-Resolution Lithofacies Prediction Using CWT-Enhanced Seismic Attributes and Gradient Boosting: A Case Study from the Lower Goru Formation

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ATTRIBUTE ASSISTED SEISMIC PROCESSING AND INTERPRETATION

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Summary

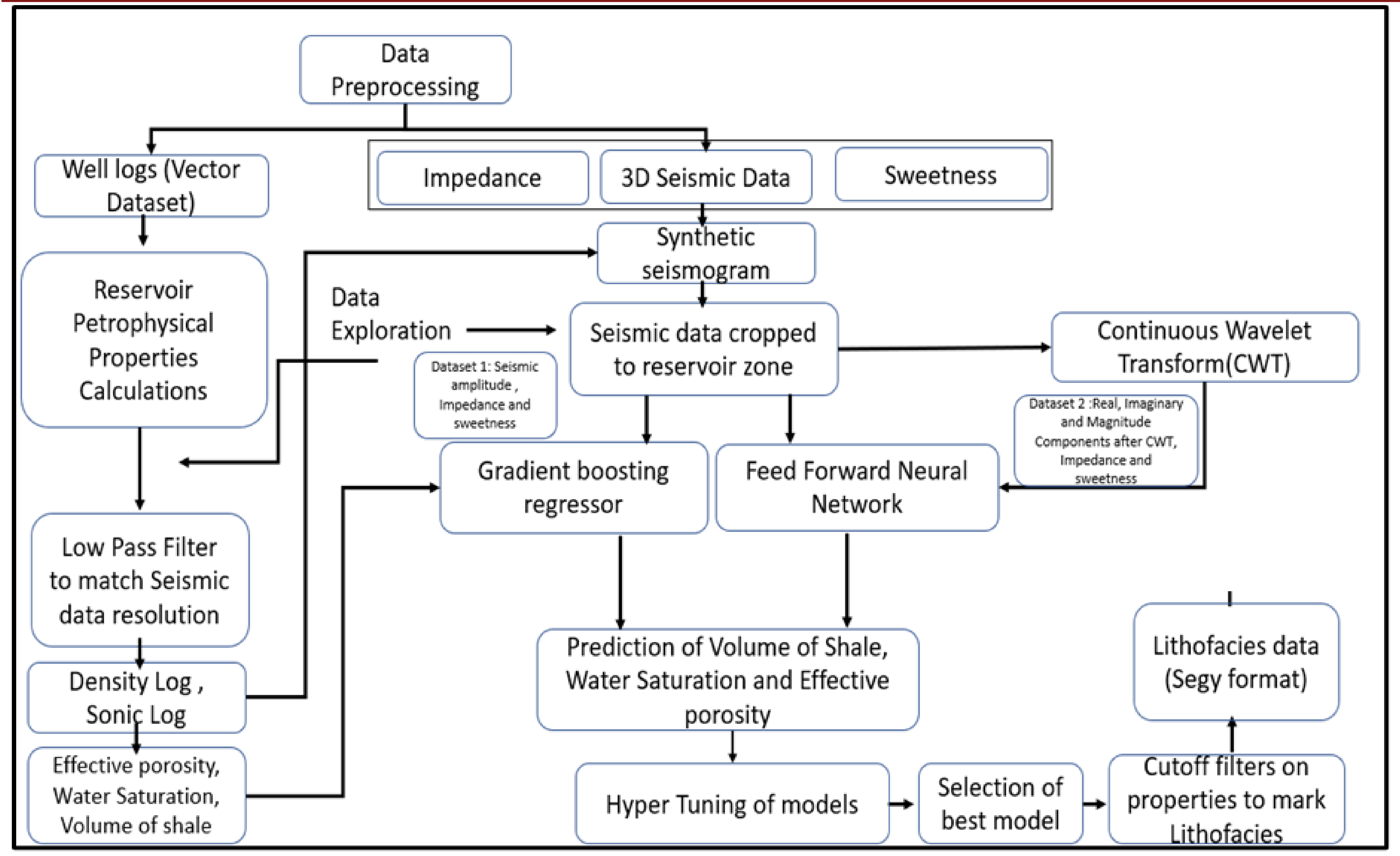
Finding oil and gas requires accurately identifying rock layers thousands of feet underground – but traditional seismic methods often can't distinguish thin sand and shale layers that control where hydrocarbons flow. We apply Continuous Wavelet Transform (CWT) to enhance seismic resolution, then uses Gradient Boosting Regression (GBR) and Feed-Forward Neural Networks (FNN) with seismic attributes like sweetness and acoustic impedance to achieve over 97% accuracy in lithofacies prediction. Testing on Pakistan's Lower Goru Formation in the Sawan Field demonstrates a new workflow that reduces drilling risk and provides exploration teams with reliable, web-based reservoir characterization tools.

