Characterizing Mesozoic Strike-Slip Faults in China's Tahe Oilfield: A Multi-Method Comparison from Traditional Seismic Attributes to AI

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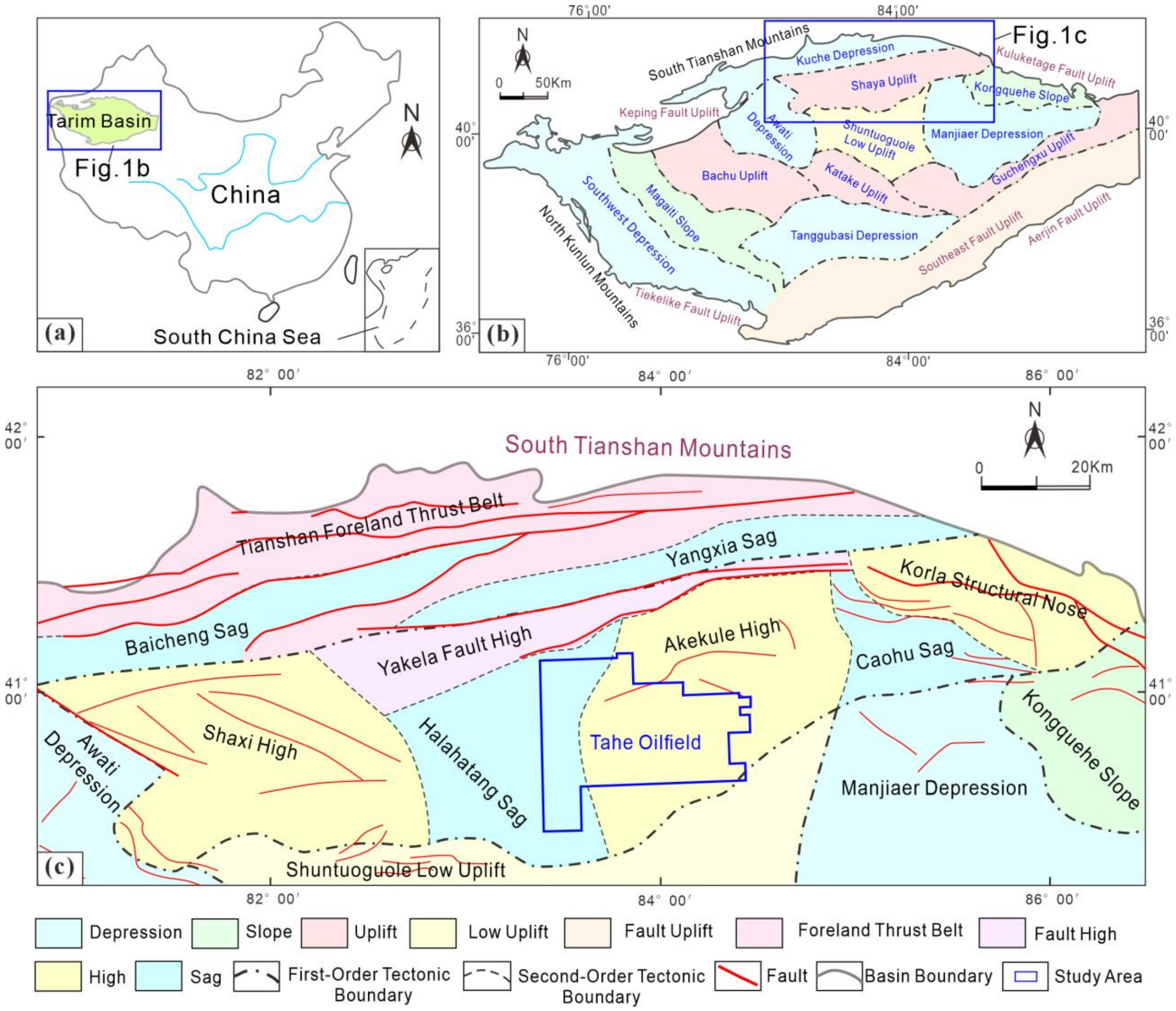
➤ Background

