

The Late Tertiary Deep-Water Siliciclastic System of the Levant Margin - An Emerging Play Offshore Israel*

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Abstract

Recent gas discoveries highlight the hydrocarbon potential of the Late Tertiary section in the Levant margin, offshore Israel. The margin is a Mesozoic, Tethyan structure that was partially inverted during the Alpine orogeny. The Late Tertiary comprises 2-6 km thick, deepwater mud-dominated sedimentary section that contains a significant amount of sand. Seismic mapping reveals an extensive, vertically stacked drainage system composed of deeply incised submarine canyons and valleys that extend up to 100 kilometers west of the Mediterranean coastline. This regional drainage system acted as a fairway for submarine gravity flows and transported sands from the continental shelf in the east to the slope and deep-marine basin in the west.

A series of wells drilled during the early 2000's discovered gas in turbidite sands and mounded sand complexes of Pliocene age, at the mouth of the Afiq Canyon, in the southern part of the margin. Recent well results confirmed the existence of large quantities of gas in Lower Miocene sands, trapped in 'Syrian Arc' type folds at the northern part of the margin. 3D seismic data shows various types of submarine channels and lobes on the Oligocene and Miocene slopes that were not yet tested by drilling. Proven gas reserves in the Late Tertiary section of the Levant margin amount to 9 Tcf. We estimate high potential for hydrocarbon discoveries in this emerging province, offshore Israel.

References

Frey Martinez, J., J. Cartwright, B. Hall, and M. Huuse, 2007, Clastic intrusion at the base of deep-water sands: A trap-forming mechanism in the Eastern Mediterranean, *in* A. Hurst and J. Cartwright (editors), Sand Injectites: implications for hydrocarbon exploration and production: AAPG Memoir 87, p. 49-63.

Gardosh, M., Y. Druckman, B. Buchbinder, and M. Rybakov, 2008a, The Levant Basin Offshore Israel: stratigraphy, structure, tectonic evolution and implications for hydrocarbon exploration (revised edition): Geological Survey of Israel Rep. GSI/4/2008, 118 p.

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The Late Tertiary deepwater siliciclastic system of the Levant margin - An emerging play offshore Israel

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Topics:

Exploration history

Geologic setting

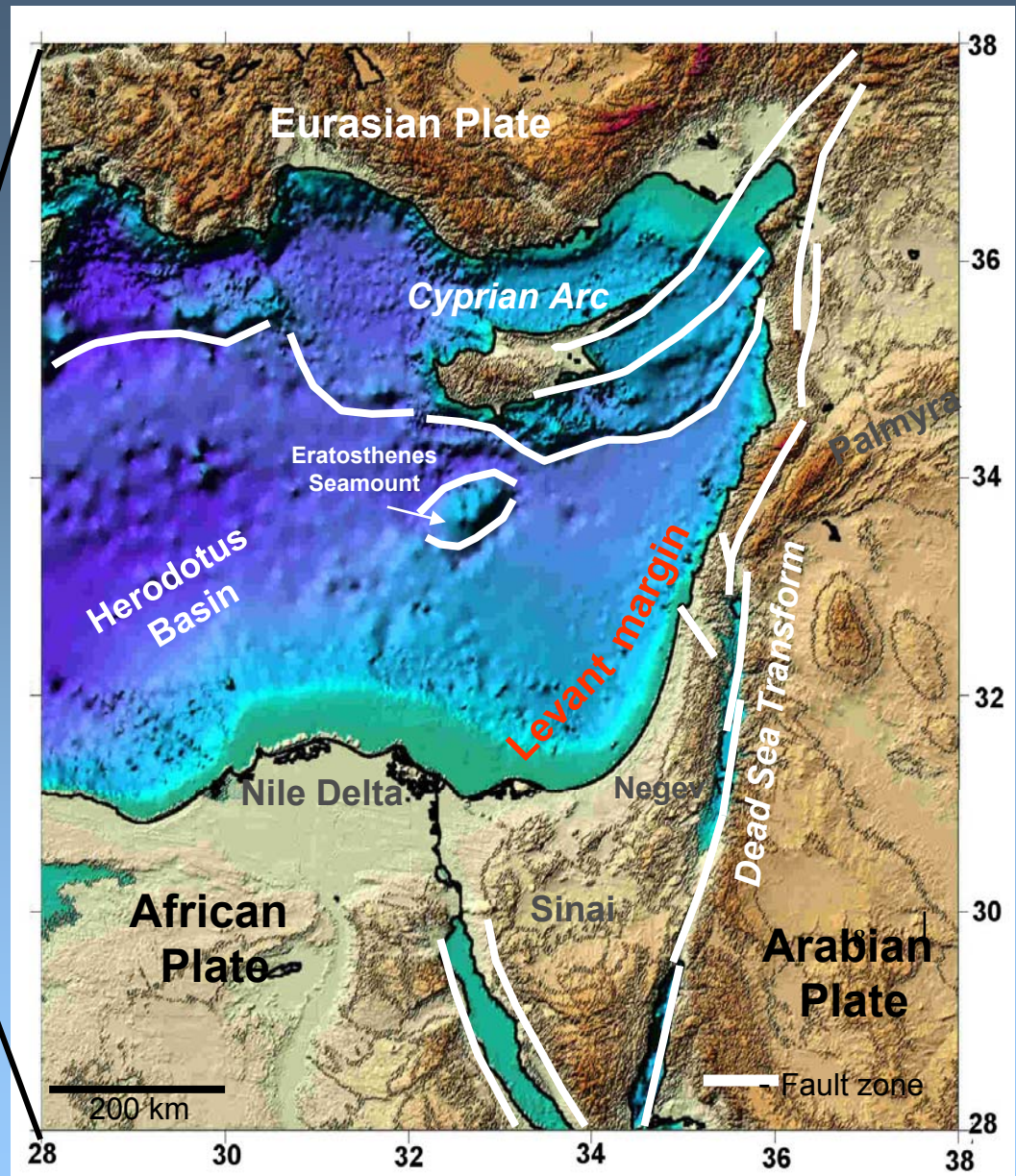
Types of plays:

