Israel: Seeing Deeper

Imaging new play concepts with Clari-Fi™ broadband reprocessing

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Interpretation Geophysicist
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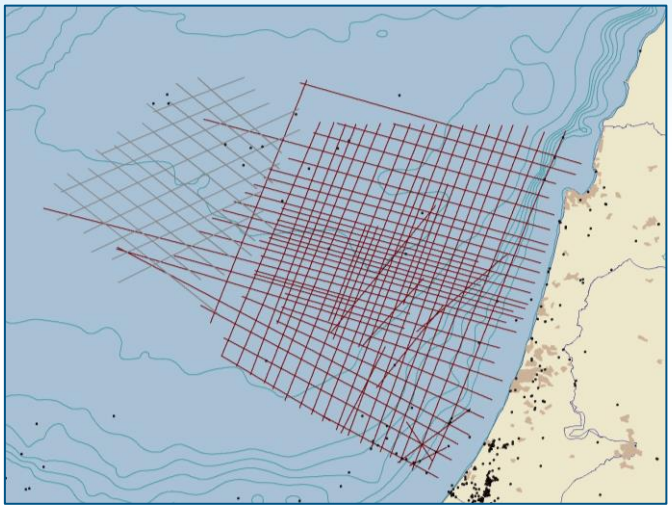
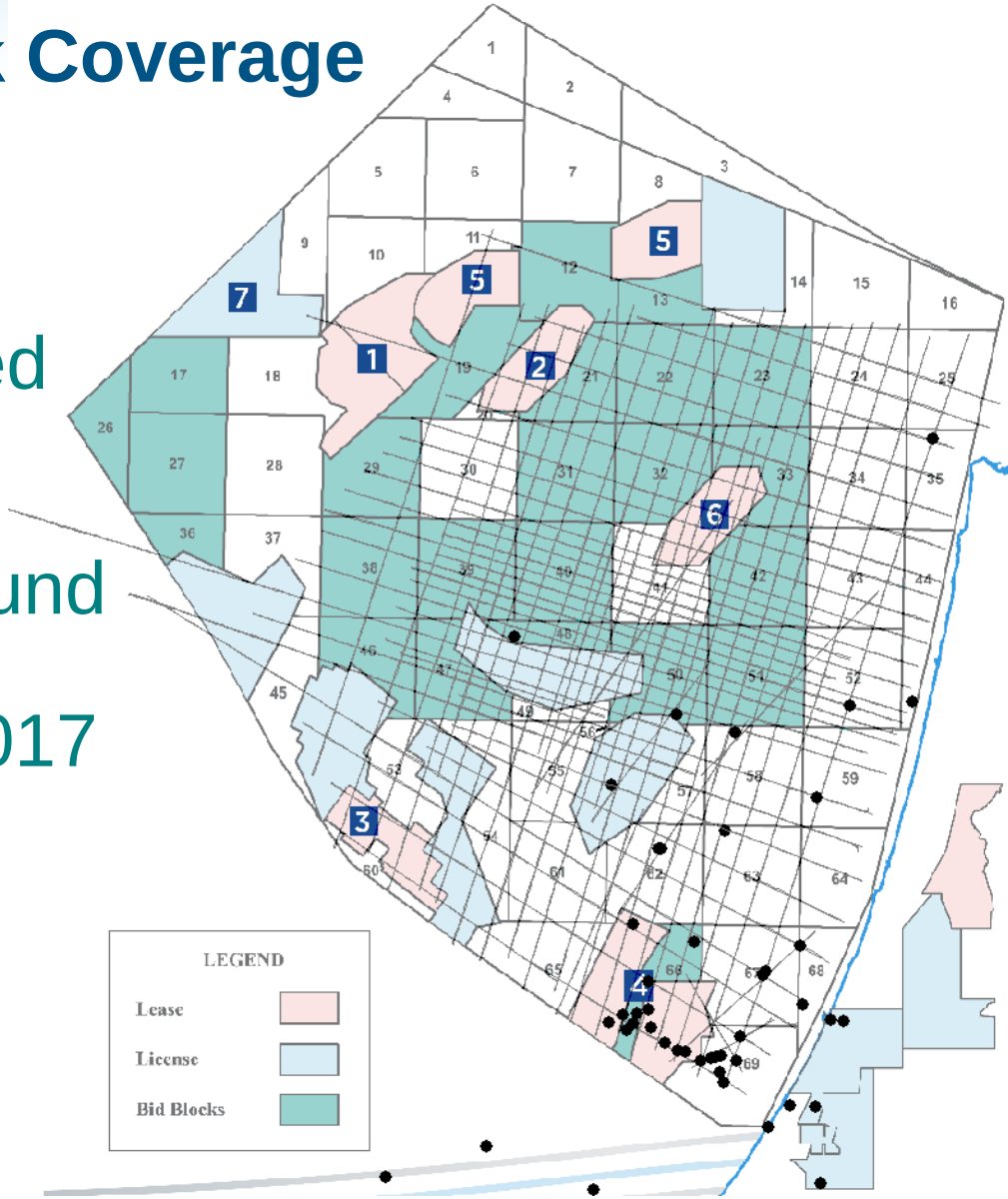
TGS in Israel



- Seismic Data (in bid data pack)
  - 6,831 km in 2001 (vintage)
  - 1,329km in 2008 (Yoad vintage)
- 2001 Data Broadband reprocessed using TGS Clari-Fi™ 2016
  - Time Data Complete
  - Depth Data to follow Q1 2017
  - Not in bid data pack
- Digital Well Log Database of 52 workstation ready wells
- Interpretation studies
  - 2016 *An Assessment of the Mesozoic Oil Potential of the Levant Basin.* Vasiliki Kosmidou, Imperial College London. MSc Sponsored by TGS

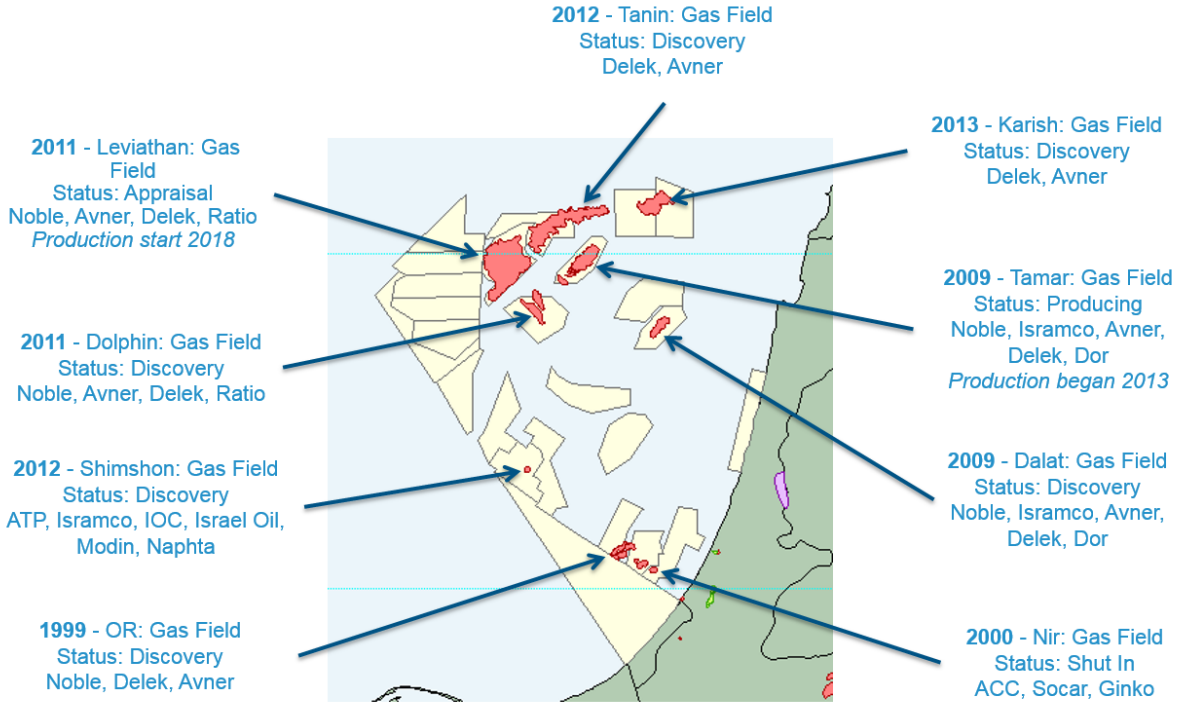
TGS in Israel: Bid Block Coverage

- Well data available
- 6,831 km 2D reprocessed seismic (shown)
- 24 blocks in 2016 bid round
- Bid round closes April 2017



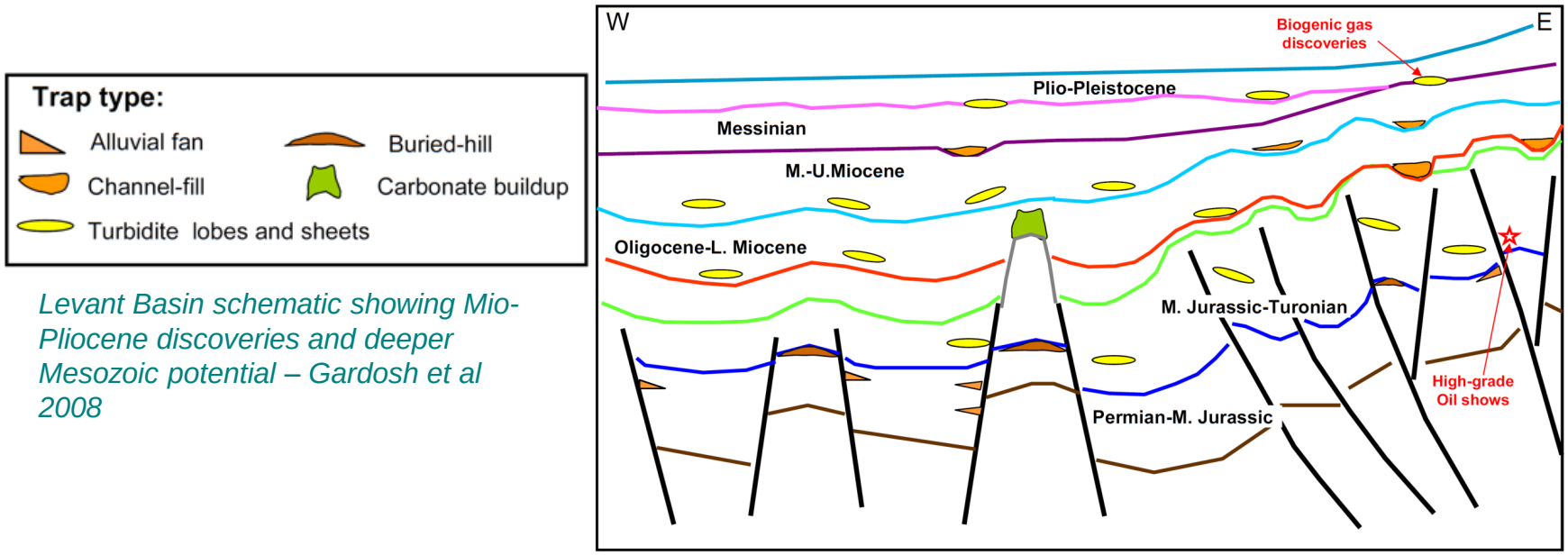
Geological Overview: Exploration History

- The Tertiary biogenic gas petroleum system in the Levant Basin has renewed interest in offshore Israel.
- Recent discoveries have opened up an abundance of exploration opportunities within this play, and new broadband reprocessing of seismic data allows for continued identification of shallow prospects.