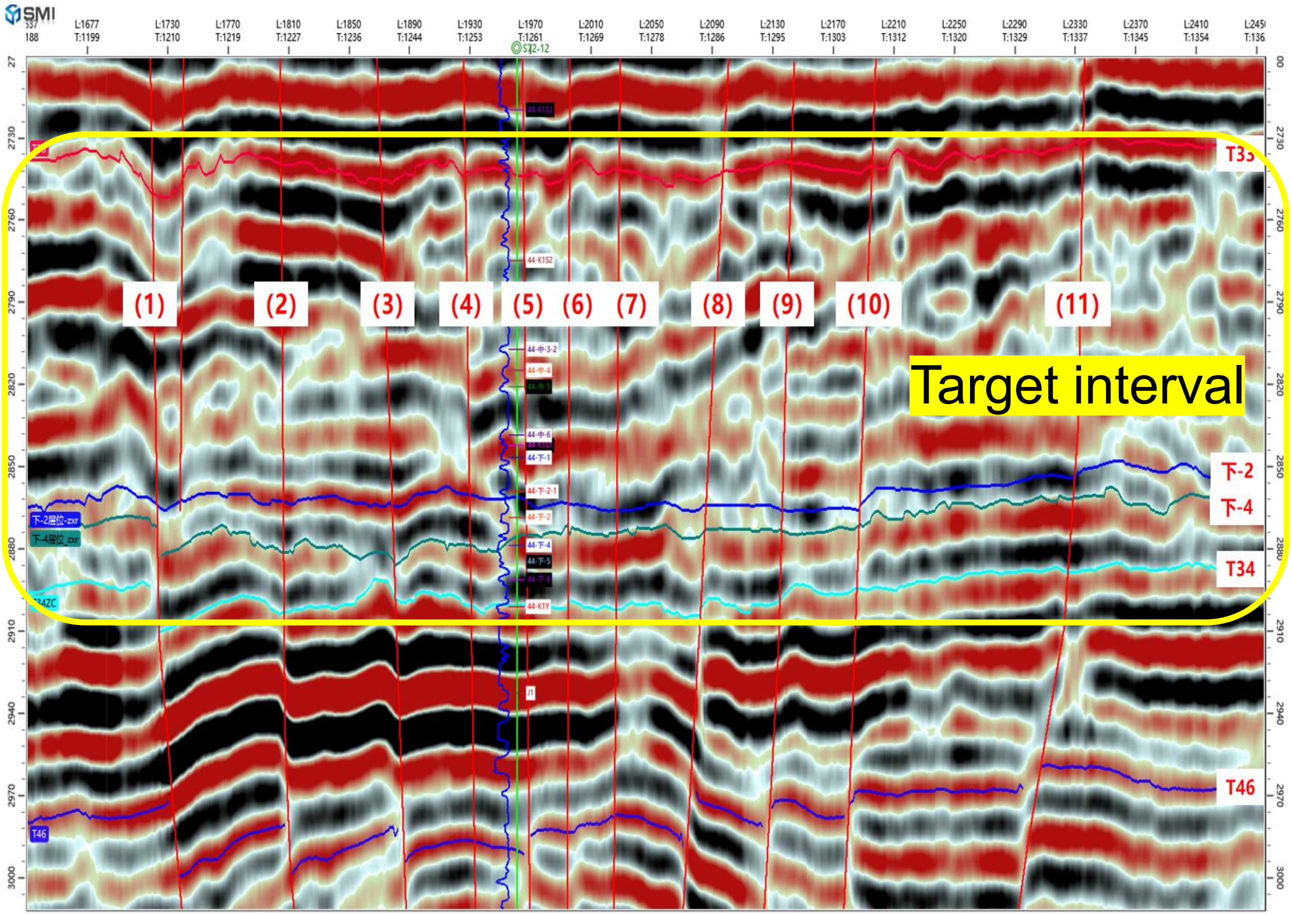


Regional location map of Tahe Oilfield, Tarim Basin

Research Background

- Tahe Oilfield, NW China
- Mesozoic clastic reservoirs
- Strike-slip faults control hydrocarbon migration

Challenges



Seismic Responses of Mesozoic Strike-Slip Faults in the Tahe Oilfield

Key Challenges

- Low impedance contrasts → weak reflections
- Steep dips & small throws → ambiguous signals
- Manual interpretation: inefficient & non-unique

Objective

Systematically compare conventional seismic attributes vs. AI-based fault probability volume for strike-slip fault detection in the Tahe Oilfield.

Evaluation Criteria

- Fault boundary clarity
- Detection of secondary faults
- Geological plausibility
- Noise resistance & continuity

Workflow Overview

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Input Data

3D seismic volume data cube

Preprocessing

Structure-oriented filtering (SOF)