Syrian Arc Folds

Deepwater Channels

Pliocene Sand Mounds

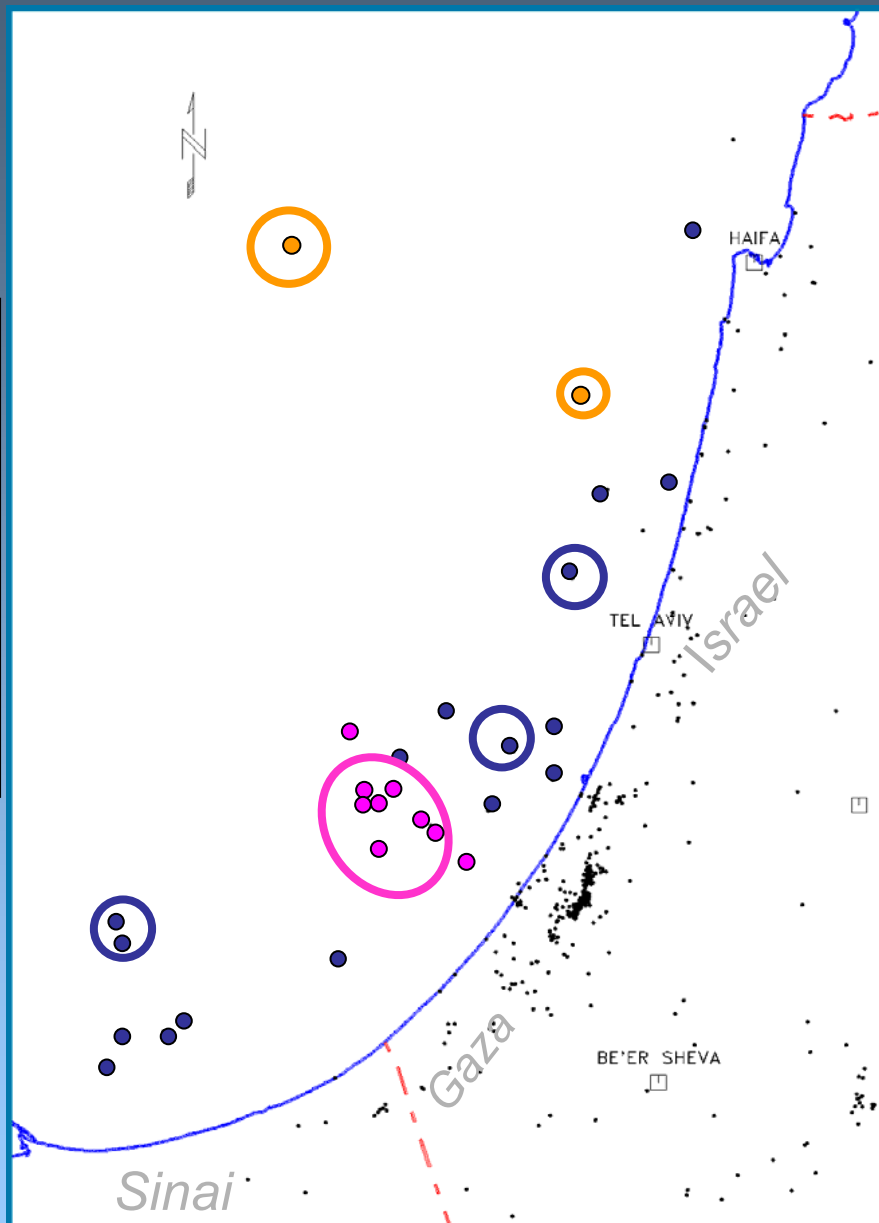
Regional Setting



Offshore exploration history

Years of Drilling

- 1969-1999
- 1999-2001
- 2002-2005
- 2008-2009



**Gas Discovered
in Lower Miocene
deepwater sands
(Proven reserves=6Tcf)**

**Gas Discovered
in Pliocene
deepwater sands
(Proven reserves= 3Tcf)**

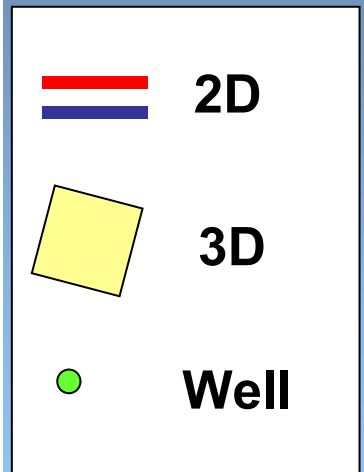
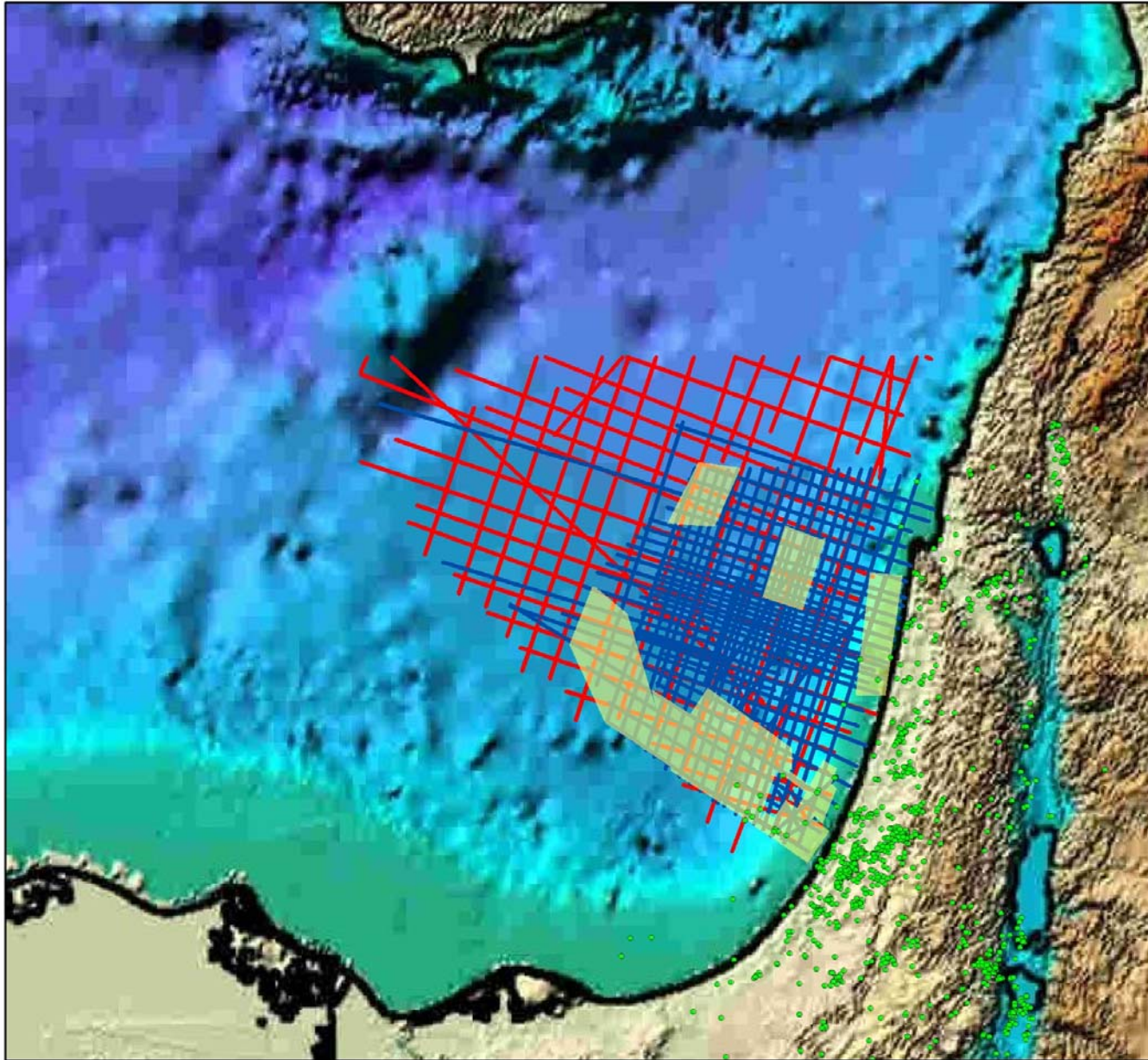
**Gas and light oil
shows in Mesozoic
reservoirs**

Presenter's Note:

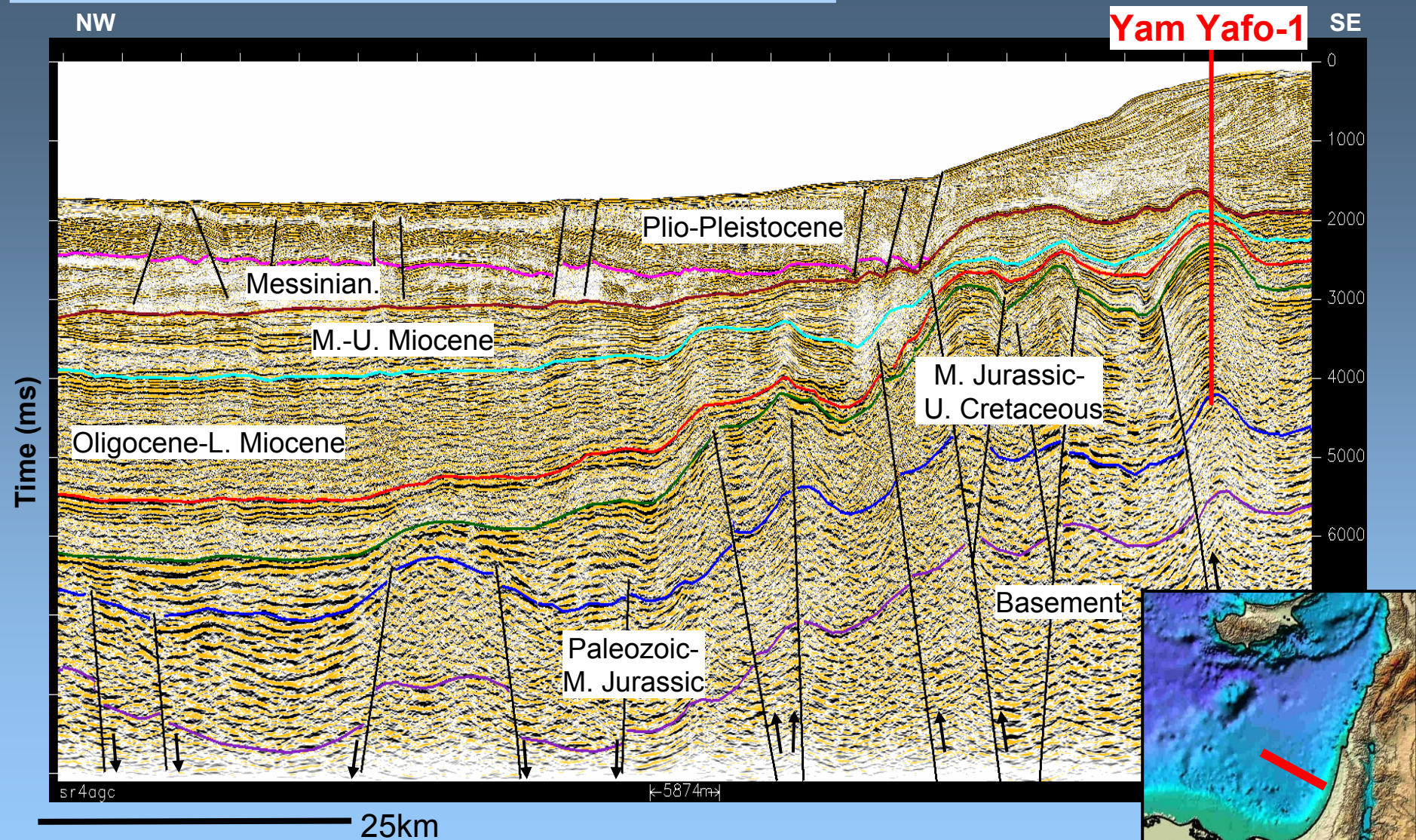
Most of the drilling activity prior to 1999 was focused on Mesozoic reservoirs in Late Cretaceous fold structures. The discovery of gas in Pliocene sands shifted the exploration efforts to the Upper Tertiary sedimentary section.

