[PS] Assessment of Controlling Factors in Mixed Biogenic and Thermogenic Petroleum Systems – A Case Study from the Levantine Basin*

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Abstract

The Levantine Basin in the Eastern Mediterranean has become an attractive area for oil and gas exploration due to pioneering efforts of several E&P companies, which have resulted in the discovery of major gas fields in the pre-salt sequences. Information on whether the gas in these new discoveries is of biogenic or thermogenic origin was restricted for a while, as the strategic implications of this knowledge are clear: if the gas is thermogenic, then the chance of deeper thermogenic oil potential could be reduced or even excluded, while biogenic gas would leave an opportunity open for deeper thermogenic systems which could include oil. Publicly available knowledge is developing quickly and it is now accepted that the gas that has been discovered so far in fields such as Tamar and Leviathan is of biogenic origin. As a result, exploration for deeper thermogenic systems is now under way. We will present a sensitivity analysis of the basic elements of the petroleum systems based on the data that is publicly available at the time of the presentation. In the first part, a regional type-section is used to show the data and interpretations related to the construction and calibration of the model, as well as the underlying assumptions that were used to constrain the model properties and boundary conditions. In the second part of the talk, we will then investigate the properties and processes related to the formation of the currently known biogenic system within these constraints. This will include gas generation, migration and accumulation timing and the controlling factors such as biogenic generation kinetics, gas migration volumes and rates, and seal quality evolution through geologic time. This will enable us to illustrate sensitivities in the system and how well it can be constrained, and to assess the timing relative to the Messinian Salinity Crisis. In the third and final part, we then assess the assumed deeper thermogenic petroleum systems which are at the moment speculative in the study area, and show which range of conditions could lead to the co-existence of biogenic and thermogenic petroleum occurrences. We will be updating the presentation with the latest information available from ongoing exploration efforts in the region. This will be of particular interest, as these activities are expected to result in important enhancements of our knowledge of the role and potential of thermogenic petroleum systems in the area of interest.

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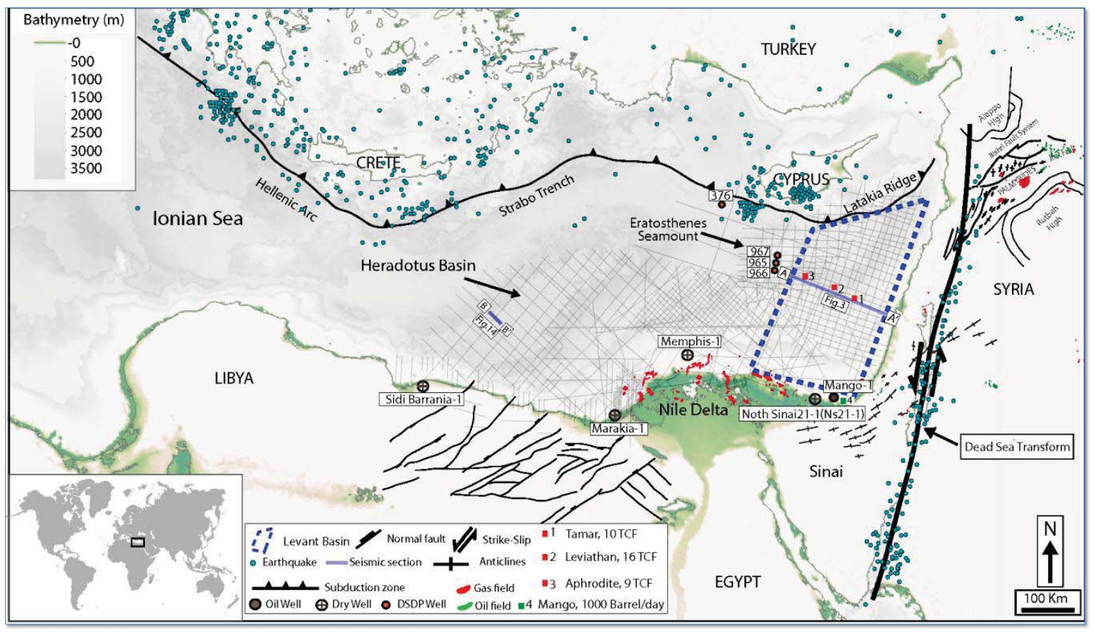
Study Area: Eastern Mediterranean and Levantine Basin



