

Improved Resolution of a Subtle Stratigraphic Play in a Mature Basin: Integration of Traditional Geological Techniques and Seismic Geo-modelling Technology*

Siddharth Mukund¹, Ingelise Schmidt¹, and David Alan Stanbrook²

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Abstract

Exploration for hydrocarbons in mature basins is increasingly challenging and potential prospects have a greater degree of complexity and uncertainty associated with them, compared to historical finds. The case study area has been explored for hydrocarbons for more than 25 years during which time there has been a notable degree of success in drilling reservoirs in structural closures. As a result, there is a need to explore for the difficult hydrocarbons, which are possibly sitting in stratigraphic traps and other complex settings unlike conventional structural traps. A potentially large turbidite system was identified from seismic data using conventional interpretation methods and attribute extractions that proved to be seismically anomalous. Regional well-based geological work established gross depositional environments across the region that indicated a sand prone provenance area to the north of the area of interest. However, the geological context of these isolated sand deposits has been limited due to the uncertainty associated with the seismic interpretation in a structurally complex geological setting. Conventional interpretation techniques limit the ability to interpret and analyze these stratigraphic levels of interest across an inversion structure to an inferred sand provenance area. In this paper, we demonstrate and evaluate the possibility of discovering more subtle hydrocarbon reservoirs within the prospective interval of interest, using an integrated interpretation strategy exploiting geological and geophysical data and using innovative interpretation approaches. An innovative geo-modeling technology has been exploited to develop a methodology that helps to reduce the uncertainty of the seismic interpretation process and improves our understanding of the stratigraphy. In addition, data from seismic inversion was also integrated for interpretation purposes. The approach to interpretation demonstrated in this paper has helped to impose strong constraints to

guide the seismic interpretation and reduce uncertainty. The techniques used to construct a reliable geo-model eventually made it possible to correlate horizons across the inversion structure, which revealed amplitude anomalies suggesting a channel system across a shelf area down to the anomalies in the deeper basin thereby completing the geological model.

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Maersk Oil & Gas

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Background – Early Seismic Interpretation

The Challenge

Geo-modeling Technology

3D Geo-model QC & Constraints

Geo-model Constraint using Seismic Inversion

Seismic Attribute Interpretation using High Density Geo-Model Horizons

Conclusions

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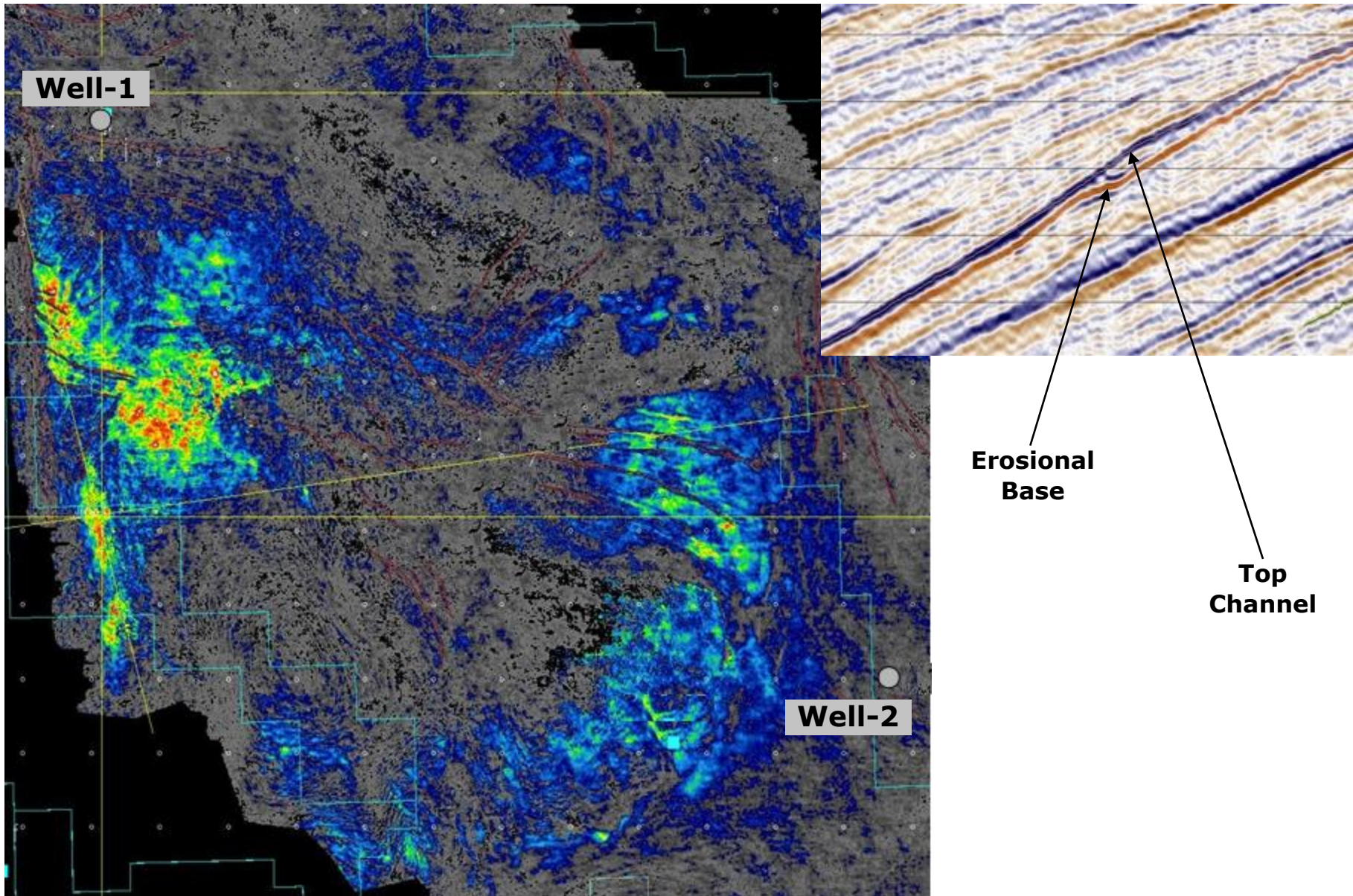
3D Geo-model QC & Constraints

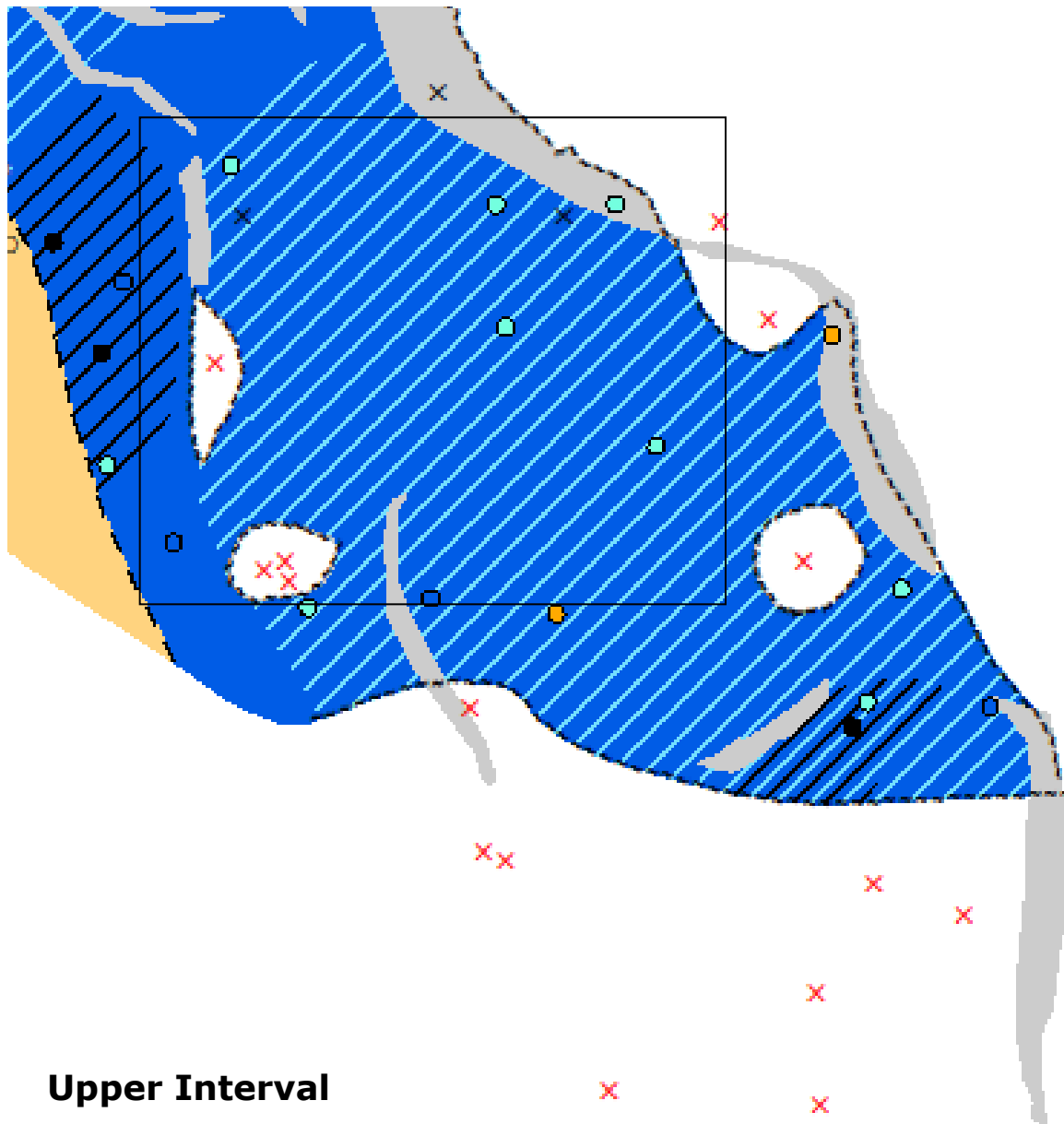
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Early Work – RMS Amplitude





WELL DEPOSITIONAL ENVIRONMENT

- Lower Shoreface / Transition
- Offshore / Shelfal
- Marine, Minor Terrestrial Input
- Marine, Major Terrestrial Input
- Deep Marine
- Restricted Marine
- × Not Known / Uncertain / Undifferentiated
- × Not Penetrated
- × Missing Section

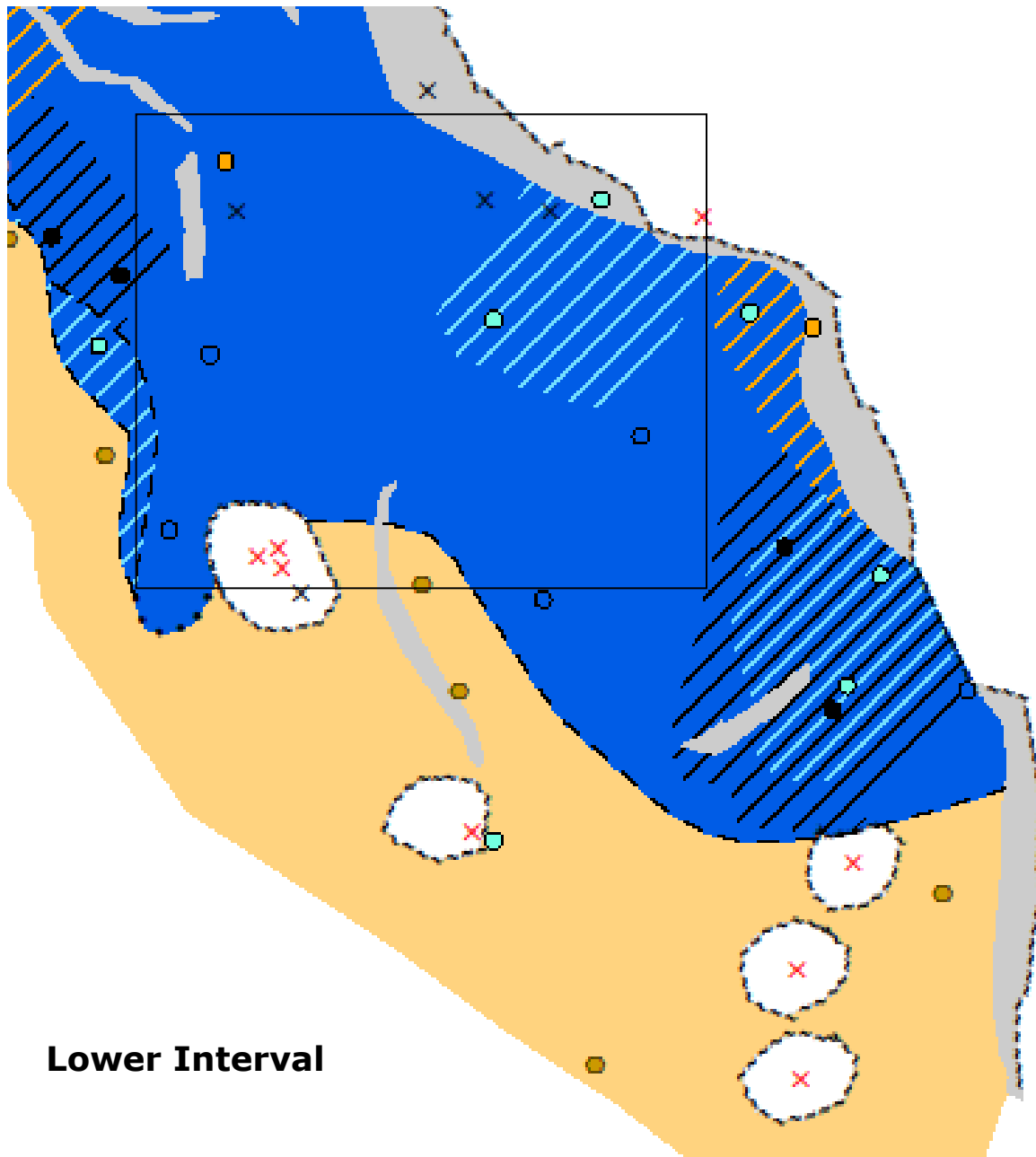
ENVIRONMENT OF DEPOSITION

- Lower Shoreface to Offshore
- ▨ Marine, Minor Terrestrial Input
- ▨ Marine, Major Terrestrial Input
- ▨ Restricted Marine
- Deep Marine
- Missing section