Geological Overview: Play Concepts

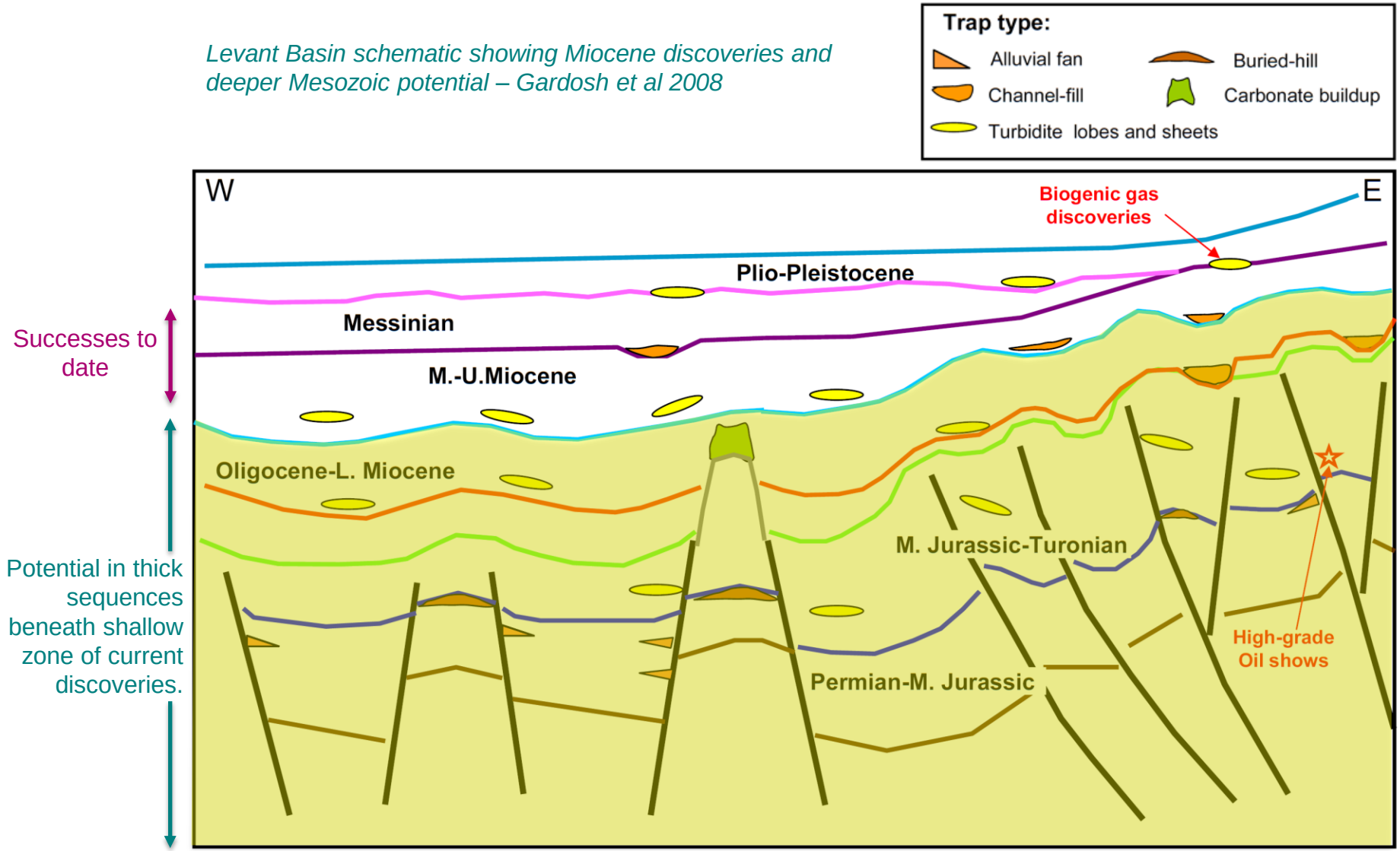
- However, this broadband reprocessing dramatically alters our understanding of the deeper geology of the Levant Basin and, impacts development of deeper Mesozoic play concepts that have only been explored in the shallow water regions previously.
- Mesozoic hydrocarbons have been reported onshore Lebanon (10% TOC reported in Kimmeridgian shales; Terbol-1 well). It is anticipated that these Mesozoic source rocks could generate hydrocarbons if buried offshore due to increased maturity (Roberts & Peace 2007).



Levant Basin schematic showing Mio-Pliocene discoveries and deeper Mesozoic potential – Gardosh et al 2008

Geological Overview: Play Concepts

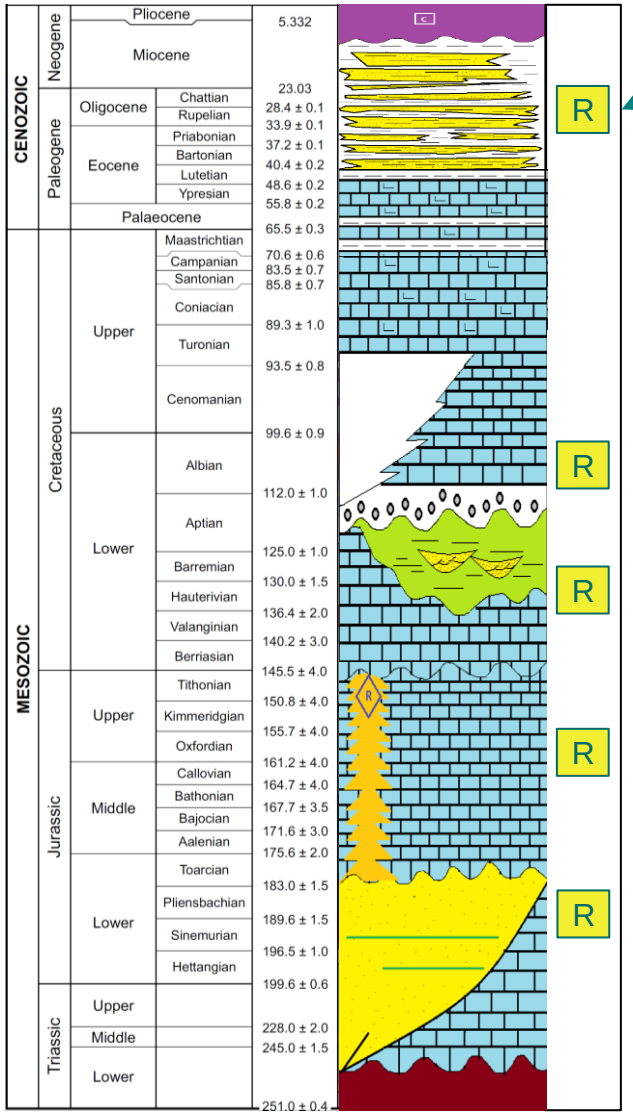
Levant Basin schematic showing Miocene discoveries and deeper Mesozoic potential – Gardosh et al 2008



Geological Overview: Stratigraphy

- Reservoir potential in Jurassic, Lower Cretaceous and pre-salt Tertiary.

Modified after Roberts & Peace 2007 and Kosmidou 2016



Leviathan, Tamar, Dalit, Noa

Geological Overview: Stratigraphy

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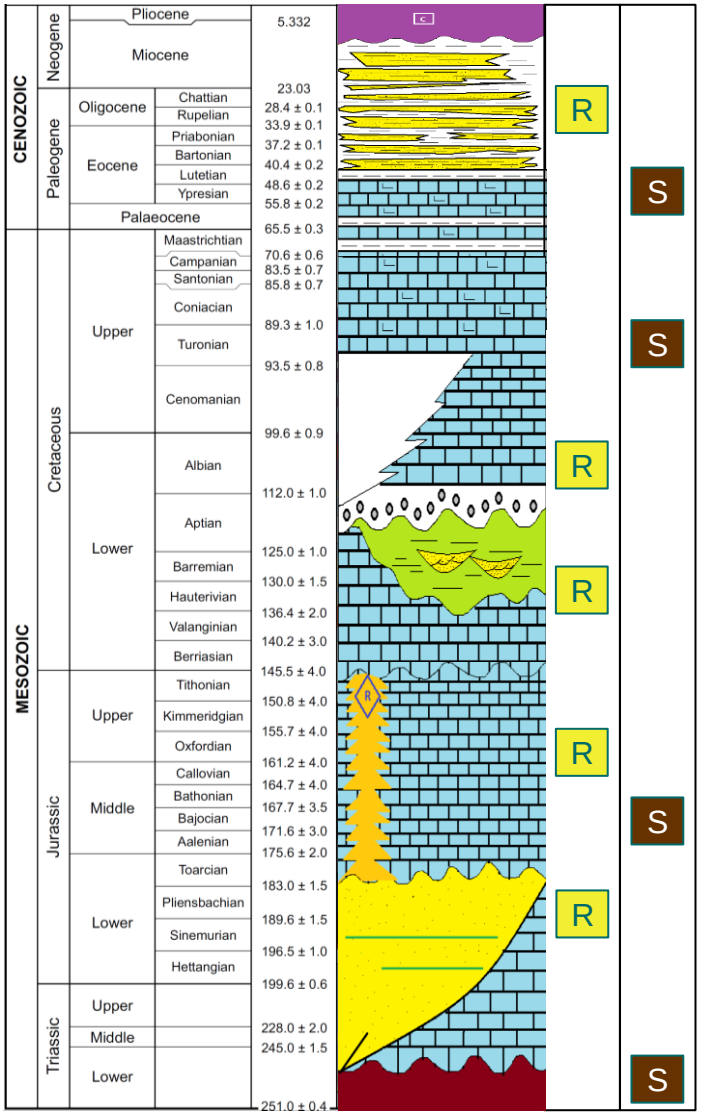

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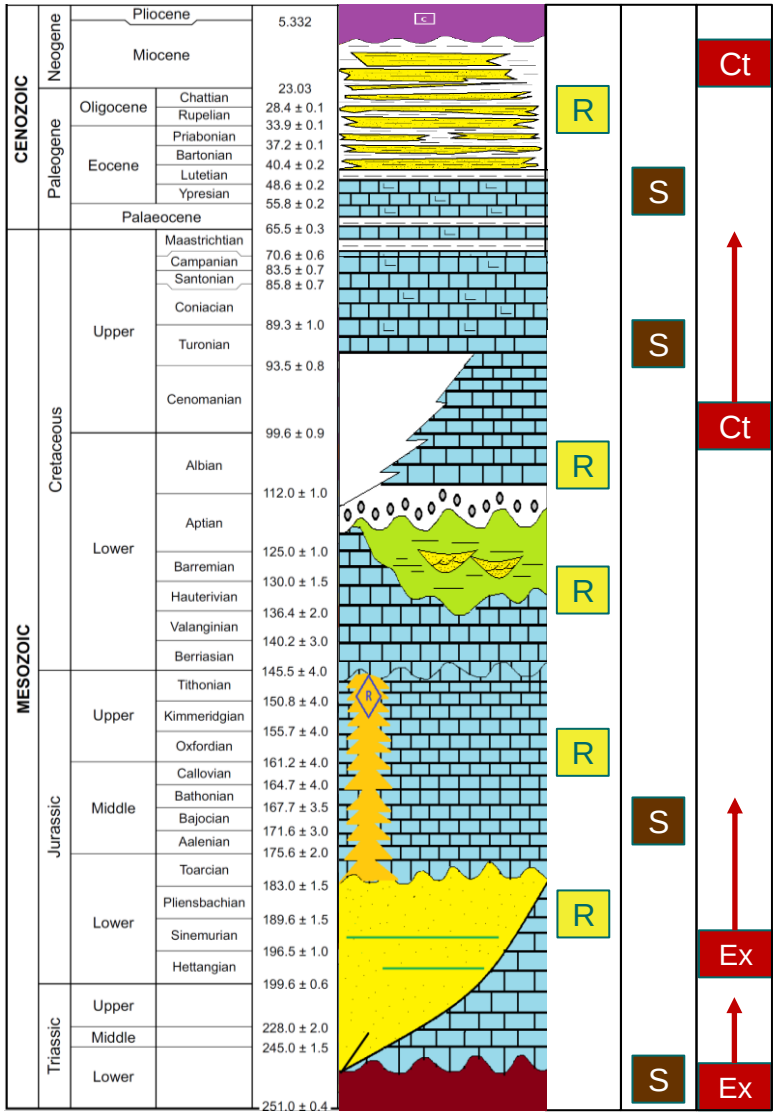
- Tectonic extension occurred throughout the Permo-Triassic (Tethys Rift) and Lower to Middle Jurassic; tectonic contraction occurred in the Upper Cretaceous and Miocene (Syrian Arc Phases 1 and 2).