Parallel Analysis Paths

Conventional

Coherence, Curvature, Likelihood

AI-based

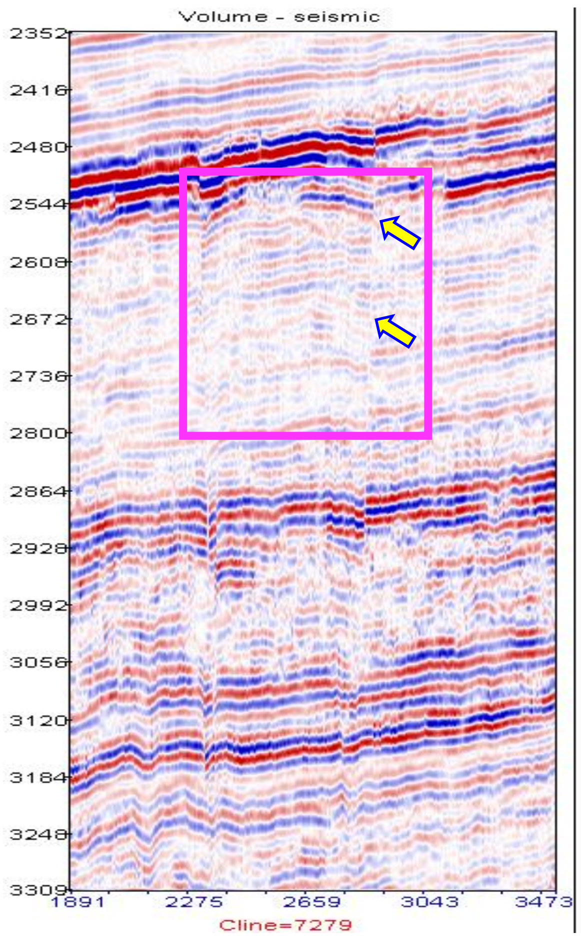
ResU-Net + Transfer Learning

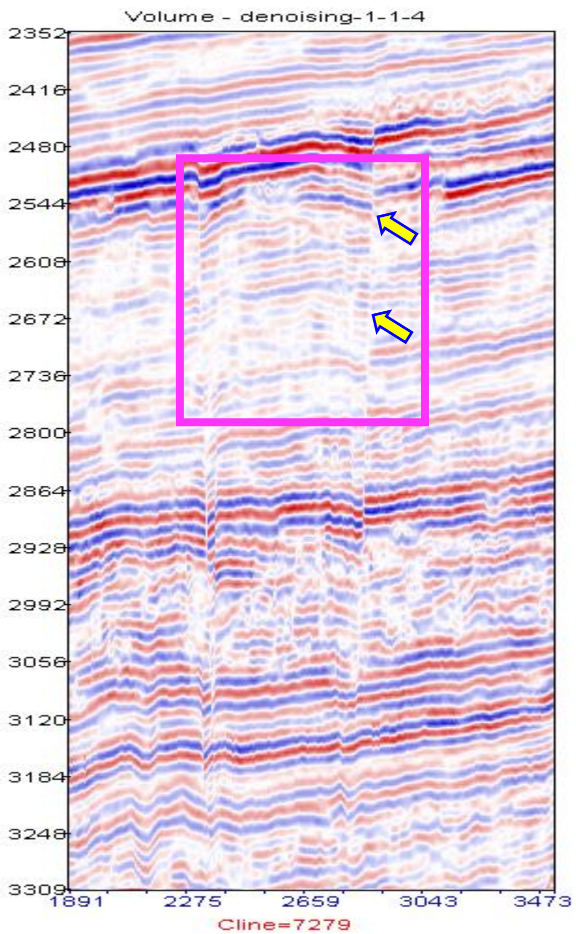
Output & Optimization

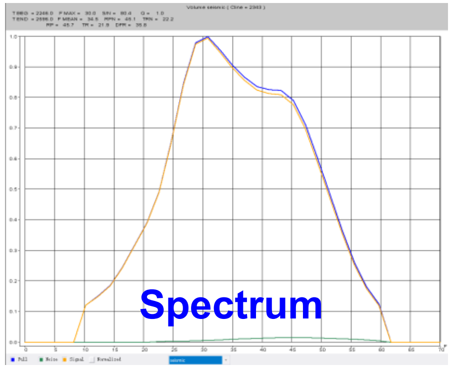
1. Generation of Fault Probability Volumes from both paths.
2. Direct comparison of results to identify discrepancies.
3. Final optimized interpretation incorporating the best features of both methods.

This integrated workflow leverages the speed of AI with the interpretability of conventional attributes for robust subsurface fault detection.

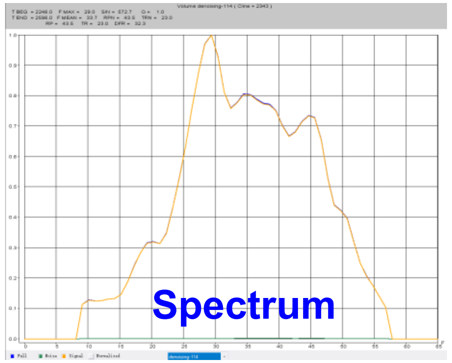
➤ Structure-Oriented Filtering







Before Filtering



After Filtering

Before Filtering
Low S/N, Disrupted Continuity.

After Filtering
High S/N, Continuous Events.

Key Functions of Filtering

Continuity Enhancement
Improves lateral continuity of seismic events

Discontinuity Preservation
Retains fault-related geological features

Noise Suppression
Eliminates random background noise

"Improved S/N ratio and event continuity for subsequent analysis, ensuring reliable attribute calculation and AI model training."