DEPOSITIONAL BOUNDARY

- Known
- - - - Erosive / Non-deposition
- - - - Inferred
- • • • Speculative

Upper Interval



WELL DEPOSITIONAL ENVIRONMENT

- Lower Shoreface / Transition
- Offshore / Shelfal
- ◻ Marine, Minor Terrestrial Input
- ◻ Marine, Major Terrestrial Input
- Deep Marine
- Restricted Marine
- × Not Known / Uncertain / Undifferentiated
- × Not Penetrated
- × Missing Section

ENVIRONMENT OF DEPOSITION

- Lower Shoreface to Offshore
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DEPOSITIONAL BOUNDARY

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Lower Interval

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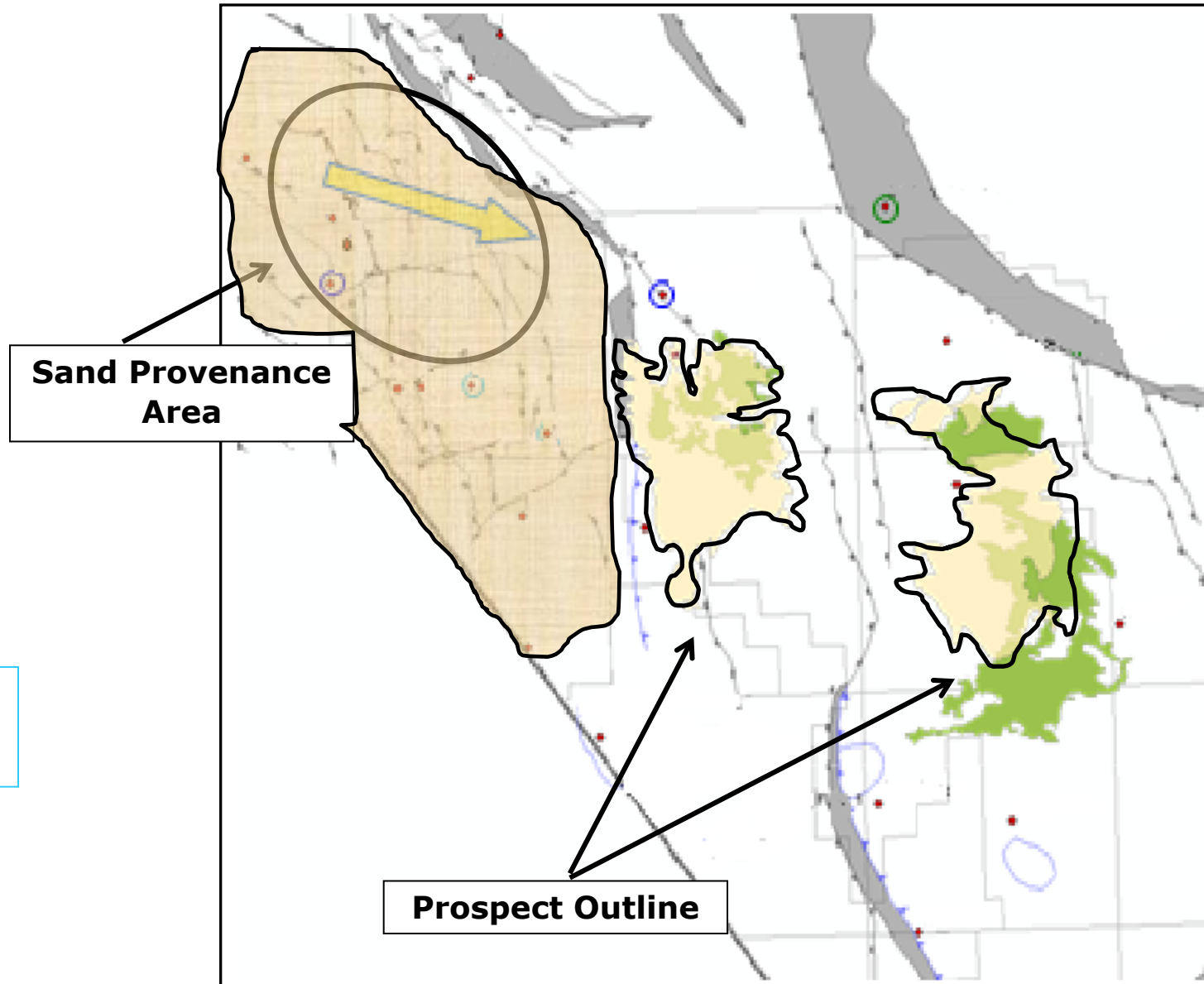
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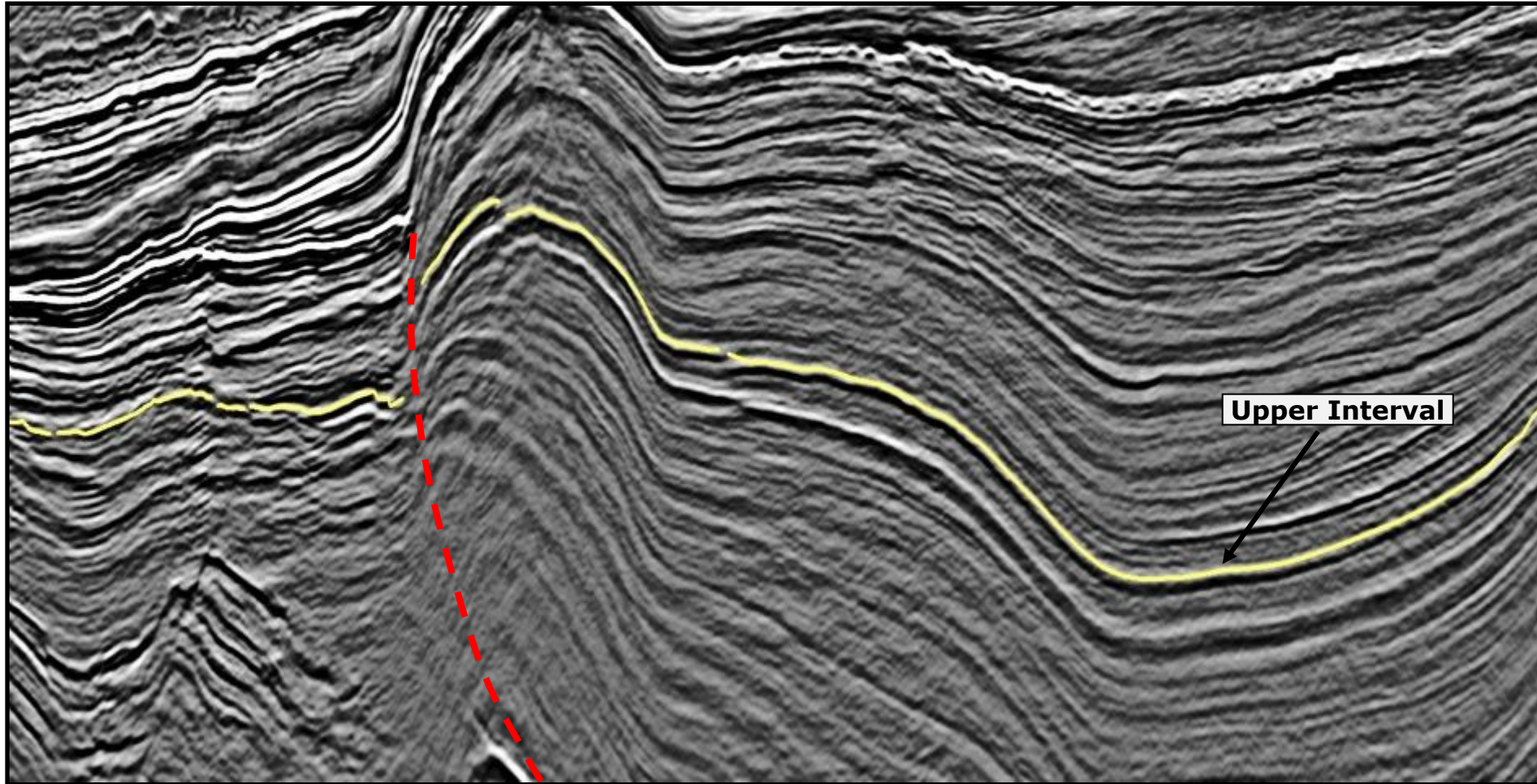
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Depositional Environment