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Seismic data acquired during 2000-2001



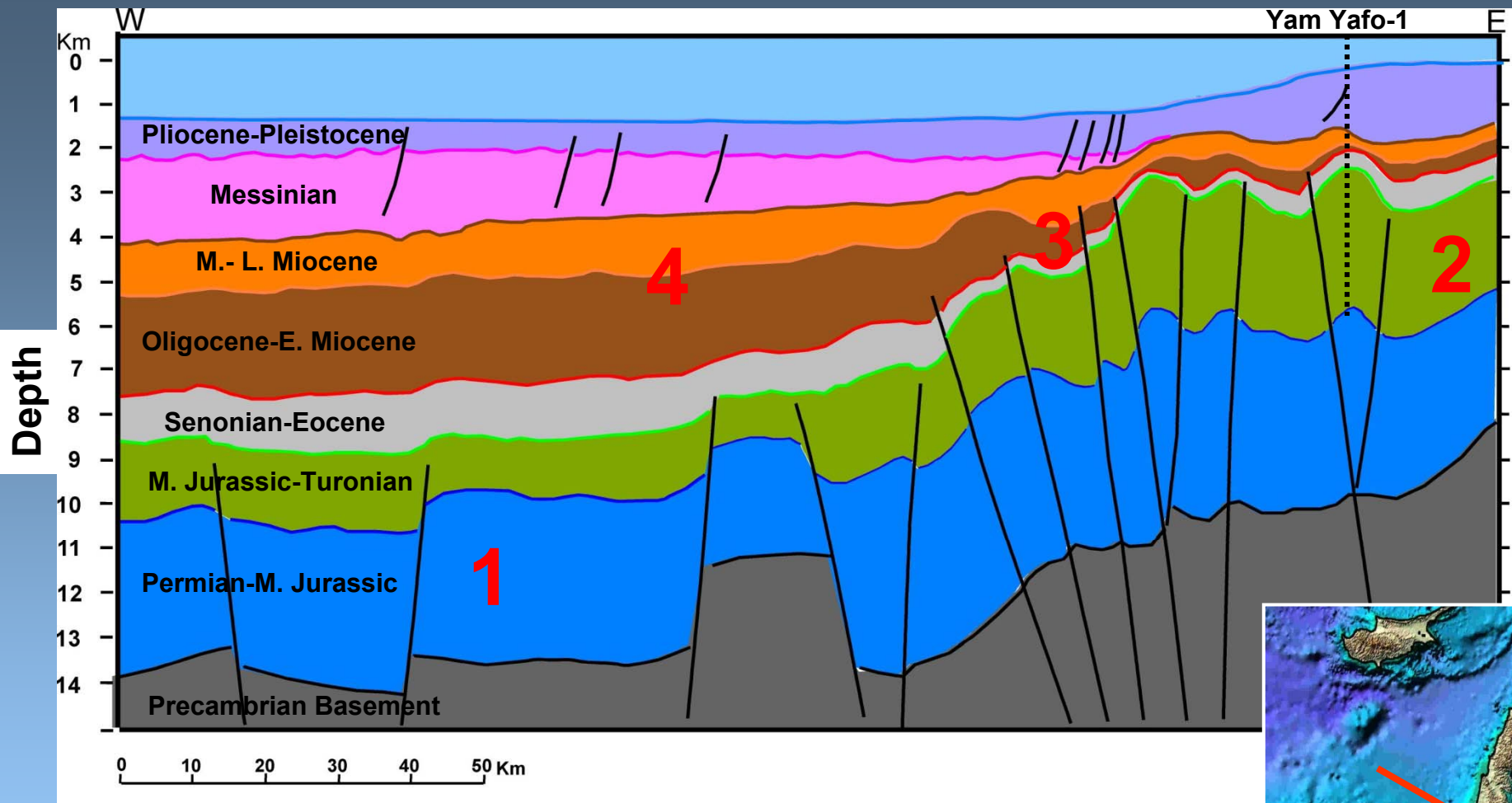
Seismic characteristics of the Levant margin



Presenter's Note:

Mesozoic strata is characterized by relatively continuous high- and low-amplitude reflection series. Upper Tertiary, discontinuous, high frequency reflections onlap the base Oligocene unconformity (red marker). Normal faults (left side of profile) are associated with Early Mesozoic rifting. Folds and reverse faults (right side of profile) reflect inversion of the older structures during a Late Cretaceous and Early Tertiary contraction phase.