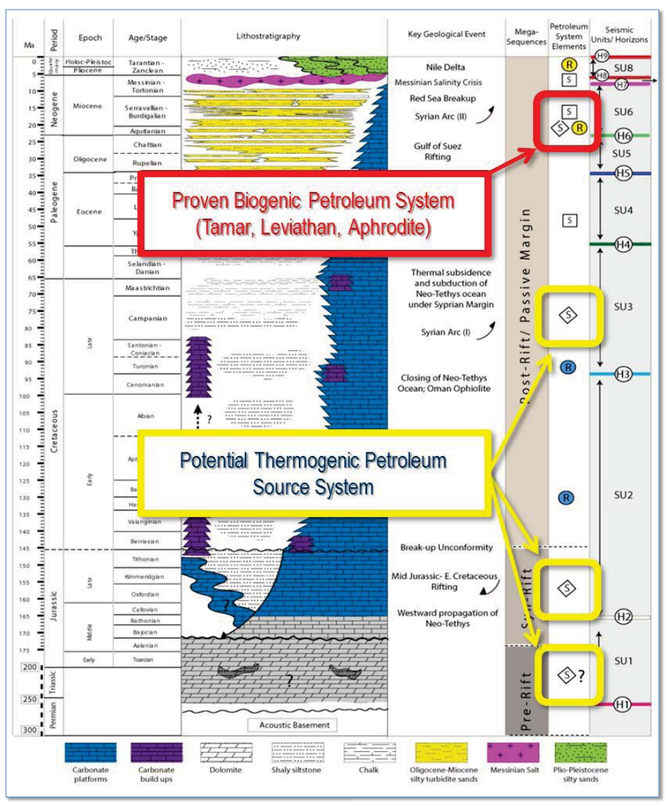
Location map of the Eastern Mediterranean Basins showing the main tectonic elements of the region and the distribution of the oil and gas fields. Recent giant pre-Messinian gas discoveries are shown by the red squares. The dashed polygon defines the boundary of the Levantine Basin

Tectono-Stratigraphic Chart

Tectono-stratigraphic chart showing the key geologic events that shaped the present day Levant basin and the distribution of the petroleum system elements (source, carrier/reservoir and seal).

The key seismic horizons (H1-H9) bounding the major seismic units (SU1-SU8) are shown in the chart.

The proven biogenically sourced petroleum system in the Oligocene-Miocene, and the speculative deeper thermogenically sourced systems are also shown.

