Petroleum System Modeling offshore Israel-Impact on Southeastern Levant Basin Oil and Gas Prospectivity

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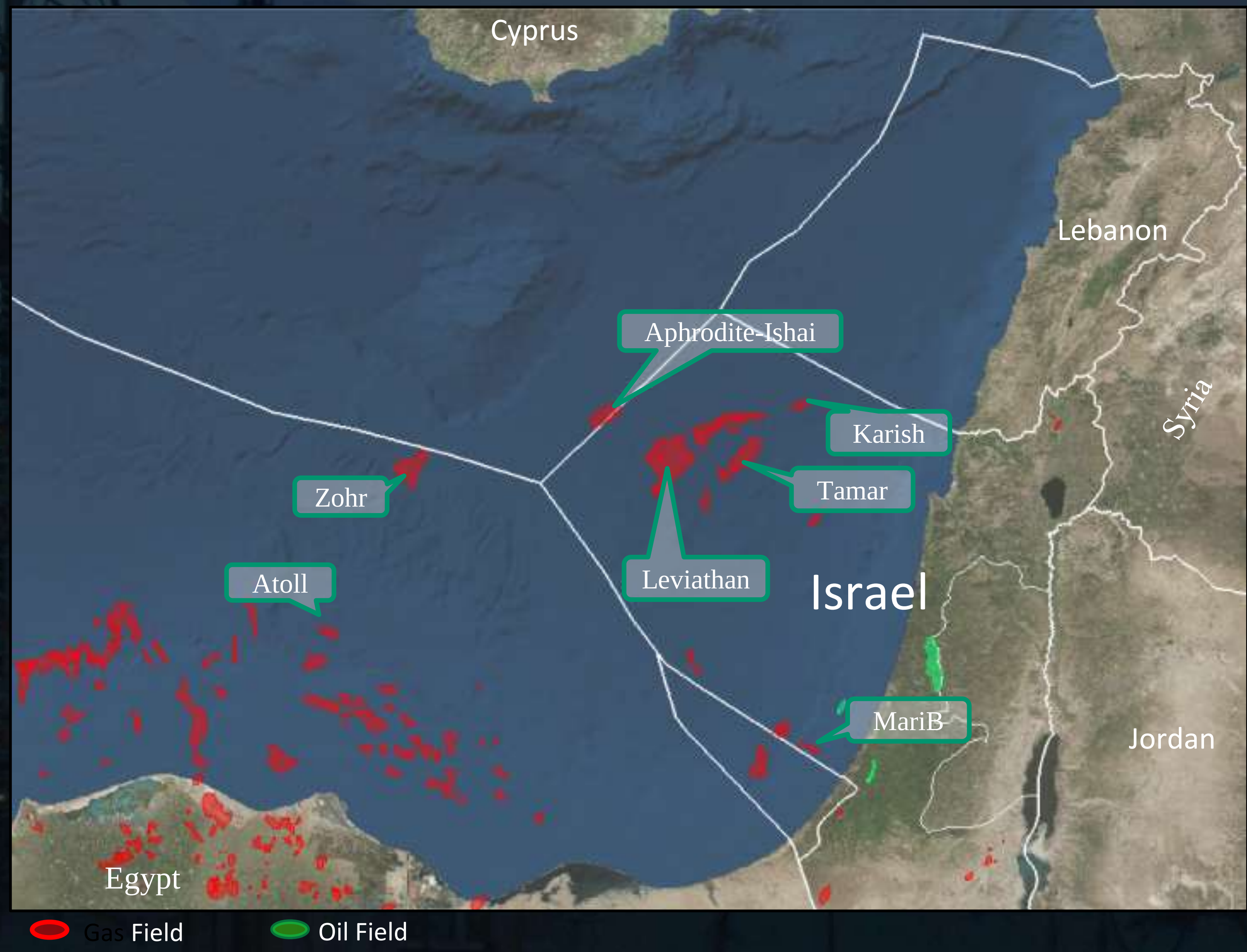
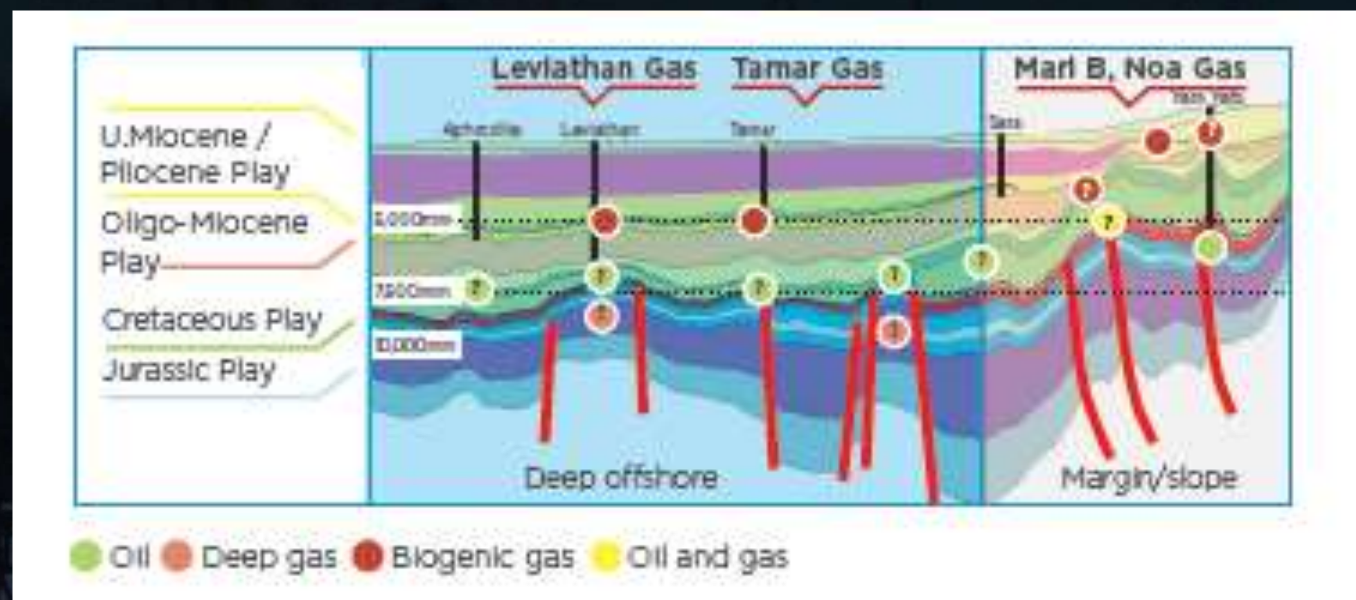
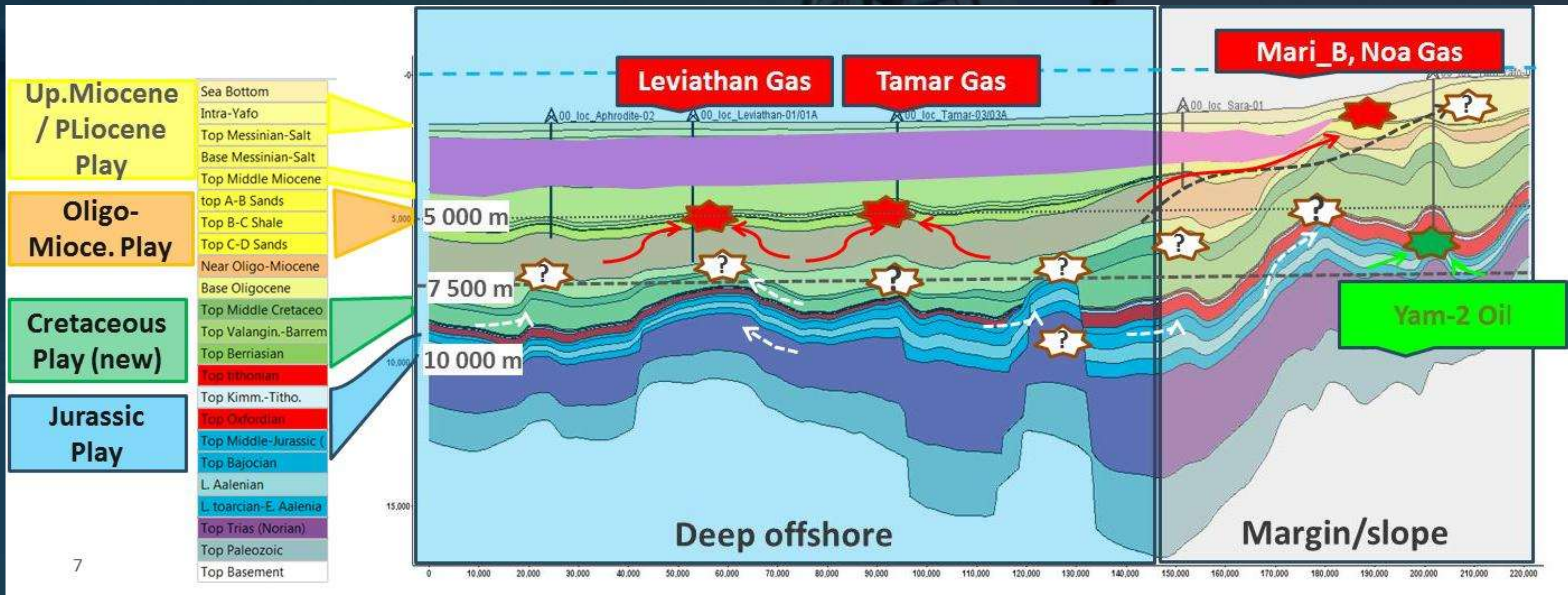
Project Objectives

- The Levant Basin is a proven gas province offshore Israel, Cyprus and Egypt
- Numerous oil shows have also been reported near shore Israel and offshore N. Sinai.
- The Ministry of Energy contracted BeicipFranlab in 2015 to perform a Basin Analysis and Petroleum system modeling offshore Israel
- The project was aimed at providing a consistent scheme of oil and gas distribution, through 1D, 2D and 3D modeling, namely:
  - Reservoir/seal distribution
  - Source-rocks occurrence
  - Oil and Gas charge





