Improved machine-learning fault detection at the San Juan Basin CarbonSAFE project site

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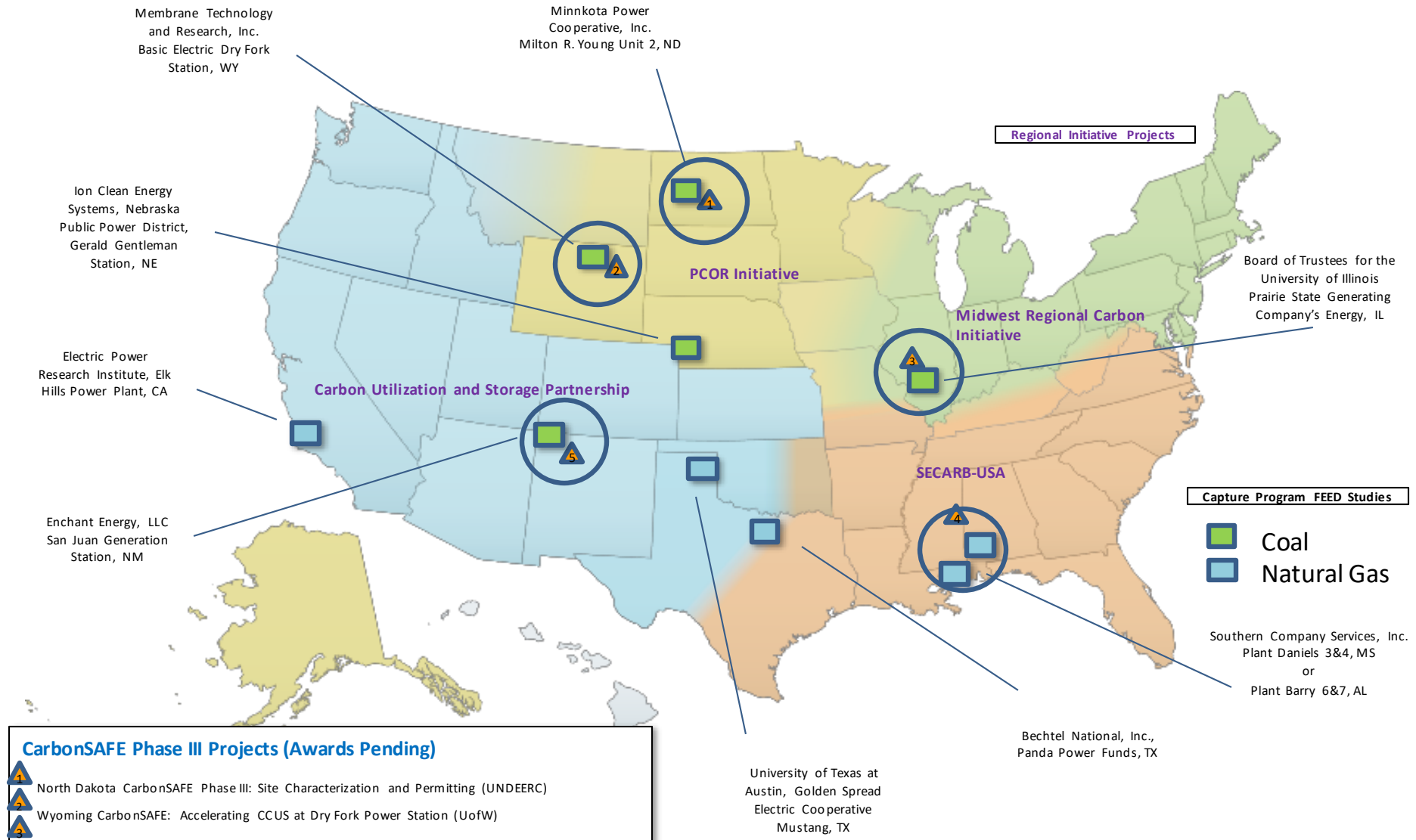
Objective

- Subsurface fault detection is crucial for site characterization and risk assessment in geologic carbon storage.
- The objective is detecting geologically undetected faults if any on a 3D seismic migration image for site characterization at the San Juan Basin CarbonSAFE project site in New Mexico, USA.

Outline

- Brief introduction of the San Juan Basin CarbonSAFE project
- Legacy 3D surface seismic data and workflow
- Machine-learning fault detection on a 3D prestack depth migration image
- Conclusions

DOE-Supported Major Carbon Capture and Storage Projects

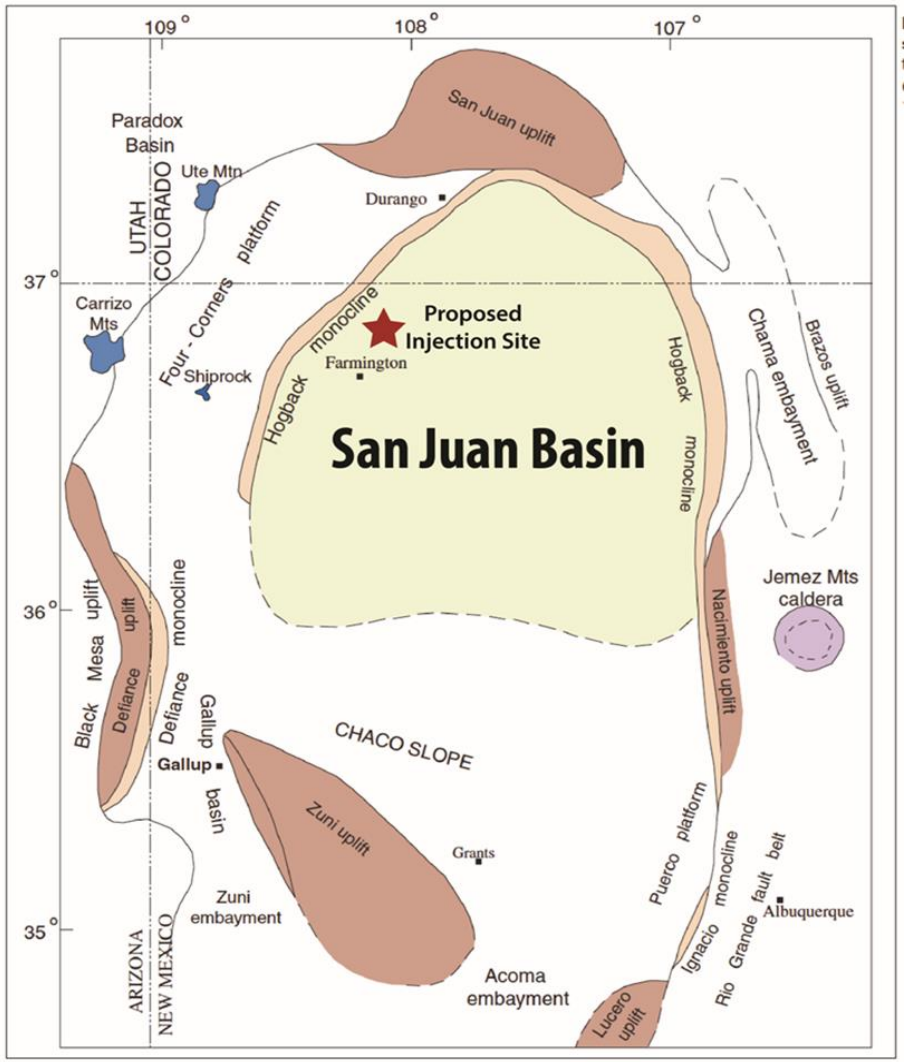


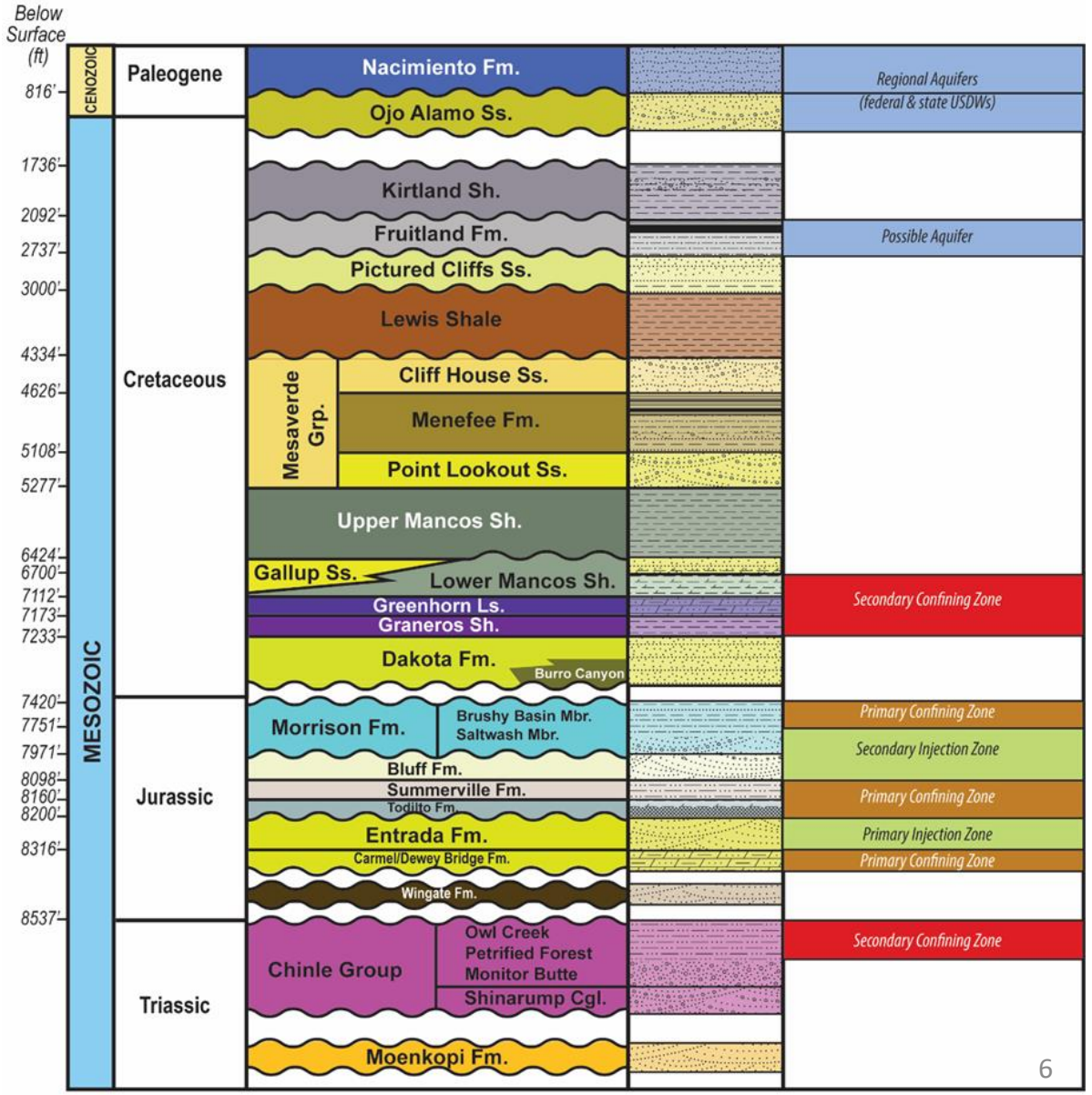
Source: US DOE, 2020

San Juan Basin (SJB) CarbonSAFE Project

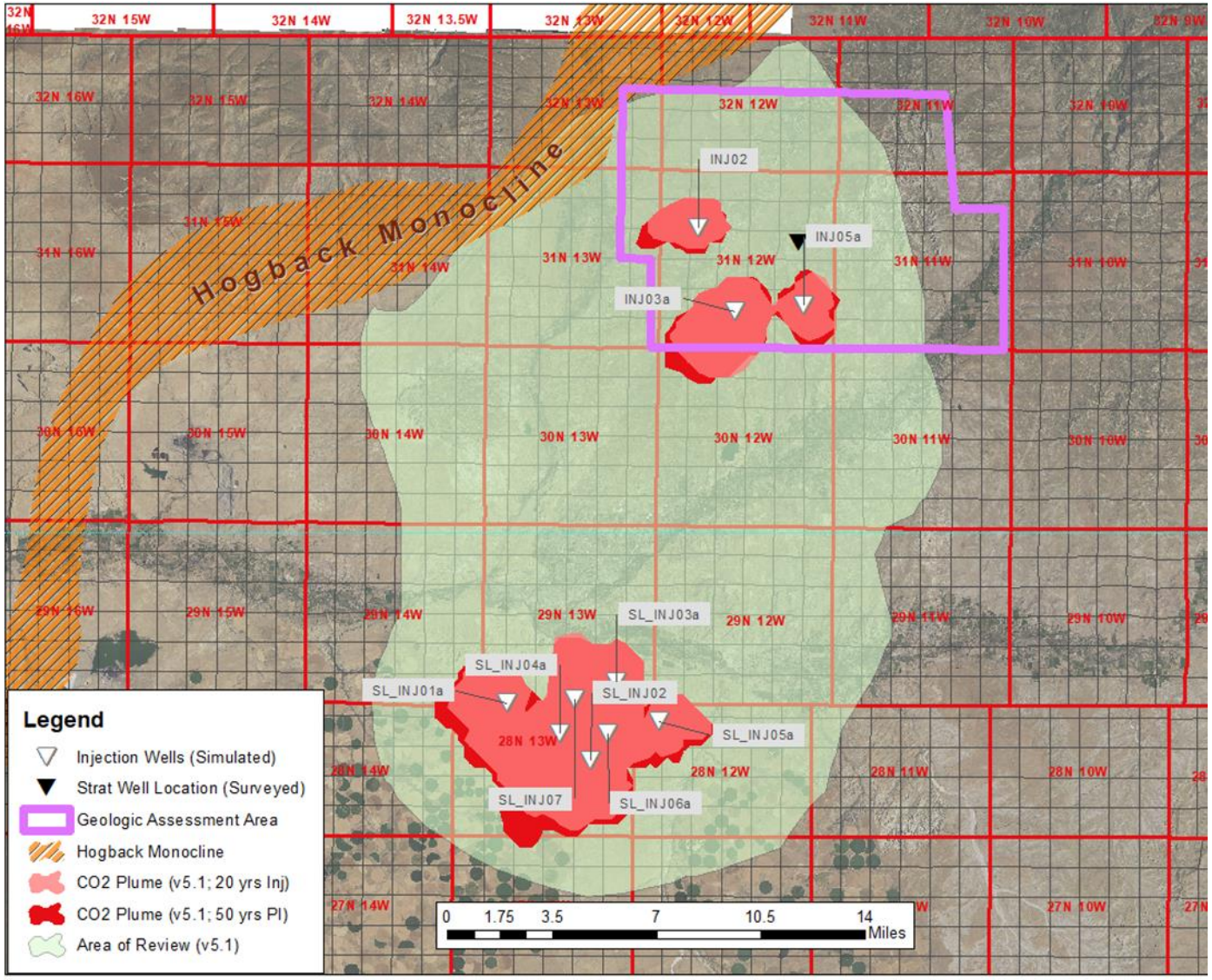
- The San Juan Basin CarbonSAFE Phase III project is performing comprehensive site characterization for geologic carbon storage in the San Juan region located in northwest New Mexico, USA.
- The project uses the available data and analysis results to prepare, submit, and obtain UIC Class VI permit from the Environmental Protection Agency (EPA).

