Spatial Distribution of Miocene Diapirs in the Southern Levant Basin: A Fundamental Element for Future Hydrocarbon Exploration in the Eastern Mediterranean*

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Abstract

The Levant Basin became a focus of hydrocarbon exploration due to recent major gas discoveries, predominantly biogenic, offshore Egypt, Israel, and Cyprus. The main discoveries are within Miocene structures in high-porosity turbidite sand complex. The deep section, though, remained largely unexplored.

The Southern Levant Basin is located on the northern margin of Gondwana and is assumed to be underlain by Paleozoic stretched continental crust, exceeding a depth of about 15 km. The region experienced an Alpine contraction due to collision of the African and Eurasian plates since Late Mesozoic, expressed in the Syrian Arc anticlines along the margin. While the collision continues up to nowadays along the Cyprus Arc, contractional structures have not yet been observed in the Levant deep basin; moreover, the basin subsided and accumulated about half of the sedimentary column since the Late Eocene, with even higher subsidence rate in the north, offshore Lebanon. Using a comprehensive 2D and 3D seismic data, we have reconstructed the Miocene structures in the basin, finding a set of sediment highs, possibly diapirs, that spread across the southern part of the basin. These structural highs might extend up to the eastern flank of the Eratosthenes Seamount and continue eastwards up to the Levant continental slope.

We hereby present, for the first time, a detailed mapping of the shape and position of the structural highs, discussing a possible origin and the tectonic processes that shaped these important, newly recognized structures of the Levant Basin. In the absence of drilling data, we postulate that weak and unconsolidated sediments, possibly of infra-Jurassic age, might have fed them. The diapirs appear along few trajectories trending N-S to ENE-WSW.

The origin and nature of these structures in the Levant Basin might have a profound effect on the petroleum systems of the basin; because while up-building folds above the diapirs formed excellent traps in the Oligo-Miocene section, they might have pierced older traps, if existed. These new findings have therefore diverse implications for the prospectivity of deep targets in the Levant Basin, because these structures might create potential deep traps along their top sand flanks. This interpretation could therefore open new targets for the future exploration stages in the Levant Basin.

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SPATIAL DISTRIBUTION OF MIOCENE DIAPIRS IN THE SOUTHERN LEVANT BASIN: A Fundamental Element for Future Hydrocarbon Exploration in the Eastern Mediterranean

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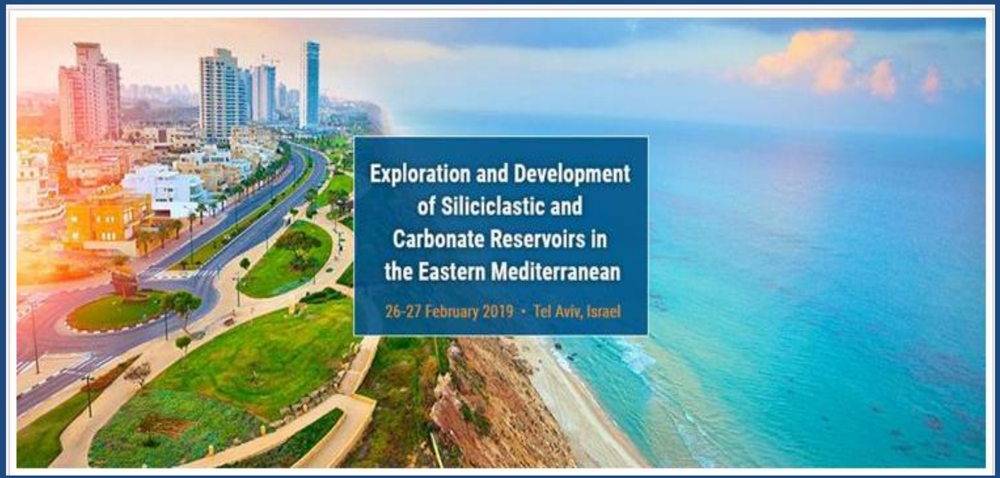

Talk Outline:

1. **Geological Setting**
   - **Oil and gas fields in the Levant Basin**
2. **Database**
   - **Magentic Field**
   - **Seismic 2D grid**
   - **Basin Evolution**
   - **Seismo-stratigraphy**
3. **Seismic Interpretation of the Southern Levant Basin**
   - **Regional geometry**
   - **Detailed seismic observations across the main structures**
   - **Summary view of the basin**
   - **Main spatial trends of Miocene structures**
4. **Conclusions**

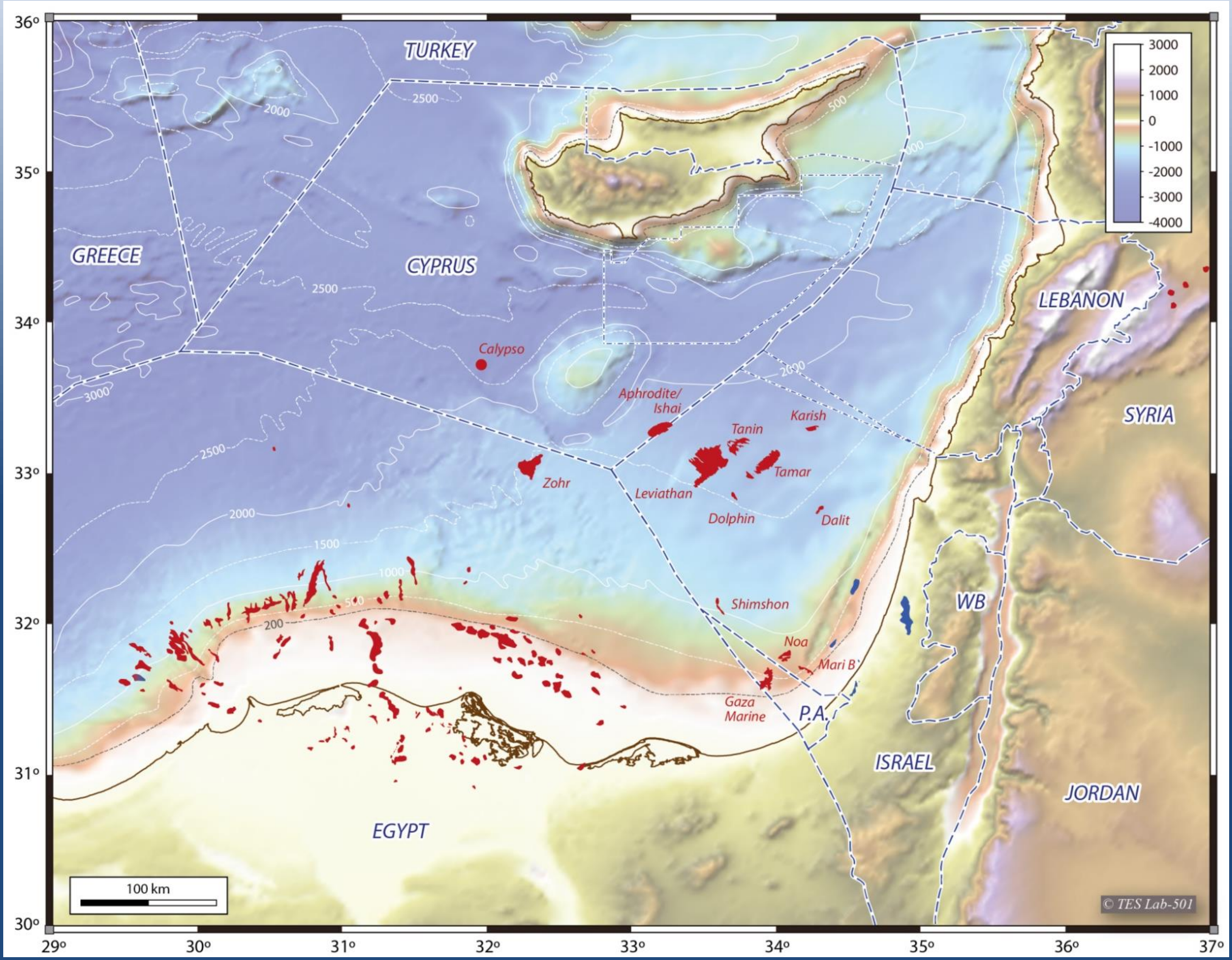

Fig. 1. Physiography of the Levant Basin and Hydrocarbon Fields (gas: in red; oil: in blue).

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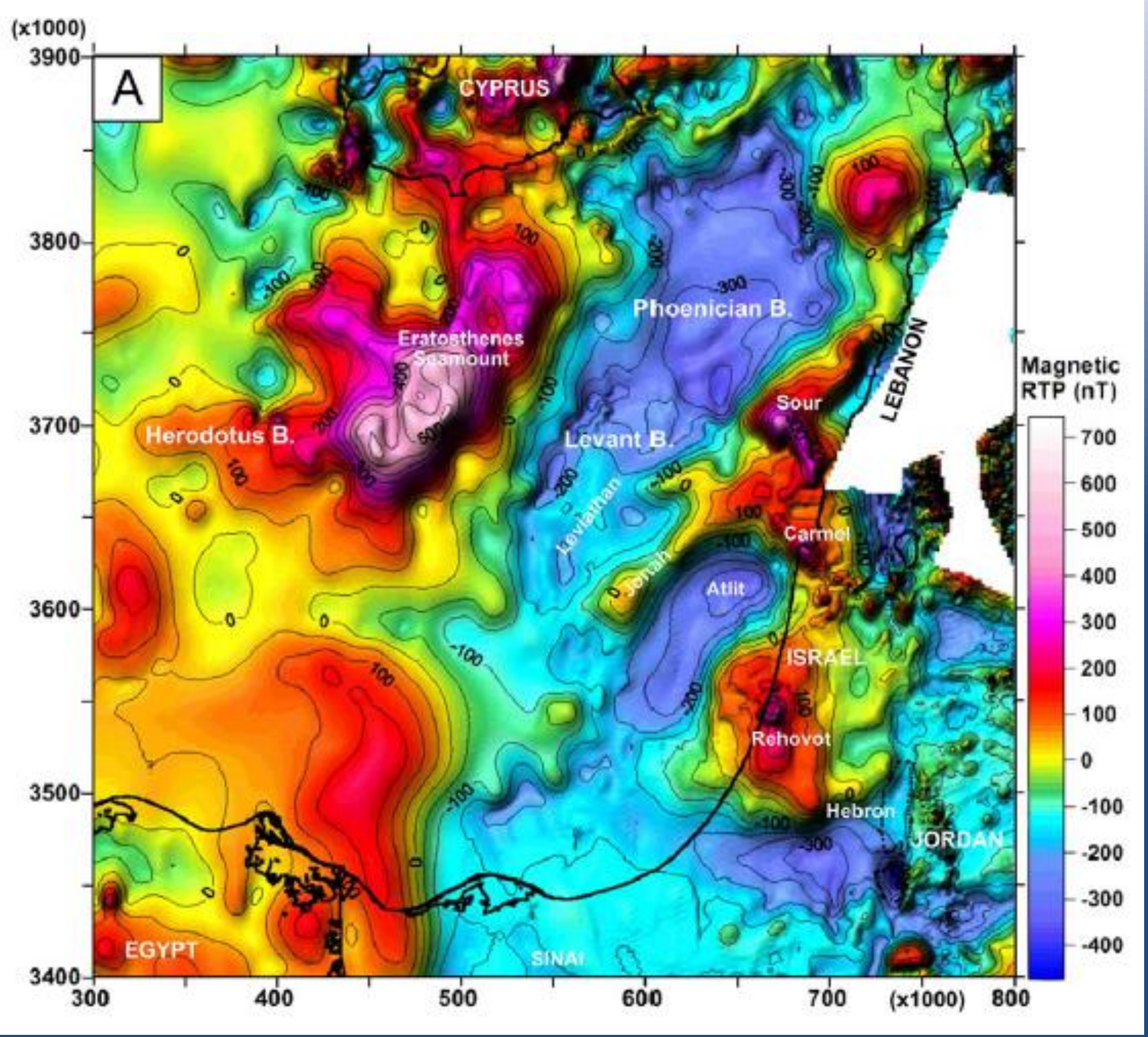