Main Petroleum plays of the Levant Basin



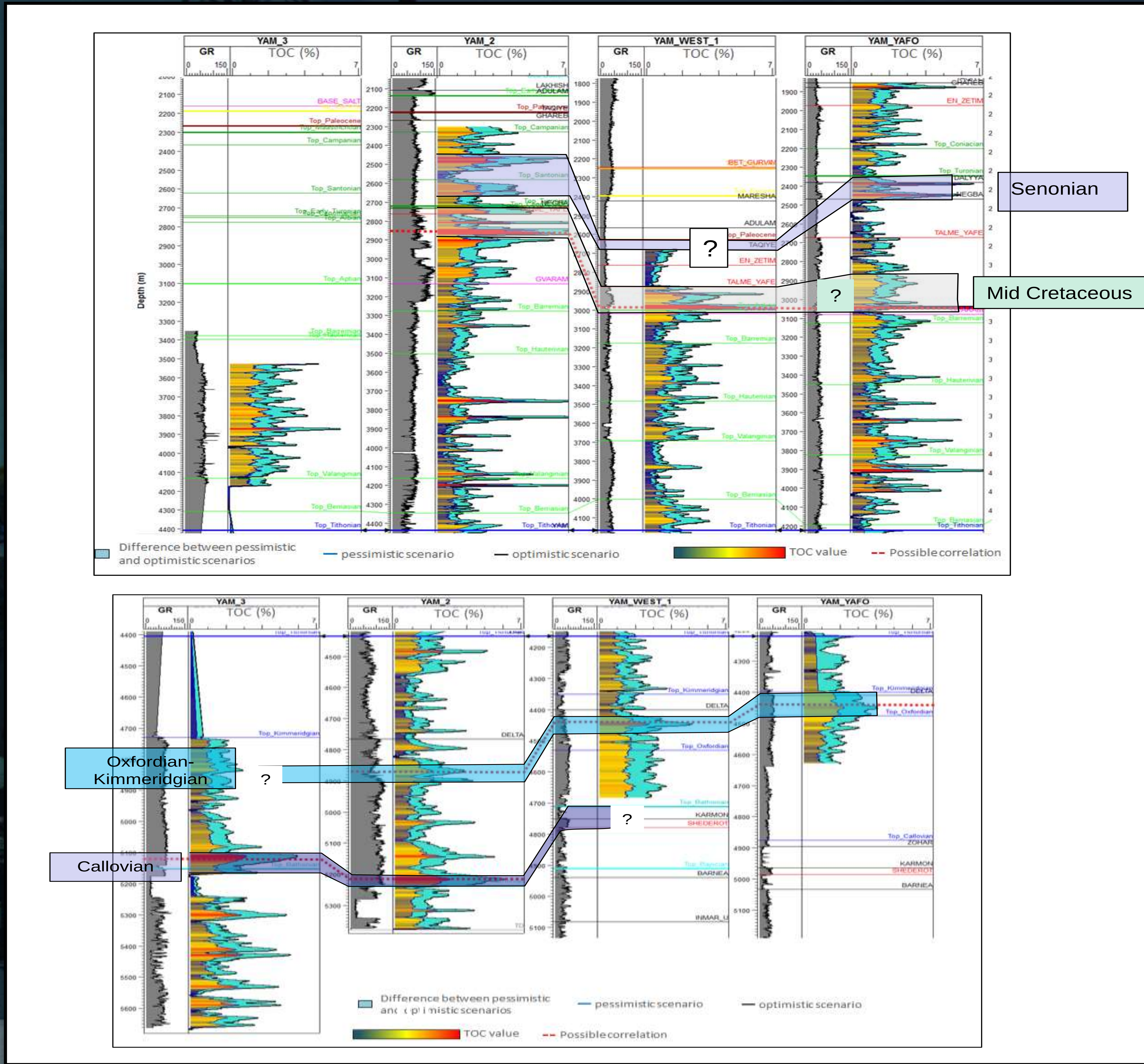
Plays / Elements	*Source Rock*	*Reservoir Rock*	*Seal*
Pliocene	**Upper-Miocene Type III**	**Turbidite Sands above Messinian unc.**	**Pliocene shales**
Mid-Upper Miocene	**Intermediate Shale Type III**	**Turbidite Sands**	**Messinian salt**
Oligo- Miocene	**Oligocene Baffle shale Type III Early Gas**	**Turbidite Sands (ABCD reservoir)**	**Middle Miocene shale**
Lower Cretaceous	**Upper Jurassic (Kimm.) Type II**	**Turbidites Sands**	**Middle-Upper Cretaceous shale**
Middle Jurassic	**Middle/Upper Jurassic. Type II ?**	**Fractured Carbonates**	**Upper Jurassic/Lower Cretaceous shale**

Mesozoic Source-rocks (Carbolog Analysis)

- Wells on the slope indicate TOC rich levels that can be correlated stratigraphically

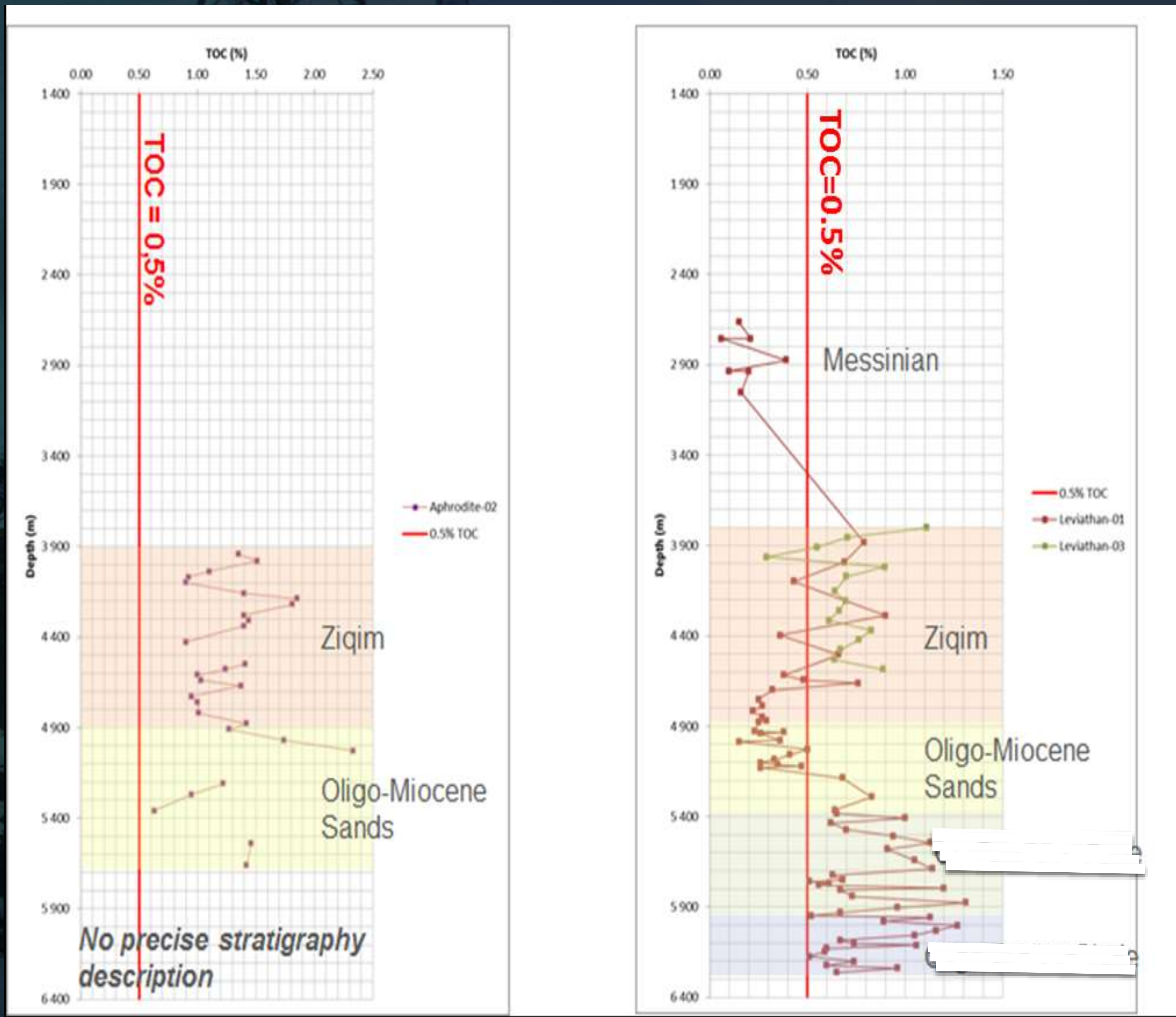
- Senonian
- Mid Cretaceous
- Oxfordian-Kimmeridgian
- Callovian

