A Newly Discovered Giant Dome of Early Mesozoic age in the Prolific Levant Basin, Eastern Mediterranean*

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Abstract

The prolific Levant basin is a prime exploration objective in the Mediterranean Sea due to recent major gas discoveries in Cretaceous to Pliocene active petroleum systems offshore Egypt, Israel, and Cyprus. A previously unreported, large deeply buried fold of Triassic - Early Jurassic age has been revealed recently from a newly acquired 3D seismic data set in the Levant basin, offshore Israel. It is the first reported Early Mesozoic folding phase in the basin, where previous structural interpretations suggested a pattern of Early Mesozoic horsts and grabens formed in an extensional tectonic regime, related to rifting and opening of the Neo-Tethys. Dakar fold, only part of which is covered by the seismic data set, is a basement-involved structure, associated with a distinct magnetic anomaly. It is characterized by its large size, semi-circular shape, lack of significant faulting, lack of distinct trend patterns and solitary occurrence. Accordingly, the structural style is classified as a basement-involved dome, meaning dominant vertical movements in Triassic - Early Jurassic time, in this part of the basin. Dakar dome is buried under 6000 meters of younger sediments. Stratigraphically, the upper sequence in the fold exhibits characteristics of a mobile sediment, such as soft shale or a mixture of shale and salt. It is chaotic to transparent, distorted and typically thickens considerably toward the structural crest, forming a crestal diapir penetration into overlying Cretaceous to Oligocene sediments. This newly identified dome provides a novel insight into the Early Mesozoic tectonic evolution of the southern Levant basin. The large fold topped by excellent sealing sediments highlights new potential objectives for future hydrocarbon exploration in the basin.

Selected References

Ben-Gai. Y., and J. I. Soto, 2019, Spatial Distribution of Miocene Diapirs in the Levant Basin – A Fundamental Element for Future Hydrocarbon Exploration in the Eastern Mediterranean, Abstract Submitted to the AAPG GTW, Tel-Aviv.

Ben-Gai, Y., and Y. Druckman, 2013, Mega-scale swells and diapirs in the deep Levant basin, Eastern Mediterranean and their association with recent world-class gas discoveries: Search and Discovery Article #10518 (2013). Website accessed December 2, 2018,

Bowman, S.A., 2011, Regional seismic interpretation of the hydrocarbon prospectivity of offshore Syria: GeoArabia, v. 16/3, p. 95-124.

Breman, E., 2006. Oil and gas plays in the East Mediterranean (expanded abstract): 5th Petroleum Exploration Society of Great Britain/Houston Geological Society, African Conference, London.

Gardosh, M. A., and S. Lipman, 2017, Proven and New Plays in the Levant Basin – The Next Step in Developing Hydrocarbon Resources Offshore Israel, Abstract, AAPG, Larnaca.

Gardosh, M.A., and Y. Druckman 2006. Seismic stratigraphy, structure and tectonic evolution of the Levantine Basin, offshore Israel, *in* A.H.F. Robertson and D. Mounttrakis, editors, Tectonic
Development of the Eastern Mediterranean Region: Geological Society of London Special Publication no. 260, p. 201-227.

Gardosh, M.A., Z. Garfunkel, Y. Druckman and B. Buchbinder 2010. Tethyan rifting in the Levant Region and its role in Early Mesozoic crustal evolution, *in* C. Homberg and M. Bachmann, editors, Evolution of the Levant Margin and Western Arabia Platform since the Mesozoic: Geological Society of London Special Publication no. 341, p. 9-36.

Lowell, J.D., 1985, Structural Styles in Petroleum Exploration: OGCI, 450p. (Pennwell Corporation, 504p).

Rybakov, M., V. Goldshmidt, and Y. Rotstein, 1997, New regional gravity and magnetic maps of the Levant: Geophysical Research Letters, v. 24/1, p. 33-36

Roberts, G., and D. Peace, 2007, Hydrocarbon plays and prospectivity of the Levantine Basin, offshore Lebanon and Syria from modern seismic data. GeoArabia, v. 12/ 3, p. 99-124.

Segev, A., and M. Rybakov, 2010, Effects of Cretaceous plume and convergence, and early Tertiary tectonomagmatic quiescence on the central and southern Levant continental margin: Journal of the Geological Society of London, v. 167/4, p. 731-749.

Segev, A., E. Sass, and U. Schattner, 2018, Age and structure of the Levant basin, Eastern Mediterranean: Earth Science Reviews, v. 182, p. 233-250.

Steinberg, J., Z. Gvirtzman, Y. Folkman, and Z. Garfunkel, 2011, Origin and nature of the rapid Late Tertiary filling of the Levant Basin: Geology,v. 39, p. 355-358.

Steinberg, J., A.M. Roberts, N.J. Kusznir, K. Schafer, and Z.Karcz 2018, Crustal structure and post-rift evolution of the Levant Basin: Marine and Petroleum Geology, v.96, p. 522-543.

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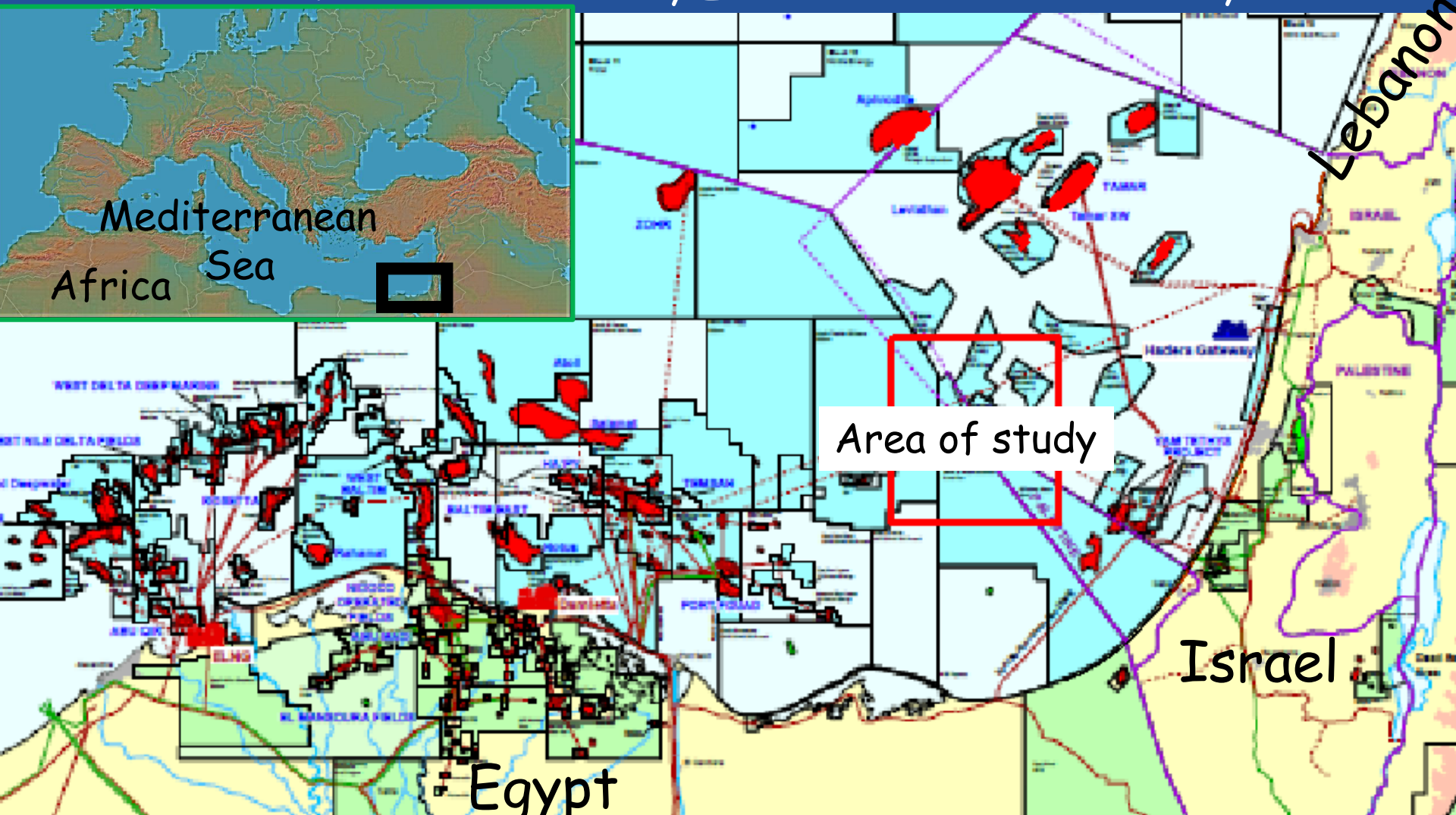
A newly discovered giant dome of early Mesozoic age, in the prolific Levant basin, Eastern Mediterranean

