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Estimating Shear Wave Velocity Using Deep Learning and Mineralogical Proportion Logs in the Búzios Field

José Augusto Dias (Grupo de Interpretação Exploratória e Caracterização de Reservatórios), Matheus Nilo (GIECAR), Isadora Dutra (Fluminense Federal University), Wagner Lupinacci (GIECAR)

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Introduction

The shear wave velocity (VS) log is essential for various analyses in the oil and gas industry, particularly for rock characterization, Amplitude versus Offset (AVO) analysis, identification of high-attenuation zones, and distinguishing between pressure and saturation changes in 4D seismic data. However, this log is not always available in the basic well log suite. To estimate VS when it cannot be measured directly, several approaches have been developed, including empirical relationships, laboratory measurements, elastic inversion from pre-stack compressional waves, and machine learning techniques.

Machine learning has become increasingly common in tasks such as well log regression, lithofacies classification, and seismic interpretation. The Búzios Field, covering an area of 852.2 km² with an average production of 639 thousand barrels per day, is currently the largest deepwater oil producer in the world. Therefore, a better understanding of its main reservoirs, Barra Velha, Itapema, and Piçarras, is essential. This work used not only the basic log suite but also mineralogical proportion logs to estimate VS.

Method and/or Theory

To estimate VS, a deep neural network and two classical machine learning methods, XGBoost and CatBoost, were used. The algorithms were implemented in Python. Data from 12 wells provided by Petrobras were used. The input features included density (RHOB), porosity (NPHI), and compressional velocity (VP) logs.

The wells with the highest mineralogical variability,identified based on the calcite, dolomite, and quartz proportion logs, were selected for training. These mineralogical profiles were included as input features to improve the robustness of the models. This allowed the models to be trained on a broader range of geological scenarios, increasing the robustness of the predictions. XGBoost and CatBoost are tree-based supervised machine learning algorithms that are widely used due to their performance and interpretability.

Results and Conclusions

The initial results showed satisfactory performance, with a coefficient of determination (R^2) of approximately 94% when using deep learning. This new methodology, which calculates VS based on mineralogical fractions, has the potential to overcome the limitations of datasets with gaps and may yield better results compared to classical machine learning methods.