Geological Overview: Stratigraphy

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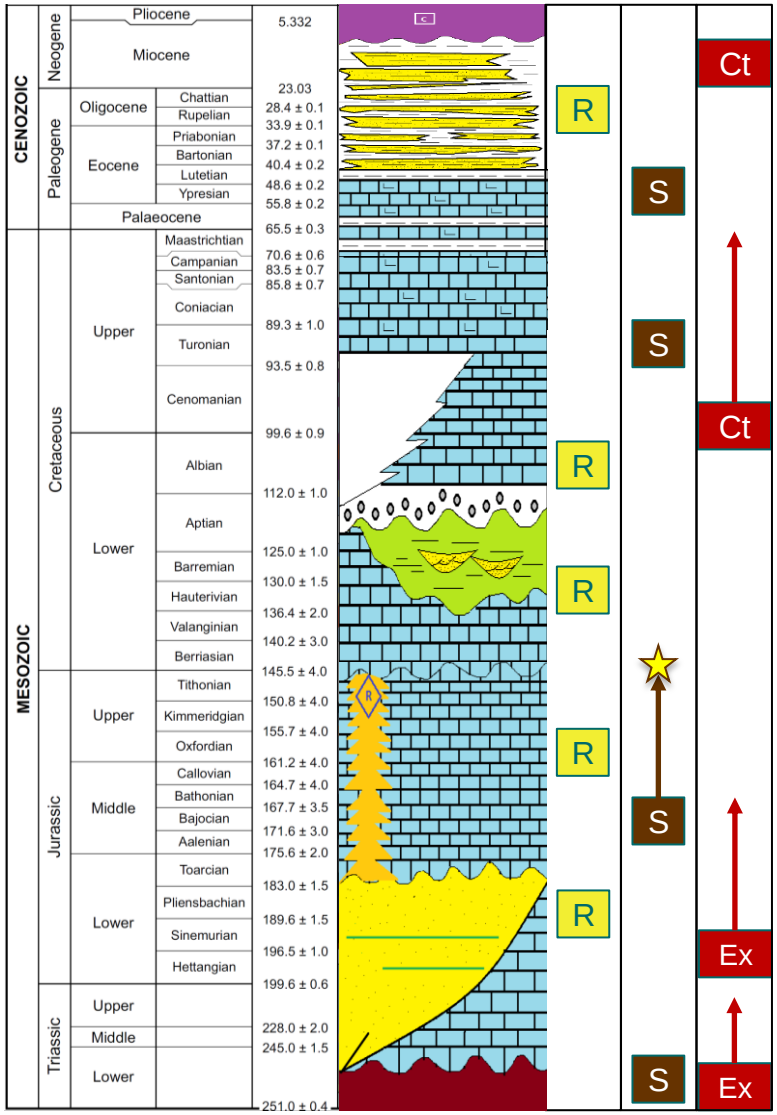
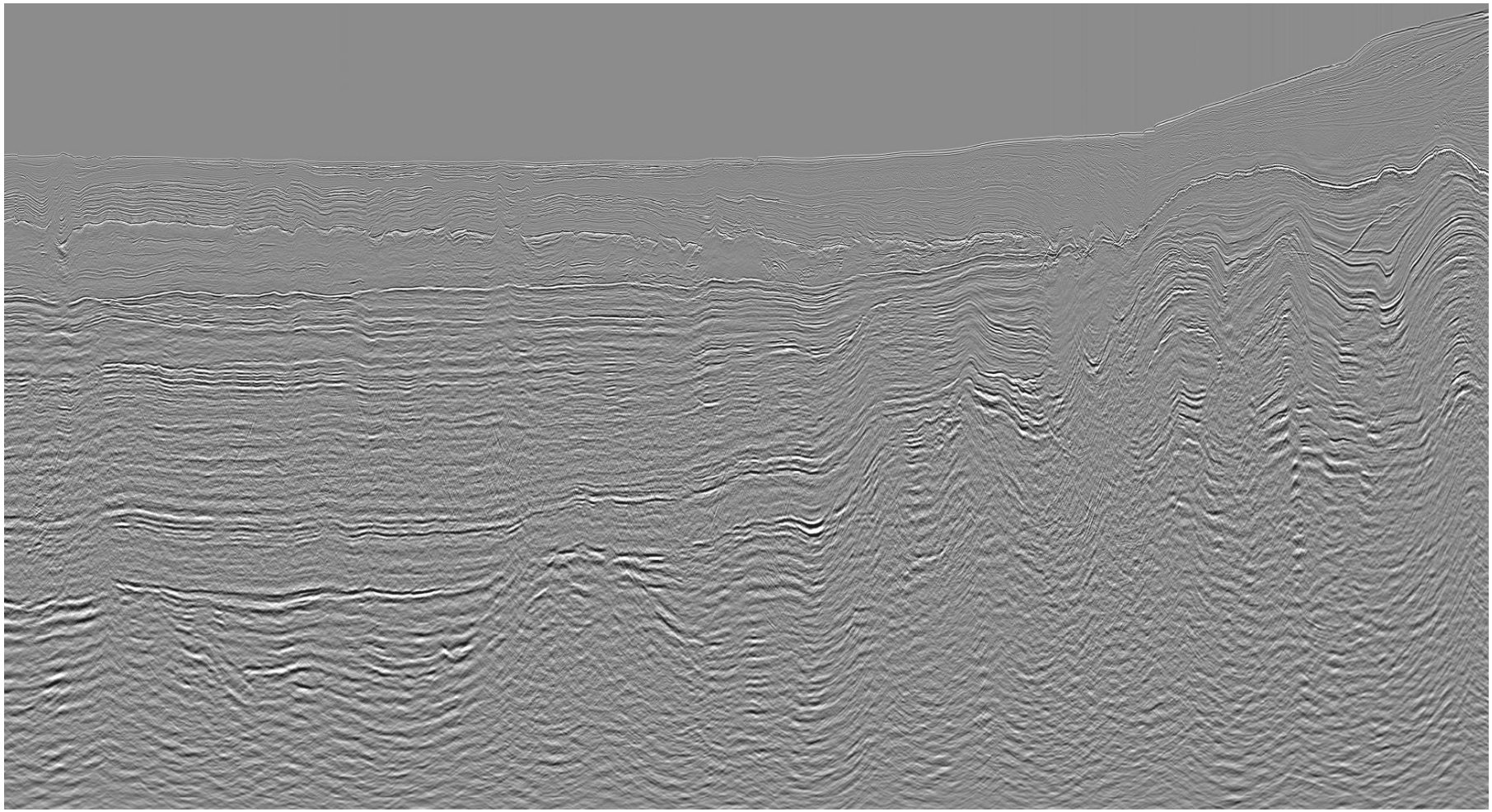
- Reservoir potential in Jurassic, Lower Cretaceous and pre-salt Tertiary.
- Source rock potential in Lower Triassic, Middle Jurassic, Upper Cretaceous and Early Tertiary.
- Tectonic extension occurred throughout the Permo-Triassic (Tethys Rift) and Lower to Middle Jurassic; tectonic contraction occurred in the Upper Cretaceous and Miocene (Syrian Arc Phases 1 and 2).
- Our expectation based on the work by Kosmidou (Imperial College) is that a Middle Jurassic source rock would have reached peak expulsion by the earliest Cretaceous Passive Margin phase; traps in place prior to expulsion.

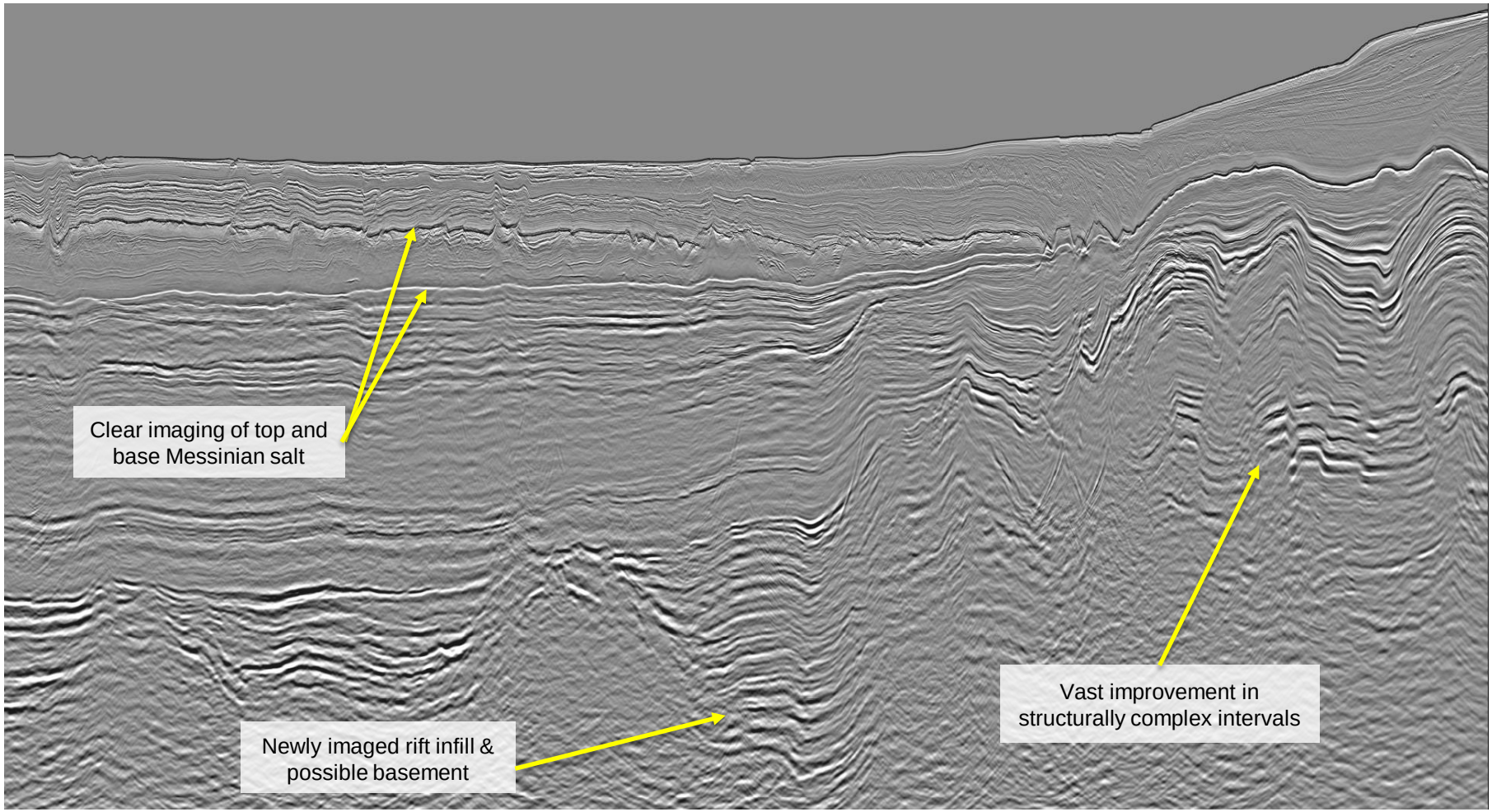


Clari-Fi™ broadband reprocessing data examples

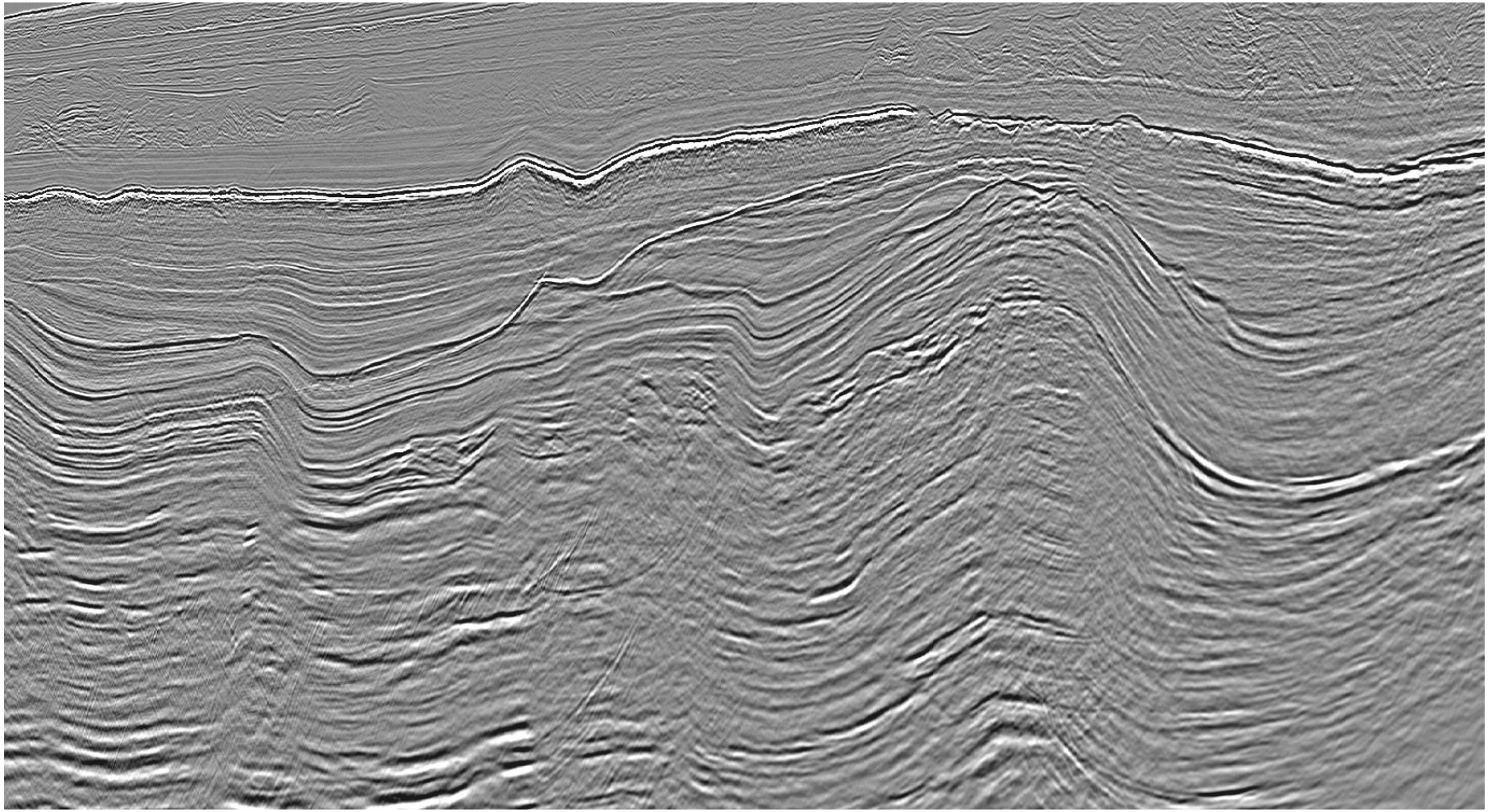
2035-IS – Vintage (data pack)