➢ Conventional Seismic Attributes

Attribute	Principle	Limitation
Coherence	Measures waveform similarity across traces	Highly sensitive to random and coherent noise
Curvature	Quantifies strata bending and flexure	Primarily captures large-scale folds, limited resolution
Ant Tracking	Agent-based foraging algorithm for line detection	Prone to redundant artifacts and poor lateral continuity
Likelihood	Measures deviation from a seismic reflection trend	Difficult to distinguish main faults from secondary fractures

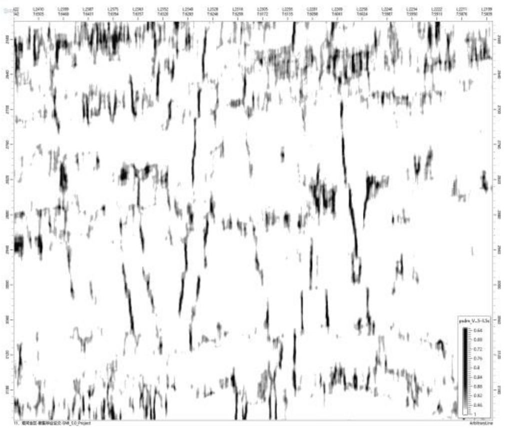
Typical Output Characteristics (Schematic)

