Tectonostratigraphic Evolution and Exploration Potential of the Northern Levant Basin*

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Abstract

The discovery of large gas fields offshore Cyprus and Israel in the Southern Levant Basin has attracted industry's attention to this underexplored part of the Eastern Mediterranean. Recent large 2D and 3D seismic programmes have dramatically changed the way we see and understand the basin evolution, fill, and petroleum systems of the Levant.

Regional seismic mapping shows that the Cenozoic basin fill of the Northern Levant is significantly thicker than that of the Southern Levant. Giant discoveries in the South (e.g., Tamar, Leviathan, Aphrodite) are all made in Lower-Middle Miocene deep-water fan sandstones in large structural 4-way traps with deep focus that possibly involve basement. In contrast, the Northern Levant does not contain large structural traps in the central part of the basin, and acoustic basement is not visible on regional seismic profiles, implying a thinner continental or possibly oceanic crust. The package containing the reservoirs for the Southern Levant fields can be mapped for hundreds of kilometres from Egypt to northern Cyprus and Lebanon. This package consist of a series of fans that onlap the Eratosthenes "Seamount" to the west, the Lebanon and Syria continental slope to the east, and are partially caught up in the Latakia Ridge to the north, which has experienced recent movement and uplift.

The northern Levant basin is likely to be the source of a large volume of biogenic gas and form at least part of the fetch areas for the fields along the "Tamar Arch". A different structural play, however, exists south of the Latakia Ridge in the frontal fold belt. The structures along the ridge have a good chance to tap into the Northern Levant kitchen and receive substantial hydrocarbon charge.

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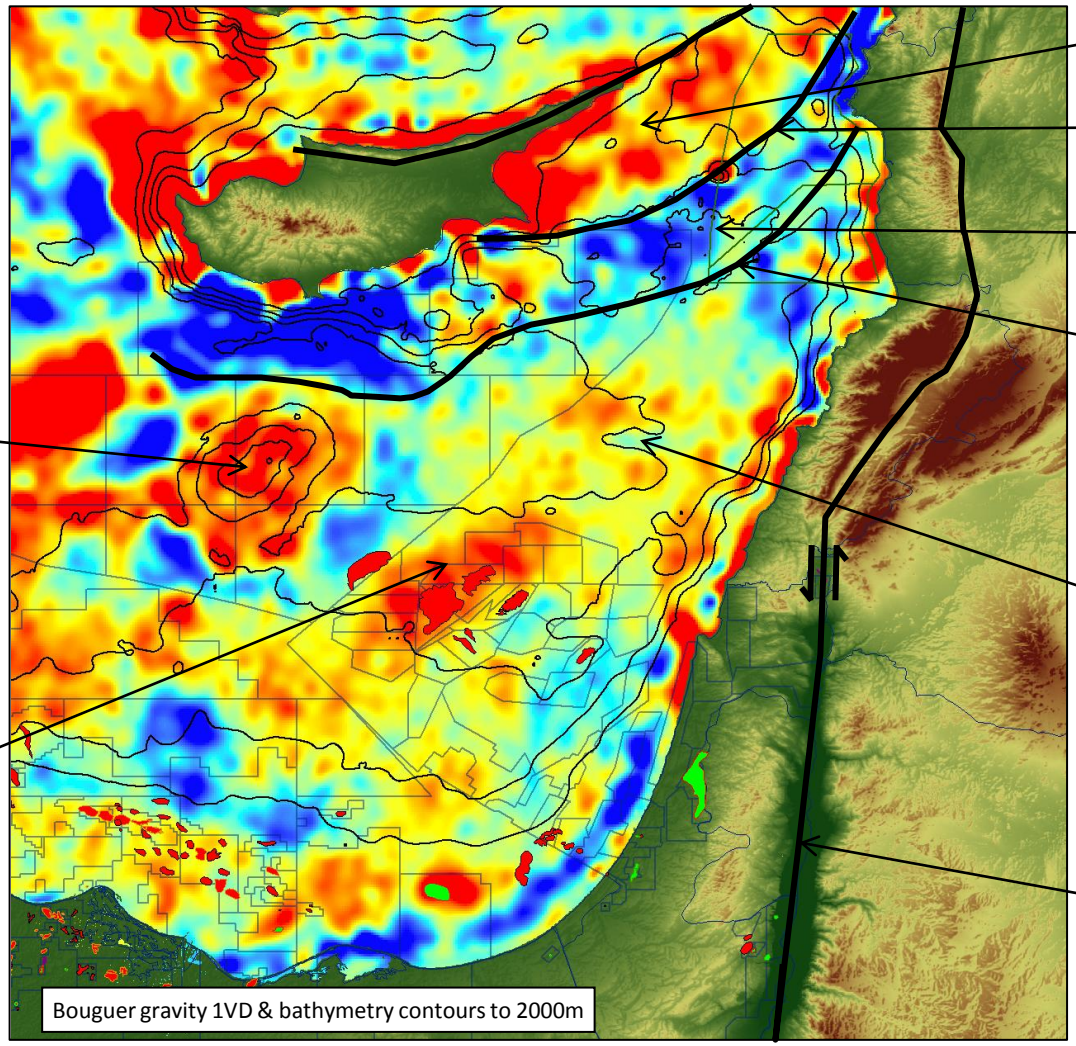
Presentation Outline

- Regional setting and tectonic model
- Tectonostratigraphic evolution of the Northern Levant
- Levant Basin discoveries – implications for exploration potential of the Northern Levant
- Northern Levant exploration potential

Levant Basin Regional Setting



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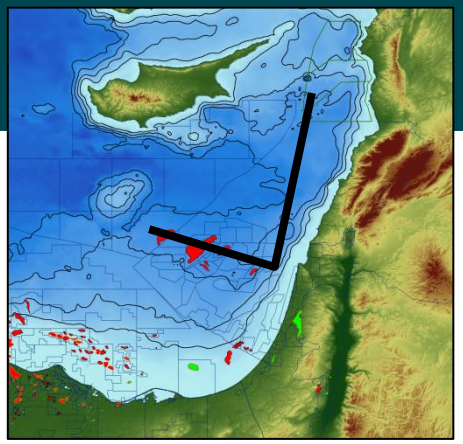
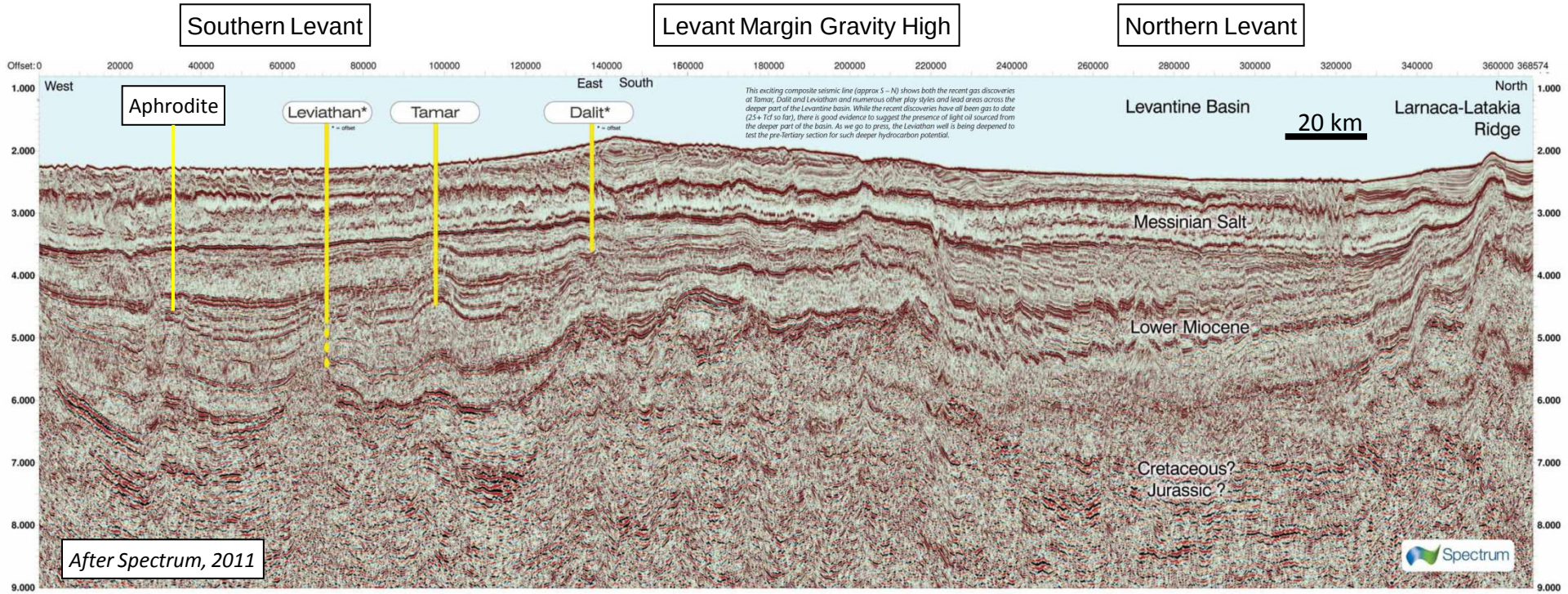
Regional Seismic Profile