Folkman, Yehoshua (Shuka) and Ben-Gai, Yuval

Gas fields in the Levant basin

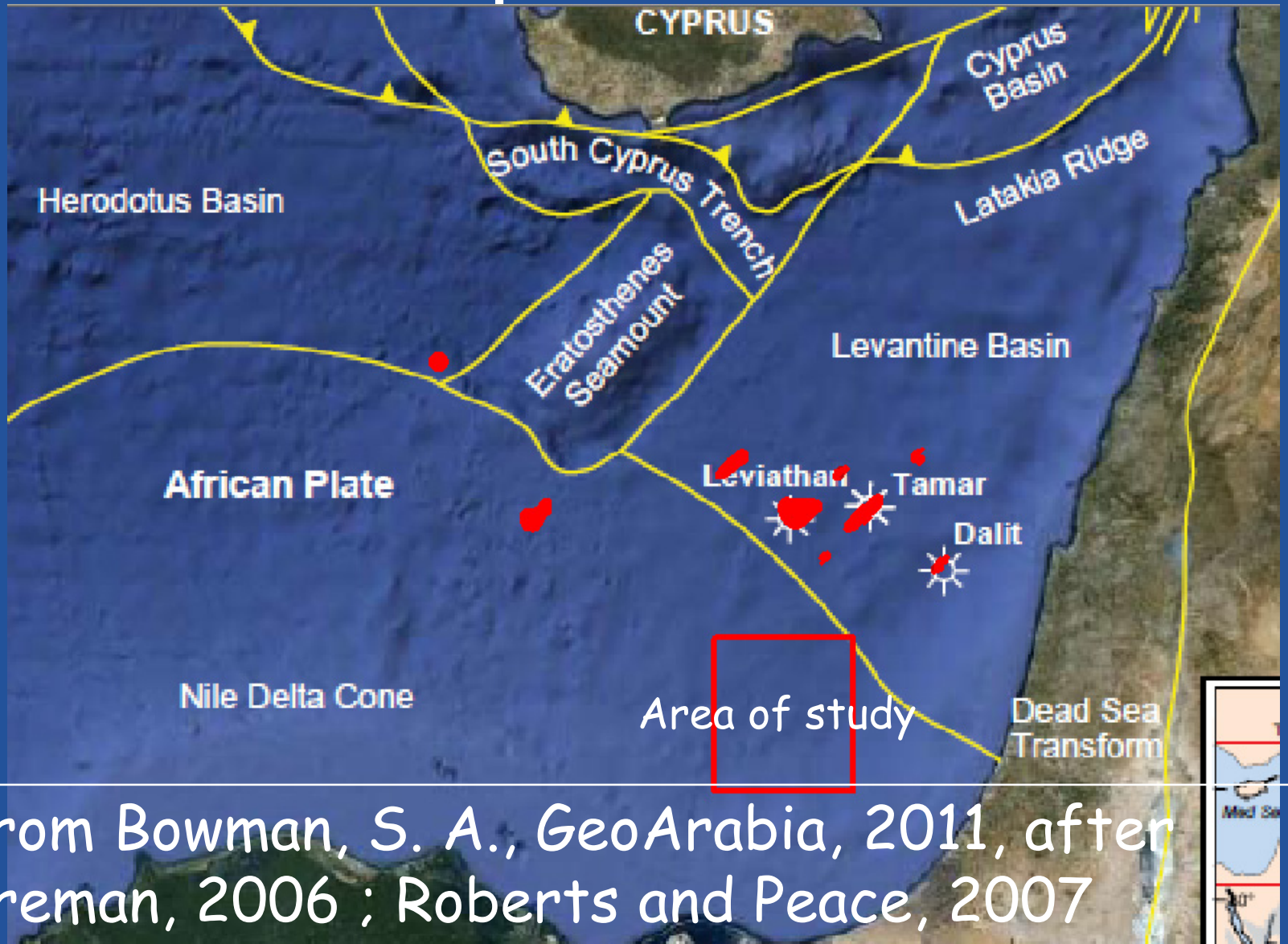
Source: Wood Mackenzie, Eastern Mediterranean, 2016



1. Introduction
2. Structural Background
3. Dakar anticline
   - Structure
   - Stratigraphy
4. Tectonic implications
5. Conclusions

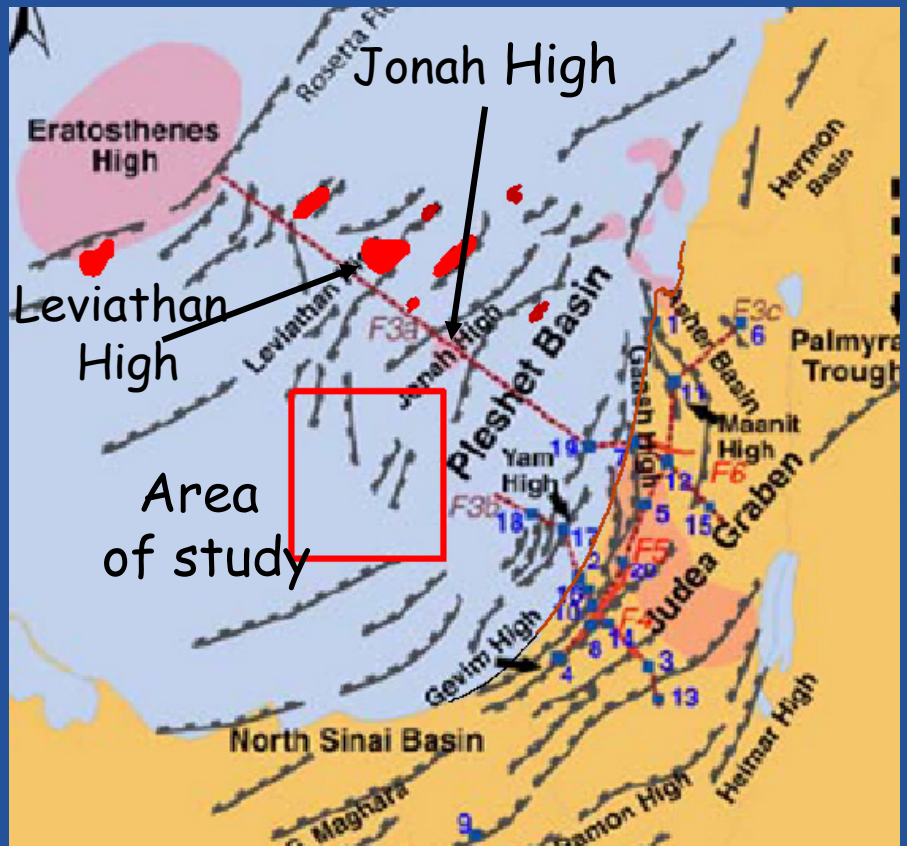
Area of study

Tectonic plates and basins



From Bowman, S. A., GeoArabia, 2011, after Breman, 2006 ; Roberts and Peace, 2007

Widely agreed structural style in Early Mesozoic



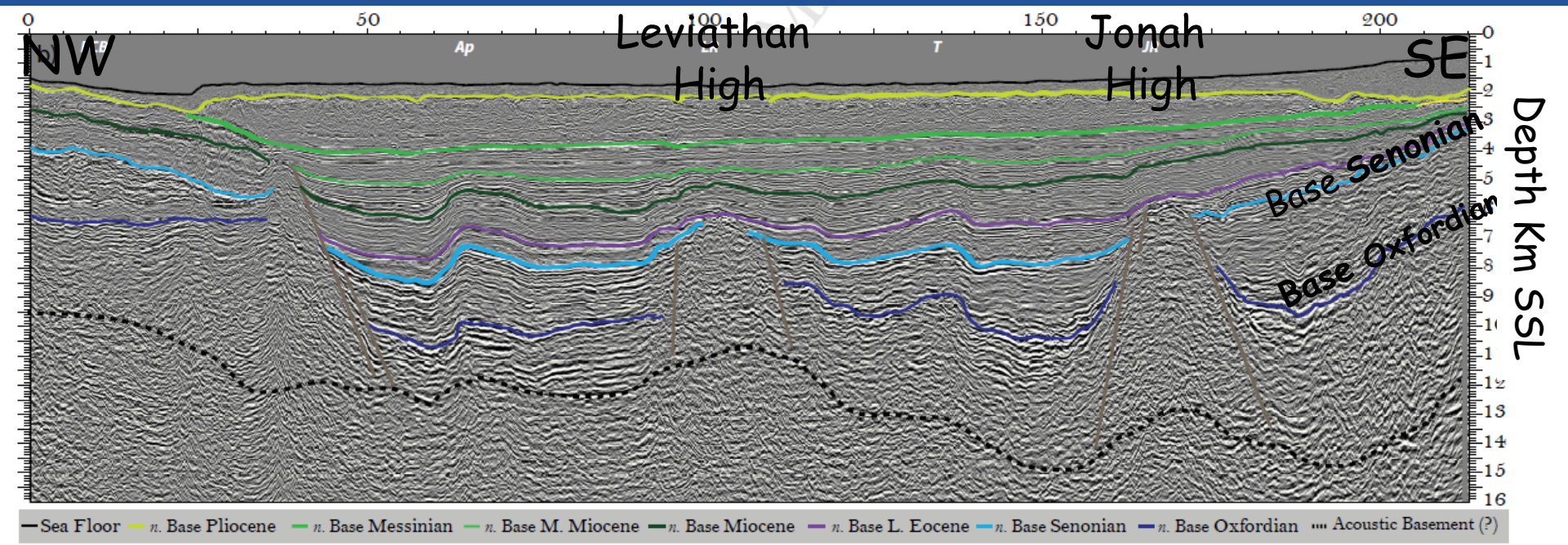
Extensional regime associated with rifting phases and opening of the Neo Tethys.

Pattern of extensional horsts and grabens.