- TOC up to 3%
- Type II and III



Tertiary Source-rocks

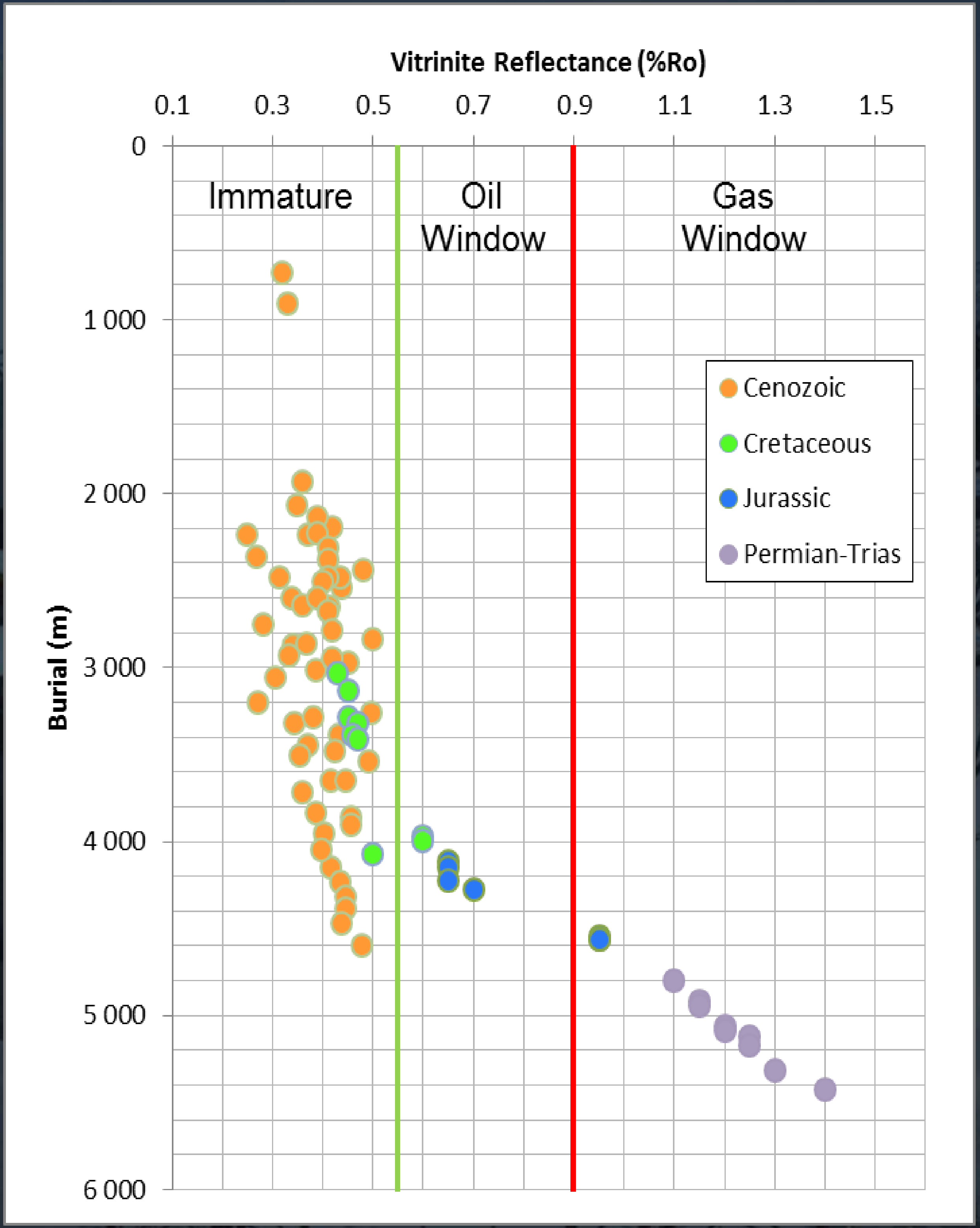
- Wells in the basin show TOC values in the range of 0.5% - 1.5%, which are considered favorable for biogenic gas generation, in Upper Miocene and Oligocene strata



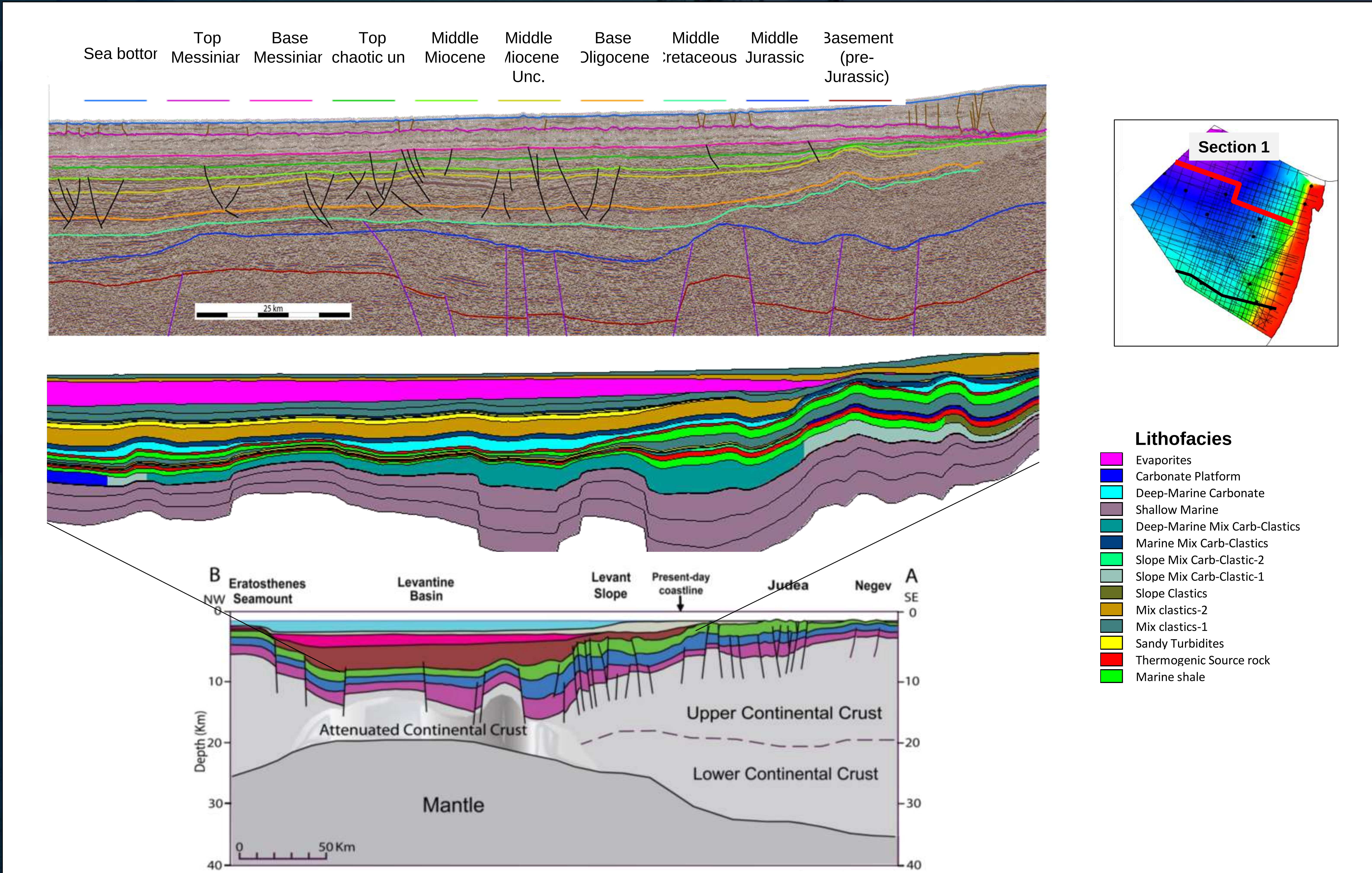
1D Data and Modeling - Thermal Regime

- Present day thermal regime in the Levant Basin is characterized by:
  - Average to high Geothermal Gradient nearshore and onshore (28°C/km - 35 °C/km)
  - Low Geothermal Gradient in the deep offshore (20-22°C/km)

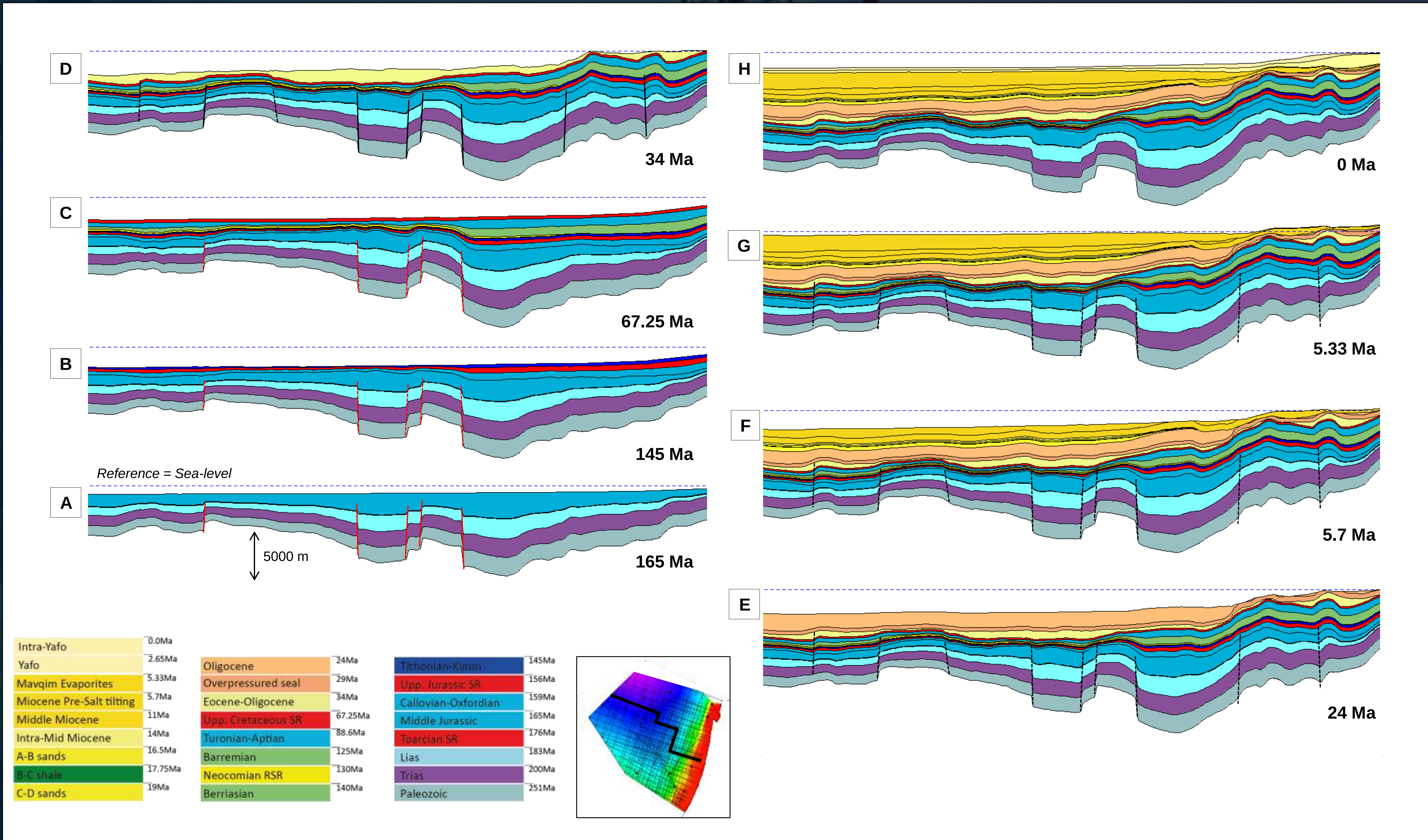
- Low GG in deep offshore is the results of:
  - High sedimentation rate
  - Salt presence (highly conductive)
  - thinned Crust (with low crustal radiogenic contribution)