After Spectrum, 2011

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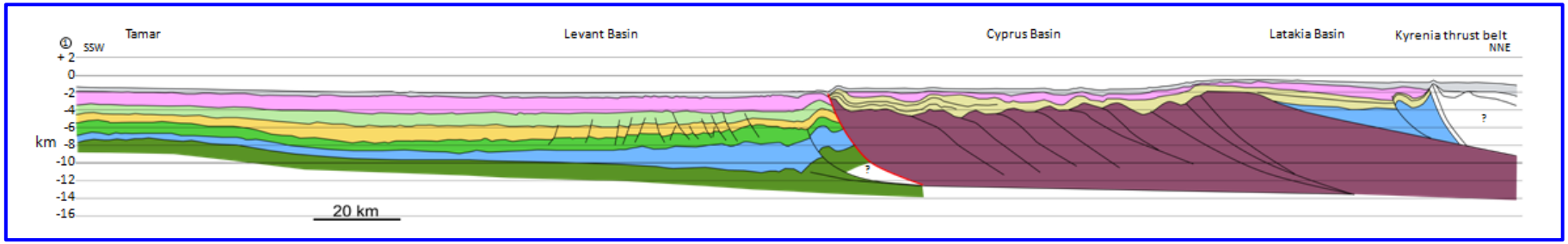
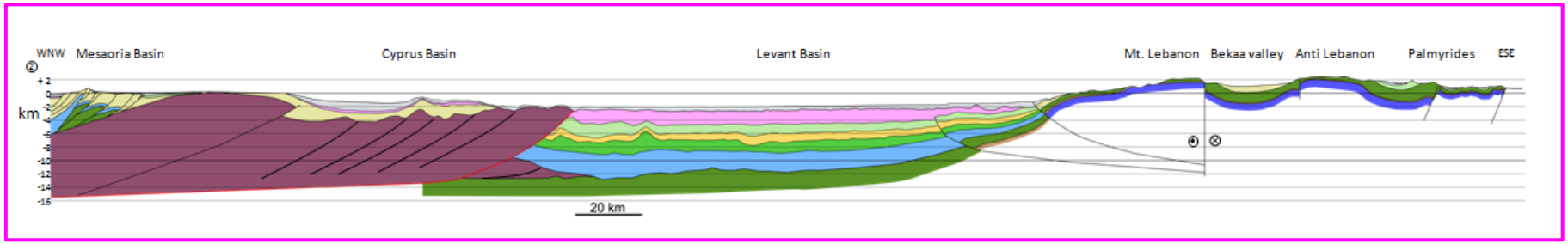
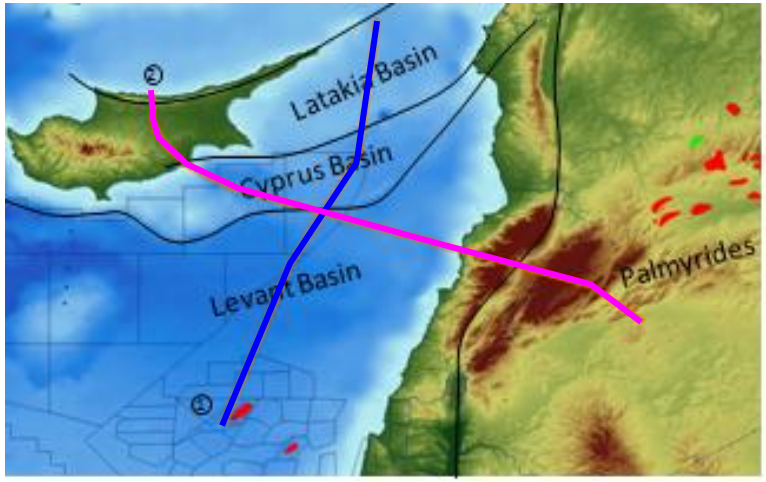
Regional Cross Sections Linking Onshore & Offshore





- Pliocene to Quaternary
- Maastrichtian
- Undifferentiated Cenozoic
- Middle Miocene to Base Maastrichtian
- Lower Miocene
- Oligocene
- Paleocene to Eocene
- Cretaceous
- Jurassic
- Ophiolite, ophiolitic mélange and passive margin carbonates



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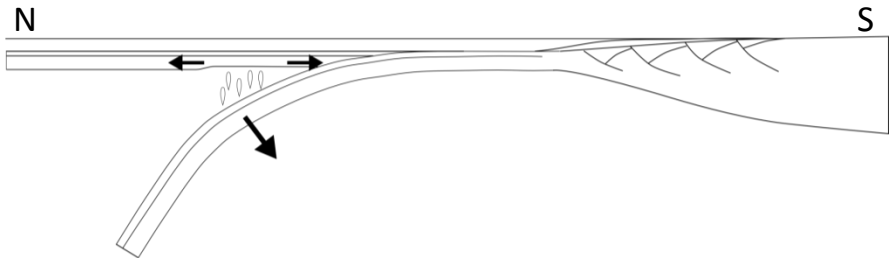
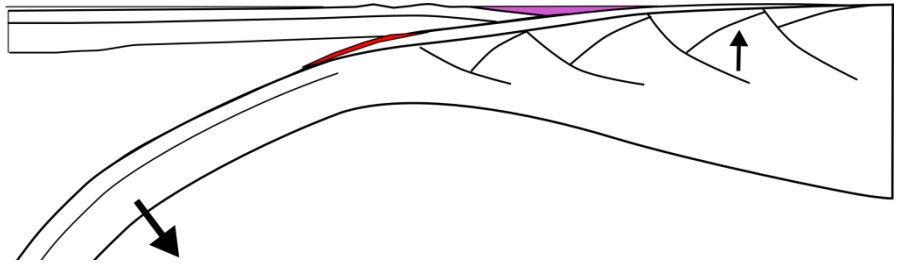
Northern Levant Regional Tectonic Model

Campanian



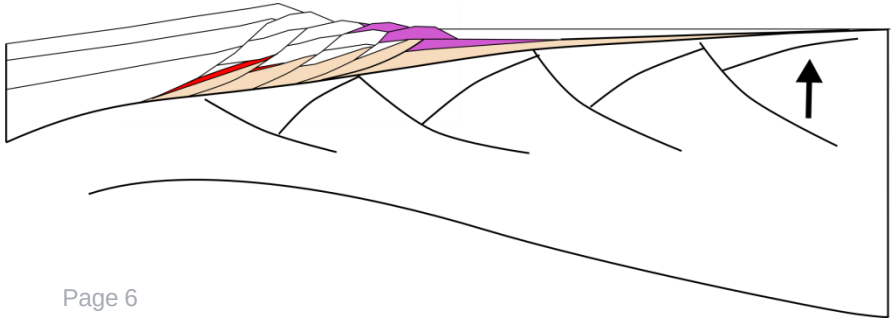
- Formation of SSZ ophiolite due to rollback of African Plate to the south

Maastrichtian (early obduction)



- Melange deposited in foredeep
- Formation of metamorphic sole and erosion above migrating forebulge causing Senonian unconformity

Maastrichtian (late obduction)



- Imbrication of leading edge of ophiolite with melange and passive margin carbonates

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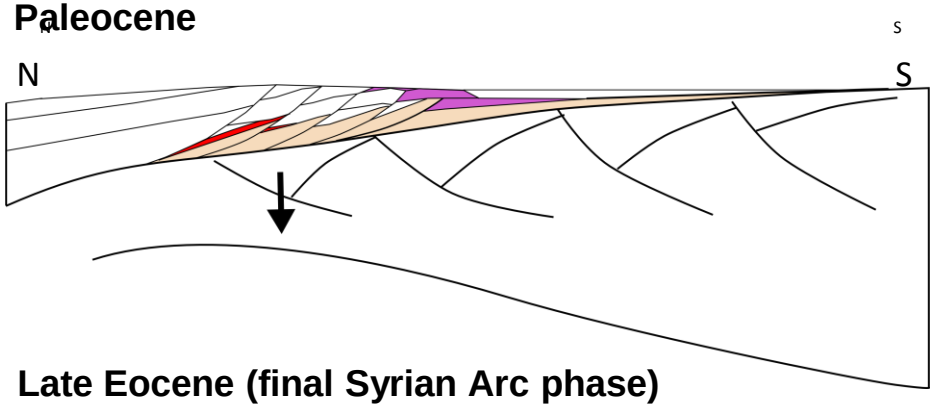
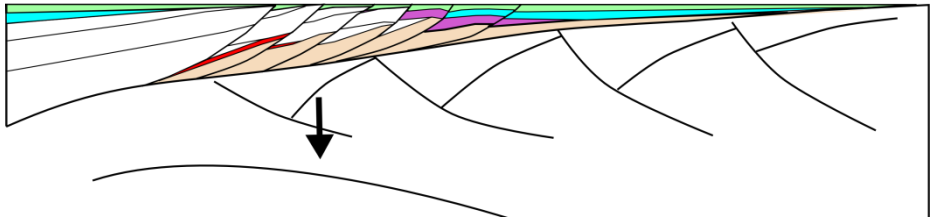
Northern Levant Regional Tectonic Model