Main tectonic phases



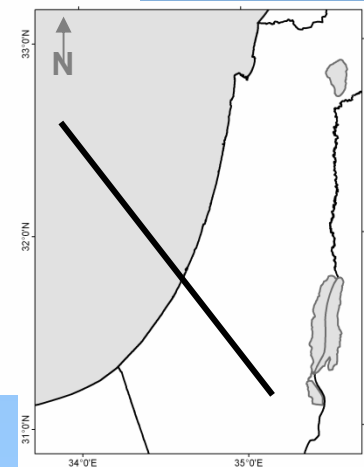
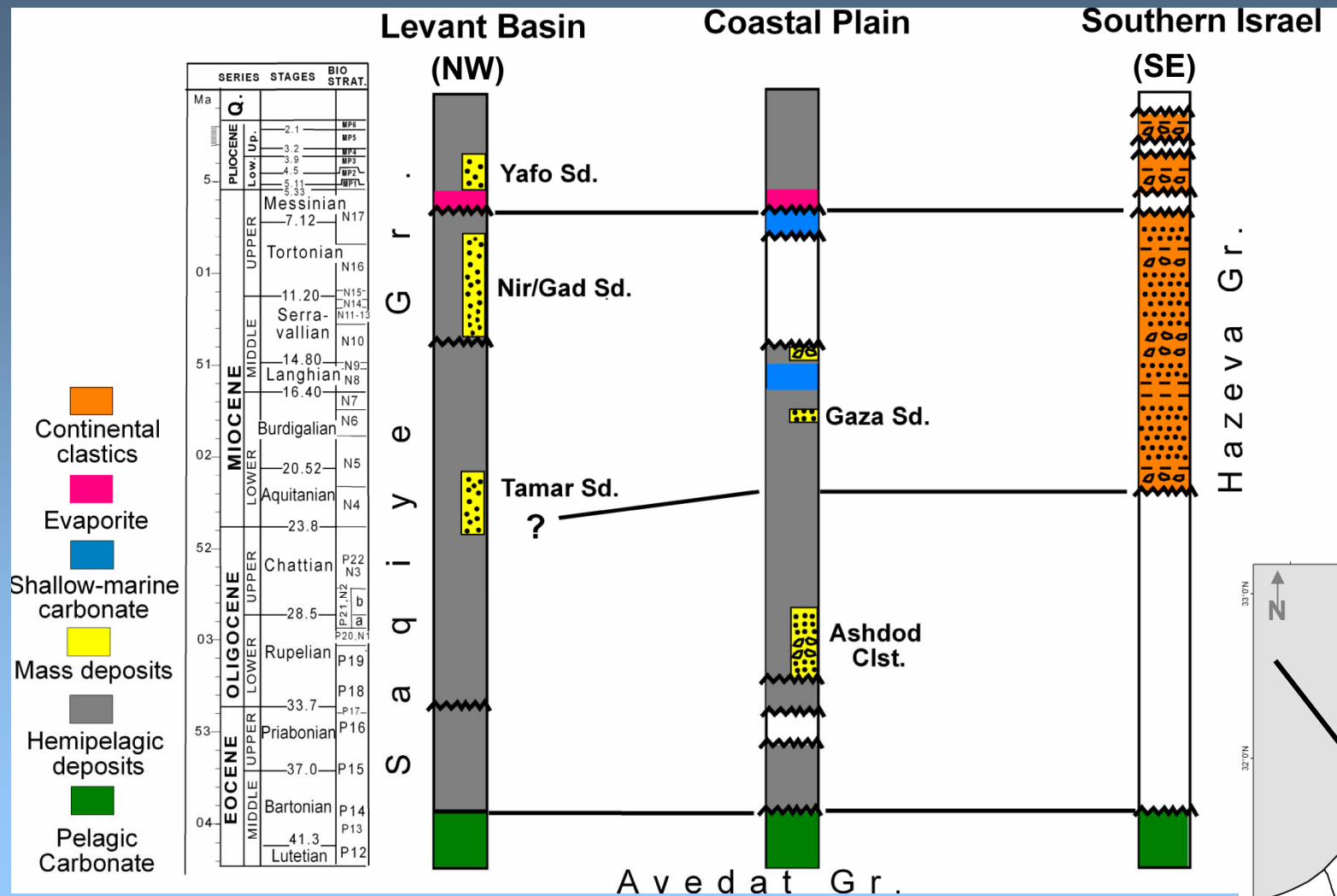
1- Tethyan Rifting

3- Syrian Arc Contraction

2- Passive Margin

4- Tertiary Basin Infill

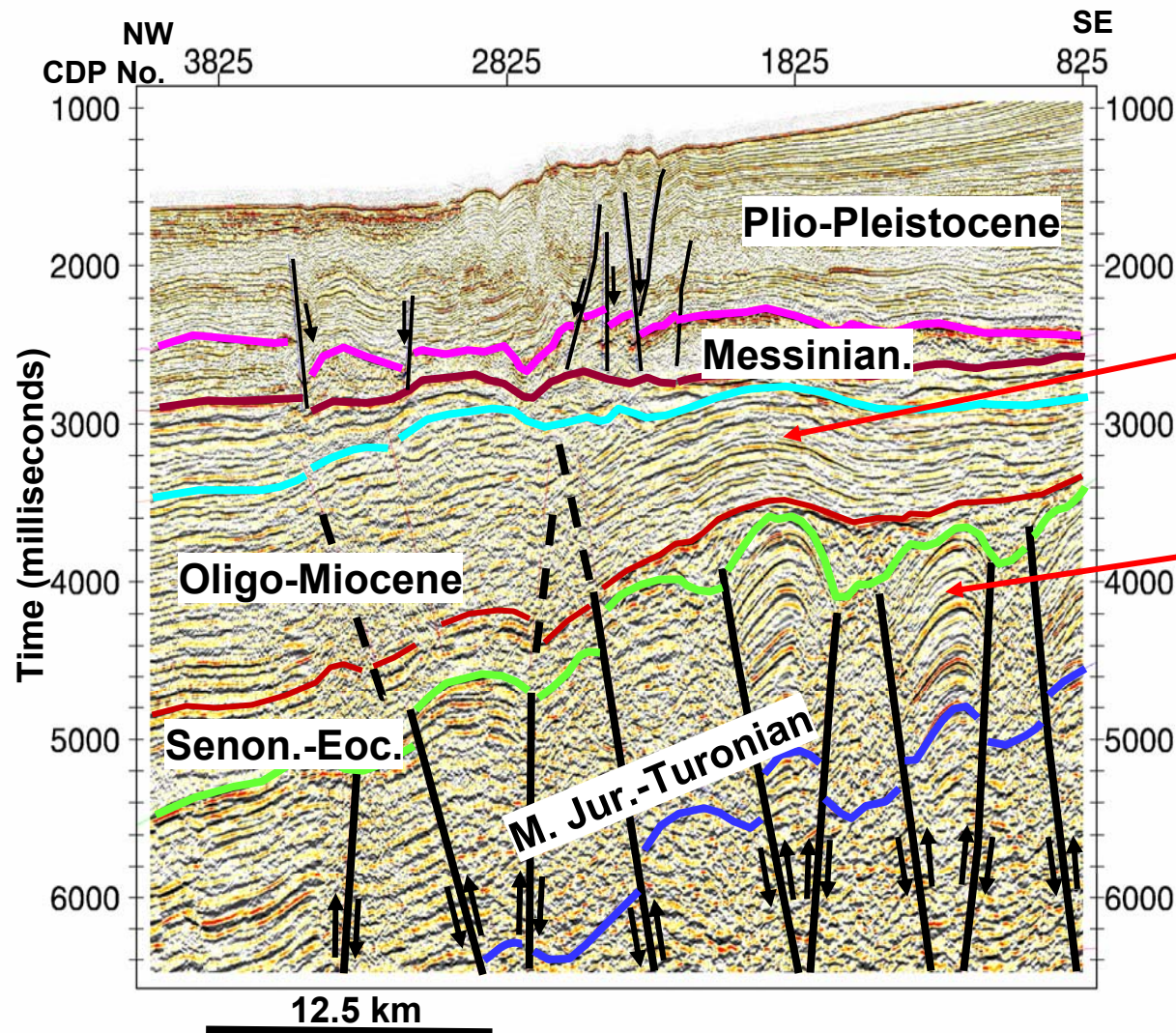
Late Tertiary stratigraphy of Israel



Presenter's Note:

The Upper Tertiary sedimentary record inland show abundant erosional unconformities and missing sections. Sands found within deepwater mud near the coast and in the Levant Basin were likely eroded and transported from the exposed shelf on the east.