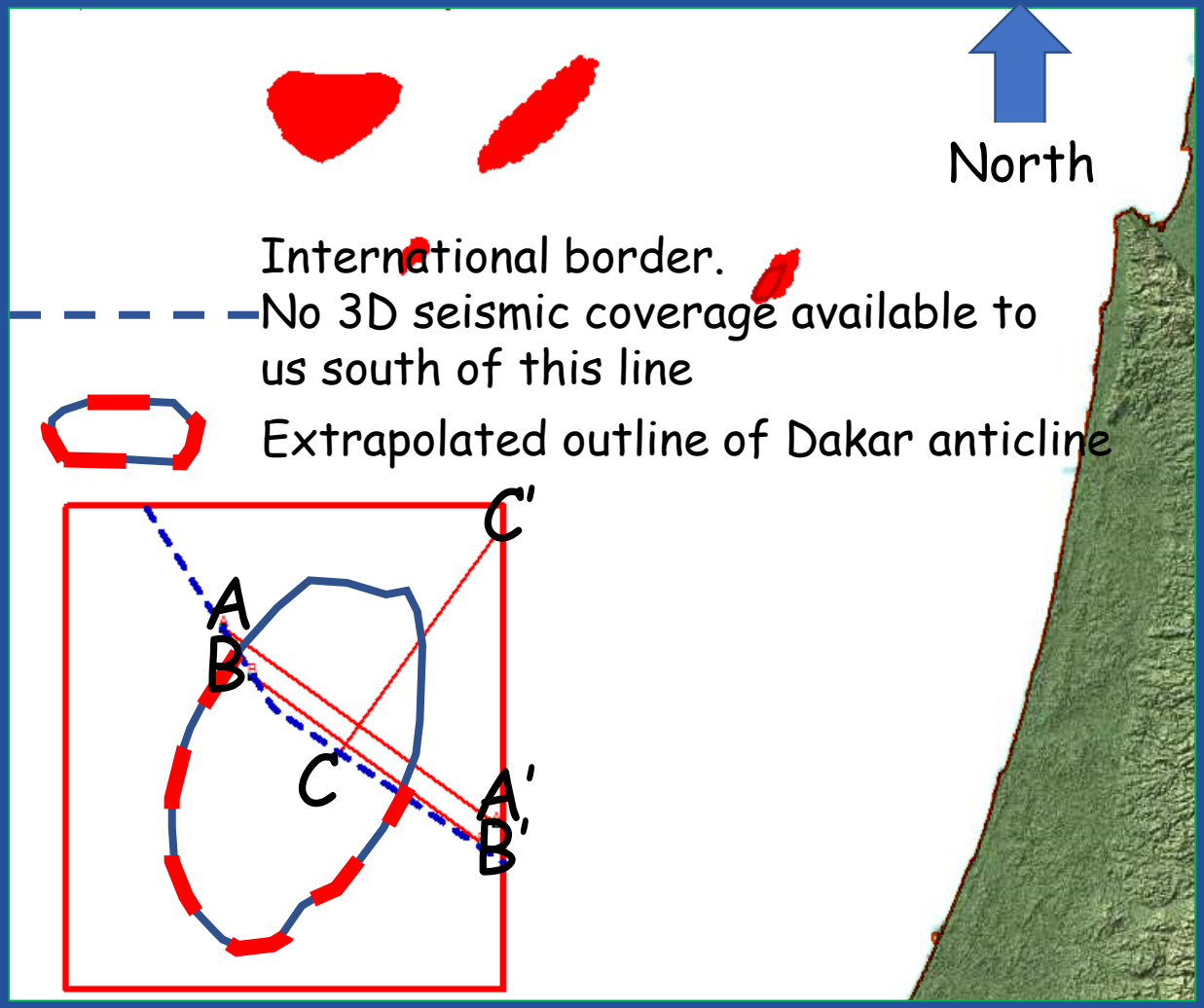
The Tethyan rift system of the Levant. From Gardosh et. Al., Geol. Soc. Lon. Spe. Pub., 2010