Paleocene



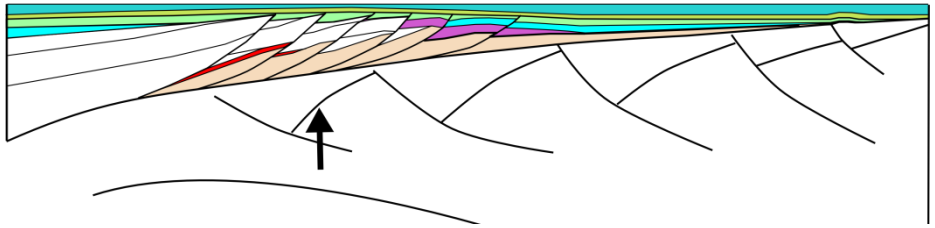
- Erosion and peneplanation of imbricated sequence

Late Eocene (final Syrian Arc phase)



- Reactivation of imbricates and deposition of foreland basin wedge
- Non-deposition/erosion at the end of the period

Early Miocene



- Short quiescent period, followed by uplift of the thrust belt (detachment of subducted slab?)
- Inversion anticlines form to the south – initiation of movement on the Dead Sea Transform

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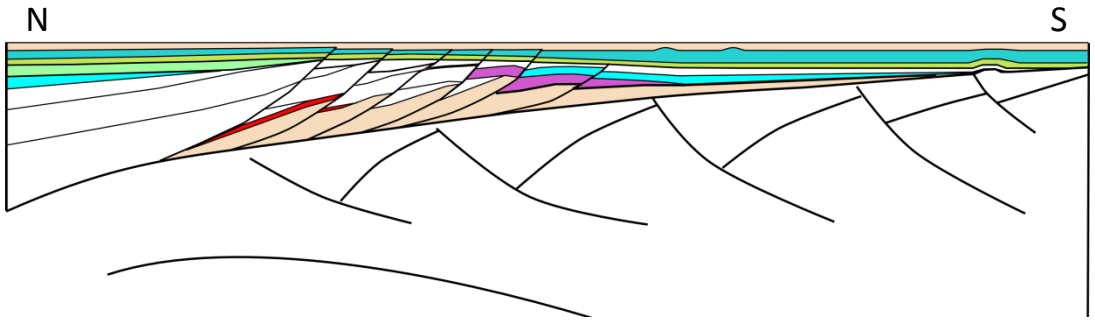
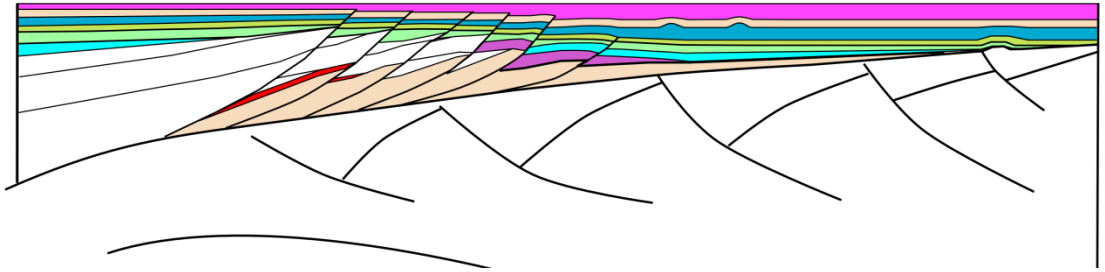
Northern Levant Regional Tectonic Model

Middle Miocene



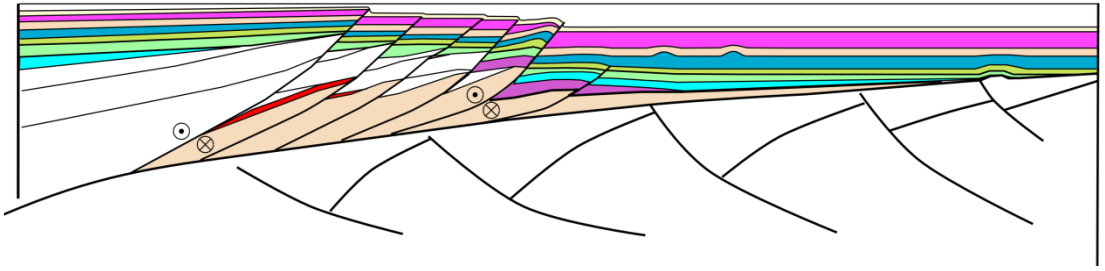
- Reactivation of imbricates
- Initiation of detachment folds
- Reactivation of inversion anticlines
- Hiatus in propagation of Dead Sea Transform
- Deformation in Palmyrides

Messinian



- Reactivation of imbricates and detachment folds

Plio-Pleistocene



- Renewed propagation of the Dead Sea Transform
- Sinistral transpression reactivation of Latakia and Larnaca Ridges continuing to present day

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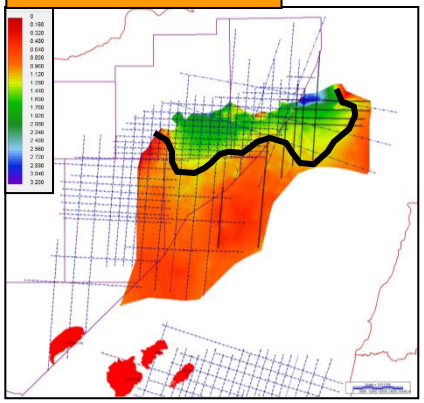
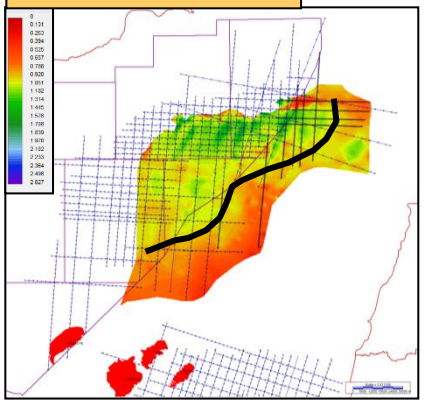
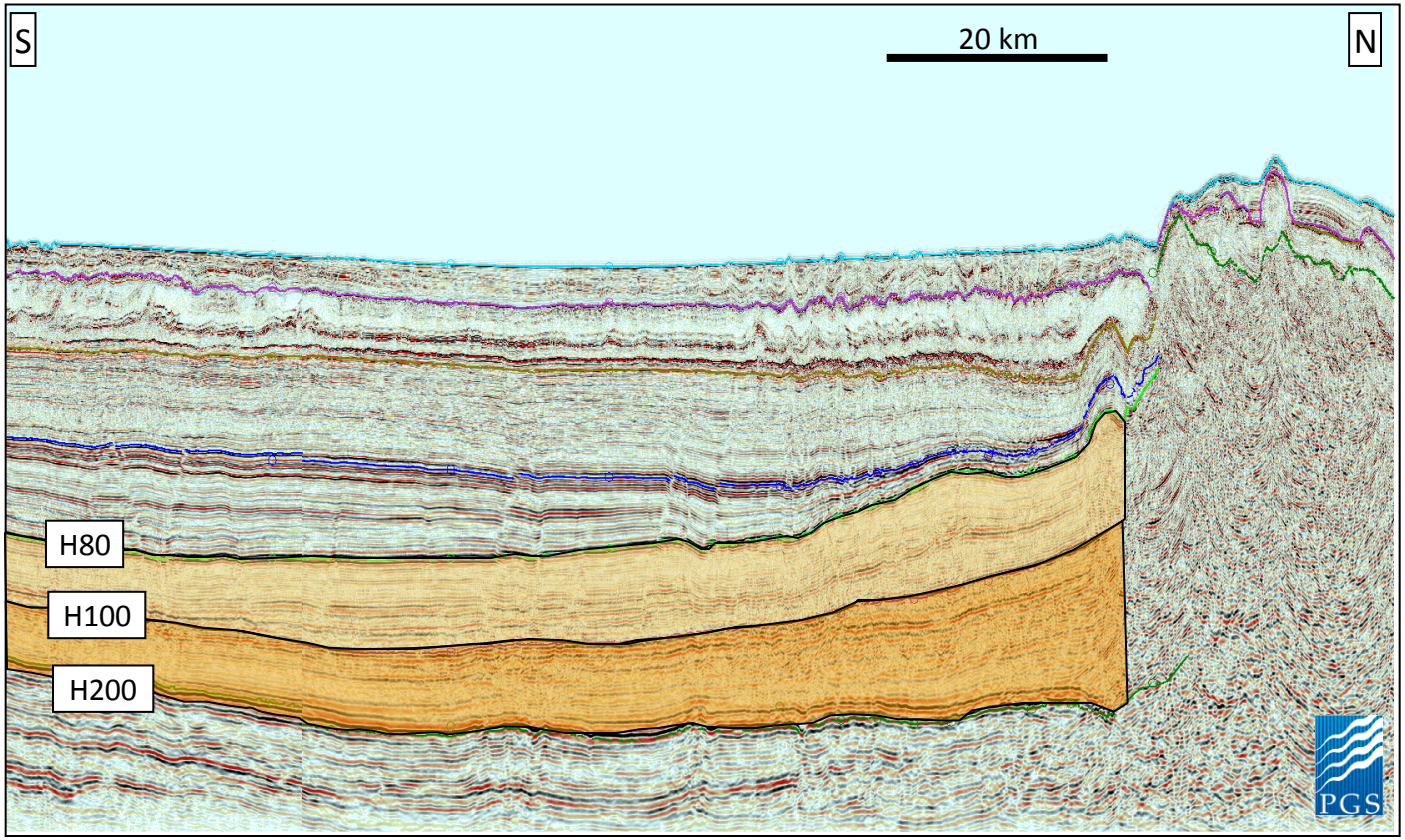
Tectonostratigraphic Evolution of N. Levant Foreland