The Syrian Arc, multi-phase contractional deformation



**Middle-Late
Miocene
contraction**

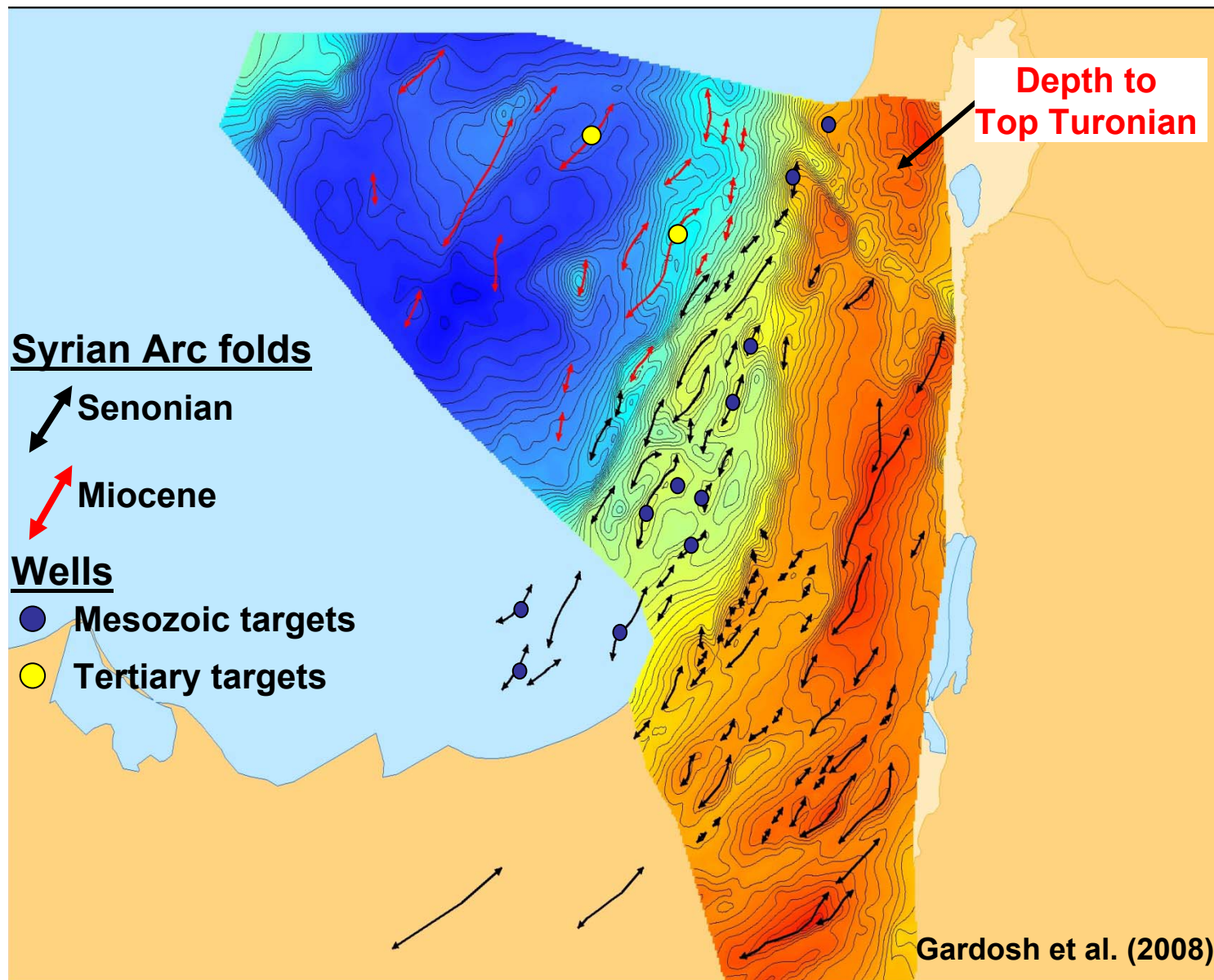
**Senonian
-Eocene
contraction**

Presenter's Note:

The 'Syrian Arc' contractional deformation in the Levant margin reflect the advance of the Alpine orogeny and the African-Eurasian plate collision further to the north. An early phase of deformation produced series of high-amplitude, short wavelength structures. A later phase produced lower amplitude folds.

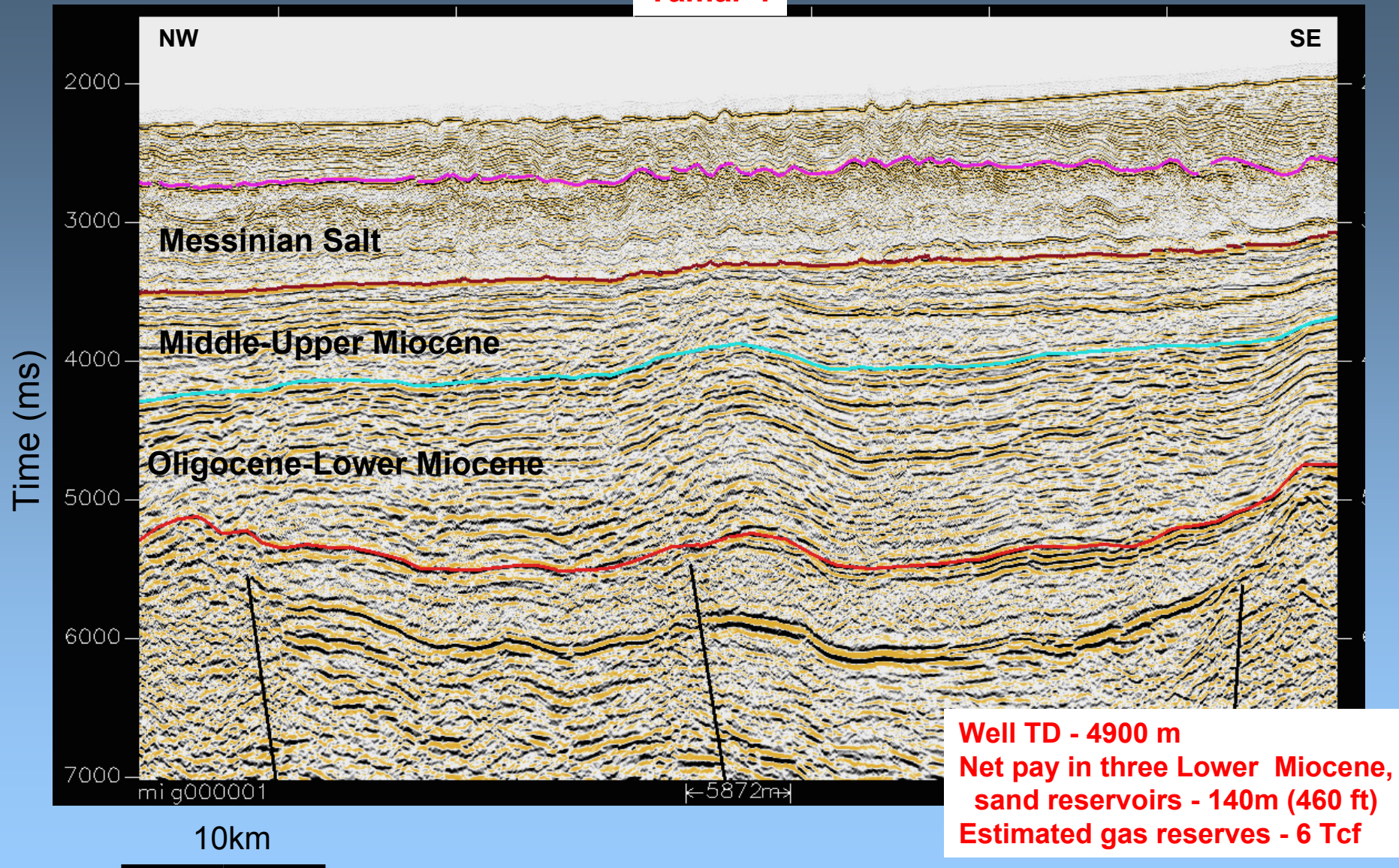
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Syrian Arc folds in the southern Levant area

