

# LEBANON OIL & GAS 2013 SUMMIT

BEIRUT, 22-23 APRIL, 2013

## *FROM OUTCROP TO DEEPWATER OFFSHORE LEBANON PROSPECTIVITY*

*MODEL OF SEDIMENT PROVENANCE & DISPERSAL*

**Enzo Zappaterra**



***PetroServ (CY) International, LLC.***



## ... *First offshore oil production ...*

*Using sponges to collect naphtha from the surface of the waves*



*Naphtha Bituminis est liquidi genus:  
in mare manat Montibus e' Siculis,  
fluidisque supernatat undis.*

*Spongia eam excipiunt Nautae,  
expressamque recundunt Ollis,  
ut varios hominum seruentur in usus.*

**Bitumen naphtha is a kind of liquid:  
it flows into the sea from the mountains  
of Sicily and floats on top of the waves.**

**Seamen collect it with sponges and,  
after squeezing them out, they store it  
in pots for people to use it in various ways.**

**Giovanni Stradano (1523-1605)**

Seep near Agrigento in Sicily reported in the 1<sup>st</sup> Century BC by the greek physician Dioscorides: "bitumen is found in its liquid state near Acragantium in Sicily. It floats on the surface of springs and is used in lamps instead of olive oil".

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*FRAMING THE ISSUE*

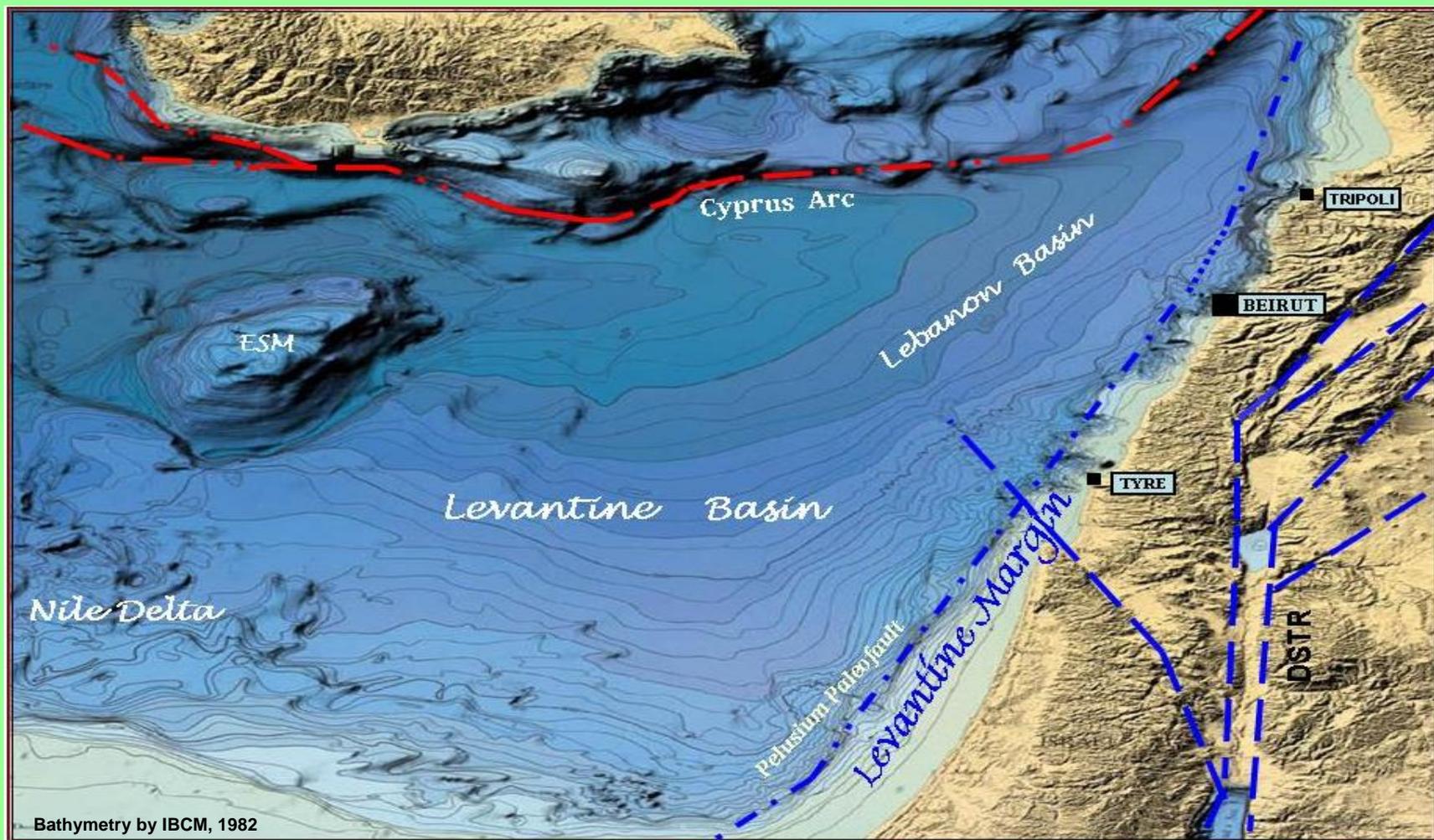
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## Offshore Lebanon basin