Eocene, H100-H200



Oligocene, H80-H100





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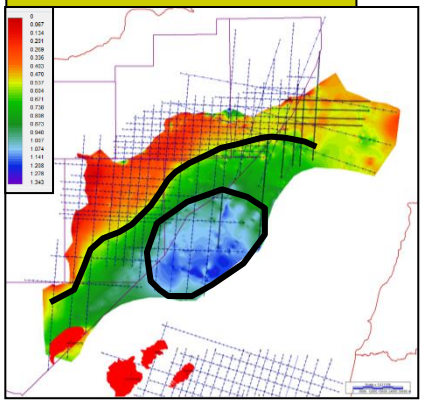
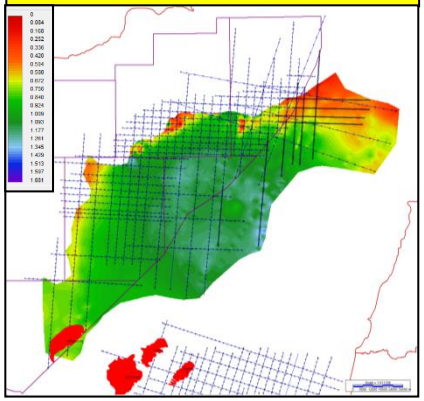
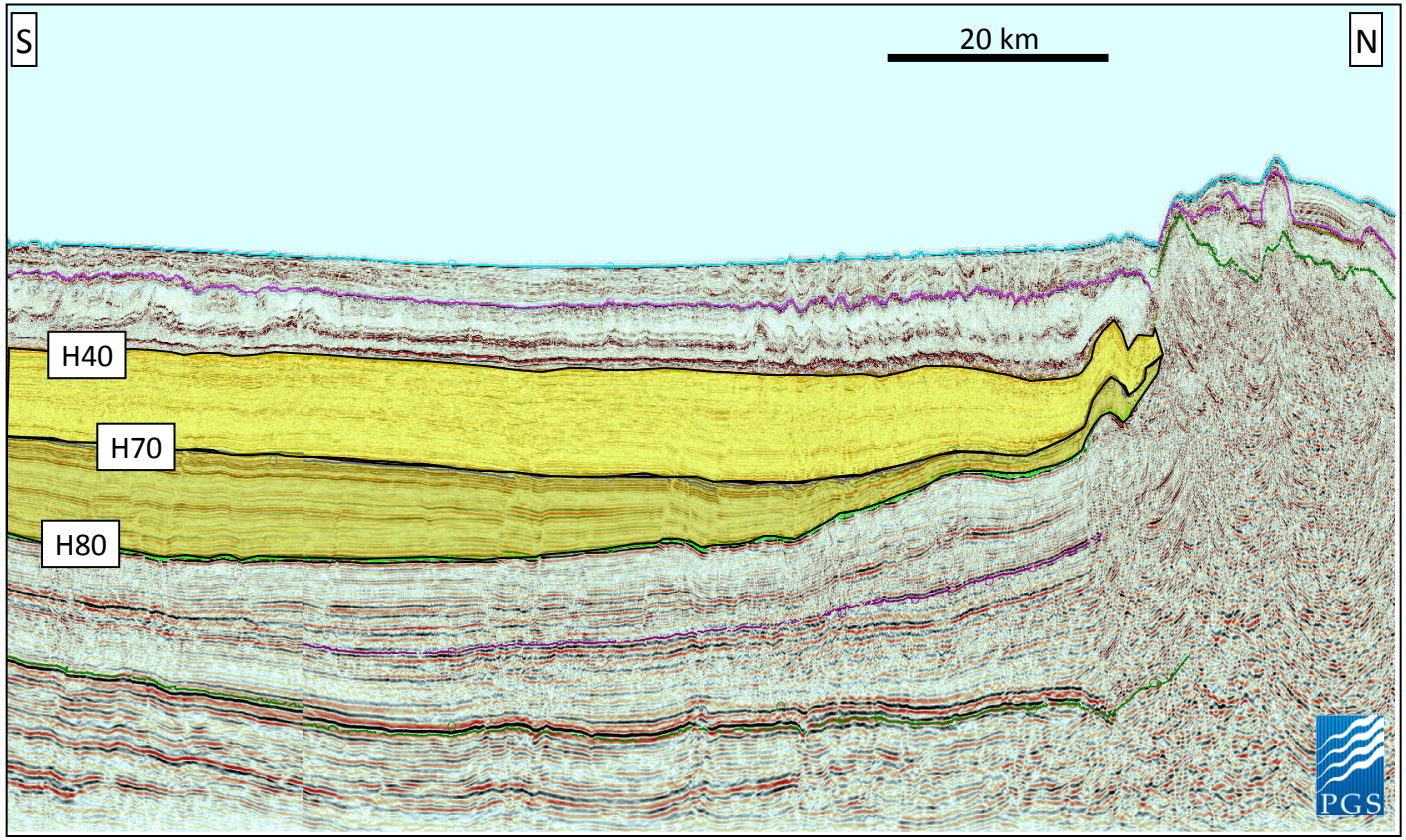
Tectonostratigraphic Evolution of N. Levant Foreland