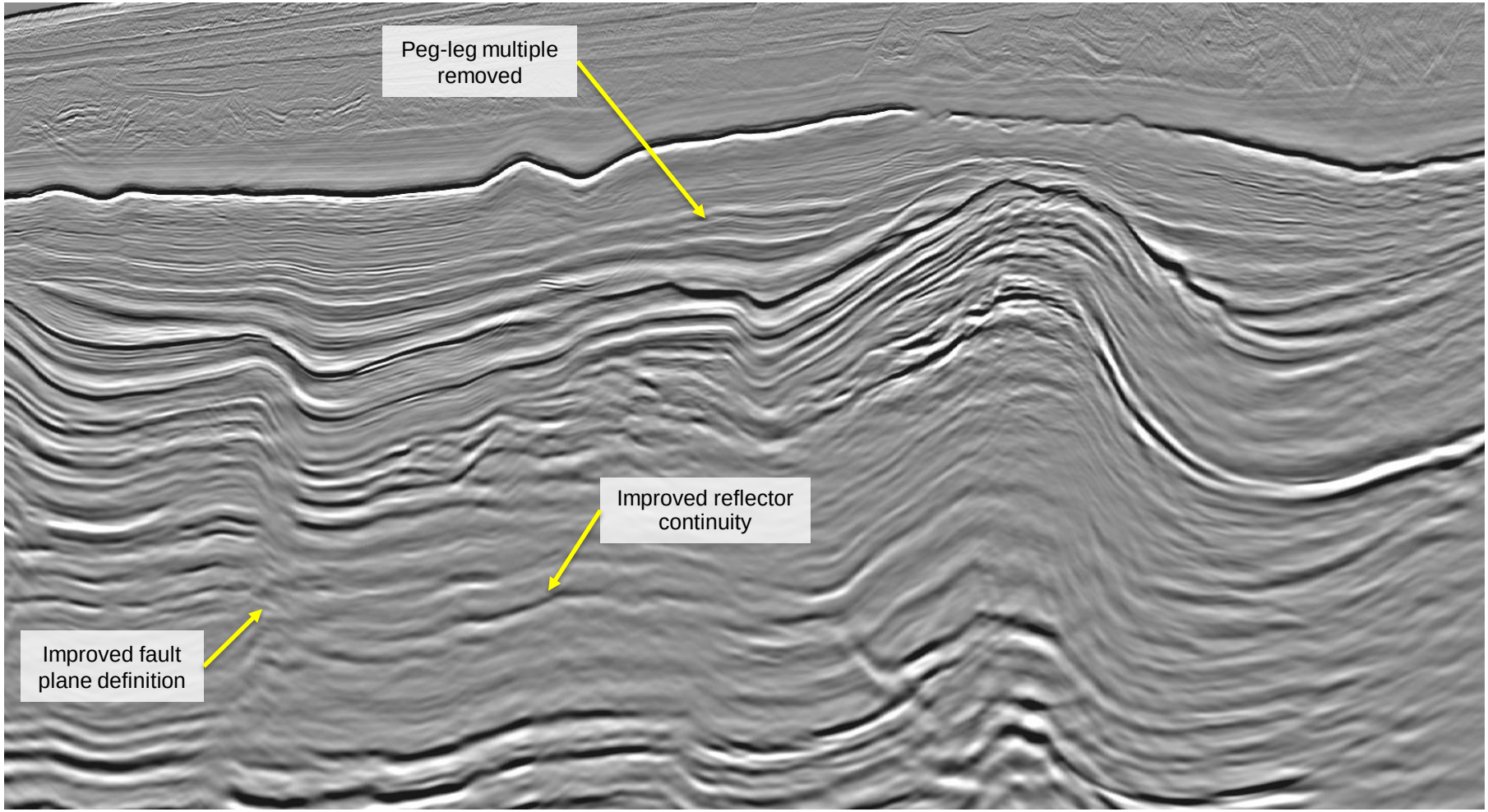
2035-IS – Clari-Fi™ reprocessed



2039-IS – Vintage (data pack)



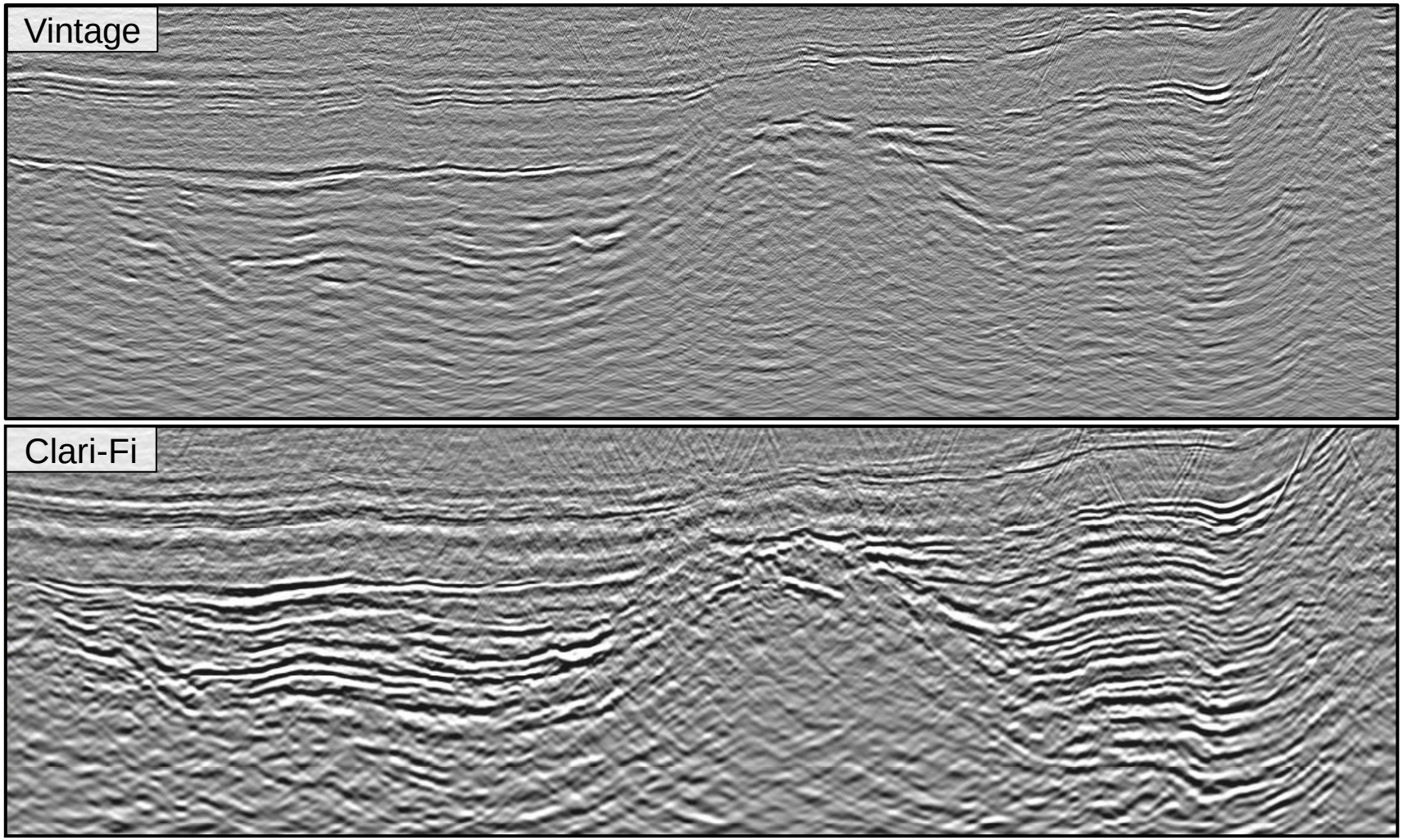
2039-IS – Clari-Fi™ reprocessed



Imaging new play concepts with Clari-Fi™

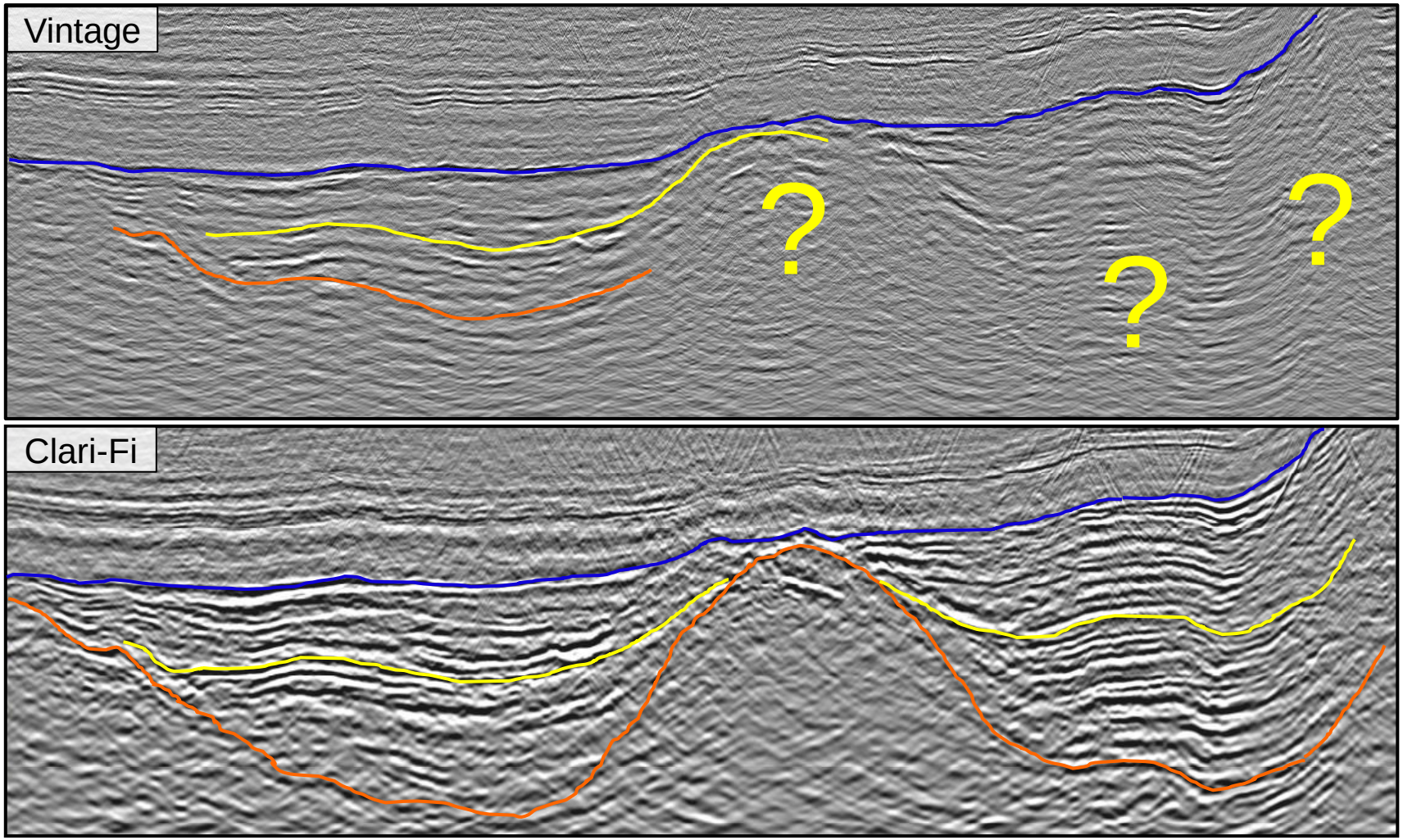
1. Impact on temperature models

- Comparison between Vintage data and Clari-Fi™ reprocessed data on deep geological structure.



