Geohazard Characterization in OBN seismic data via high-resolution seismic interpretation and Machine-learning

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Geohazards constitute a risk for both infrastructure on the ocean bottom floor and well drilling stability, which may cause environmental issues. Therefore, hazard risk management may strongly impact economic and environmental safety along Production and Production Development Projects (DP&P) due to preventing a partial or total loss of wells, minimizing drilling costs associated with Non-Productive Time (NPT), and avoiding environmental issues. For instance, the build of a model predictive of hazard has the potential to mitigate risky well trajectory, correct depth of footing, use of the most suitable drill bit types, and weight and type of drilling fluid. Nevertheless, the overburden absence of prior information (e.g., well electric profiles) for pre-salt reservoirs complicates the application of semi or supervised seismic technics to support geohazards model building.

This study aims to improve the seismic hazard characterization using a high-resolution automatic interpretation combined with seismic attributes and unsupervised machine learning models by considering an Ocean-Bottom Nodes (OBN) seismic data as input in a Pre-salt mega field from Santos Basin, Southeast Brazilian margin. Multiples azimuth stack volumes, each highlighting different geological features according to the medium azimuth direction, were interpreted with the software Paleoscan. The semi-automated interpretation allowed the build of an ultra-thin pos-salt model that, aside from the main basin mega-sequences, reveals internal seismic horizons that represent high-resolution geological features variations in the overburden.

Moreover, we applied Variational Auto-encoder deep learning models to seismic pattern recognition considering as input a set of azimuthal pre-stack gathers as independent multi-channel. The VAE algorithm is an unsupervised generative model that also learns efficient data encodings from the seismic data as input (Kingma et al., 2013). Furthermore, unlike an autoencoder (AE) algorithm, the VAE forces the latent variables codes to become normally distributed, making the latent space more continuous and less sparse (Higgins et al., 2021), which brings coded interpretations benefits (Li et al., 2021). Then, a Gaussian Mixture Model (GMM) is applied to fit the data distributions and obtain seismic facies. This integrated strategy improved the recognition of geohazard features registered as severe losses. Also, it accelerates and improves the geohazards model's accuracy significantly, enabling the detection and characterization of previously unobservable hazard features, which is one of the primary applications of this method (Figure 1). This finding has been critical for better budgetary planning of field production, such as improving the allocation of drilling wells.

Figure 1 shows the ultra-thin pos-salt geomodel and geological features highlighted in horizon slices considering the high-resolution stratal framework.

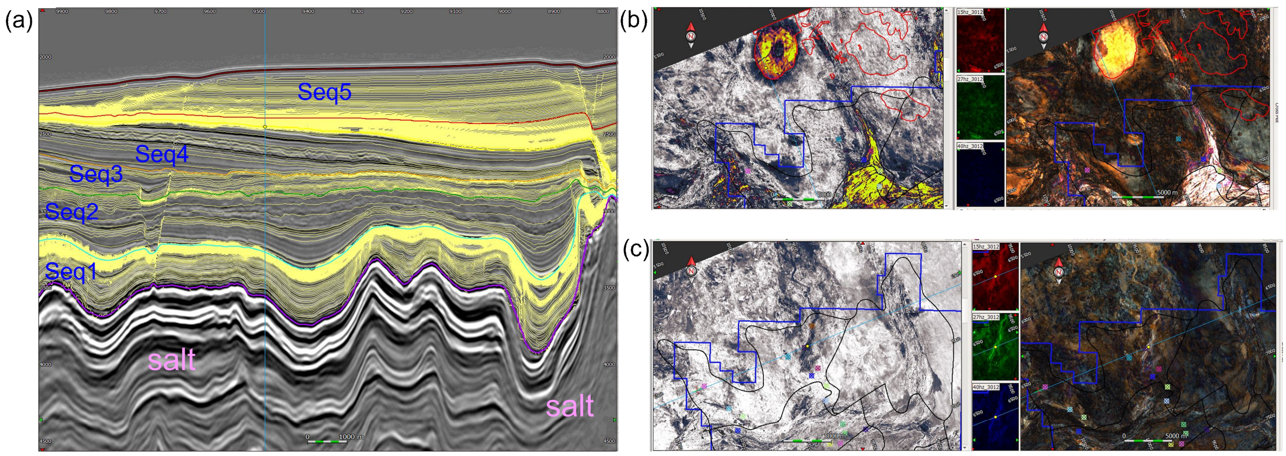

Figure 1: (a) Ultra-thin seismic stratal framework inside the Pos-salt section. Notice that, aside from the main basin mega-sequences, it was possible to individualize internal zones in high resolution. (b) Vulcanic features highlighted using discontinuity and spectral decomposition seismic attributes as considering the ultra-thin stratal framework; (c) Paleochannels geological features highlighted using discontinuity and spectral decomposition seismic attributes as considering the ultra-thin stratal framework.