Fig. 2. Reduced-to-Pole Magnetics (from Segev et al., 2018)

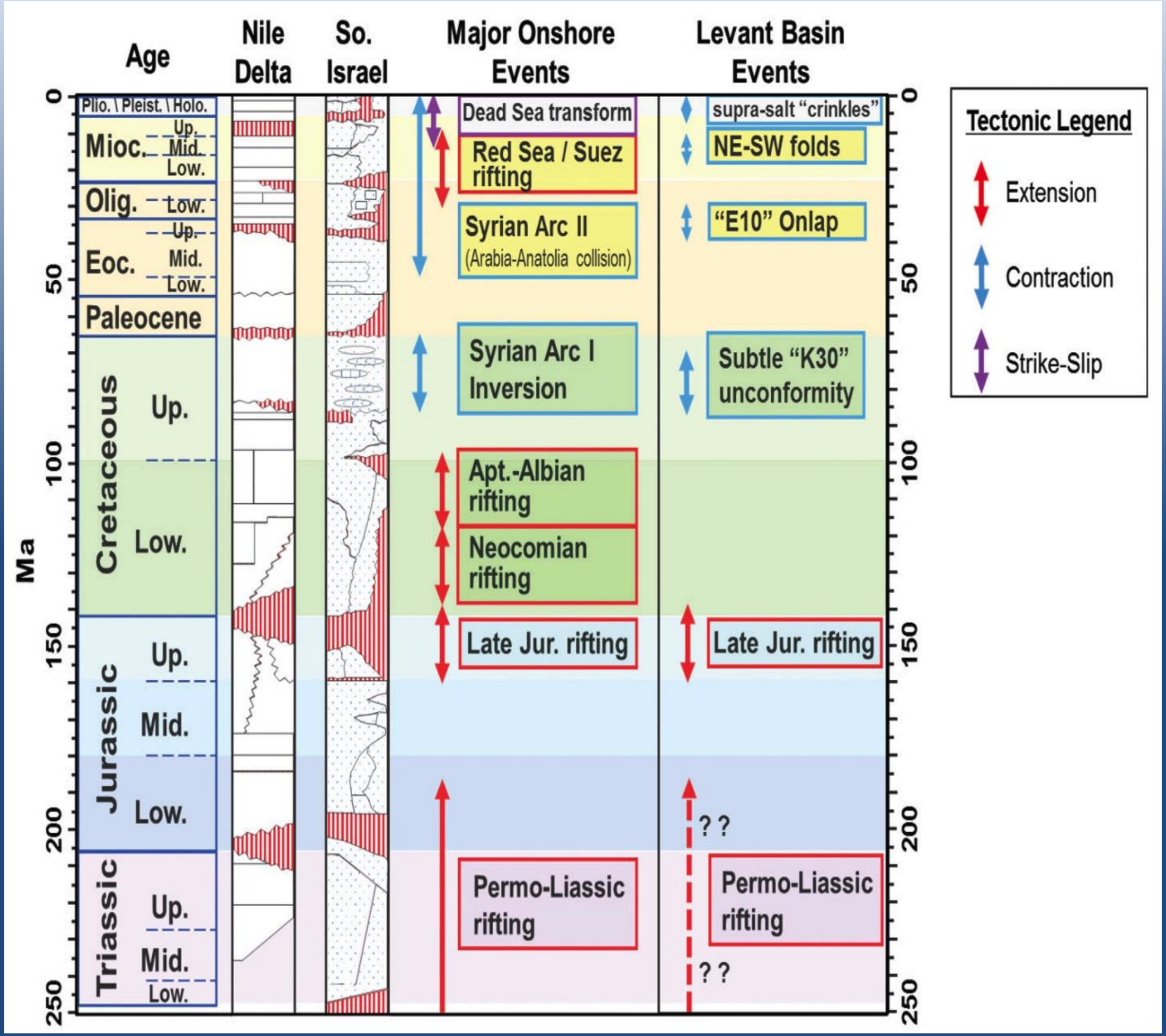


Fig. 3. Chrono-Stratigraphy and Basin Evolution (from Needham et al., 2017)

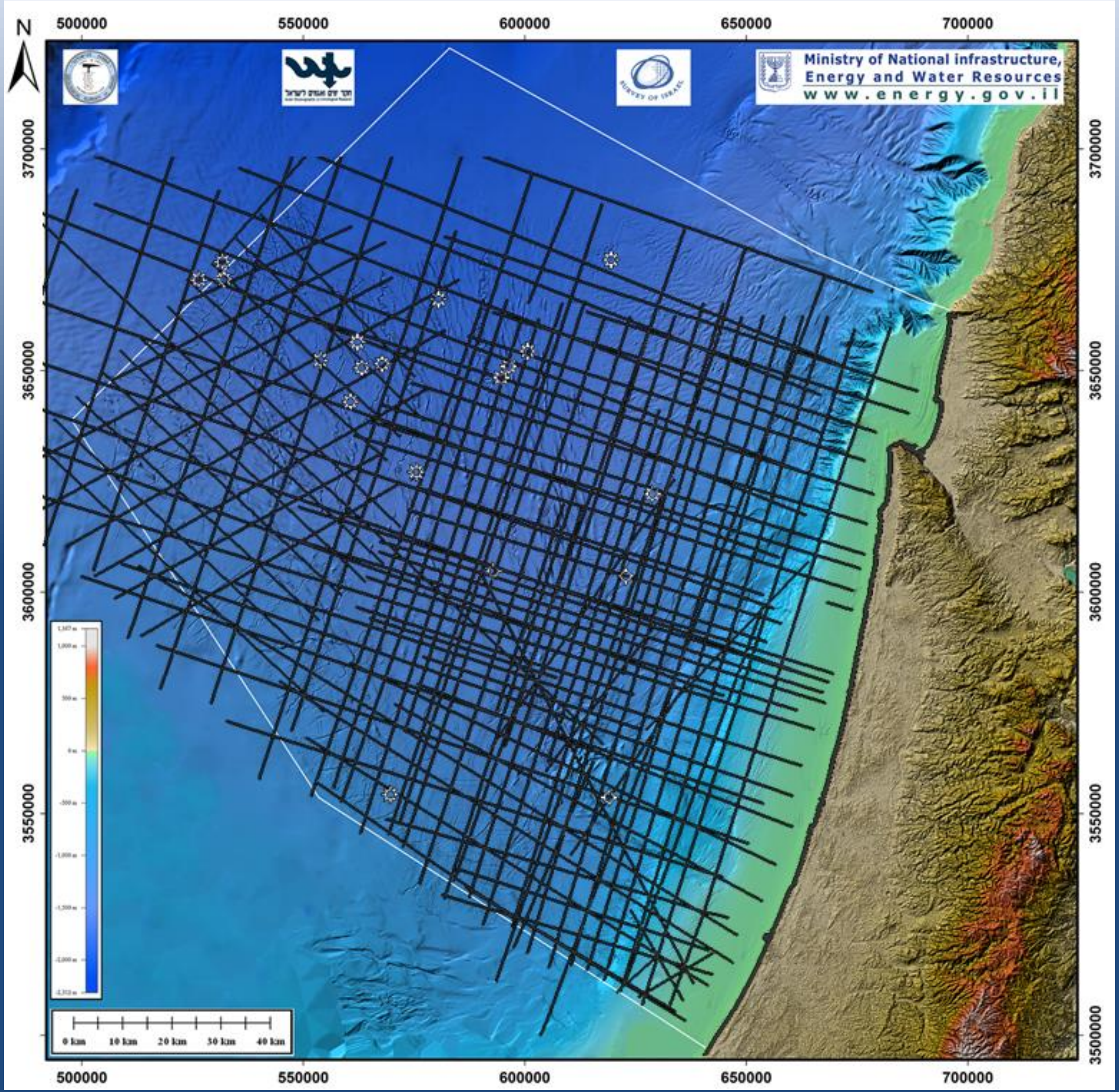


Fig. 4. Seismic Database used for this study over a bathymetry map of the Southern Levant Basin

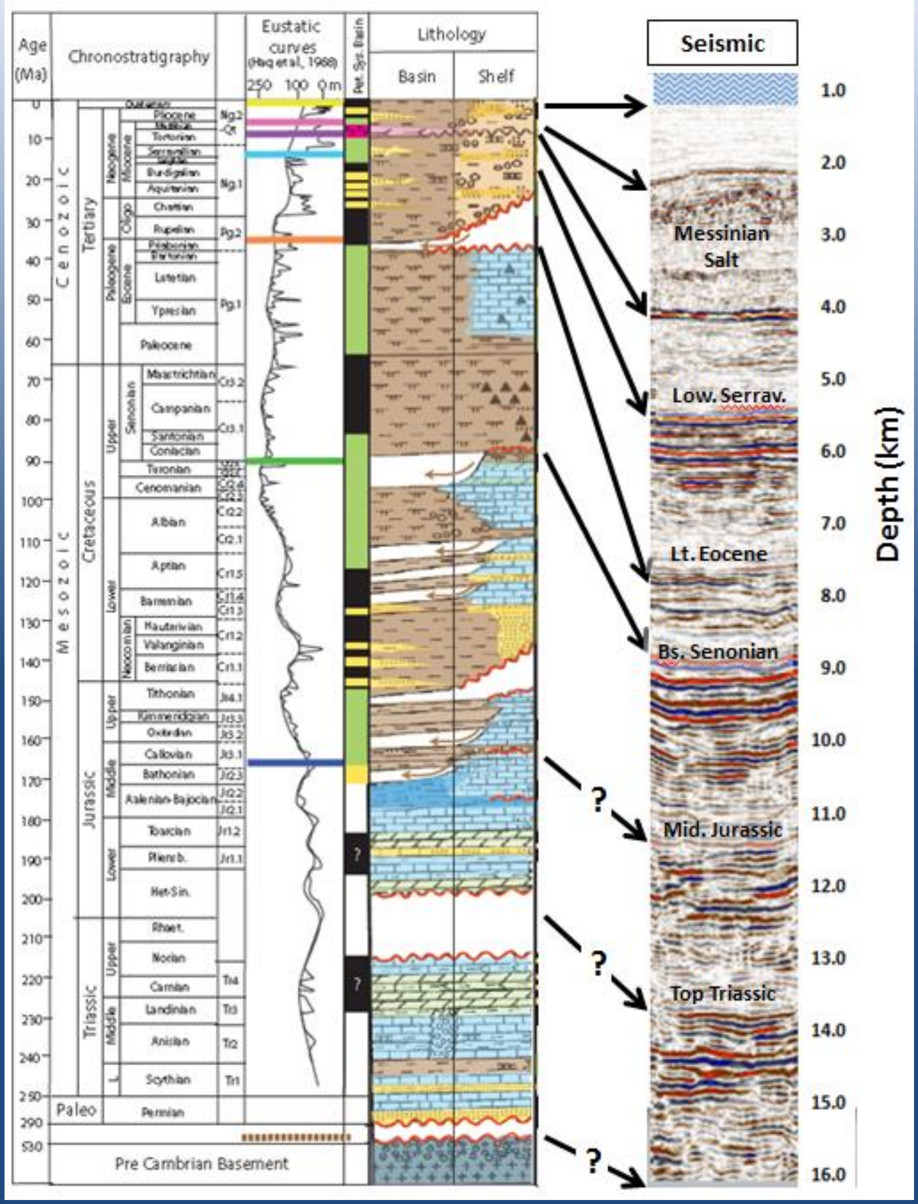


Fig. 5. Stratigraphy (modified after Gardosh and Lipmann, 2017) and seismic expression of the main discontinuities used in this study. Notice that about half of the section has been deposited since the Late Eocene (Steinberg et al., 2011).