Introduction and motivation

Every oil well is a multi-million dollar gamble on subsurface geology. Conventional seismic imaging struggles to resolve thin interbedded sand-shale sequences in clastic depositional environments – layers often just meters thick but critical for hydrocarbon accumulation. Traditional seismic-to-well workflows rely heavily on interpreter experience when correlating seismic attributes with petrophysical properties, introducing subjectivity that can lead to costly drilling mistakes.

Machine learning algorithms excel at recognizing nonlinear relationships between seismic data and rock properties that humans might miss. Gradient Boosting and Neural Networks can reliably connect multi-attribute seismic volumes (sweetness, impedance, spectral decomposition) to actual lithofacies and reservoir properties. **When combined with CWT enhancement that improves vertical resolution beyond conventional processing limits, these methods offer exploration teams more confident drilling decisions and reduced exploration risk in heterogeneous reservoir systems.**

Methodology



Results and discussion

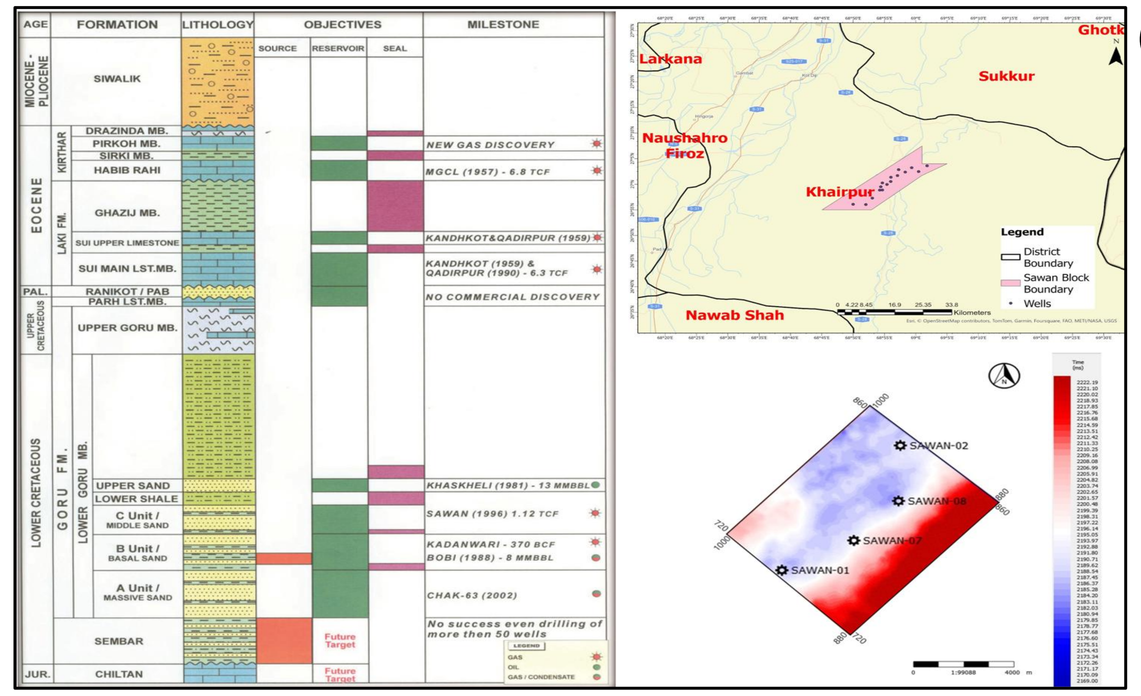


Figure 1. Regional stratigraphy, Sawan Block extent, and reservoir time-structure map providing geologic and structural context.