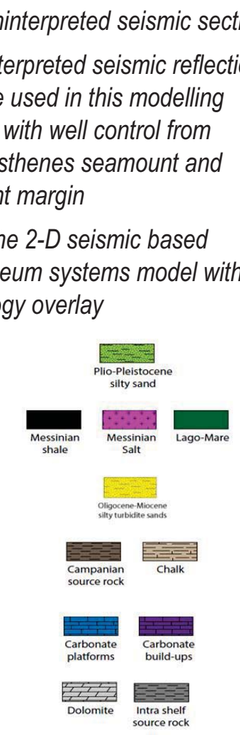


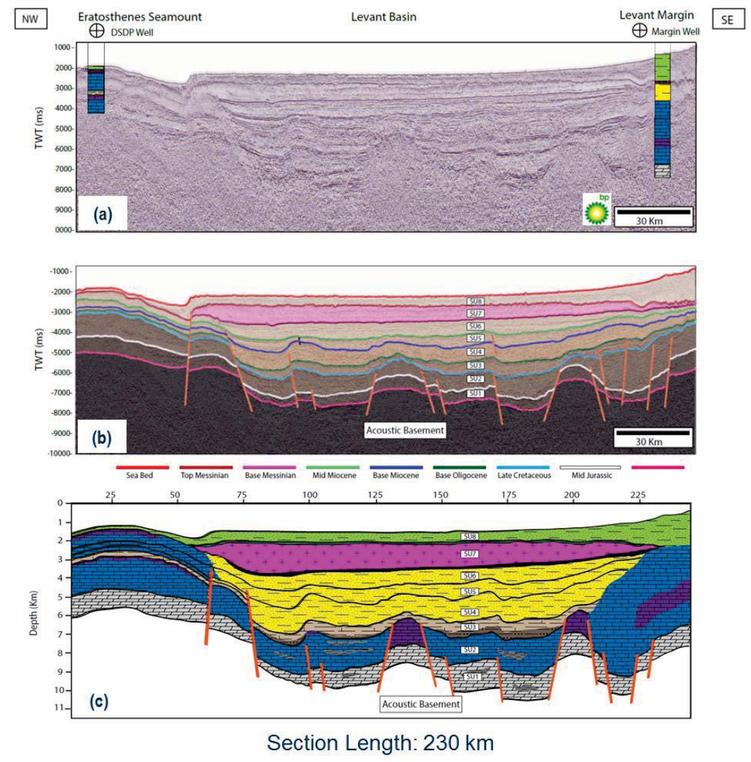
Seismic to Petroleum Systems Model

(A) uninterpreted seismic section

(B) interpreted seismic reflection profile used in this modelling study with well control from Eratosthenes seamount and Levant margin

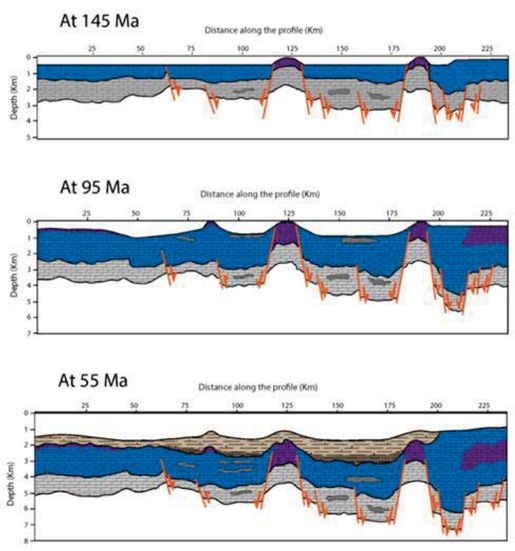
(C) The 2-D seismic based petroleum systems model with lithology overlay