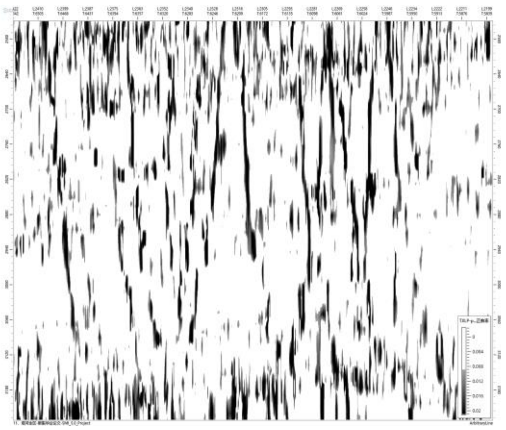
Coherence
Sharp discontinuities

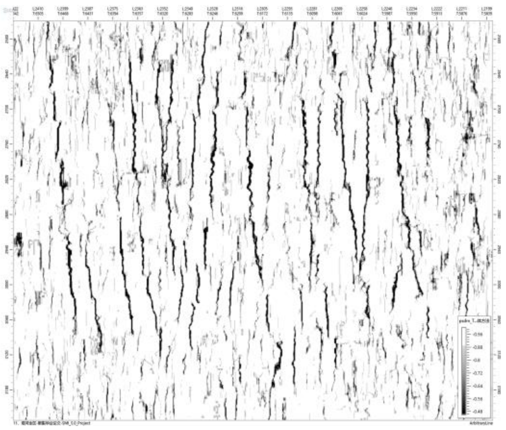
Curvature
Curved structural features

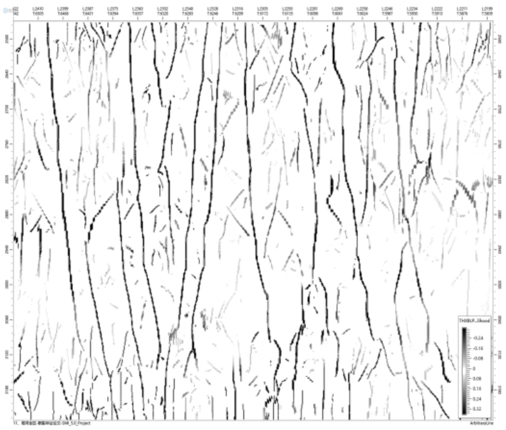
Ant Tracking
Linear fault traces

Likelihood
Trend deviation map

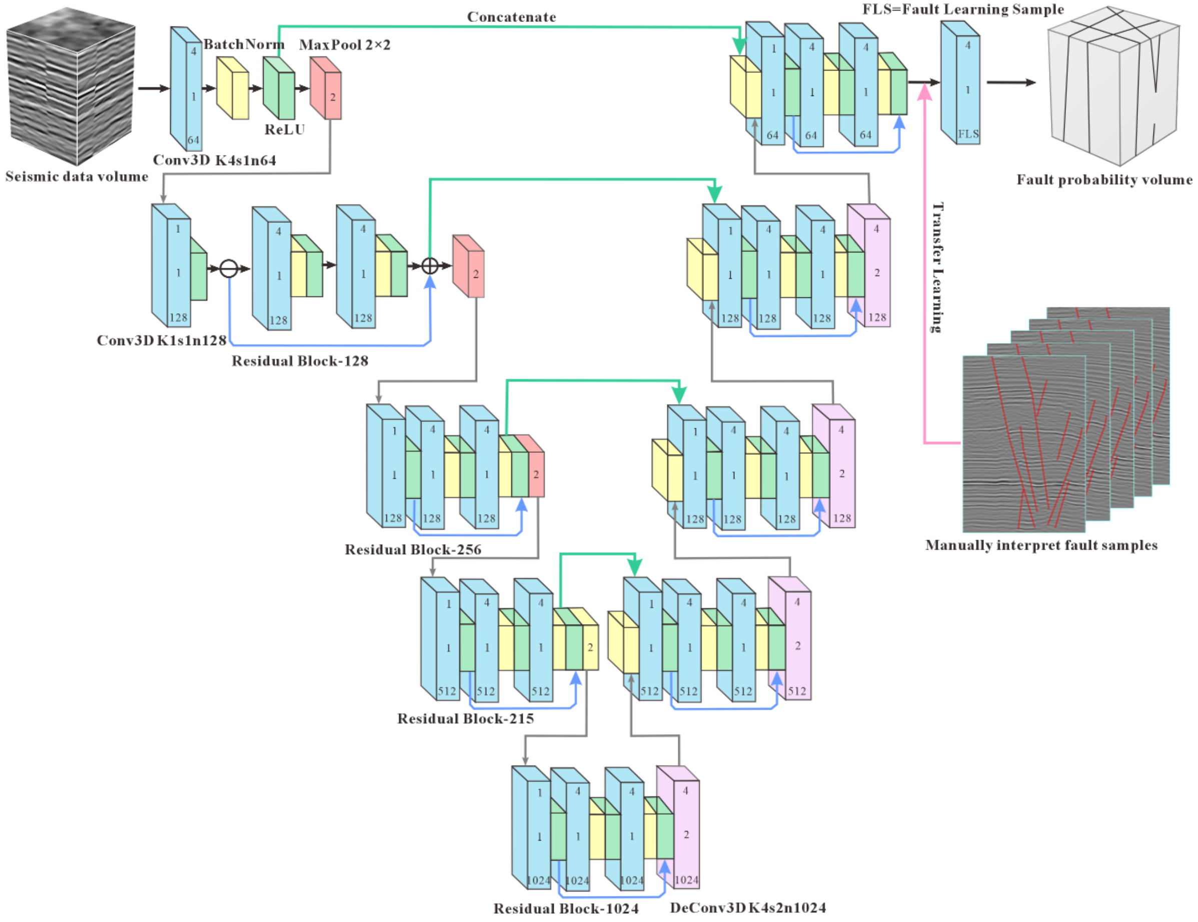








➢ AI Model: ResU-Net Architecture



ResU-Net Network Structure

Architecture

U-Net encoder-decoder + ResNet residual connections (>100 layers)

Pre-training Data

>1×10^5 synthetic & real seismic samples from diverse geological settings

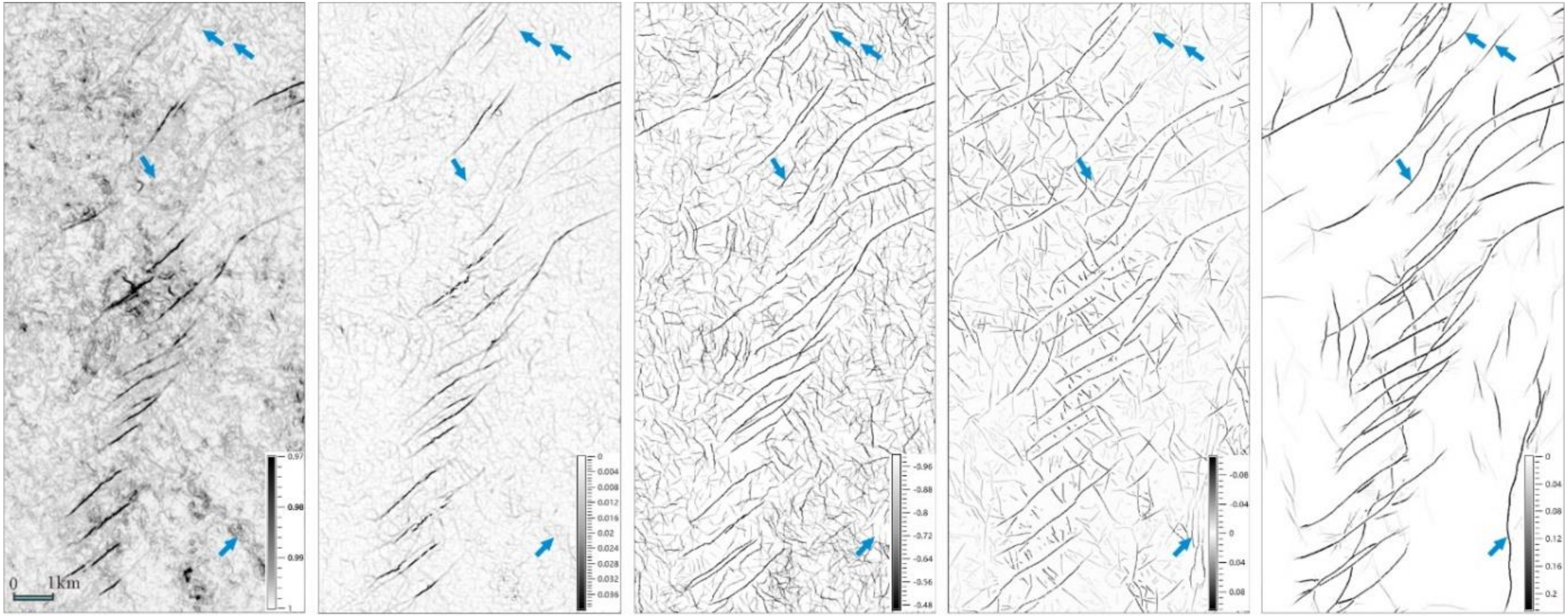
Transfer Learning

Fine-tuned with 65 manual fault traces (Tahe Oilfield, 20% validation)