Example of interpreted Early Mesozoic horsts

From Steinberg et al., Marine and Petroleum Geology, 2018

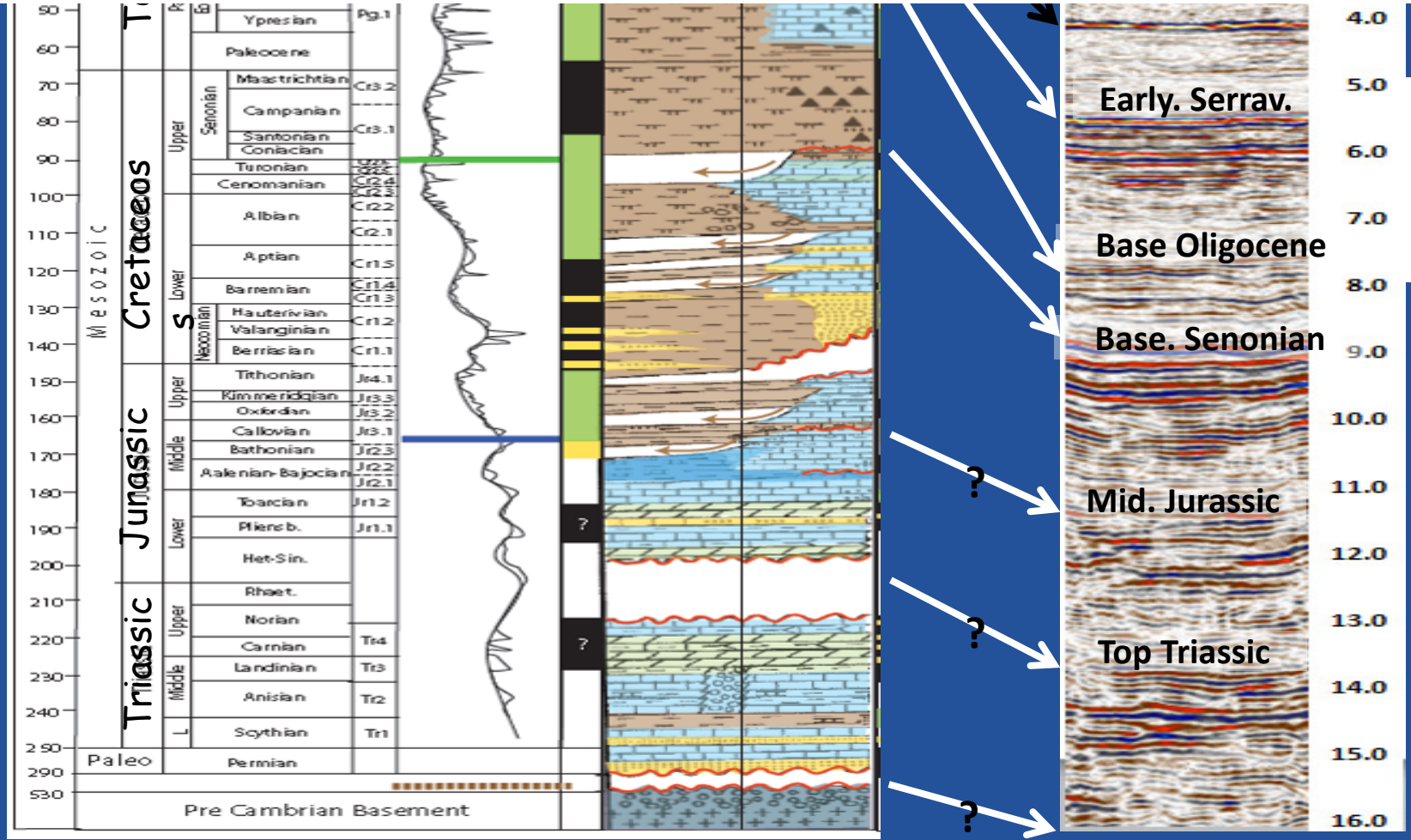


Location of Dakar anticline and exhibited seismic sections

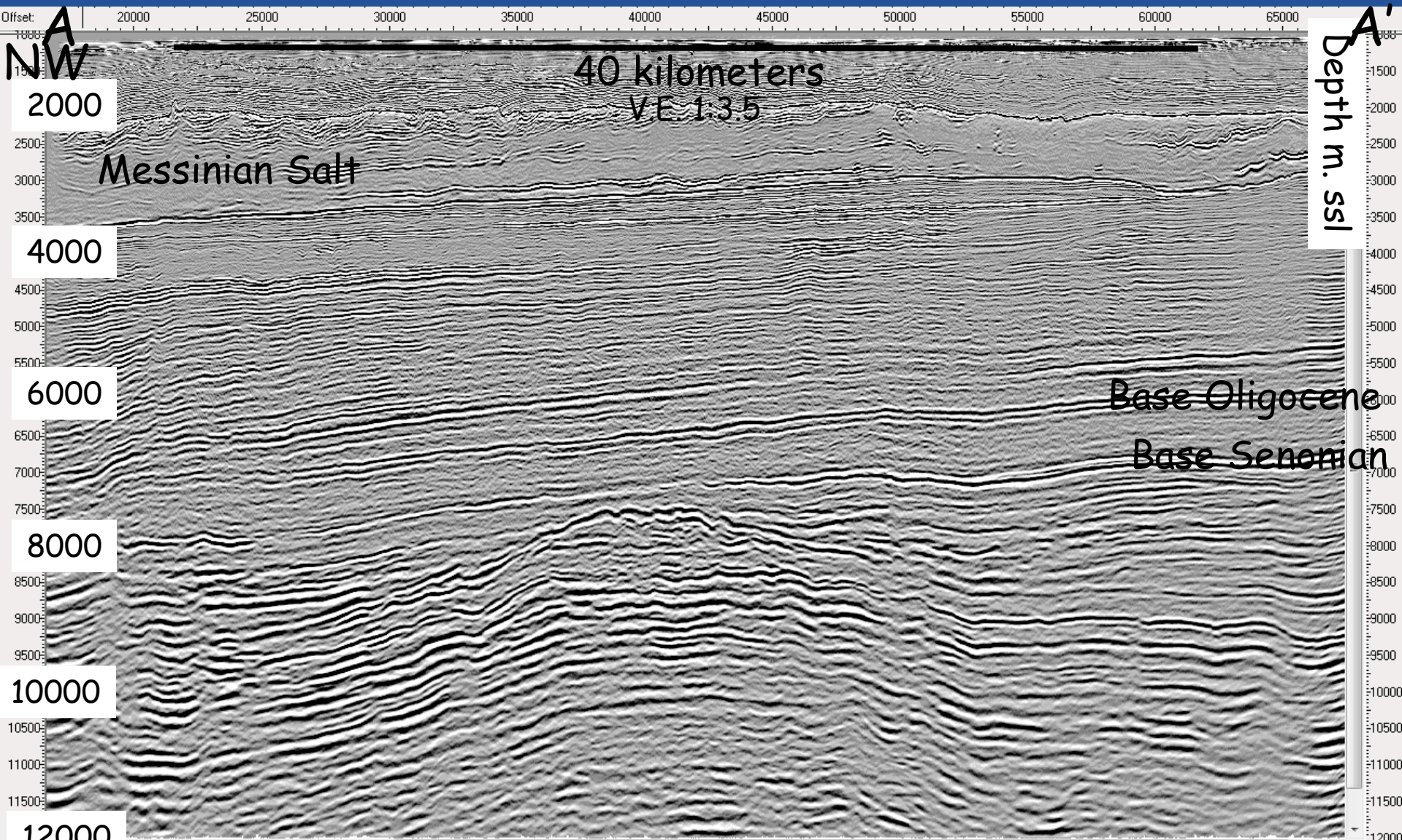


Stratigraphic column and thickness of sequences

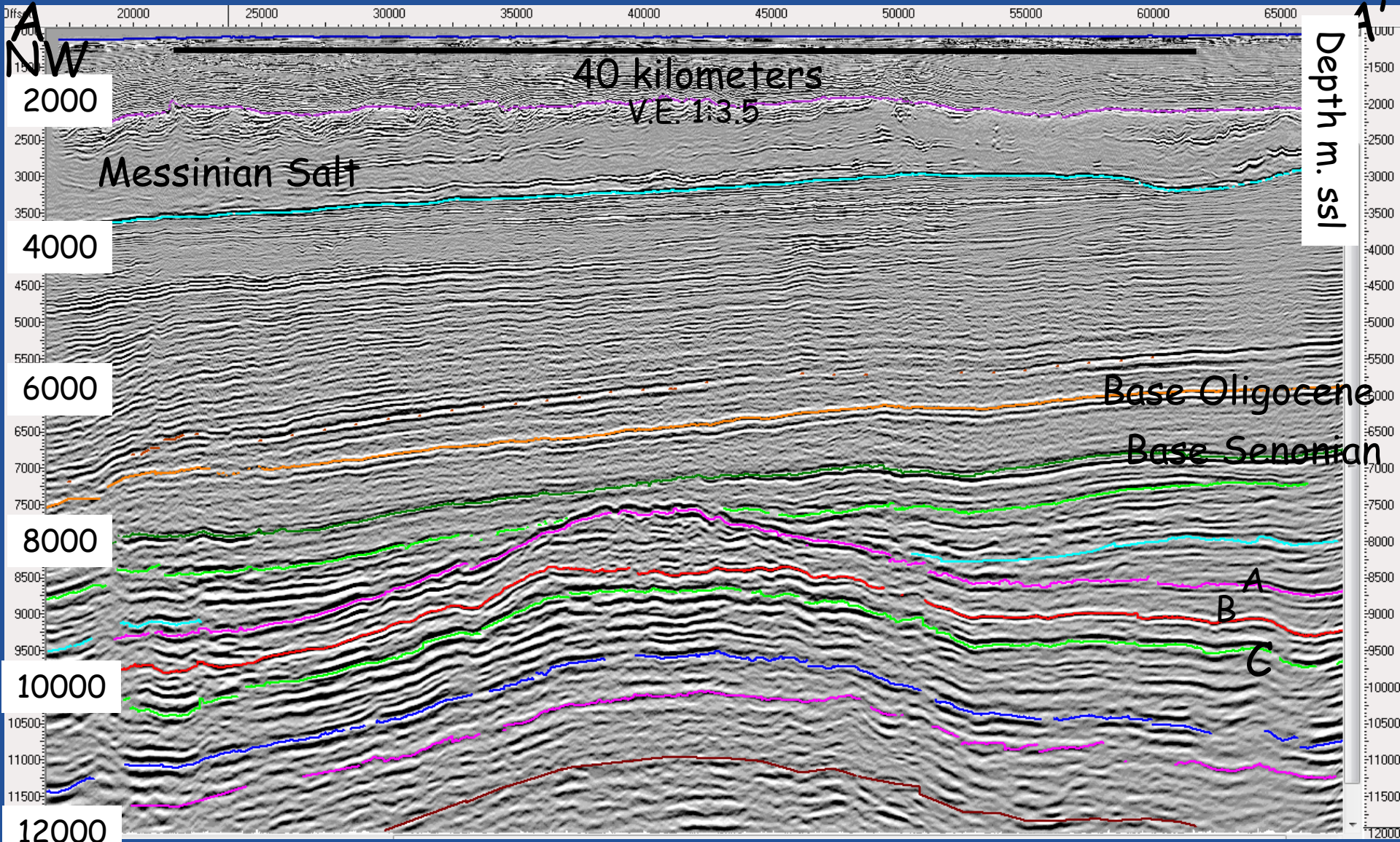
After Gardosh, M. and Lipmann, S., 2017 and Ben-Gai, Y. and Soto, J. I.,2018.



PSDM dip section A across Dakar



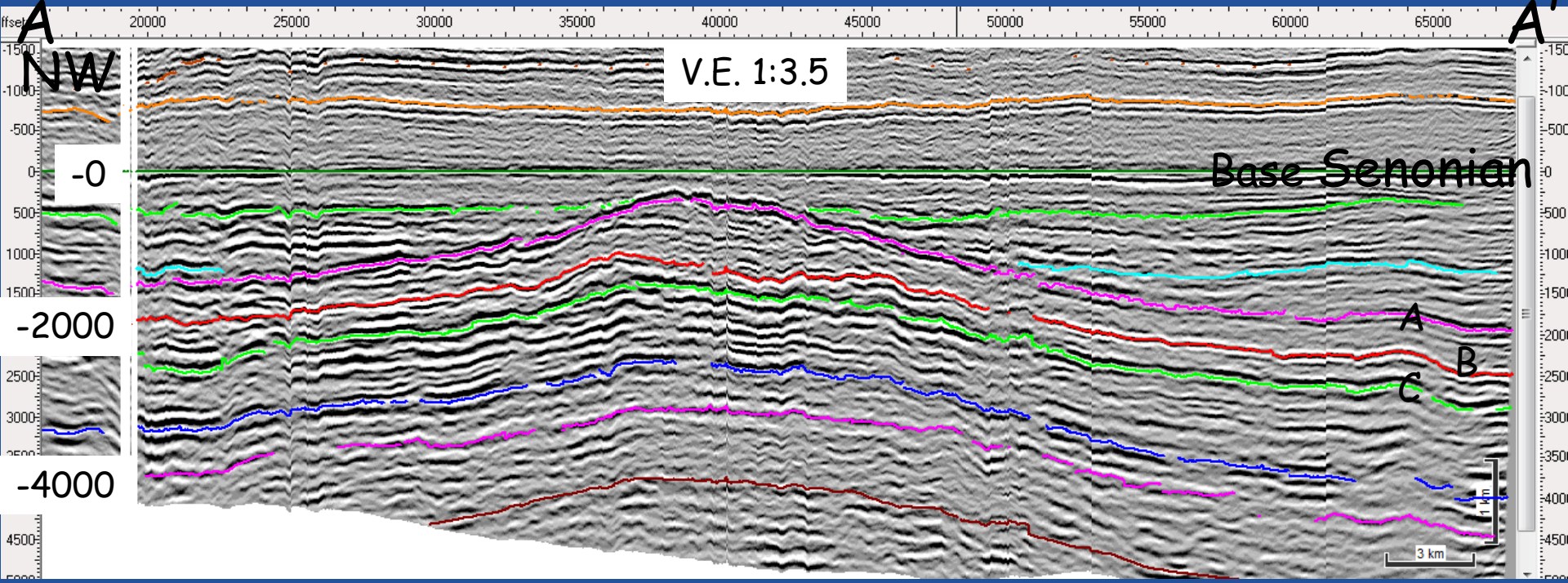
PSDM dip section A interpreted



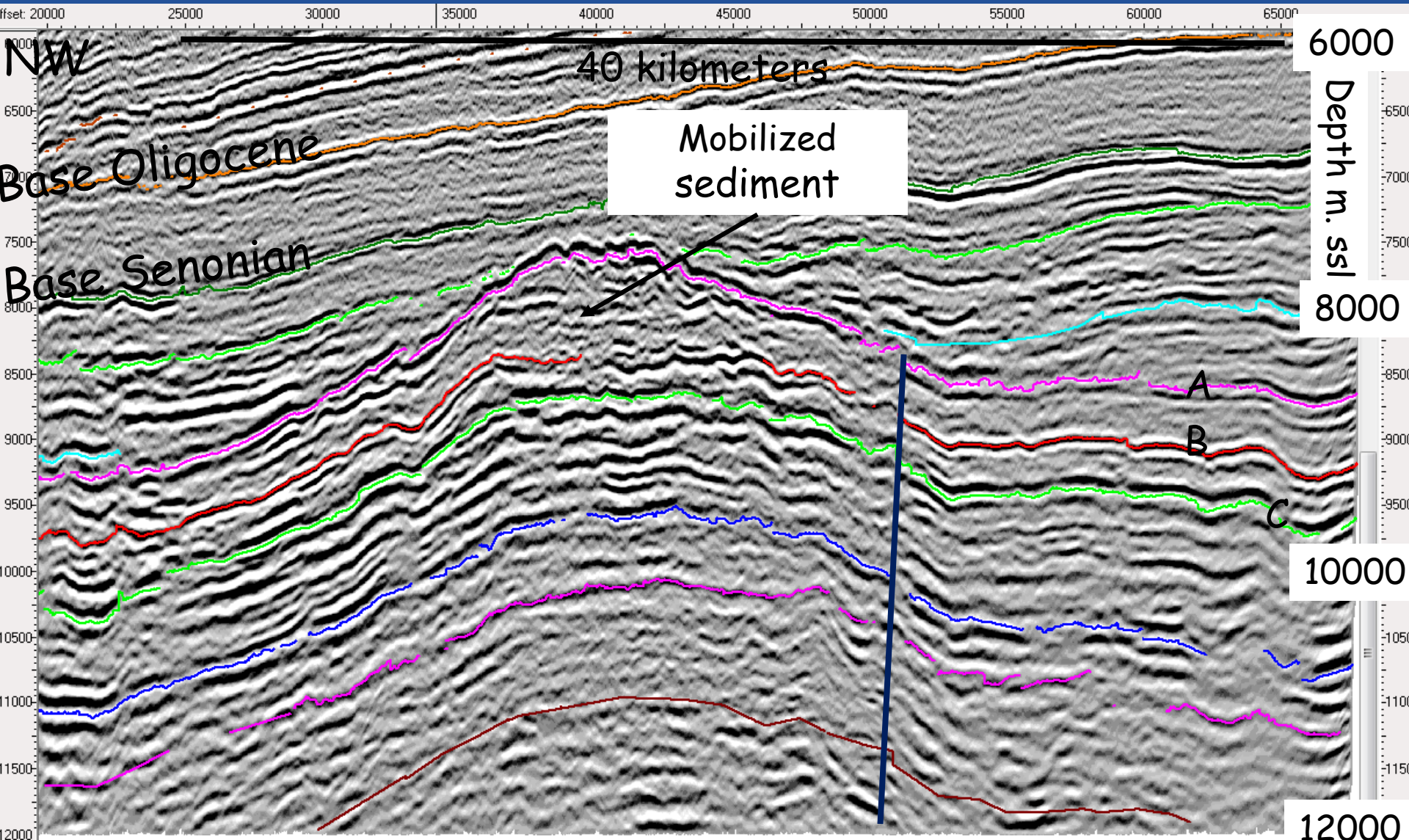
Reconstructed structure to account for Senonian and younger tectonics