To Inject CO_2 into Entrada Fm. at ~ 2.5 km depth





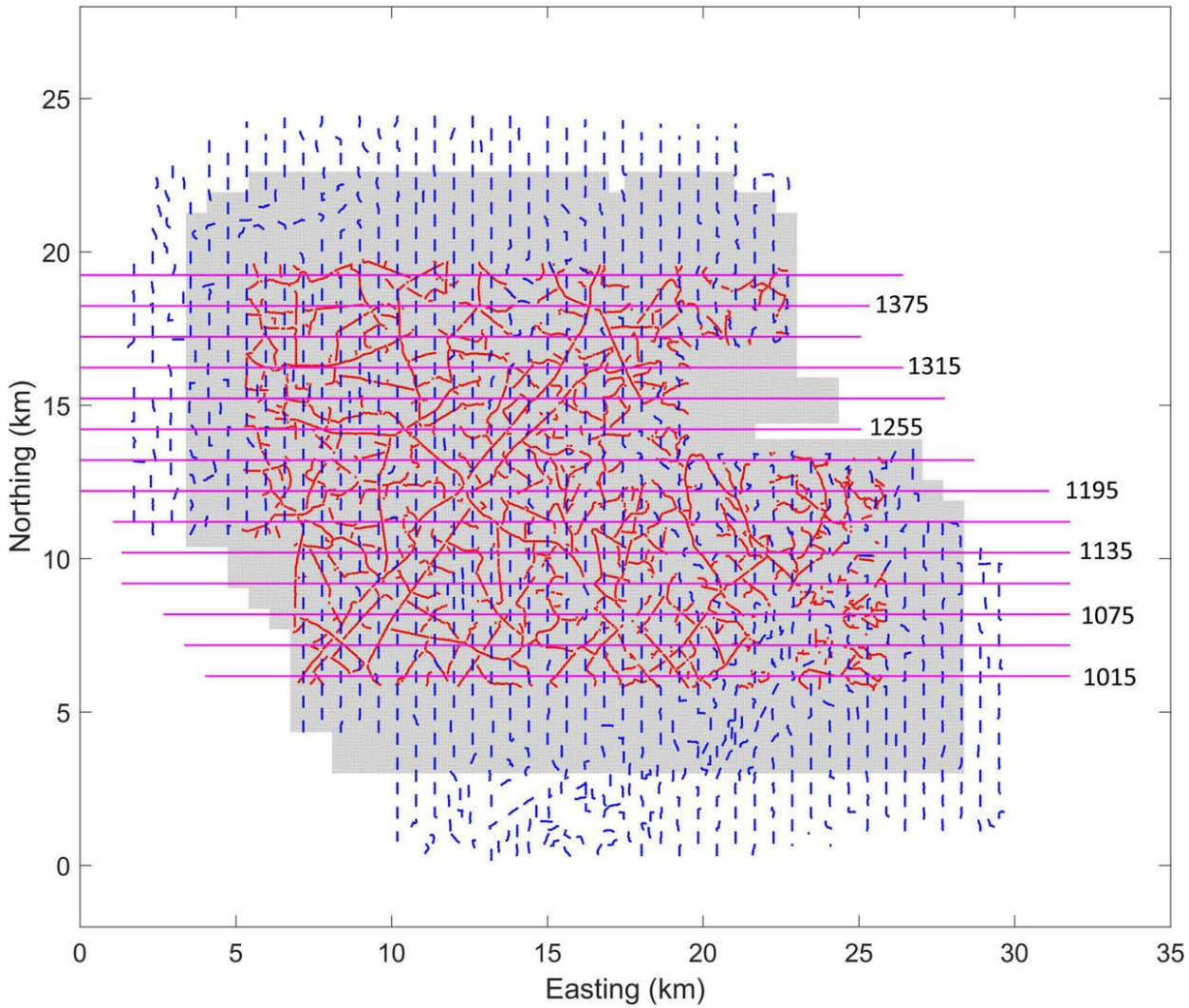
Legacy 3D surface seismic data, CO_2 Plume, AoR Modeling



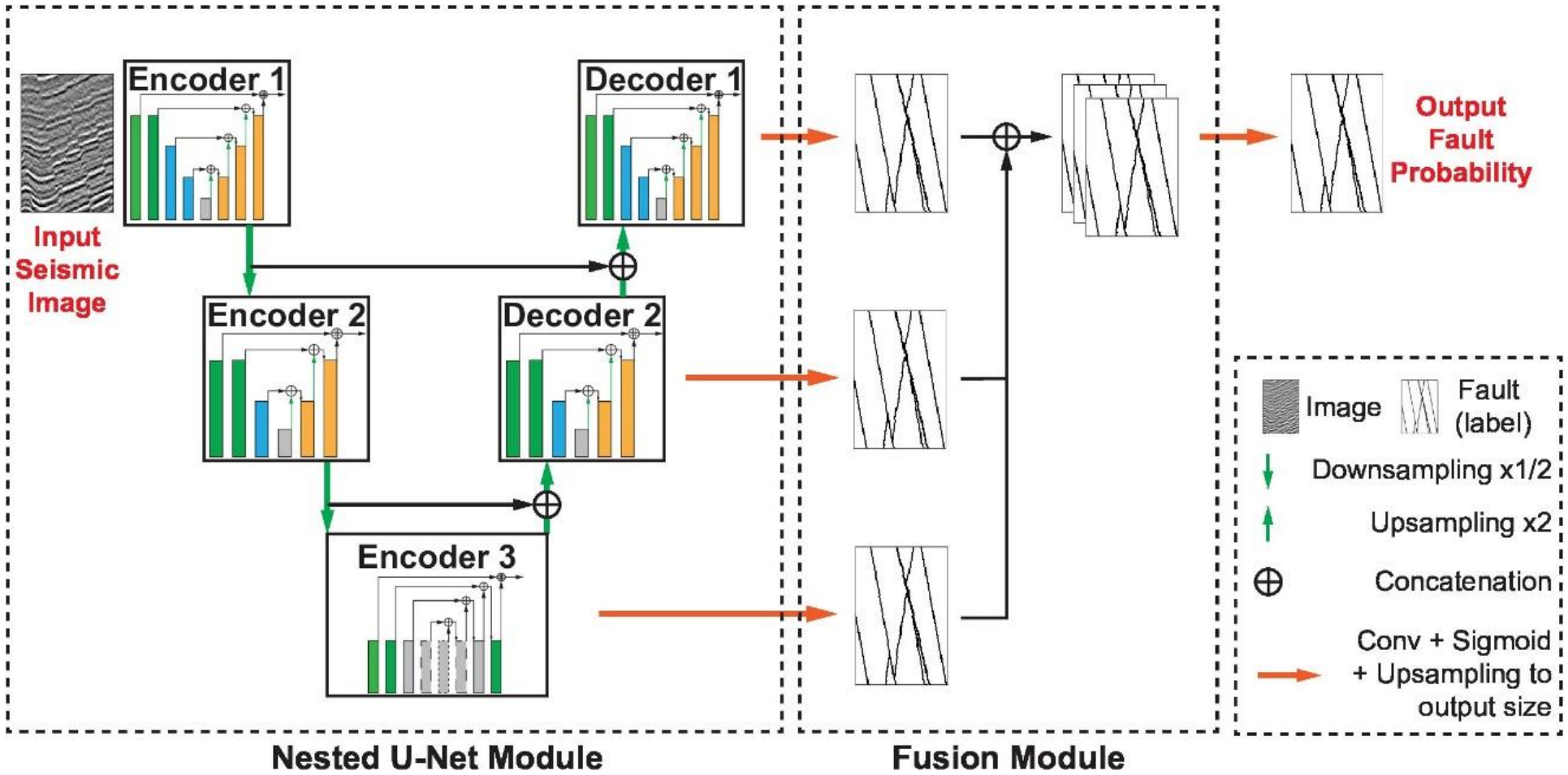
Workflow

- The project procured a legacy 3D surface seismic dataset acquired at the San Juan CarbonSAFE storage site in 1998.
- We update the 3D velocity model using prestack depth migration velocity analysis (MVA) with the Paradigm™ 22 Software Package.
- We perform 3D prestack depth migration to obtain subsurface structural image.
- We use anisotropic diffusing filtering to reduce image noise and improve the reliability of fault detection.
- We dilineate faults on the 3D migration image using LANL's recently developed machine-learning algorithm (Gao, Huang, Zheng, 2022).