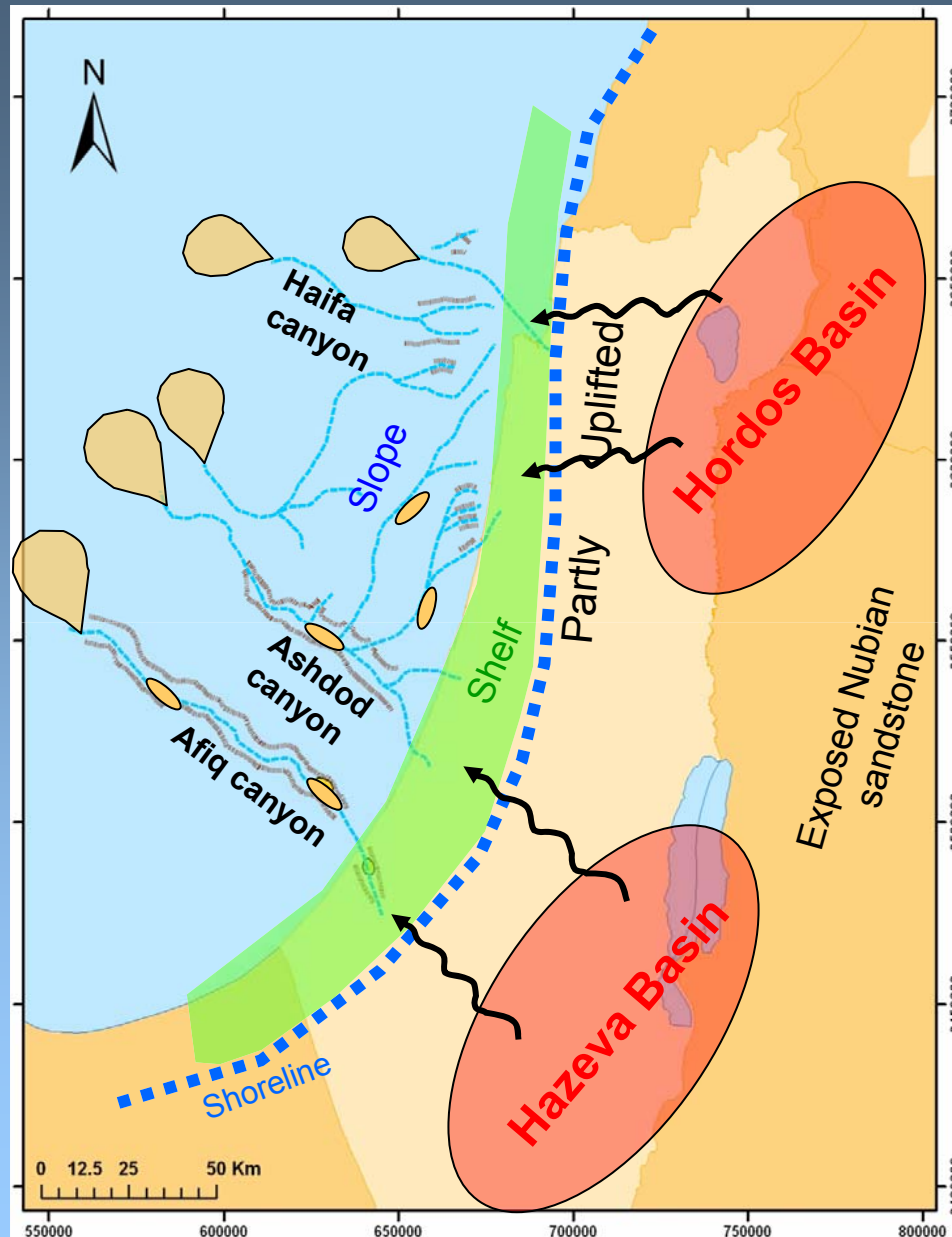
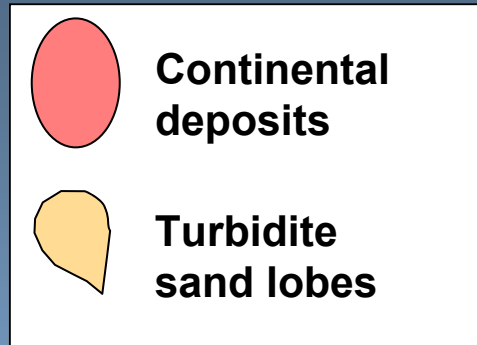


The Tamar structure

Tamar-1



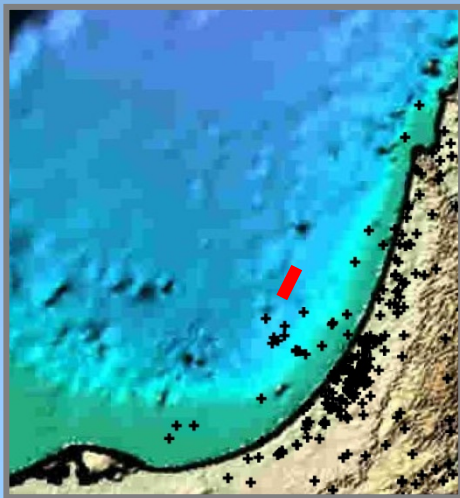
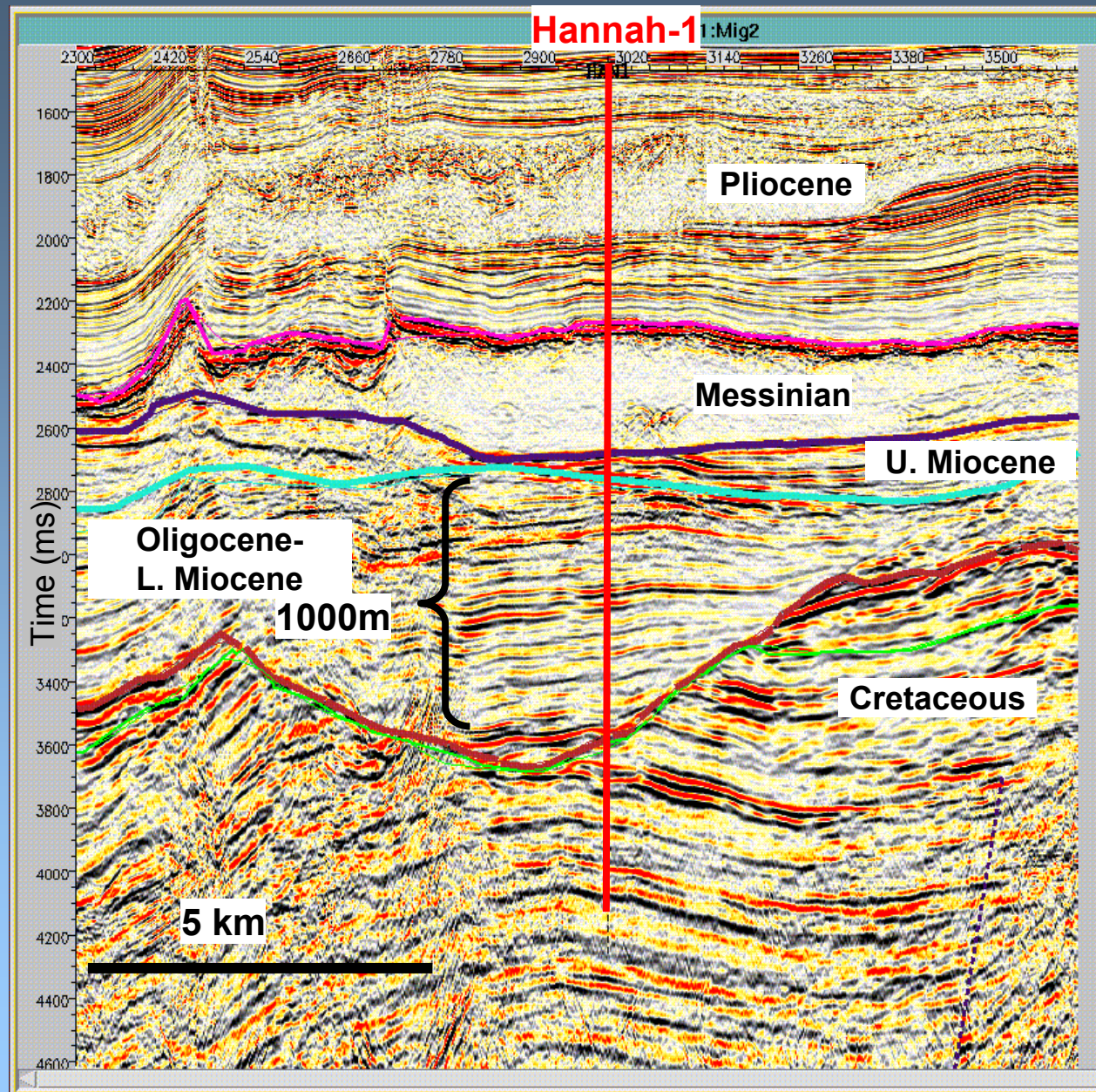
Schematic Oligo-Miocene paleogeography of the southern Levant