Conventional Seismic Interpretation



High Vertical Exaggeration

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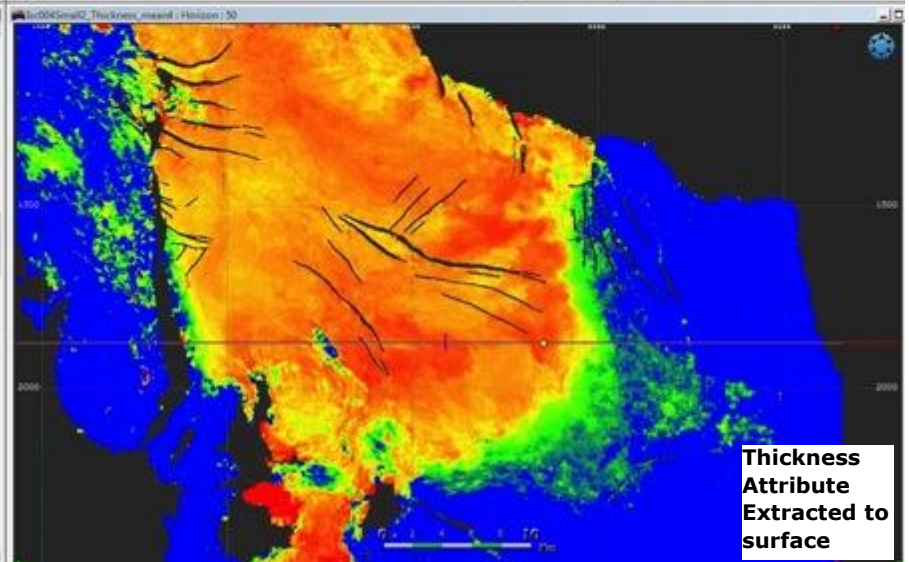
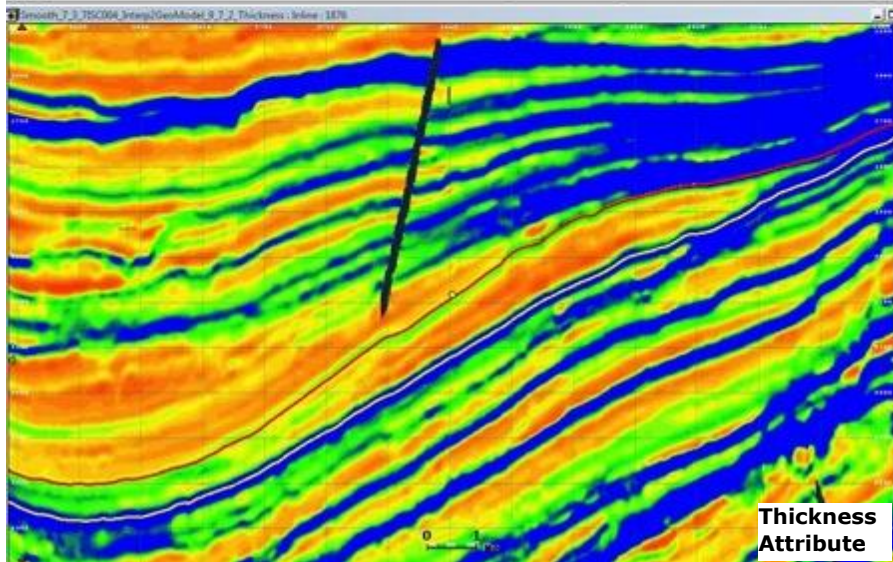
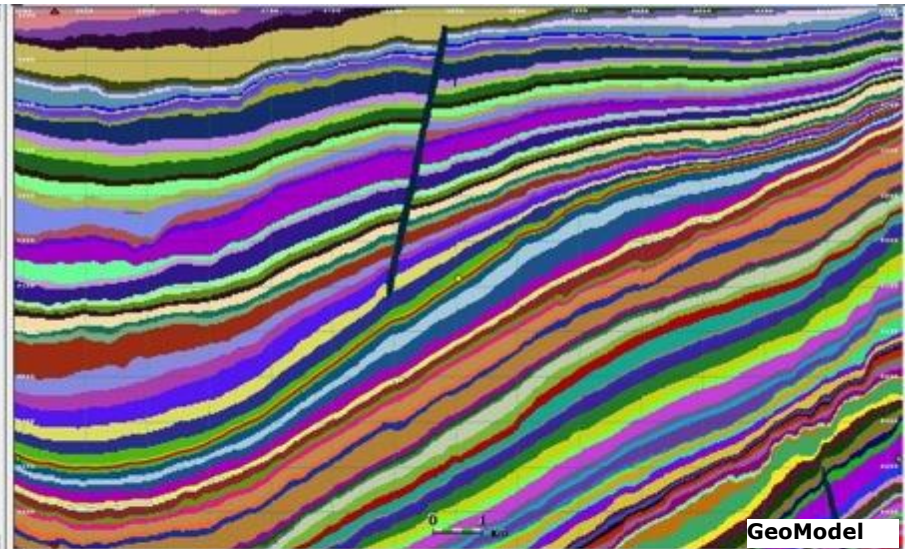
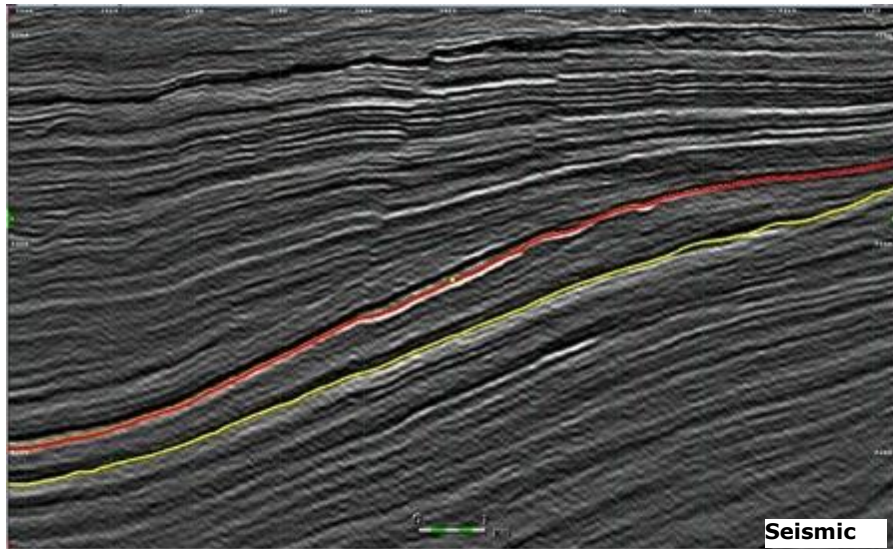
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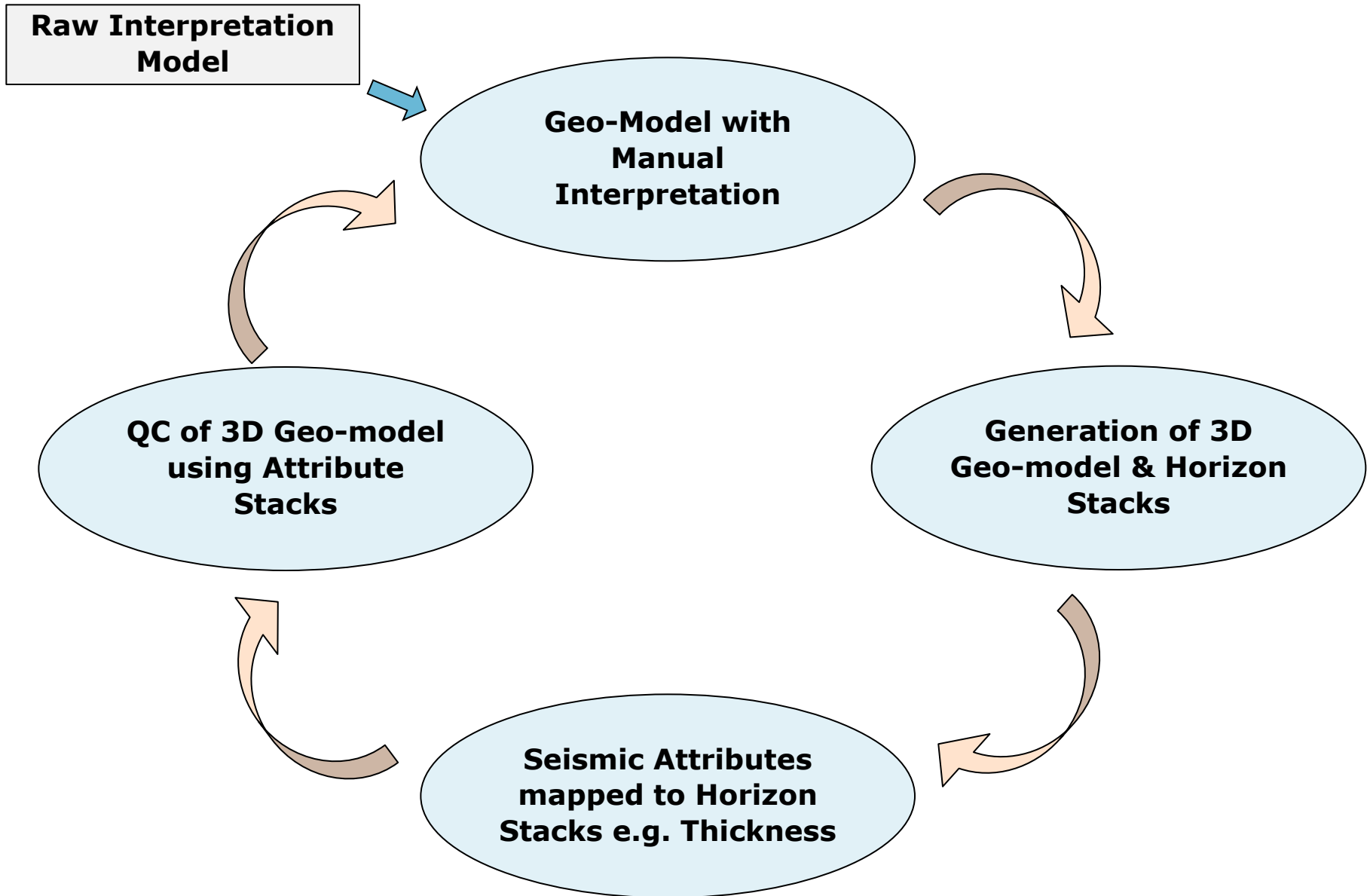
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Geomodelling Technology



Geomodelling Technology Workflow



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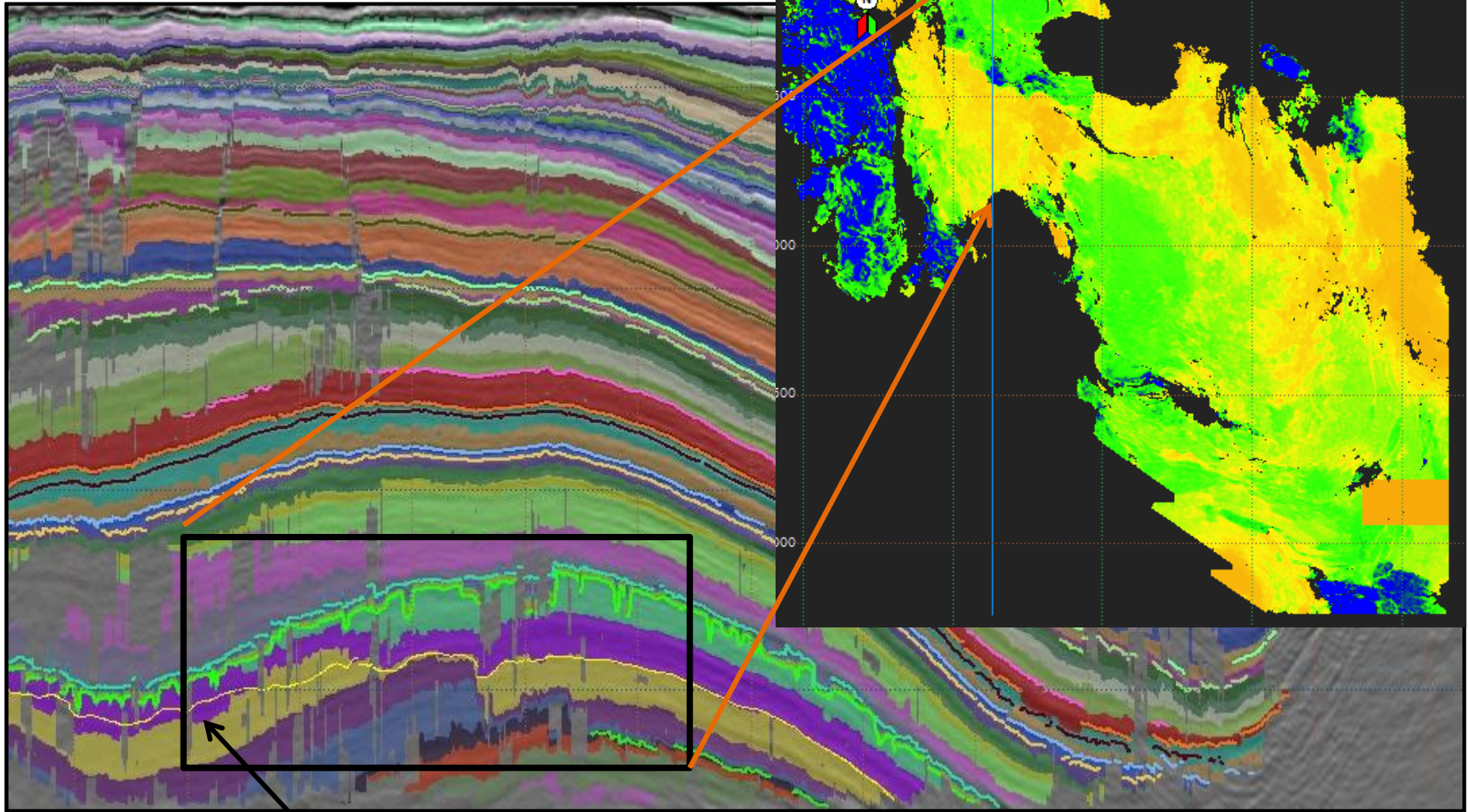
3D Geo-model QC using Thickness Attribute

Geo-model Constraint using Seismic Inversion

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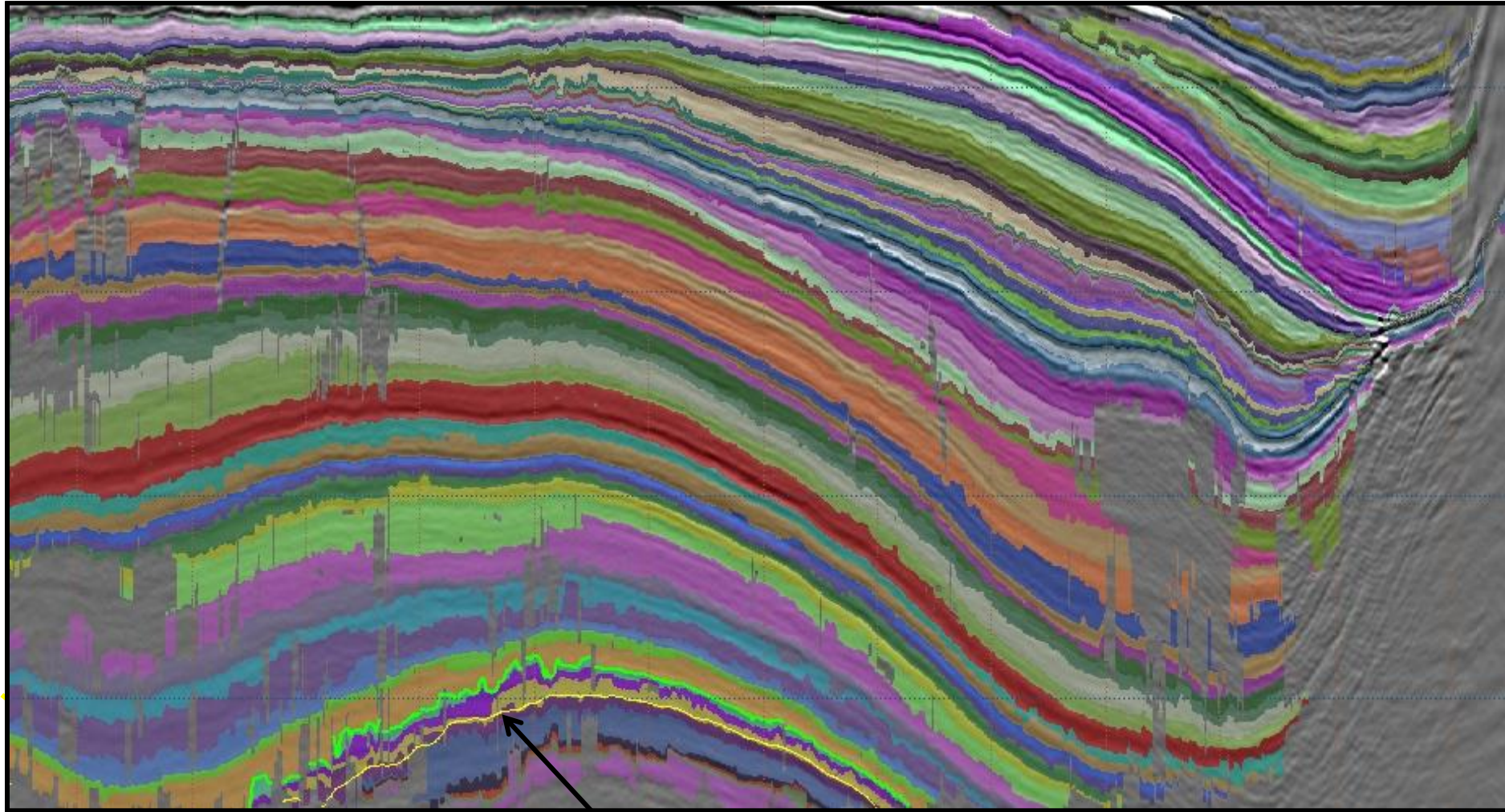
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Geo-model QC using Thickness Attribute