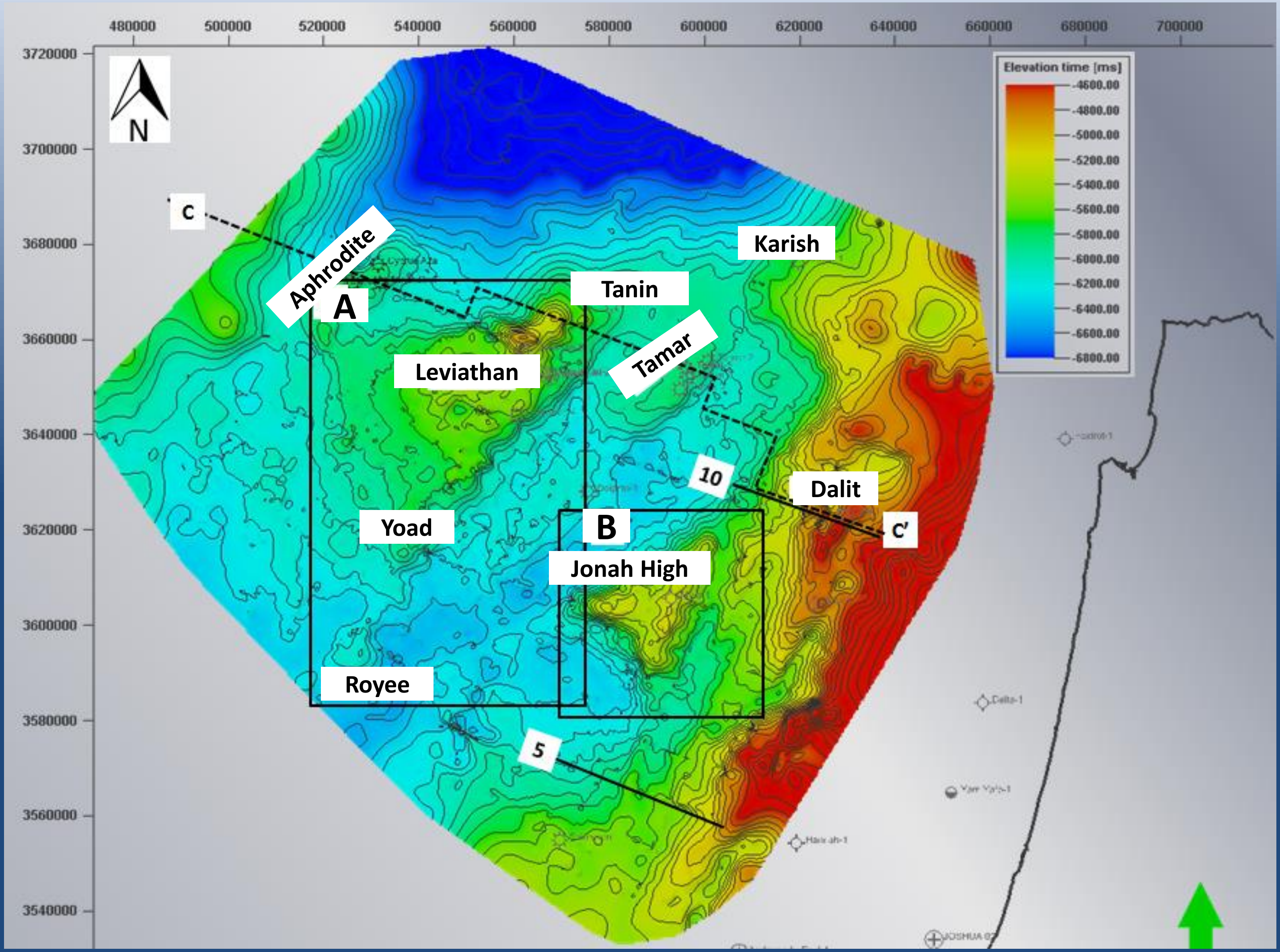


Fig. 6. Reference map (Base Senonian, in twtt) for the insets and seismic sections shown below

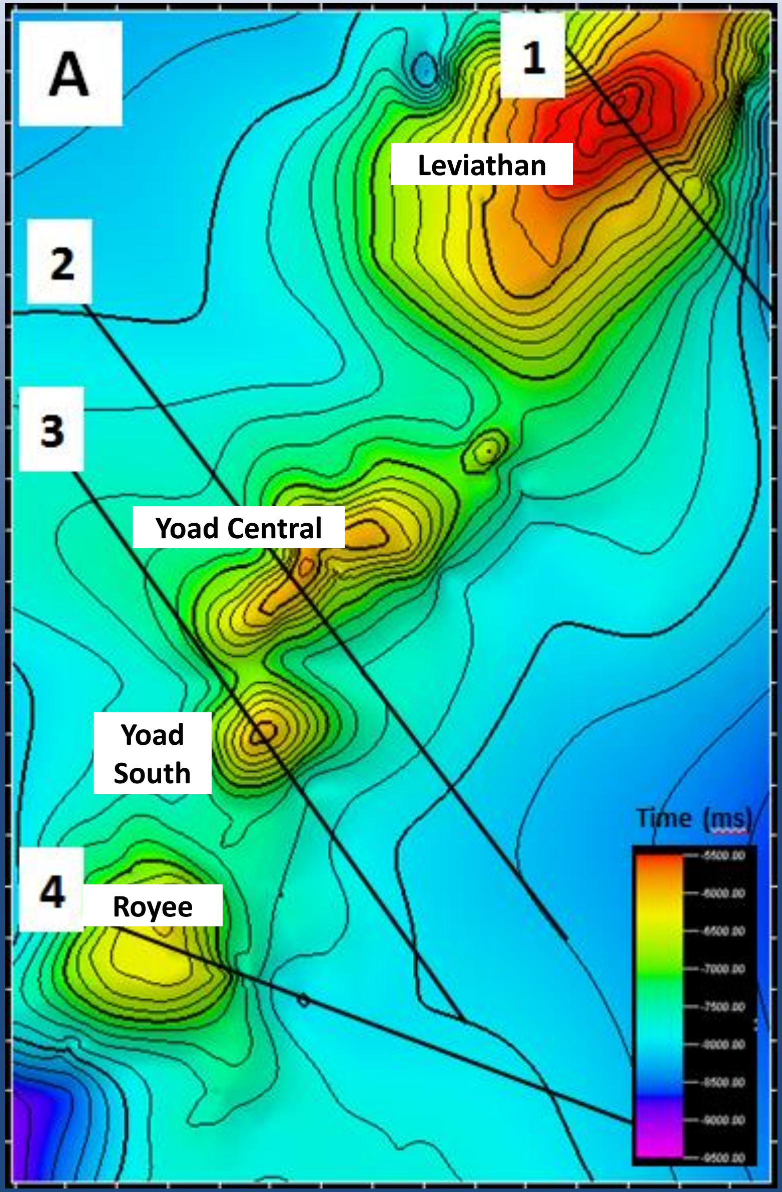


Fig. 7. Contour map (in twtt) of the diapir cores. Notice the sub-circular and the SW-NE-elongated shape of the structures.

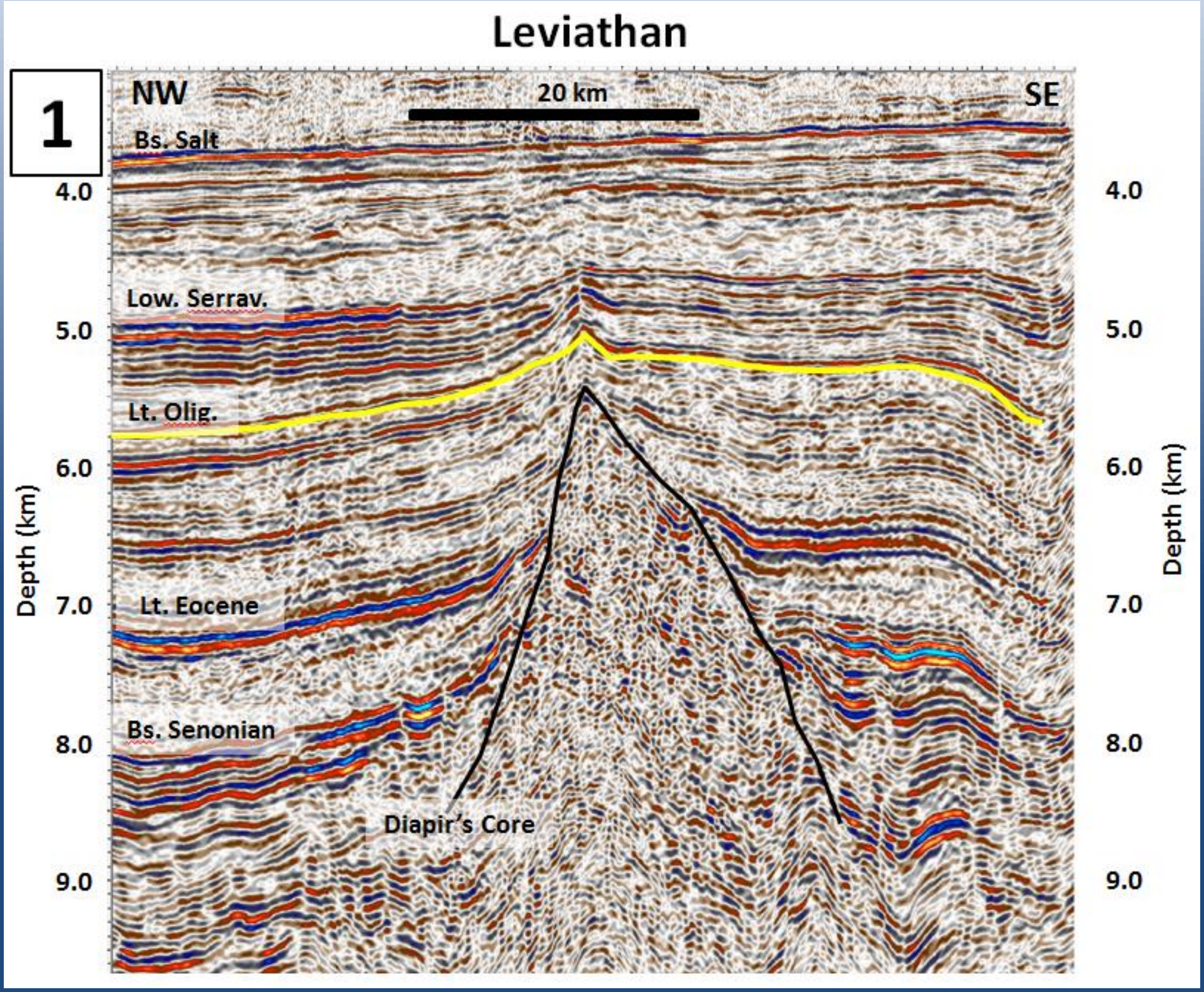


Fig. 8. The Leviathan Diapir (Ben-Gai, 2018). Notice how the structure is piercing the Middle Miocene sequences. This line is close to the culmination of the Leviathan Diapir.