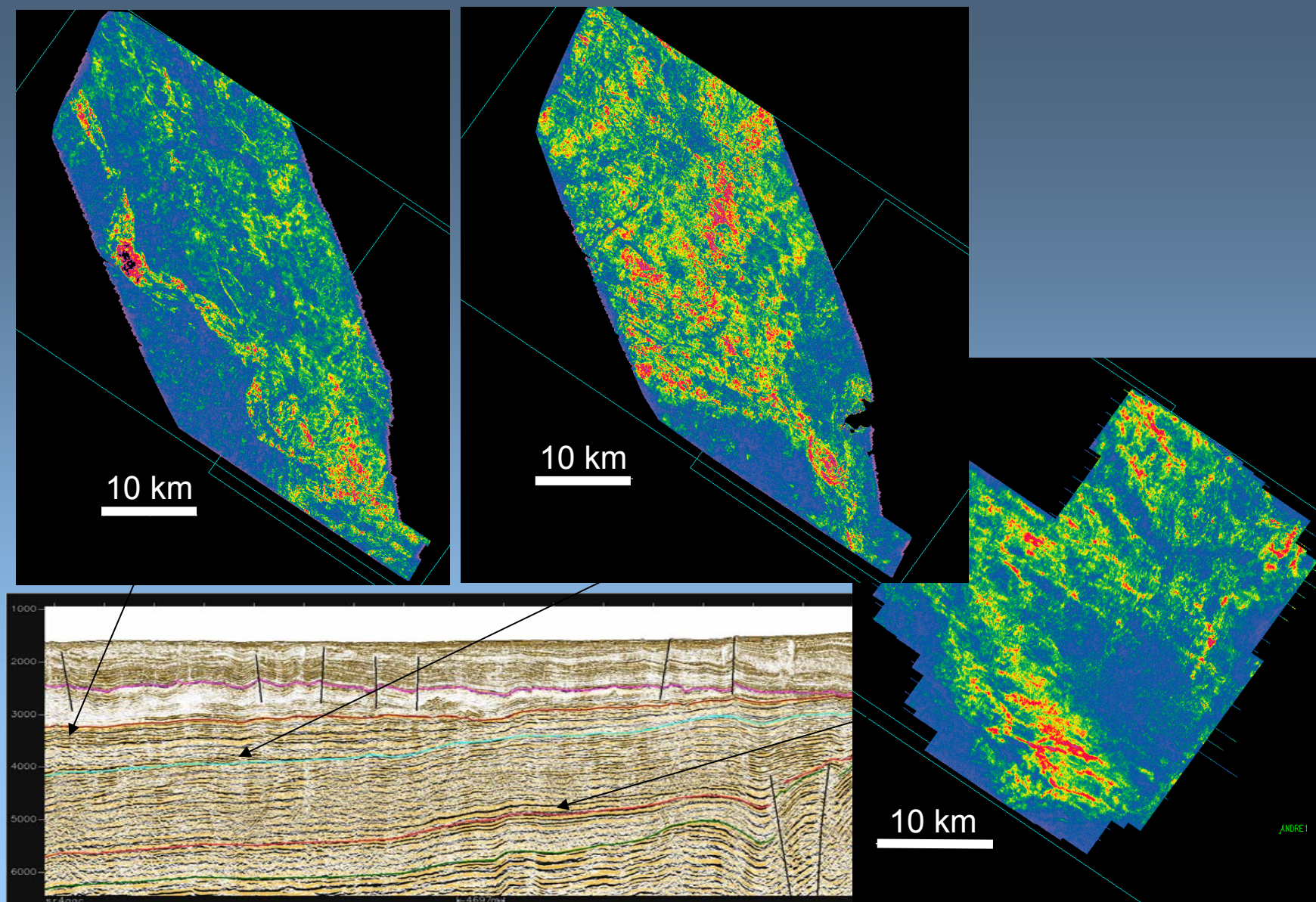
Presenter's Note:

An extensive, submarine canyon system developed on the Levant slope during the Late Tertiary. The canyons acted as fairways for gravity flows that carried coarse-grained siliciclastics from the shelf on the east.

The Ashdod canyon



Oligo-Miocene slope channels

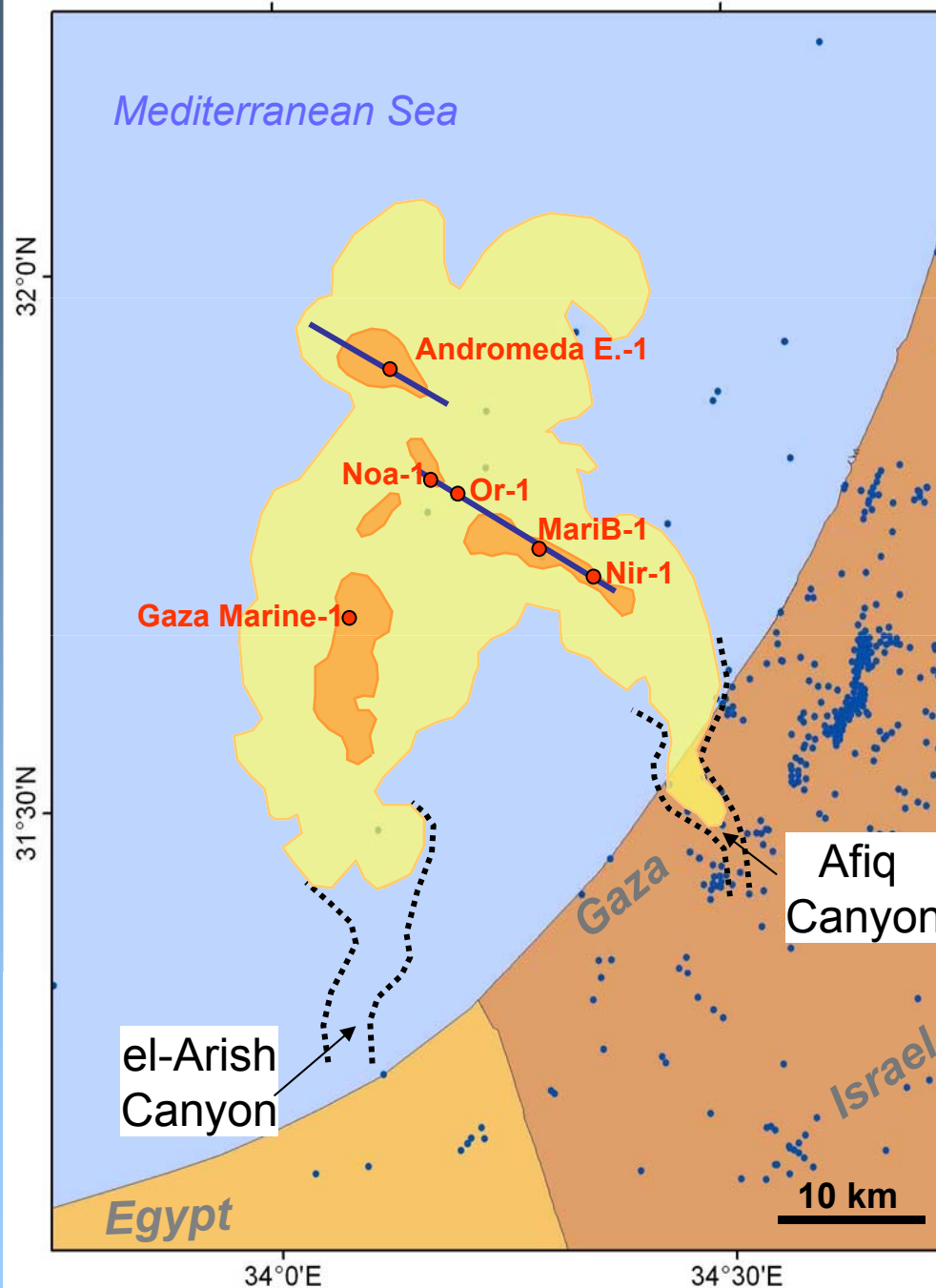
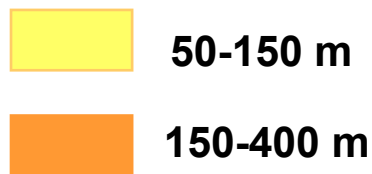


Presenter's Note:

RMS Amplitude extraction maps taken from 3D data show braided and meandering slope channels of Oligocene and Miocene age on the Levant slope. These features that are not yet drilled, likely contain significant amounts of sands that are charged with hydrocarbons.

**Gas bearing,
Pliocene sand
bodies in the
southern
Levant margin**

Yafo Sand Mb.