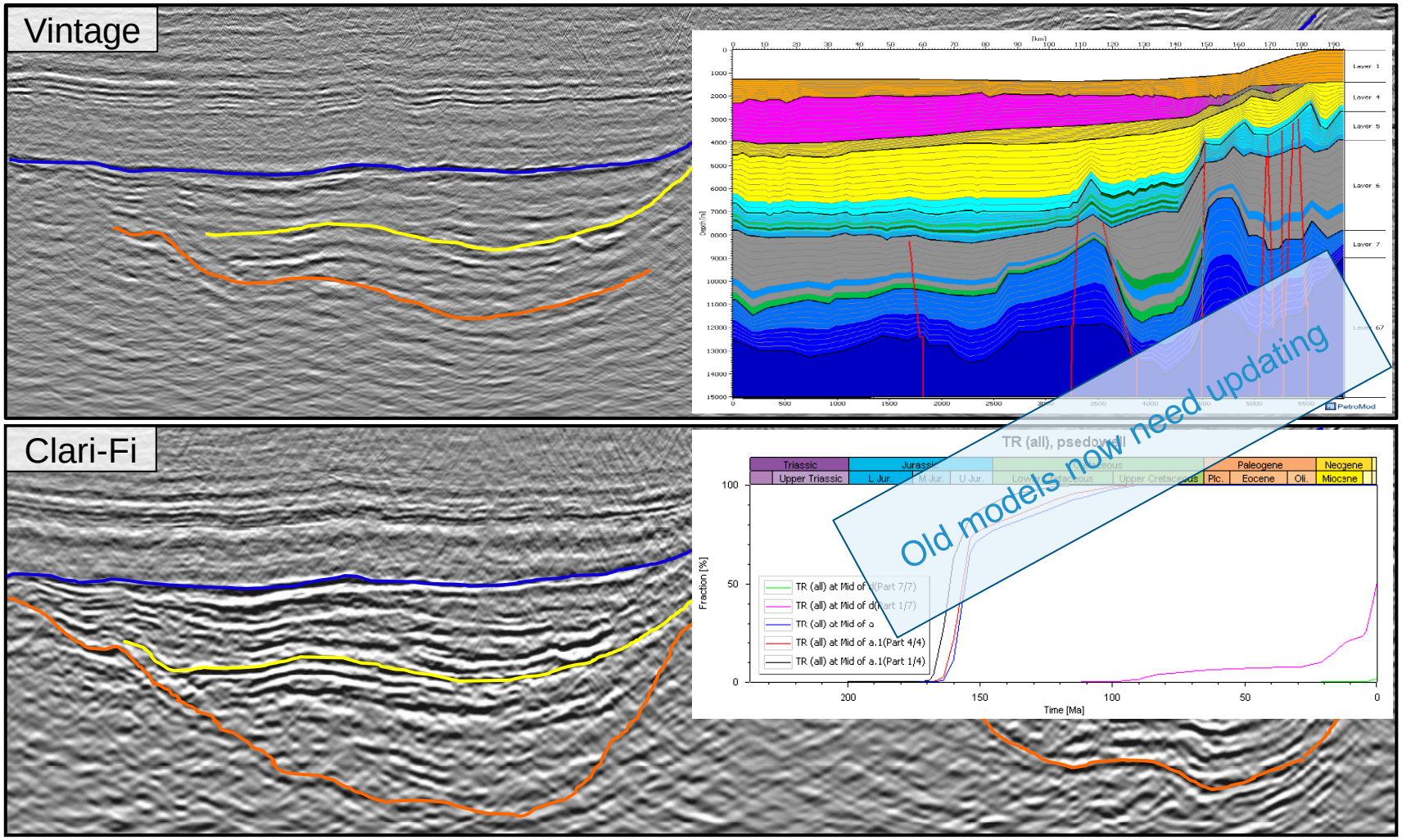
1. Impact on temperature models

- Clari-Fi™ repro data enables more confident interpretation of the lower syn-rift and basement surfaces.



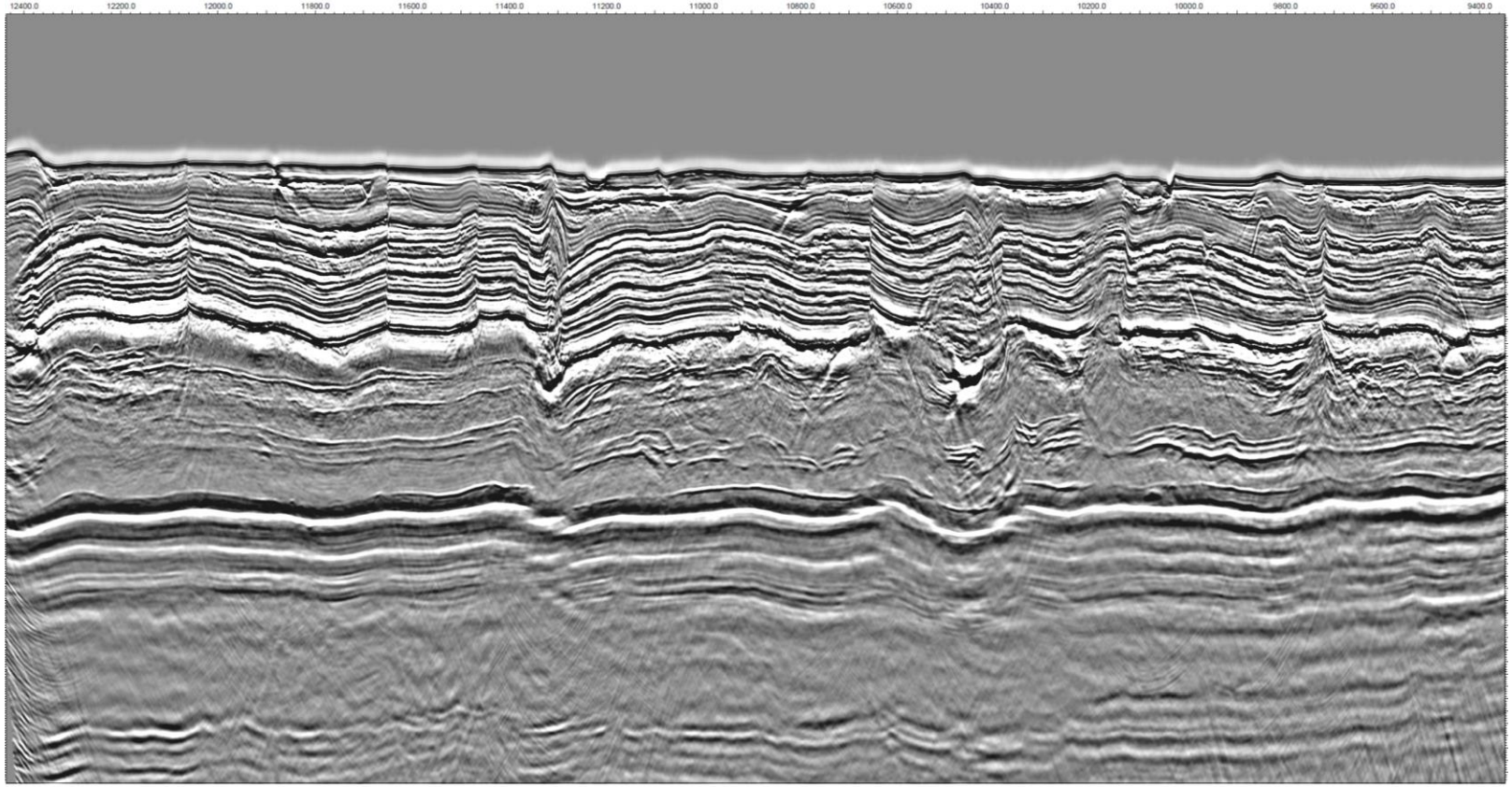
1. Impact on temperature models

- Clari-Fi™ repro data enables more confident interpretation of the lower syn-rift and basement surfaces.
- This allows for better control on basin temperature models and, hence, petroleum system modelling.



1. Impact on temperature models

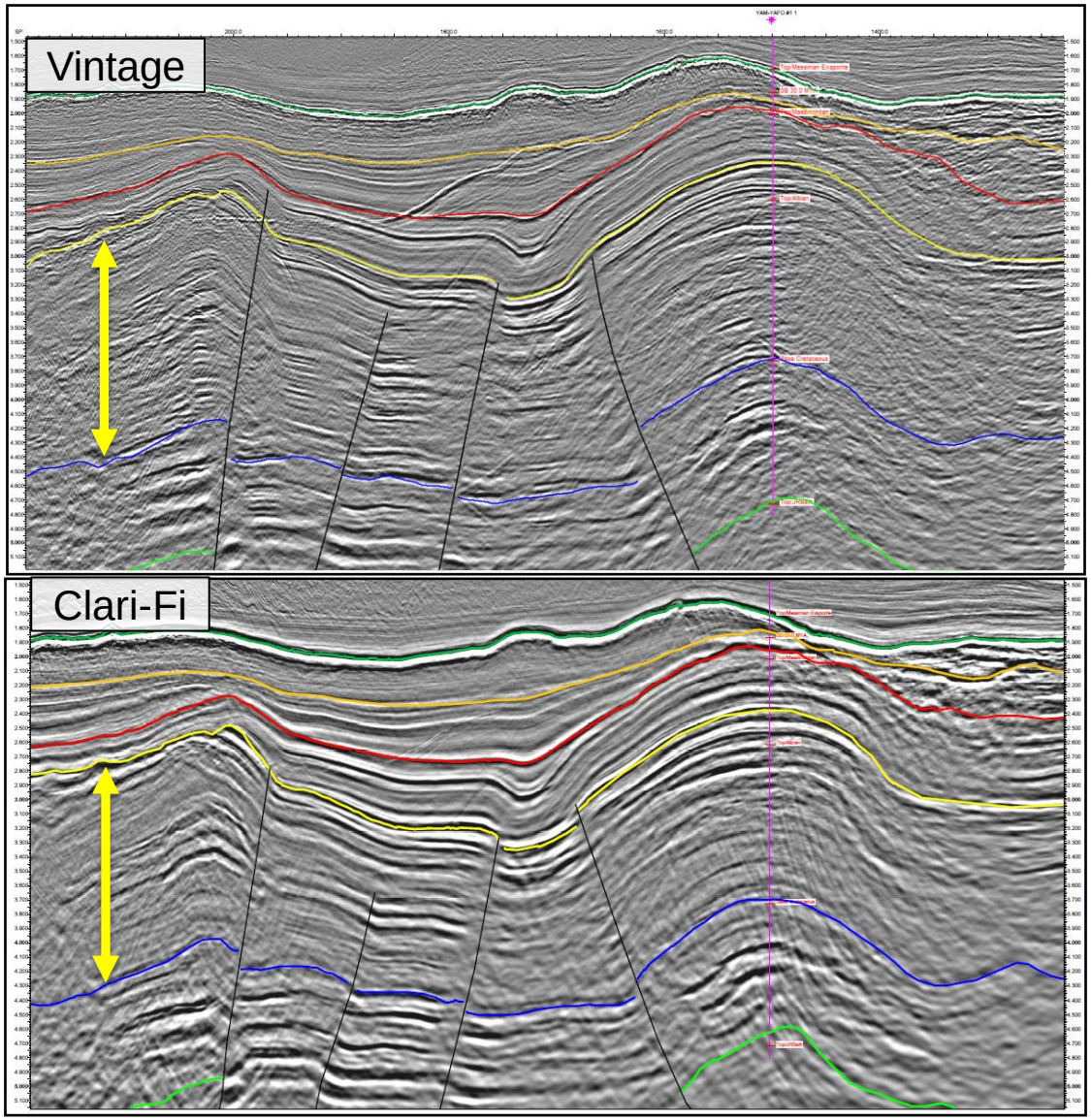
- Improvement within the shallow evaporite sequence is also apparent.
- Clari-Fi™ reprocessing images greater internal reflectivity within the salt interval, possibly representative of sediment inclusions or variation in evaporite chemistry which would also affect the basin temperature regime.



2. Improvements to seismic facies identification

- Mapping of seismic facies and calibrating to well data to understand paleo-environments is a powerful tool for predicting source rock and reservoir distribution.

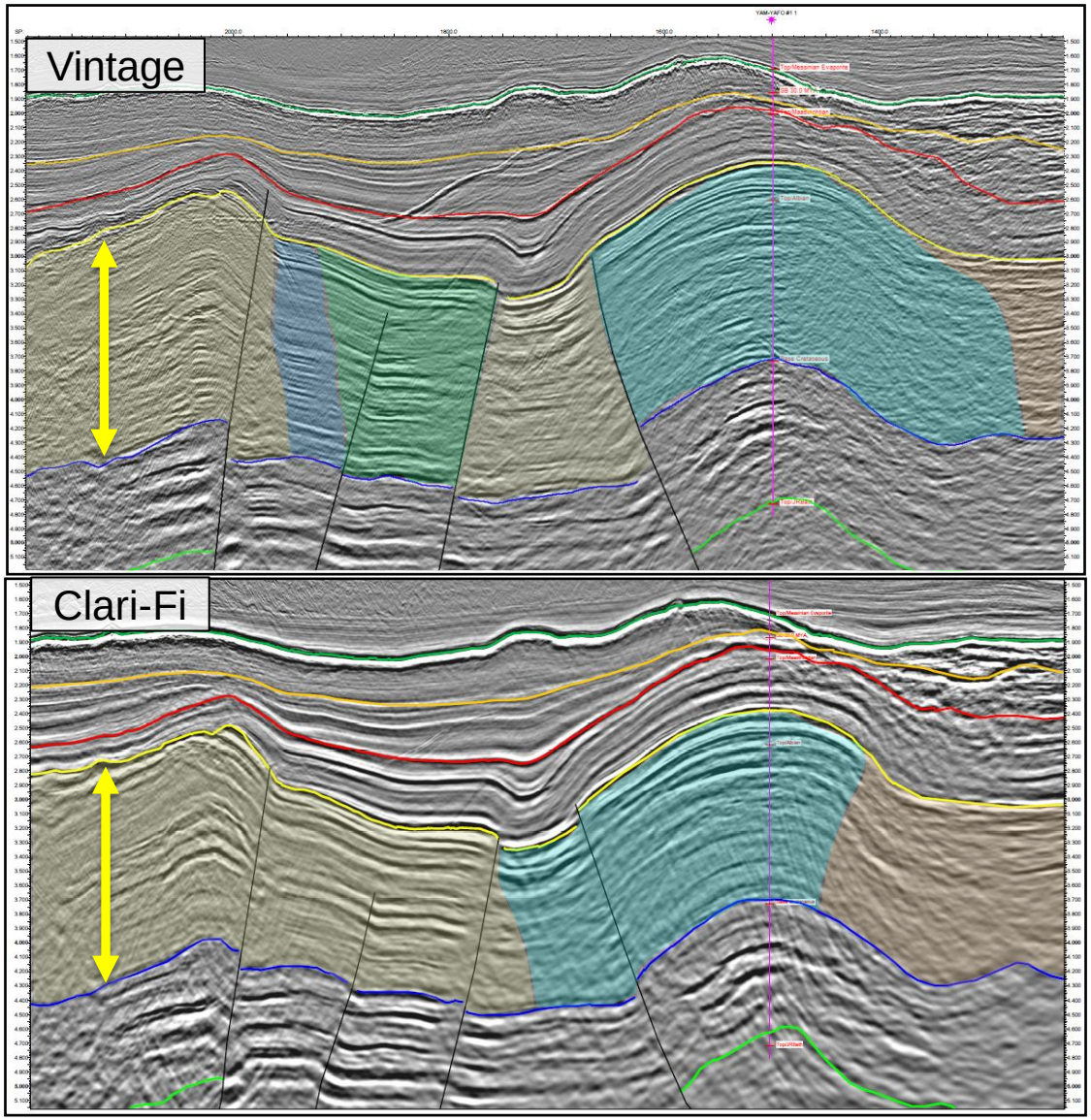
- The megasequence indicated by the yellow arrow consists of at least 5 laterally varying seismic facies units on vintage data…



2. Improvements to seismic facies identification

- …but reprocessing has revealed that these variations (previously predominantly defined by fault and fold geometries) are not representative of the true geology. The reprocessed data shows much better continuity of reflectors and, hence, less separate seismic facies units.