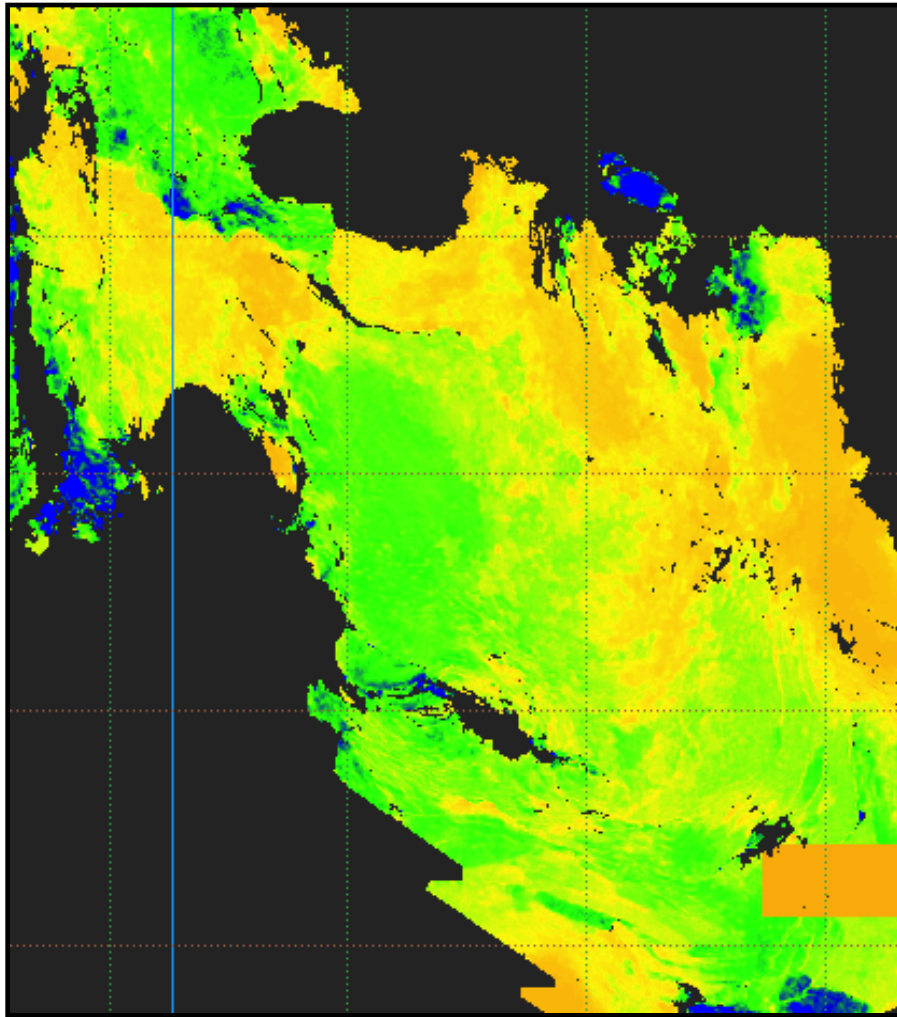
Geo-model Horizon

Geo-model QC using Thickness Attribute



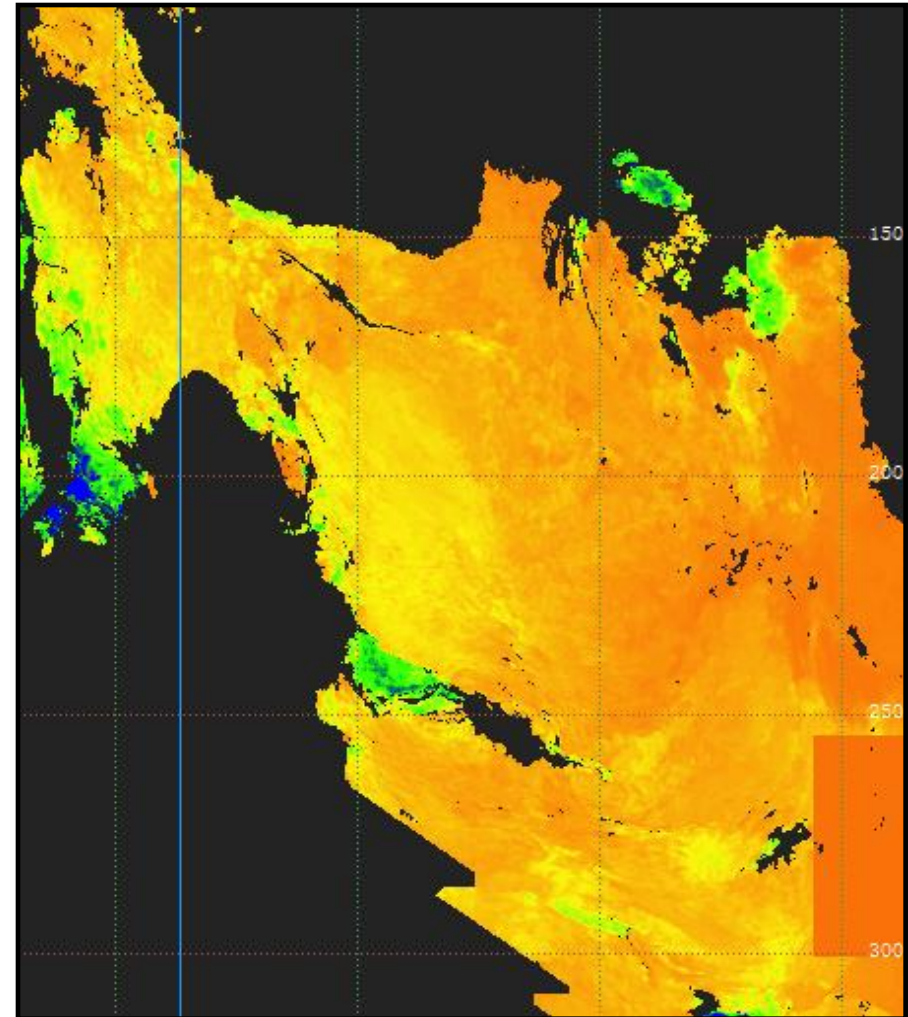
Geo-model Horizontal Constraint
Geo-model after Additional Constraint
Geo-model after Additional Constraint

Geo-model QC using Thickness Attribute



**Thickness Attribute Map -
Before**

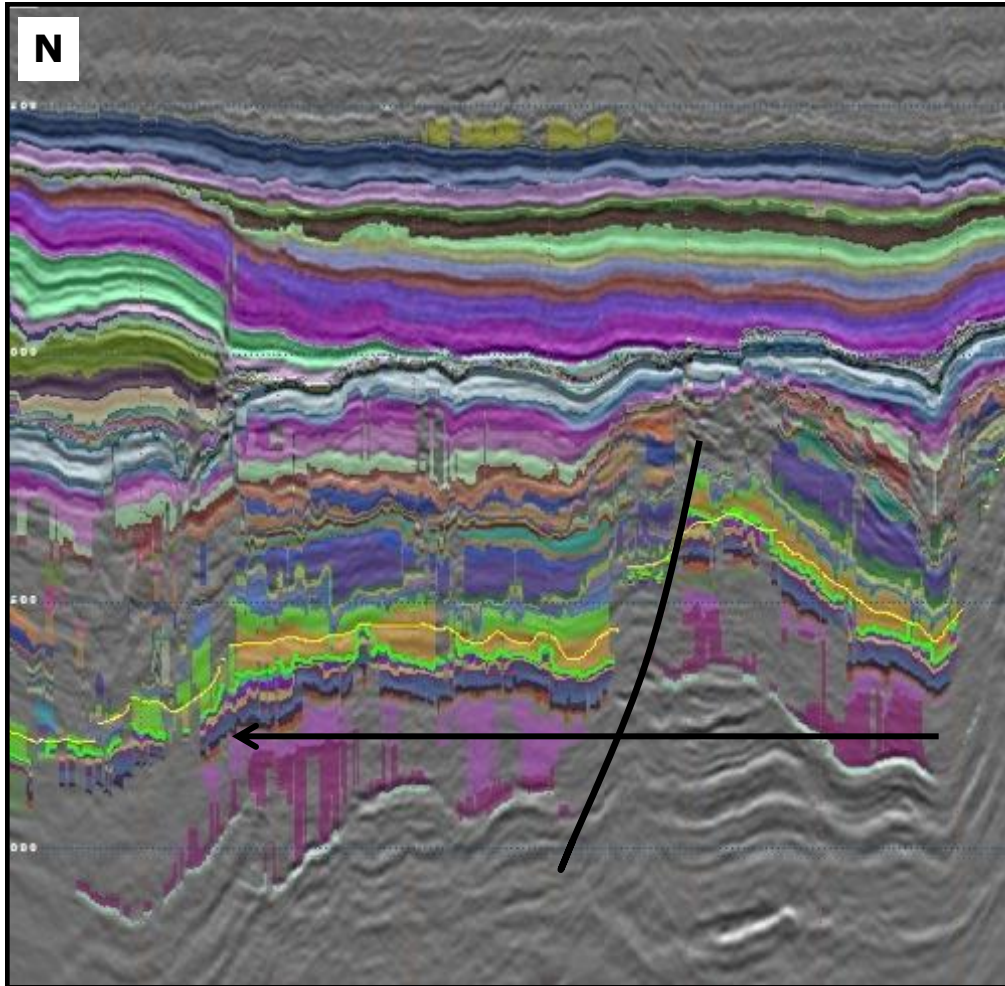
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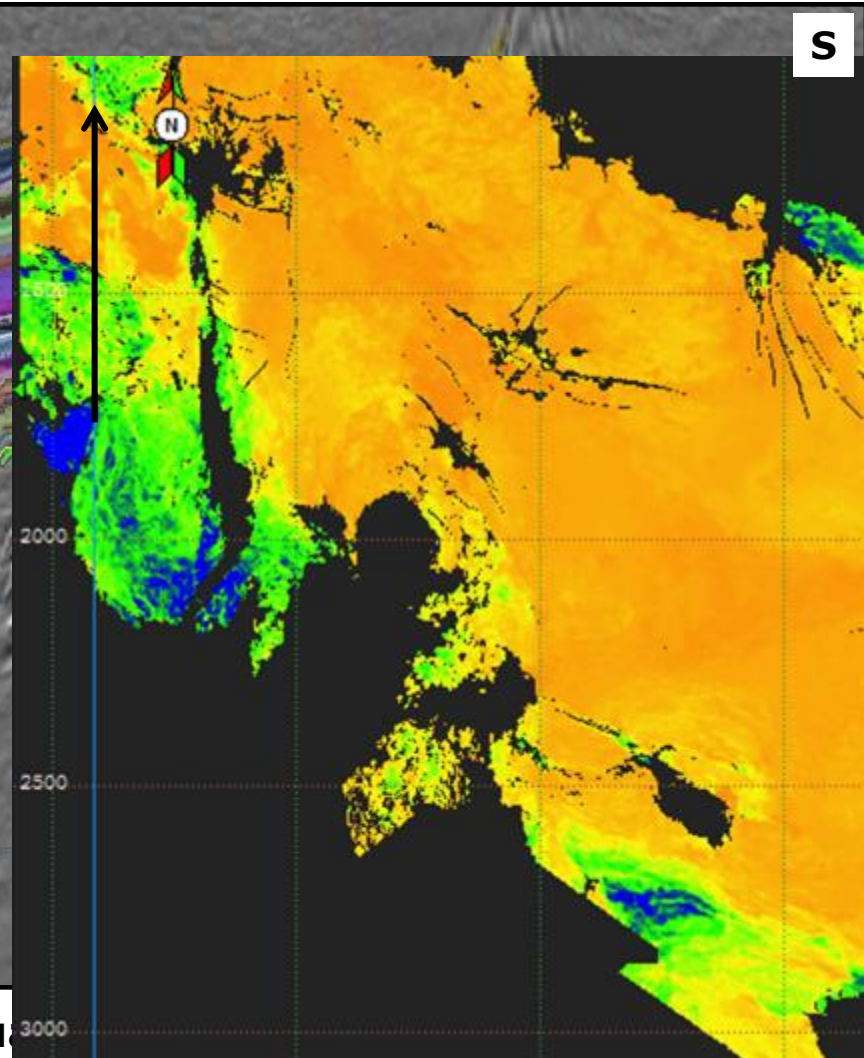
**Thickness Attribute Map -
After**

