Direct seismic modeling of carbonate architectural elements considering the reservoir scale: examples of possible applications in the Brazilian pre-salt fields.

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Abstract

The carbonate reservoirs in the pre-salt section of the Brazilian continental margin are currently the main oil producers. After more than a decade of efforts to explore, develop and produce these reservoirs, geoscientists still face enormous challenges regarding the depositional geometries' characterization and the facies property to build the related internal stratigraphic framework. These challenges basically relate to two main factors: the presence of intrinsic uncertainties in the geological environment, and the uncertainties associated with the available data, especially the seismic data. The pre-salt carbonate reservoirs show great sedimentological and petrophysical heterogeneity, especially due to diagenetic processes. Additionally, the seismic vertical resolution is quite restricted for these reservoirs located at great depths. The non-uniqueness of the seismic signal responses corresponds to a classic limitation of the indirect geophysical methods, leading to produce incorrect interpretations. Despite being very sparse, the well data can be used to mitigate the concerns related to seismic data increasing the vertical resolution. The goal of this work is to apply a direct modeling to generate 2D synthetic seismic images from geological sections containing key different architectural elements for hydrocarbon reservoirs, taking real field´s scales. The results provide a better understanding of the seismic responses of these depositional geometries, as well as assessing the impact of diagenetic processes, and consequently their respective seismic responses. Direct modeling based on depositional geometries and rock properties allows us to relate the seismic facies to the designed geological model. This methodology can improve the analysis of the seismic facies of synthetic seismic data, in comparison with real responses, and to quantify the impact of the main limitations and uncertainties associated with the seismic signal, providing reliable design decisions. Considering the thicknesses observed and synthetically modeled on a field scale, the analysis can help to decide seismic data acquisition modalities and types of necessary processing strategies to increase the accuracy of seismic responses.