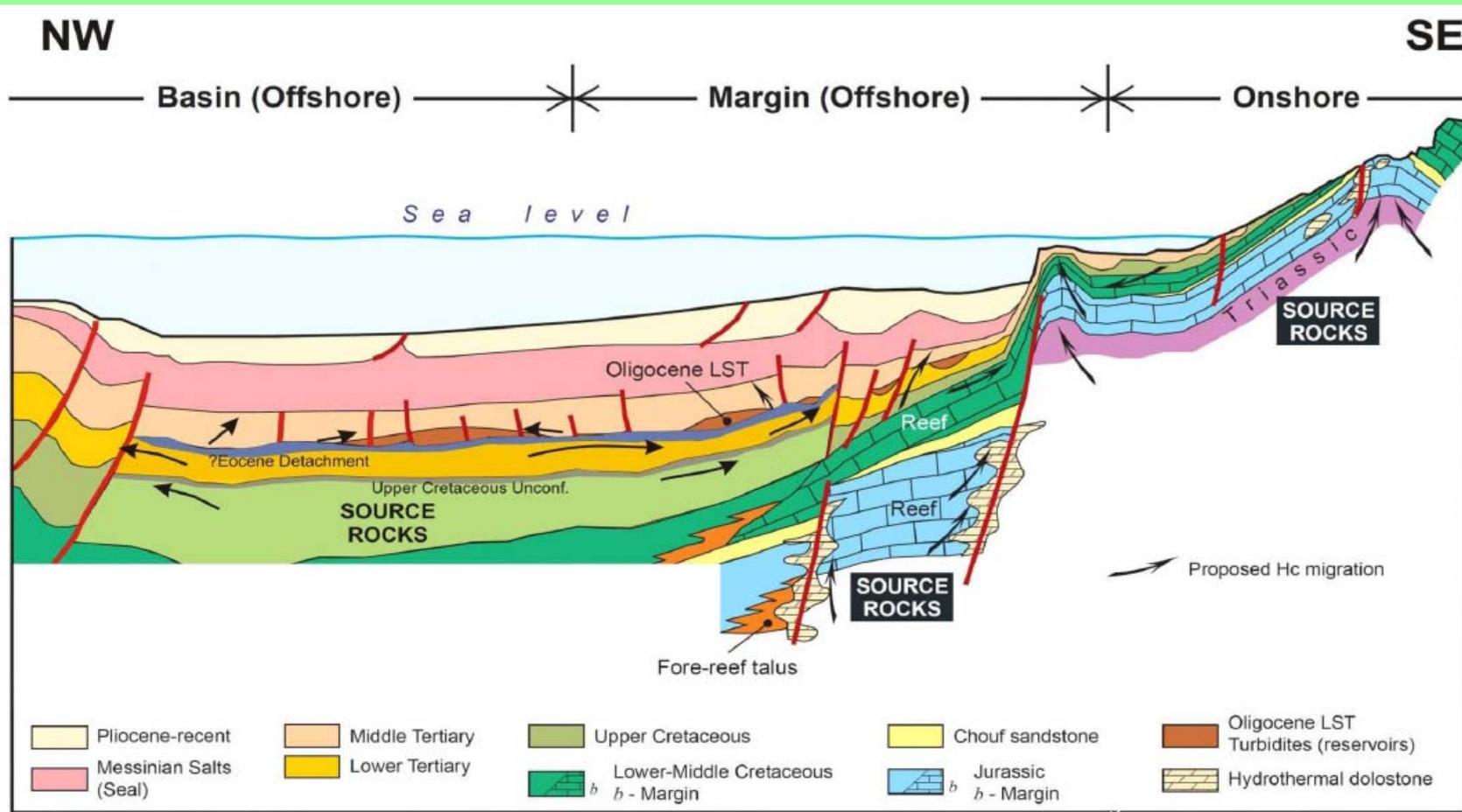


Bathymetry by IBCM, 1982



# Link offshore to onshore Conceptual Model

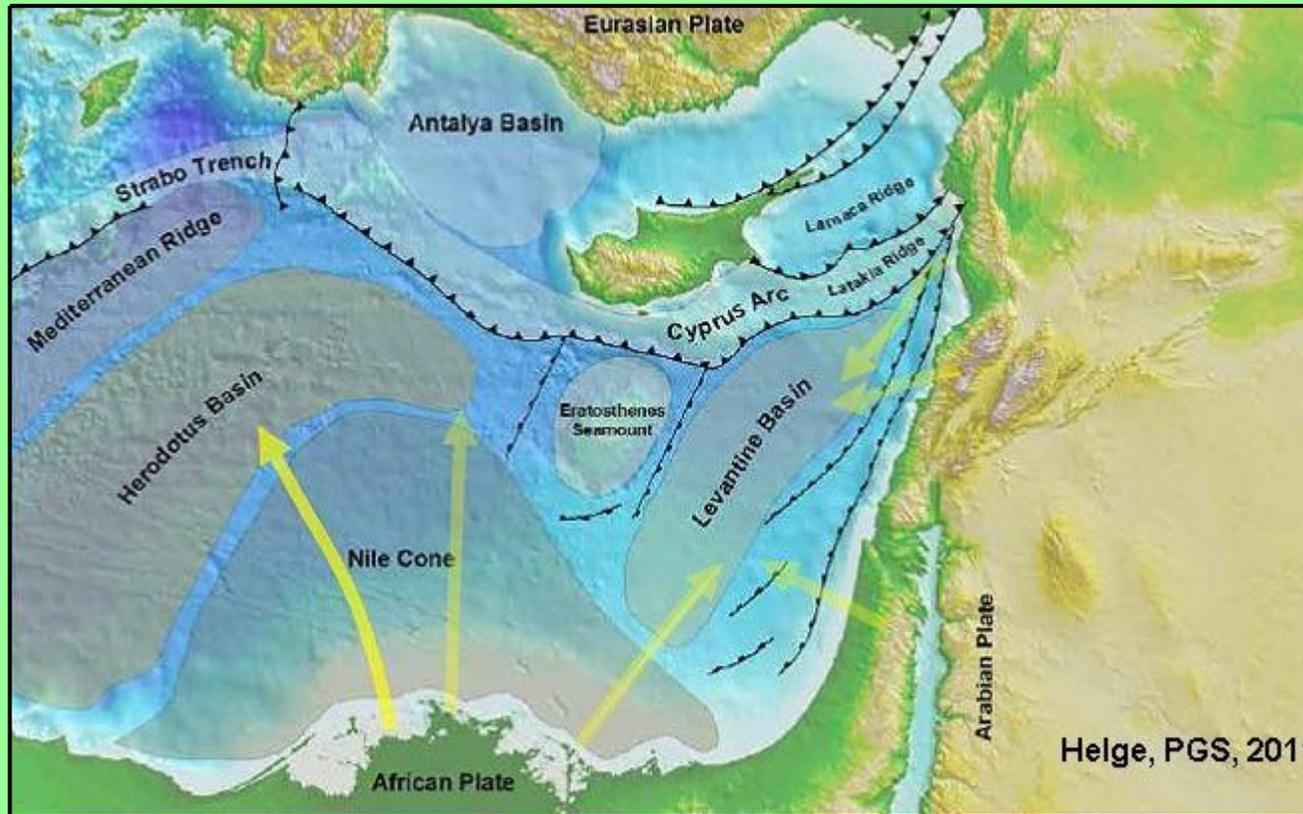
Nader, 2011/2012





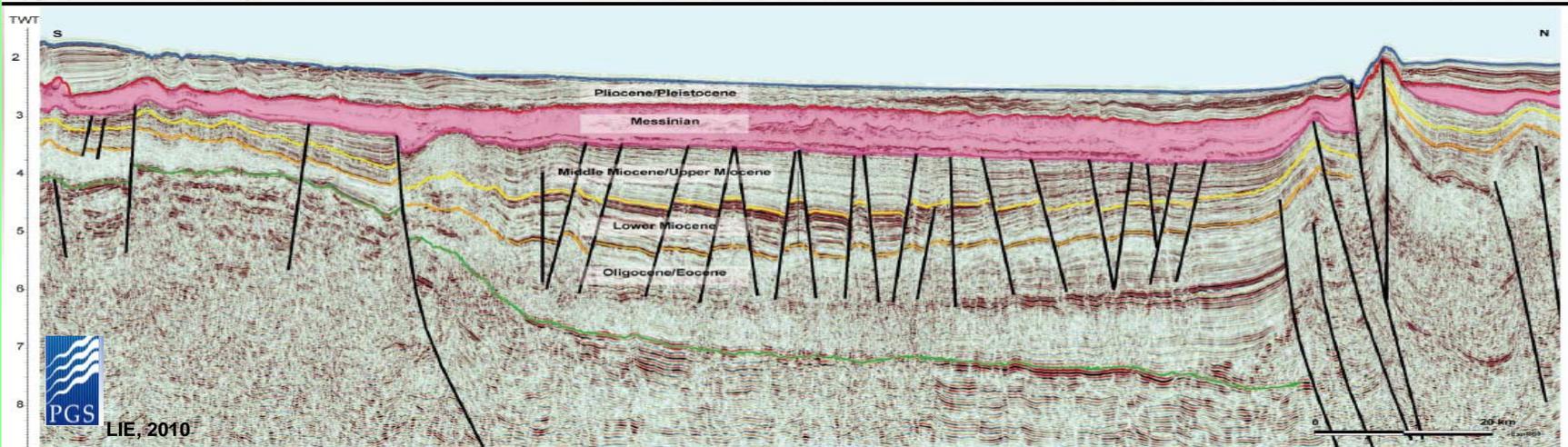
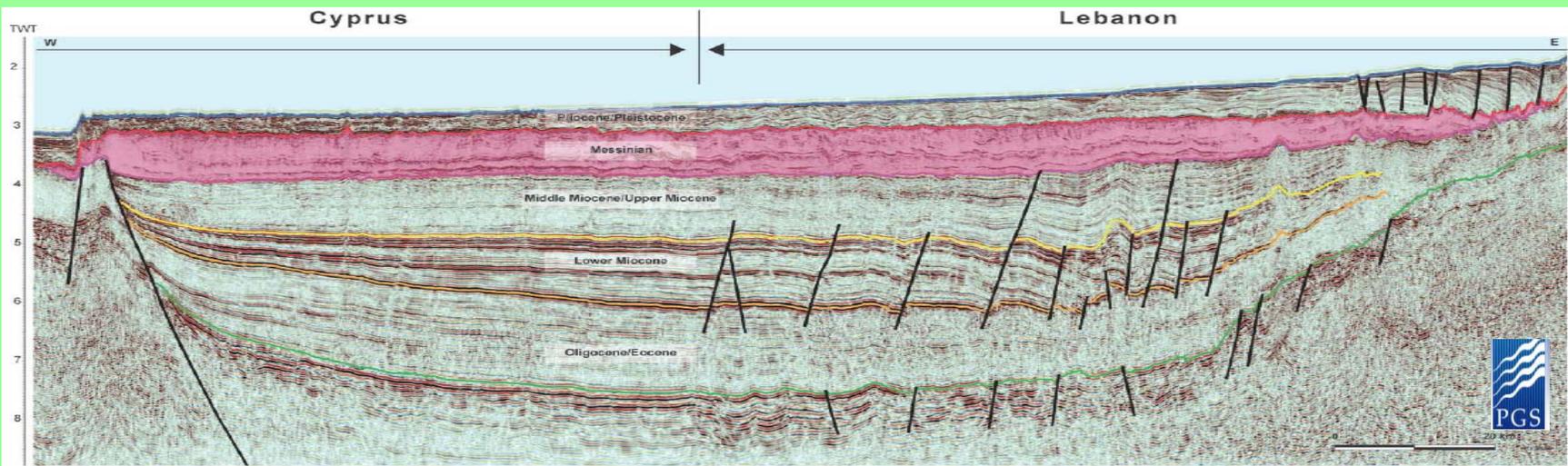
# Lebanon – Sand provenance model

Helge et al, 2011





# Seismic profiles offshore Lebanon



Levantine Basin

▶◀ Latakia Ridge