PSDM section A flattened base Senonian

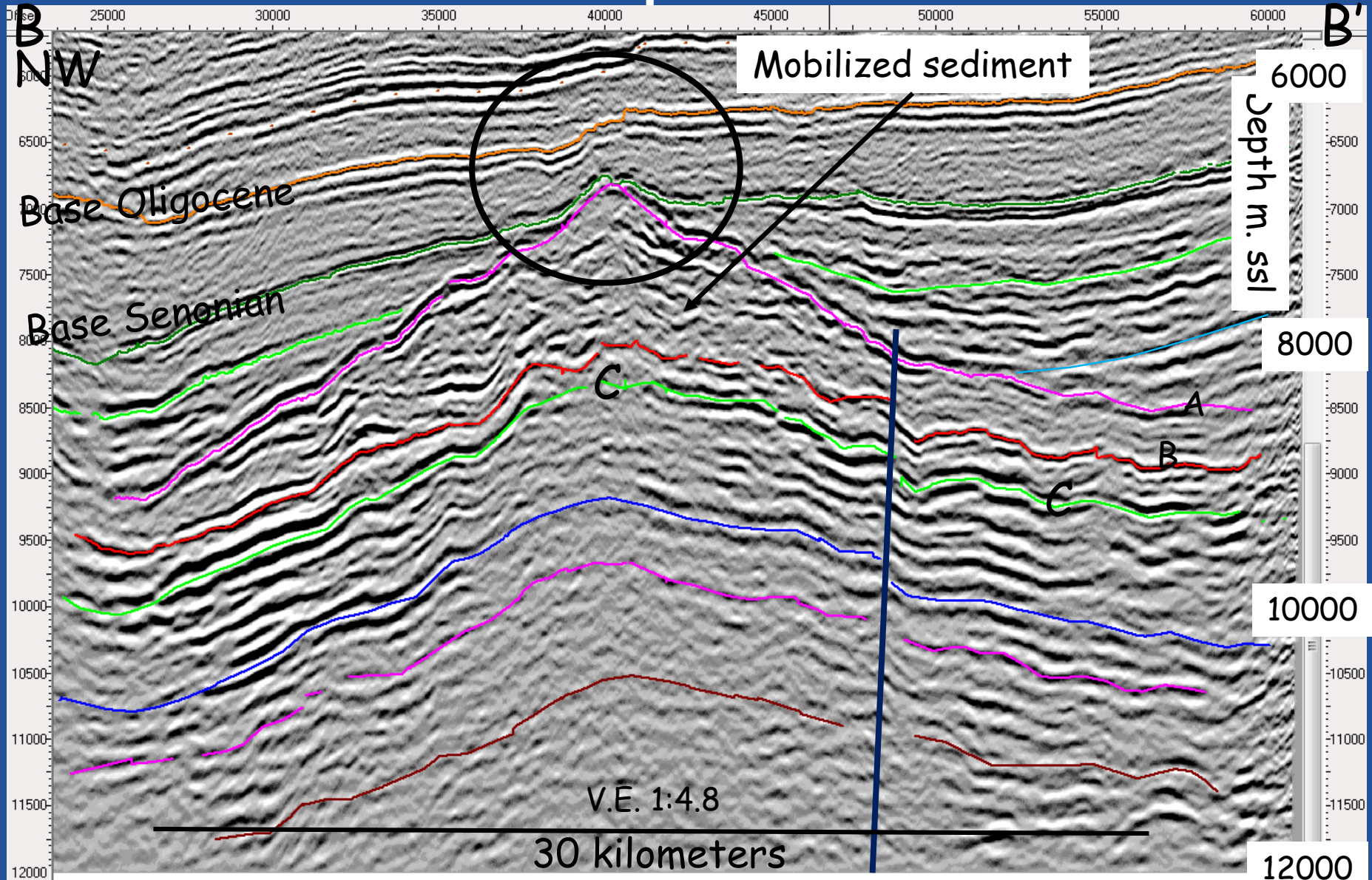
40 kilometers



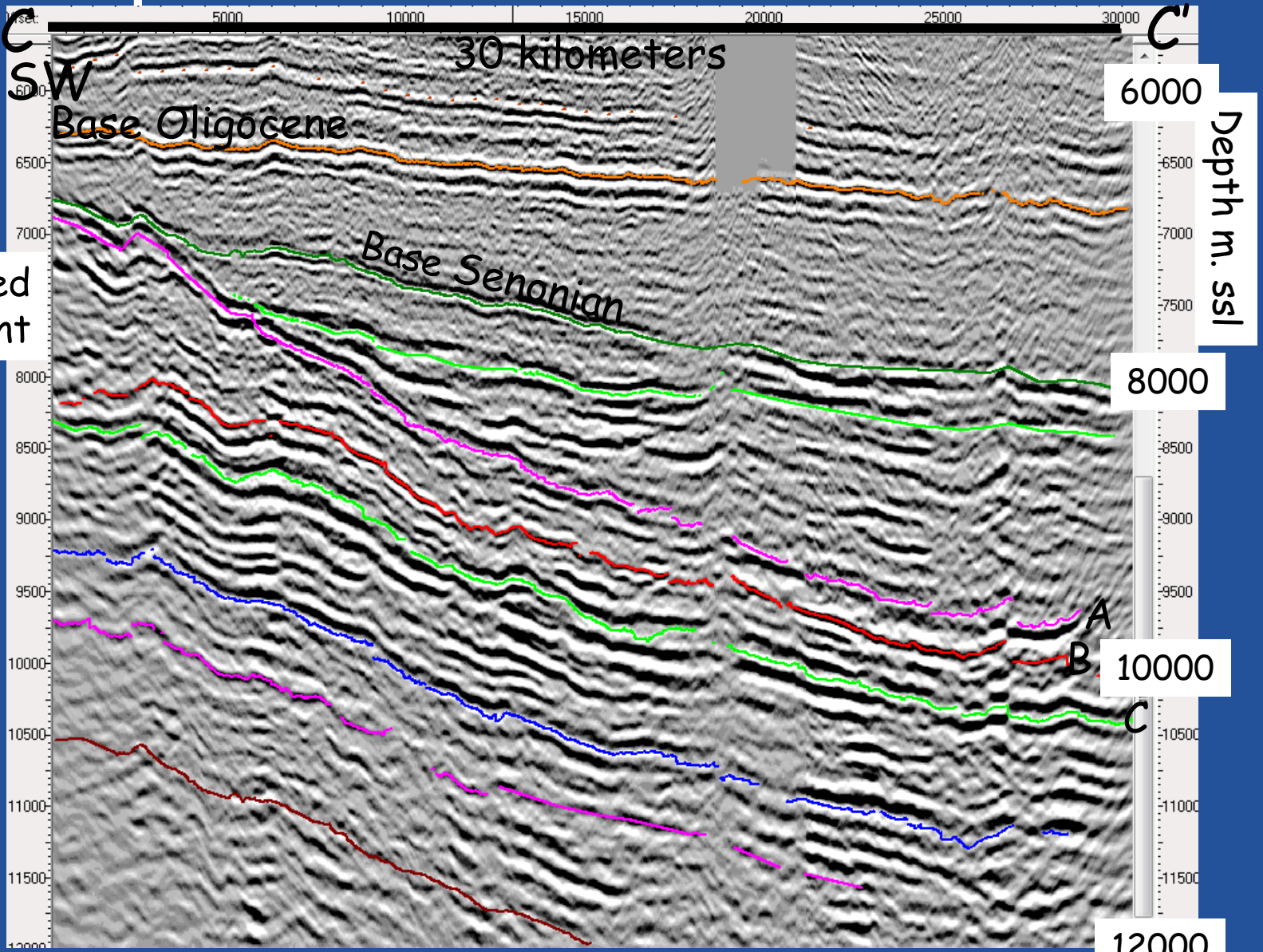
PSDM section A enlarged (V.E. 1:4.8)



