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Multiscale Reservoir Characterization in a Marine Transitional Setting: Leveraging Automated Core Data Integration and Digital 3D Outcrop Models

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Abstract

Reservoirs formed in marine-transitional environments, such as estuarine and deltaic systems, exhibit significant heterogeneity due to the interplay of fluvial and marine processes. This study presents an integrated, multiscale approach that combines automated core data analysis from the Middle to Late Jurassic reservoir in the Volve Field, Norwegian North Sea (Volve 15/9-19A and 15/9-19BT2 wells) with the interpretation of 3D photogrammetry modes from Lower Eocene analogue outcrops in the Ager Basin, Spain. The objective is to improve the characterization of heterogeneities, and facies architecture, over vertical and lateral dimensions.

Core data integration combines gamma-ray logs with high-resolution core image analysis and applies a random forest classifier to automate lithological descriptions. Then, these descriptions are refined using thin-section petrography for detailed facies analysis. Facies are then correlated with petrophysical properties such as porosity and permeability. K-means clustering then classifies rock types based on these petrophysical features, enabling reservoir zonation and heterogeneities identification. In parallel, 3D outcrop-model analysis complements core data, providing insight into lateral facies relationships, and stratigraphic continuity. Together, these datasets enable robust facies correlation and upscaling of vertical trends observed in core.

Automated lithological description significantly reduces interpretation time while maintaining consistency and quality. Core analysis delivers high-resolution vertical profiles of lithofacies and reservoir quality; however, its narrow lateral reach constrains broader interpretation. Outcrop analogs address this limitation by offering a wider context to better understand subsurface variability. Integrating core and outcrop observations facilitates the scaling of petrophysical and facies trends, leading to more reliable reservoir models.

This integrated workflow demonstrates the efficiency of machine learning in automating core interpretation and reducing manual workload. Combining analog-based and multiscale data integration improves reservoir prediction and reduces uncertainty. This is particularly effective in marginal marine settings where conventional core and log data are limited or inconclusive. Capturing heterogeneities from core to outcrop scales provides valuable insights into reservoir connectivity and fluid-flow behaviour in clastic systems.

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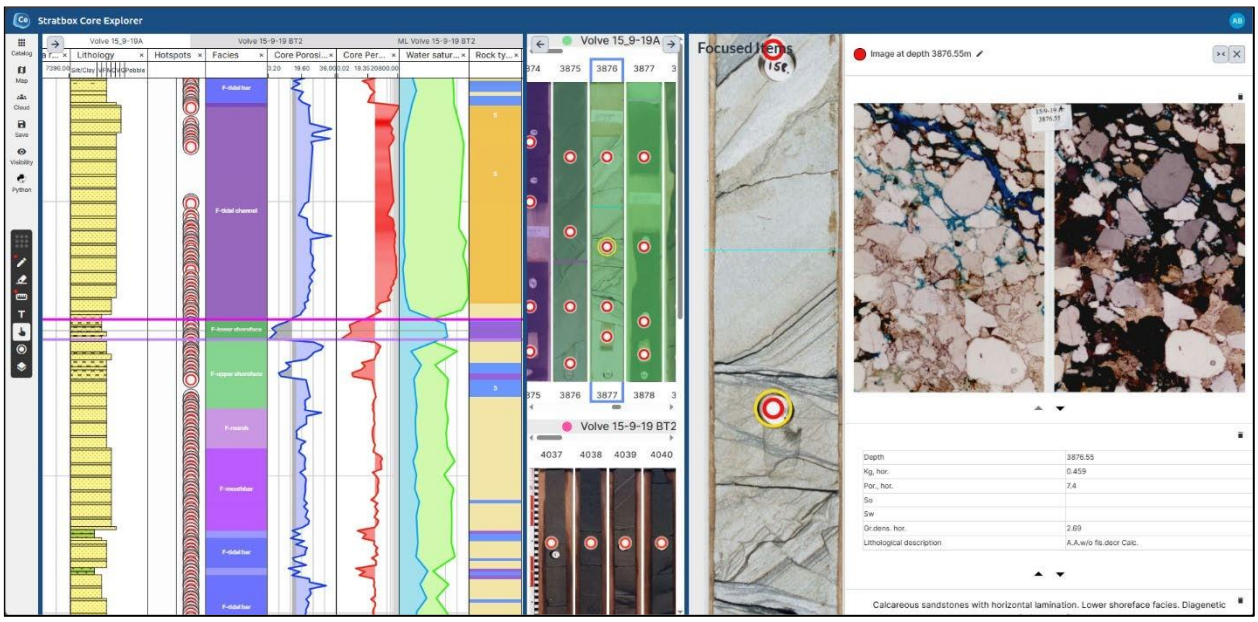

Figure 1. Multiscale integration of Middle to Upper Jurassic reservoir core data using Stratbox Core Explorer.

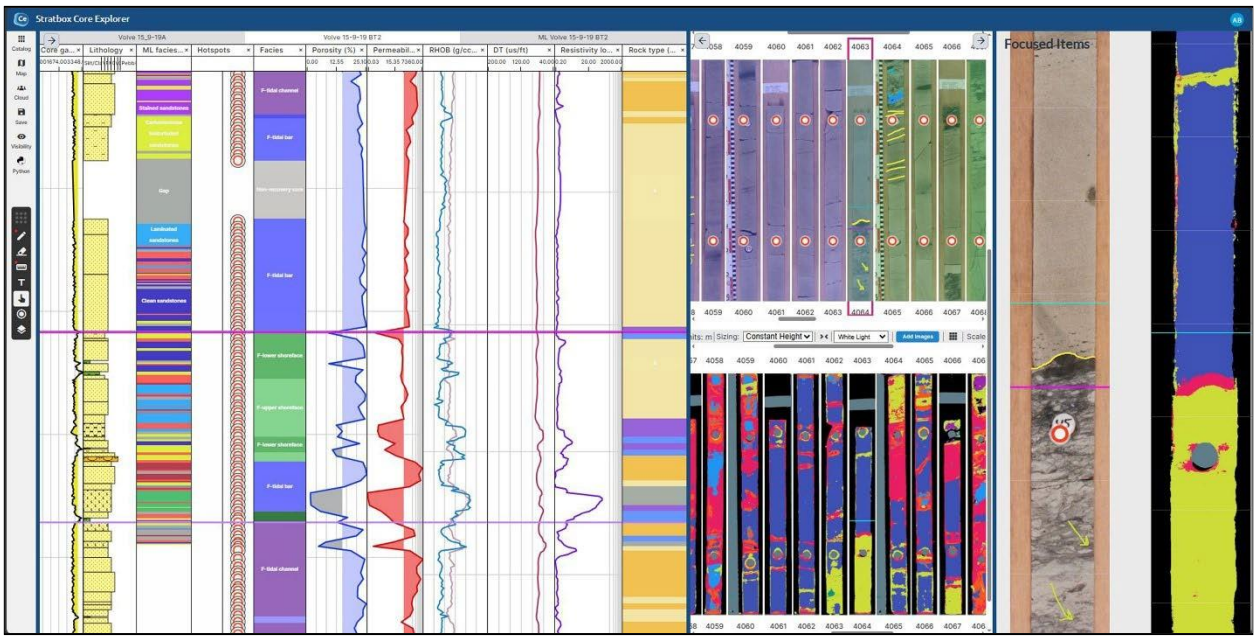

Figure 2. Automated lithological interpretation of the Middle to Upper Jurassic reservoir