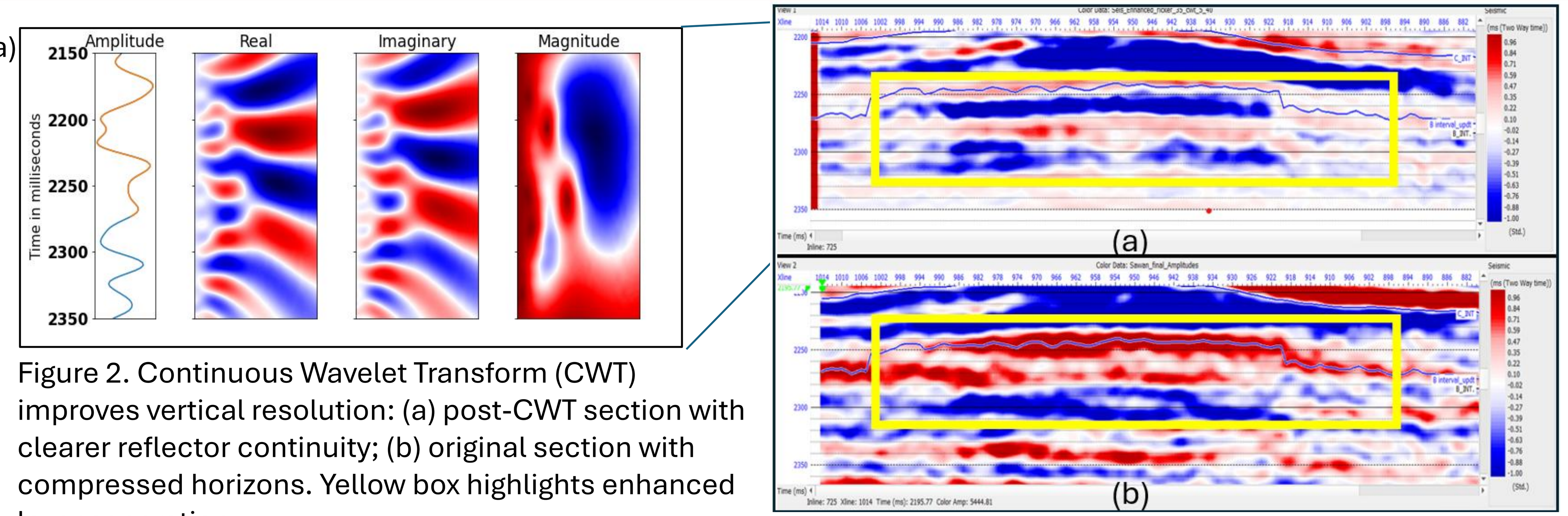


Figure 2. Continuous Wavelet Transform (CWT) improves vertical resolution: (a) post-CWT section with clearer reflector continuity; (b) original section with compressed horizons. Yellow box highlights enhanced layer separation.