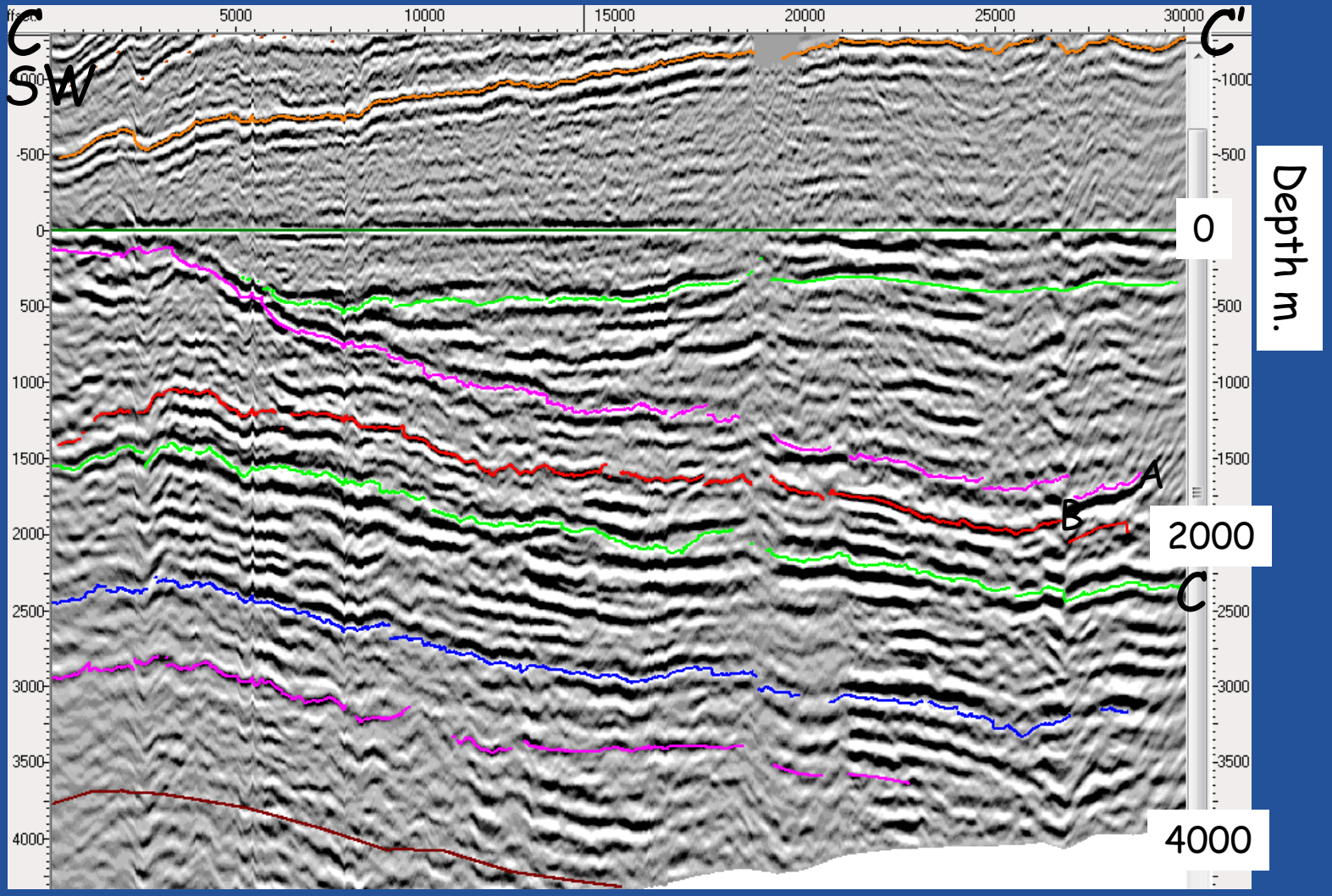
PSDM dip section B



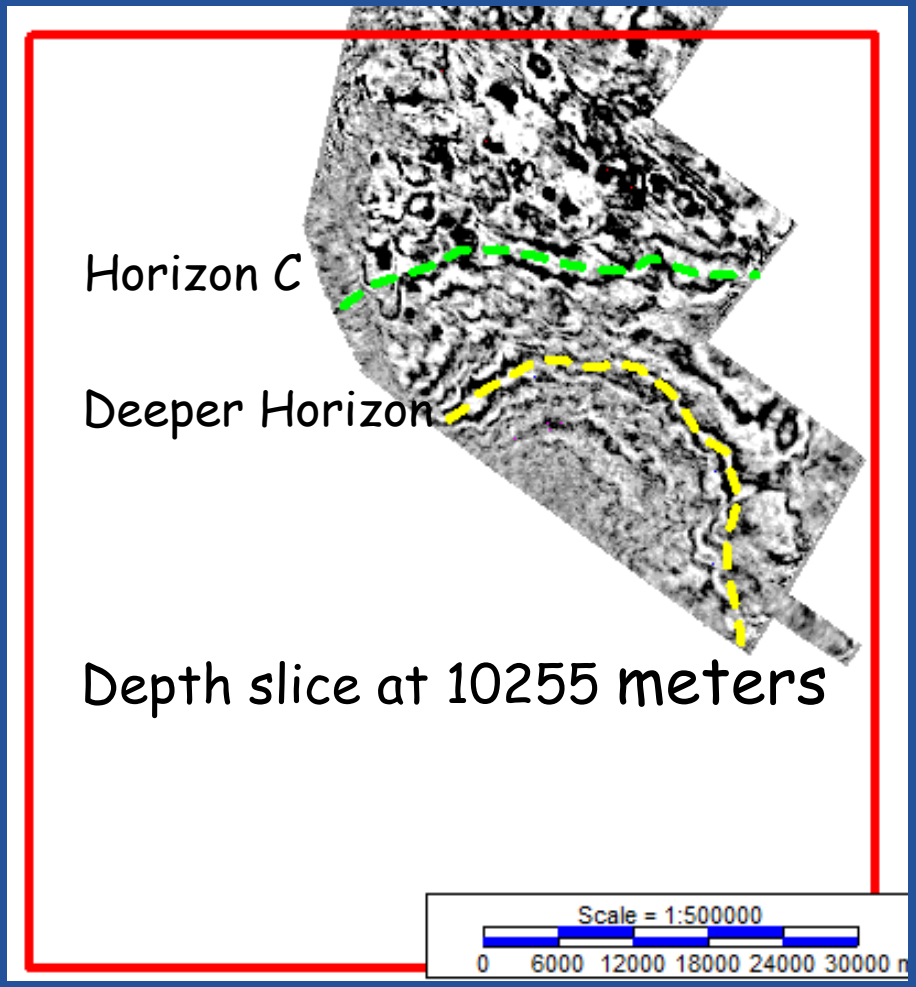
Perpendicular PSDM section C



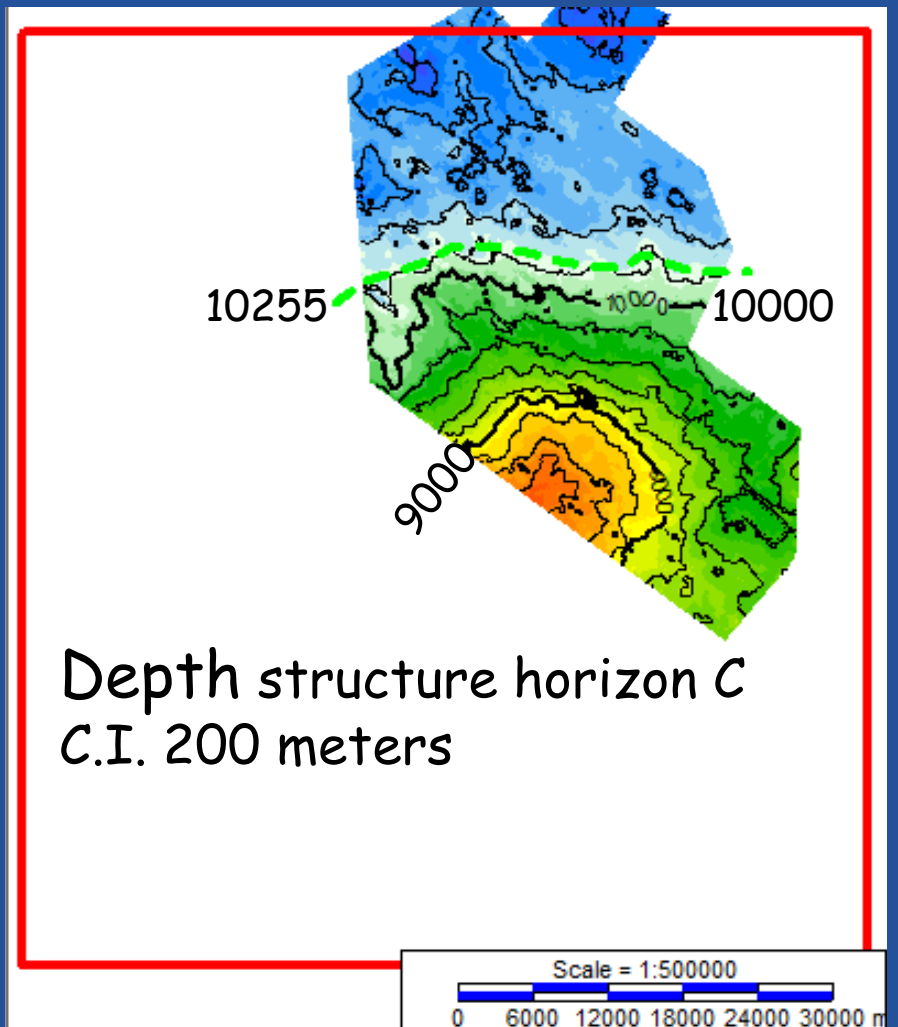
Section C flattened base Senonian



Depth structure horizon C (Triassic?) before flattening of the base-Senonian



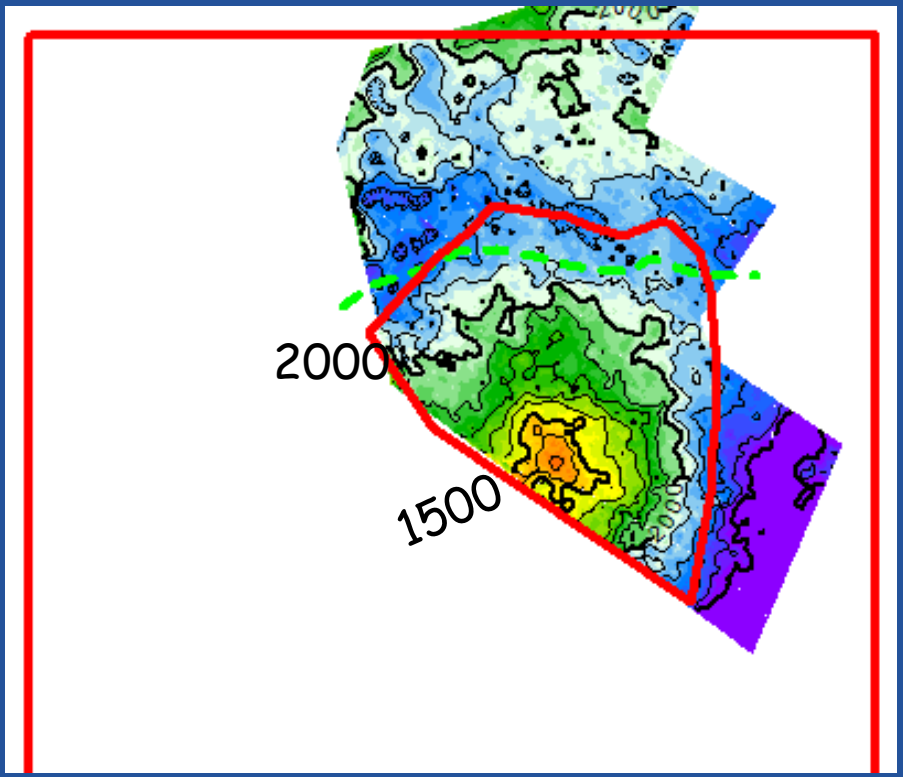
Depth slice at 10255 meters



Depth structure horizon C
C.I. 200 meters

Depth structure horizon C after flattening of the base-Senonian

Isopach map of base Senonian to horizon C
