

# Frequency-Based Facies Recognition Using Unsupervised Machine Learning

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## Abstract

Stratigraphic traps are widely prevalent in petroleum basins; yet their characterization remains an elusive challenge to exploration geoscience, particularly in geological frontiers where data is sparse. This study aims to improve facies recognition and stratigraphic trap characterization of a carbonate depositional system on seismic using AI-guided frequency-based attribute analysis.

The novel workflow employs a cascade of constrained least square spectra analysis (CLSSA) and variational Bayesian Gaussian mixture model (VB-GMM) to recognize sedimentary facies. The CLSSA is chosen for its unique formulation of spectral analysis as a constrained inversion problem, which offers superior temporal and frequency resolution over traditional spectral decomposition methods, while VB-GMM is used for its advanced clustering technique of monofrequency slices. The facies prediction workflow involves the following steps: 1) Loading the seismic data and target surface, displaying the general spectrum to determine the frequency range for spectral decomposition, and defining the extraction window; 2) Performing spectral analysis to generate multiple frequency slices using CLSSA; 3) Machine learning classification of monofrequency slices using VB-GMM to generate a facies classification map; 4) Geological validation by analyzing the relationship between a geologic feature and the facies classification map.

This workflow was used to map the facies of the late Jurassic carbonates of the Arabian basin, which primarily consist of interbedded successions of calcarenite and anhydrite units. Geologic validation of the study area is ongoing with good correlation between the initial ML-generated classification map and well logs, allowing for facies discrimination by porosity and lithology. Therefore, this technology has the potential to unlock new play concepts and reduce reservoir risk for prospect generation. To improve the geological validation process, core data integration is recommended within a sequence stratigraphic framework.