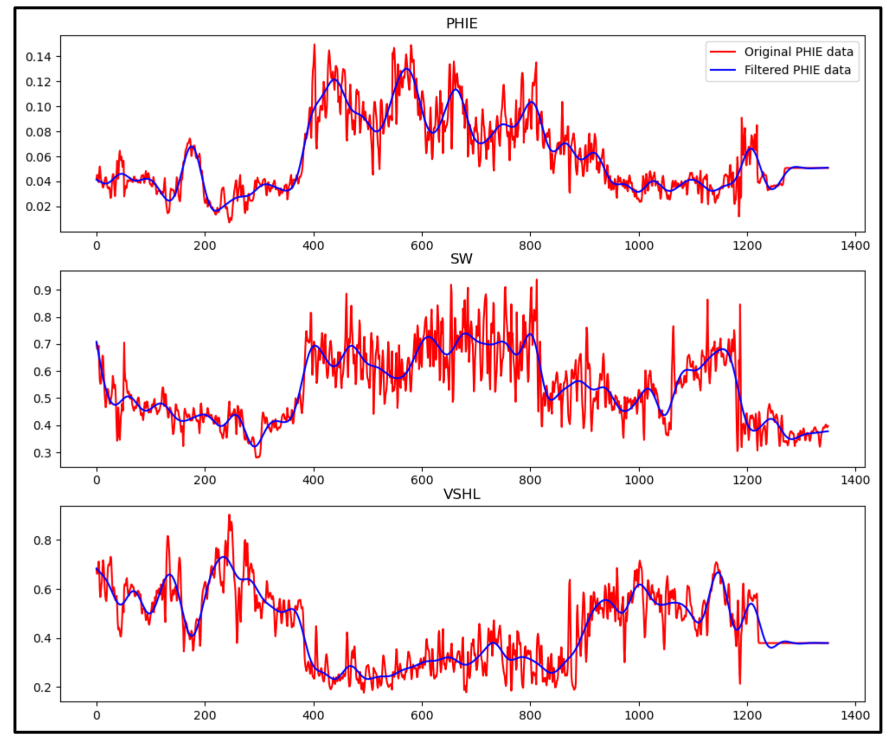


Figure 3. Application of a low-pass Butterworth filter to petrophysical logs for resolution matching with seismic data. Red curves represent the original high-frequency response, while blue curves show the smoothed logs after filtering.

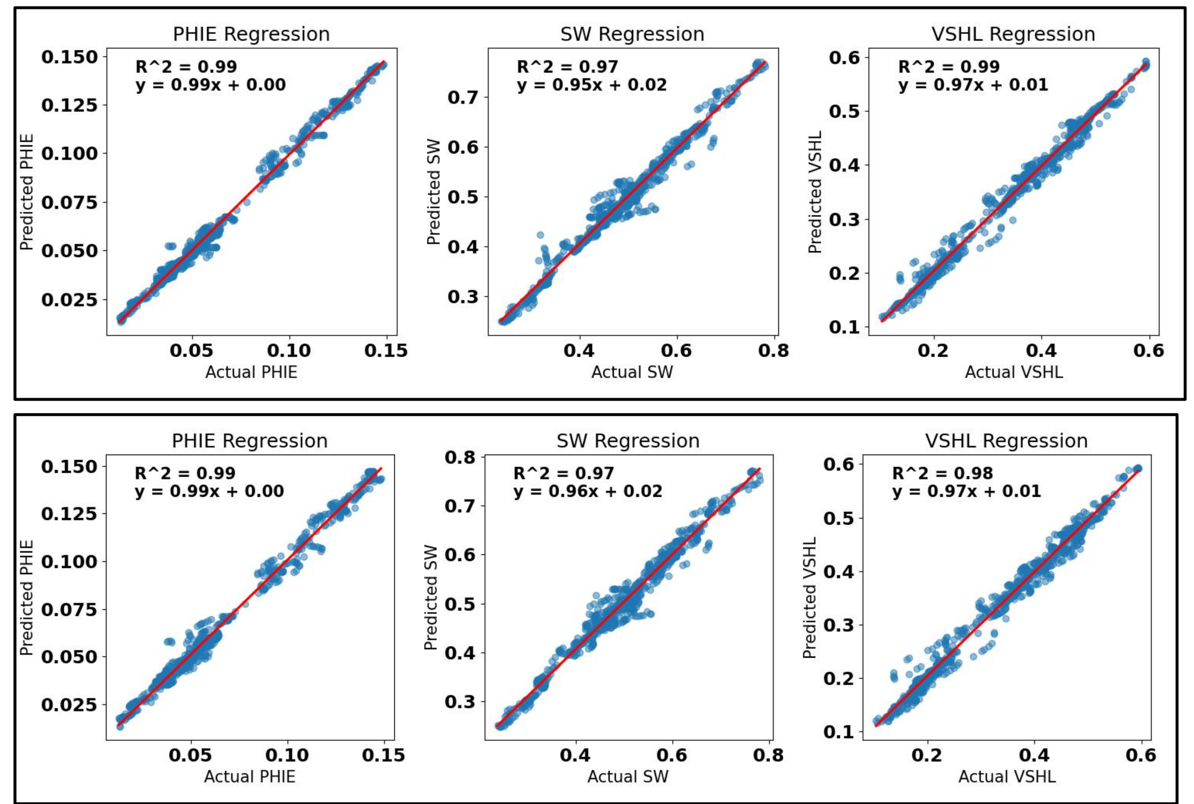


Figure 4. Scatter Plot for R^2 of GBR (a) and FNN (b)