Lower Miocene, H70-H80



Mid-Upper Miocene, H40-H70





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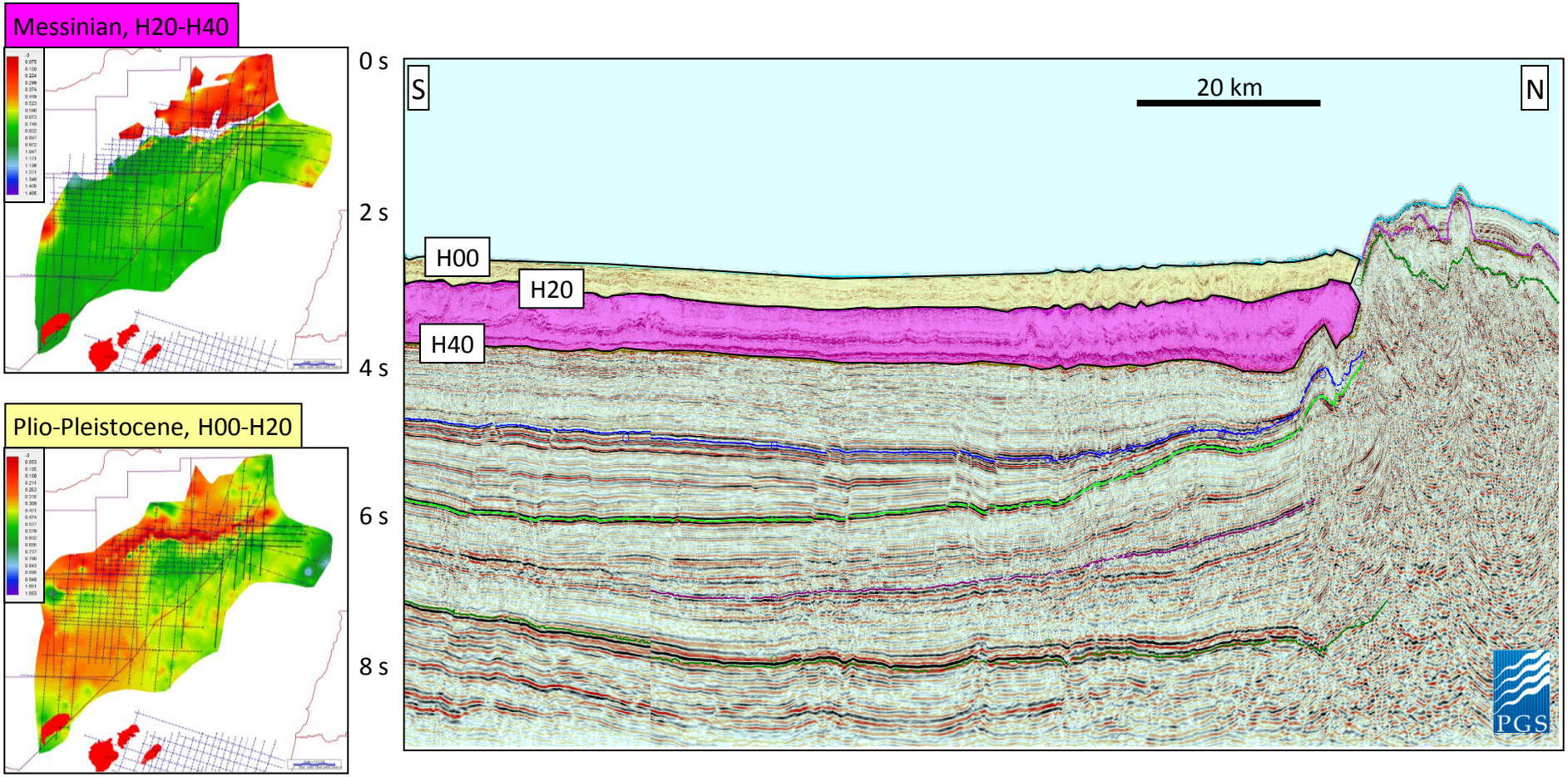
Tectonostratigraphic Evolution of N. Levant Foreland



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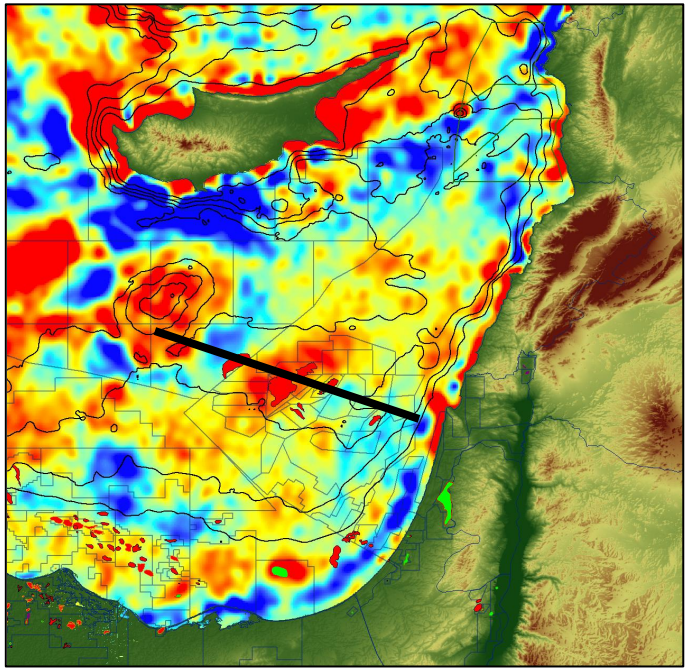
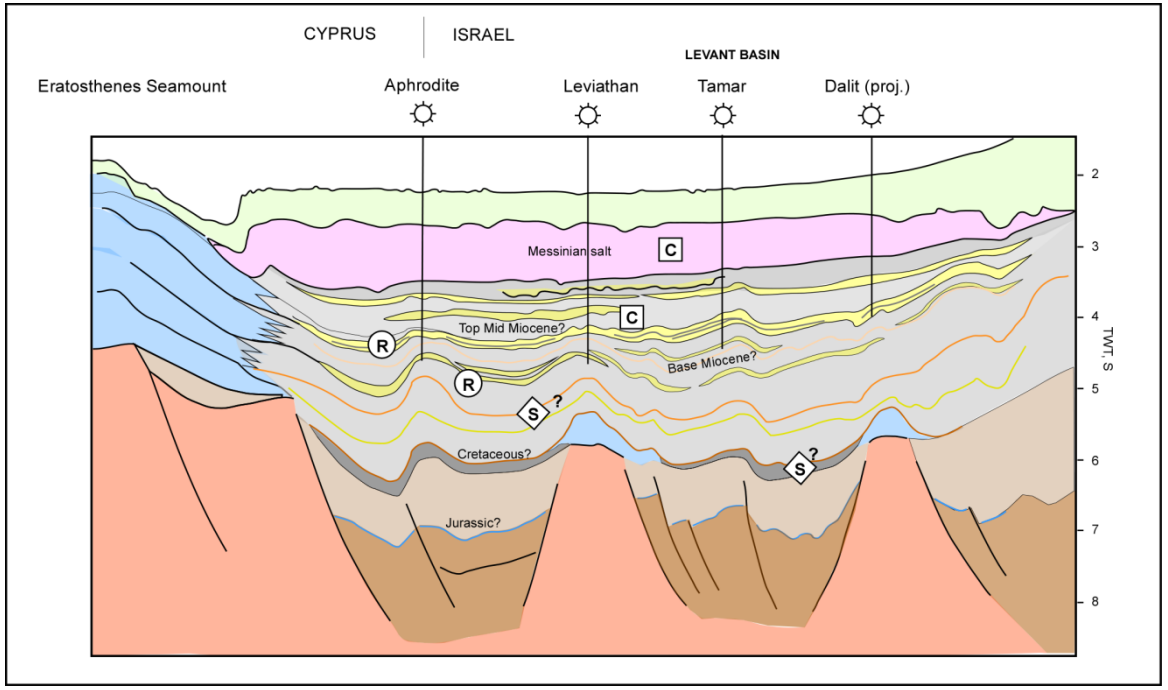
Southern Levant Discoveries – Play Concepts



Bouguer gravity 1VD & bathymetry contours to 2000m



- Biogenic gas in Lower Miocene sandstones, trapped in large four-way closures with large fetch areas
- Underpinned by deeper structure
- Potential for thermogenic hydrocarbons at deeper levels