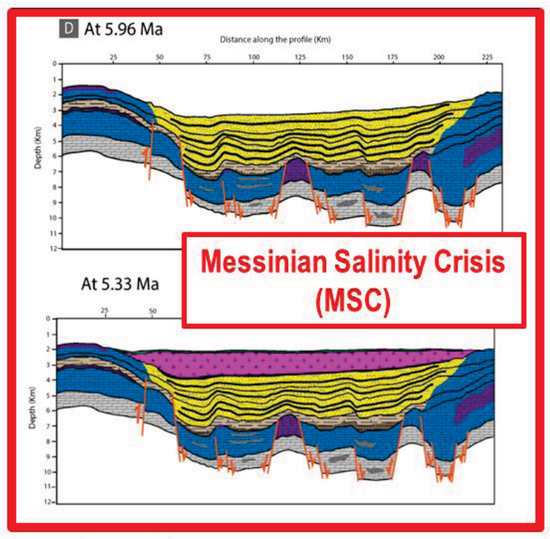




Section Length: 230 km

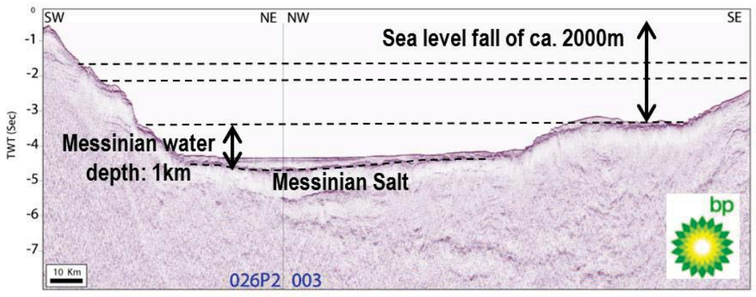
Reconstruction of Basin Geometry



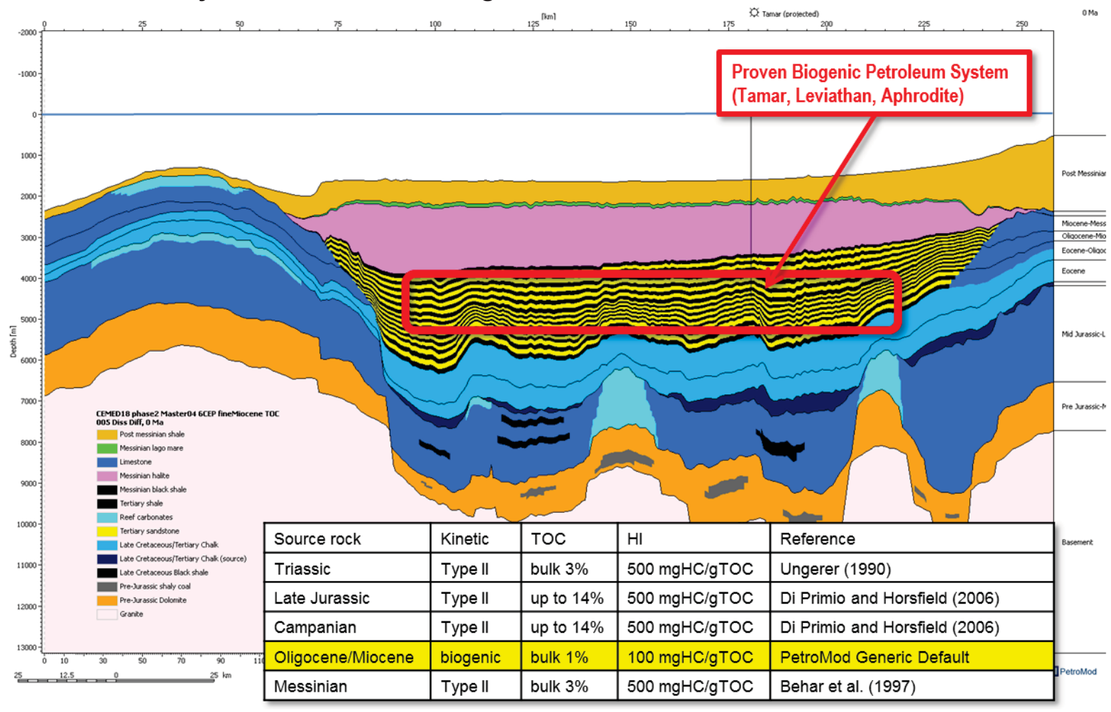


In the Late Jurassic, shallow marine carbonates dominated with build-ups on the structural highs. In the Late Cretaceous, some of the earlier rift structures were inverted and anticlines developed. In the Late Cretaceous-Eocene, organic rich source rock and chalk were deposited, followed by the Messinian Salinity Crisis (MSC):

Messinian Salinity Crisis key parameters (Fraser 2011):



2D Petroleum Systems Model – Lithologies and Source Rocks



Source rock	Kinetic	TOC	HI	Reference
Triassic	Type II	bulk 3%	500 mgHC/gTOC	Ungerer (1990)
Late Jurassic	Type II	up to 14%	500 mgHC/gTOC	Di Primio and Horsfield (2006)
Campanian	Type II	up to 14%	500 mgHC/gTOC	Di Primio and Horsfield (2006)
Oligocene/Miocene	biogenic	bulk 1%	100 mgHC/gTOC	PetroMod Generic Default
Messinian	Type II	bulk 3%	500 mgHC/gTOC	Behar et al. (1997)

