The Campeche Sound area is located southeast of the continental shelf in the Gulf of Mexico and represents about 80% of Mexico’s national oil production. Two major oil fields are in the area, the Cantarell and Ku-Zaap-Maloob fields. They both produce from a Cretaceous carbonate with a complex porous system diagenetically altered through dolomitization, dissolution, and fracturing processes. This reservoir exhibits three main types of porosity: (1) matrix, (2) fracture, and (3) vuggy porosity. However, fracture and vuggy porosities are the main porosity types due to the connectivity of porous volume.

Mapping the associated facies to these porosities is challenging due to the heterogeneous distribution related to the dolomitization process. To characterize the spatial distribution of facies and related porosity of the dolomitic reservoir, analysis of high-resolution 3D seismic was performed on post-stack-time-migrated (PSTM) and post-stack-depth-migrated (PSDM) seismic data. This study includes an elastic inversion and generation of numerous geometrical attributes. The seismic products obtained from the inversion process were used along with the geometric seismic attributes to estimate seismic facies through machine learning techniques such as Artificial Neural Net (ANN), Generative Topographic Maps (GTM), Weighted Linear Combination (WLC), Self-organized maps (SOM), and K-Means. The results obtained were compared to the original facies description from wells in the area as blind-test. Differences between the approach using PSDM and PSTM seismic data were not significant, but, for the Lower Cretaceous interval the inversion performed using PSTM had a much better result.
Using machine learning techniques for mapping dolomitized facies in a triple porosity calcareous reservoir. Campeche Sound, Gulf of Mexico

1. Antonio Cervantes Velazquez, 2Jerson J. Tellez, 1Karelia La Marca and 1Kurt Marfurt
1. School of Geosciences, University of Oklahoma, Norman, Oklahoma

Abstract

The Campeche Sound area is located southeast of the continental shelf in the Gulf of Mexico and represents about 80% of the Mexico’s national oil production. Two major oil fields are located in the area. The Cantarell and the Zaap-Malabo fields. They both produce from a dolomitic carbonate reservoir with a complex porosity system dissectively altered through dolomitization, dissolution, and fracturing processes. This reservoir exhibits three main types of porosity/11 matrix (D-matrix), vuggy (V) and vuggy porosity. However, fracture and vuggy porosities are the main porosity types due to the connectivity of vuggy porosity. Mapping the associated facies to these porosities is challenging due to the heterogeneous distribution related to the dolomitization process. To characterize the spatial distribution of facies and related porosity of the dolomitized reservoir, analysis of high-resolution 3D seismic data was performed on post-stack-time-migrated (PSTM) and post-stack-depth-migrated (PSDM) seismic data. This study includes the products of an elastic inversion, and the generation of numerous geometrical attributes to estimate seismic facies through machine learning techniques, such as Artificial Neural Net (ANN), Generative Topographic Maps (GTM), and Weighted Linear Combination (WLC). The results obtained were compared to the original facies description from a well in the area used as blind test. Differences between the approach using PSDM and PSTM seismic data were highlighted showing important differences for the Lower Cretaceous interval where data for inversion of PSTM data had a much better result.

Workflow

Figure 1: A) The location of the study area and the main structural features in the zone. Study area shows the geological history and some features with the major fields in the Gulf of Mexico, Cantarell, Kuz-Malabo and Zaap. B) Stratigraphic column for the study area and the base well for research. Dolomites generally yield better porosity than the limestones. Porosity is controlled by dolomitization and occurs in the basins of the Upper Cretaceous upper zone (CN). Map of the top of the reservoir. The study area is composed of three fields, named from North to South as A, B, and C. The field A was discovered by the well A-1. The field B has two wells. The discovery well B-1 and an appraisal well B-2/01 that was used as a blind test. The C well has two wells the discovery well C-1, only drilled 1 km inside the reservoir and the appraisal well C-2/CIL.

Study area and stratigraphy

Results

For the ANN model in the PSDM attributes the zones Ku-3 and Ku-2 are successfully predicted as dolomitized, however the zone Ku-2 is predicted as mainly dolomitized (porosity 11 matrix) and zone Ku-3 as dolomitized and Vuggy (V). The results of the blind test well show successful results and predict the formation as dolomitized and Vuggy, except for two wells which are predicted as dolomitized. The WLC model was the next best with the prediction of dolomitized facies. The GTM/WLC combination had the same results obtained in the blind test well were poor with the ANN prediction of dolomitized zones. The GTM model was the most accurate to predict the expected lithologies. The GTM/WLC combination achieved the best results. The limestone interval around the well C-2/CIL was predicted successfully. This results obtained in the blind test well were not failing to predict the limestone in lower section.

Acknowledgements:

This research was done using the AASPI and PSTM workflow supported by Schlumberger at the University of Oklahoma. The data was provided by PEMEX and funded by the National Council of Science and Technology (CONACYT) in Mexico.