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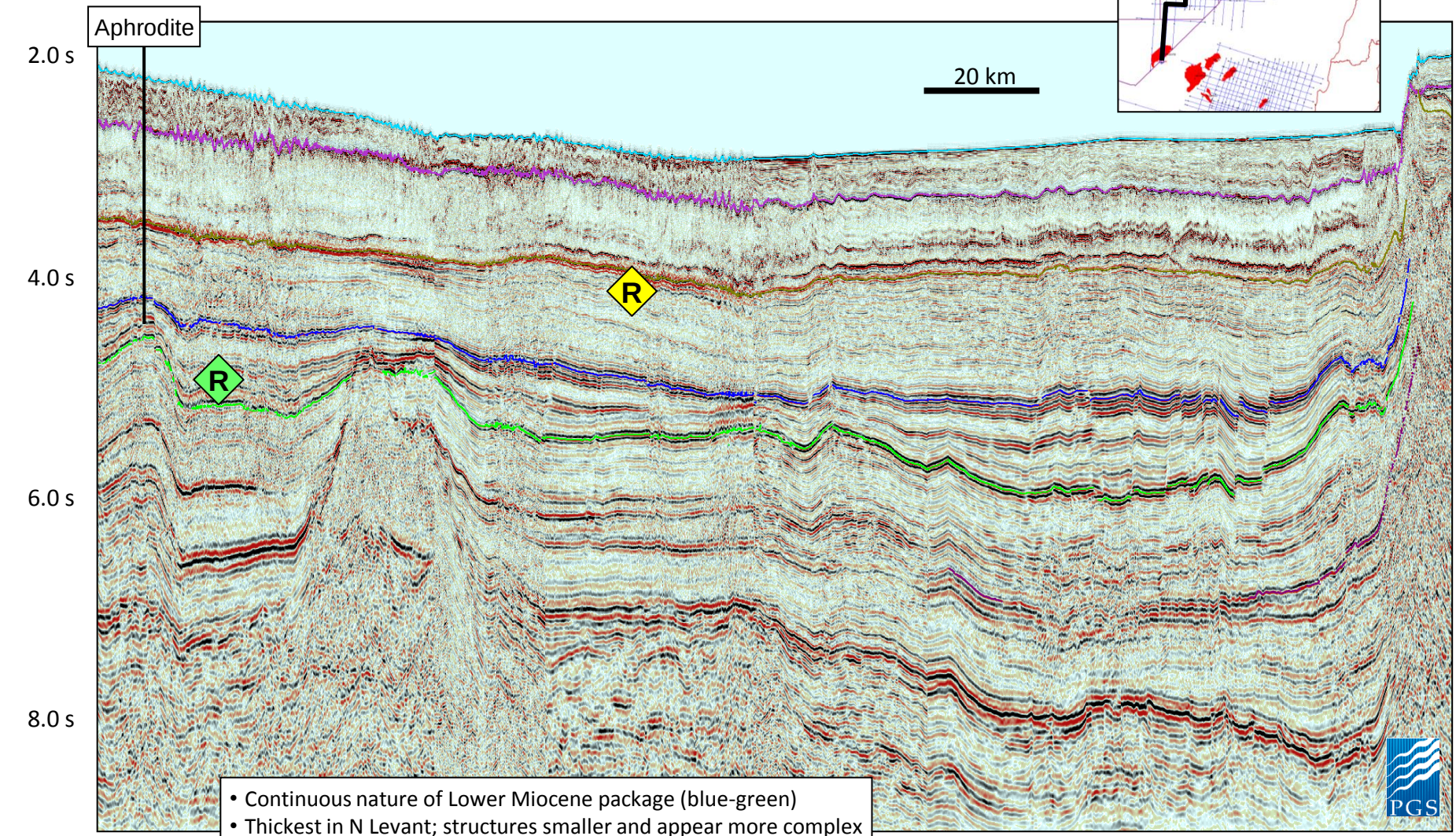
Miocene Reservoir Distribution



- Continuous nature of Lower Miocene package (blue-green)
- Thickest in N Levant; structures smaller and appear more complex
- Simpler structures closer to Latakia Ridge
- Pre-Messinian reservoir also likely to be present

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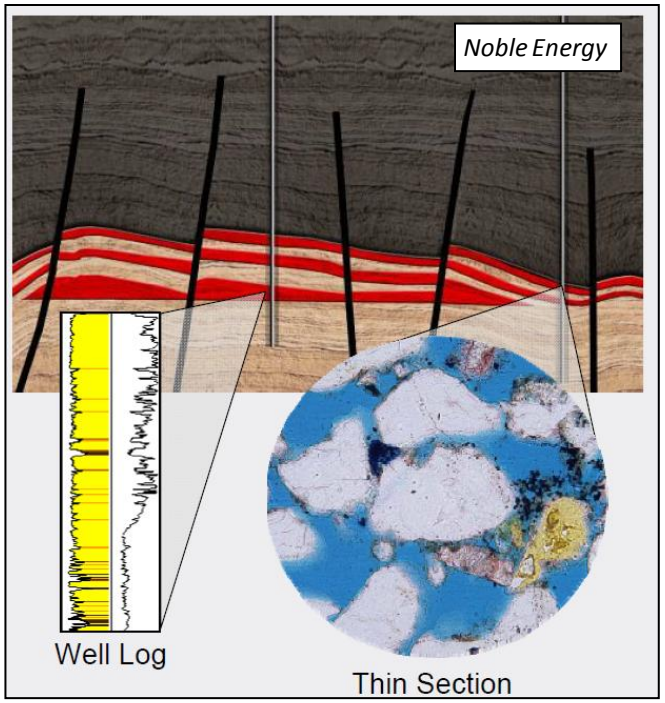
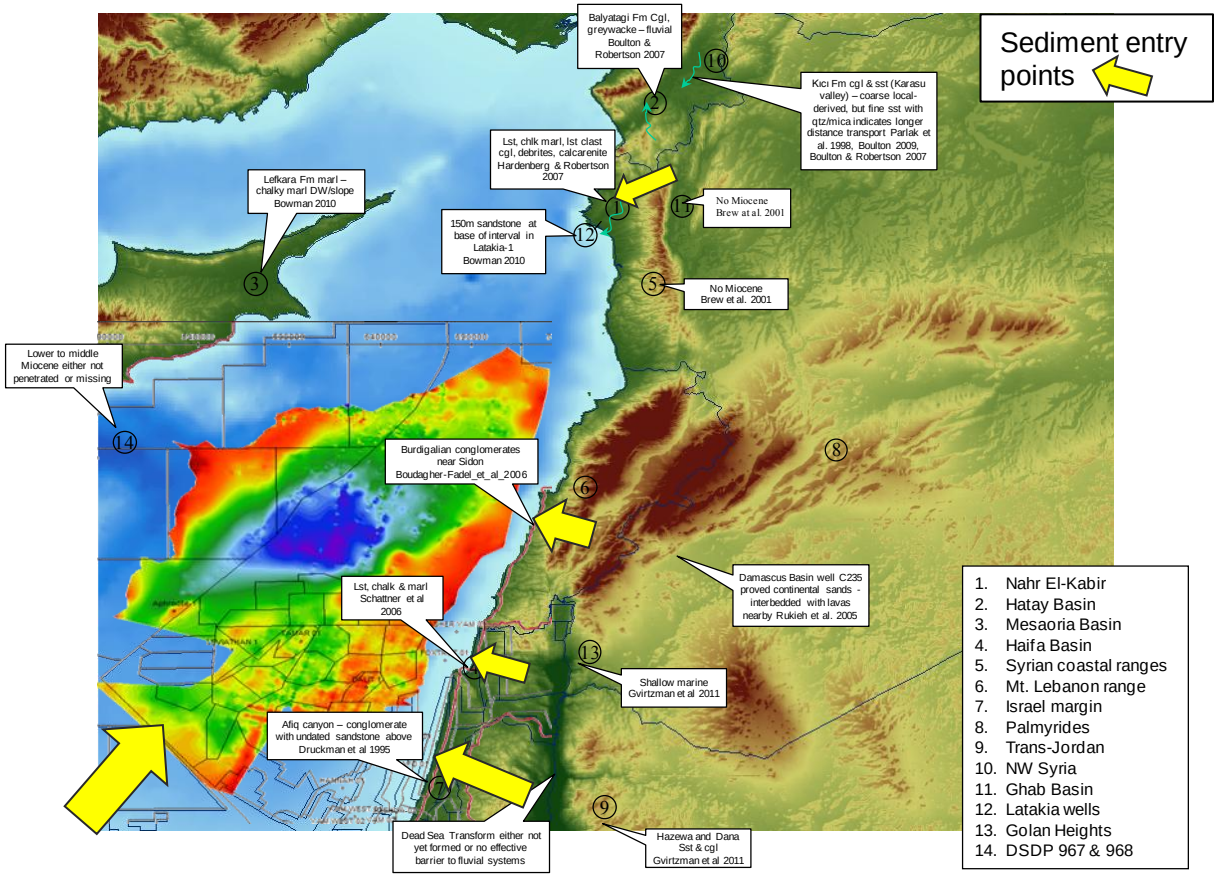
Lower Miocene Reservoir Provenance



- Clean sands, 1 Darcy permeability & 25% porosity
- What is the provenance of these sands?
  - Paleo-Nile
  - Levant Margin prior to uplift associated with motion of the Dead Sea Transform
  - Possible contamination of clean sands by input from north of ophiolite derived material