Source and Receiver Distributions

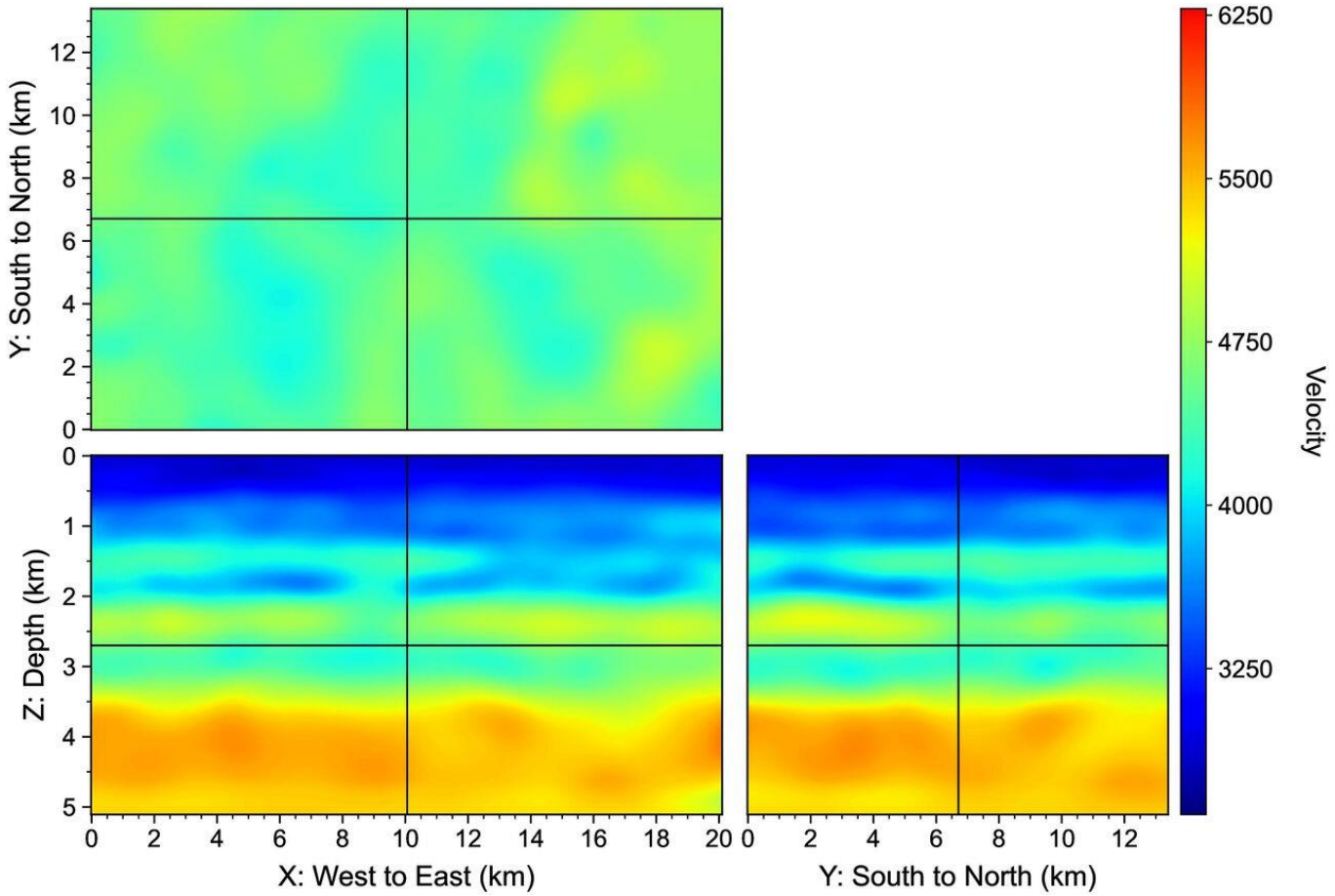


Nested-Residual U-Net (NRU) Fault Detection

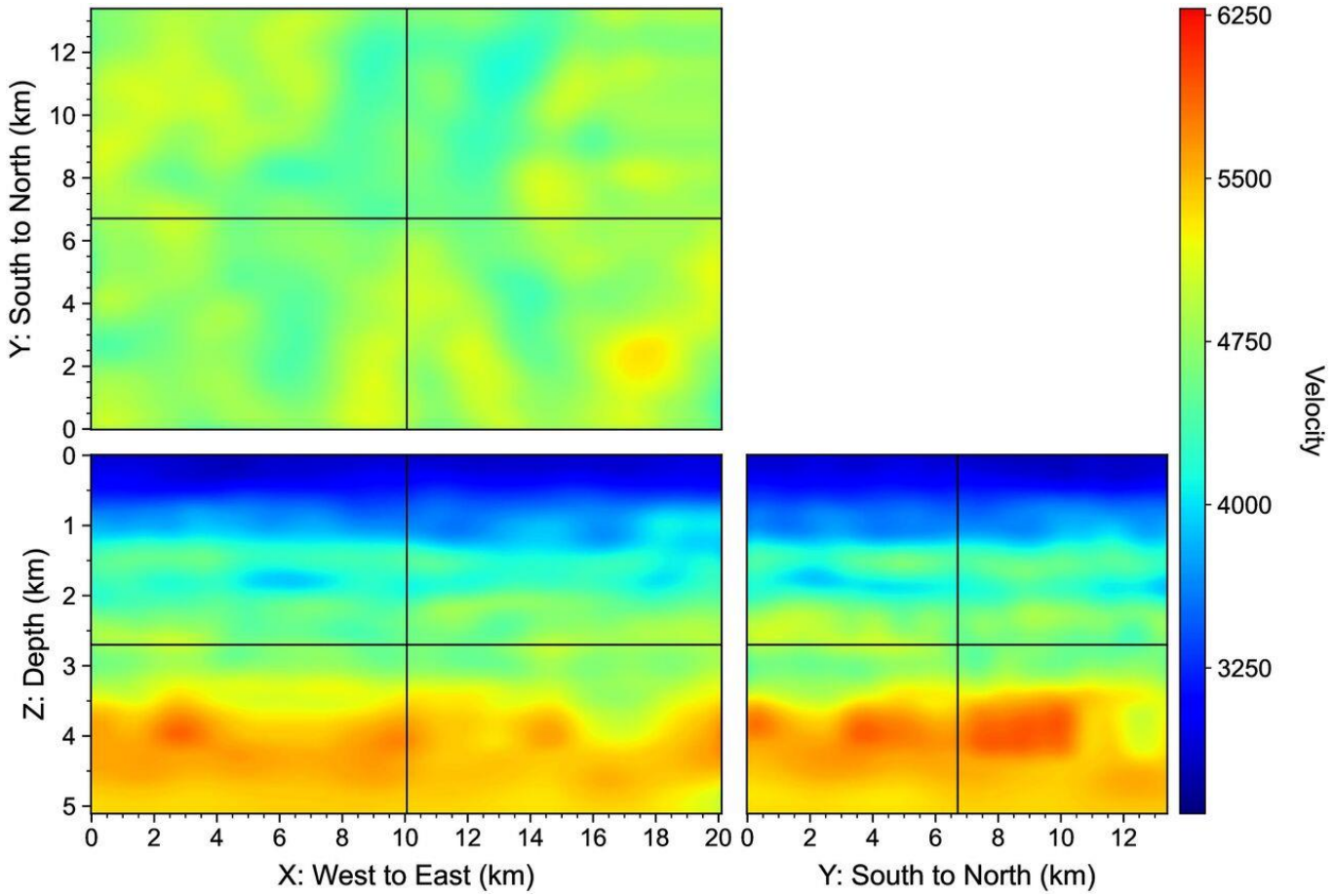


(Gao, Huang, Zheng, 2022)