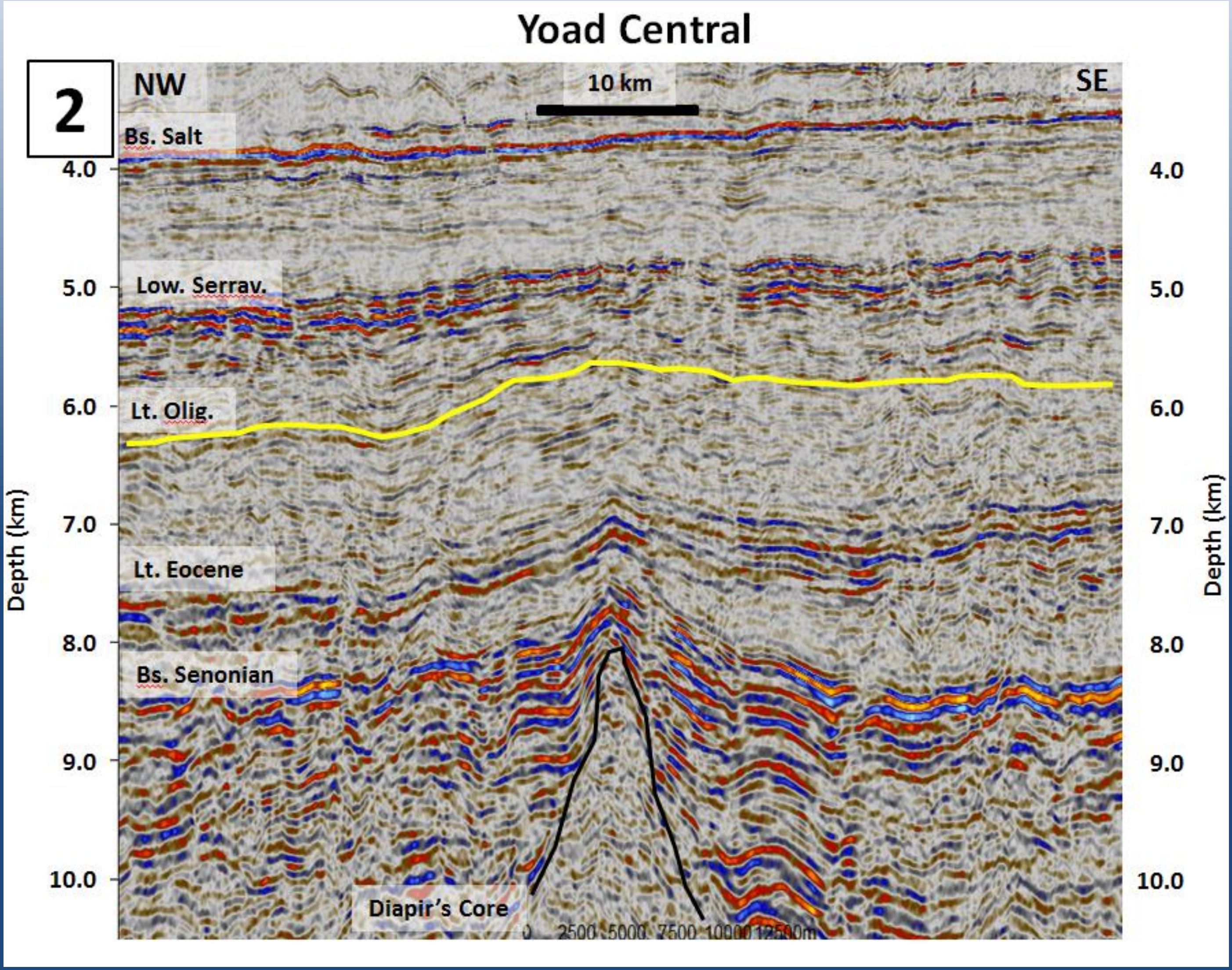


Fig. 9. Gentle folding of the Early to Middle Miocene sequence above the Yoad High with onlap towards the culmination, and the congruent, parallel folding of the pre-Miocene sequences.

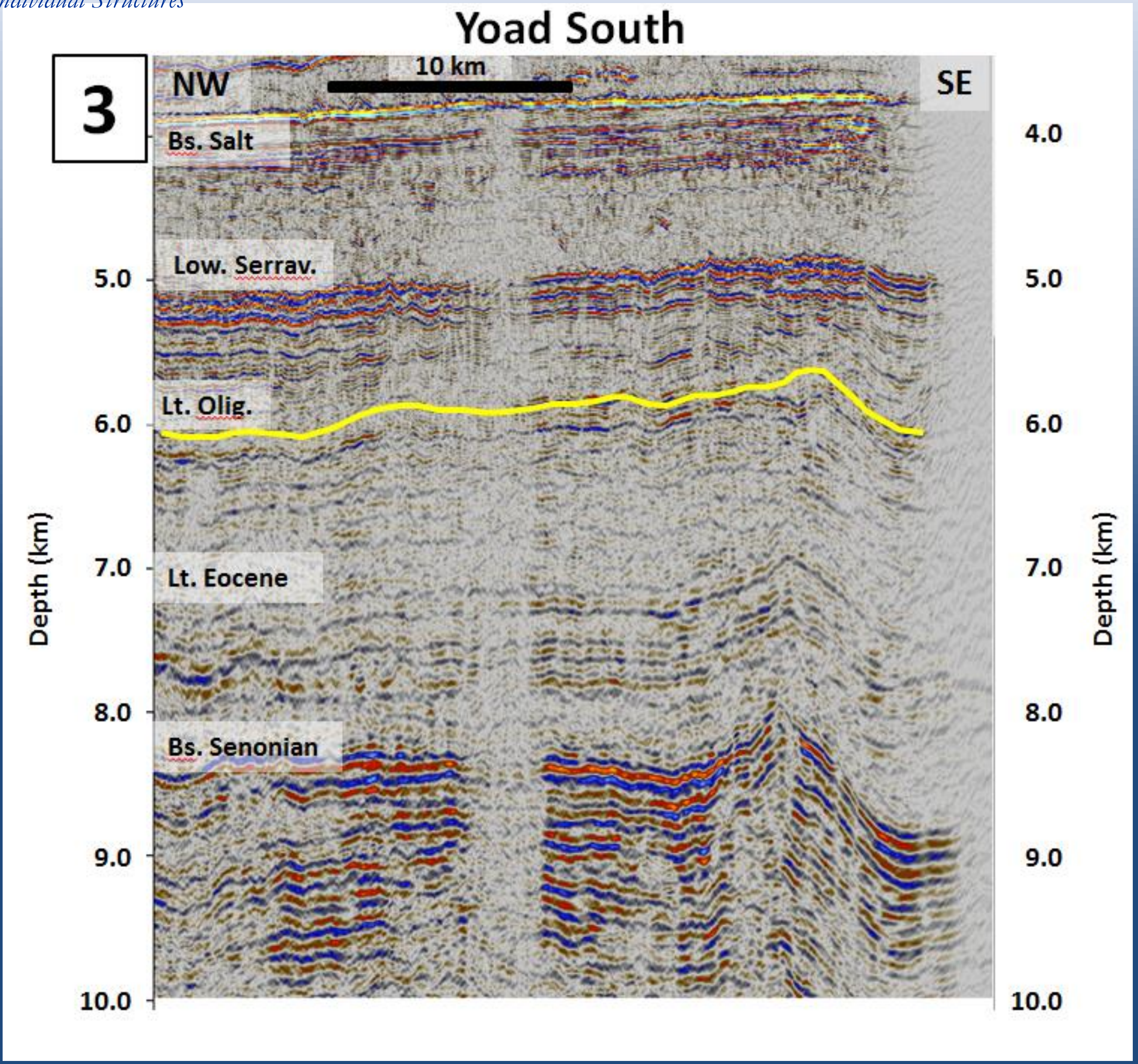


Fig. 10. Similar observations and deformation style and timing across the southern culmination of the Yoad High.

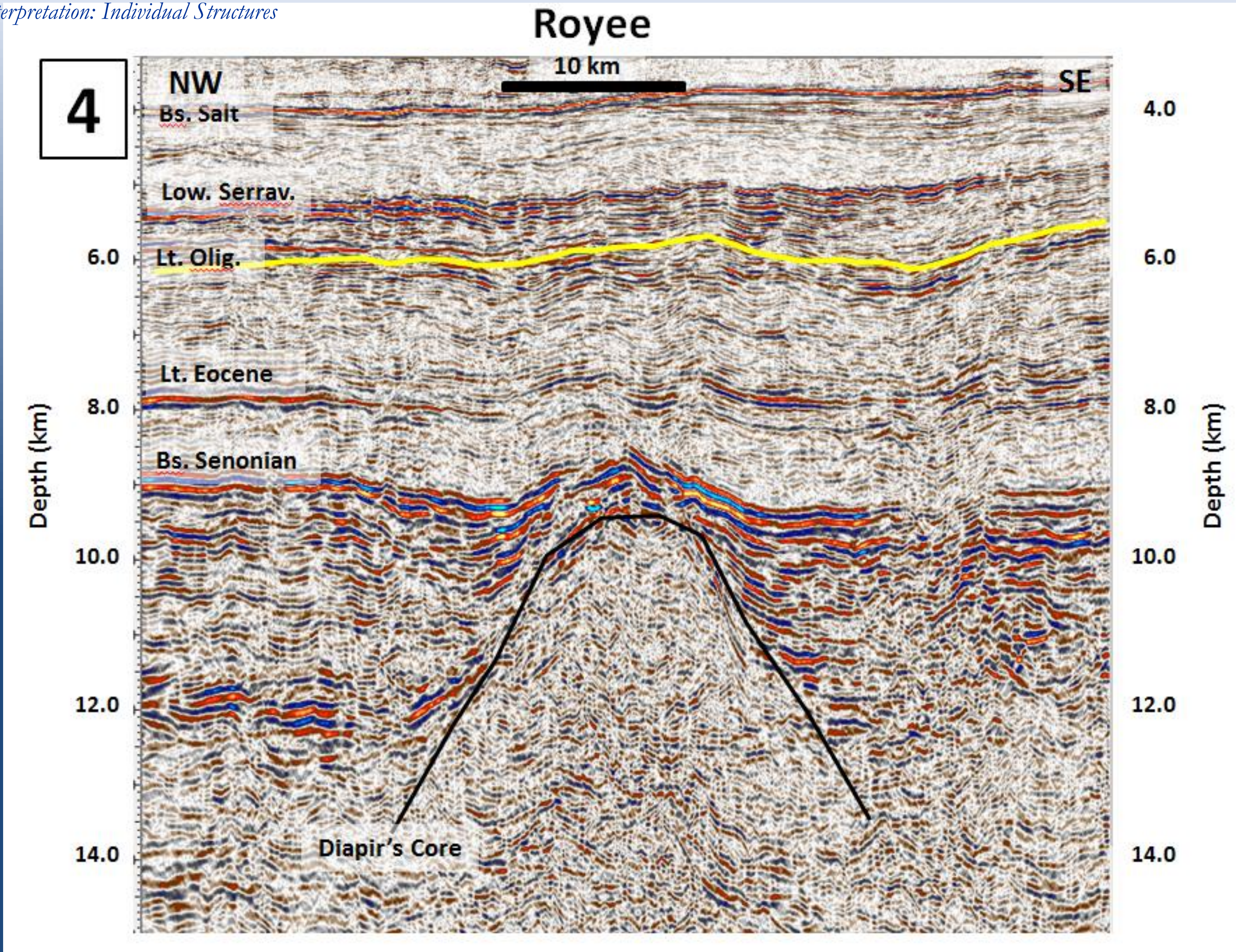


Fig. 11. Seismic section across the Royee High, showing a subdue folding of the Early-to-Middle Miocene sequences above the high.