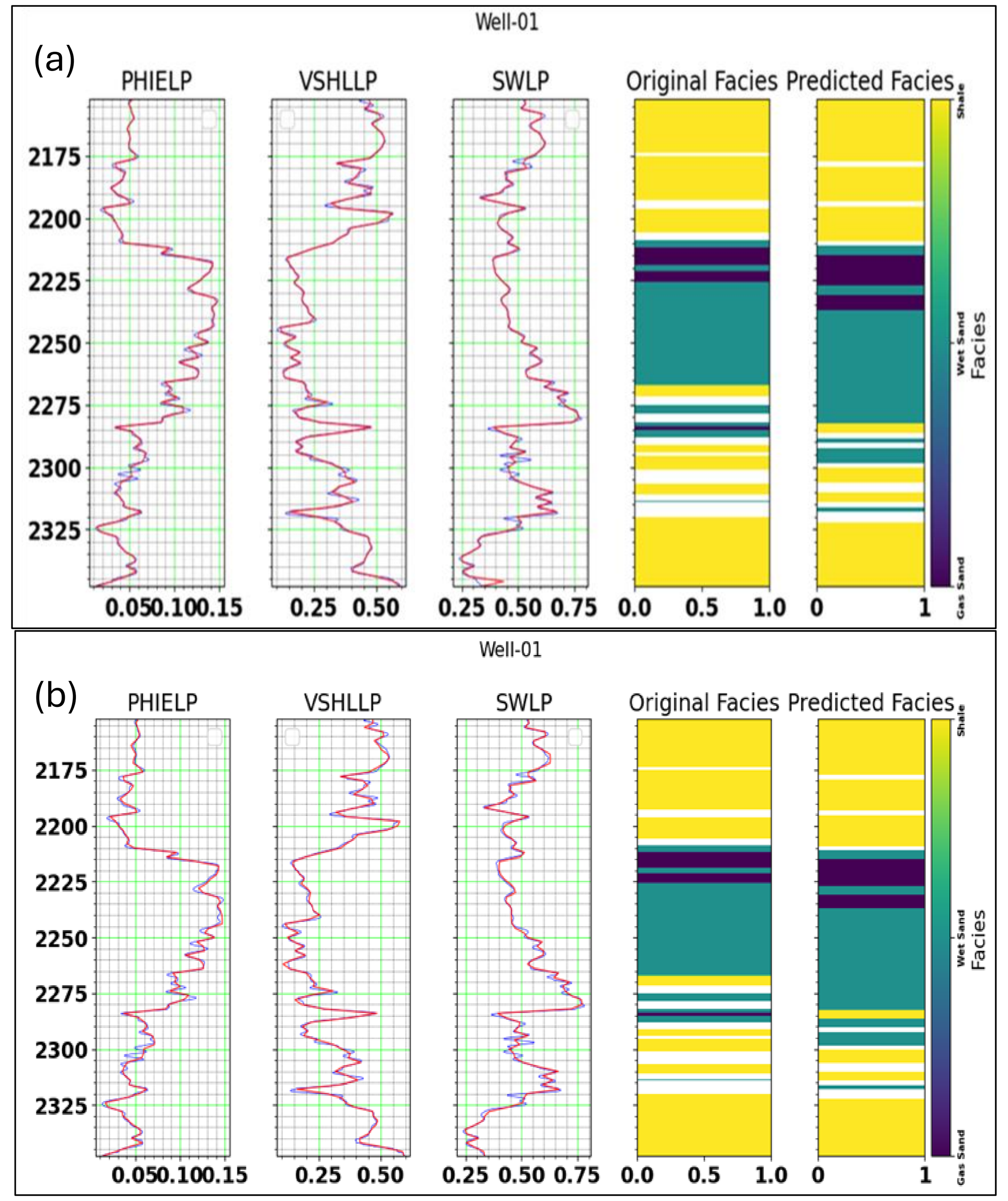


Figure 5. Lithofacies prediction at Sawan-1: (a) GBR results; (b) FNN results.

