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

RESULTS

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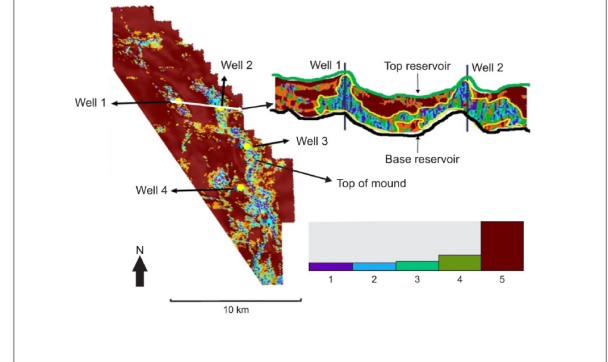
Seismic facies. Structural map of the top of the reservoir, highlighting the carbonate mounds.

APPLICATION
Emerson Echos™, SeisEarth™, Stratimagic™, VoxelGeo™

CUSTOMER
Petrogal Brasil

CHALLENGE
Brazil has been producing oil from pre-salt carbonate reservoirs for the past 10 years. These reservoirs have reached an incredible output of over 1.7 million barrels of oil equivalent per day, representing more than half of the country's daily production 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.
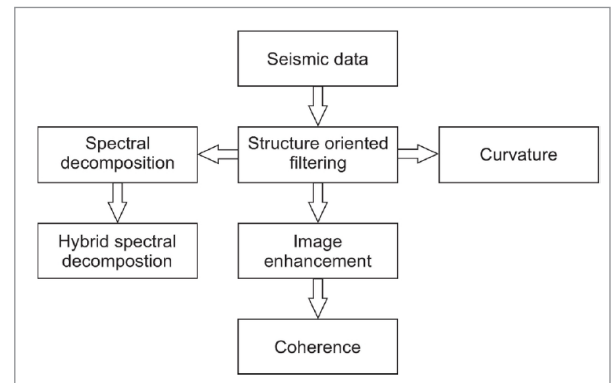
Seismic attenuation can greatly affect the quality of seismic signals perpetuated at great depths. Consequently, mapping carbonate mounds in the Brazilian pre-salt fields, which lie at depths of 5,000 - 6,000 meters, and below an approximately 2,000-meter thick layer of salt, is a major challenge for 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.

SOLUTION
To resolve this issue, a workflow was proposed that would combine hybrid spectral decomposition (HSD) with curvature and coherence geometrical attributes. 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.

> *"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**

Steps used to calculate seismic attributes

Emerson E&P Software

For more information:
www.Emerson.com/EPsoftware

EMERSON™

Spectral decomposition (a), hybrid spectral decomposition (b)

Emerson solutions were used in every step of the workflow: Echos for amplitude gain and structure-oriented filter; 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.

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. 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.

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

RESULTS

Geometric attributes (curvature and coherence) 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.

BENEFITS

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.
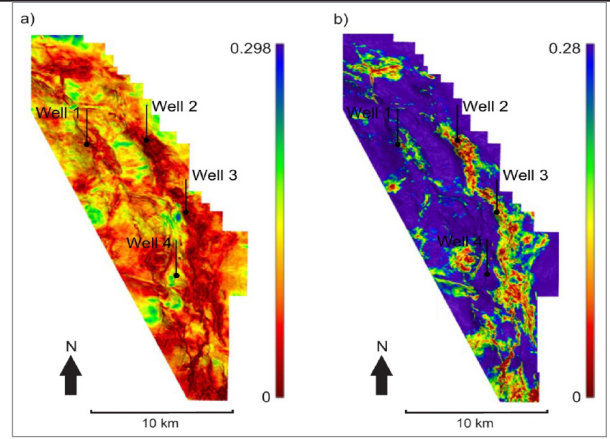
RESOURCES

Based on an article, "Multiattribute framework analysis for the identification of carbonate mounds in the Brazilian presalt zone", by Carlos Jesus (Petrogal Brasil and Universidade Federal Fluminense), Maria Olho Azul (Petrogal Brasil), Wagner Moreira Lupinacci (Universidade Federal Fluminense), Leandro Machado (Emerson)", Interpretation, May 2019
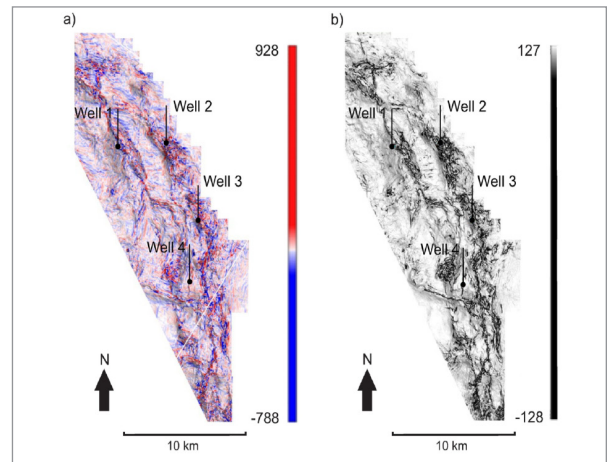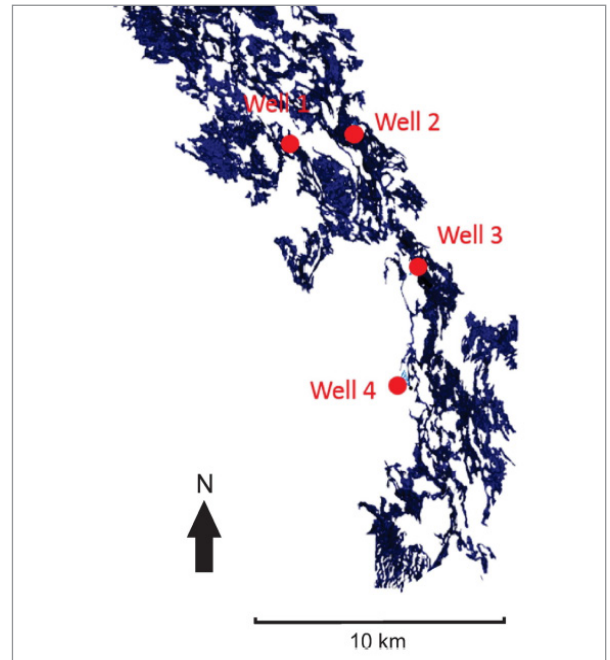
Geobody of carbonate mounds extracted from seismic facies classification