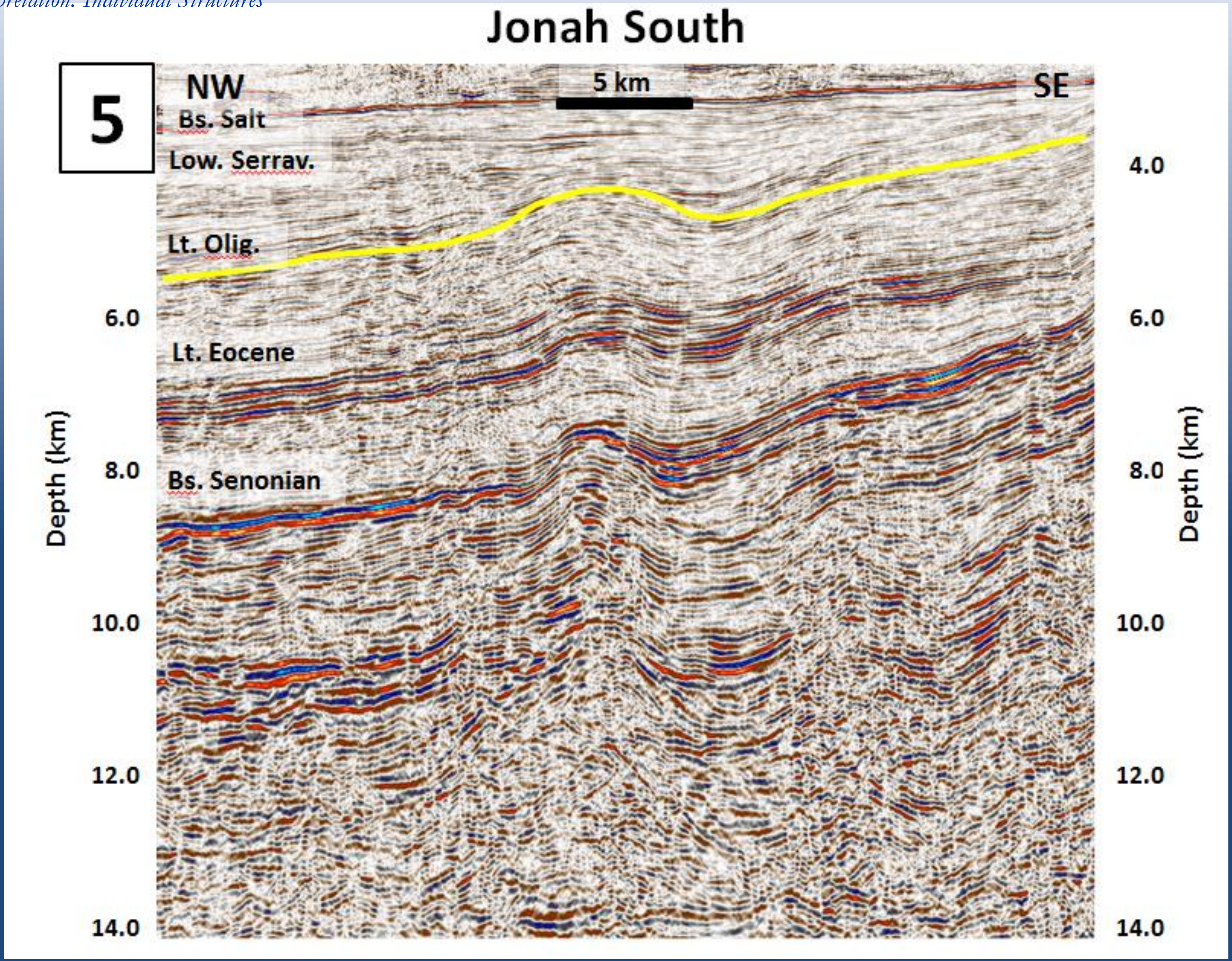


Fig. 12. This line shows a possible southward prolongation of the Jonah High. Miocene folding is clearly observed.

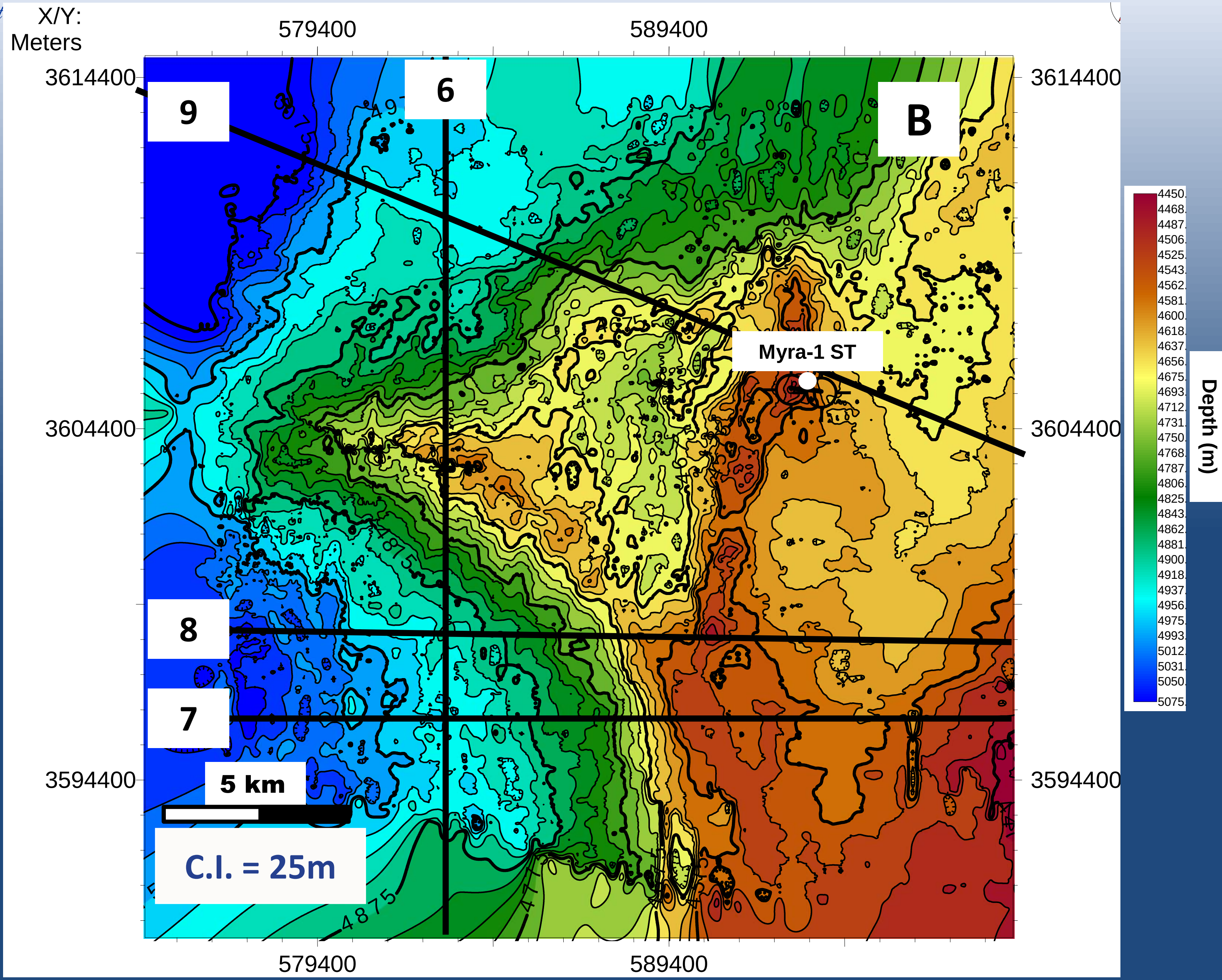


Fig. 13. Depth-contour map of the Lower Serravalian marker over the Jonah High. Notice the bifurcated intrusion (Ben-Gai, 2019).

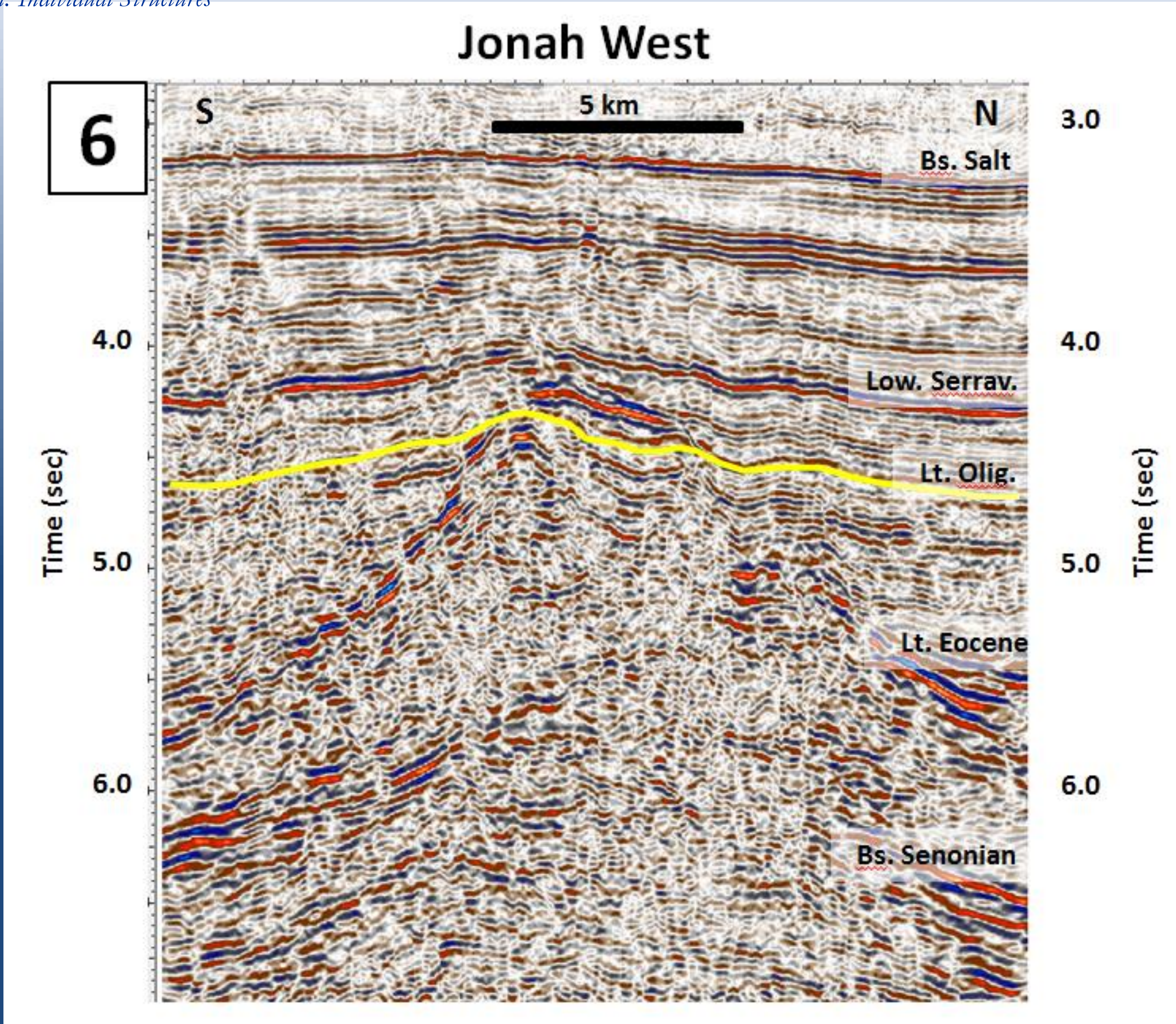


Fig. 14. 3D crossline over the enigmatic Jonah High. Notice the gentle dip of the sequences in the northern flank of the structure.

