical feature of pre-salt carbonate mounds, HSD enabled the discrimination of good reservoir quality carbonate mounds from poor zones (e.g. well 4). Multi-attribute facies classification generated a geologically significant outcome for static modeling, and the extracted geobody was used as an additional spatial indicator of porosity distribution. This workflow has been successfully applied in three other pre-salt carbonate fields.

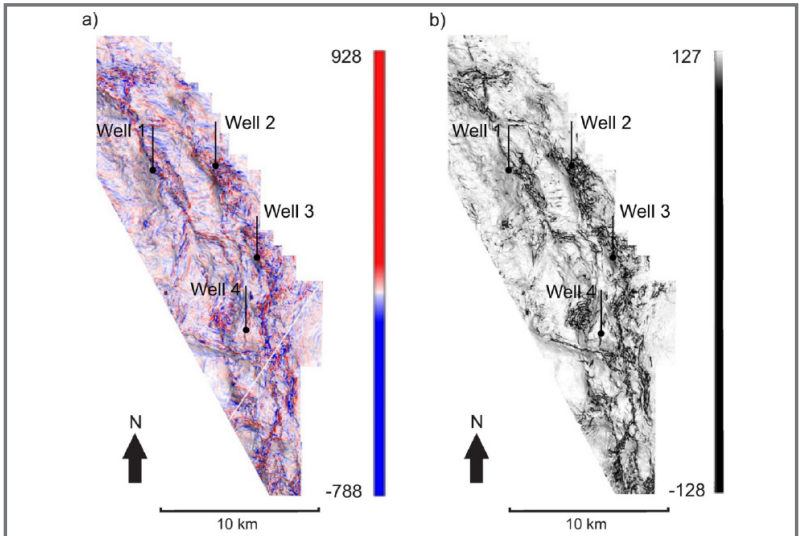

Figure 9: Curvature (a) and coherence (b) attributes applied to the structural map of the top of the reservoir, revealing faults and fracture zones around the wells.

Figure 5. Geobody of carbonate mounds extracted from seismic facies classification.

About AspenTech

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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