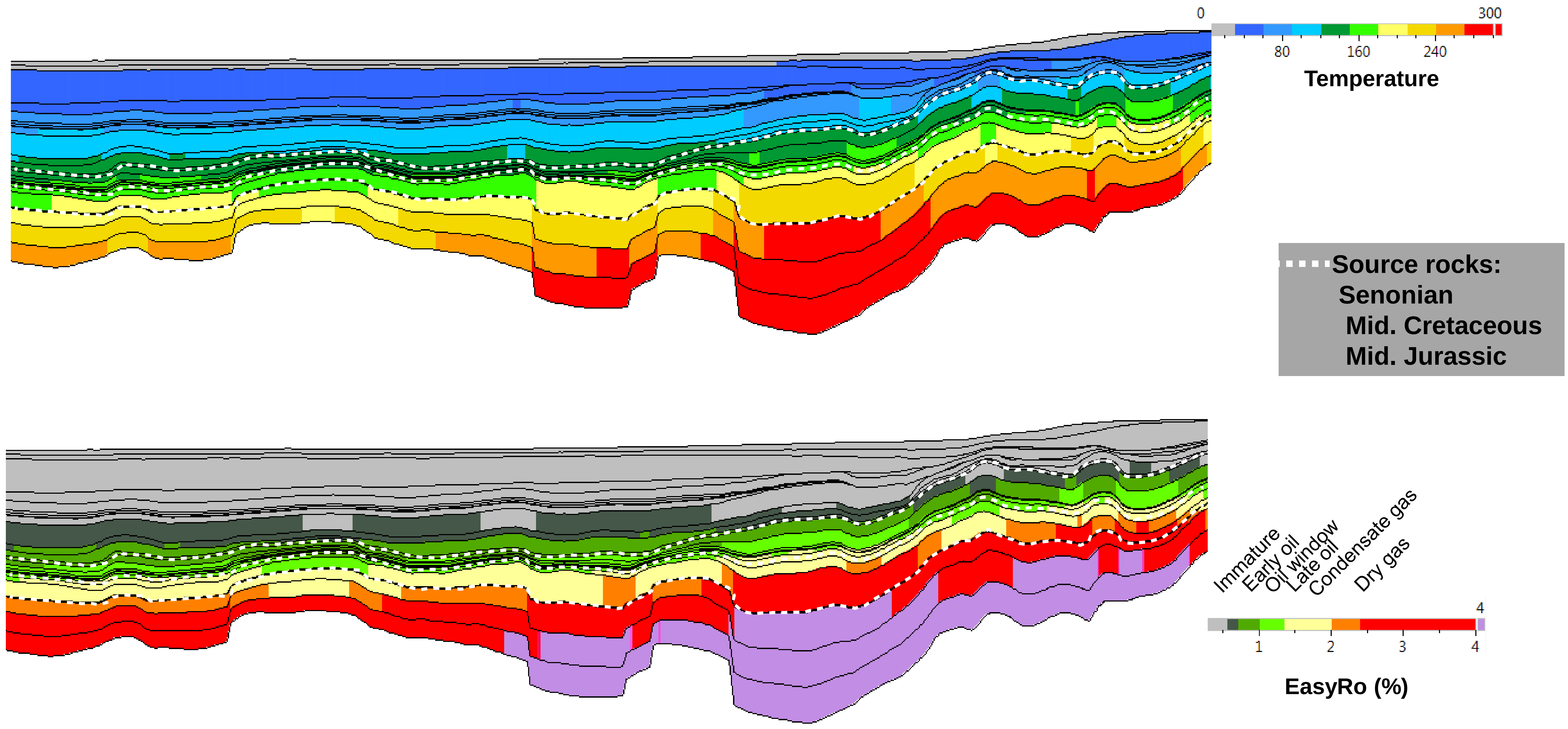
2D Modeling


Sea bottor
Top Messiniar
Base Messiniar
Top chaotic un
Middle Miocene
Middle Miocene Unc.
Base Oligocene
Middle Cretaceous
Middle Jurassic
Basement (pre-Jurassic)
25 km
Section 1
Lithofacies
Evaporites
Carbonate Platform
Deep-Marine Carbonate
Shallow Marine
Deep-Marine Mix Carb-Clastics
Marine Mix Carb-Clastics
Slope Mix Carb-Clastic-2
Slope Mix Carb-Clastic-1
Slope Clastics
Mix clastics-2
Mix clastics-1
Sandy Turbidites
Thermogenic Source rock
Marine shale
B
NW
Eratosthenes Seamount
Levantine Basin
Levant Slope
Present-day coastline
Judea
Negev
A
SE
Upper Continental Crust
Attenuated Continental Crust
Lower Continental Crust
Mantle
Depth (Km)
0 10 20 30 40
0 50 Km

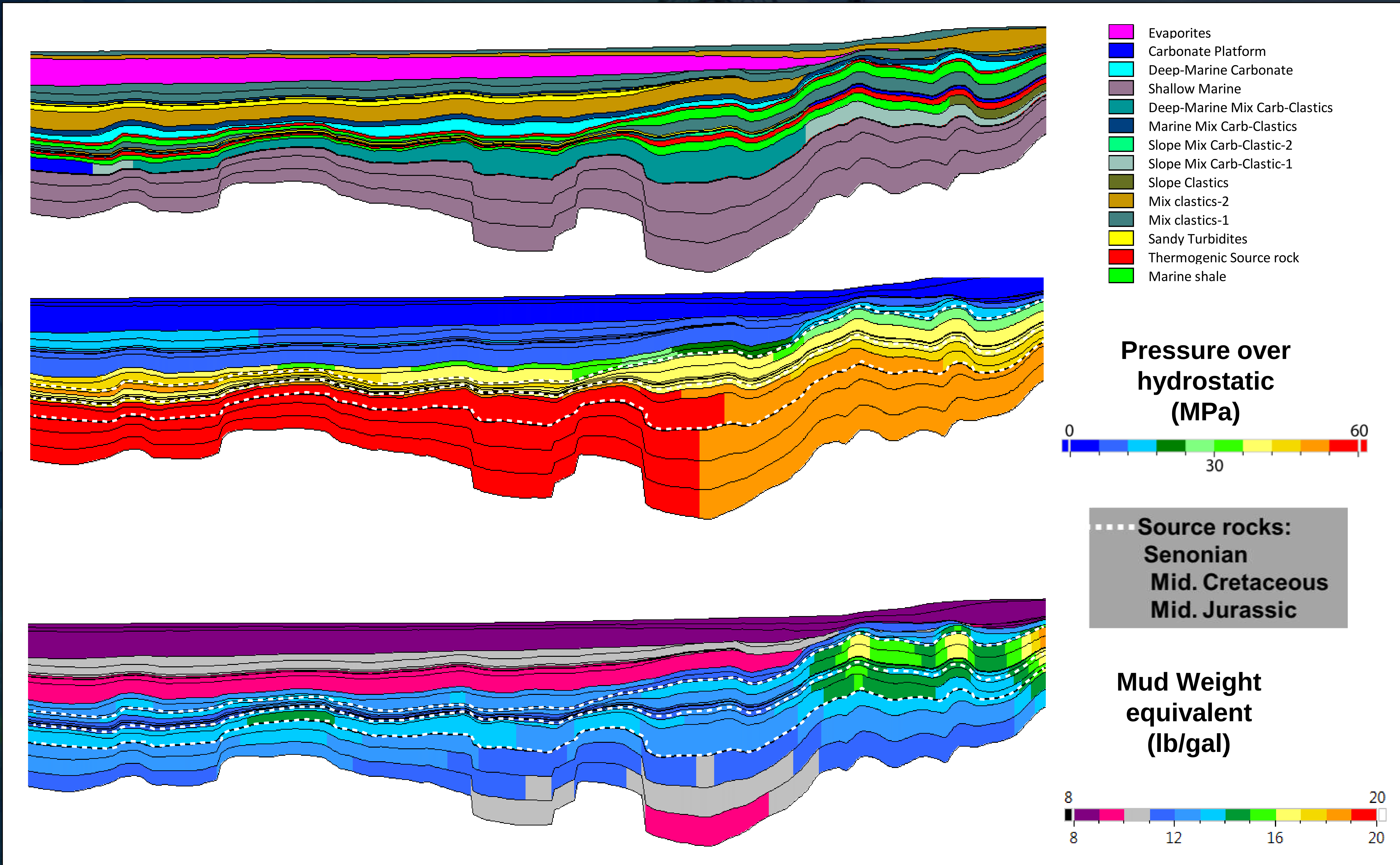
2D Structural Evolution using Backstripping Algorithm