▶◀ Cyprus Arch

LIE, 2010

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## *SEDIMENT PROVENANCE & DISPERSAL A MODEL*

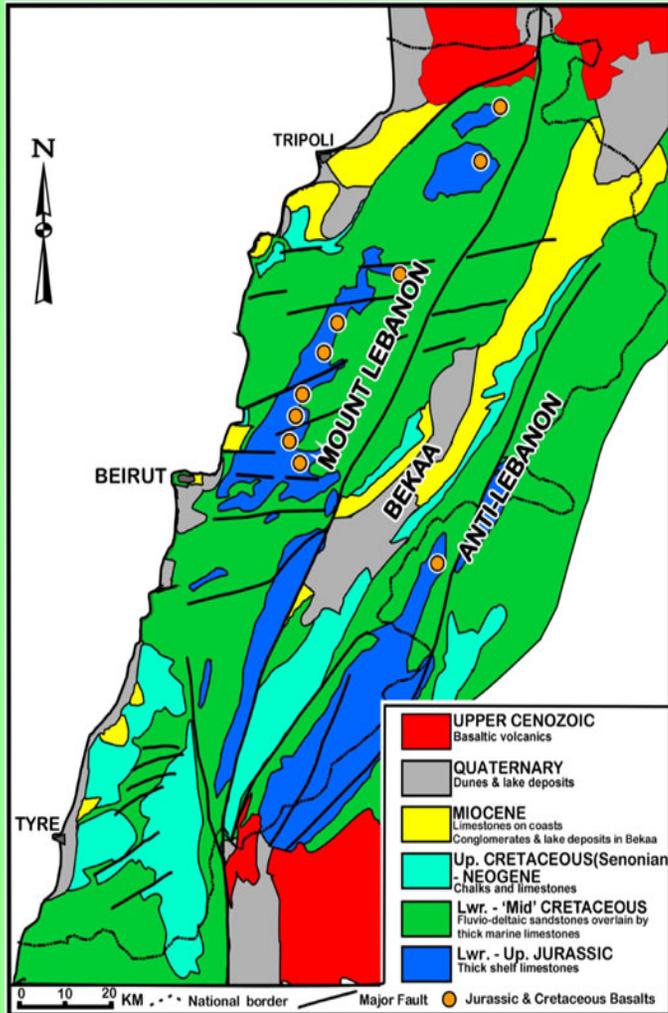
Enzo Zappaterra



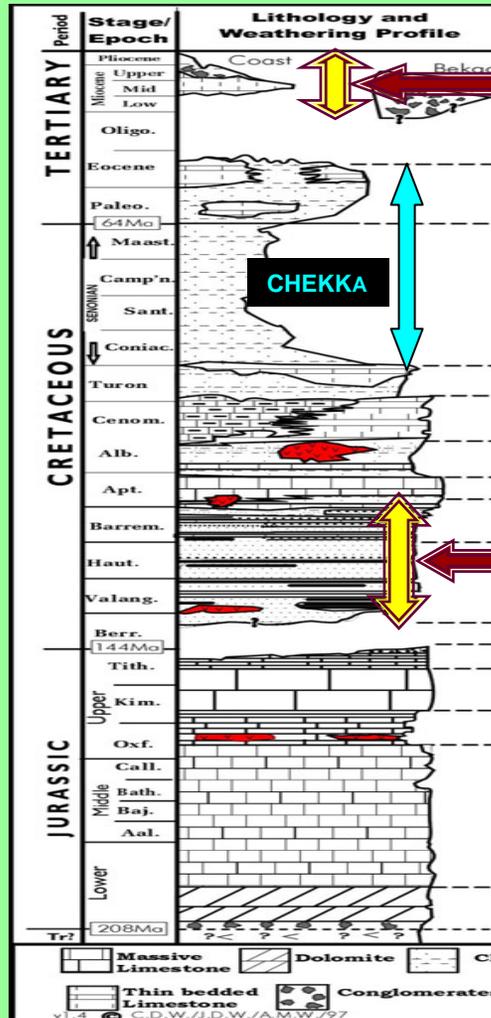
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# Onshore stratigraphy



Walley, 1998



Miocene: patchy and irregular coastal distribution, with minor coarse clastics.

