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Texture Attributes for Machine Learning Classification of Seismic Facies in the Pre-Salt Reservoir of the Santos Basin, Brazil

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Abstract Summary

Most of machine learning approaches for automatic seismic facies classification involve seismic attributes as inputs. It is required that these attributes express some geological feature. However, selecting appropriate attributes can be complex, especially in cabonate settings, due to the large number of available attributes, facies heterogeneities and seismic noise. Additionally, incorporating geologically irrelevant seismic attributes into machine learning training can result in erroneous predictions. In this study, texture attributes were examined using 3D seismic data from the pre-salt carbonate reservoir of the Santos Basin, Brazil. The results demonstrate that these attributes are useful for identifying carbonate build ups, establishing them as potentially valuable for machine learning-based seismic facies classification in pre-salt carbonate reservoirs.

Introduction

In order to build machine learning models for the automatic classification of seismic facies, the selection of appropriate seismic attributes (SAs) as inputs is fundamental. These attributes are required to express some specific geological features. However, this selection is particularly challenging in carbonate settings. It is not straightforward due to the large number of SAs, facies heterogeneities and seismic noise. Increasing the number of attributes without geological calibration during machine learing traning may reduce prediction accuracy. Kalkomey (1997) showed that increasing the number of attributes raises the chance of prediction failure. On the other hand, experience suggests that geometric and spectral attributes perform particularly well in siliciclastic settings. A few studies, including Marfurt and Chopra (2007), have indicated that texture attributes (TAs) can be effective for karst environments. More recently, Machado (2023) showed that TAs can be effective for Bayesian classification of cabonate facies in the Santos Basin. In the present study, TAs including *angular second moment, energy, entropy, homogeneity* and *dissimilarity* have been explored for the detection of cabonate build ups in pre-salt reservoir of the Santos Basin, Brazi, in the Búzios Field (Figure 1).

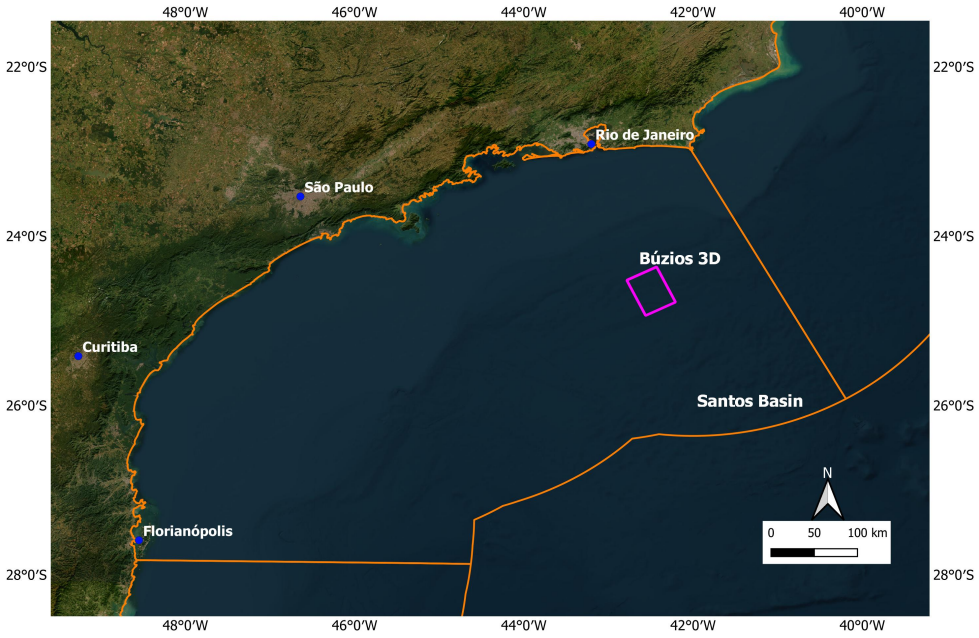

Figure 1: The study area corresponds to the Búzios 3D seismic location in the Santos Basin, Brazil.