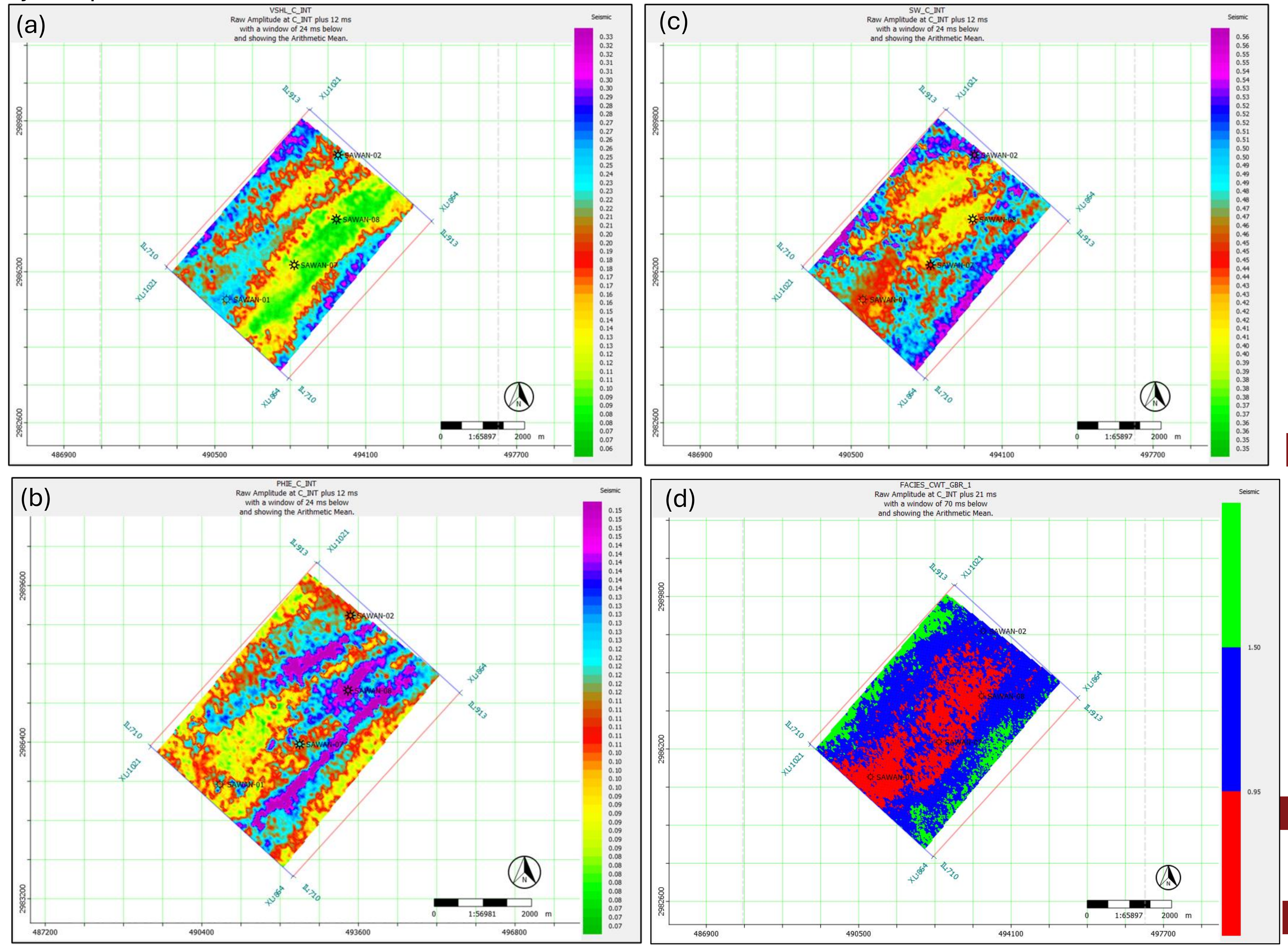


Figure 6. GBR-based predictions: (a) shale volume, (b) effective porosity, (c) water saturation, and (d) lithofacies map showing gas sands in NE and SE sectors.

Conclusion

This CWT-enhanced machine learning approach successfully resolves thin-bed geological complexity that has long challenged seismic interpretation. The integrated workflow delivers superior prediction accuracy for shale volume, effective porosity, and water saturation while reducing interpretation uncertainty in complex clastic depositional systems. **By combining advanced signal processing with robust machine learning algorithms, this research provides exploration geophysicists with both improved technical methods and practical web-based visualization tools for more reliable reservoir characterization and optimized drilling programs.**

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References

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