Lower-Middle Cretaceous rocks have widest distribution.

Lower Cretaceous: thick clastic wedge, fluvial to deltaic sandstones.

*"There are very few, if any, other countries in the world whose geological history goes no further back than the surface rocks and there are certainly very few whose pre-Jurassic history is so sketchy" (C.D. Walley, 1998)*



## Present-day drainage network



Wikipedia, 2007

**Prevailing lateral, transversal system of rivers with a predominant east-west direction, flowing westward into the Mediterranean Sea.**

**Relatively short rivers with headwaters in Mt Lebanon to the east.**

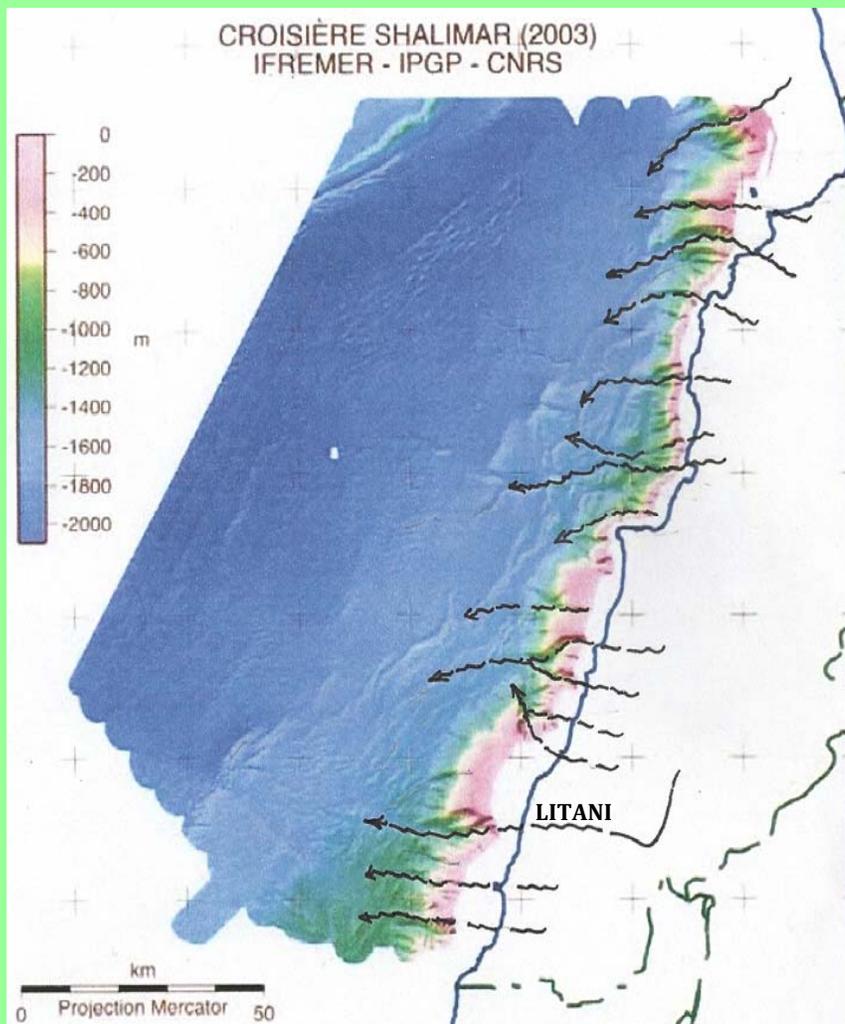
**Longitudinal system of rivers with a NNE-SSW direction restricted to the Bekaa Valley.**

**Litani River is the longest and most important waterway; it originates in the Anti-Lebanon Mt. and flows southward, but has a significant east-west change in direction, as it empties into the Mediterranean north of Tyre.**

**The Al Assi River flows northward into Syria**

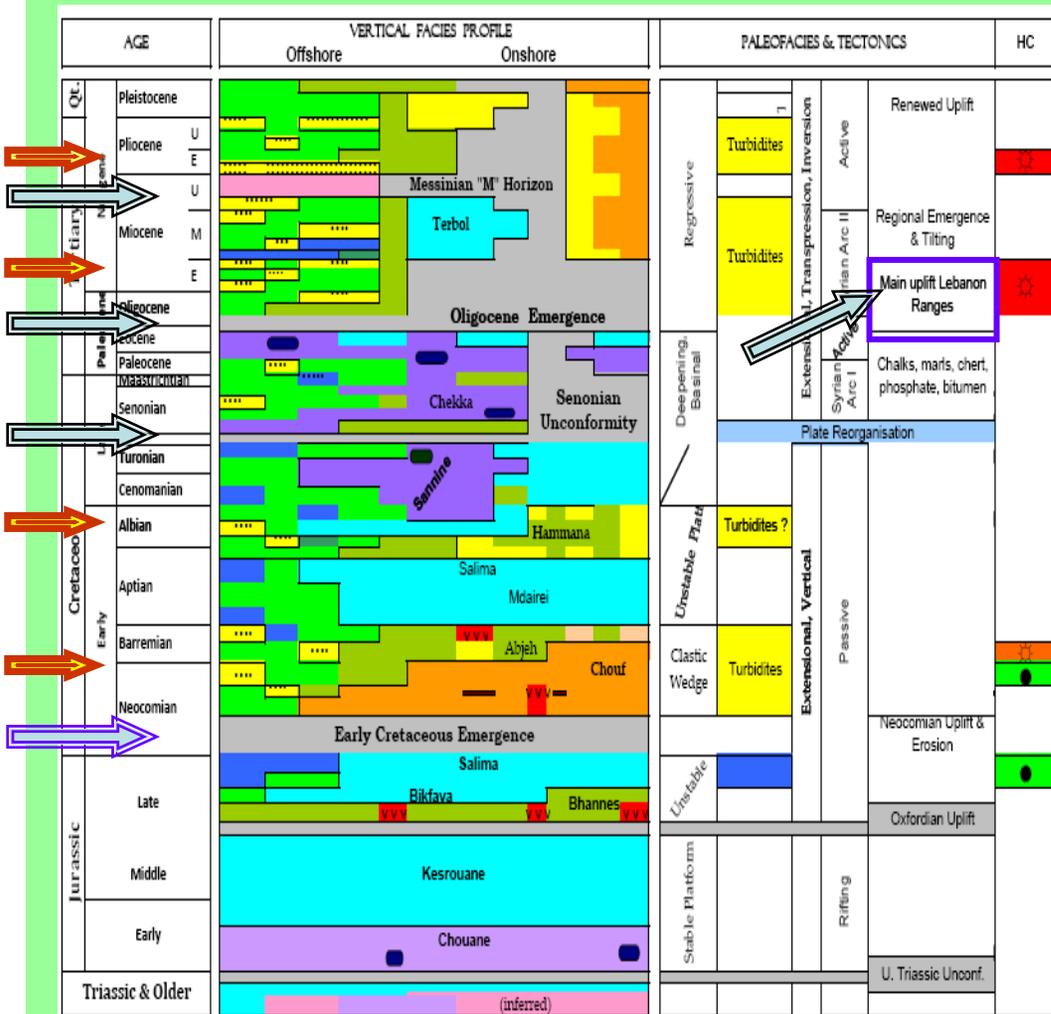


## *Offshore canyons vs onshore rivers*





# Lebanon geological model



**From M. Jurassic onward:** prevailing deeper marine and slope basin domain.

**Platform to basin transition:** fairly localised during most of the Mesozoic and Cenozoic, within a narrow area sub-parallel to the present coastline of Gaza to Lebanon.