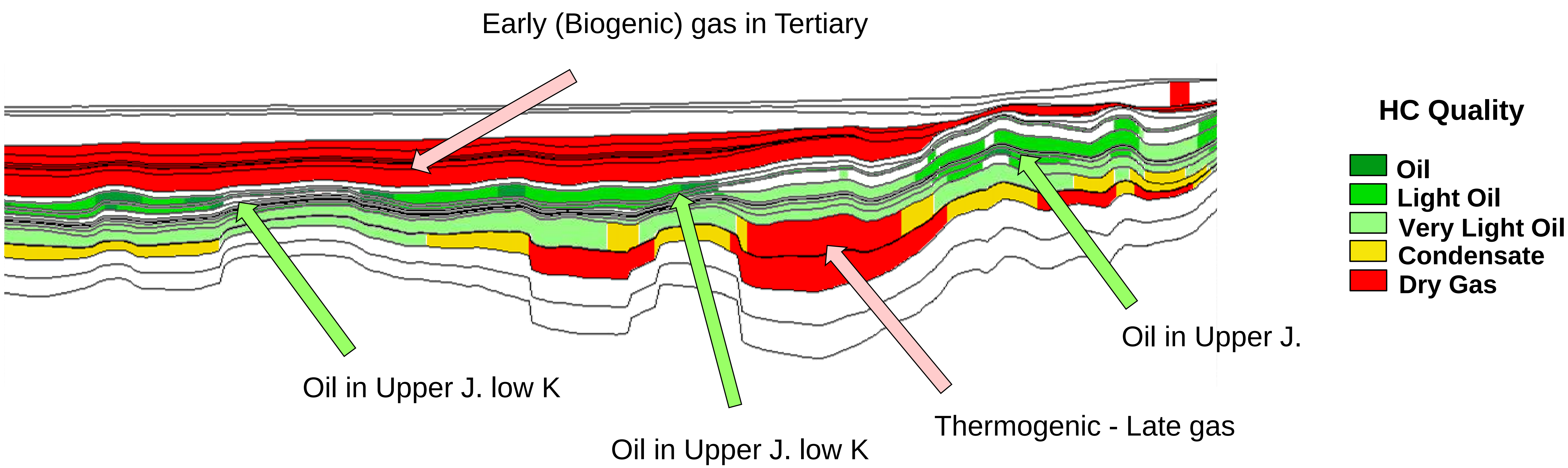
2D Maturity and HC generation setting



2D Overpressure Modeling



Oil and Gas Distribution



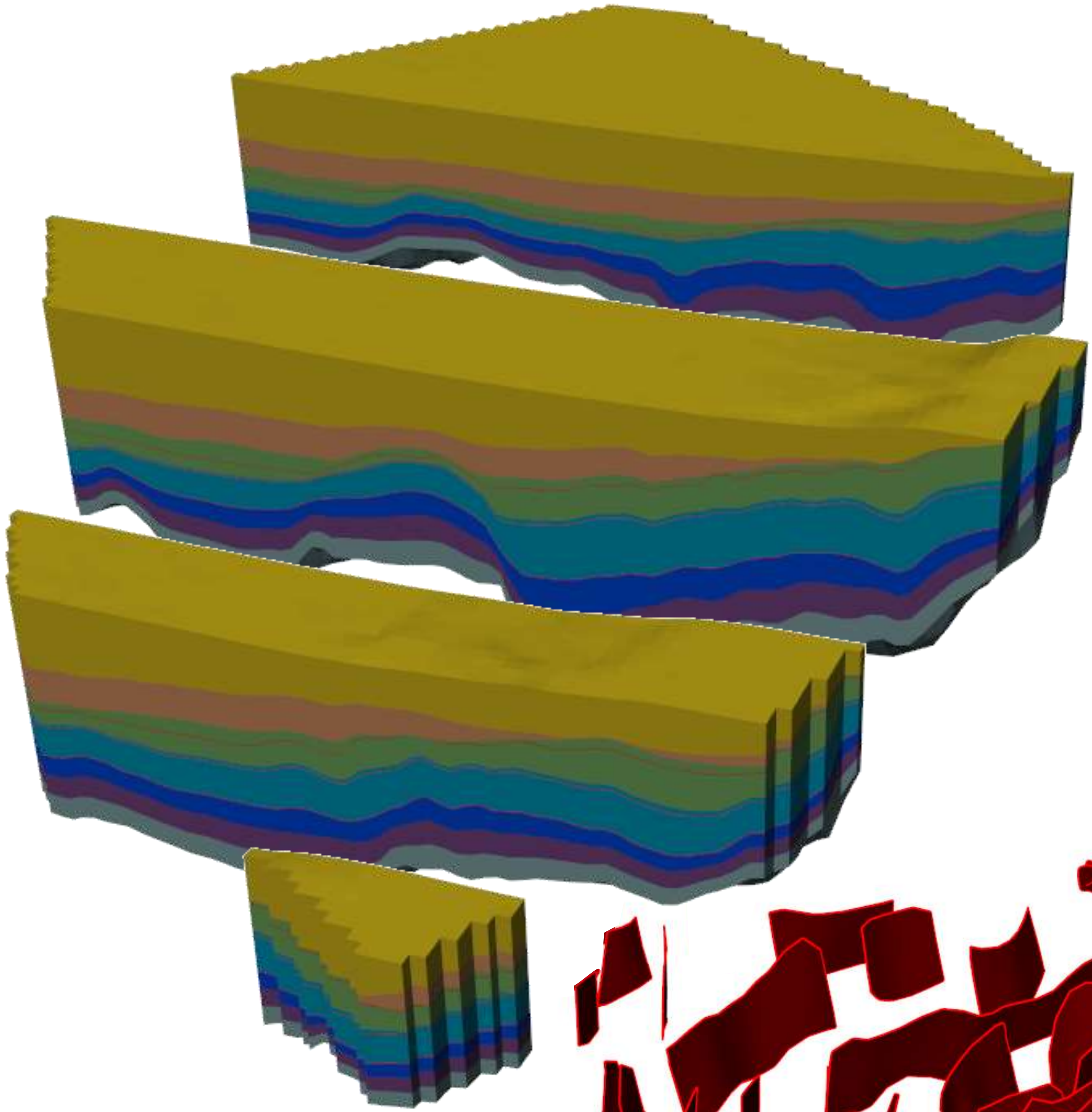
- Oil and gas quality derived from compositional modeling of HC generation/expulsion and migration
- Tertiary system sourced by TOC lean source-rocks (early gas prone)
- Mesozoic system oil sources mainly by Middle-Upper Jurassic source-rock
- No communication between Mesozoic system (oil and gas prone) and Tertiary system (early gas prone)

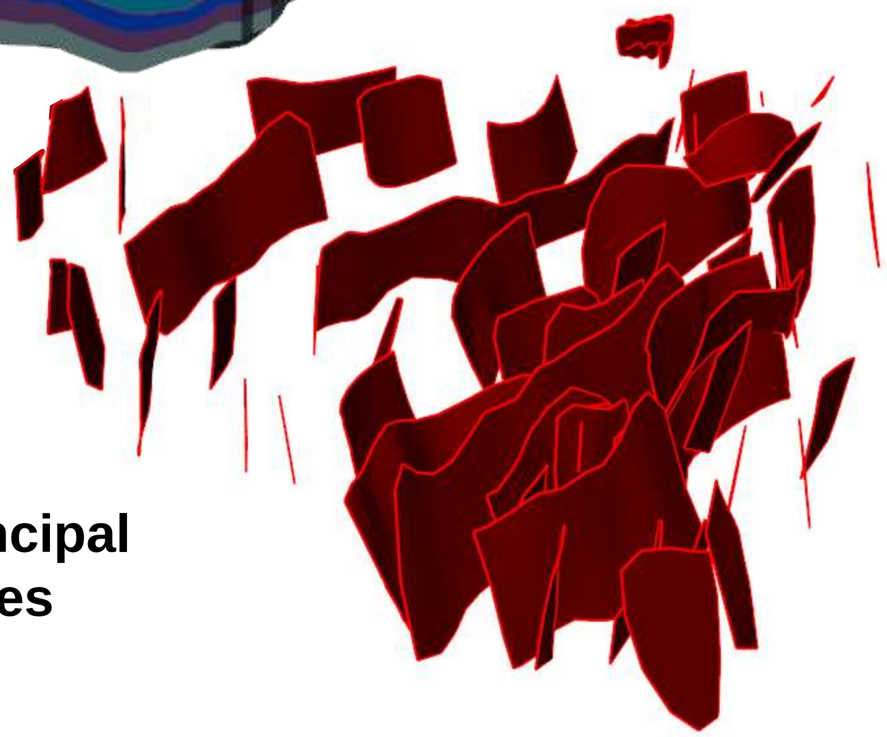
3D Modeling of HC charge

Main components of the petroleum system and layer lithologies used in the 3D model

	Period	Age (Ma)	Petroleum system			Seismic horizons	Main lithologies		
			source Rock	Reservoir	Seal		*Basin*	*Slope*	*Shelf*
26	Upper Plio-Quat	0 - 2.665				*Base Yafo*			
25	Lower Pliocene	2.665 - 5.33							
24	Messinian Evaporites	5.33 - 5.6				*Top Evaporites*			
23	Gap	5.6 - 5.7				*Base Evaporites*			
22	Tortonian-Messinian	5.7 - 11							
21	Serravalian-Langhian	11 - 14	Biogenic						
20	Intra-Middle Miocene	14 - 16.5				*Mid Miocene*			
19		16.5 - 17.75		Sand A-B					
18	Chattian-Burdigalian	17.75 - 19			B-C Shale				
17		19 - 24		Sand C-D					
16	Late Oligocene	24 - 29	Biogenic						
15	Lower Oligocene	29 - 34							
14	Senonian-Eocene	34 - 67.25				*Base Oligocene*			
13	Upper Cretaceous	67.25 - 88.6	thermogenic						
12	Turonian-Aptian	88.6 - 125				*MiddleCretaceous*			
11	Barremian	125 - 130							
10	Valanginian-Hauterivian	130 - 140		Neocomian sands					
9	Berriasian	140 - 145							
8	Kimmeridgian-Tithonian	145 - 156							
7	Oxfordian	156 - 159	thermogenic						
6	Callovian-Oxfordian	159 - 165							
5	Dogger	165 - 176		Bathonian		*Middle Jurassic*			
4	Toarcian	176 - 183	thermogenic						
3	Lias	183 - 200							
2	Trias	200 - 151							
1	Paleozoic (Permian)	151 - 300				*basement*			
	Basement								