December 17, 2014

Geologic Expression of Thickness Attribute



Geo-model with Conceptual



Thickness Attribute Map

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Background – Early Seismic Interpretation

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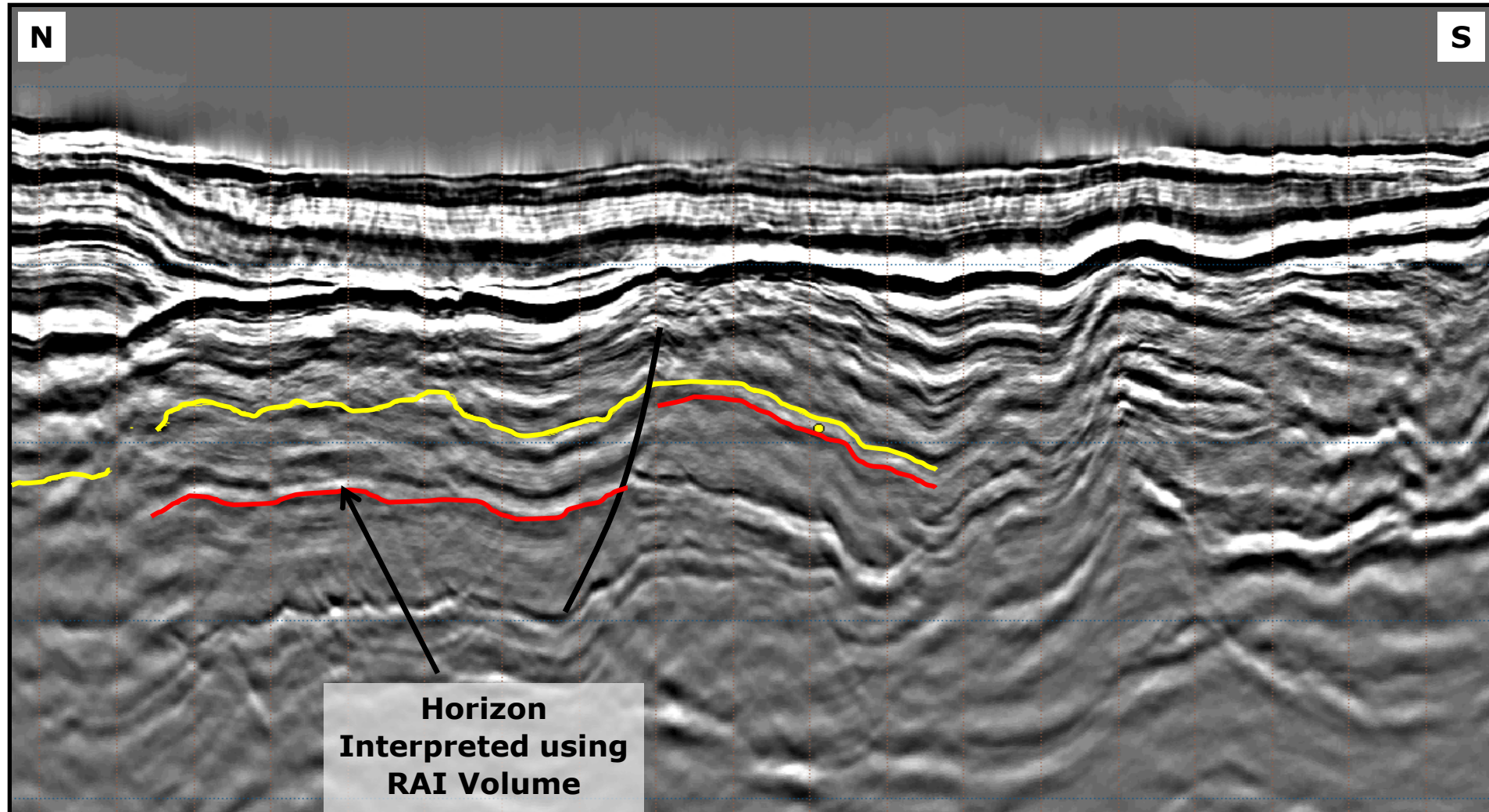
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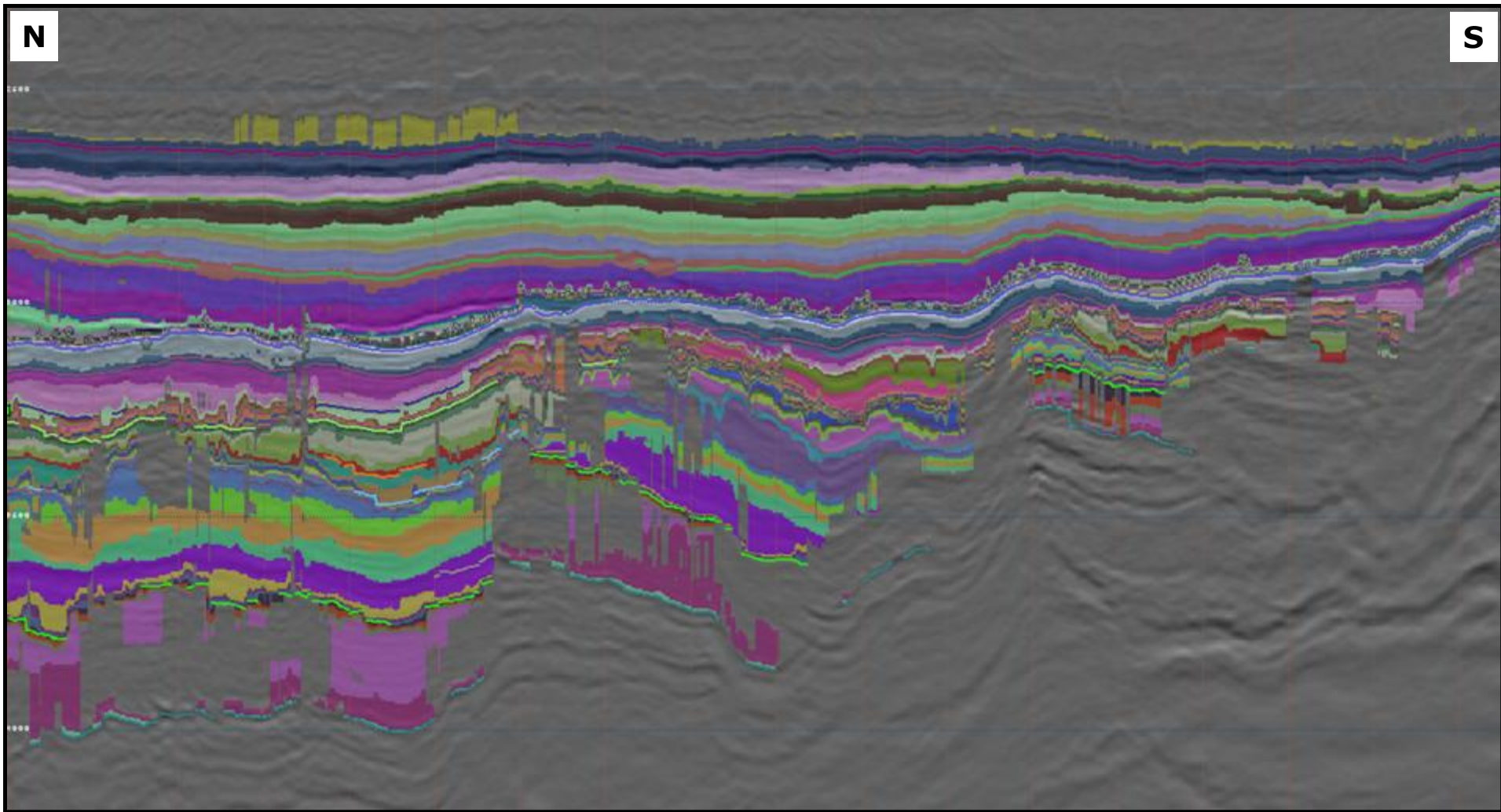
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Geo-model Constraint using Seismic Inversion