Model Output

Fault probability volume (0–1) indicating the likelihood of fault presence

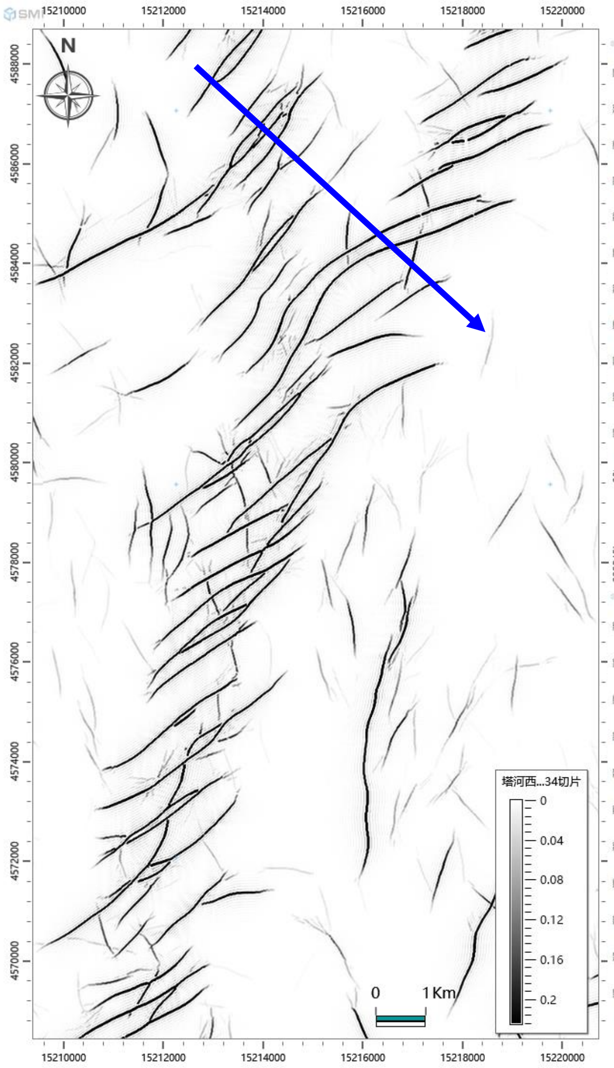
➢ Results: Fault Detection Along T34 Horizon

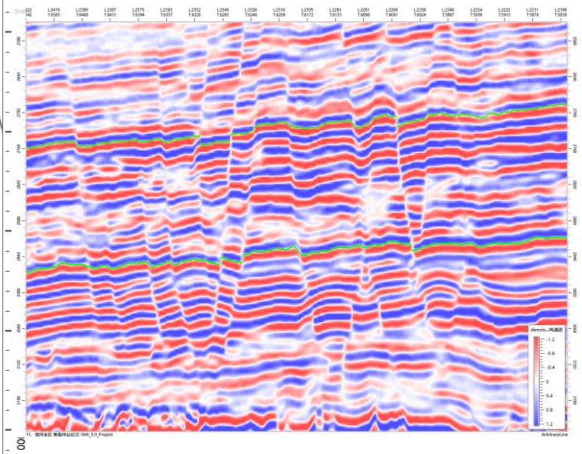


(a) Intrinsic Coherence (b) Maximum Curvature (c) Ant Body (d) Likelihood (e) ResU-Net

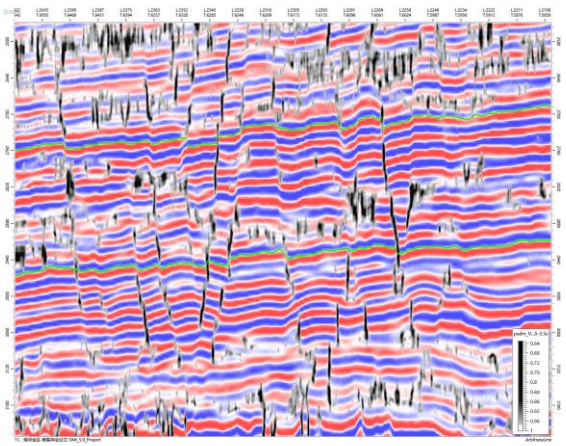
(a)	(b)	(c)	(d)	(e)
Major faults only, noisy	Large-scale features, misses secondary faults	Fragmented, high redundancy	Linear but with false positives	Continuous, clear boundaries, detects subtle faults