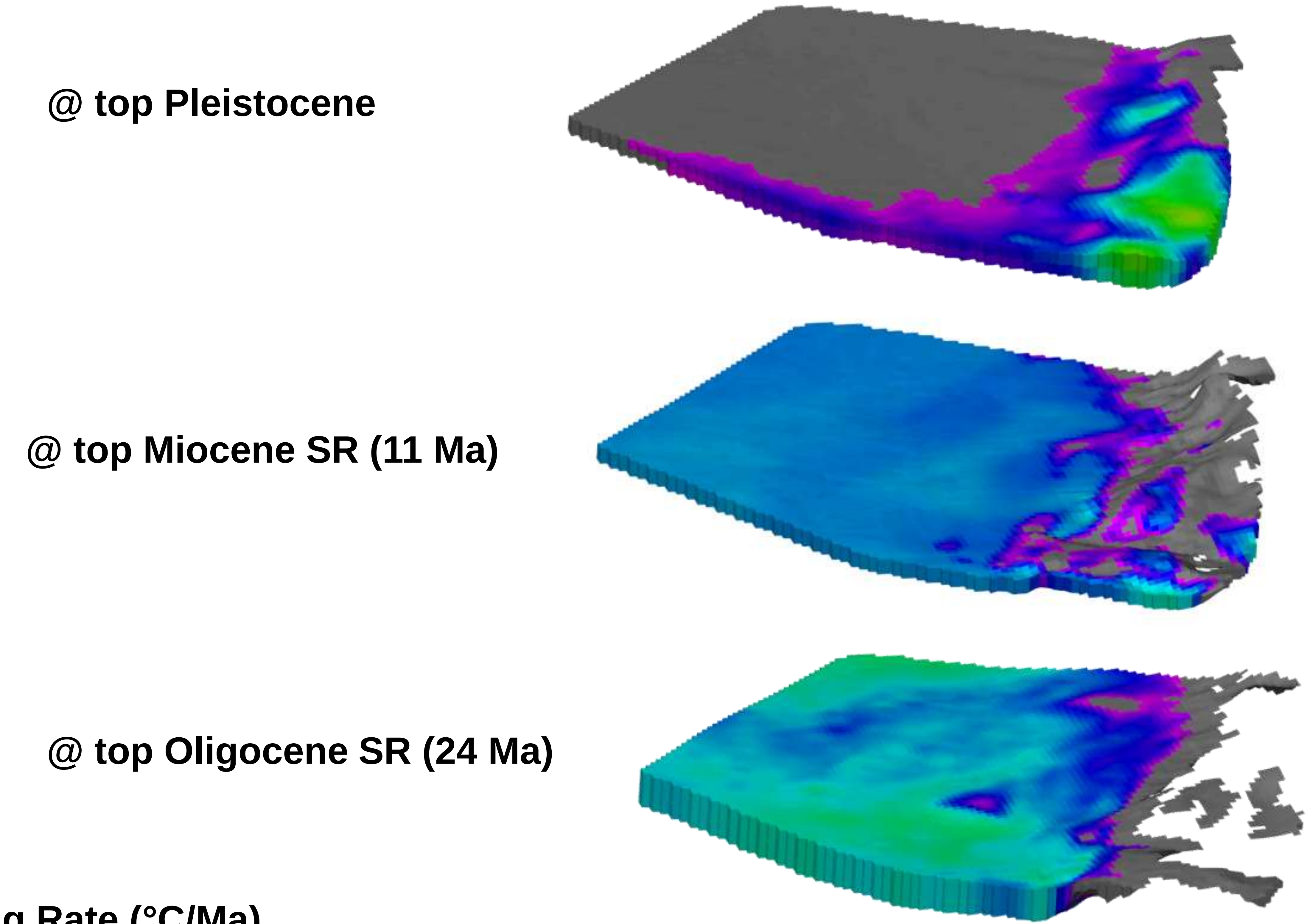
3D (fence diagram) stratigraphic view with the final block layering



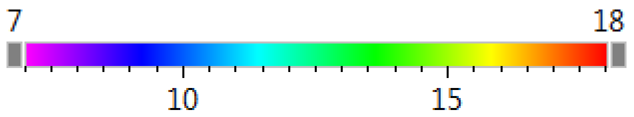


3D view of principal fault surfaces

Origin of early (biogenic gas) Heating Rate of Tertiary lean TOC shaly units during deposition

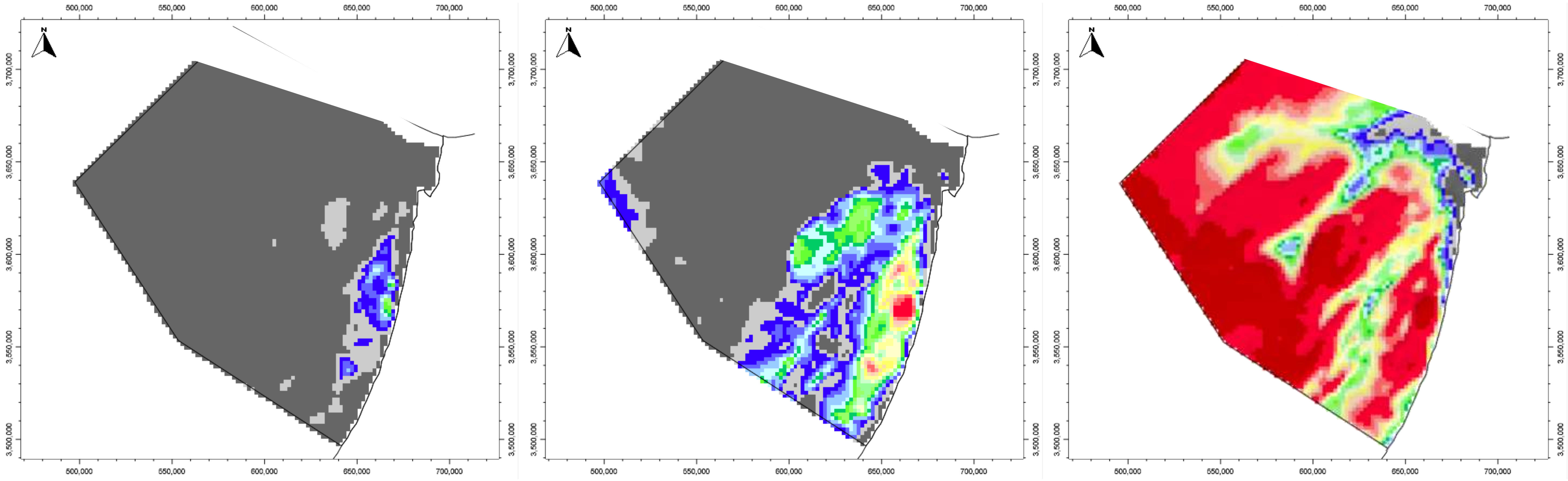


Heating Rate (°C/Ma)



- Most favorable heating rates ensuring preservation of early gas generated : 10 to 16 °C/Ma
- Sediment type (clay), Burial Rate and TOC (<1.2%) allow preservation of early gas

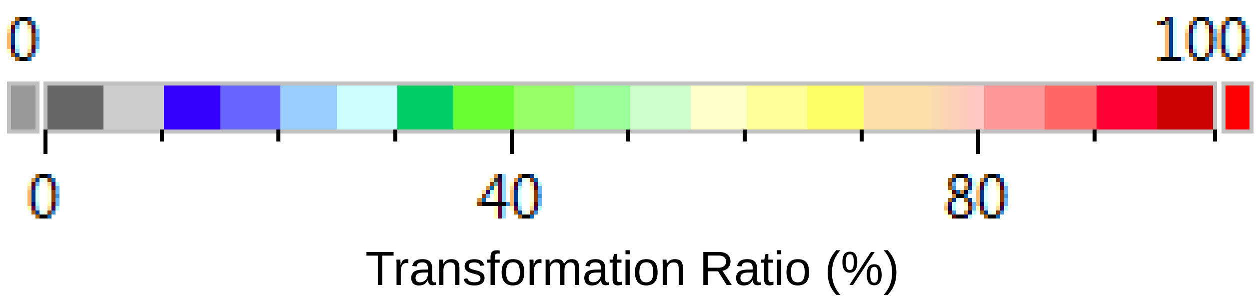
Middle-Upper Jurassic SR
Transformation Ratio through time



88.6 Ma (Early Santonian)

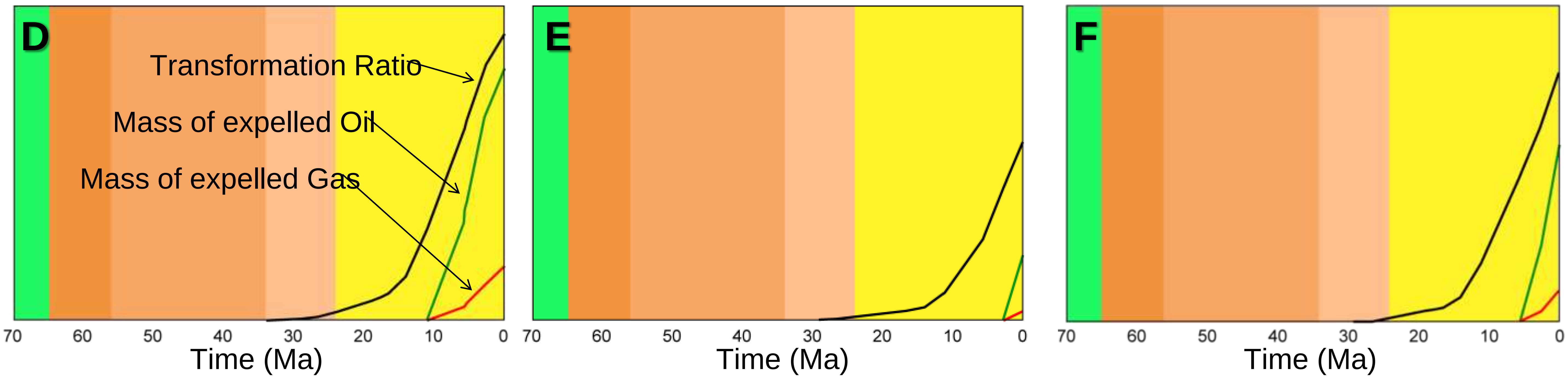
34 Ma (Base Oligocene)