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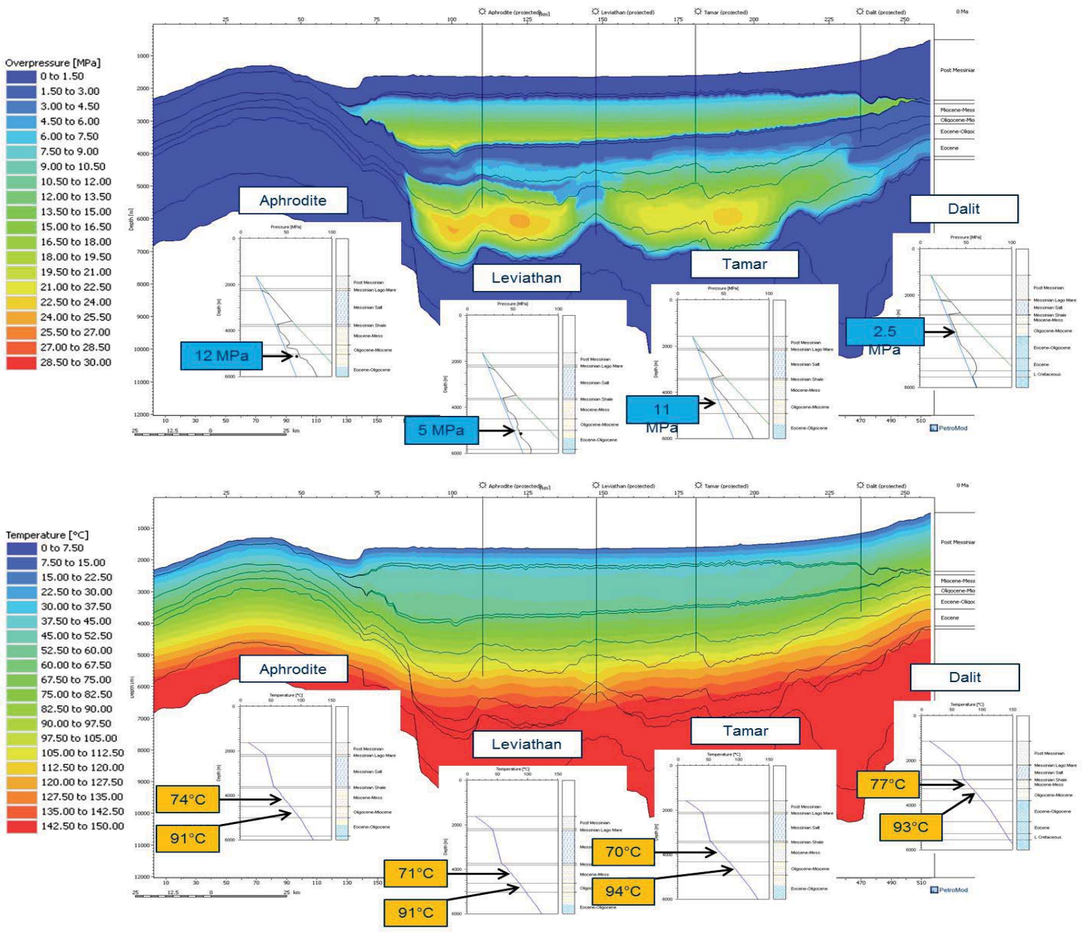
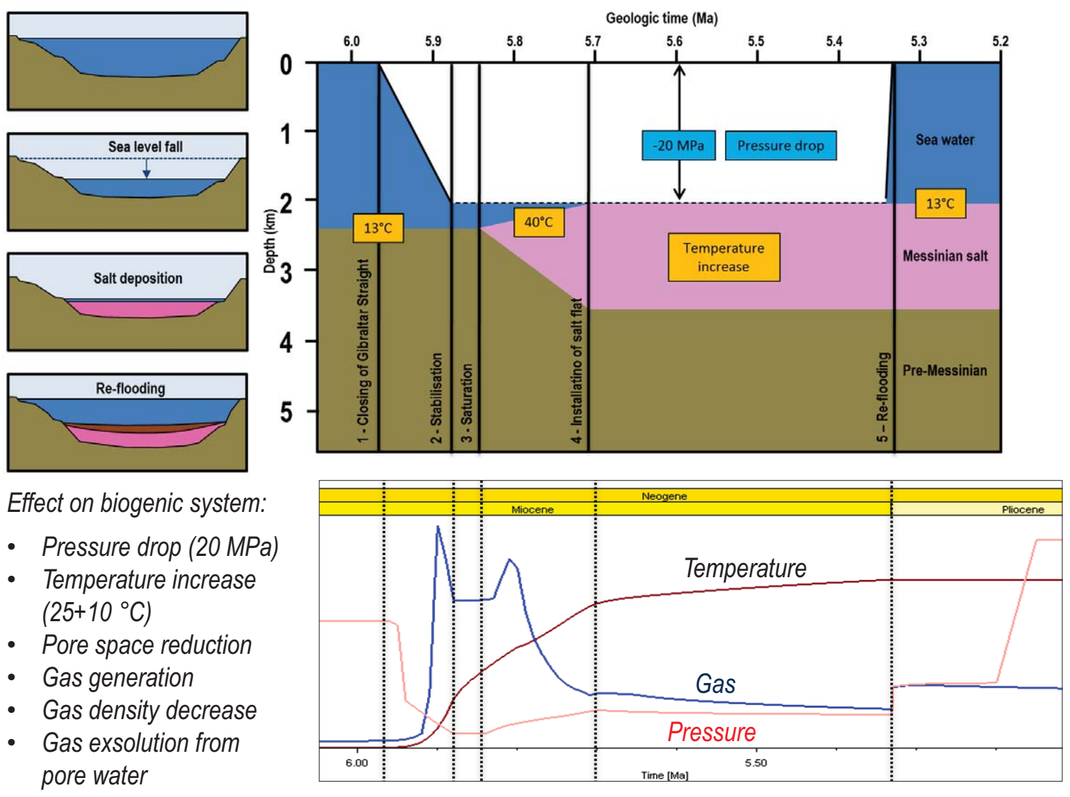
Modeled and Calibrated Pressures and Temperatures at Present