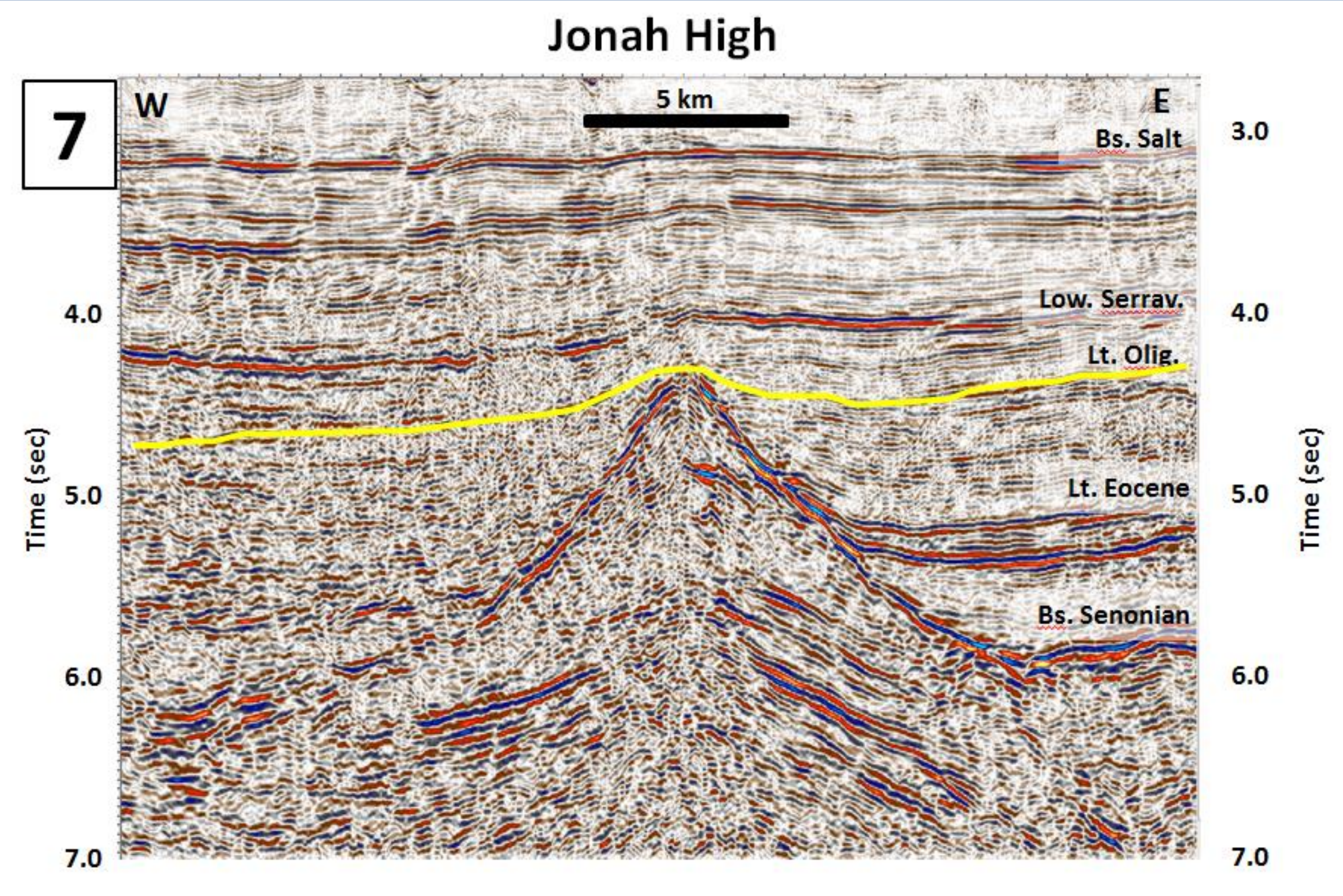


Fig. 15. 3D inline across the "root" of the Jonah High, interpreted as a bifurcated intrusion.

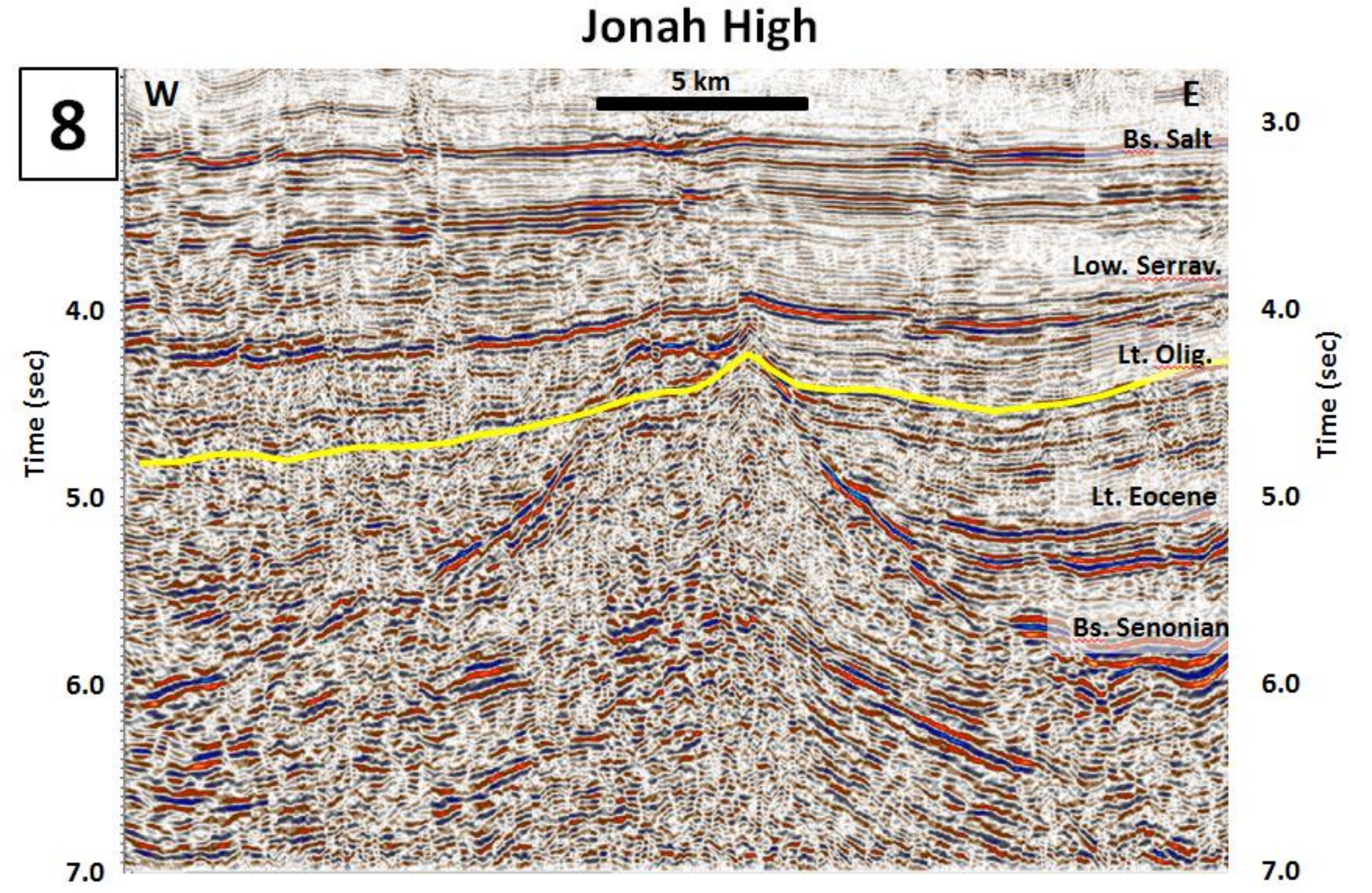


Fig. 16. Another 3D inline across the Jonah High. It is interpreted as the structure corresponds to the eastern branch of the bifurcated intrusion.