**Triassic-Early/Middle Jurassic:** large carbonate platform domain covering most of Tethys.

 Coarse clastics sedimentation

 Key event



## *Early Miocene paleodrainage network*



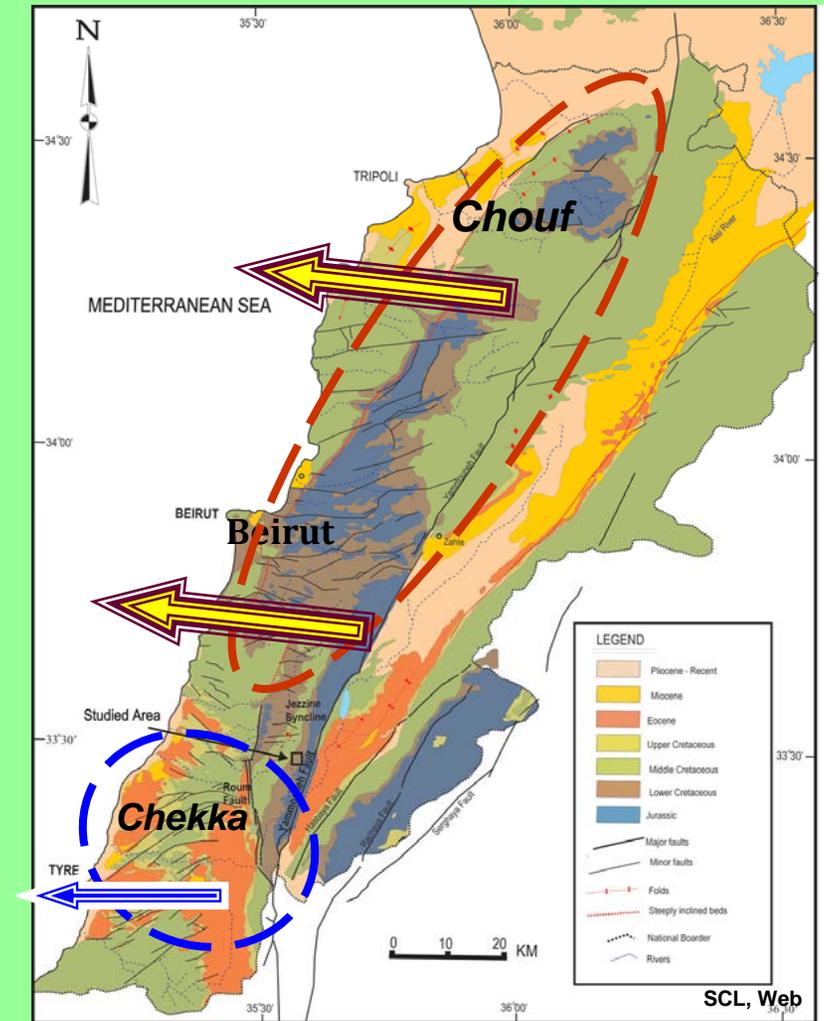
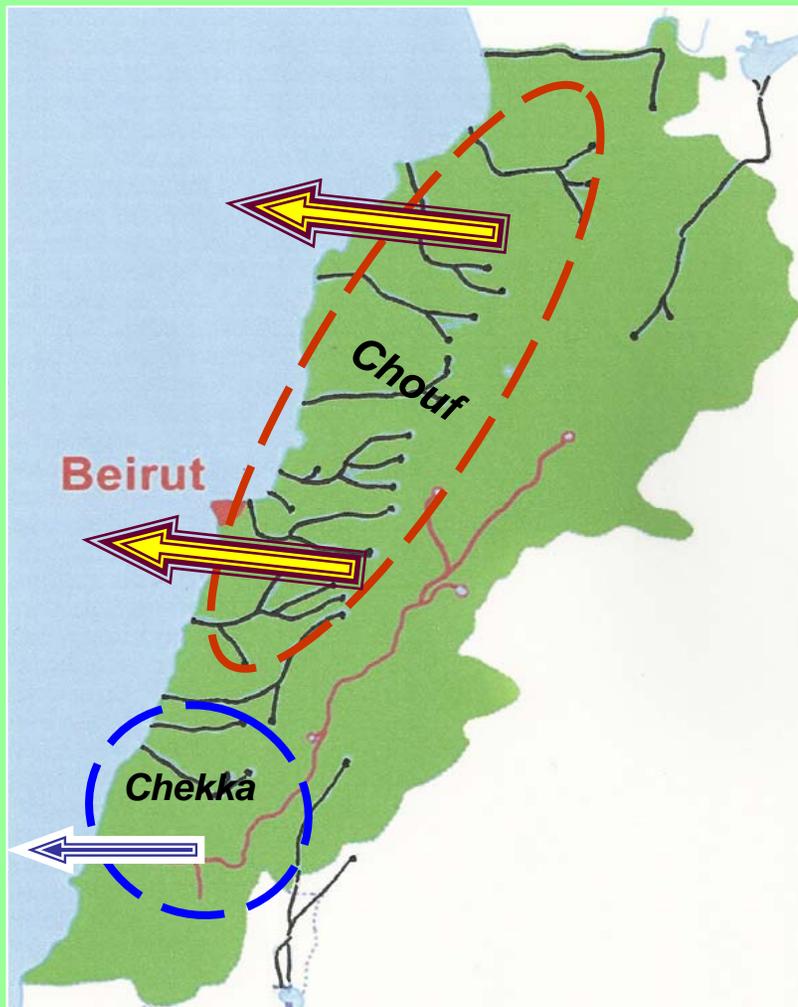
**Early Miocene and Pliocene paleodrainage network is assumed to be similar to the present-day network.**

**Paleotopography and regional paleoslope/paleoflow of Cretaceous/Jurassic uplands were about the same as they are at present.**

**Sediment supply to the offshore Lebanon basin during Oligocene-Miocene and Pliocene most likely occurred through an ancestral lateral system of short rivers flowing Westward from the Cretaceous-Jurassic uplands to the east.**



# Sediment supply areas



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## *OFFSHORE LEBANON PROSPECTIVITY*