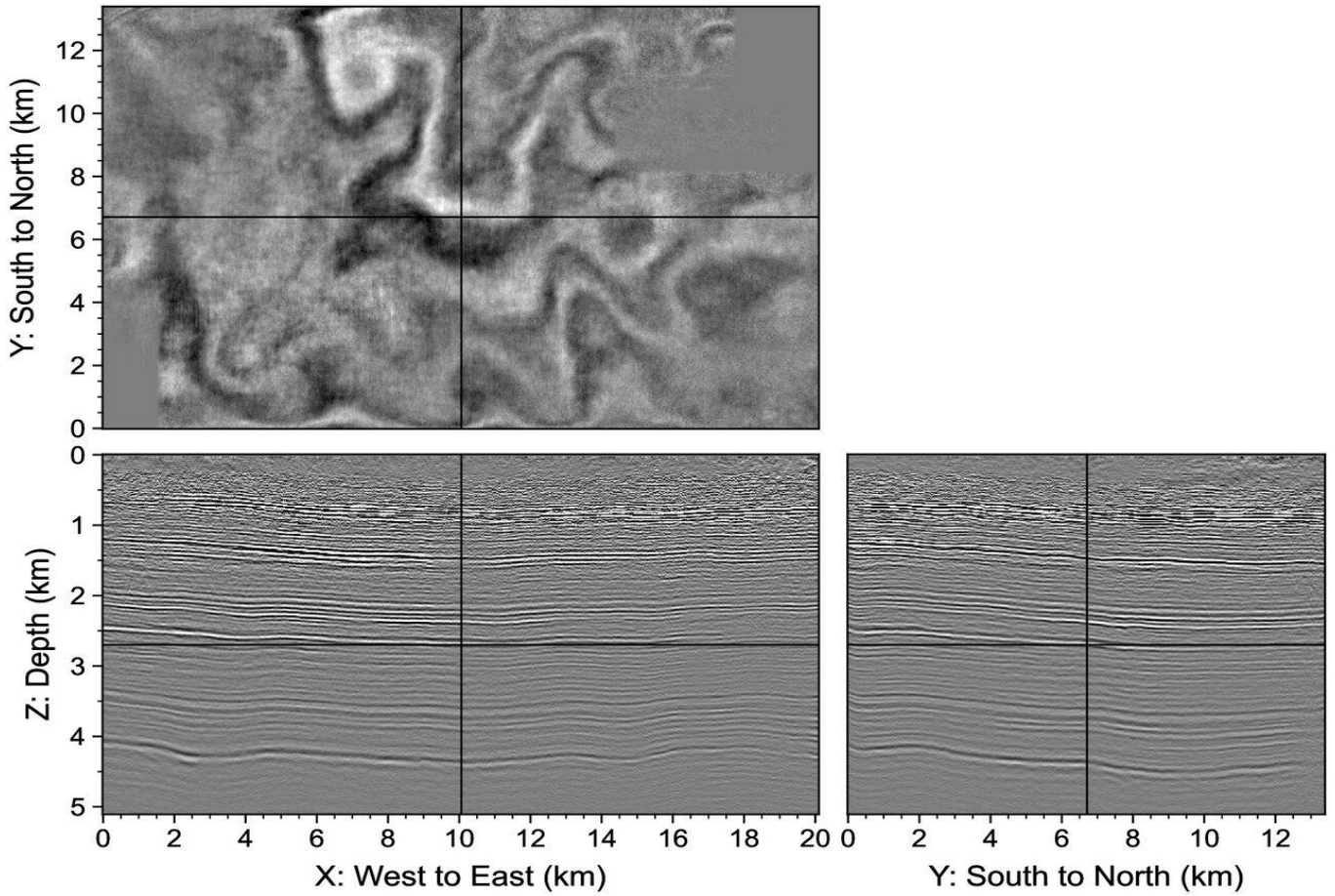
Initial 3D Velocity Model



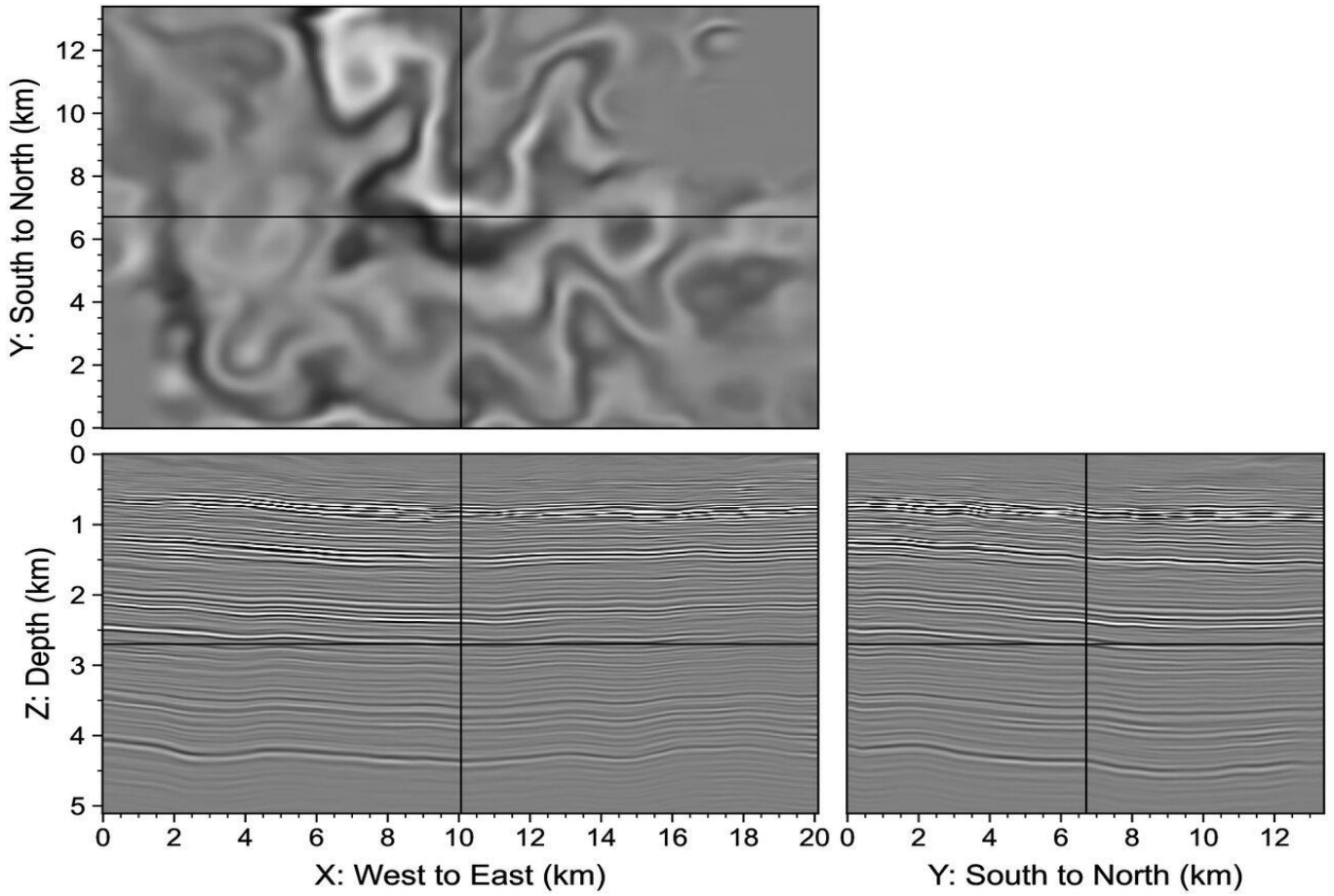
MVA-Updated 3D Velocity Model



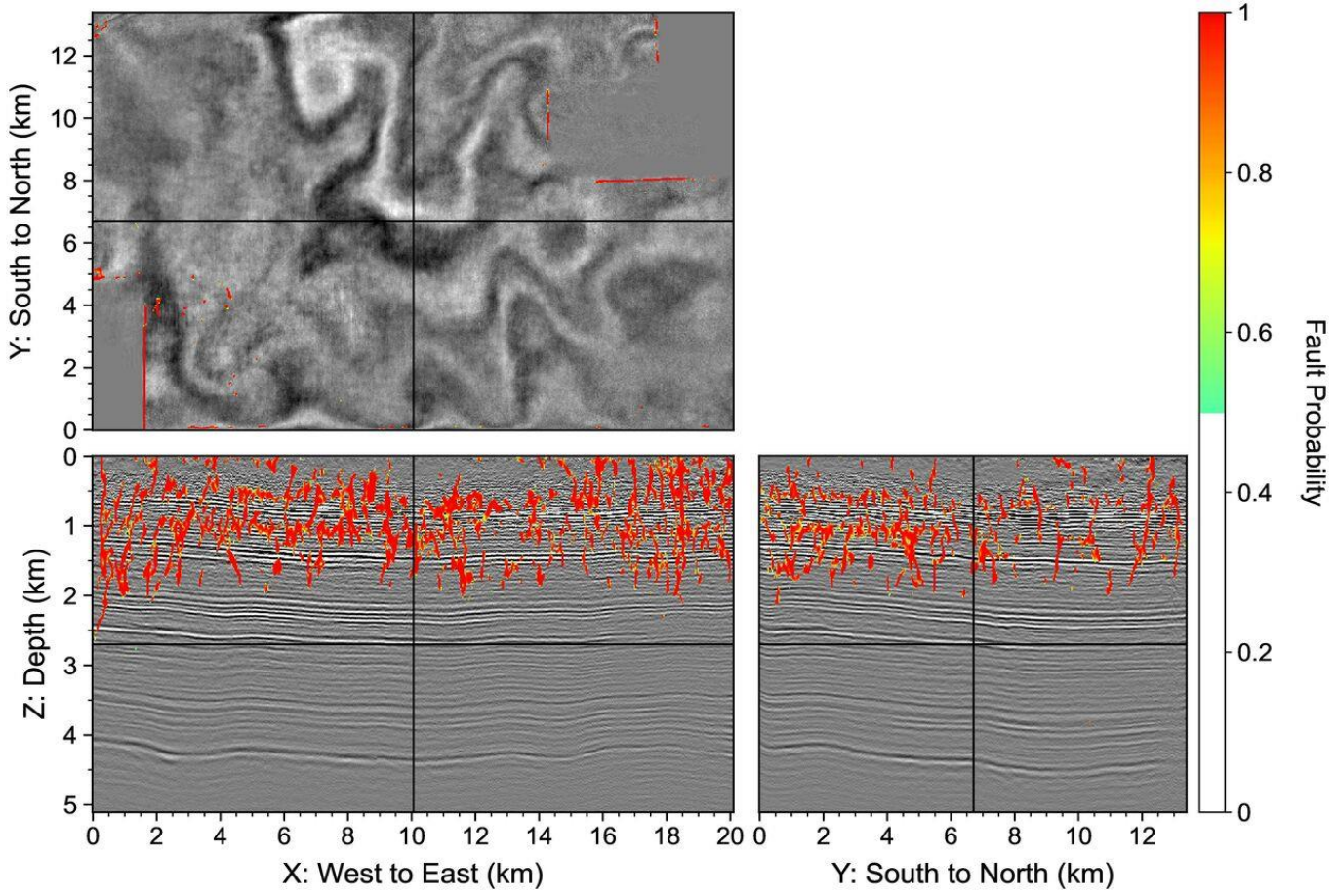
Original 3D Migration Image



Denoised 3D Migration Image



ML-Detected Faults on Original 3D Migration Image



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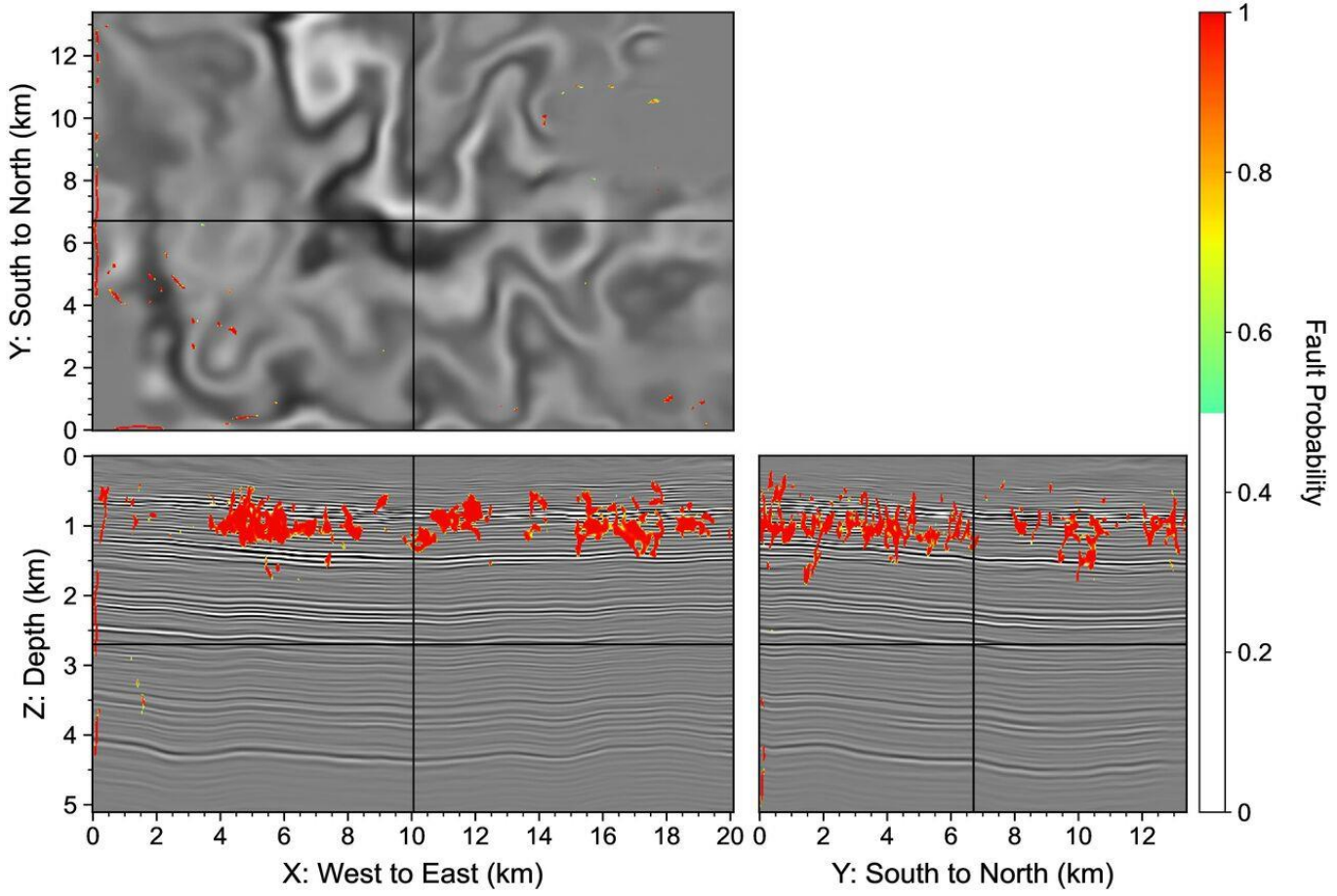
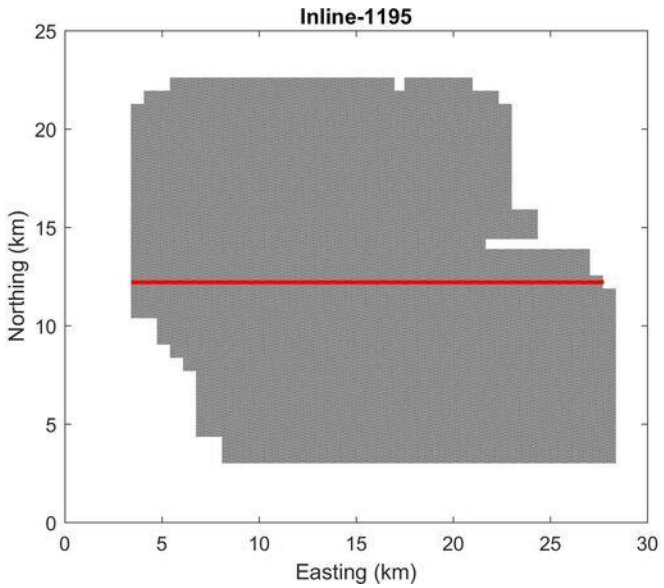
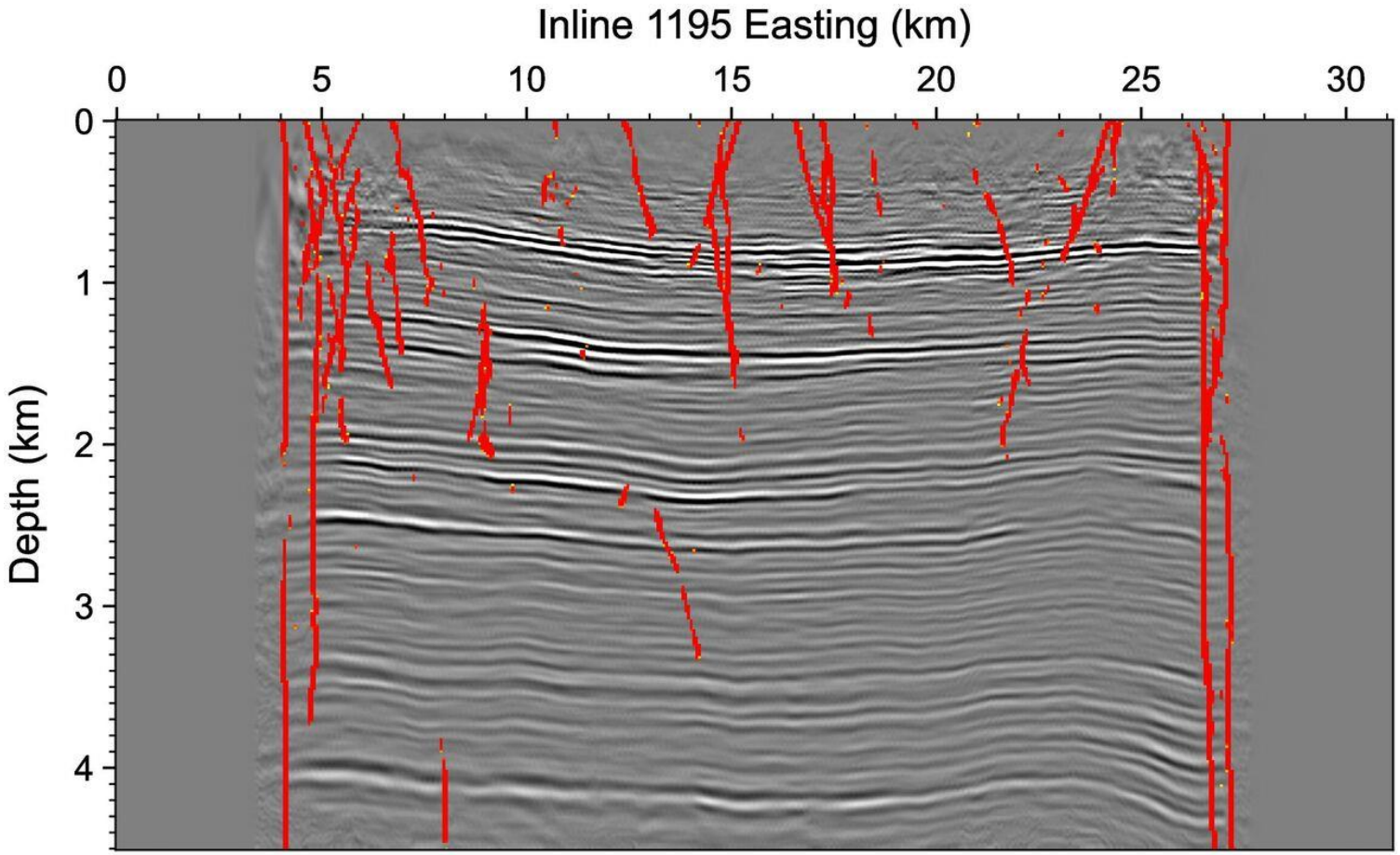
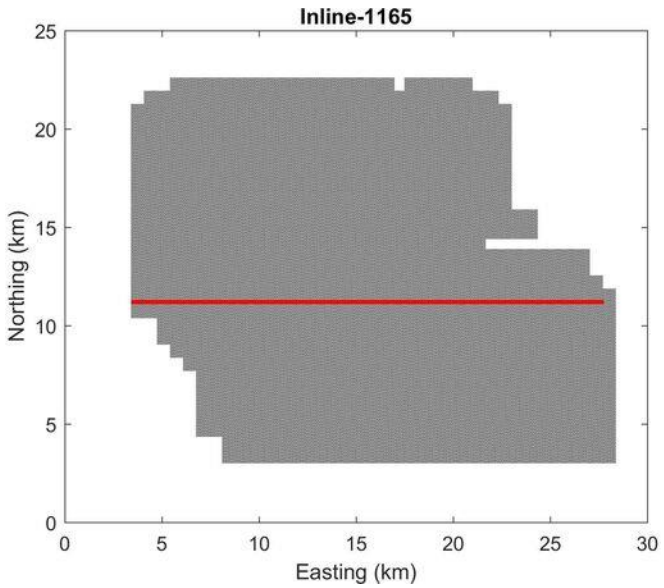


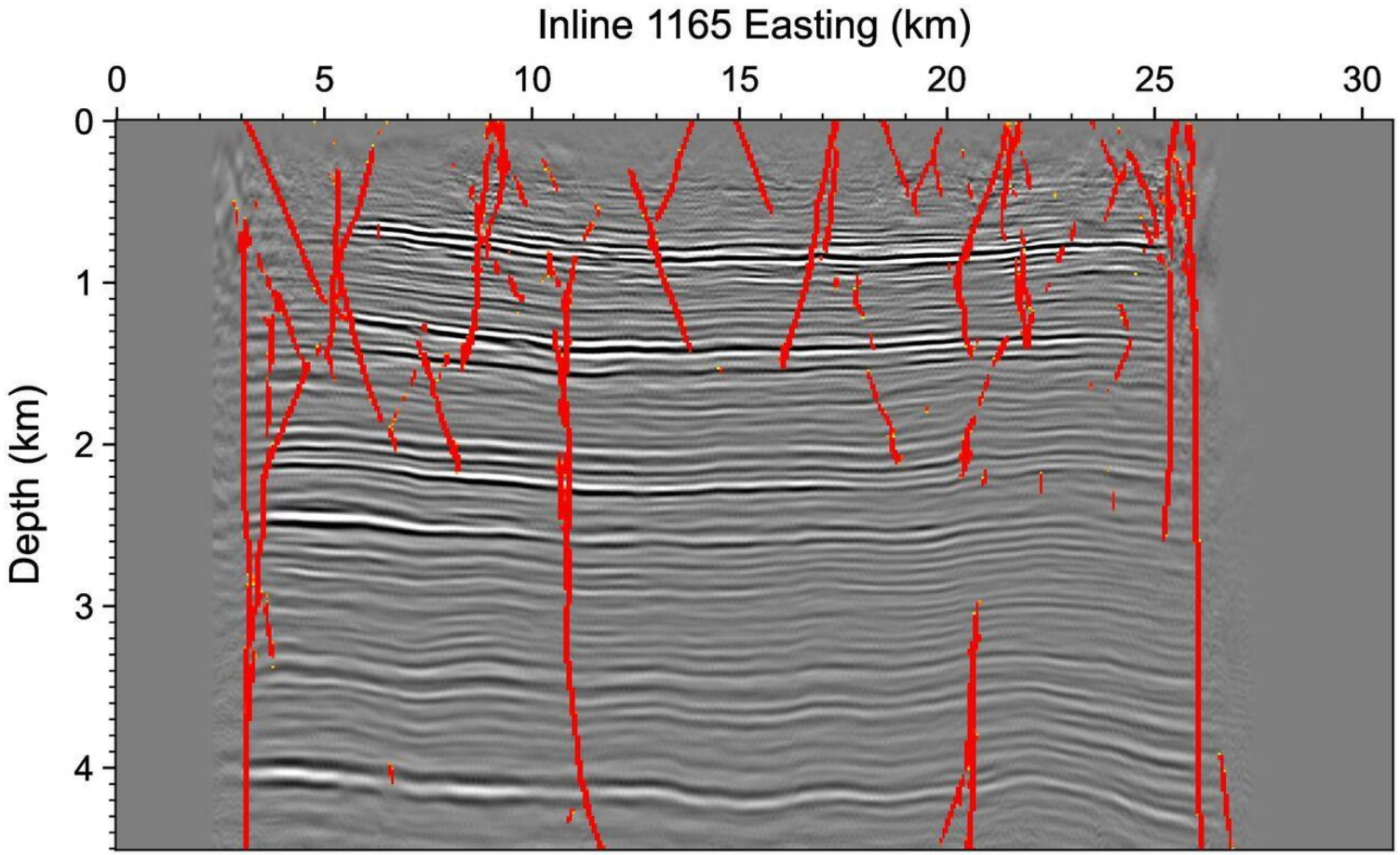
3D vs 2D (2023 SSA Annual Meeting)