Geo-model Constraint using Seismic Inversion



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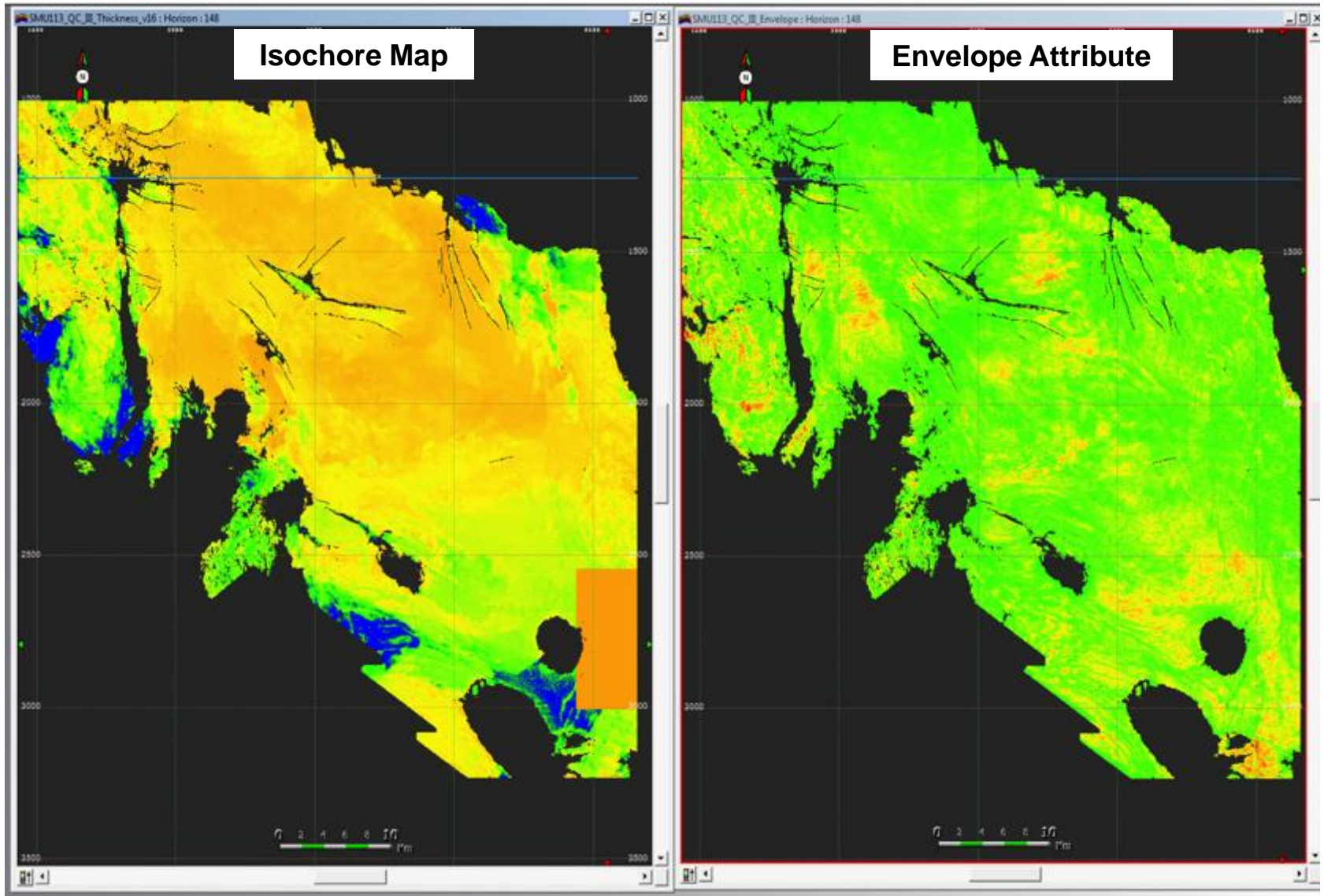
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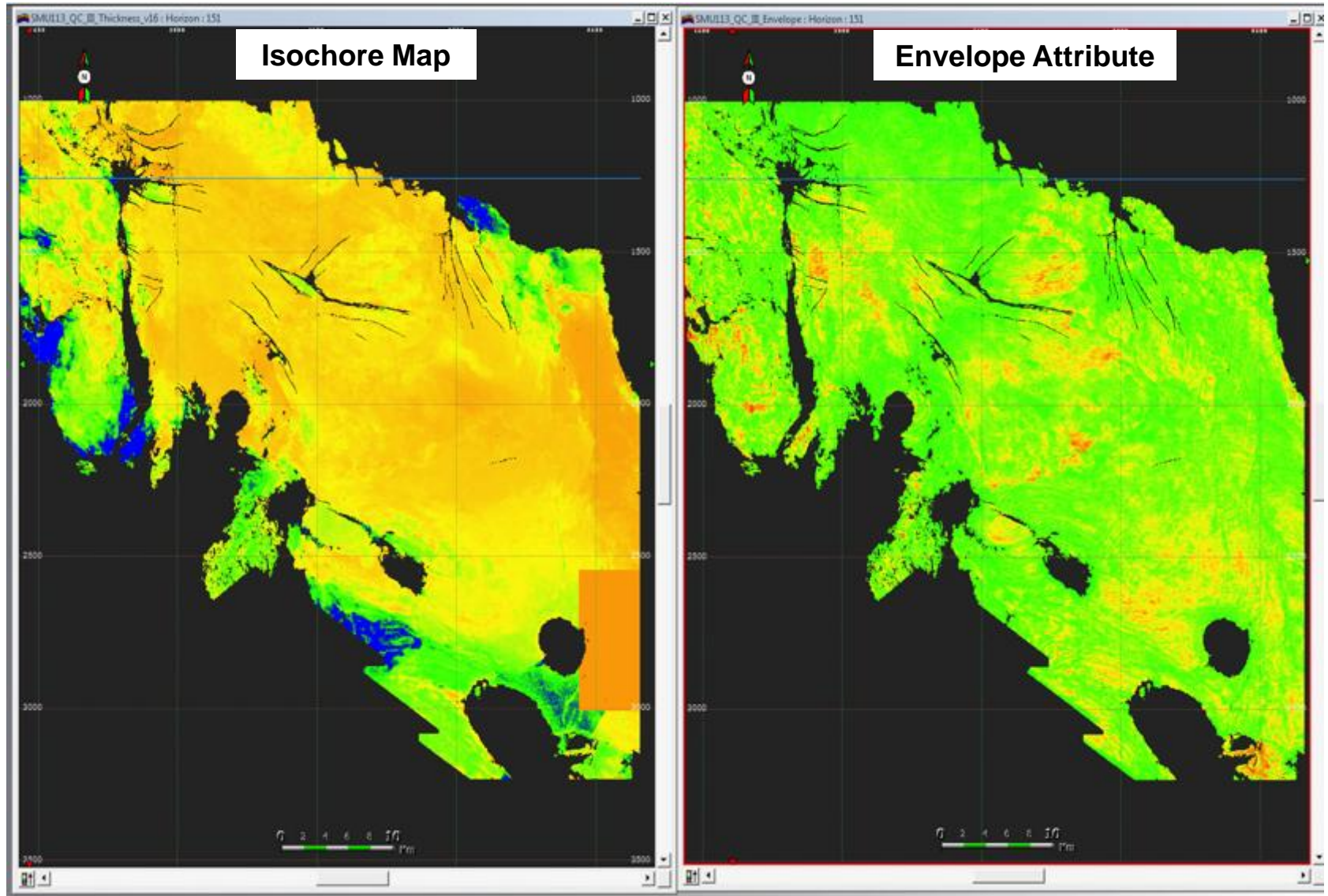
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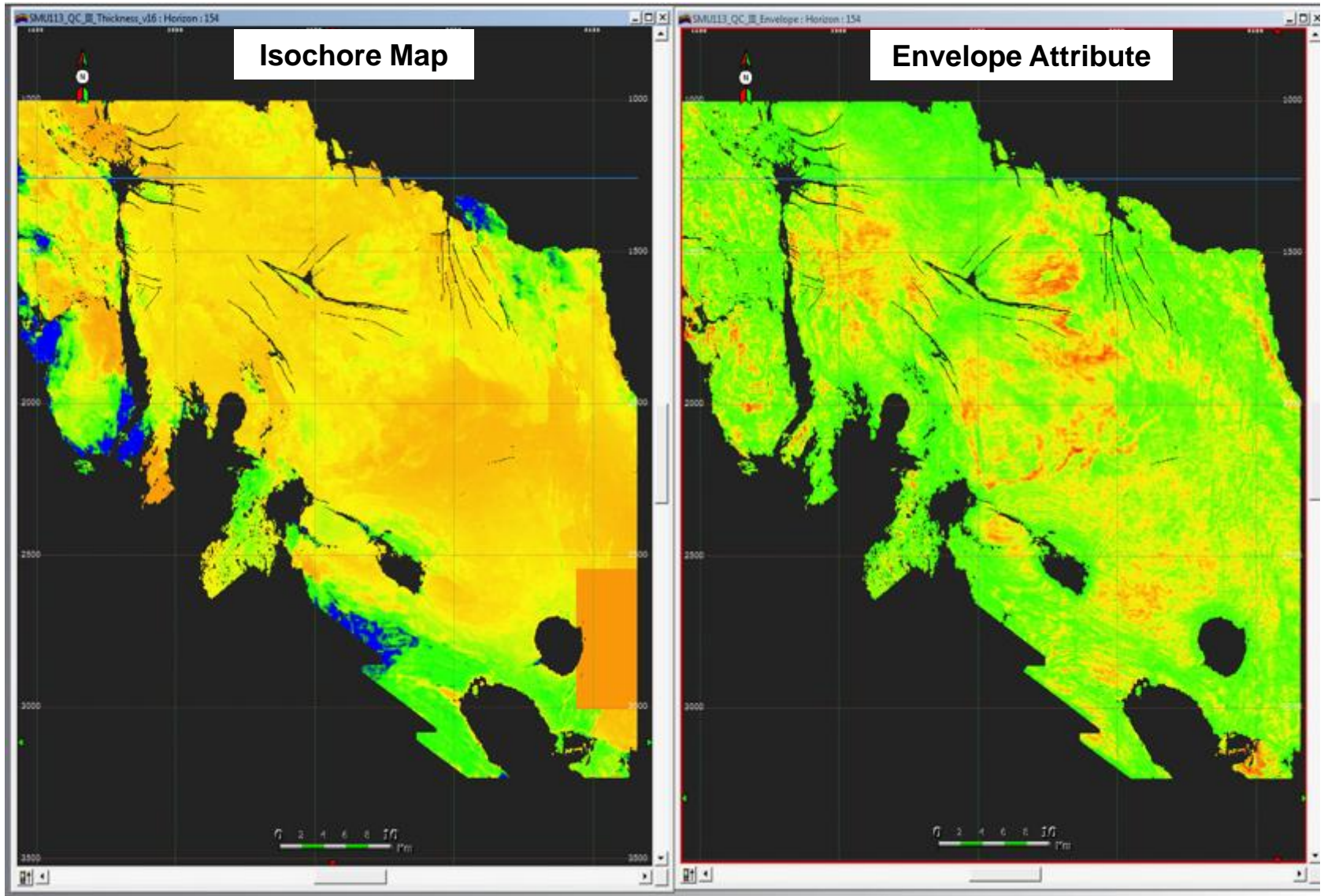
Basin Evolution from Attribute Stack



