# Abstract

Geological faults are the discontinuities in rock formations caused by relative movement of blocks. Faults are crucial for identifying potential hydrocarbon reservoirs and determining the optimal direction for drilling wells. However, manual interpretation of seismic data is time-consuming and labor-intensive, mainly due to significant variations in the data. Intelligent computerized algorithms are necessary for every oil industry to deal with such problems.

In recent decades, the use of multi-attribute analysis has revolutionized seismic data interpretation, offering efficient methods for seismic fault detection. The first part of the thesis deals with the determination of an optimal attribute combination of various attribute sets. Initially, we employ a series of processing steps such as dip-steered median filtering to enhance the resolution of the input seismic volume. To perceive subtle and minor faults, we utilize a saliency approach in conjunction with the directional center-surround model. This involves decomposing the $3D$-FFT spectrum of the curvature attribute and application of Log-Gabor to enhance fault visualization. Further, a conventional structure tensor is constructed based on the smoothed outer products of the directional derivatives. We calculate directional derivatives perpendicular and parallel to seismic structures using eigenvectors of the structure tensor. This produces a directional structure tensor aligned with dipping directions, capturing subtle discontinuities in the volume. The same process is repeated for the analytic structure tensor, which is obtained by the Hilbert transform of a seismic volume. Finally, we utilize the eigenvector associated with the dominant eigenvalue of the directional structure tensor to calculate crossline and inline structural dip. The resulting dip images exhibit clear and continuous fault characteristics.

Furthermore, facies categorization is crucial for reservoir characterization, but it is challenging to extend it across the full reservoir due to the absence of precise data far away from the well. Therefore, it is essential to combine lithofacies categorization with well-log data. Integrating lithofacies categorization with well-logs enable comprehensive classification of the entire reservoir model. In this work, we adopt a modified support vector machine algorithm for facies classification to address the issue of a highly imbalanced dataset. We break down the classification task into two stages for reducing complexity and impose a different penalty term for each lithofacies class to balance class accuracy. Additionally, we investigate the identification of bed boundaries, which is crucial for geophysical interpretation in reservoir analysis, particularly in locating hydrocarbon-filled zones. This approach enables us to accurately distinguish between different lithofacies, including the identification of thin sediment layers that may contain water or hydrocarbons in complex shaly environments. The results obtained from our study demonstrate the effectiveness of our approach in improving the accuracy of facies classification.

**Keywords**: Geological fault detection, Seismic attributes, Visual saliency, Gradient structure-tensor, Lithofacies classification, Regularization parameter, Multistage classification.