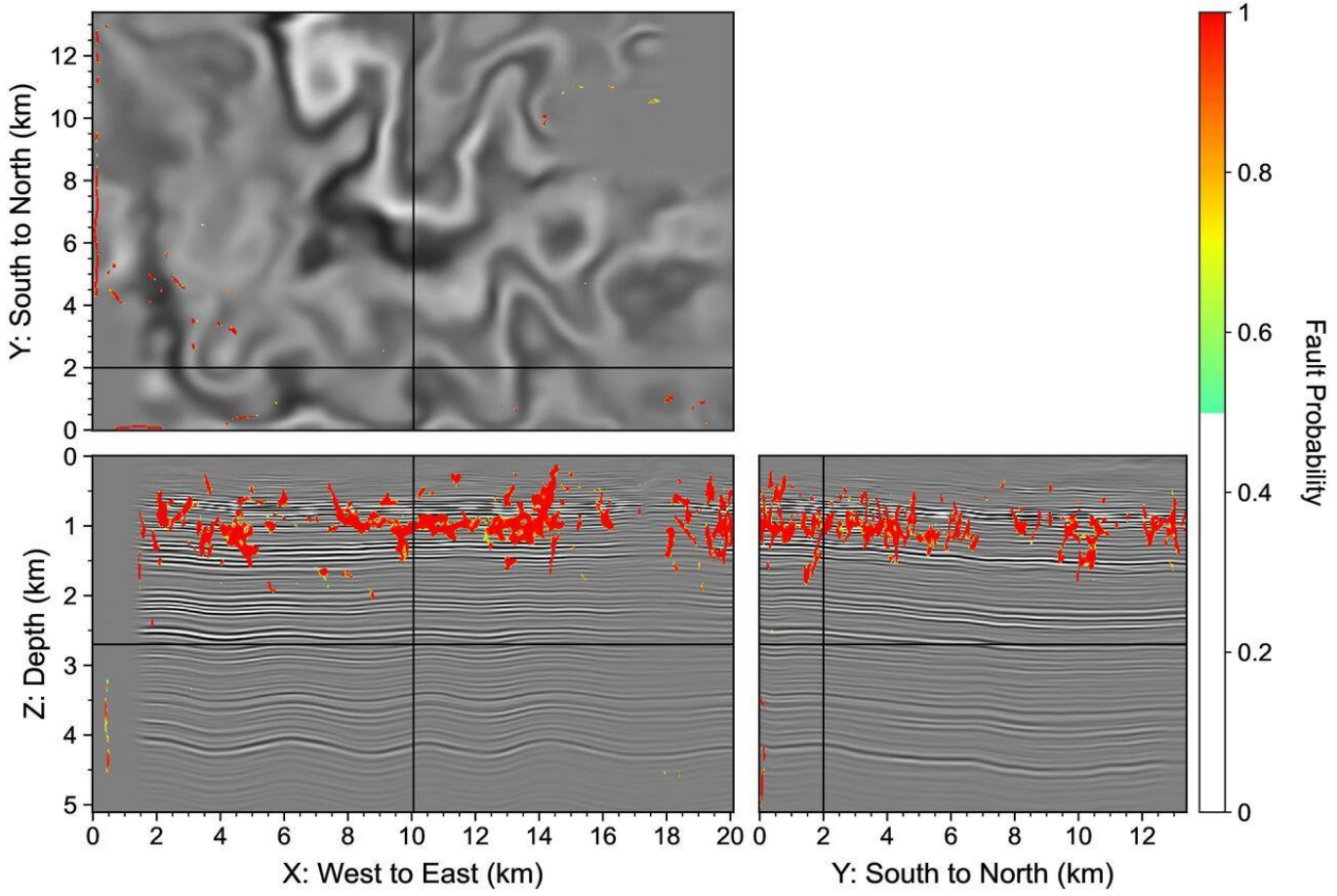
3D vs 2D (2023 SSA Annual Meeting)





ML-Detected Faults on Denoised 3D Migration Image

Y=2km



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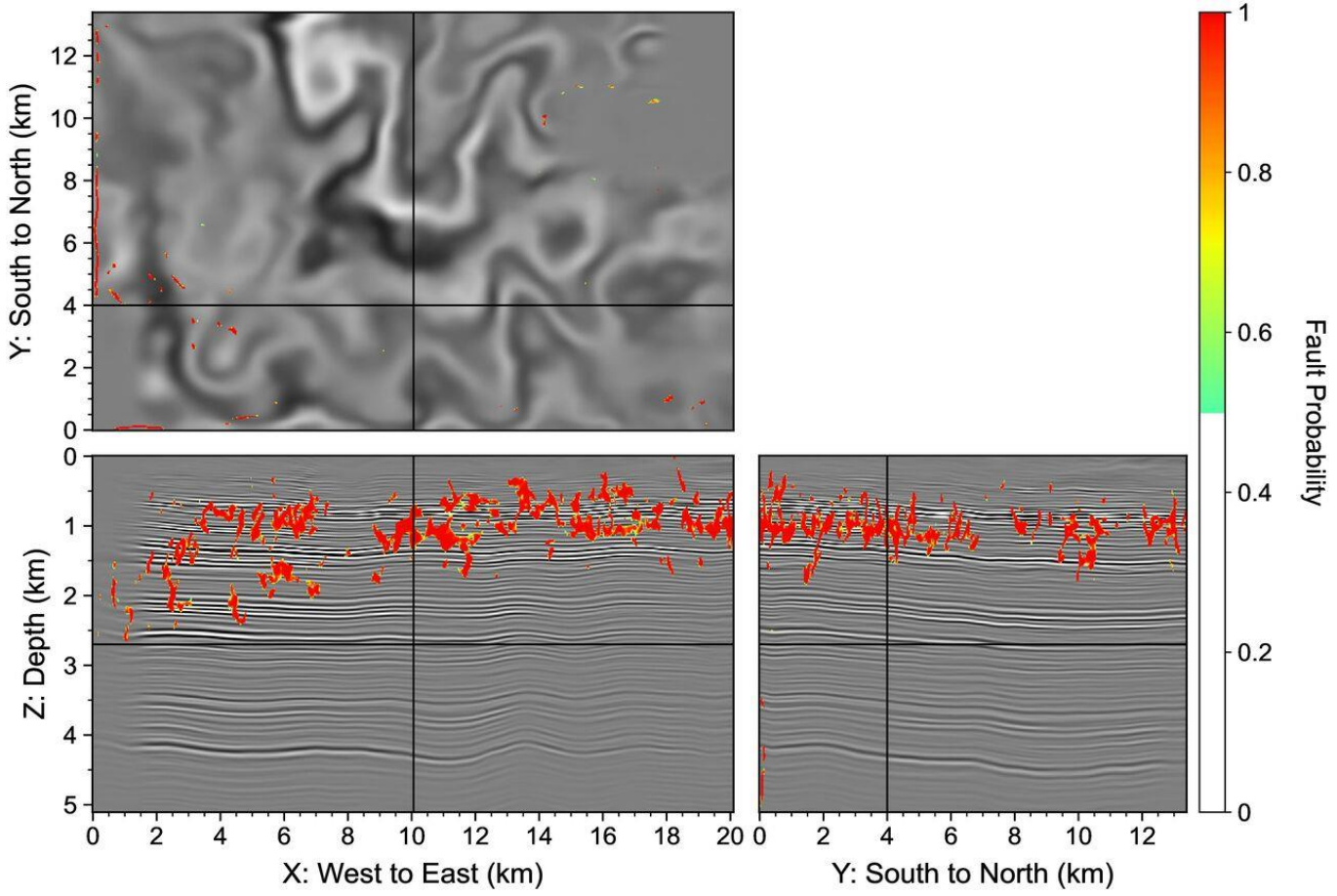

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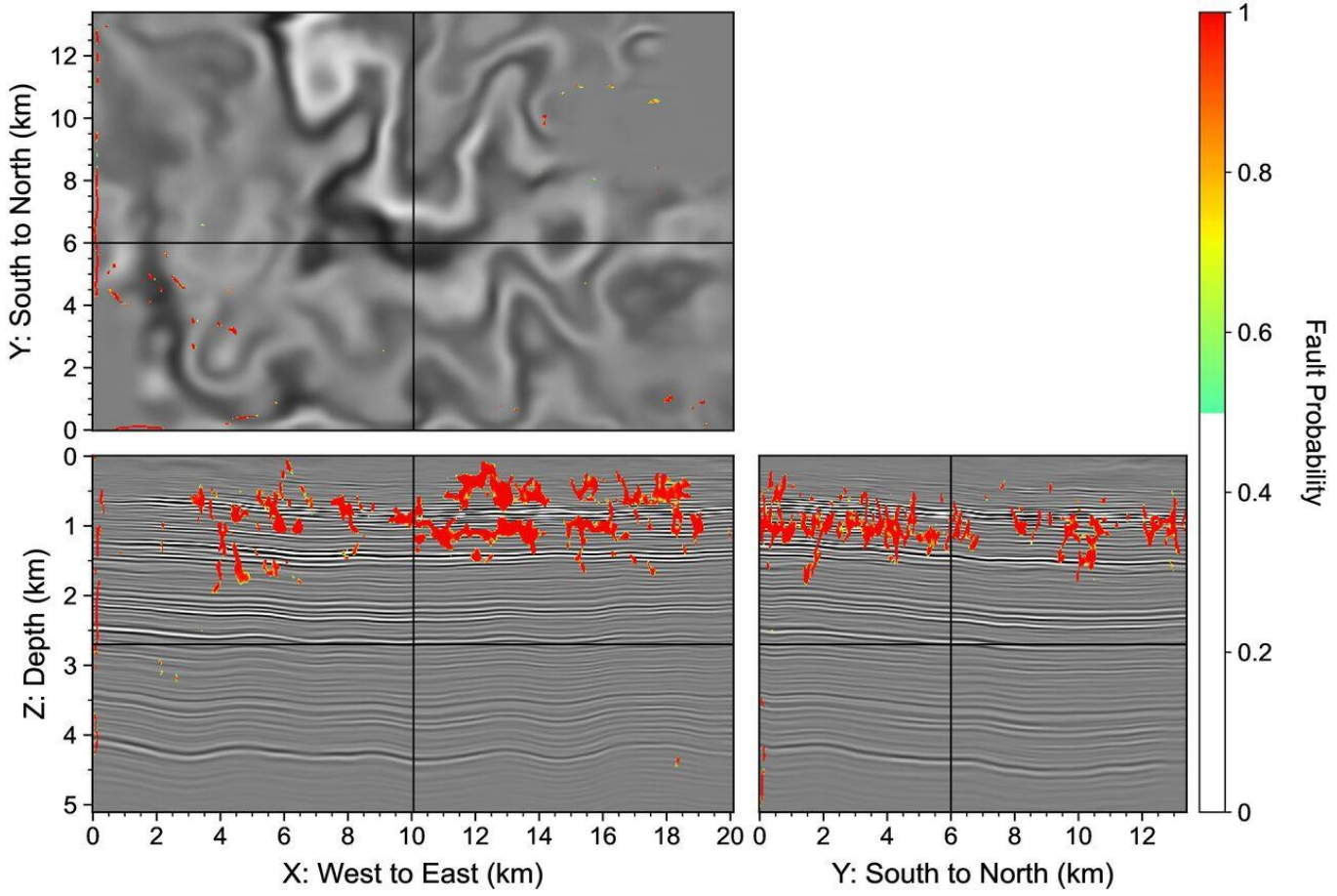
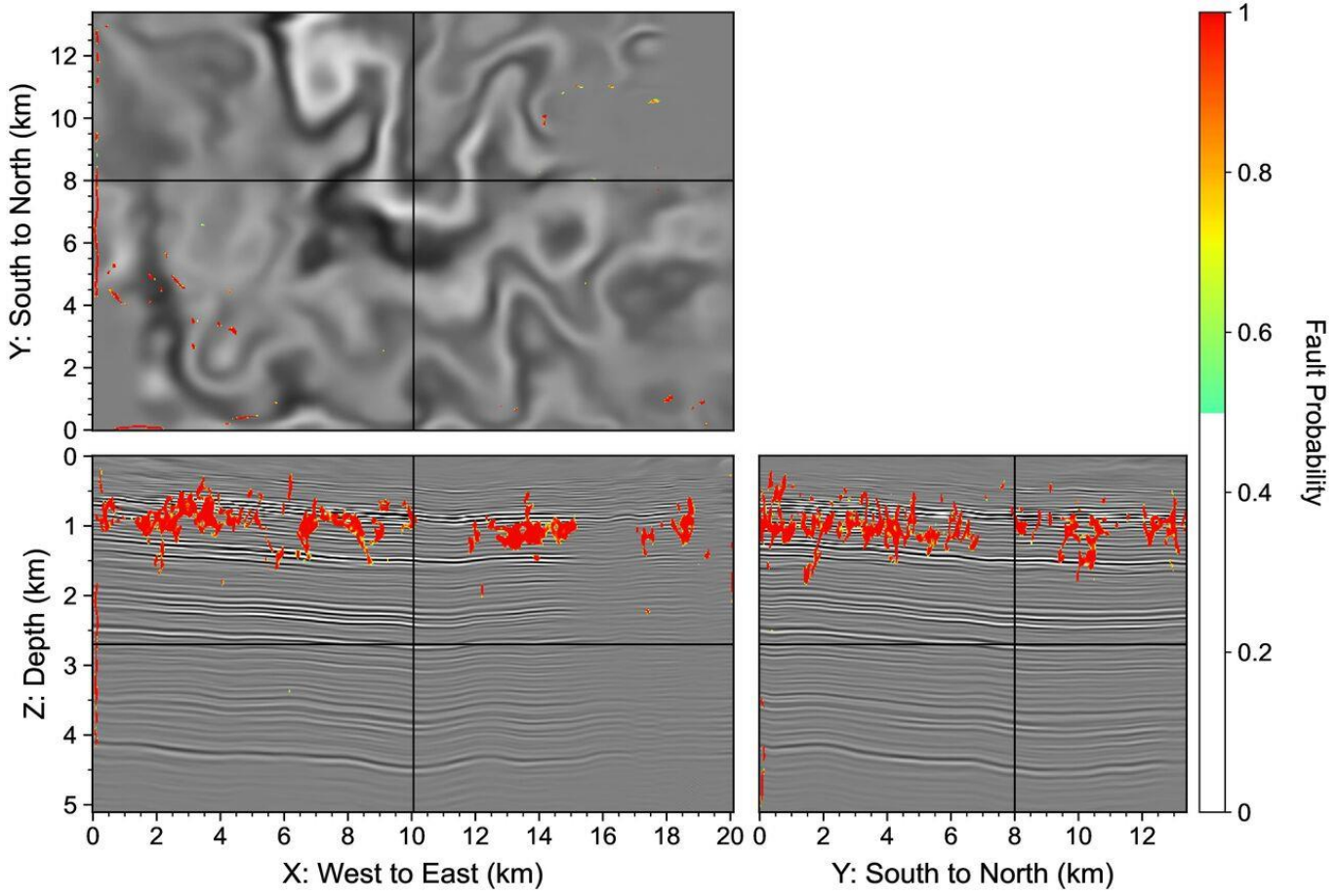
Y=6km