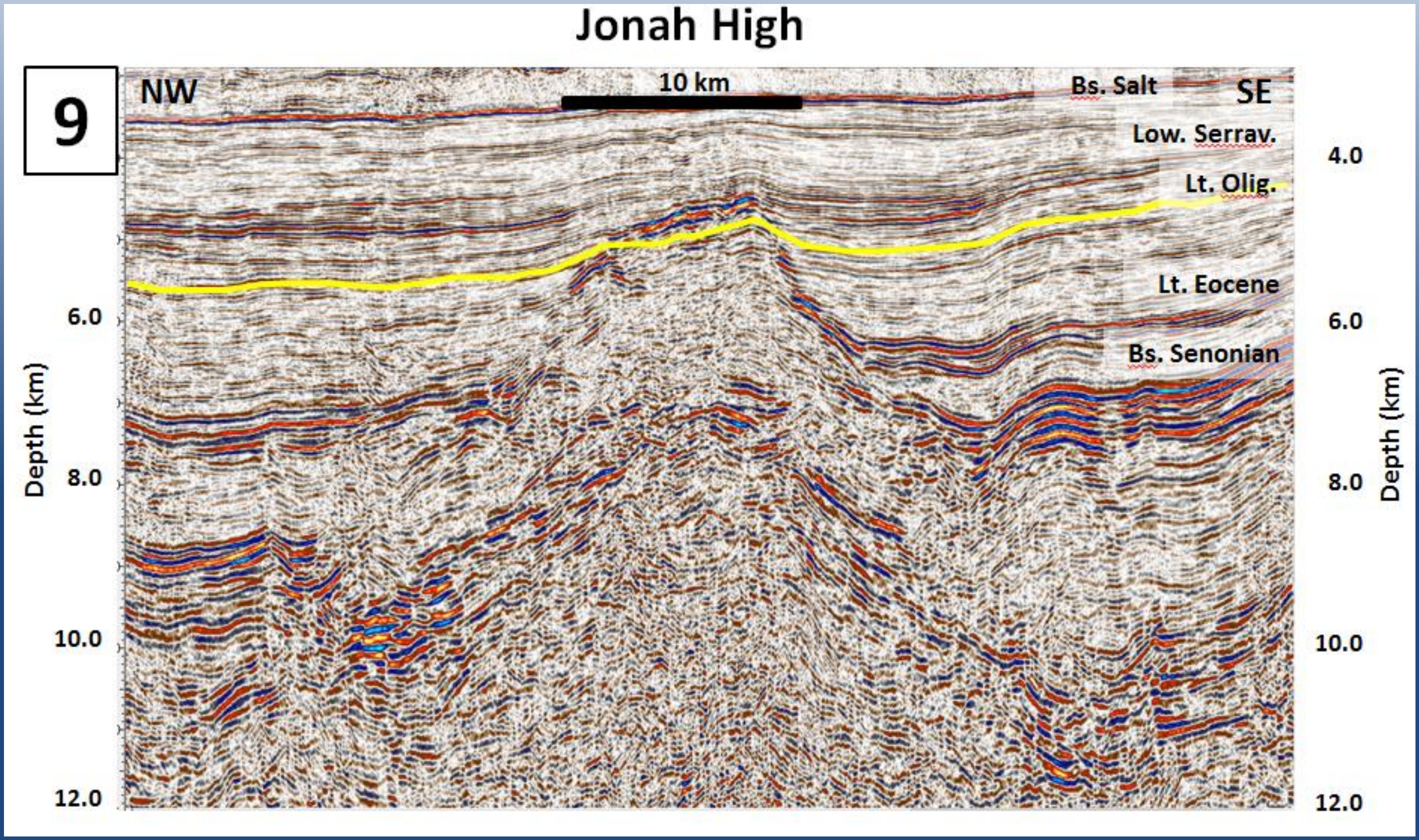


Fig. 17. 2D line across the Jonah High. Like in previous seismic sections, the Late Oligocene reflection cover the structure, whereas the older series appear to be truncated in the flanks and onlapping the high.

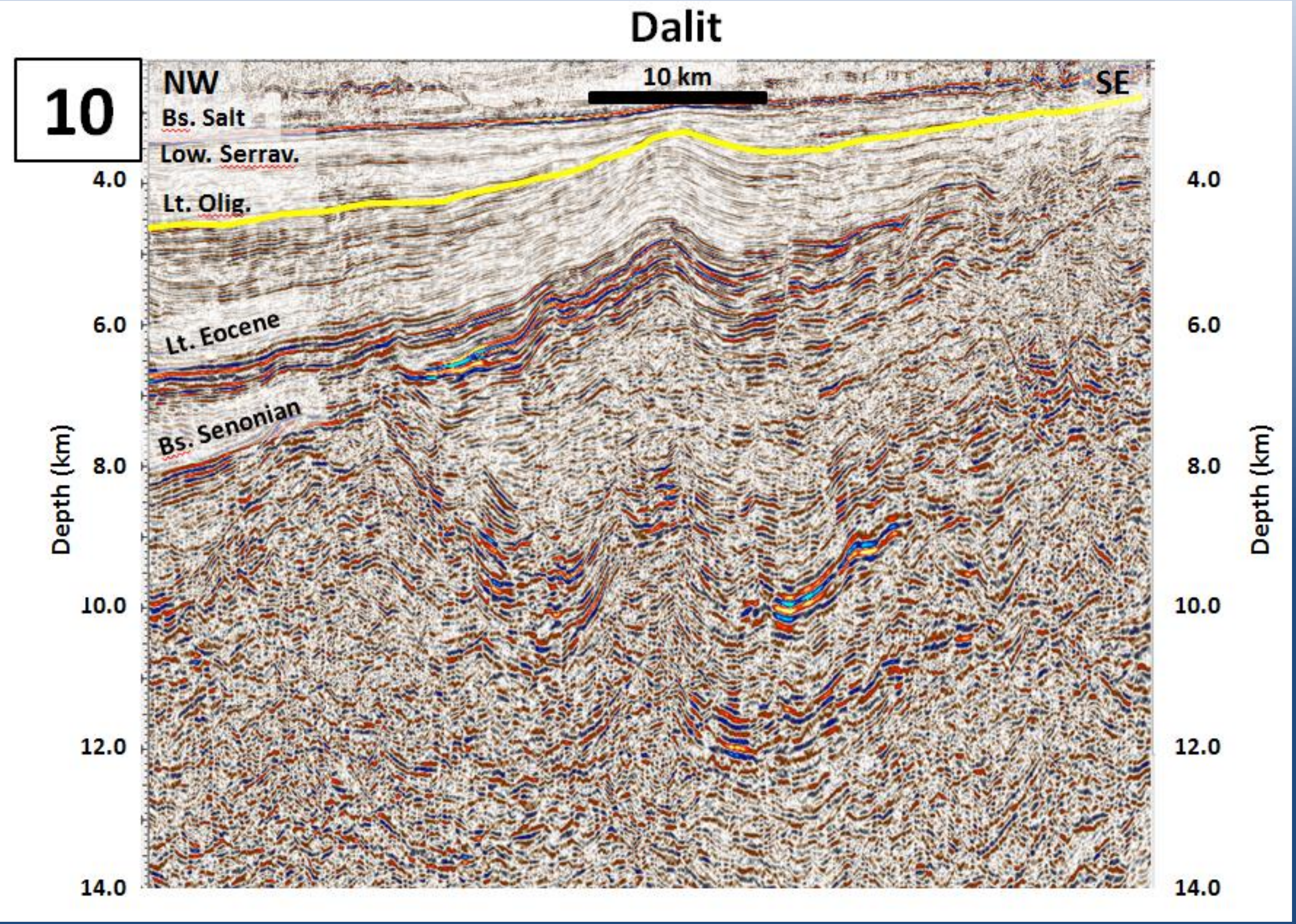


Fig. 18. 2D line across the Dalit gas discovery. The geometry of the Early-to-Middle Miocene sequence suggest syn-growth folding of the structure, like other comparable structures in the Southern Levant Basin.

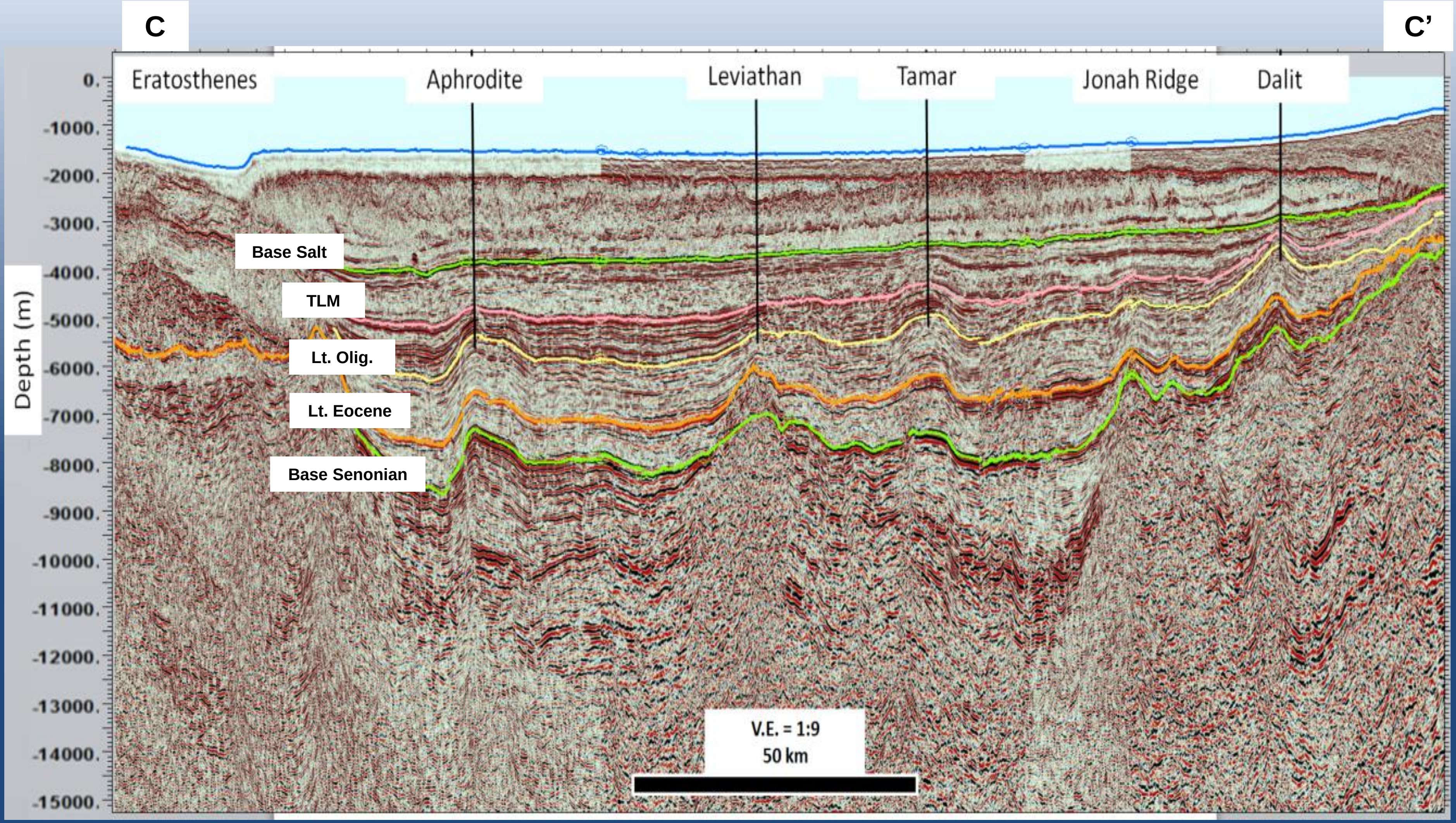


Fig. 19. Regional seismic line across the Southern Levant Basin showing the main Miocene structures. Dalit, Jonah Ridge and Leviathan highs have probably been fed by piercing sediments (over-pressured shales?); whereas the Tamar and Aphrodite highs document congruent folding of the pre-Miocene series (Ben-Gai and Druckman, 2013).