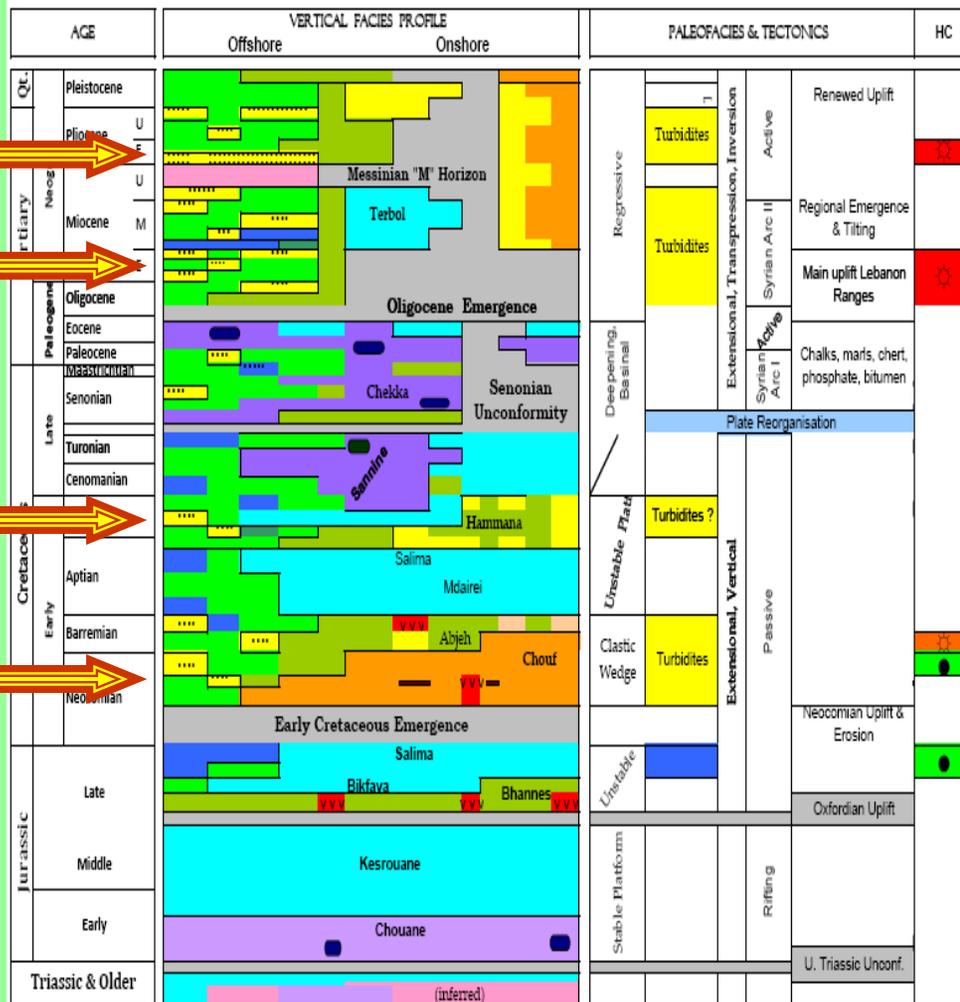
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# Potential sand-rich pay-zones & offshore prospectivity



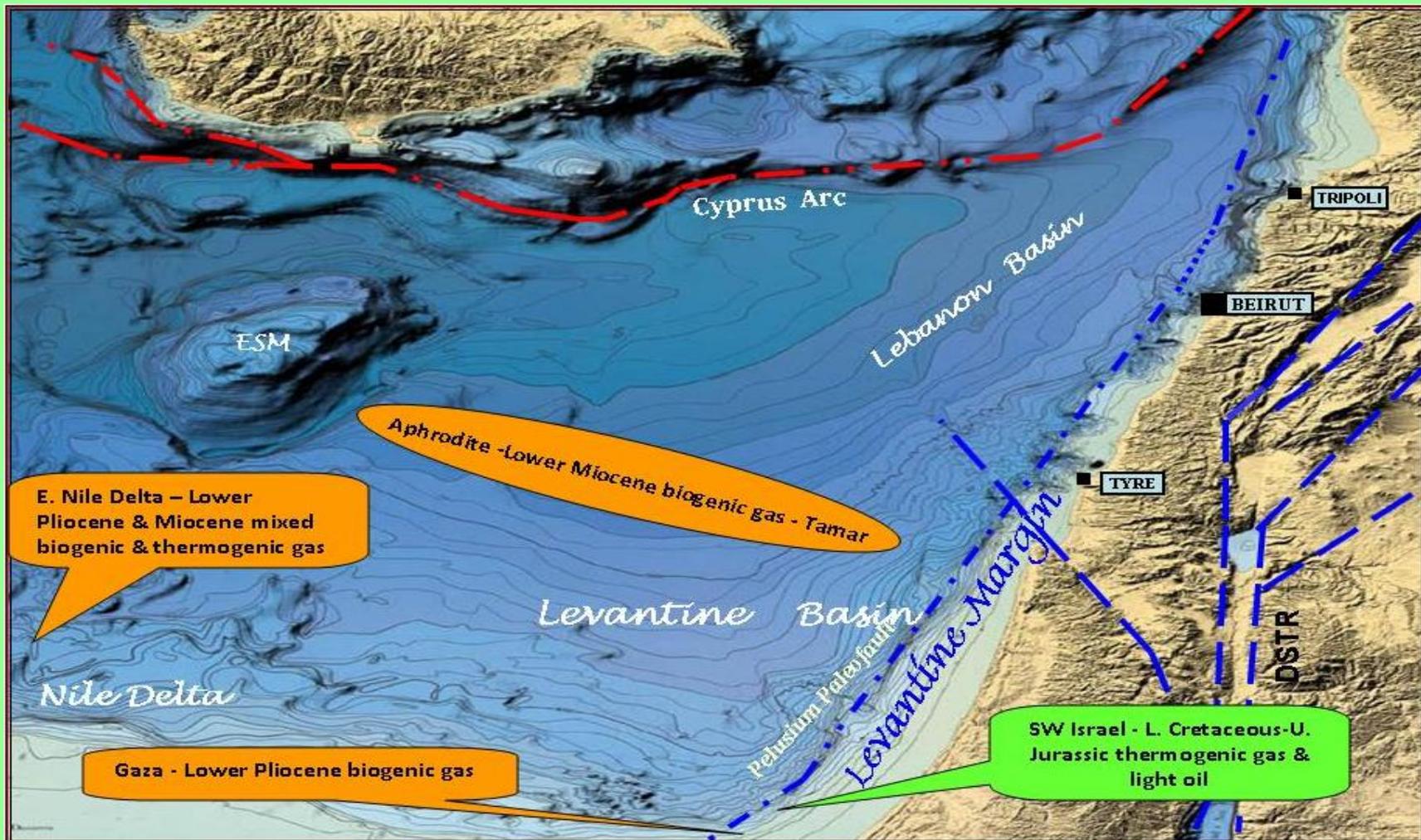
Regional setting - shelf carbonates in the east, deeper marine facies to the west - has persisted during most of the Mesozoic and Early Tertiary, determining overall prospectivity of the offshore Levant Margin & Levantine Basin.

Best prospective reservoirs are low-stand sandstones deposited following regional uplift and erosion during regional tectonic events in Early Cretaceous, Early Oligocene, and during the Messinian (latest Miocene).