C.I. 100 meters
Closing contour ~-2200 meters below base Senonian
Structural amplitude ~ 800 meters
Area within 3D seismic coverage ~ 550 sq km

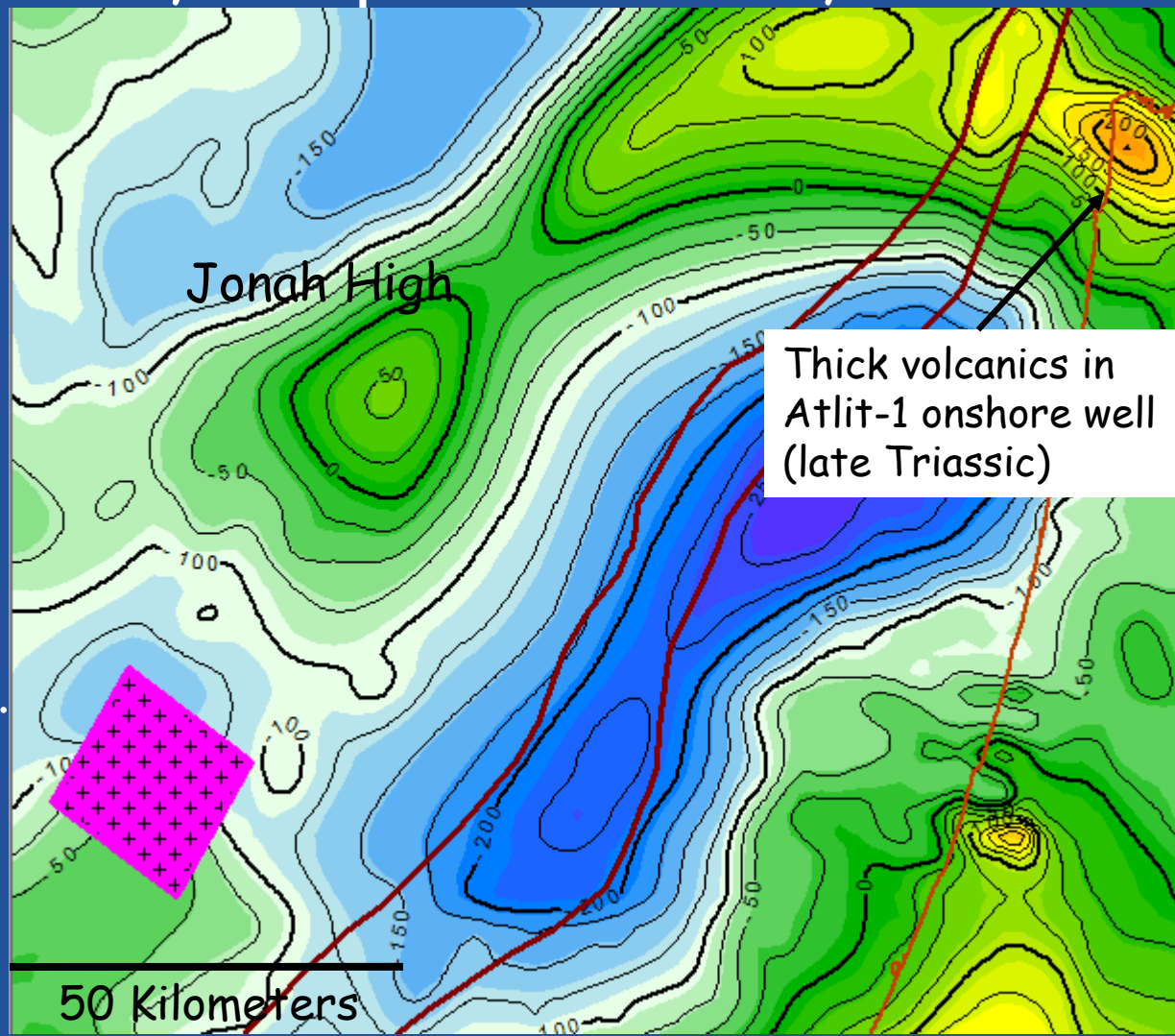


Total field magnetic anomaly map

After Rybakov et al., Geoph. Res. Lett. , 1997

Continental margin
Major down to the
west fault zone

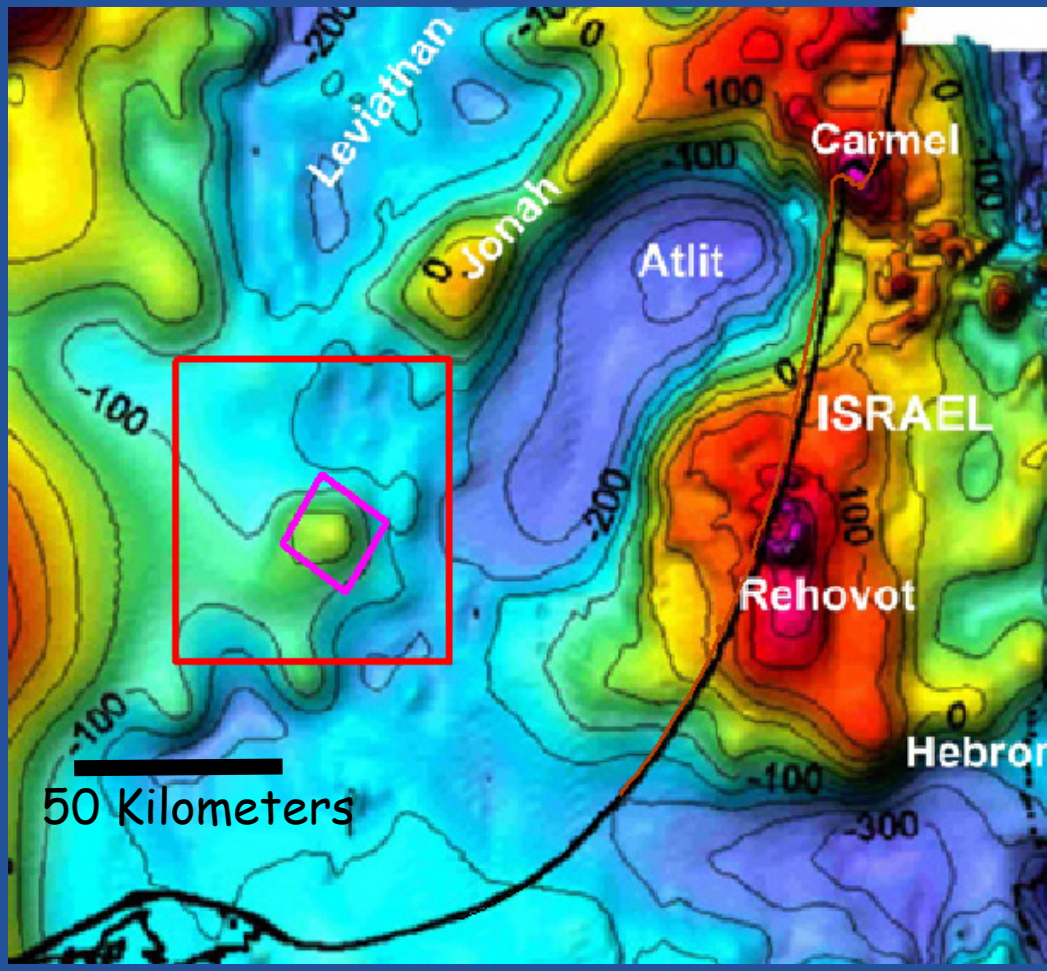
Dakar schematic outline of
interpreted causative body.
Area ~ 400 sq km
Estimated Depth to top
~ 11 kilometers SSL