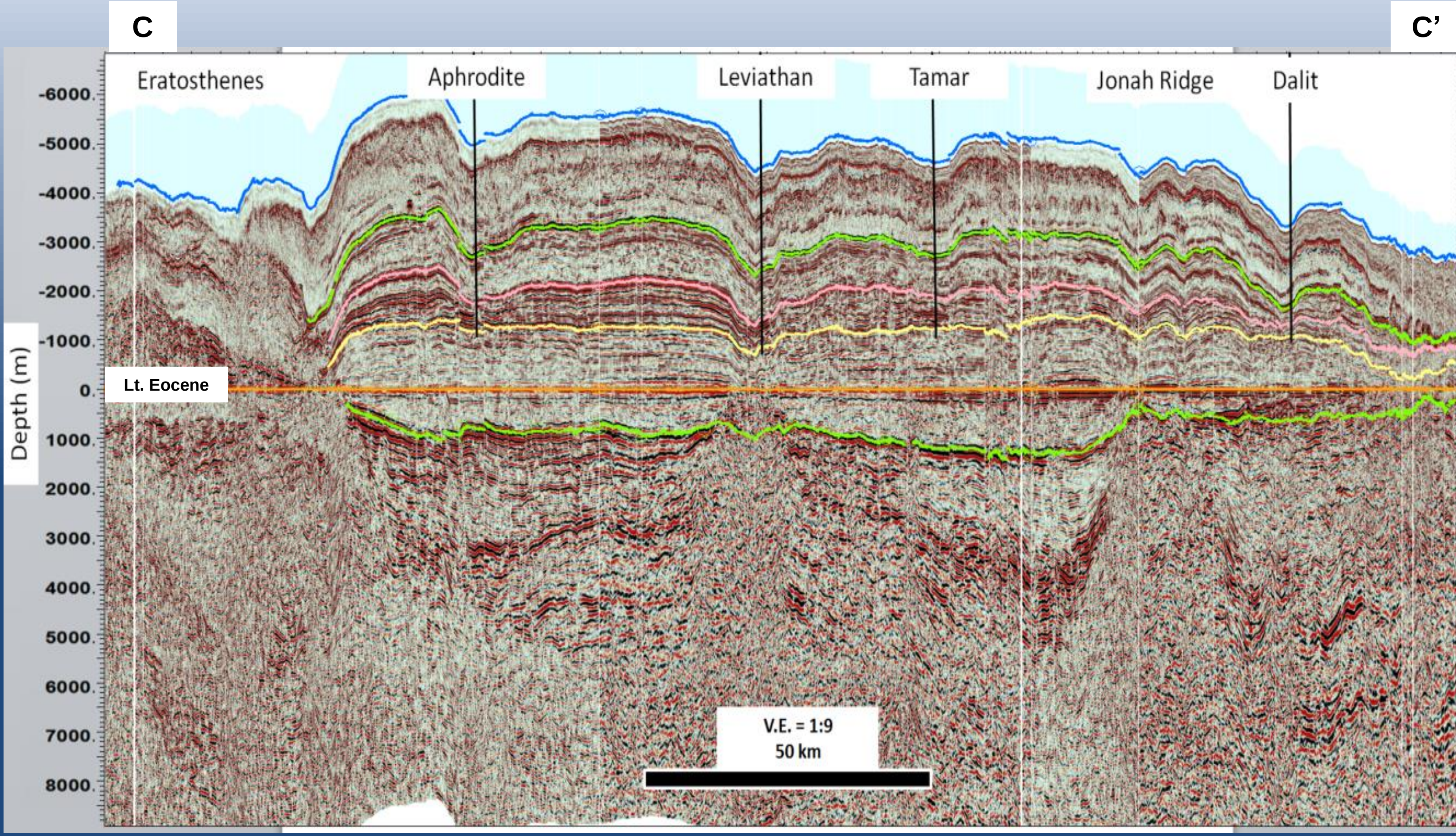


Fig. 20. Flattening of the previous seismic section (Fig. 19) with reference to the Late Eocene seismic reflection.

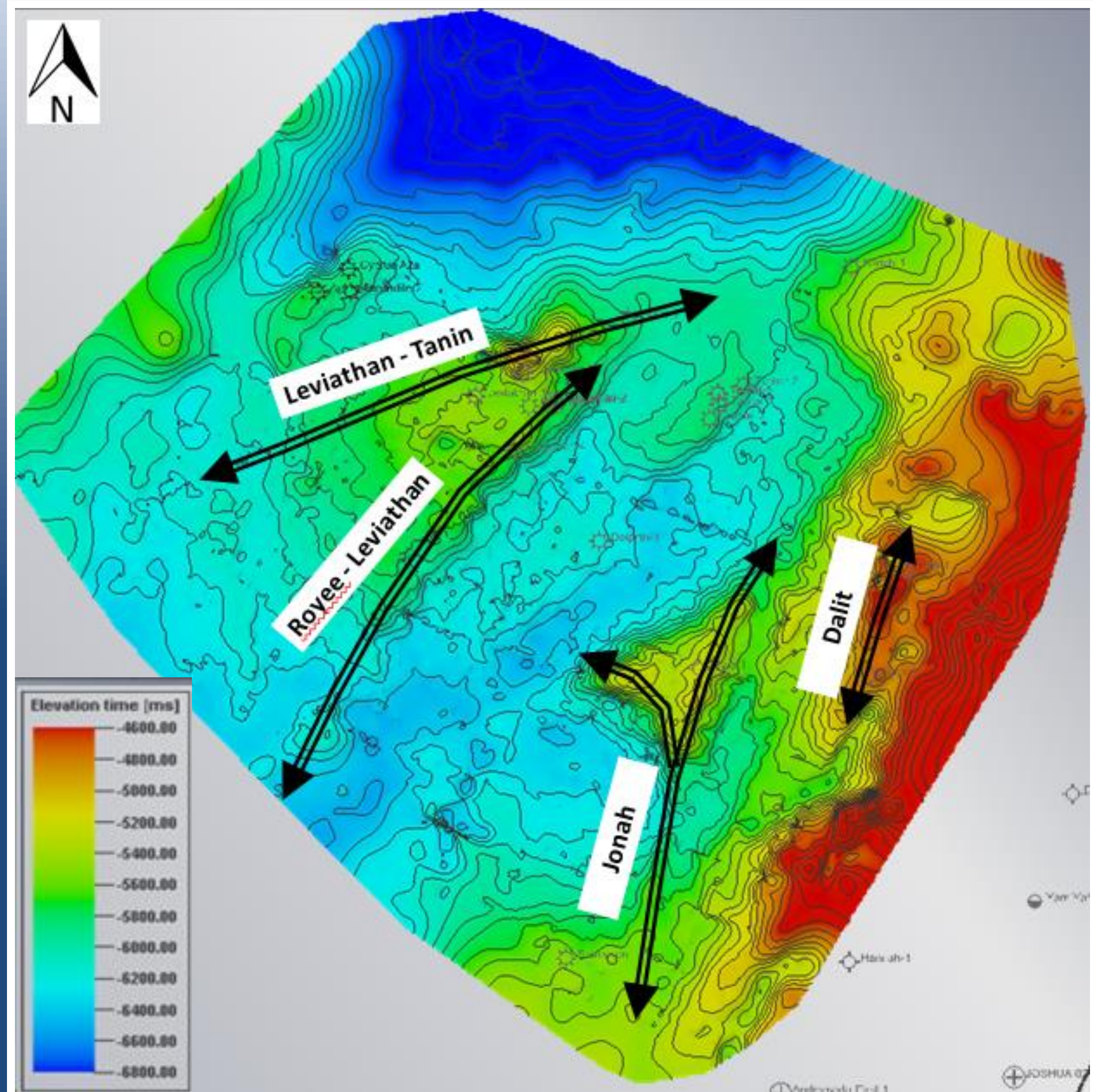
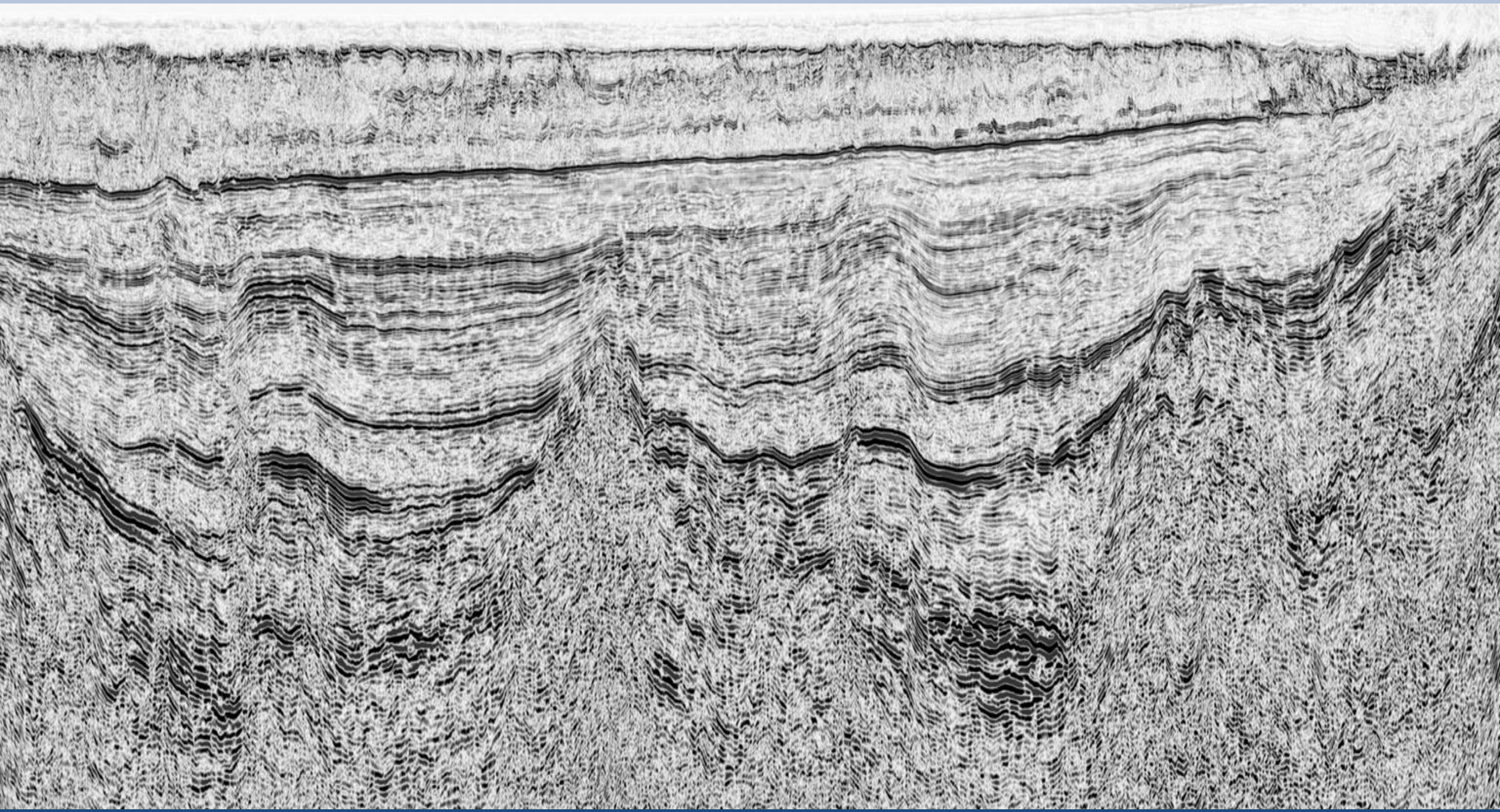


Fig. 21. Main trends of the Miocene structures in the Southern Levant Basin, overlying the contour map (in twtt) of the Base Senonian reflection.

Conclusions

- The Southern Levant Basin is dominated by Early-to-Middle Miocene tectonic activity, generating sub-circular and elongated structures trending N-S to ENE-WSW and even NW-SE.
- Some of these structures resemble diapiric structures. Our interpretation is that the piercing material in these diapirs comes from deep, possibly pre-Jurassic, mobile shales.
- The orientation and distribution of the culminations in the Southern Levant Basin, in conjunction with the geometries and timing of the folded sequences, require further study to understand how they relate to the Early-to-Middle Miocene maximum shortening direction, while the basin experiences an accelerated subsidence-rate since the Late Eocene.
- Some of these structures have proved to have gas accumulations at their tops, because the highly-porous Oligo-Miocene tubiditic sands formed excellent traps.
- The diapirs might have pierced older traps, if existed, but also formed these proven traps on top and potential traps at depth.
- Further studies on these structures, analyzing their core, the piercing mechanisms and the detailed relationships with the country sediments, may assist in the near-future hydrocarbon exploration activities in the basin.



Thank You