➢ Results: Fault Identification Profile Comparison

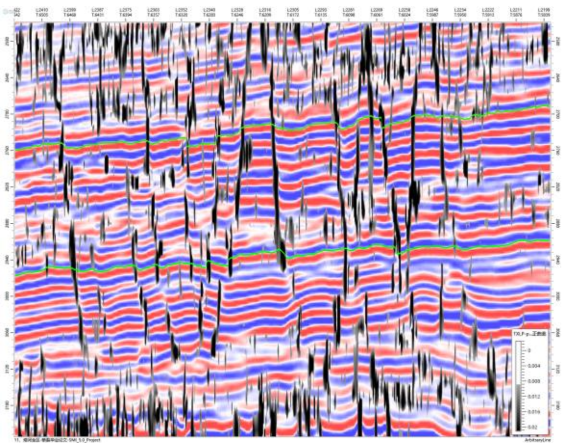




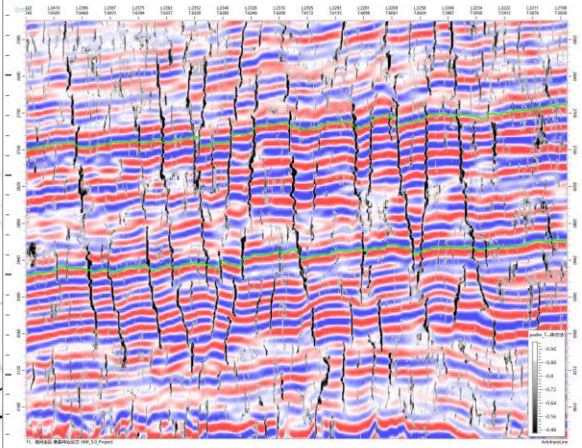
Raw Seismic Profile



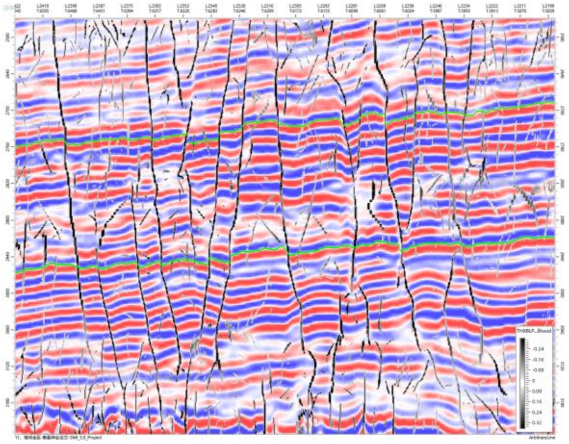
Intrinsic Coherence



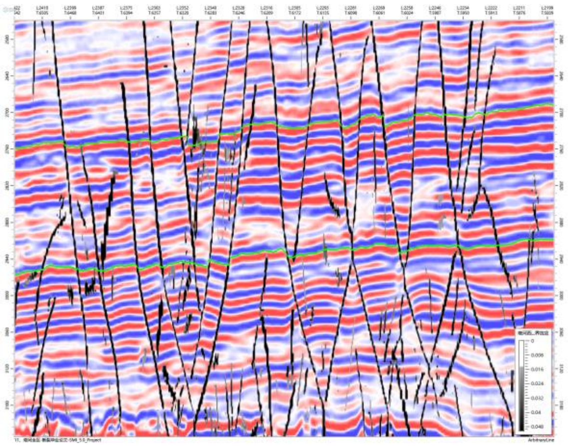
Maximum Curvature



Ant Tracking

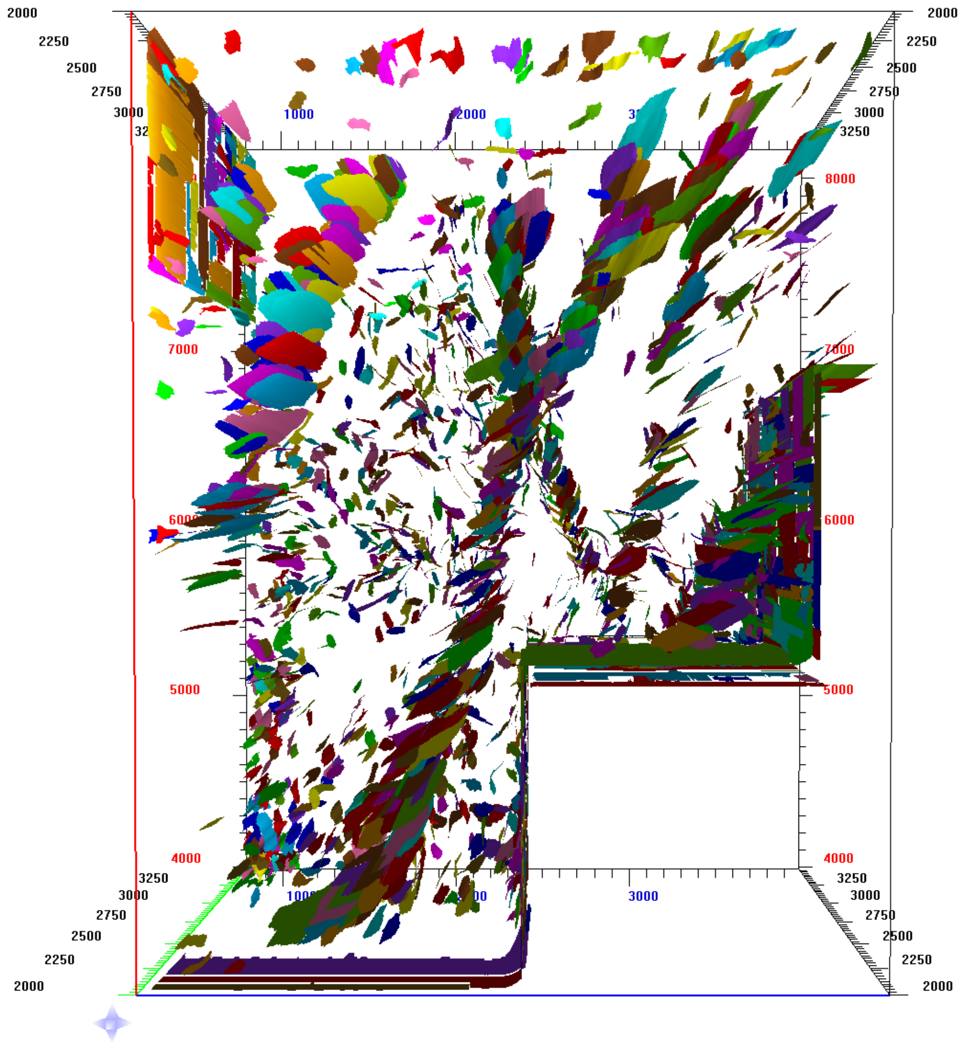


Likelihood



ResU-Net

Results: 3D Fault Surface Extraction



3D Visualization of Extracted Surfaces

AI-Driven Automatic Extraction

Directly derived from AI probability volumes, eliminating manual interpretation bias and significantly reducing processing time.

Geologically Plausible Closed Models

Generates structurally consistent and closed fault surfaces that adhere to geological principles, avoiding non-physical artifacts.

Foundation for Reservoir Modeling

High-quality fault models serve as critical input for accurate reservoir characterization and hydrocarbon prediction workflows.

Performance Comparison

Method	Continuity	Noise Resistance	Small-Fault Detection	Geological Plausibility
Coherence	★★☆☆☆	★★☆☆☆	★☆☆☆☆	★★☆☆☆
Curvature	★★☆☆☆	★★★☆☆	★☆☆☆☆	★★☆☆☆
Ant Tracking	★☆☆☆☆	★☆☆☆☆	★★☆☆☆	★☆☆☆☆
Likelihood	★★☆☆☆	★★☆☆☆	★★★☆☆	★★☆☆☆
AI (Ours)	★★★★★	★★★★☆	★★★★★	★★★★★

Conclusion:AI probability volume integrates strengths of all conventional methods while suppressing their weaknesses, achieving superior performance across all metrics.

Discussion: Why AI Outperforms

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Spatial Coherence

Learns 3D fault geometries, not just 2D slices, providing a complete spatial understanding.

Context-Aware

Distinguishes reservoir-controlling faults from micro-fractures using contextual analysis.

Transfer Learning

Adapts generic fault patterns to local geology with minimal manual labeling required.

Efficiency

Once trained, can process large seismic volumes automatically and consistently.

Key Takeaway

