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Machine Learning Prediction of Slope Channel Facies Using Outcrop Analog Data, Tres Pasos Formation, Magallanes Basin, Chile

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Abstract

Deep-water slope systems hold significant economic importance as potential hydrocarbon reservoirs. Interpretation of channel architecture from well data is vital to locating zones of high reservoir connectivity for optimal well placement. Antecedent studies use machine learning (ML) to classify facies from measured sections (MS). In this study, > 5000 m of MS data from Cretaceous Tres Pasos Formation outcrops in the Magallanes Basin (southern Chile) are used to test ML detection of facies and channel architecture (i.e., element size and stacking hierarchy). This investigation expands from previous studies to incorporate data from outcrops that are up- and down-dip (up- and down-slope) from the Laguna Figueroa outcrop as well as incorporate additional statistics. The goal is predicting classes that are typically interpreted by a sedimentologist (i.e., facies and architectural) and improving ML interpretation performance with sedimentologic data.

Sedimentological features of each MS are recorded quantitatively in a relational database, including bed count, bed thickness distribution, grainsize distribution, element net to gross, and element amalgamation ratio. This is analogous to information collected from wellbore core. In the MS, facies and architectural position (axis, off-axis and margin) are manually interpreted and all aforementioned statistics grouped into these categories. Laguna Figueroa data (68 MS) with interpreted facies and positions serve as a training set for a neural network to avoid manually interpreting these categories in other MS (>100 additional measured sections). Through a series of algorithm architectures, prediction accuracy is improved until decision performance plateaus. Then, using the expanded database, ML interpretations are generated for each MS varying data density and spatial configuration between different MS. Due to non-uniqueness, the resulting predictions are cast as probabilistic realizations of facies and architectural position for each section. Furthermore, ML decision quality is assessed with confusion matrices for each facies and position classifier. Per class performance thus provides insight into relative feature importance and robustness of predictions.

Sedimentological data is often qualitative in nature and difficult to combine with ML workflows. This project optimizes the use of sedimentologic observations from outcrop analogs into ML predictions to improve subsurface interpretation. New drilling projects often suffer from limited availability of core data, making it challenging to interpret sedimentology directly from logging (1D data). This forces inference into reservoir characterization. These limitations necessitate more robust approaches to interpretation that incorporate aspects of analog datasets. ML, which is already employed in well log interpretation, represents a significant advantage over traditional manual interpretation, which is time intensive and can introduce error and bias.

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