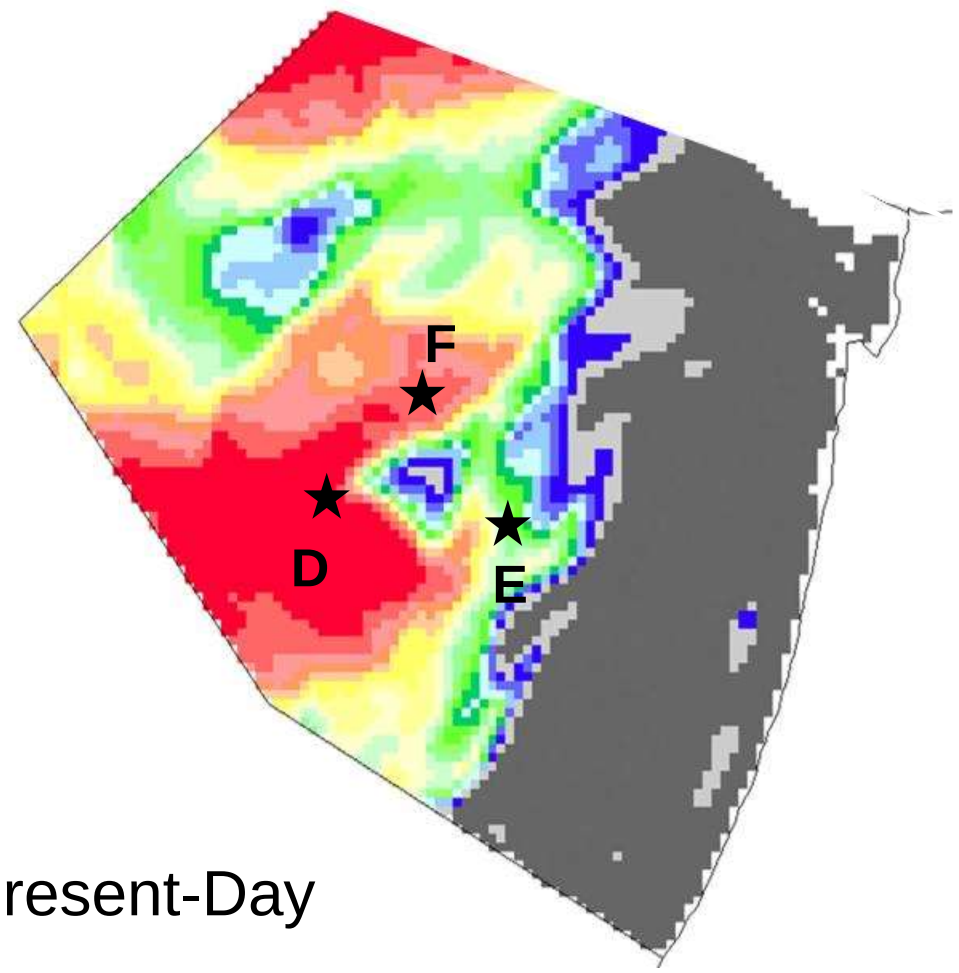
Present day



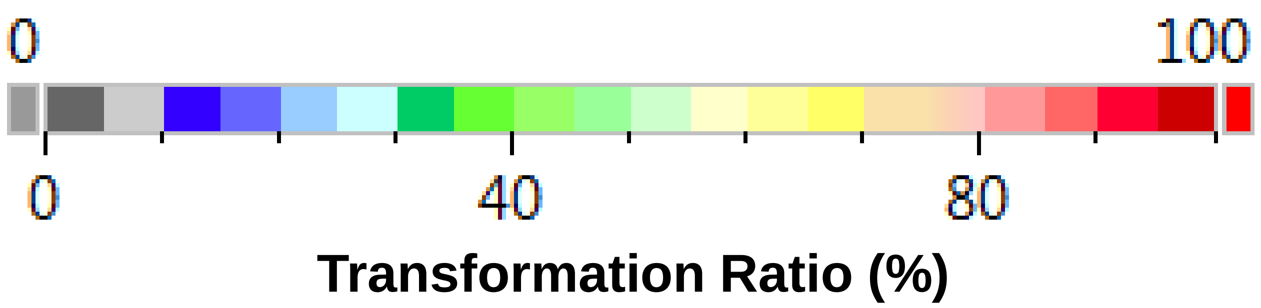
No difference between early (208-204 M) and late rifting (200-185) on Upper Jurassic maturity