- Clari-Fi™ reprocessing improves amplitude recovery and redefines seismic facies classifications. This allows for a greater understanding of the key source and reservoir intervals, which will alter paleo-environment maps and prediction of petroleum systems.



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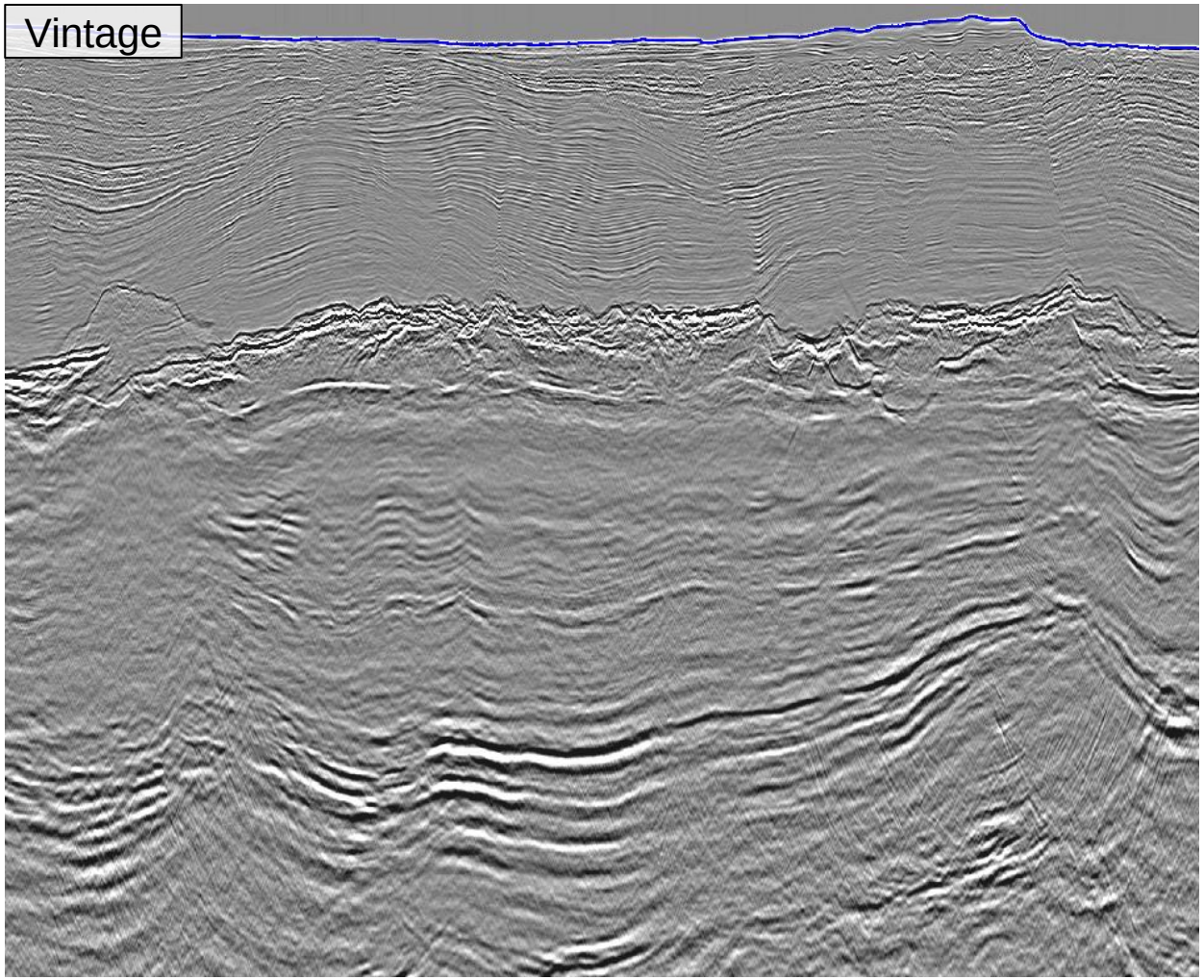

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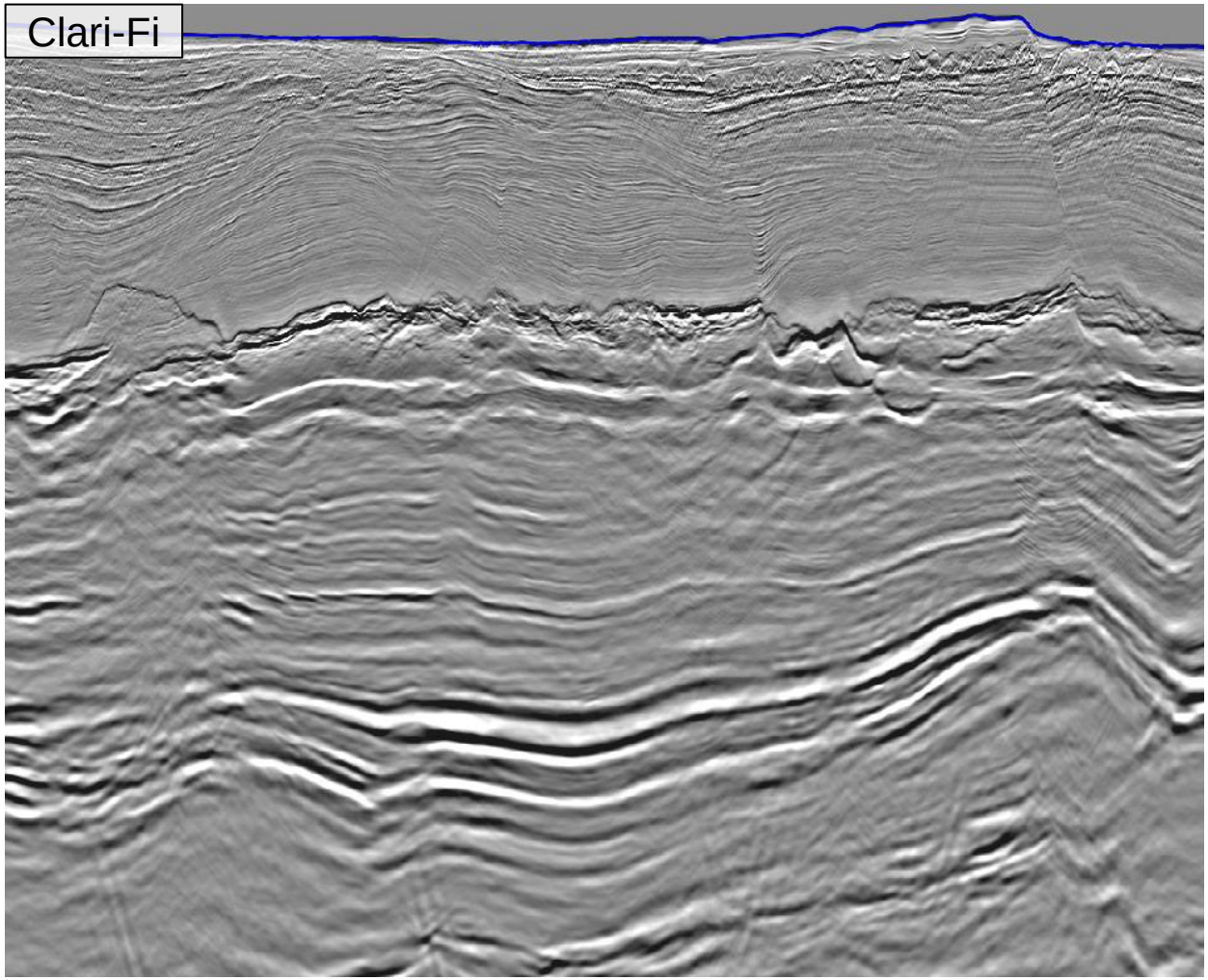

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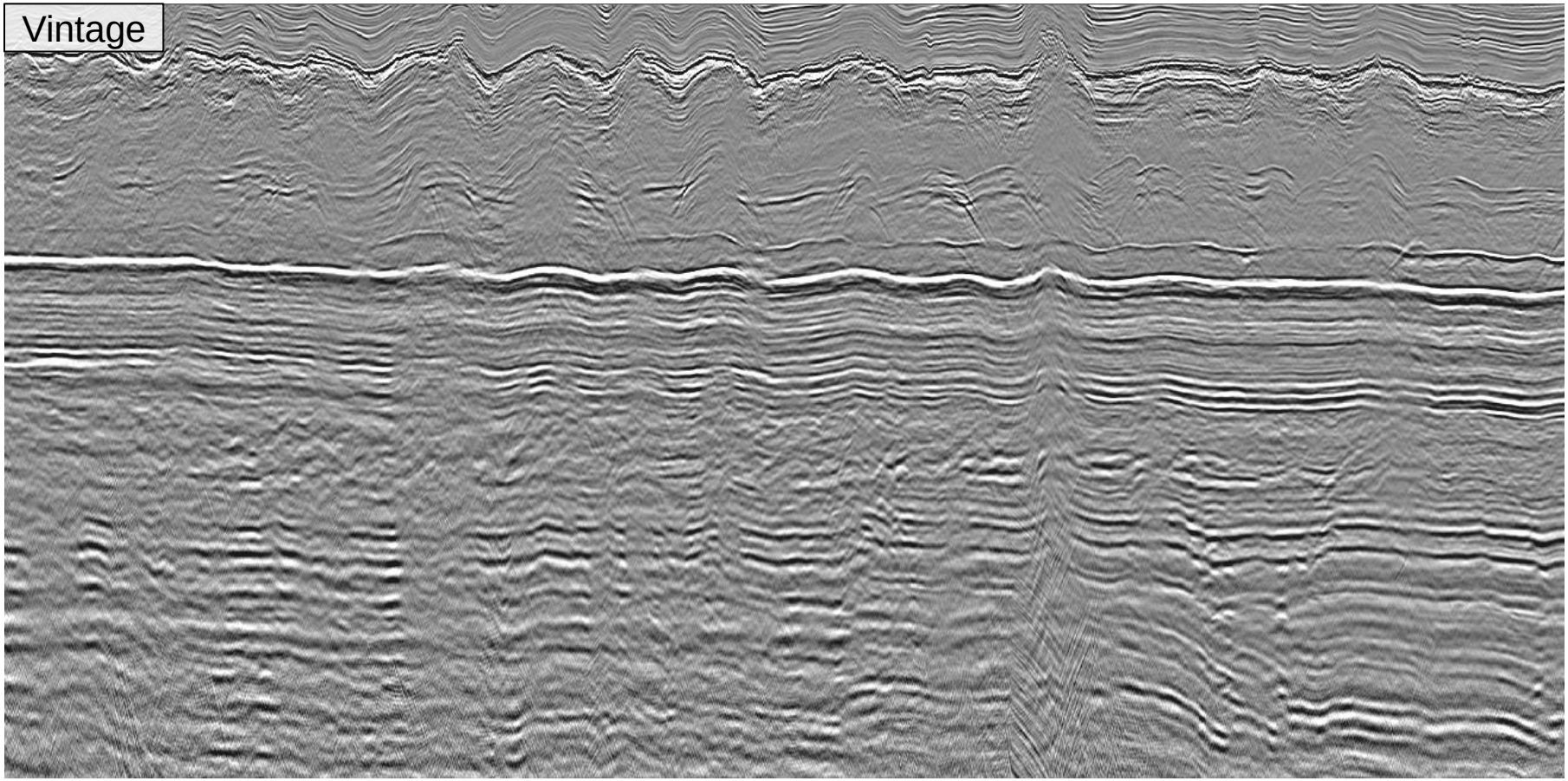