AI brings unprecedented spatial understanding and processing speed to geological fault interpretation, significantly reducing manual effort.

Conclusions

Limitations of Conventional Methods

Conventional attributes (coherence, curvature) delineate major faults but lack resolution for secondary networks; ant tracking & likelihood suffer from redundancy and poor continuity.

Superiority of AI-Based Fault Detection

AI-based fault probability volume delivers superior continuity, noise resistance, and detection of subtle strike-slip faults critical for hydrocarbon migration.

Robust Workflow for Complex Reservoirs

The proposed ResU-Net + transfer learning workflow provides a robust, scalable template for multi-scale fracture characterization in complex reservoirs.

➢ Acknowledgements & References

Acknowledgements

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Selected References

Deng, S., Qiu, H., Liu, D., Han, J., Ru, Z., Peng, W., Bian, Q. and Huang, C. [2024] Research progress on the origin and reservoir-controlling mechanisms of intra-cratonic strike-slip faults: A case study from the northern Tarim Basin. *Oil & Gas Geology*, 45(5), 1211-1225.
Fehmers, G. C. and Hocker, C. F. W. [2003] Fast structural interpretation with structure-oriented filtering. *Geophysics*, 68(4), 1286-1293.
Hale, D. [2013] Methods to compute fault images, extract fault surfaces, and estimate fault throws from 3D seismic images. *Geophysics*, 78(2), O33-O43.
Kim, D. H. and MacKinnon, T. [2018] Artificial intelligence in fracture detection: transfer learning from deep convolutional neural networks. *Clinical Radiology*, 73(5), 439-445.
Li, Y., Sun, J., Wei, H. and Song, S. [2019] Architectural features of fault-controlled karst reservoirs in the Tahe oilfield. *Journal of Petroleum Science and Engineering*, 181, 106208.
Wu, X., Liang, L., Shi, Y. and Fomel, S. [2019] FaultSeg3D: Using synthetic data sets to train an end-to-end convolutional neural network for 3D seismic fault segmentation. *Geophysics*, 84(3), IM35-IM45.