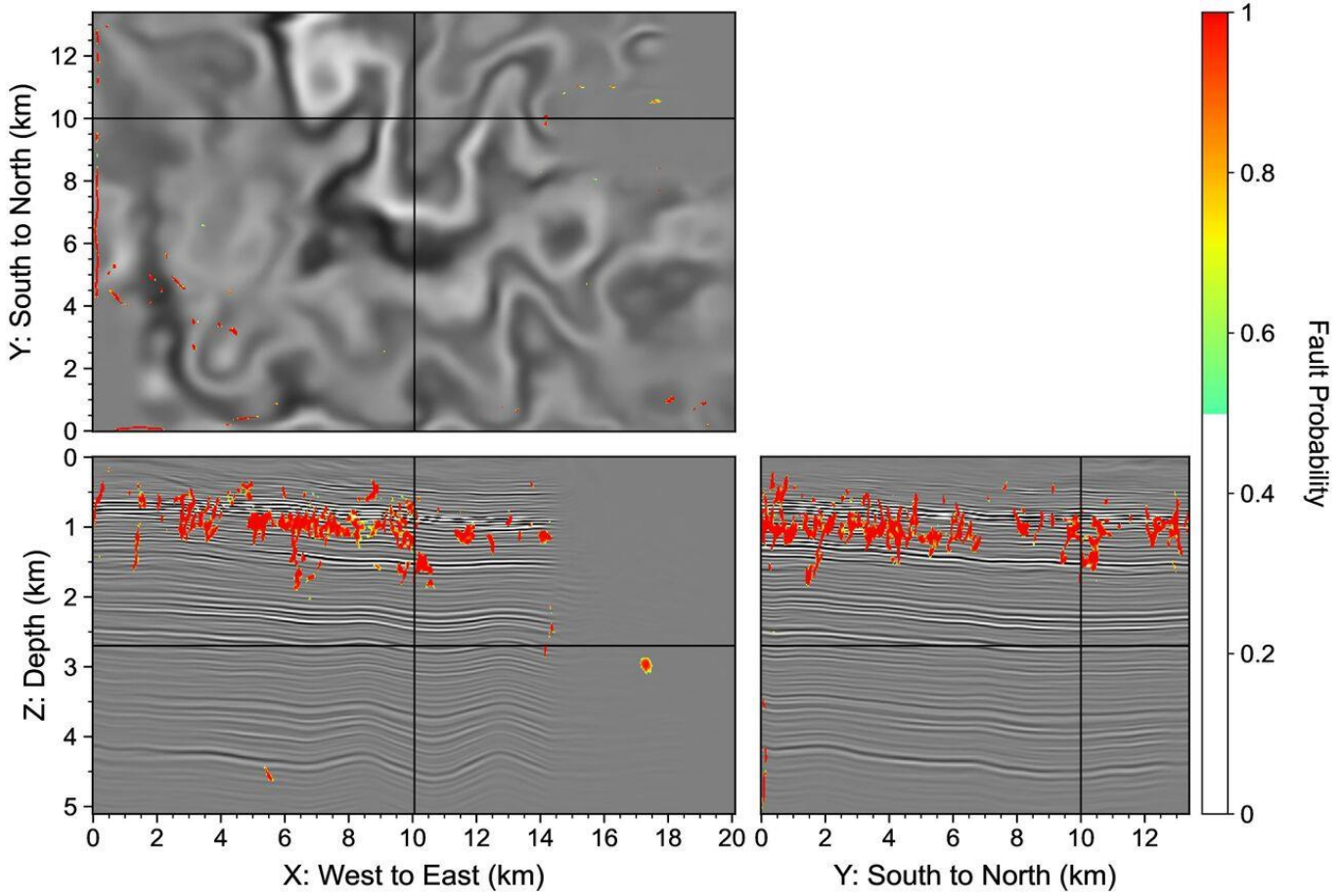
ML-Detected Faults on Denoised 3D Migration Image

Y=8km



ML-Detected Faults on Denoised 3D Migration Image

Y=10km



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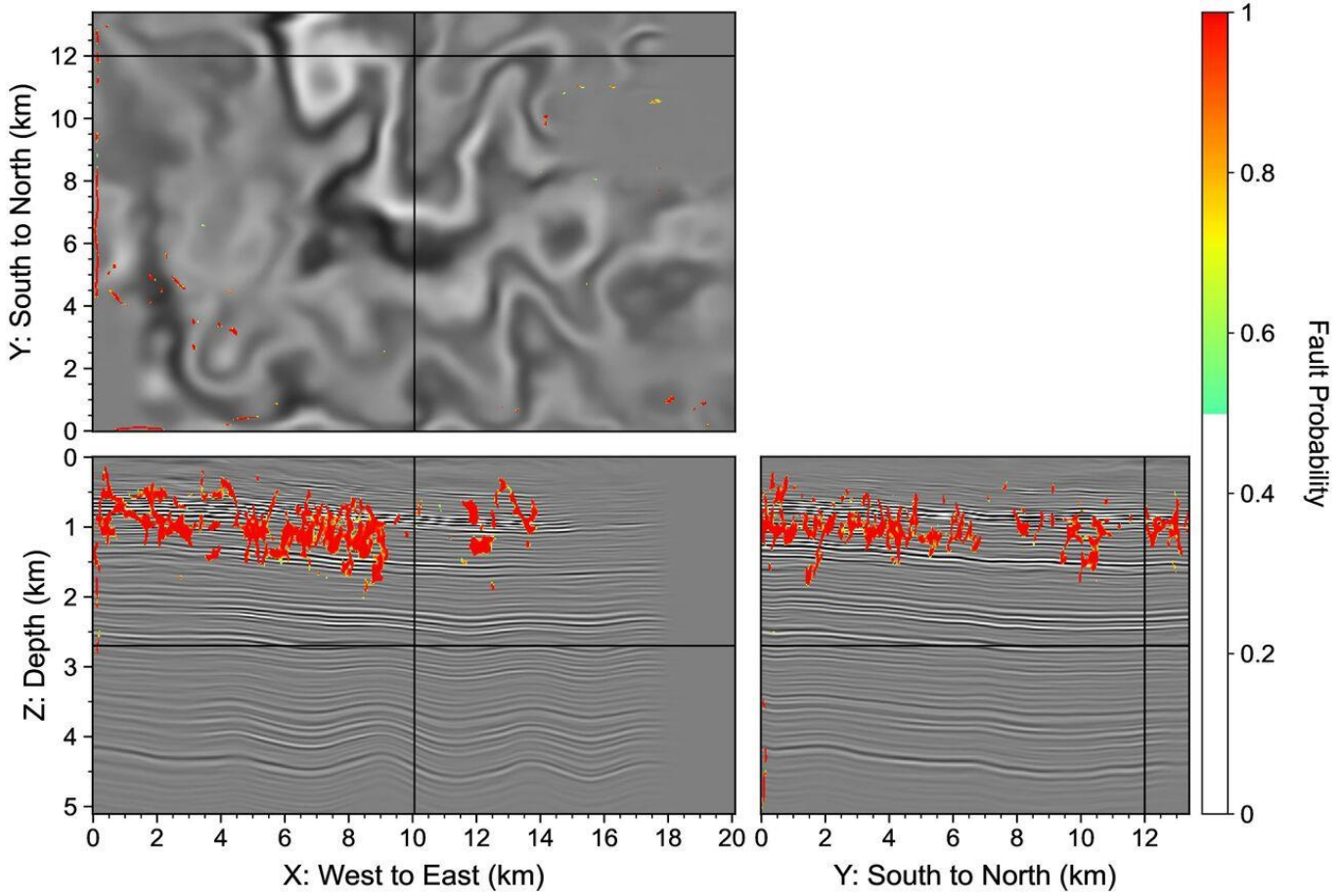

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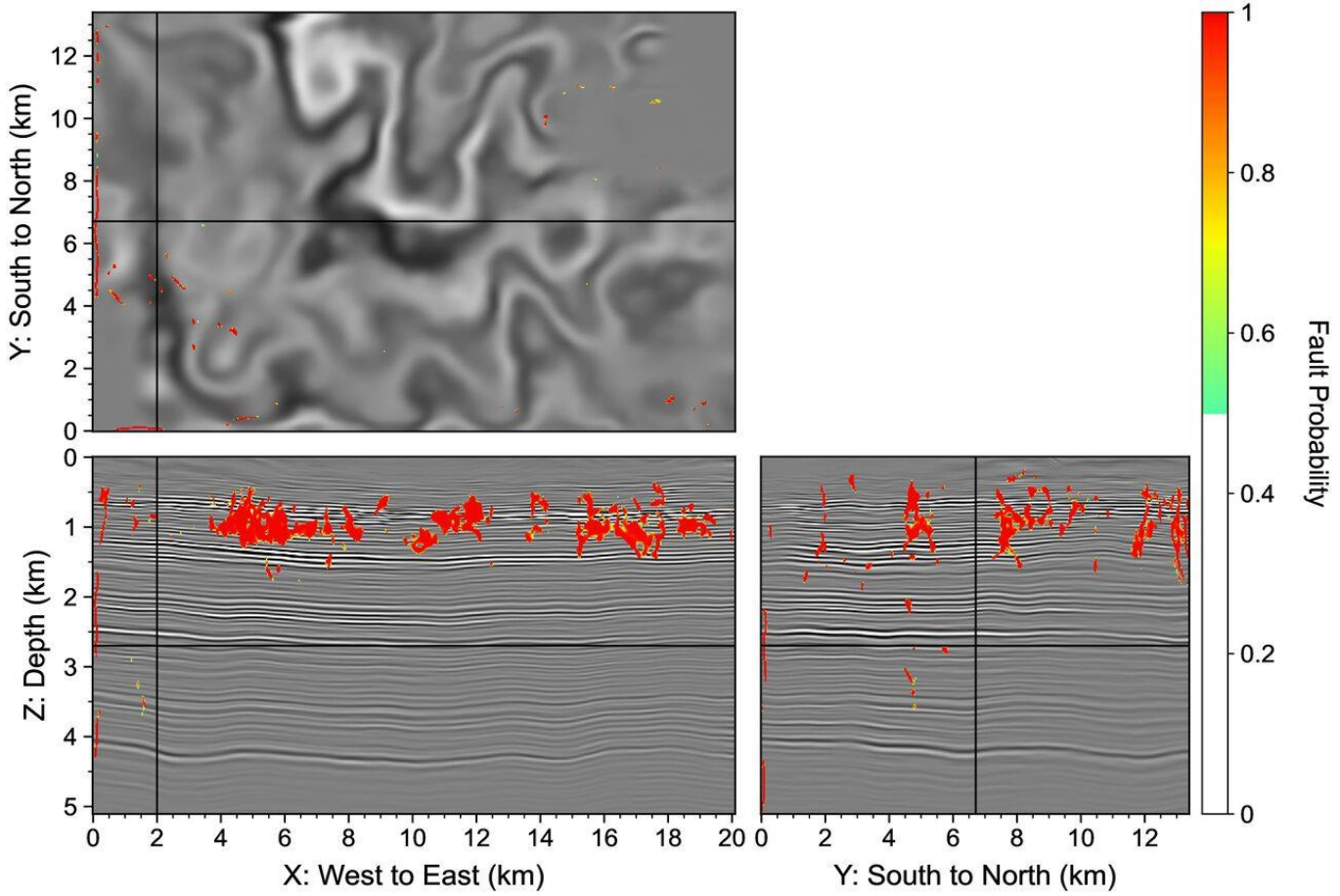

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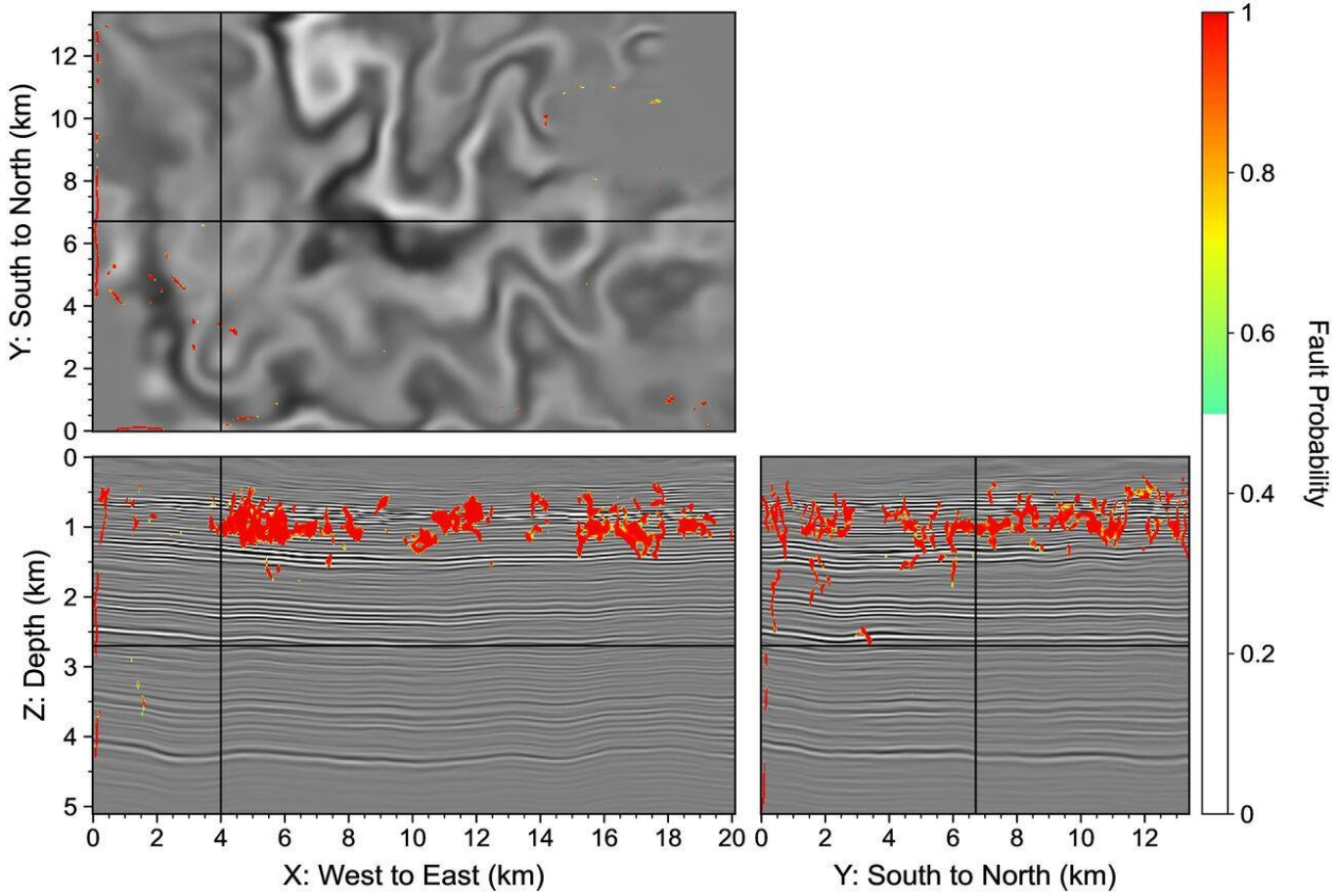