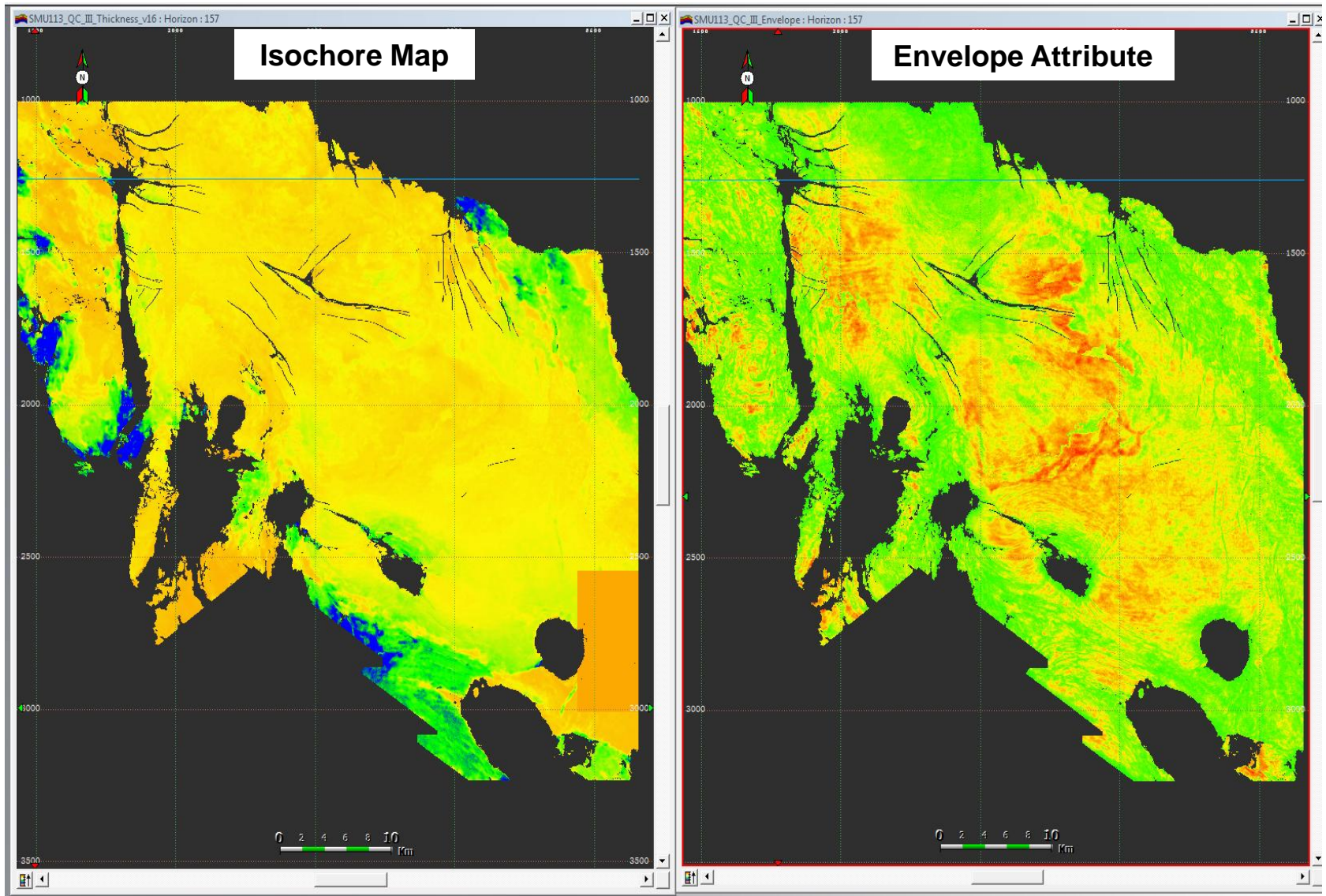
Basin Evolution from Attribute Stack



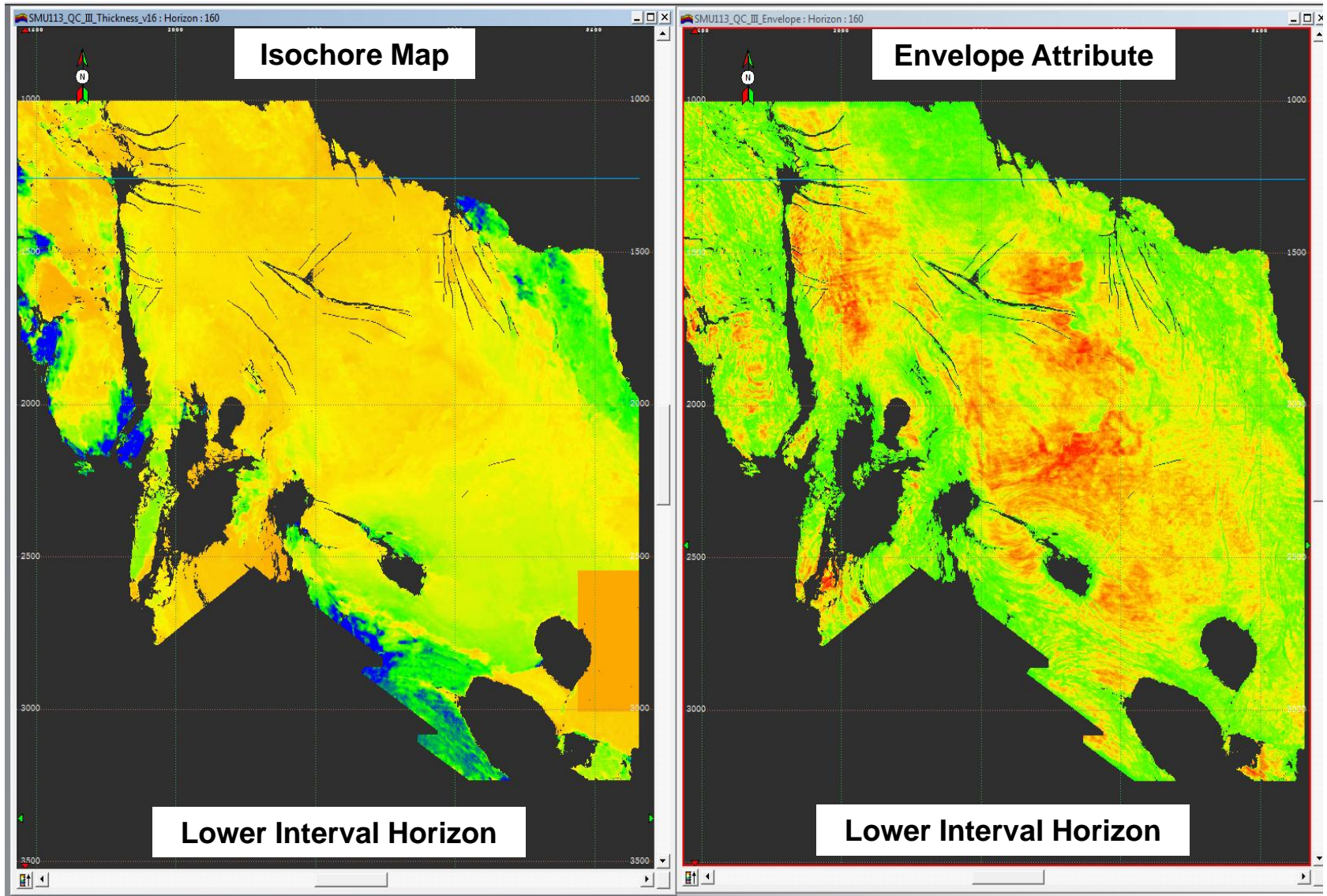
Basin Evolution from Attribute Stack



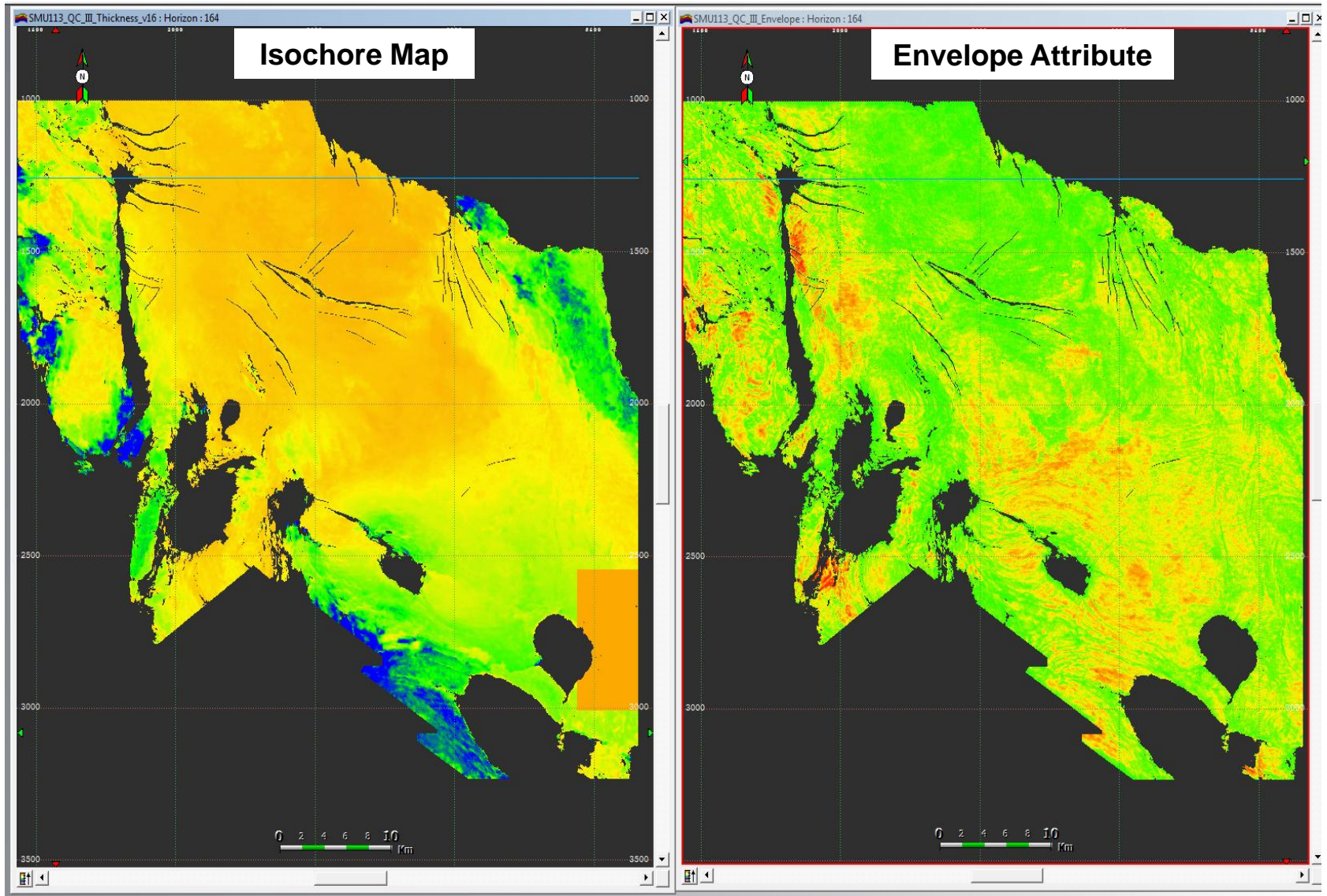
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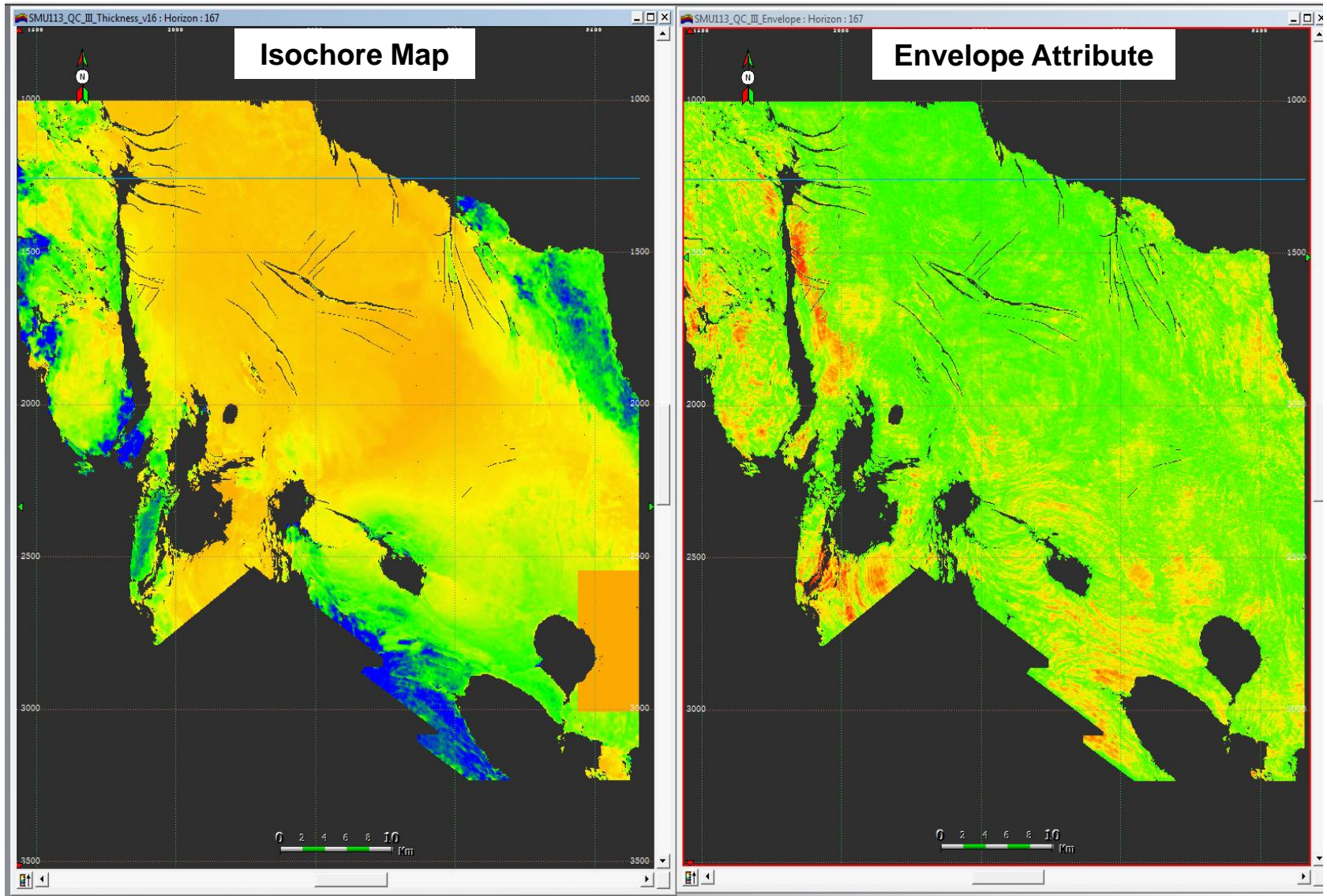
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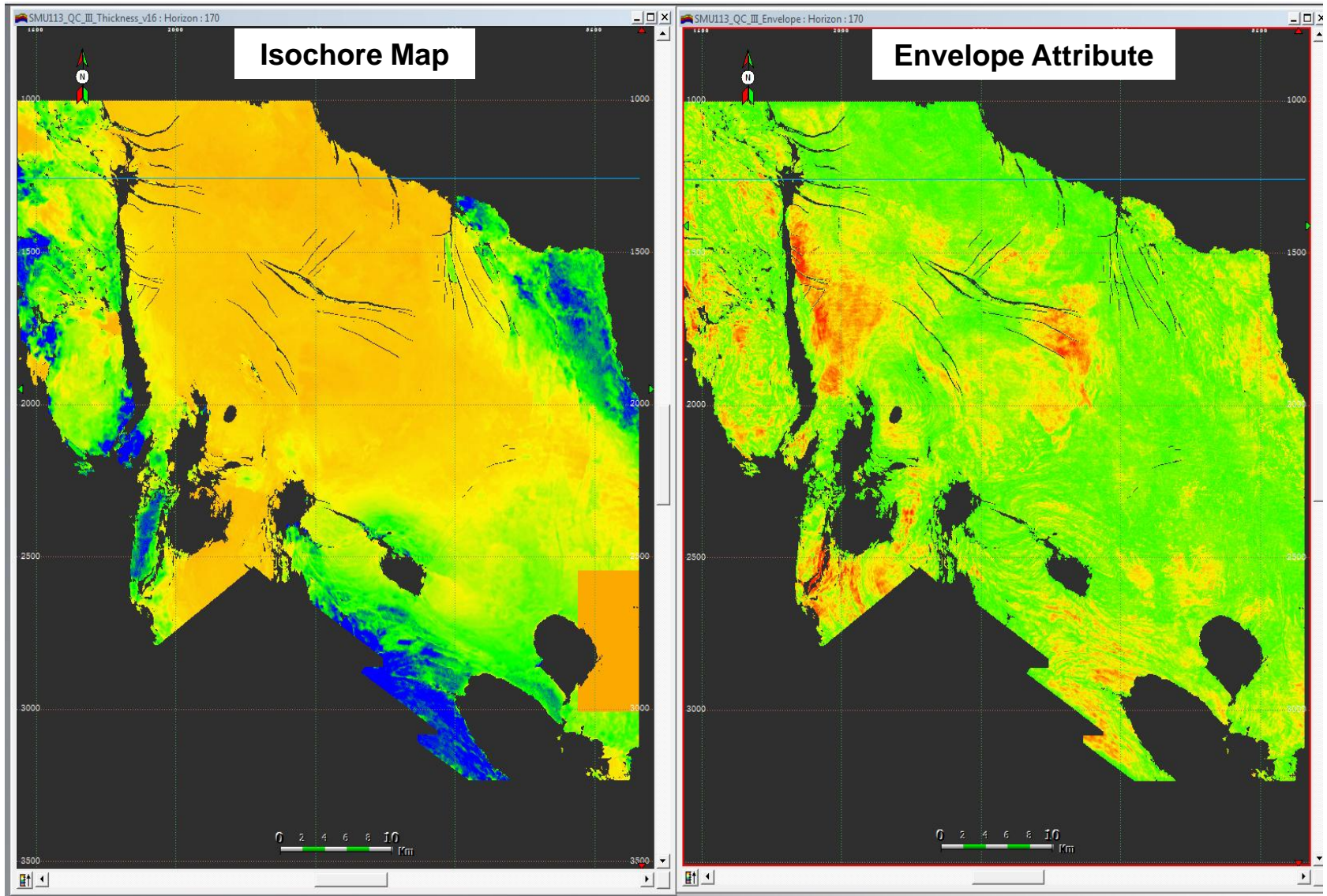
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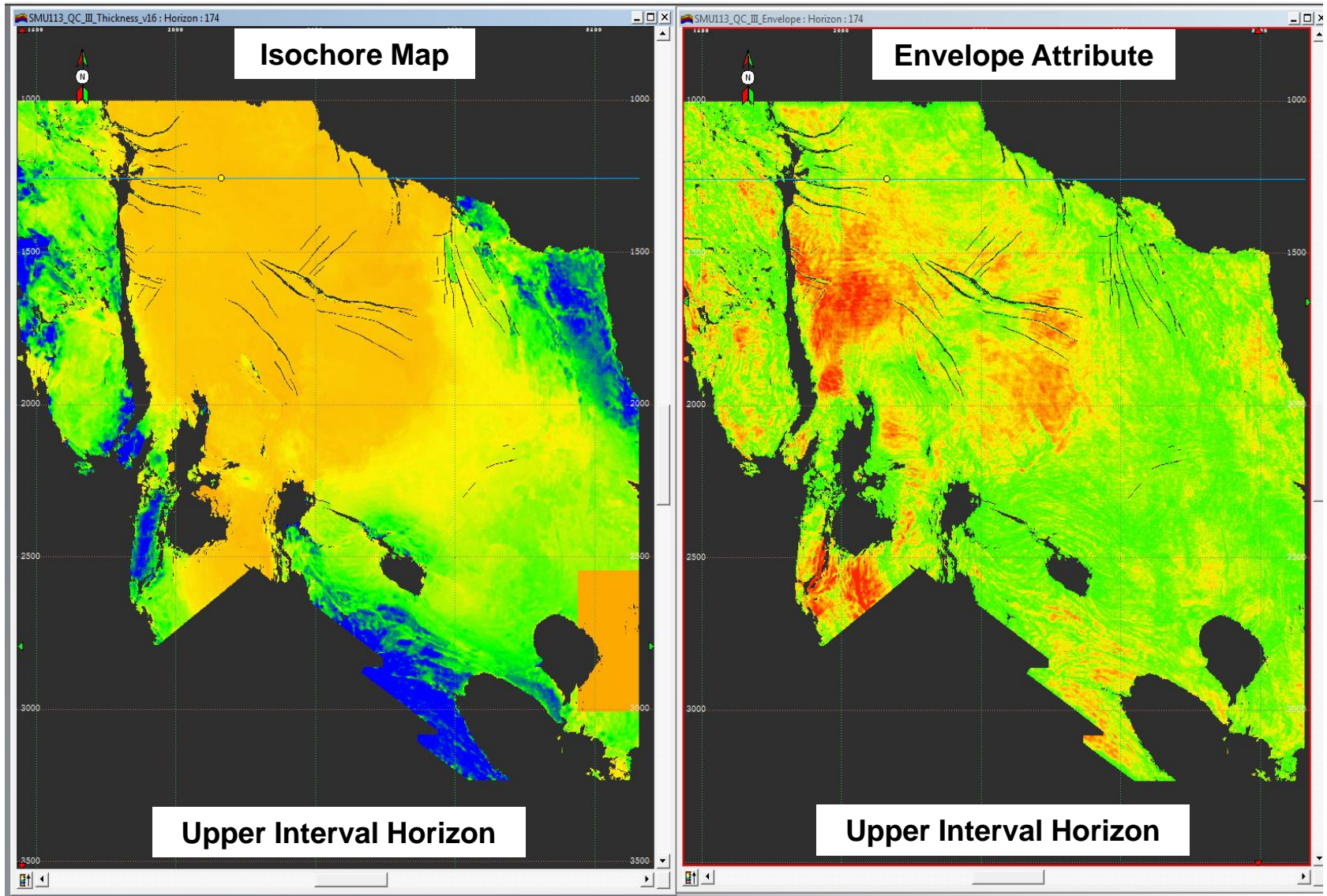
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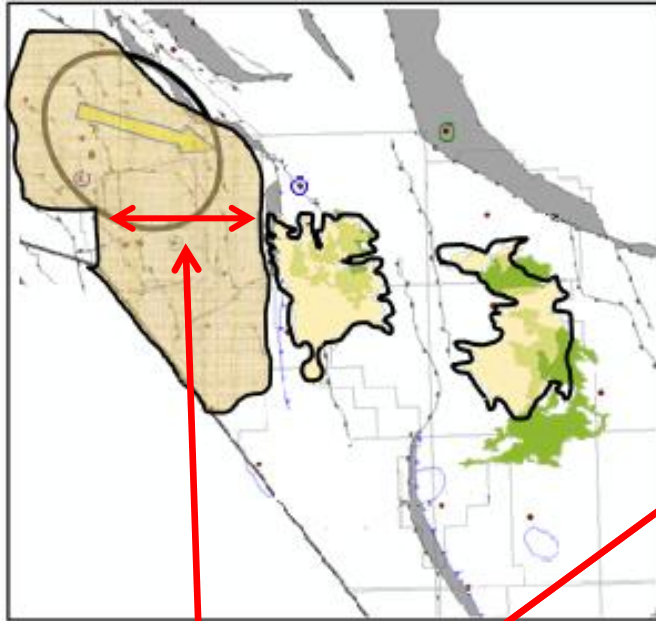
Basin Evolution from Attribute Stack