Gas Reserves

Noa- 0.3 Tcf

MarieB- 1.2 Tcf

Nir- 0.2 Tcf

**Gaza Marine-
~1.5 Tcf**

**Andromeda E.-
Dry hole**

Map modified from
Frey Martinez
et al. (2007)

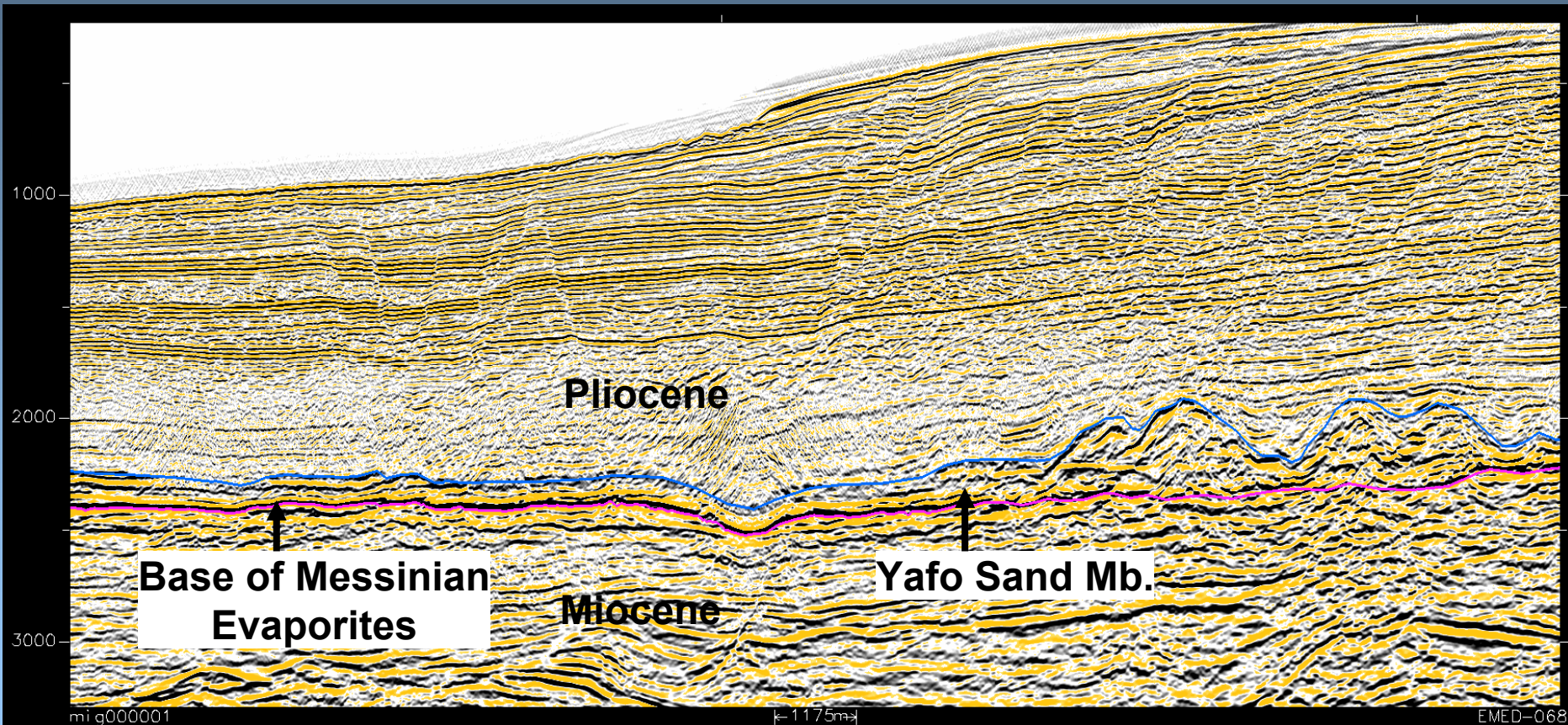
Gas bearing, lower Pliocene sand bodies

Noa-1

Or-1

MariB-1

Nir-1

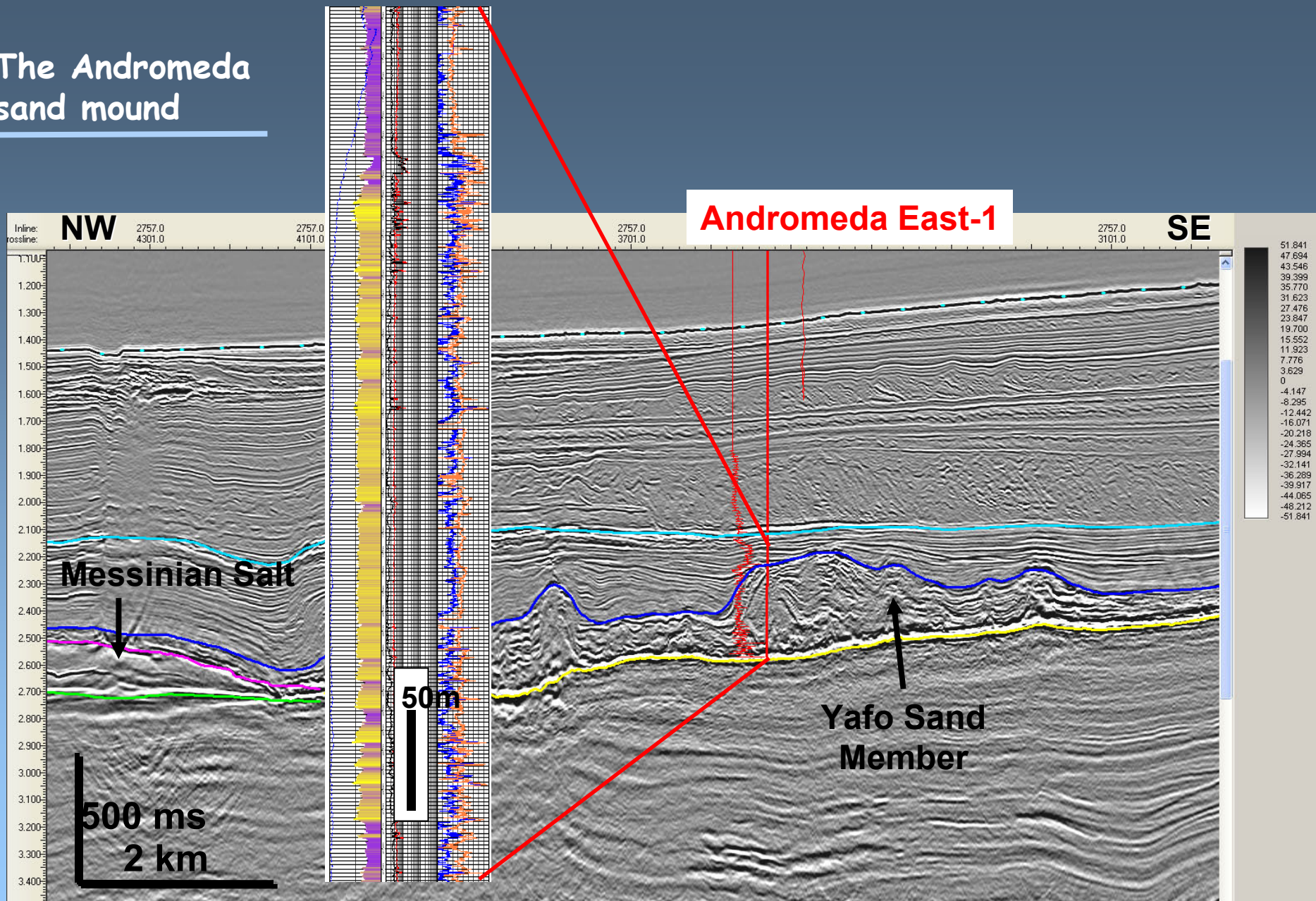


Presenter's Note:

The MarieB and Nir structures are 200-300m thick circular sand mounds found above the Messinian evaporites. The mounds were formed by remobilization and injection of sand into the Pliocene overburden. The source of the sand is the Yafo Member and possibly older, Miocene turbidite deposits.

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The Andromeda sand mound



Presenter's Note:

The Andromeda is the largest and thickest Pliocene sand mound in the Afq canyon. The mobilization of sand into this complex feature may be associated with the withdrawal of the Messinian salt layers (left side of profile). The Andromeda East-1 is a dry hole.

Conclusions

- **A 2-6 km thick, Late Tertiary deepwater siliciclastic system accumulated in the Levant margin, offshore Israel**
- **Well results show significant amounts of turbidite sands that were likely transported through submarine canyon from the nearby Levant shelf**
- **Three main play types are identified: Syrian Arc folds, slope channels and fans and mounded sand bodies**
- **To date, proven reserves amount to 9 Tcf of gas**
- **We estimate high potential for hydrocarbon discoveries in this emerging province**