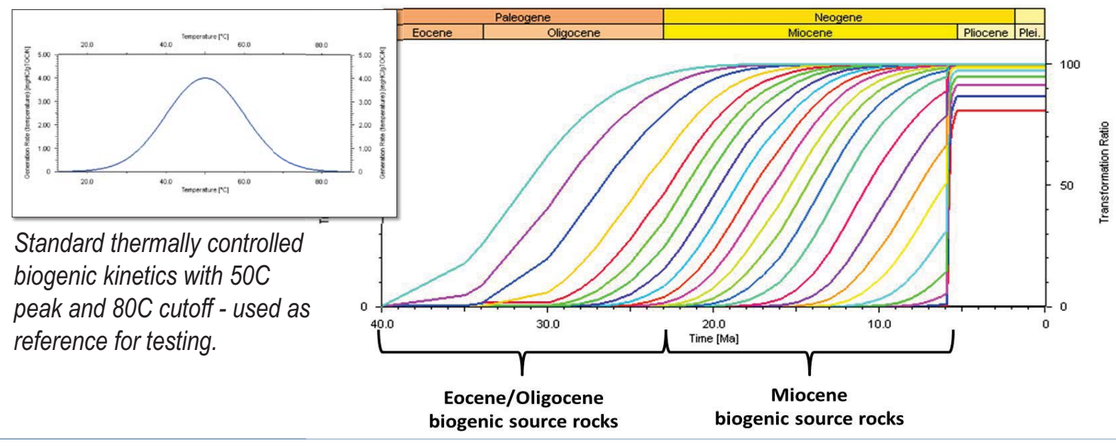
Messinian Sea Level Changes – Concept and Effects



Effect on biogenic system:

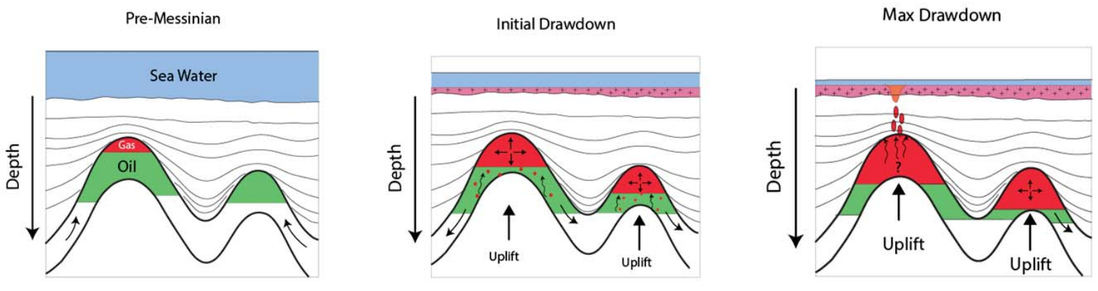
- *Pressure drop (20 MPa)*
- *Temperature increase (25+10 °C)*
- *Pore space reduction*
- *Gas generation*
- *Gas density decrease*
- *Gas exsolution from pore water*

