Submission code: MYQLBGVP0A

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Electrofacies Characterization in the Lorena Field, Potiguar Basin, Brazil: Implications for Reservoir Optimization in Mature Field

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Introduction

Lacustrine rift systems host a wide variety of depositional environments and are often marked by high heterogeneity, which presents significant challenges for reservoir modeling and production. In this context, the Pendência Formation in the mature Lorena Field, Potiguar Basin, northeastern Brazil, represents a typical example where tectonic influence and variable accommodation space govern reservoir properties. This study aims to delineate electrofacies and understand their petrophysical implications, thereby supporting more effective hydrocarbon production strategies in shale-rich rift settings.

Method and/or Theory

Geophysical well-log data from 93 wells were analyzed using Petra IHS, Kingdom IHS, and Tnavigator softwares. The logs included gamma-ray, resistivity, density, neutron porosity, acoustic, and caliper responses. A systematic classification approach was applied to define electrofacies based on log signatures and core descriptions.
A Principal Component Analysis (PCA) was conducted using calculated curves of shale volume (Vshale), effective porosity, and permeability. The objective was to reduce data dimensionality and identify consistent log response patterns reflecting reservoir rock characteristics. Clustering of the PCA output enabled the generation of electrofacies, which were then correlated to depositional environments described in core data. This correlation was guided by a Rock Quality Index (RQI), allowing the association of electrofacies to varying sedimentary settings and reservoir potential. This integrated methodology provided a robust framework for understanding lateral and vertical heterogeneity across the field and for predicting areas of enhanced reservoir quality.

Results and Conclusions

Four distinct electrofacies were identified and correlated to specific depositional environments based on the integration of well-log signatures and core sample evaluations. These electrofacies include:
(1) **Prodelta turbidite lobes**, characterized by high gamma-ray responses and significant carbonate cementation, permeability of 2- 3 mD, indicative of low-energy distal settings.
(2) **Delta-front mouth bars** associated - with low shale content and excellent porosity (20 -25%) and permeability of 10 – 20 mD, typical of high-energy distributary settings.
(3) **Estuarine distributary complexes**, showing moderate gamma-ray variability and rhythmic log patterns, consistent with cyclic sedimentation in mixed-energy estuarine environments.
(4) **Sand ridges**, defined by well-sorted sediments and high reservoir potential, representative of reworked nearshore or tidal settings, with porosity over 20% e permeability of 50 mD.

Petrophysical analysis reveals that the deeper intervals, dominated by prodelta lobes, exhibit reduced permeability and are candidates for stimulation techniques such as hydraulic fracturing. In contrast, shallower delta-front deposits present favorable petrophysical properties, allowing efficient primary hydrocarbon recovery with minimal well intervention. These findings contribute directly to reservoir management strategies in mature fields, guiding infill drilling and stimulation planning. This is the first integrated electrofacies analysis conducted in the Lorena Field by the PetroReconcavo Company, offering a valuable model for production optimization in shale-rich lacustrine systems.