 Coarse clastics sedimentation



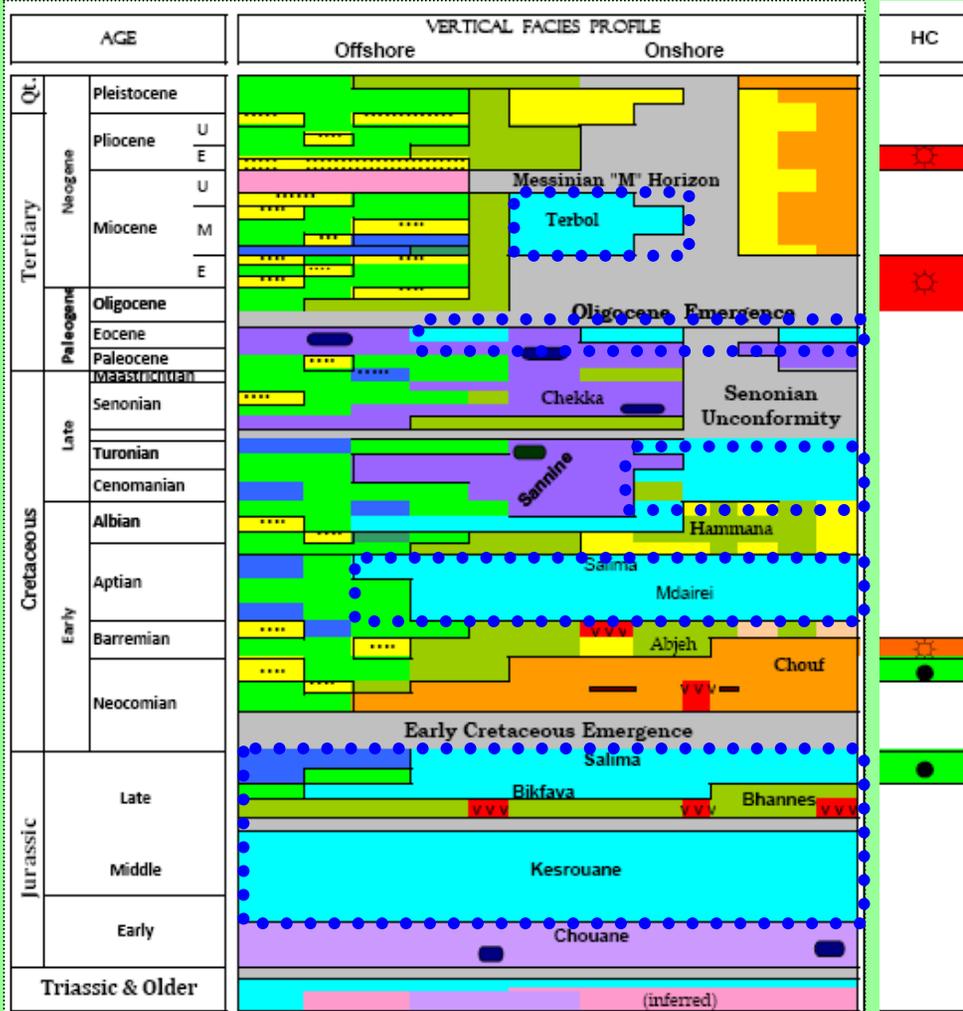
# Hydrocarbon discoveries





# Offshore Lebanon prospectivity

## Carbonate plays



Potential shelf carbonate plays on horsts, basement highs, and intra-basinal paleo-highs:

- Miocene limestones (Terbol)
- Eocene Nummulitic limestones
- Karstified and fractured Cretaceous-Jurassic carbonates.

### Play analogs:

- Gas and oil fields onshore Israel and Egypt
- Middle Cretaceous carbonates, Mango-1 well off Sinai.

### Potential deeper water plays:

- Upper-Middle Jurassic calcareous turbidites (calciturbidites).

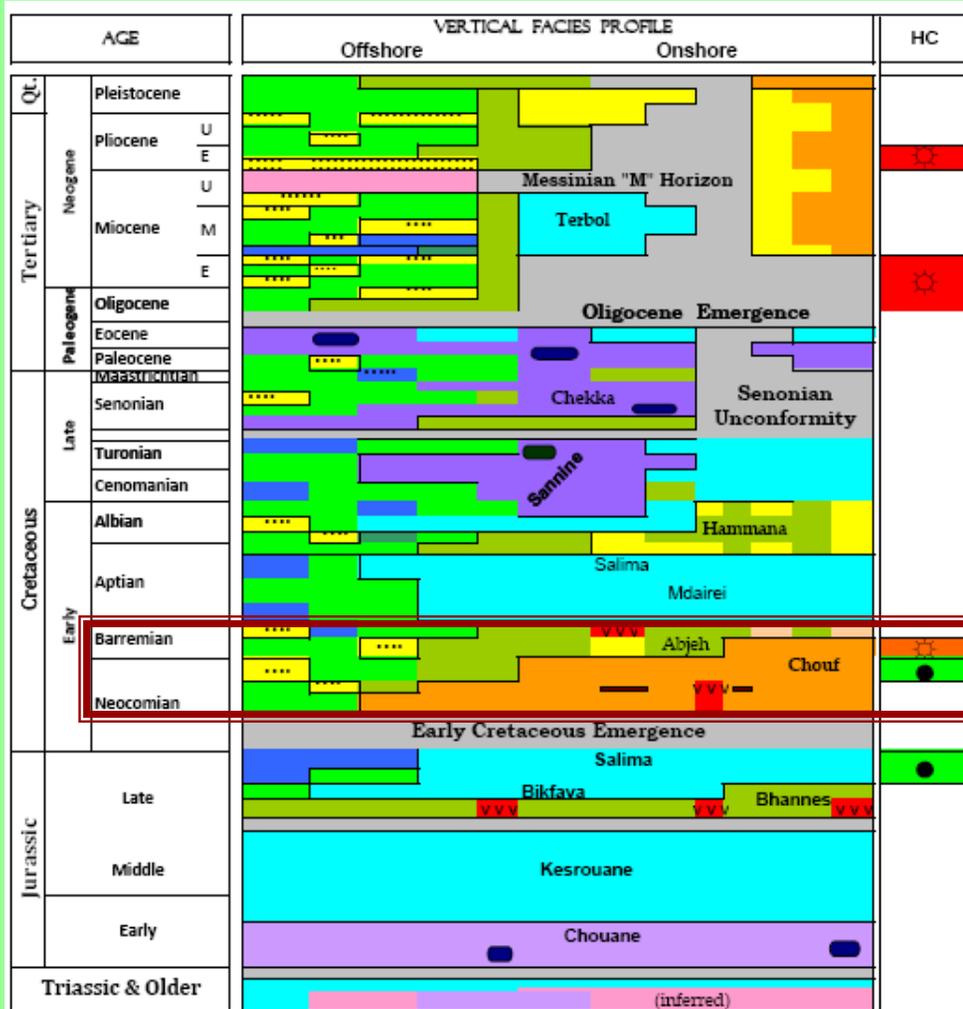
### Play analogs:

- Thermogenic gas & oil discoveries offshore SW Israel (Yam/Yam Yafo).



# Offshore Lebanon prospectivity

## Lower Cretaceous clastic play



### Early Cretaceous clastic wedge:

Dominant non-marine sedimentation (Chouf Fm) with coarse clastics supplied from exposed Nubian terranes to the south.

Speculative: sands spilled over the shelf edge and accumulated as deep water turbidites to the west.