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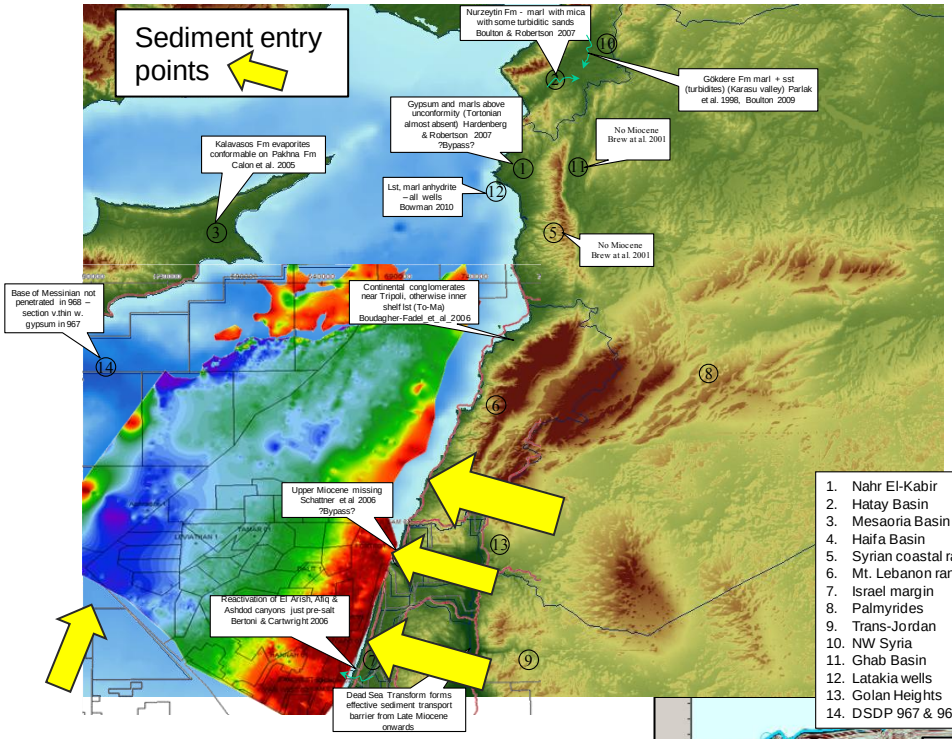
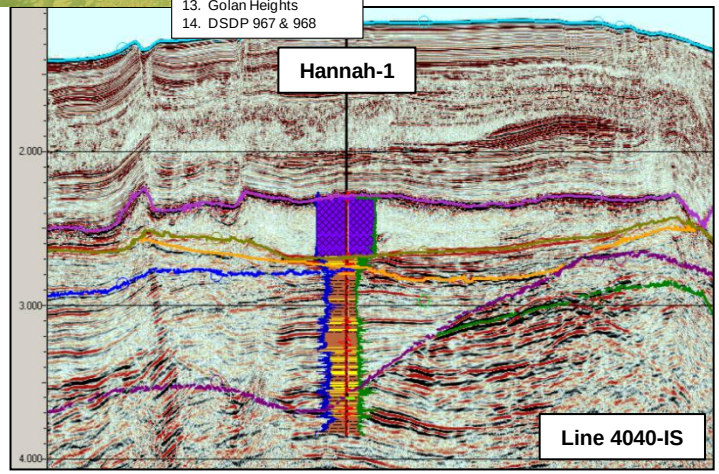
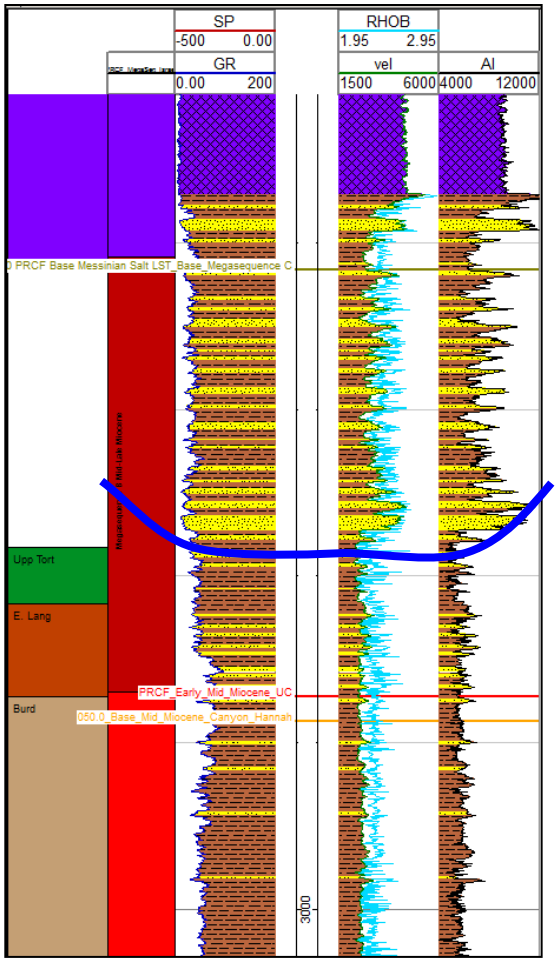
Pre-Messinian Reservoir Presence







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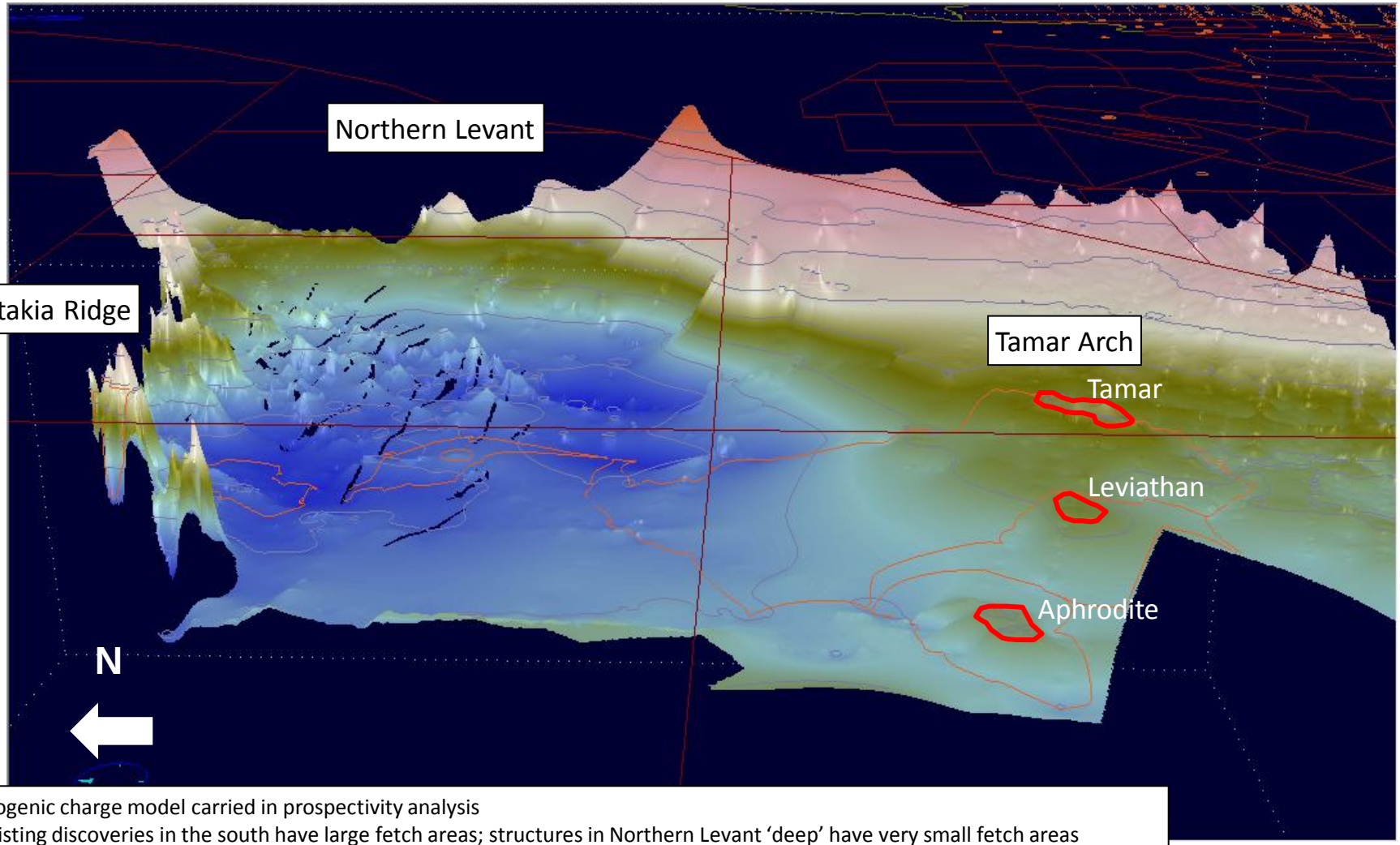
Charge Model & Fetch Areas



- Biogenic charge model carried in prospectivity analysis
- Existing discoveries in the south have large fetch areas; structures in Northern Levant 'deep' have very small fetch areas
- Northern Levant 'deep' considered as the kitchen area for the biogenic gas accumulations to the south
- Largest structures in the north are those towards the Latakia Ridge in frontal and detached fold fairways, with larger fetch areas