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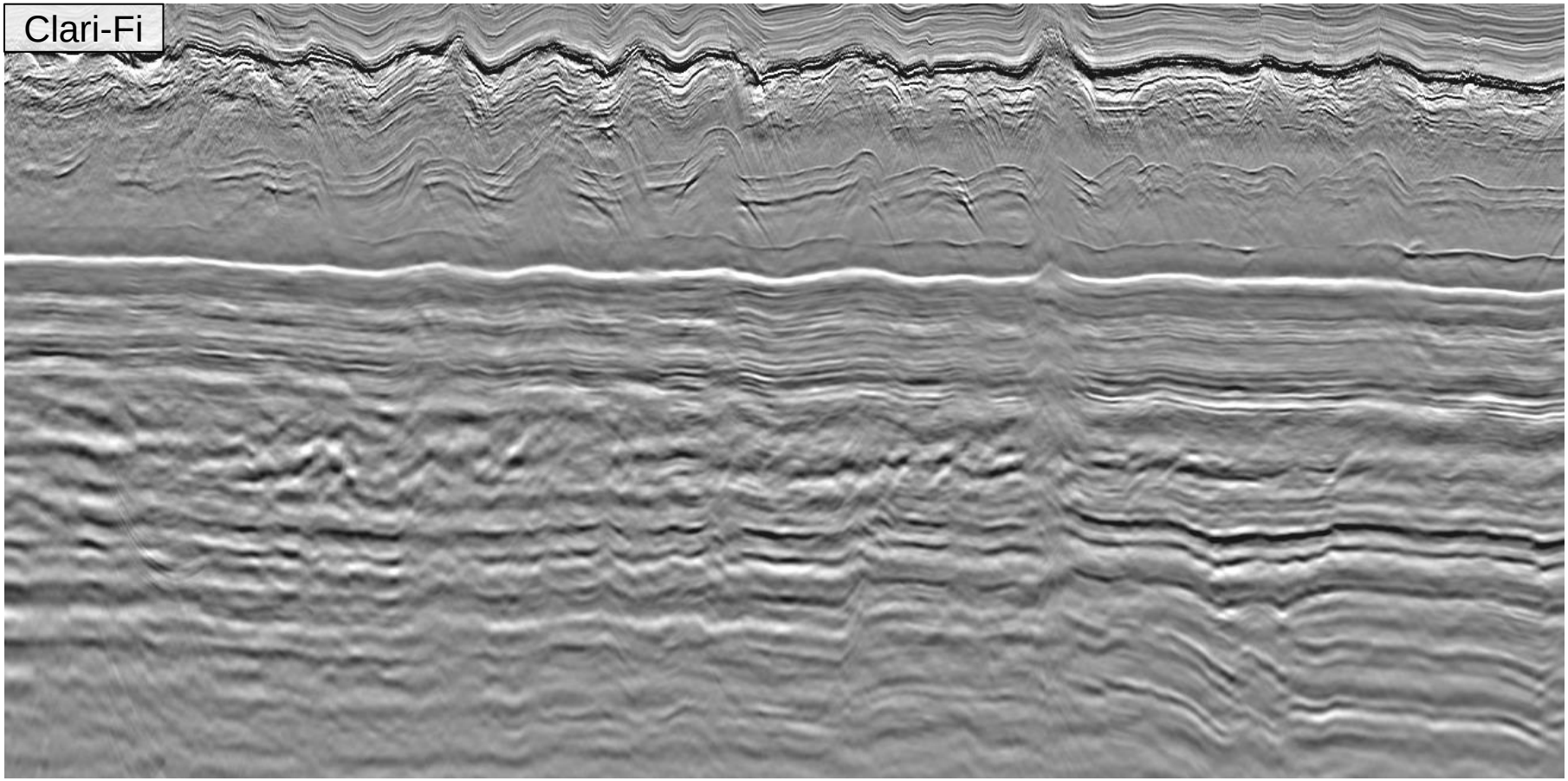
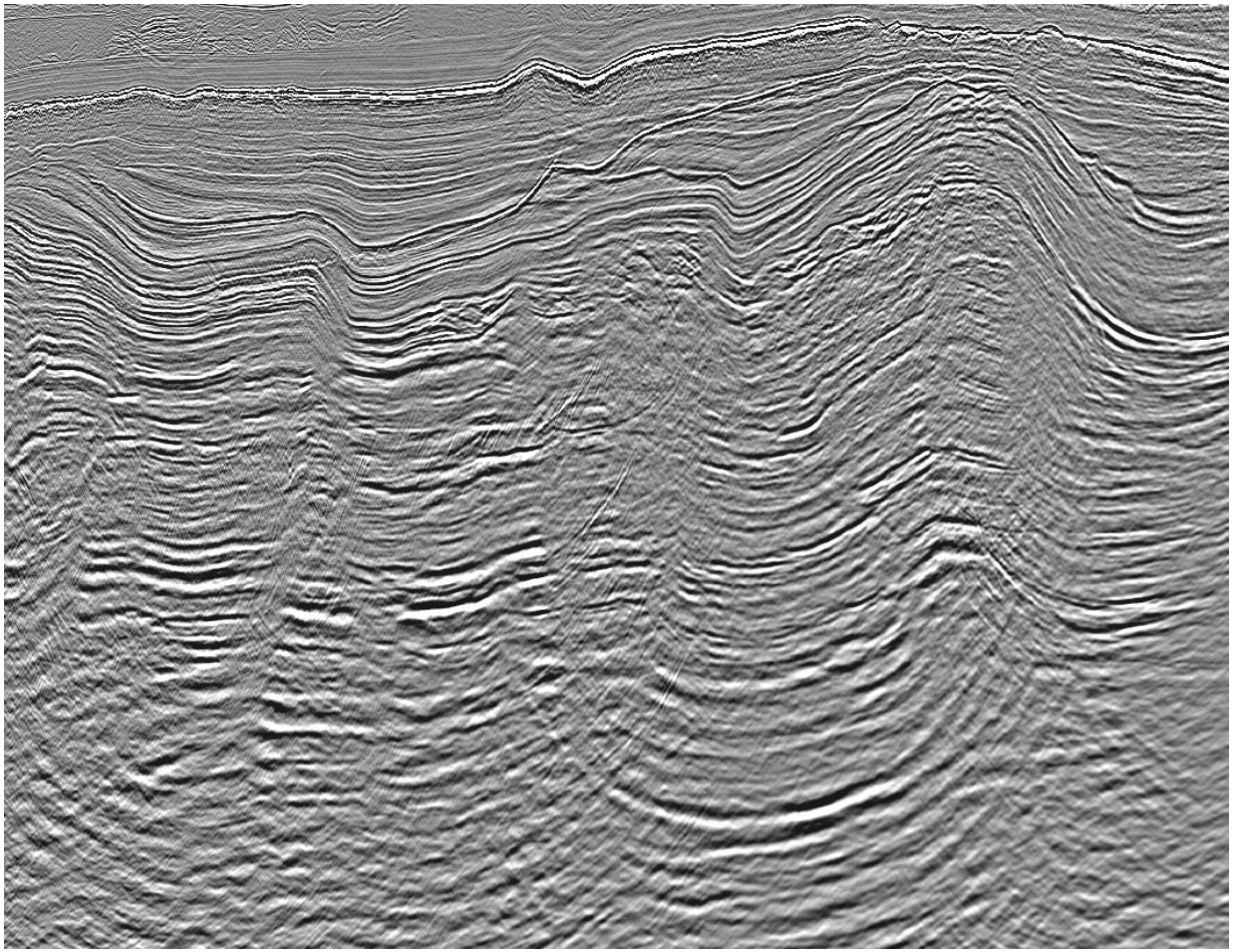


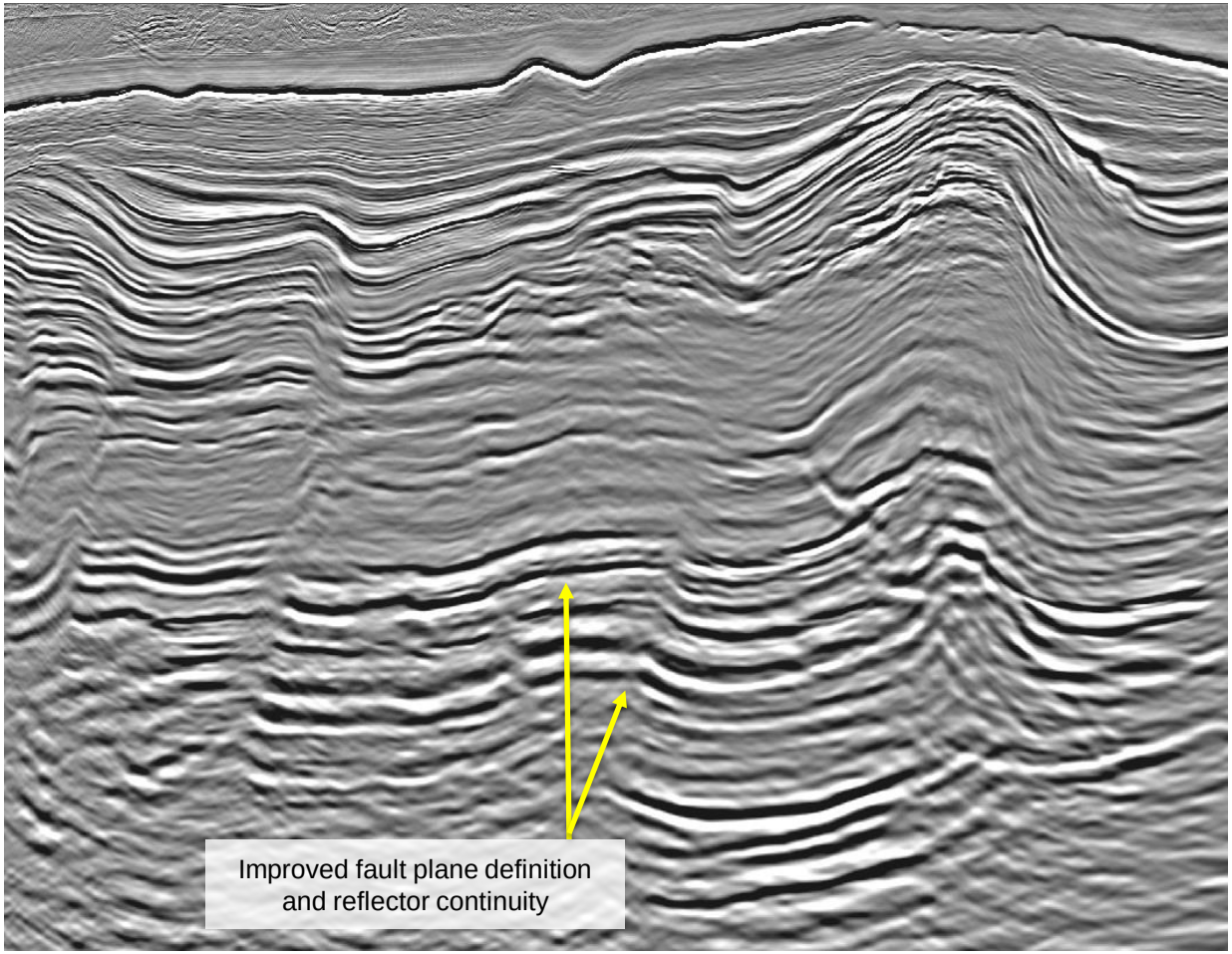
3. Better proven and potential trap definition

Development of Mesozoic leads and propects (rotated fault blocks and roll-over anticlines) is challenging on vintage seismic data.