Basin Evolution from Attribute Stack

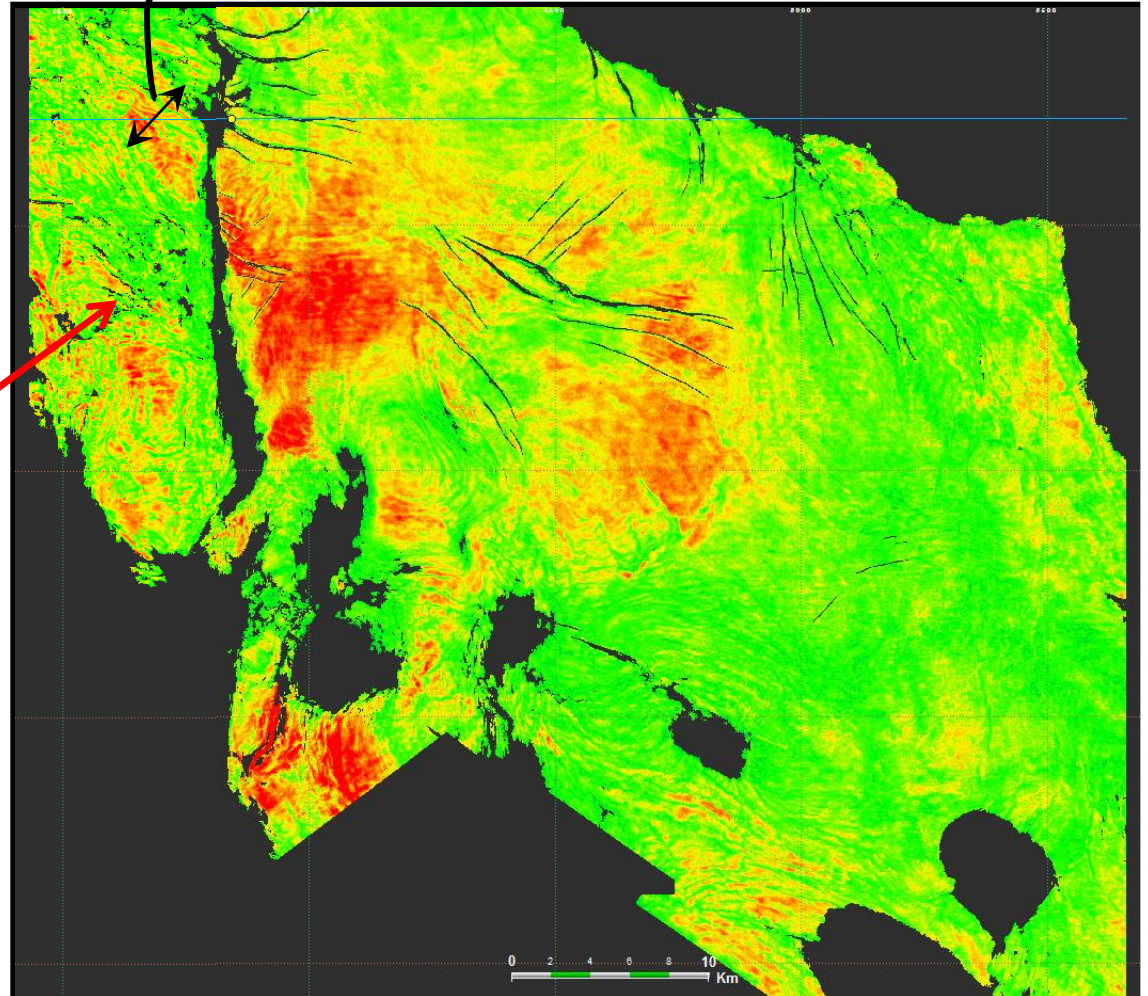


Seismic Attribute Maps from Final Geo-Model

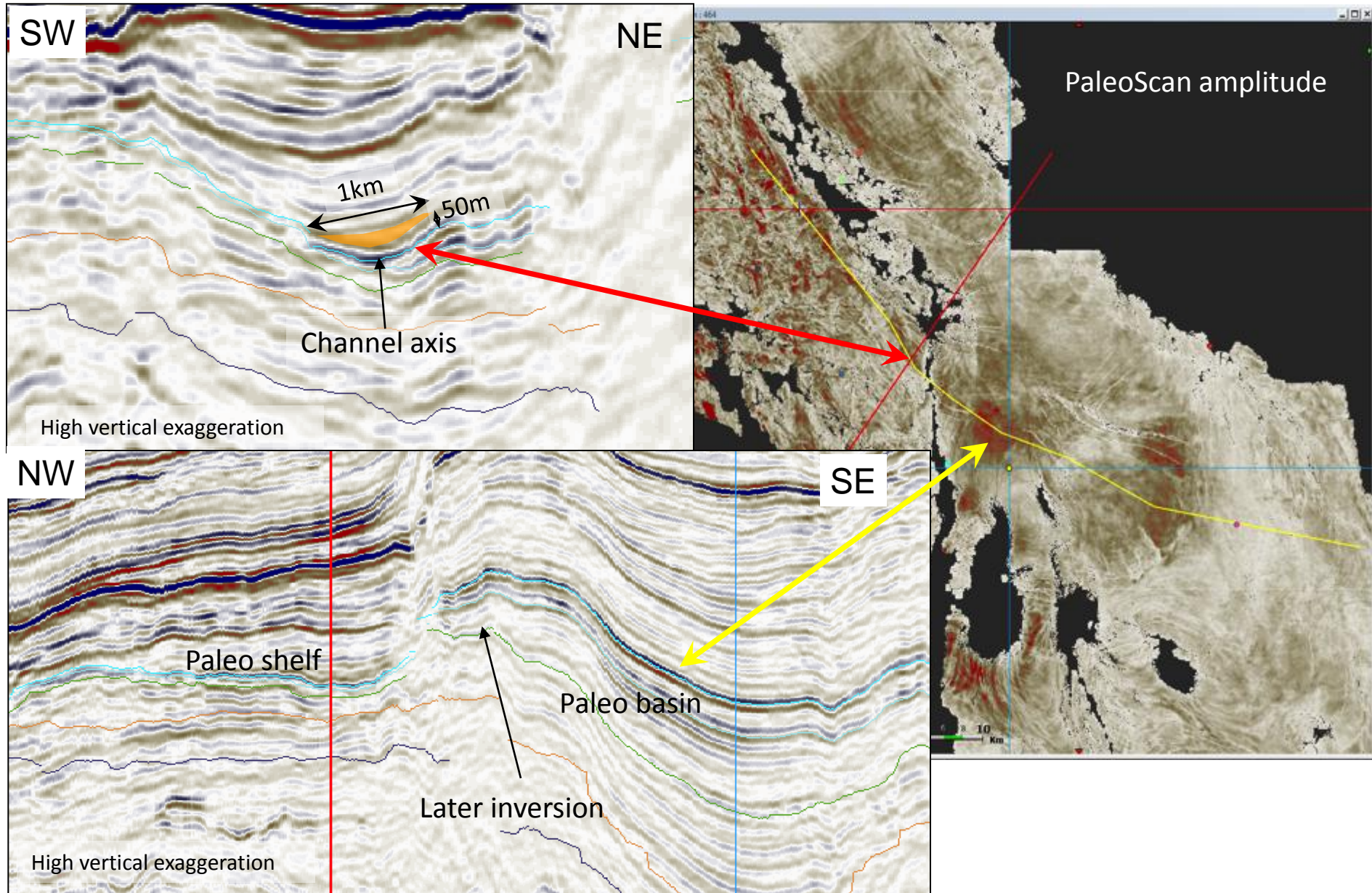


**Region across the
Inversion Structure –
No Prior Interpretation**

**Feeder Channel Expression –
Approximate Width 1 Km**



Geo-model Constraint using Seismic Inversion



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Seismic attribute expressions revealed anomalies resembling turbidite deposits; Difficulties with seismic interpretation limited the geological understanding

Conventional interpretation techniques alone were insufficient to improve our understanding of the depositional system

Geomodeling technology allows for an innovative way to study and interpret seismic volumes; providing the opportunity to generate a high density of horizons

Seismic attributes and Geomodeling technology together allow to constrain the seismic interpretation and reduce the associated uncertainty

Basin evolution and depositional model established from sedimentological study was supported through stratigraphic slicing of the thickness attribute

The study helped to link the observed amplitude anomalies to the sediment source on the seismic data with expression of feeder channels

The integrated approach combining new technology with elastic inversion and conventional sedimentological studies has helped significantly in de-risking this new play

Thank You