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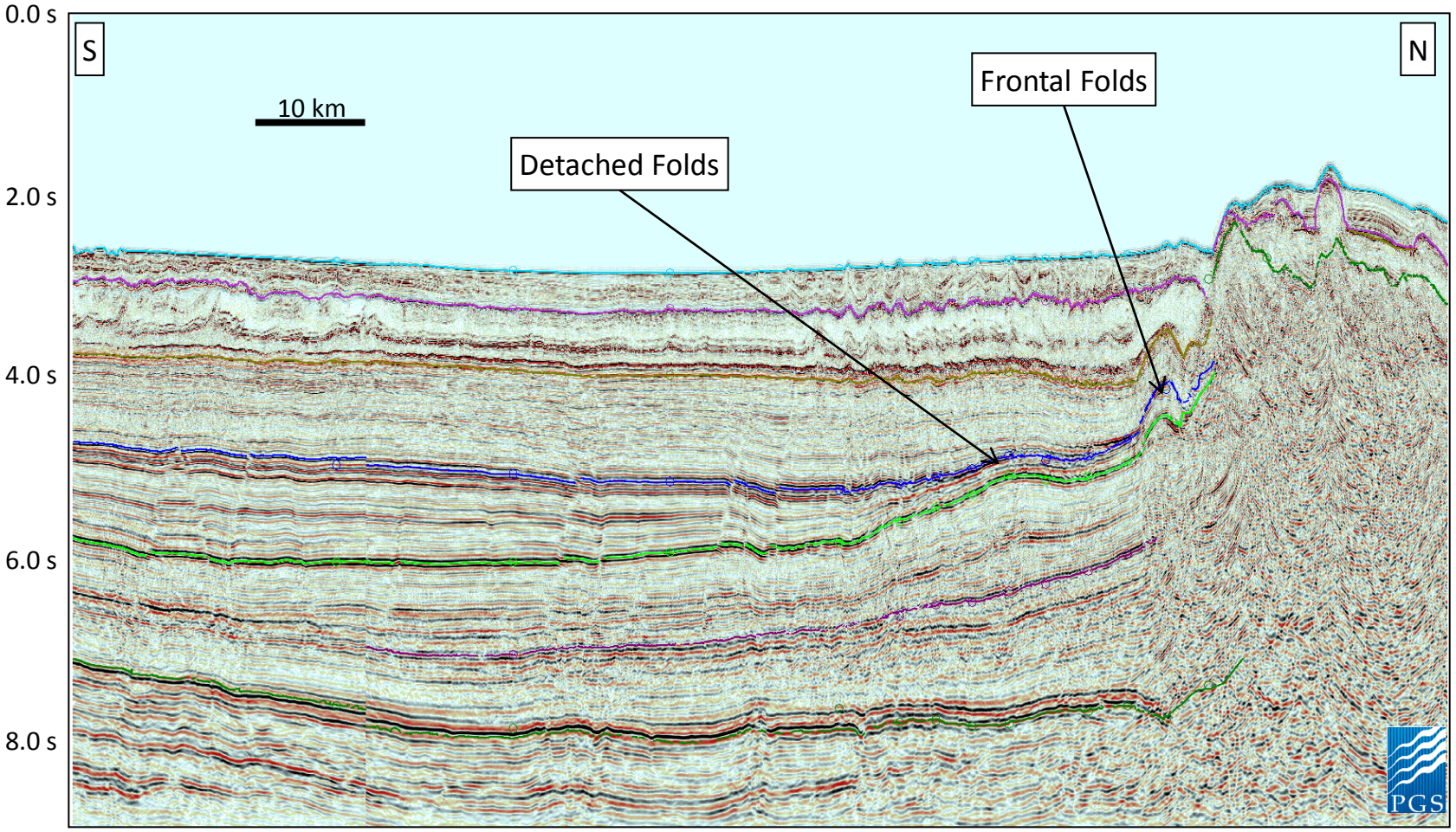
Northern Levant Exploration Potential



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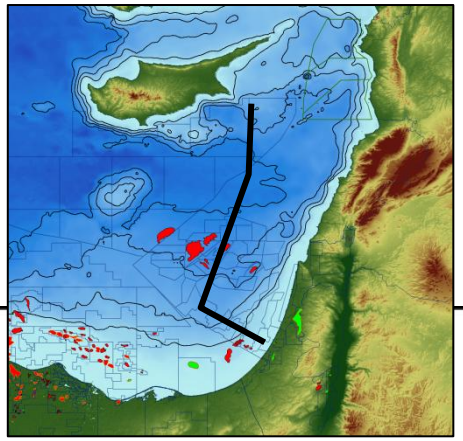
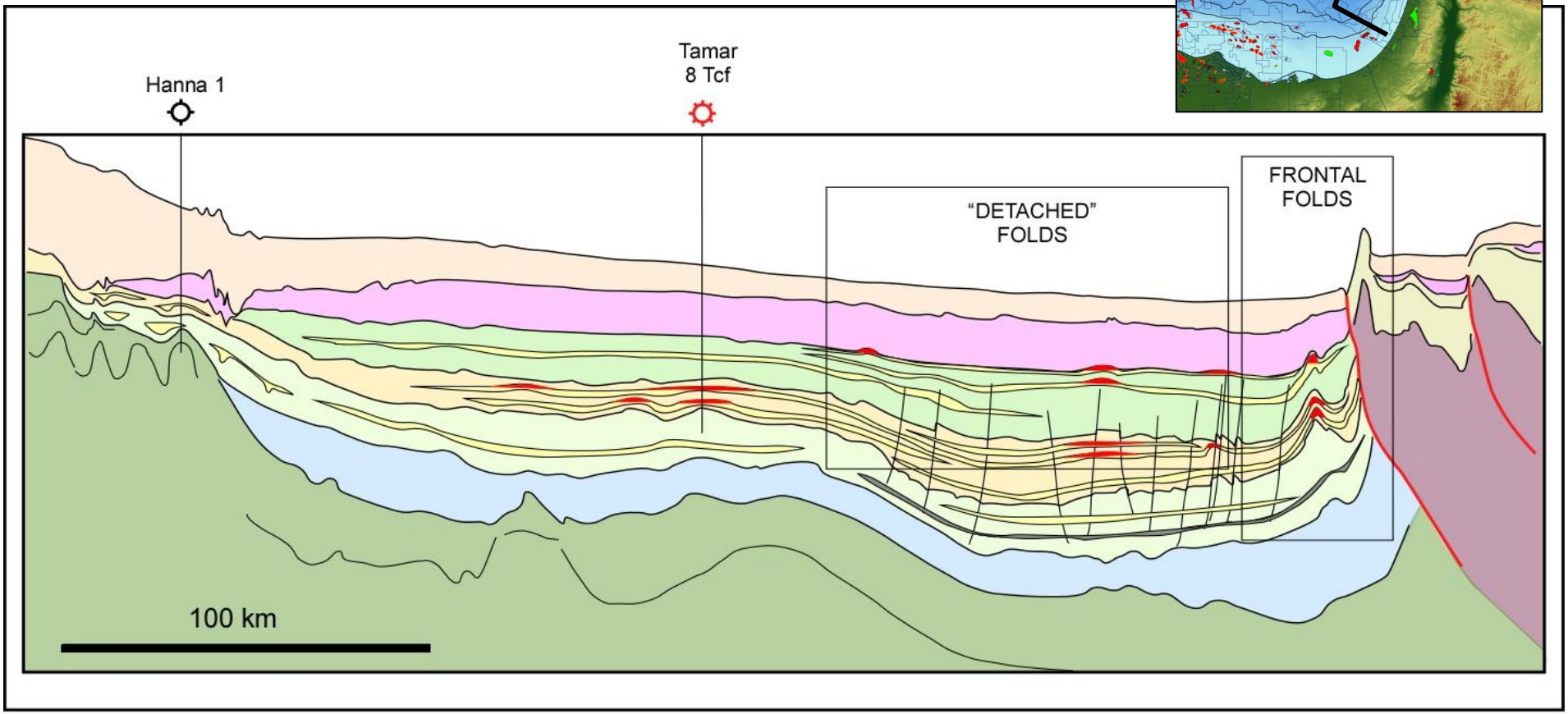
Levant Hydrocarbon Plays

- Proven Lower Miocene Tamar sands sealed by Middle Miocene shales
- Postulated pre-Messinian sands sealed by salt
- Detached and frontal fold traps have 4-way closures at both pre-Messinian and Lower Miocene target levels
- Frontal fold traps ranked higher for charge as they formed earlier than the detached folds
- Both trap types on migration pathways for biogenic gas from Northern Levant kitchen





Summary

- Northern and Southern Levant differ greatly but exploration potential remains in the north
- Highly successful Lower Miocene play extends to the Northern Levant with further potential in the Upper Miocene section
- Large simple structures exist in the far north towards the Latakia Ridge in the form of detached and frontal folds
  - Ideally located to receive biogenic charge from the Northern Levant kitchen

ACKNOWLEDGEMENTS