Theory

The task of TAs is to capturate the smoothness and/or roughness of seismic images, considering pixel values related to seismic amplitude. Basically, TAs are statistical calculations from a Gray-Level Co-occurrence Matrix (GLCM). GLCM is a tabulation of how often different combinations of pixel brightness values (grey levels) occur in an image (Hall-Beyer, 2017). The implemented TAs were *angular second moment (ASM), energy, entropy, homogeneity* and *dissimilarity*. These were implemented in OpendTect software using the following equations. Consider N as the size of the GLCM matrix, i refers to the column and j to the row, while P represents the GLCM probability matrix.

$$ASM = \sum_{i,j=0}^{N-1} P_{i,j}^2 \tag{1}$$

$$Energy = \sqrt{ASM} \tag{2}$$

$$Entropy = \sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j}) \tag{3}$$

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \tag{4}$$

$$Dissimilarity = \sum_{i,j=0}^{N-1} P_{i,j}|i-j| \tag{5}$$

Results

The application of TAs enhanced the identificacion of seismic facies related to carbonate build ups constituting the pre-salt reservoir in the Santos Basin, within the Búzios Field (Figure 2). Mounded seismic facies were highlighted, particularly by *angular second moment, energy, entropy* and *homogeneity*

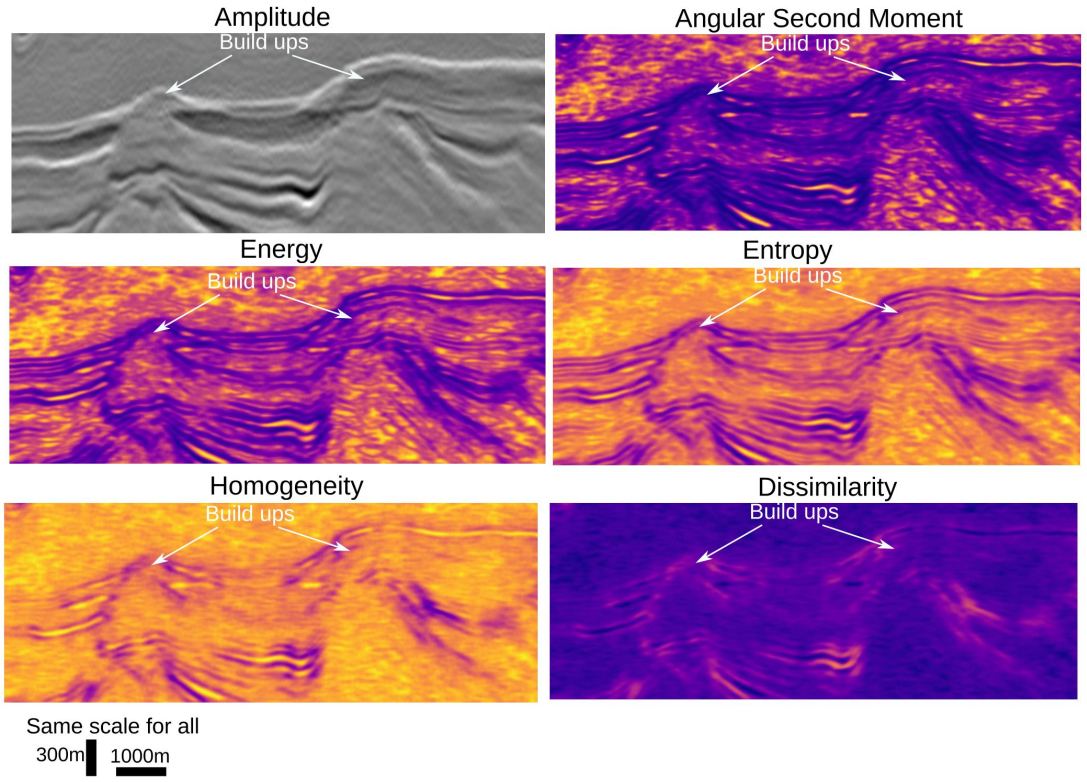

Figure 2: Texture attributes applied to 3D seismic data from the Búzios Field highlighted pre-salt carbonate build ups in the Santos Basin. The upper left corner shows the seismic amplitude.

Conclusions

Selection of SAs to be used as input for machine learning training in seismic facies classification is not straightforward and should be efficient. TAs such as *angular second moment, energy, entropy* and *homogeneity* enhance the identificacion of carbonate build ups in the Santos Basin, offshore Brazil, in the Búzios Field. These results demonstrate that TAs can potentially be used efficiently for machine learning training in pre-salt Brazilian carbonates settings.

Acknowledgments

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