Biogenic Gas Generation Modeling – Kinetics and Timing Relative to MSC



Standard thermally controlled biogenic kinetics with 50C peak and 80C cutoff - used as reference for testing.

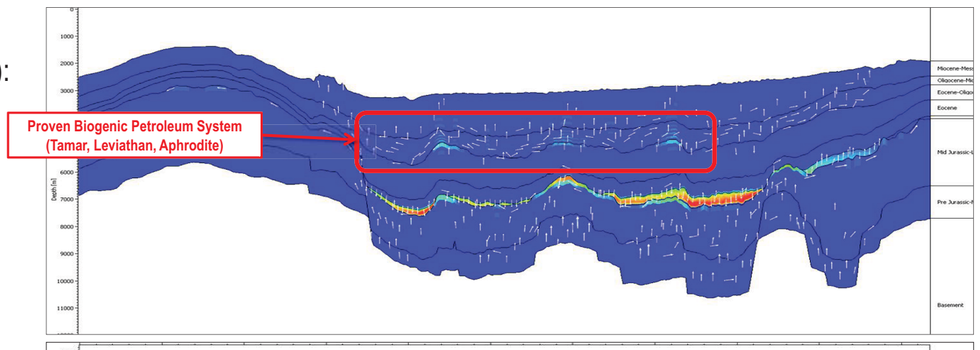
MSC Effects on PVT Conditions in Pre-Existing Reservoirs



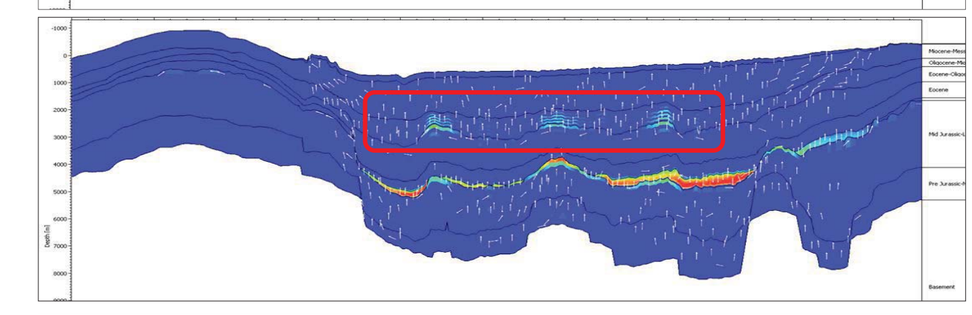
Fraser et al., 2011

Biogenic and Thermogenic Generation at Selected Key Events

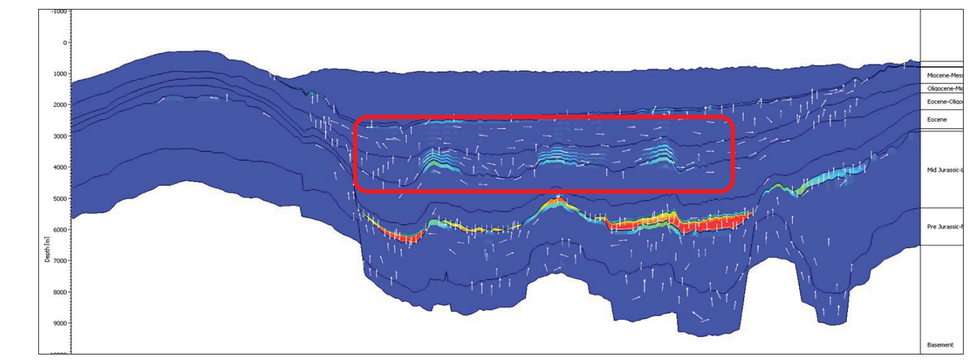
Pre-MSC (6.00 Mabp):