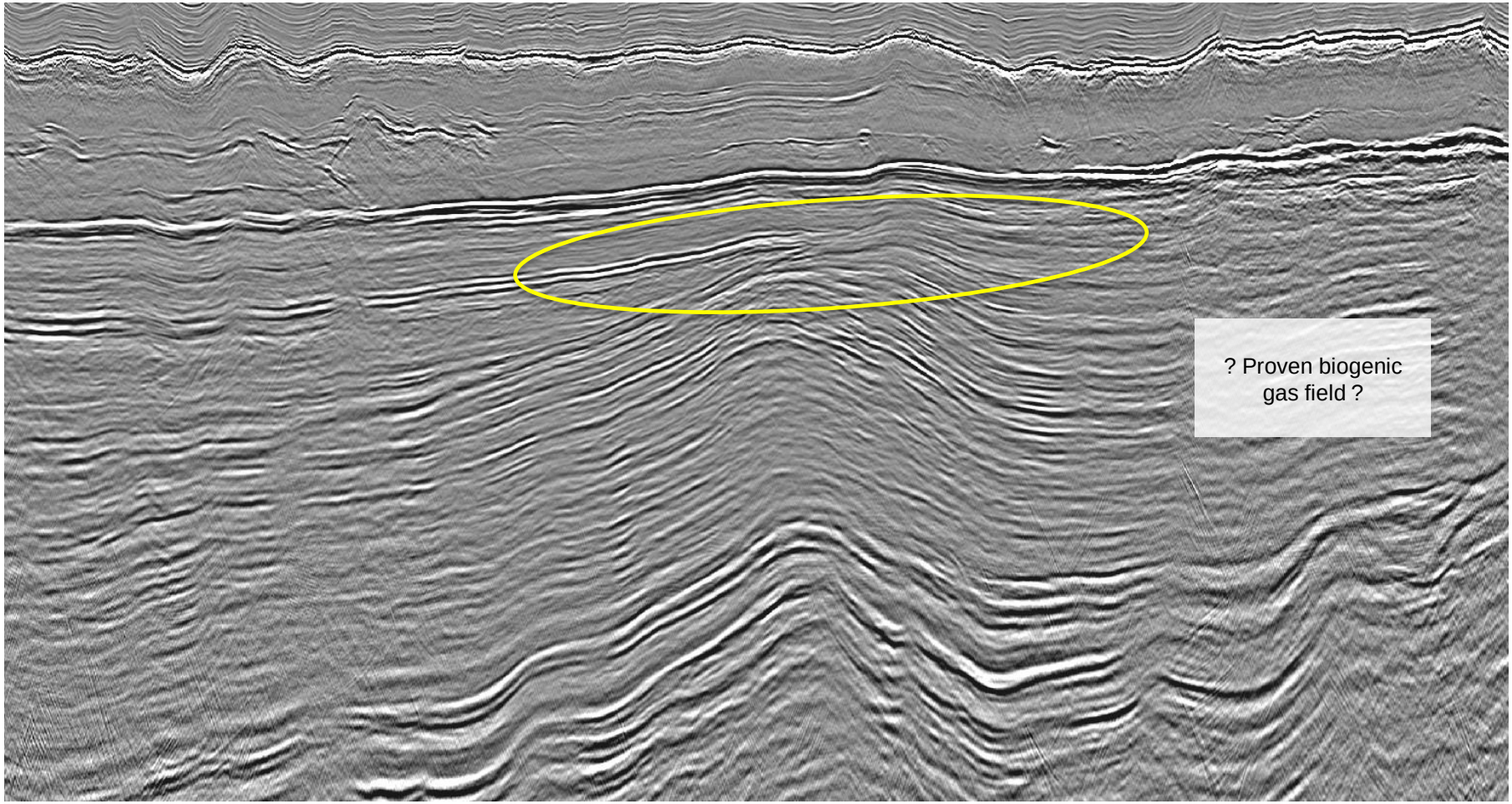
3. Better proven and potential trap definition

Clari-Fi™ reprocessing provides much greater definition of roll-over anticlines, tilted fault blocks and thrust-related structures. This allows for more accurate mapping and development of potential traps in as yet unproven plays.



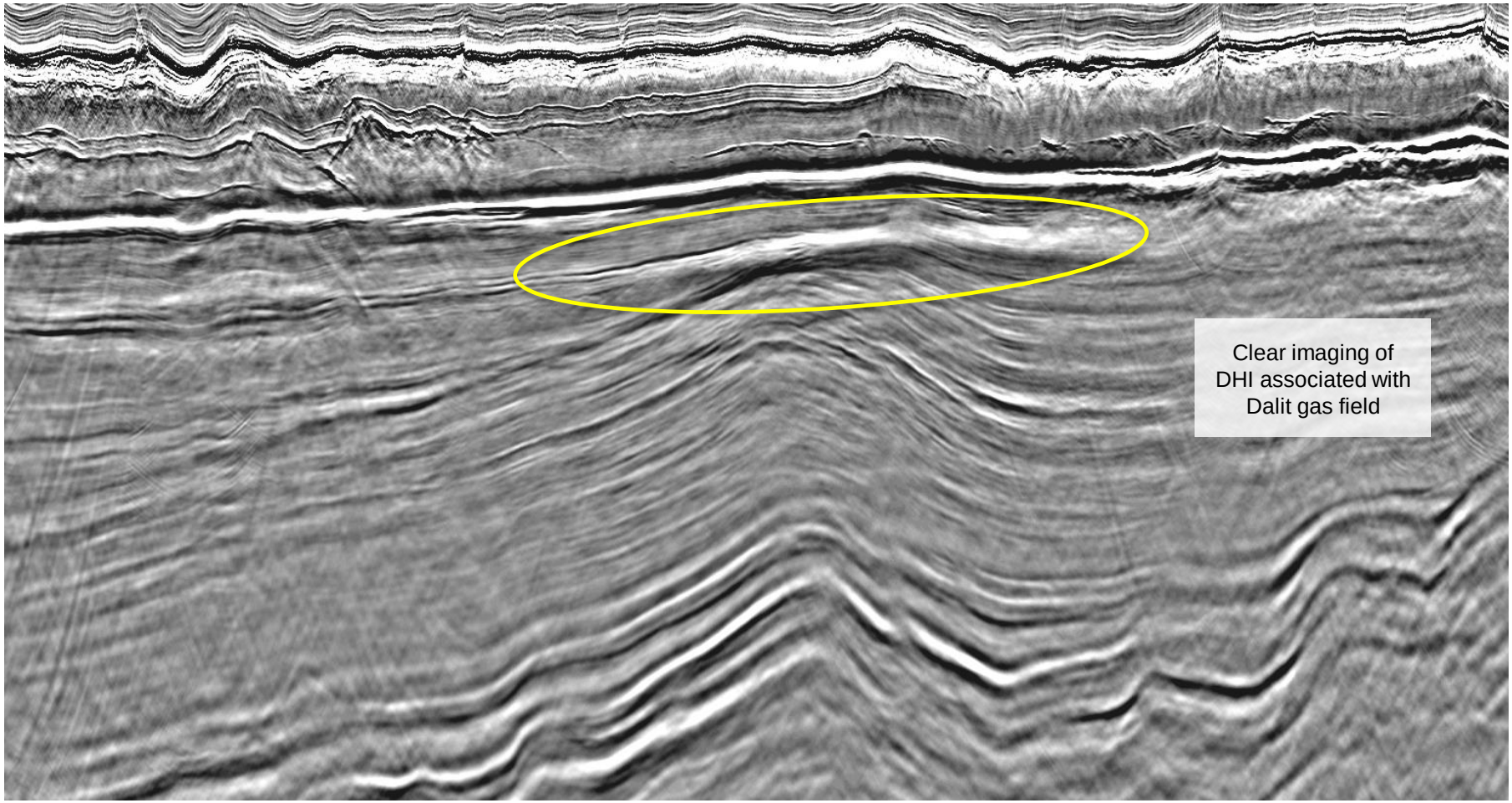
3. Better proven and potential trap definition

Example of a proven play imaged on vintage data. Obvious anticlinal structure, but no direct hydrocarbon indicators shown on vintage data.



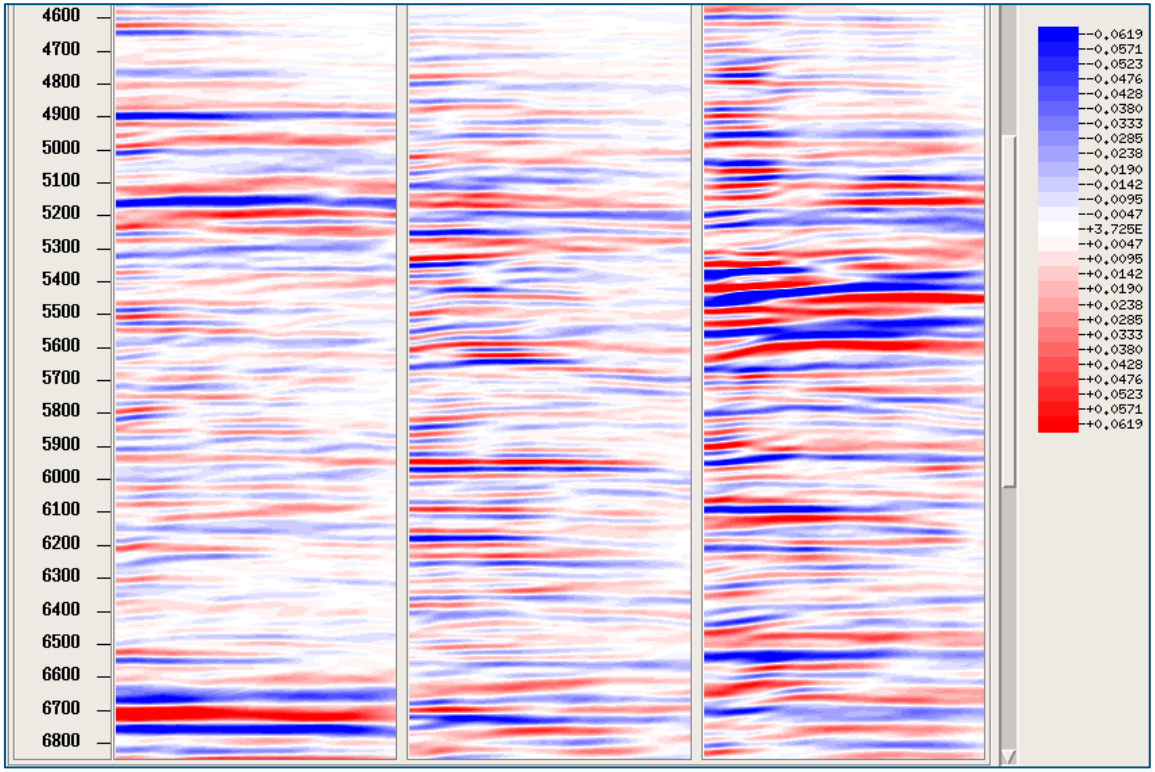
3. Better proven and potential trap definition

Clari-Fi™ reprocessed data show strong amplitude anomaly associated with the crest of the field anticline. Recovery of previously unseen DHIs is a significant advantage.



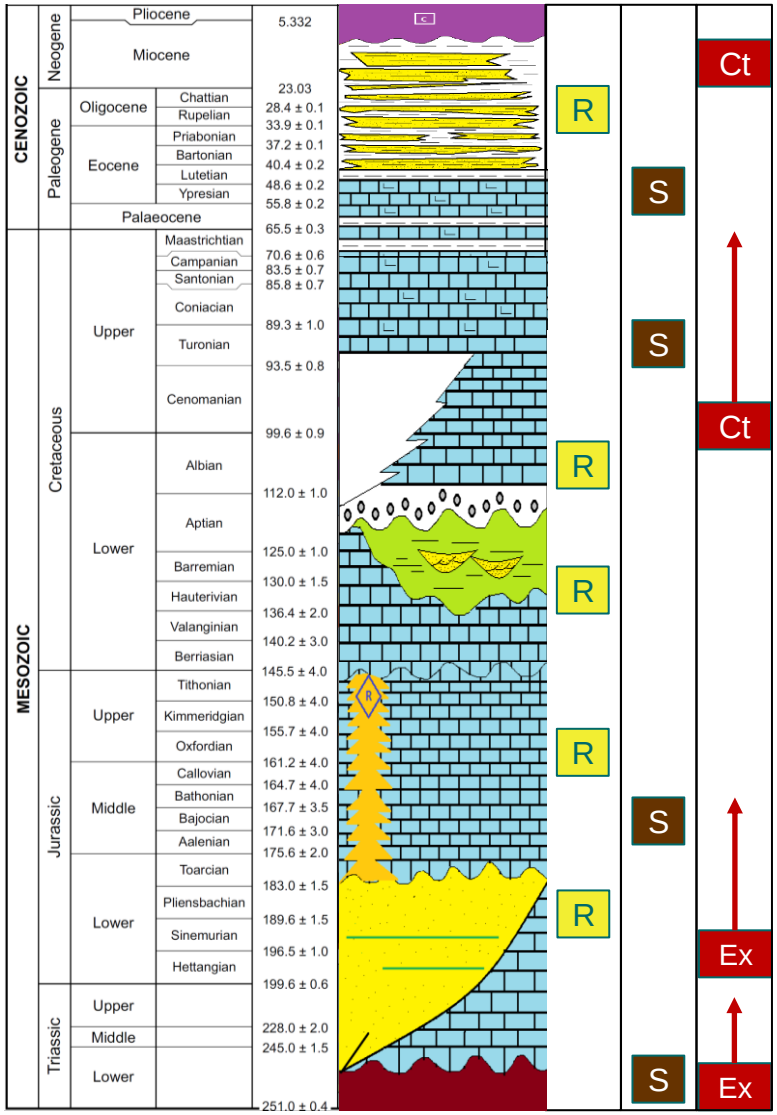
4. Improvements in gather flatness and AVO

- Gathers examples demonstrate flatness at greater offsets.
- Brighter amplitudes on far-right gather represent amplitude anomaly associated with proven biogenic gas field.
- Reduction of side lobes and improved recovery of amplitudes with offset (AVO) on Clari-Fi™ data, will also allow for more confident identification of AVO anomalies



Israel in Summary

- Vast, proven reserves of biogenic gas in the Levant Basin.
- Potential for hydrocarbon accumulations within deeper sequences; broadband reprocessing improves imaging of the deeper potential.
    1. Improved basin temperature models
    2. Increased confidence in facies distribution
    3. Better definition of traps
    4. AVO recovery
- Improved understanding of both proven and unproven petroleum systems of the basin.



Acknowledgments

- Vasiliki Kosmidou, Imperial College
- Simon Bowen & Ben Sayers at TGS
- TGS Processing team in Bedford

References

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Thank you

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