Upper Cretaceous SR (Senonian-Campanian) Transformation Ratio through time

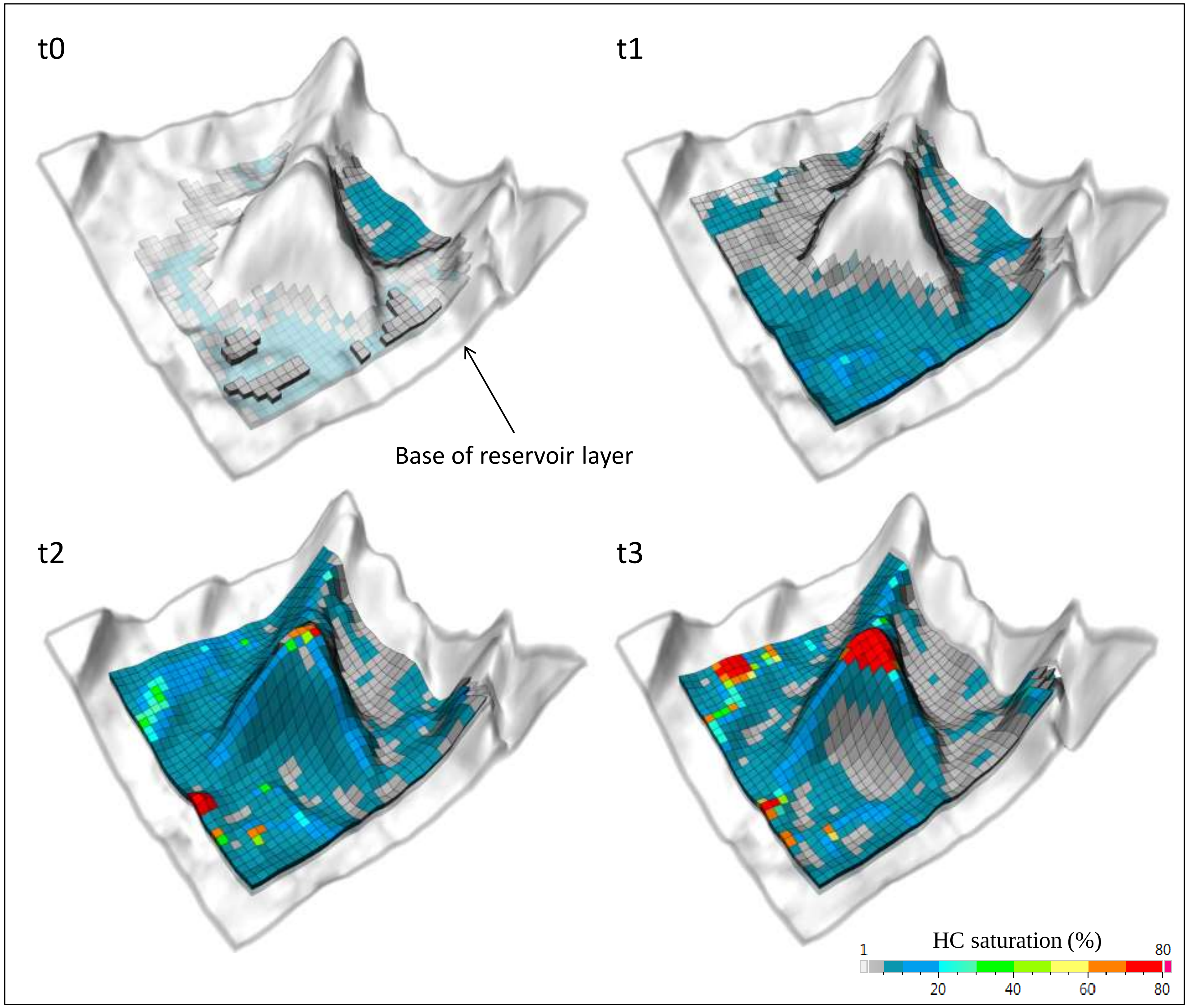




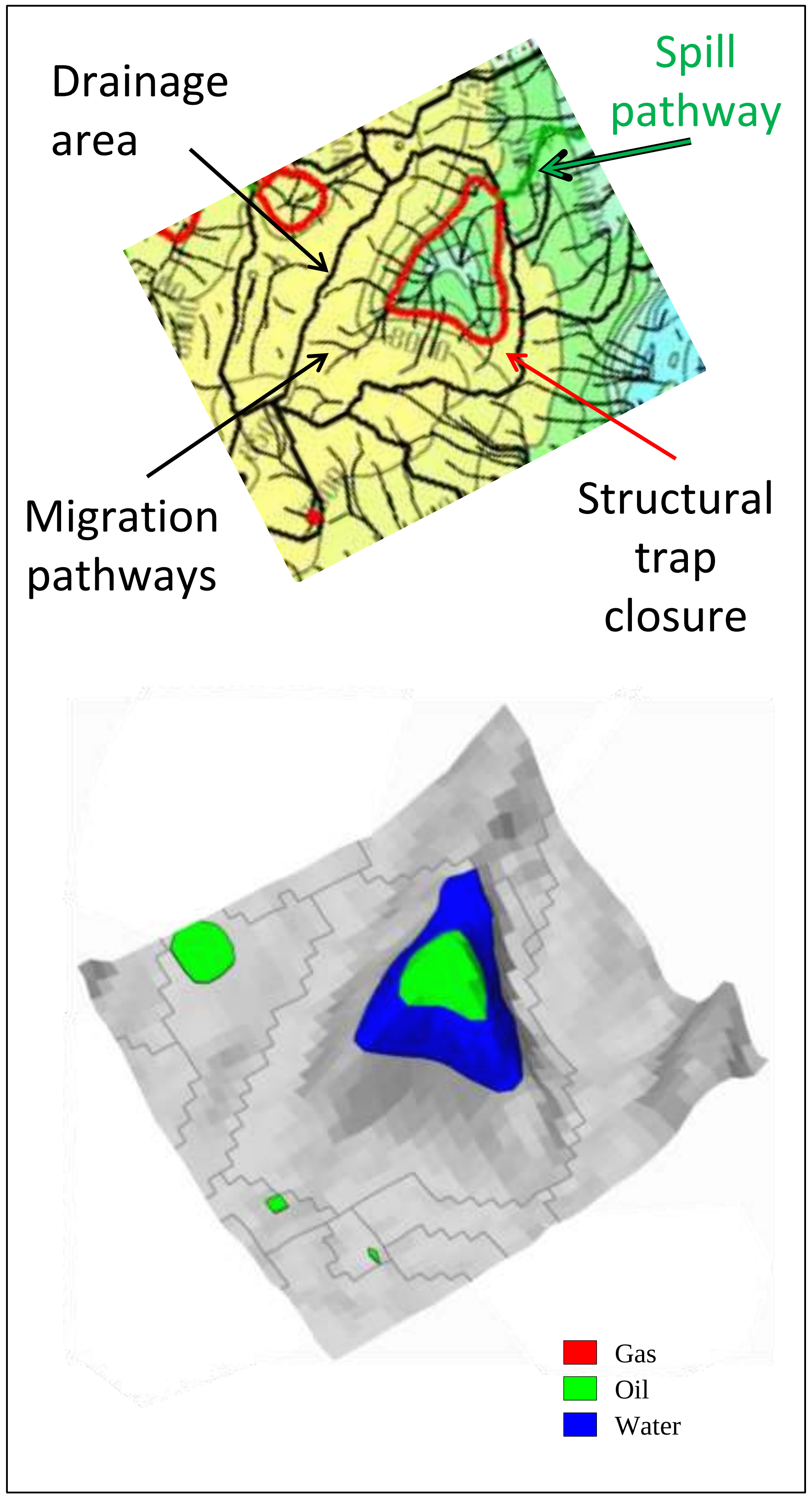
Present-Day



3D HC migration and entrapment modeling



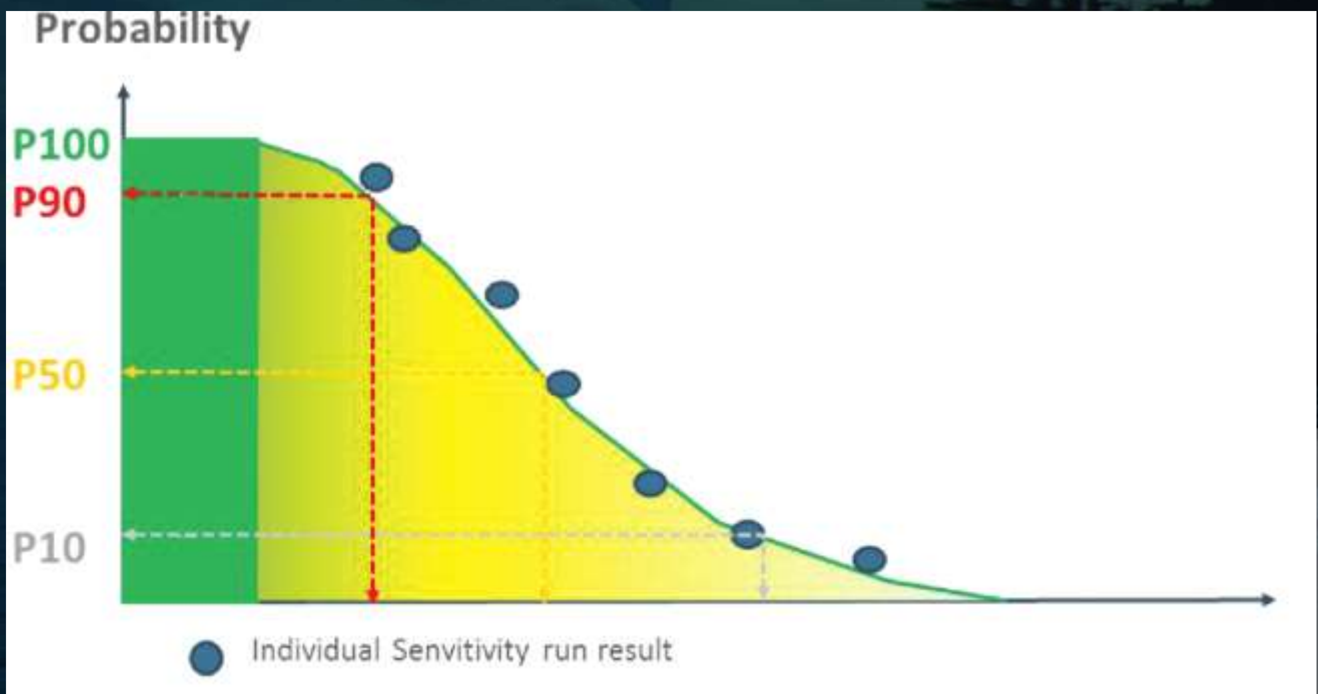
HC SATURATION Representation (through time)



Trap Fill representation (present day)

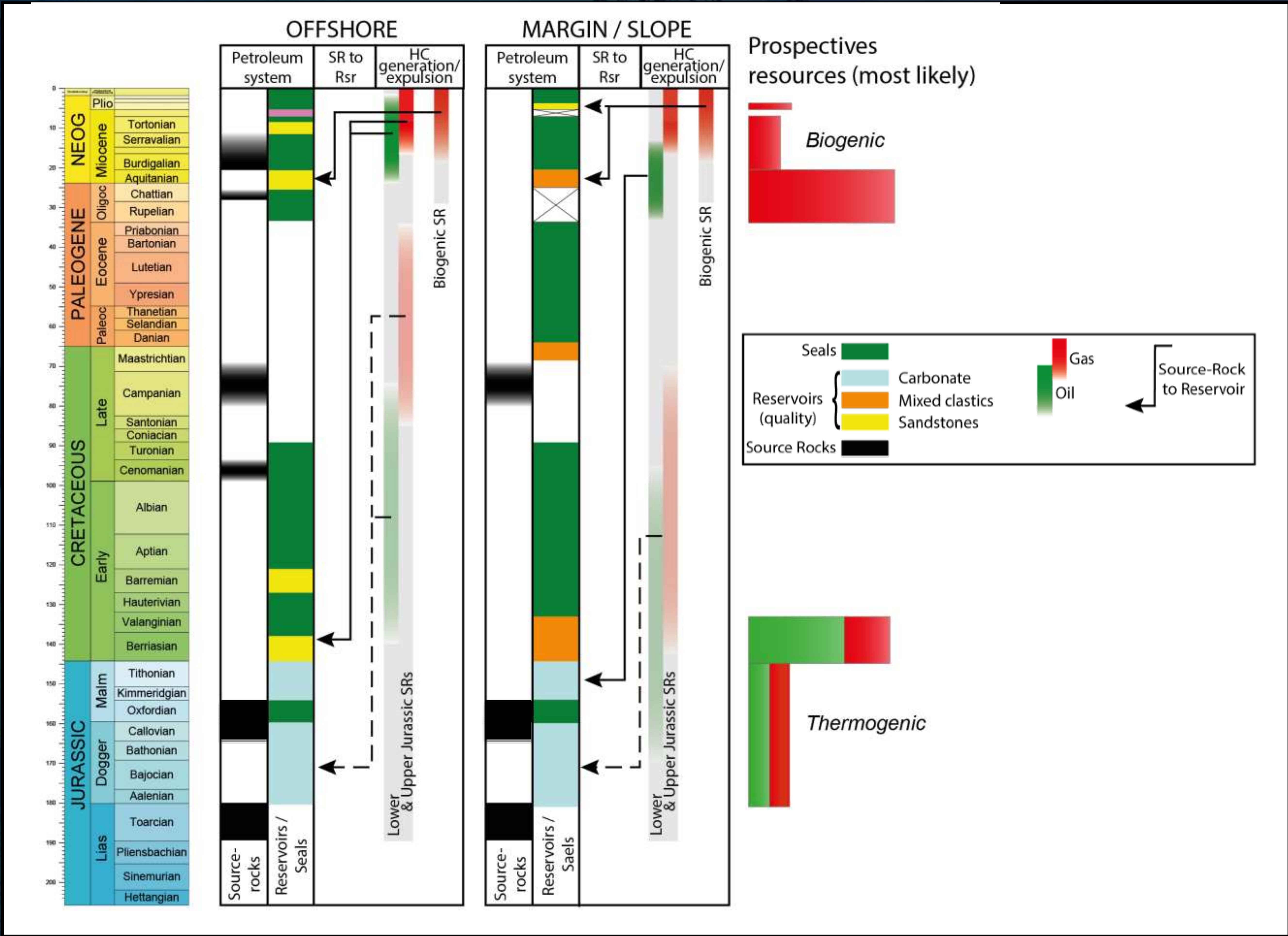
Estimation of unrisked volumes from modeling

- The unrisked volumes in place distribution can be derived from the 3D petroleum system modeling.
- Each run remains calibrated on available data (presence of oil and gas, P, T, maturity)
- The uncertainty on unrisked volumes (P90, P50 and P10) is obtained from sensitivity analysis runs on uncertain parameters such as:
  - Source-rock potential (3% to 4% for Middle-Upper Jurassic source)
  - Cutoff porosities and Net estimates in reservoir layers (5% to 10%, NTG 0.5 to 0.8)
  - HC migration parameters (capillary pressures for seals (10, 50,100 bars) , minimal HC saturation for HC movements, (2% to 5%)
  - Saturation (10 to 30%) or concentration (0.2, 0.5 or 1 T HC / m2) parameters cutoffs in traps



	TOTAL OIL	TOTAL GAS
CATEGORY of Prospective Oil and GAS		
	Billions bbl	*Billion Cu Meter*
(1) UNRISKED Volumes in Place Best guess P50 (incl. Possible + probable discovered)	26.0	7731

Petroleum system chart offshore Israel
Oil - Gas Potential Levant basin



Conclusions

- Petroleum System modeling in the Levant Basin offshore is used to constrain some key factors associated with HC generation/migration/accumulation processes
- The modeling proposes a consistent scheme of early gas charge in Tertiary accumulations, resulting from the progressive expulsion from lean shaly source-rocks
- Middle to Upper Jurassic source rocks reached high level of maturation and likely charge overlaying Lower Cretaceous sands in the deep part of the basin
- Upper Cretaceous source rocks are only partially mature
- There is high level of compartmentalization and limited connection between the deep, thermogenic systems and the shallower biogenic systems
- Large unrisked volumes of oil and gas are predicted by modeling