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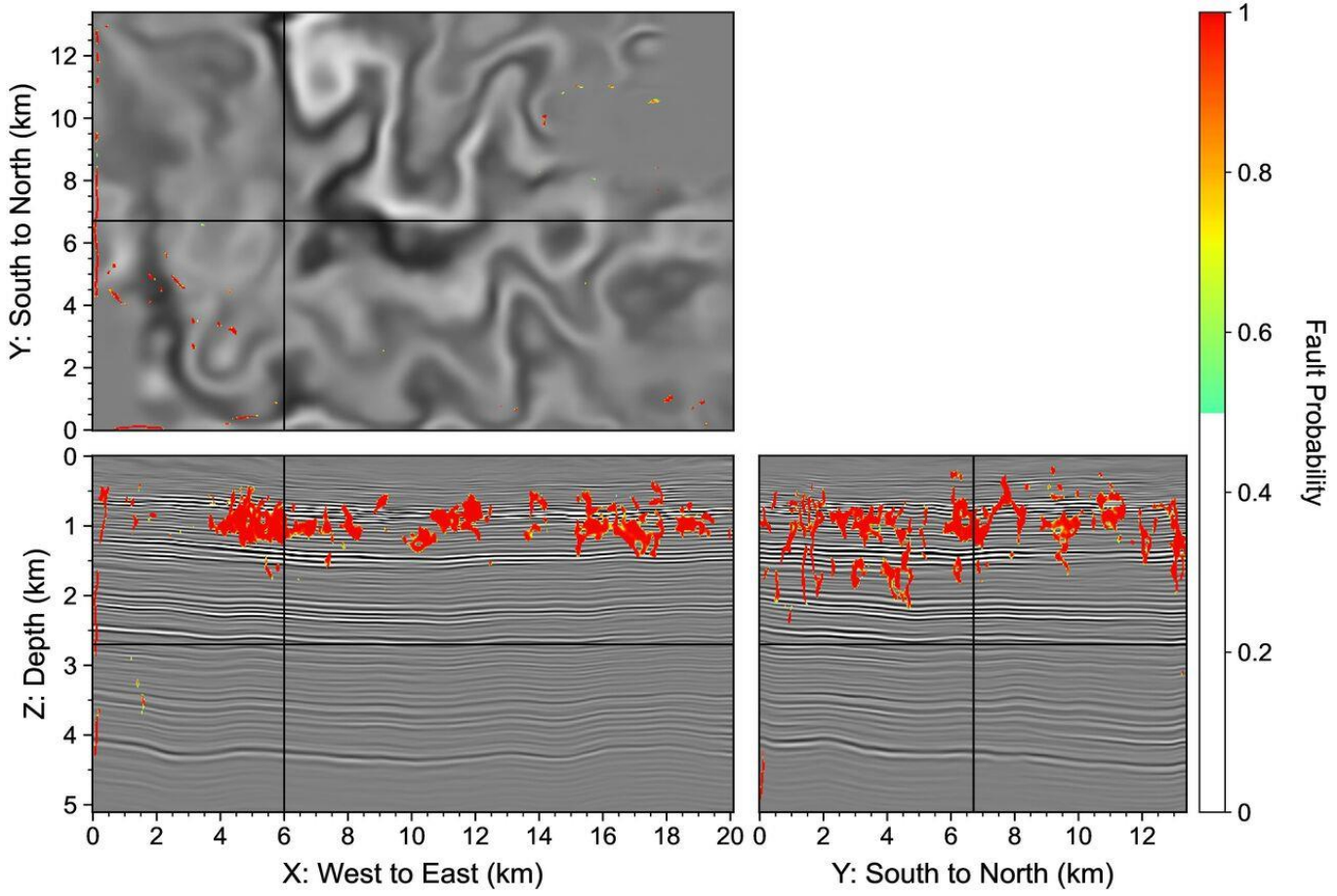

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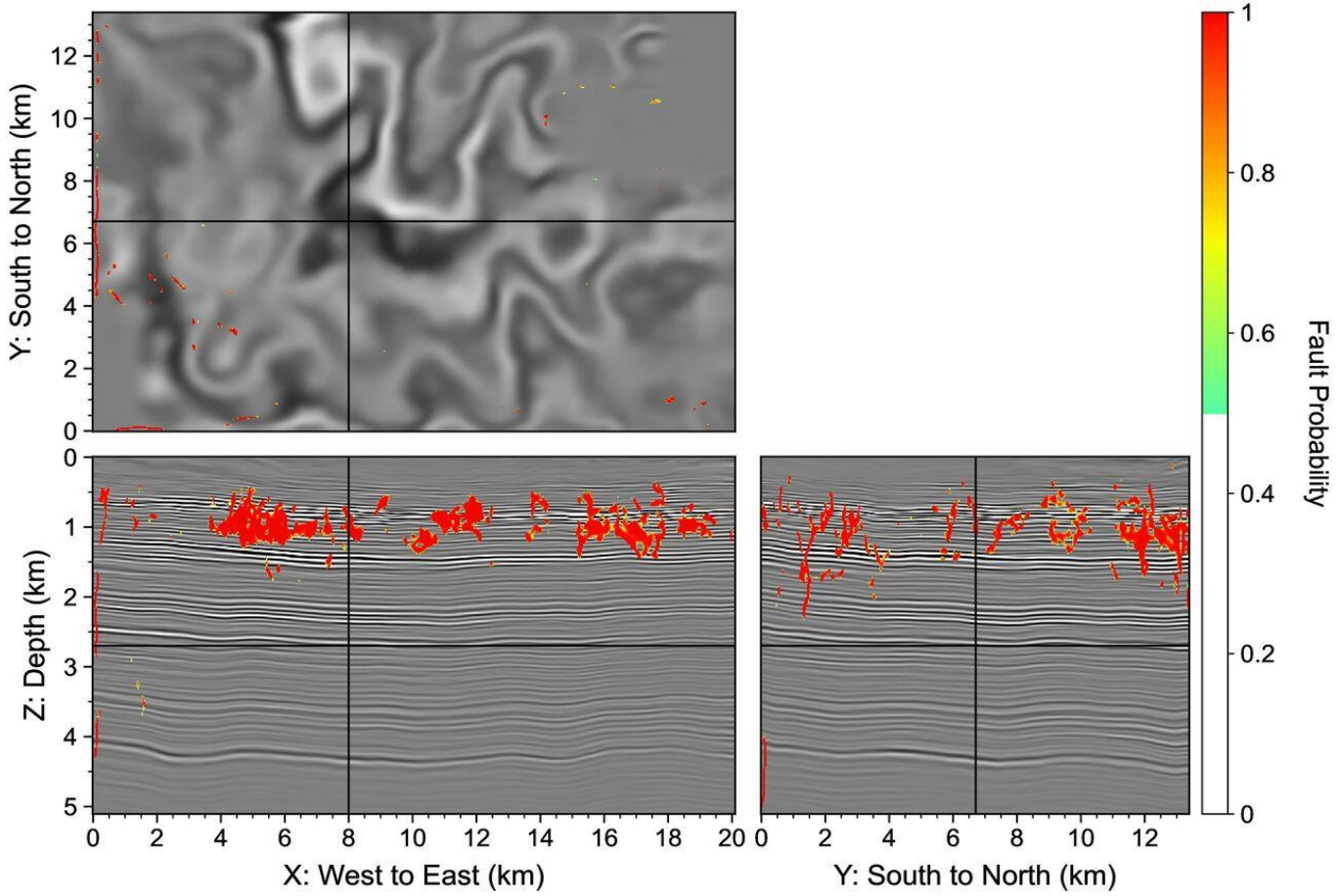
X=8km



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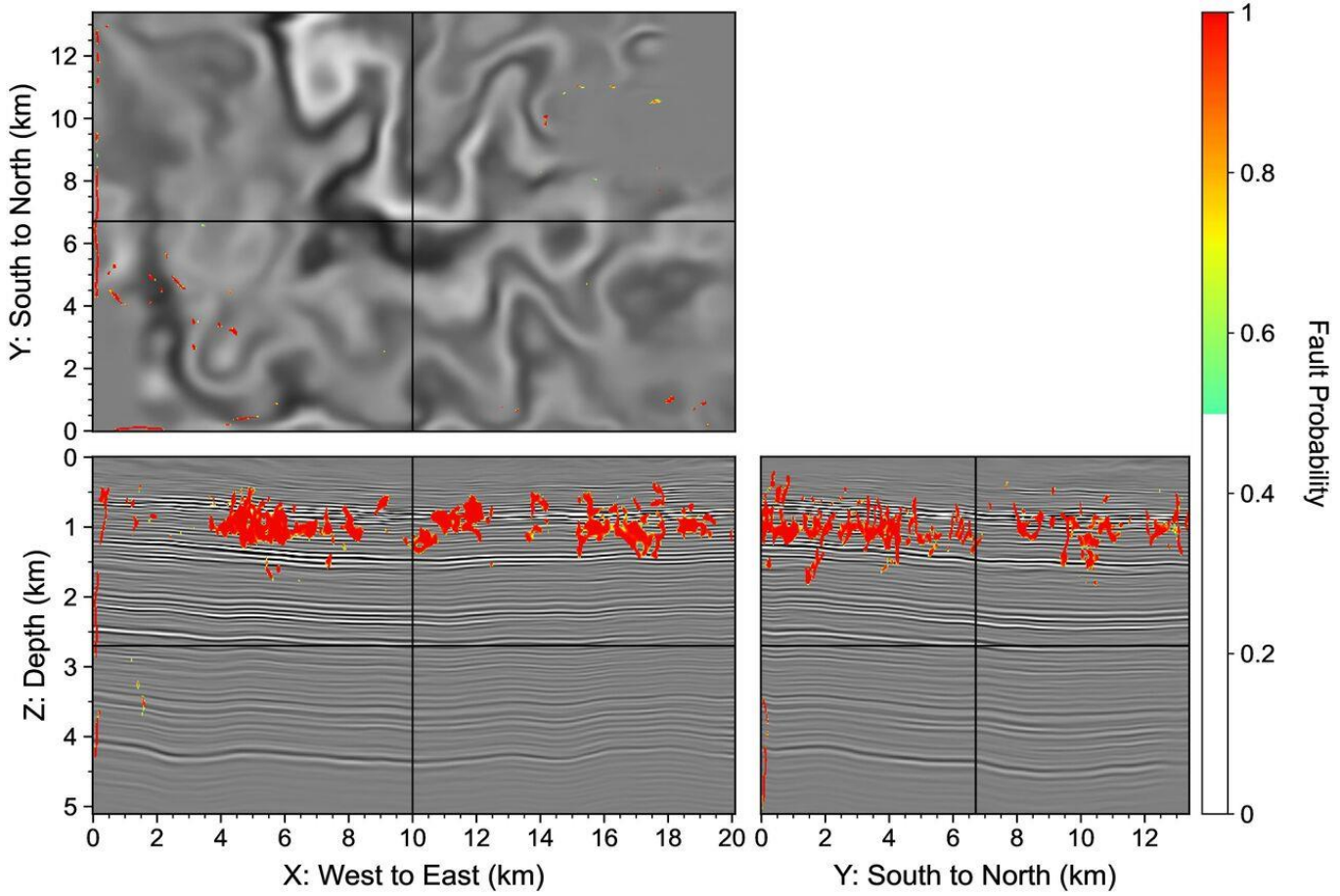
X=10km