Reduced To Pole (RTP) magnetic anomaly map

From Segev et al., Earth Science Reviews,2018

Dakar schematic outline of interpreted causative body.
Area ~ 400 sq km
Estimated Depth to top
~ 11 kilometers SSL

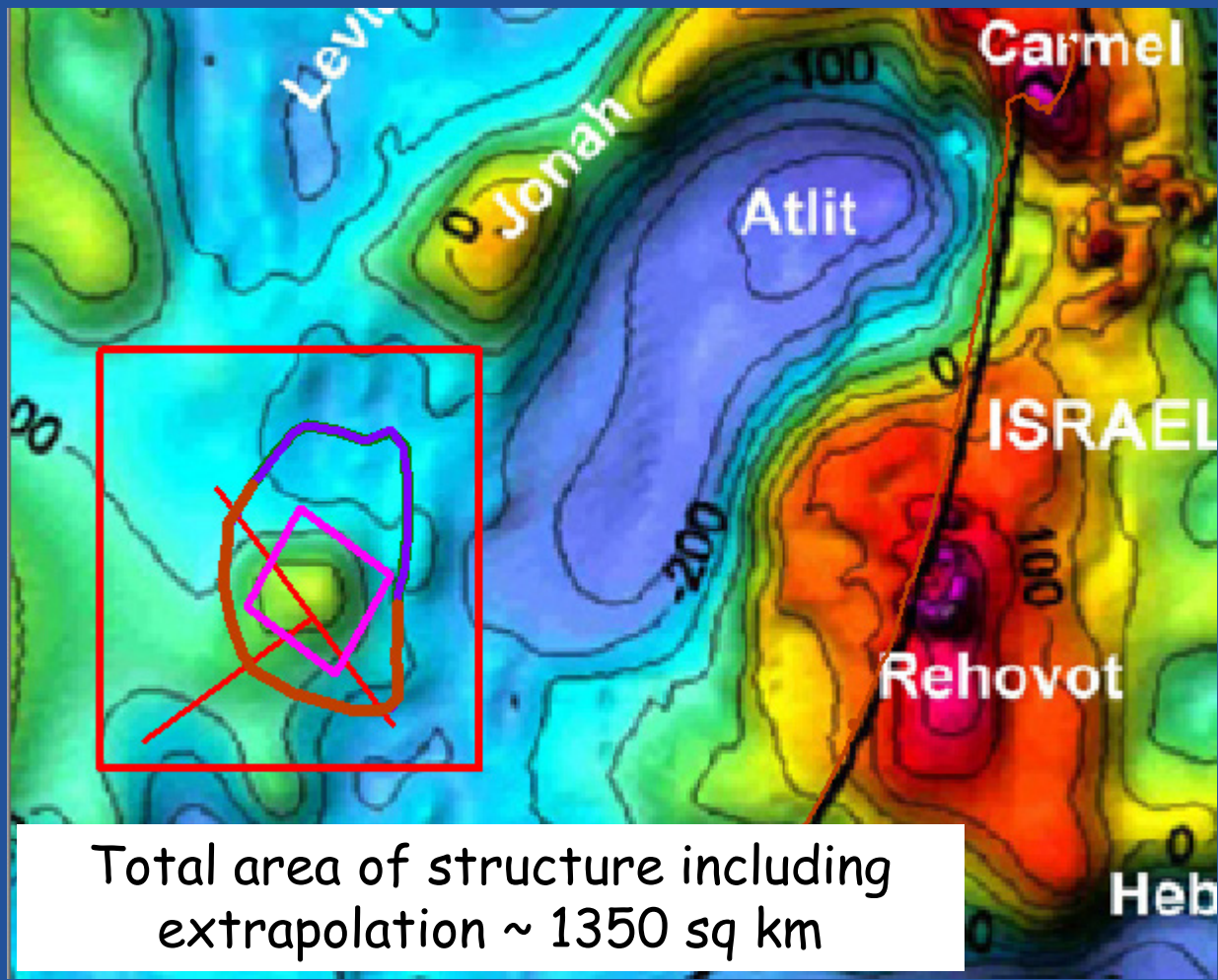


Use RTP magnetics and 2 seismic control lines to suggest southward extrapolation of Dakar, beyond available 3D seismic data set

Seismic control line

Reconstructed

Extrapolated



Total area of structure including extrapolation ~ 1350 sq km

Dakar structural style: horizontal compression or vertical movement?

Observed structural characteristics:

- Basement involved structure
- Large size
- Isolated occurrence
- Lack of significant fault control
- Lack of distinct trend patterns
- Semi-circular shape

Structural characteristics differentiating basement warps from other basement involved folds

From Lowell J.D., 1985, Structural Styles in Petroleum Exploration. OGCI

- Solitary occurrence
- Inconsistent orientation
- Lack of distinct trend patterns
- General lack of dependency on faulting for their development

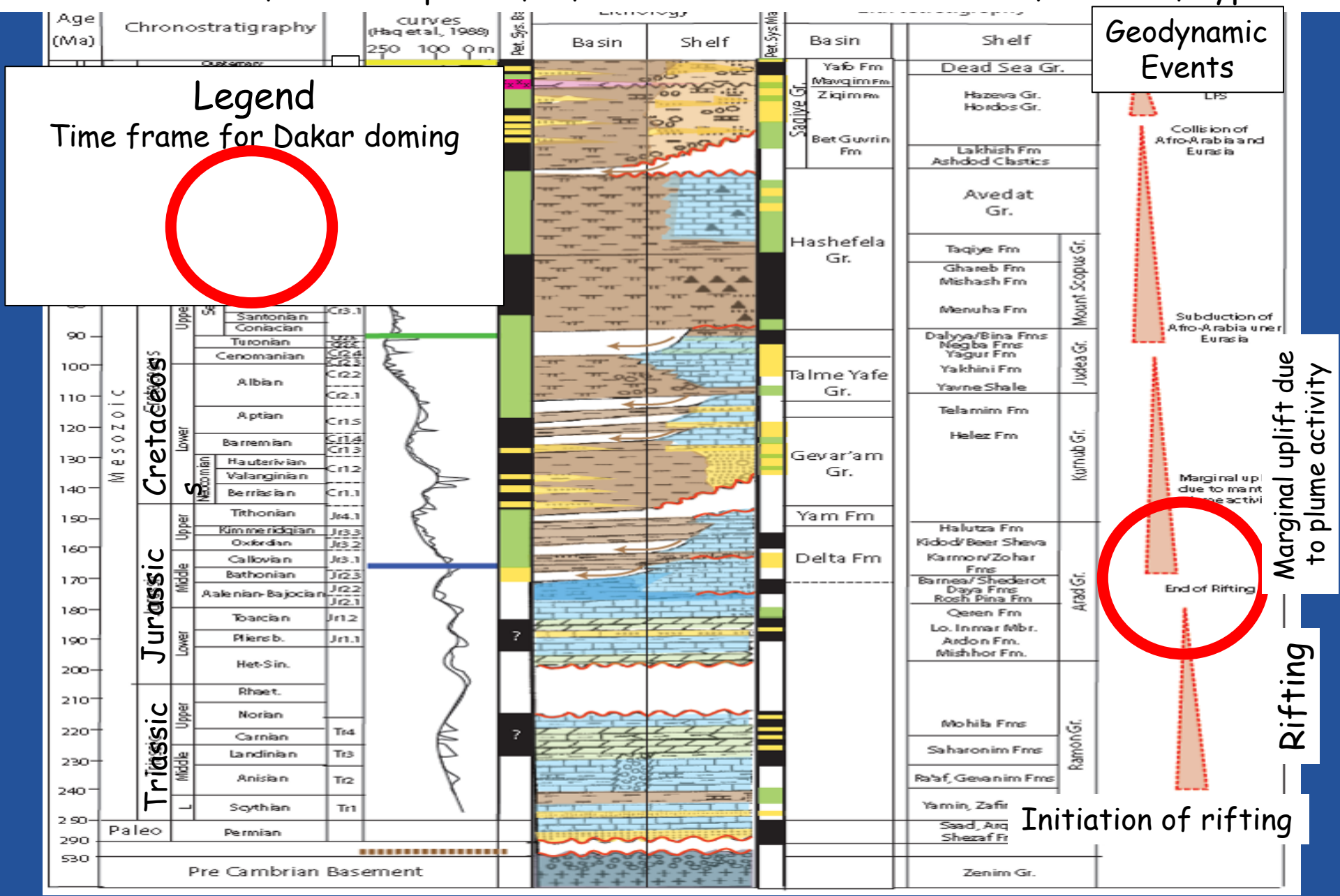
In accordance with Lowell's (1985) criteria Dakar is considered a basement involved dome, where "dominant deformation forces of sub-vertical uplift are deep seated processes (thermal events, flowage)"

Age of Dakar doming

2000+ meters of onlapping pre Senonian sediments indicate early to mid Jurassic age of doming

Stratigraphic column and geodynamic events

After Gardosh, M. and Lipmann, S., 2017. AAPG ERC Conference, Larnaca, Cyprus.



Tectonic implication

Revision is required to the story of early Mesozoic tectonic evolution of the Levant basin, with a previously unreported significant folding phase activity in the Jurassic

Conclusions

- Dakar fold is a unique deeply buried giant dome. It is a newly discovered elephant, presenting a previously unreported early to mid Jurassic folding phase in the Levant basin.
- No evidence in the study area for early Mesozoic block-fault patterns (extensional horsts and/or grabens)
- The upper sequence in Dakar exhibits characteristics of a mobile sediment that forms a crestal diapir penetration into overlaying sediments
- The large Dakar dome, topped by sealing sediments highlights new potential objectives for future hydrocarbon exploration in the basin.