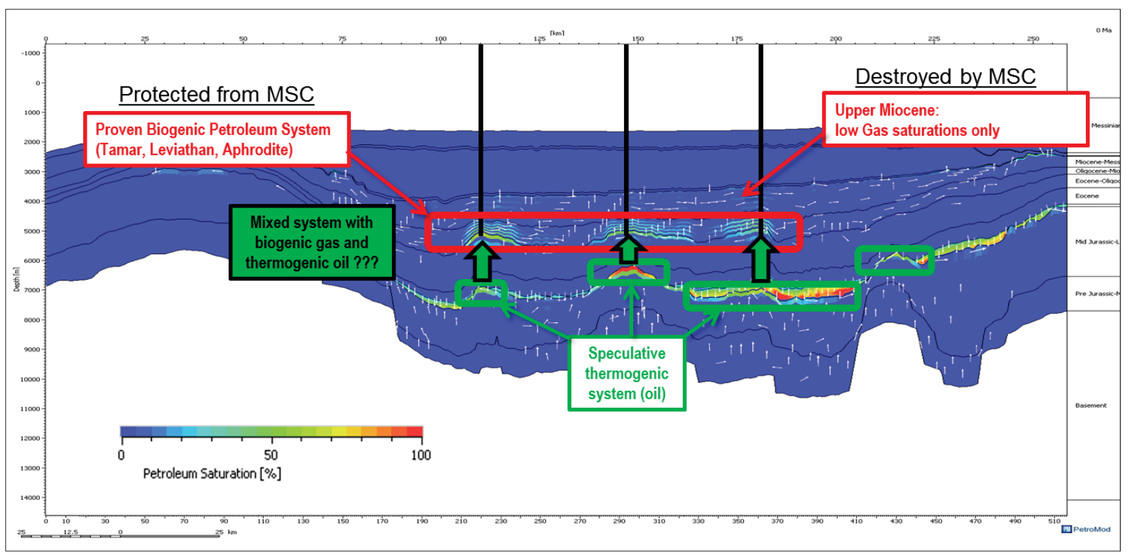
MSC (5.60 Mabp): maximum sea level reduction



MSC (5.55 Mabp): post salt deposition



Summary of Effects of MSC on Mixed Biogenic/Thermogenic System



Summary and Conclusions

The Messinian Salinity Crisis resulted in:

- Pressure drop at surface, propagated deep into the subsurface
- Temperature increase at surface, propagated into the subsurface (attenuation with depth)
- Rapid salt deposition

Likely impact on the petroleum systems:

- Shallow biogenic system (first 1000m):
  - More fluids in reduced pore space
  - Fracturing and gas leakage
- Deeper biogenic system conserved (Tamar, Leviathan, Aphrodite)
- Localized destructive impact on potential mixed biogenic/thermogenic accumulations
- Speculative deep petroleum systems are more likely to be preserved

Ongoing Investigation Tasks

Calibration:

- Temperature and Pressure Calibration
- Gas Properties incl. biogenic vs. thermogenic (condensates)

Biogenically Sourced Systems:

- Test range of biogenic models (e.g. Biogenix) and their effects on timing and generated gas
- Generation timing relative to seal quality development

Thermogenically Sourced Systems:

- Test range of potential source units and kinetics types on petroleum properties in deep targets

References:

- 2-D Basin Modeling Study of Petroleum Systems in the Levantine Basin, Eastern Mediterranean, Lisa Marlow, Kristijan Kornpihl and Christopher G. St. C. Kendall, GeoArabia, vol.16, No.2, 2011
- The Impact of the Messinian Salinity Crisis on the Petroleum System of the Eastern Mediterranean: A Critical Assessment using 2D-Petroleum System Modelling, Abdulaziz Al-Balushi, Martin Neumaier,, Alastair J. Fraser and Christopher A-L. Jackson, publication in preparation!

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