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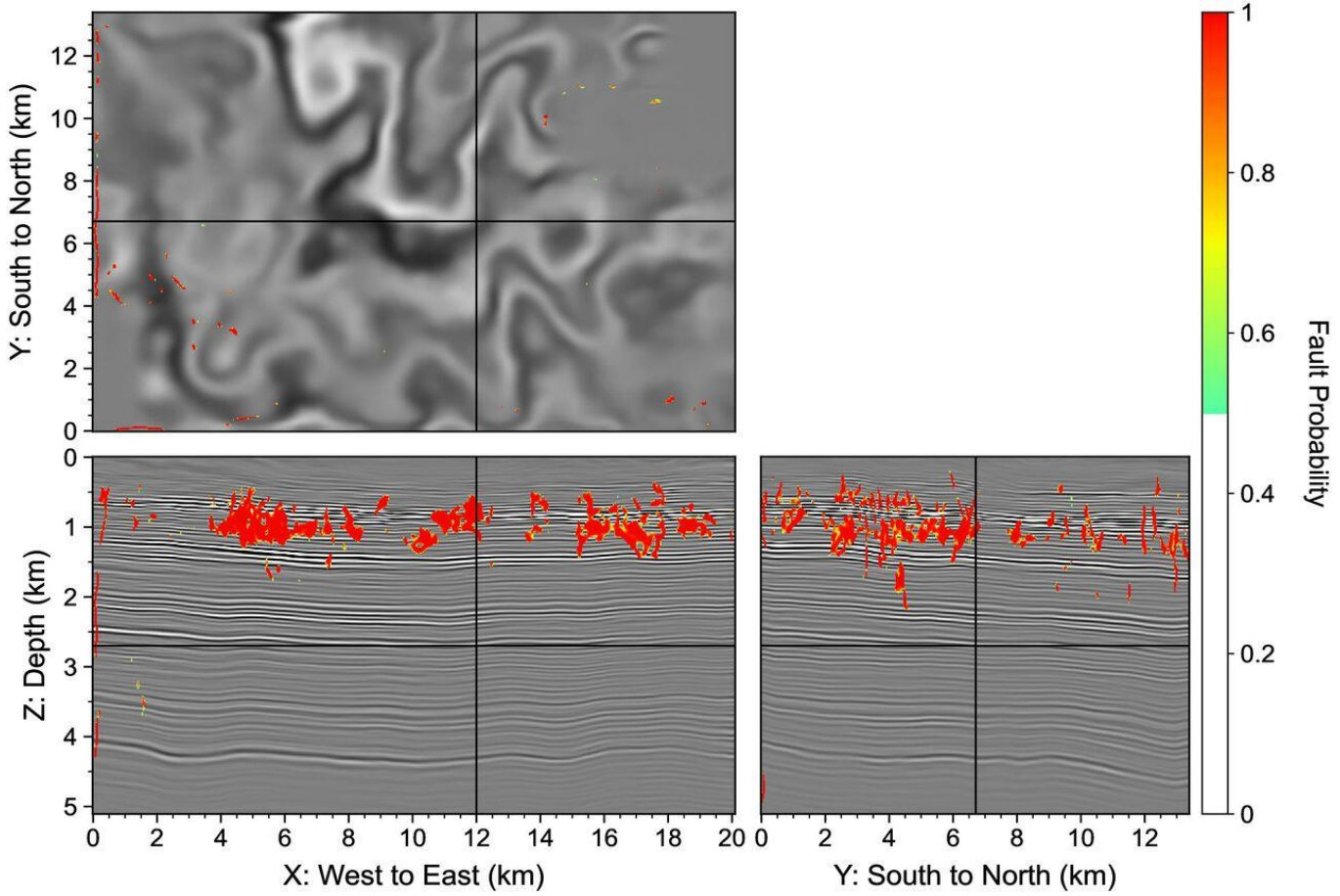
X=12km



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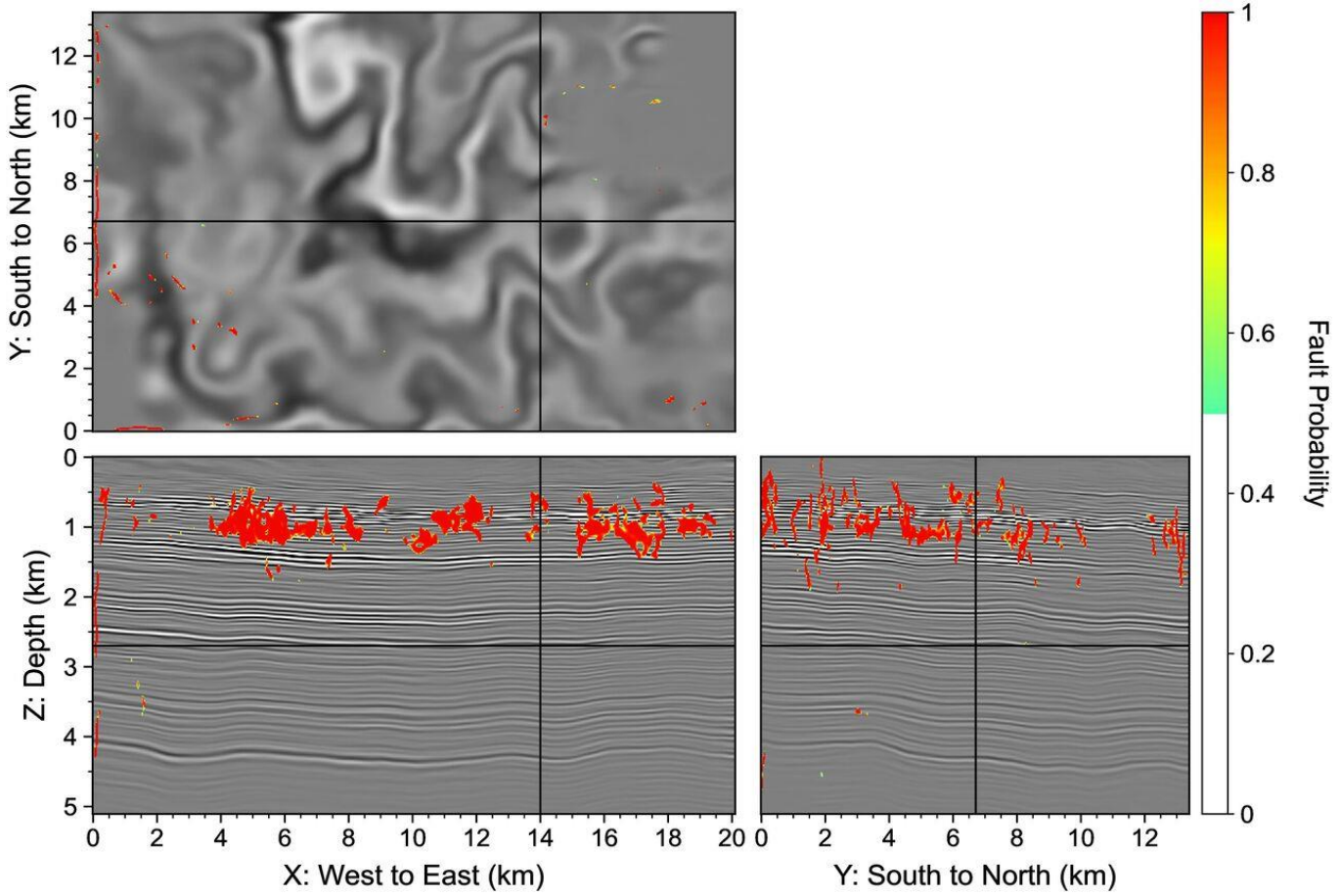
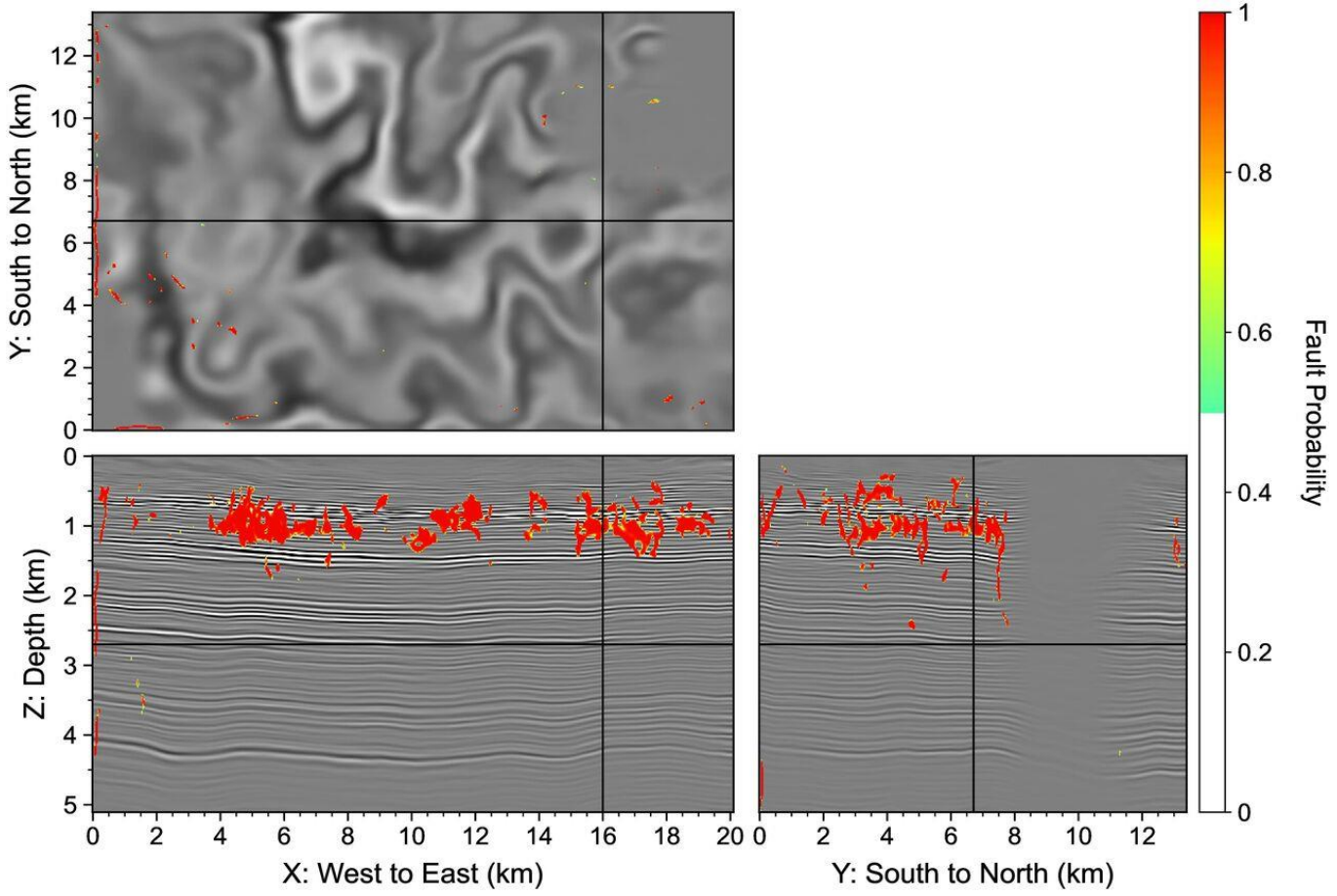
X=14km



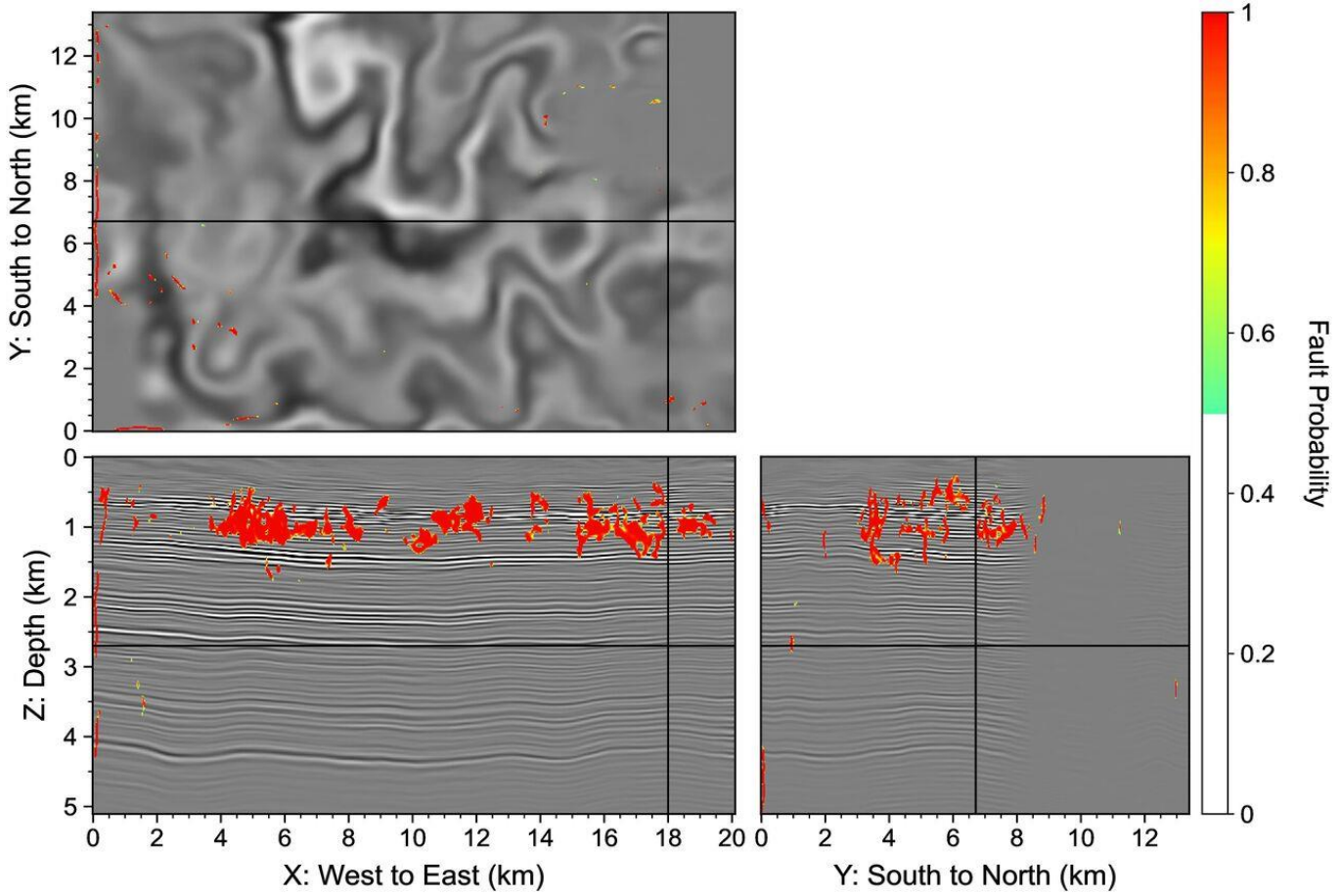
ML-Detected Faults on Denoised 3D Migration Image

X=16km



ML-Detected Faults on Denoised 3D Migration Image

X=18km



Conclusions

- We have performed 3D migration velocity analysis and prestack depth migration of the 3D surface seismic data acquired at the San Juan Basin CarbonSAFE project site.
- We have performed machine-learning fault detection on the denoised 3D migration image.
- We found that there are no major faults around the primary CO_2 injection zone, the Entrada formation at ~ 2.5 km depth, and that there are no major basement faults either.
- Our results provide valuable information for site characterization and risk assessment at the the San Juan Basin CarbonSAFE project site.

Acknowledgments

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