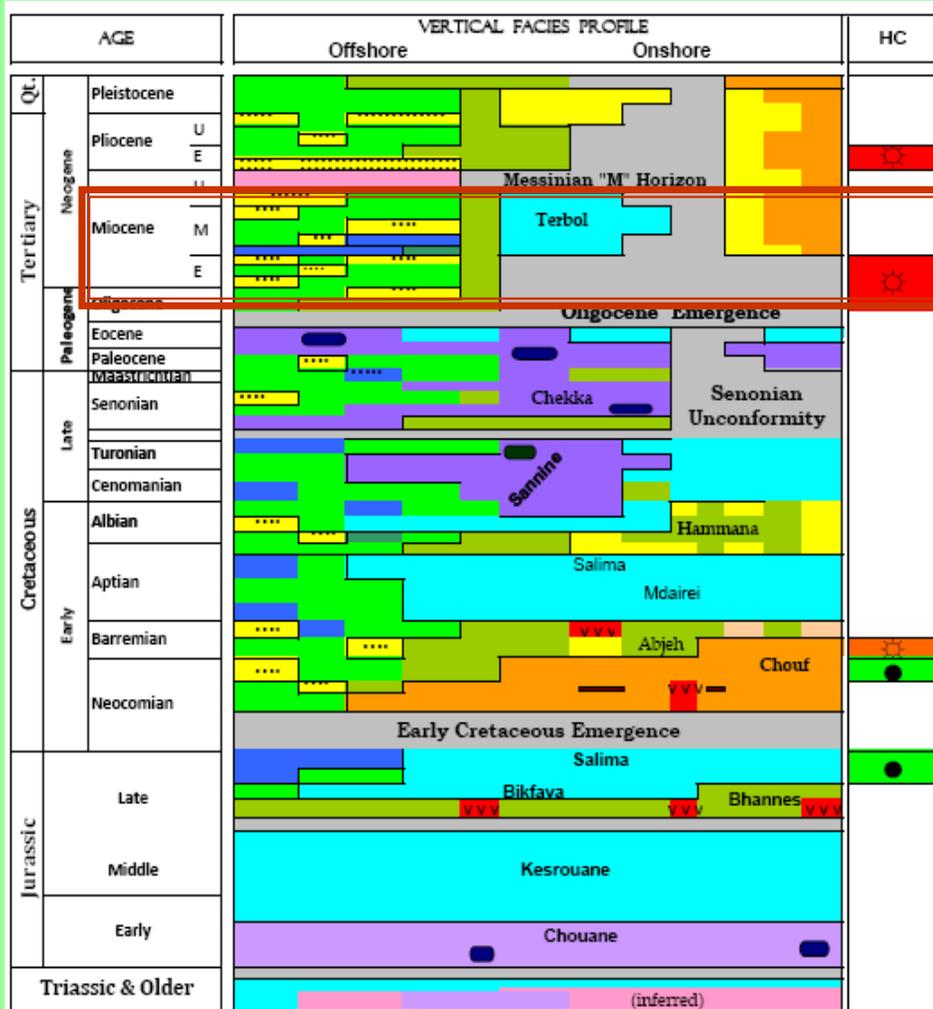
### Play analog:

- Lower Cretaceous sands containing thermogenic gas and light oil offshore SW Israel.



# Offshore Lebanon prospectivity

## Oligocene – Miocene turbidite play



### Oligocene Emergence: Key event

- Strong uplift and severe erosion of the hinterland during the Late Eocene-Early Oligocene;
- Regional down-warp and westward tilting of most of the Levant Margin.

### Plays:

- Oligocene-Miocene turbidite sands offshore. Primary play.
- Messinian channel sands & turbidites.

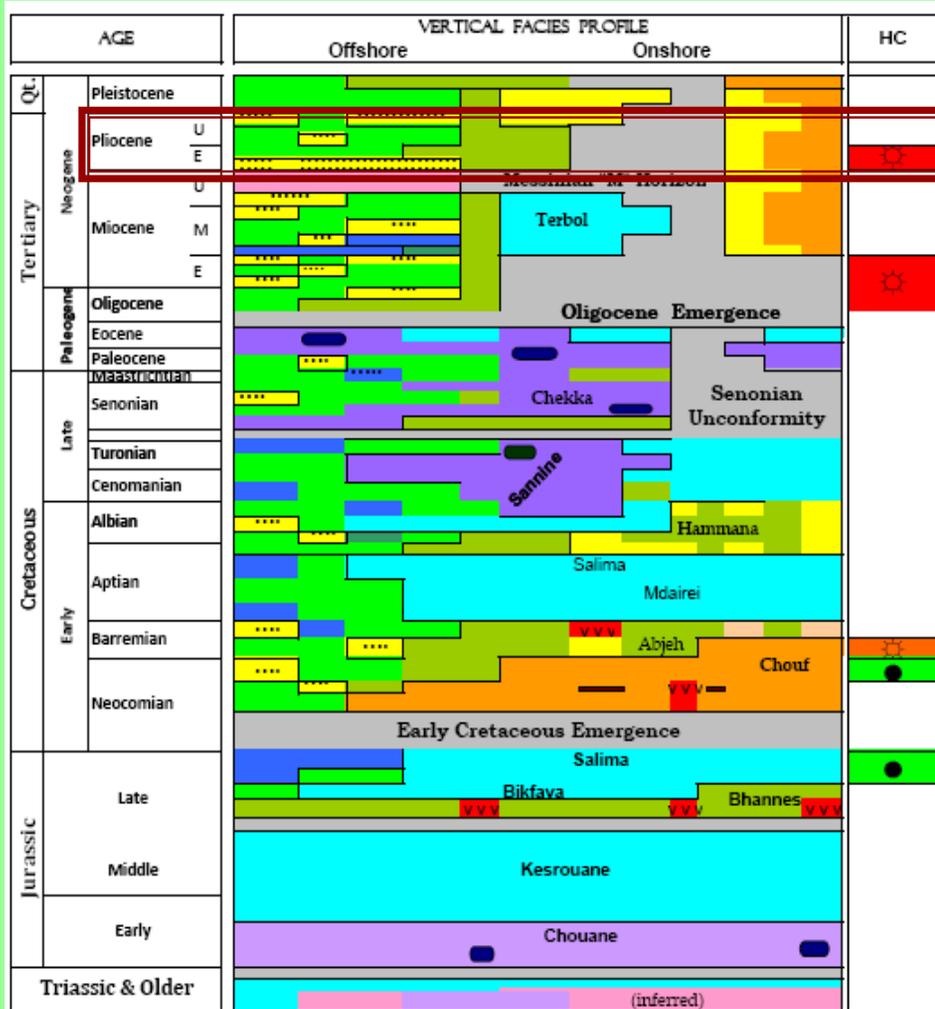
### Play analogs:

- Lower Miocene gas discoveries off Israel and Cyprus
- Messinian channel sand and basin floor fans of the NE Nile Delta.



# Offshore Lebanon prospectivity

## Pliocene turbidite sands play



### Key Events:

- Messinian desiccation and salt deposition of the Mediterranean Sea.
- Pliocene lowstand: significant lowering of sea level in earliest Pliocene resulted in deposition of turbidite sands in basin floor or lower slope settings of the Levant Marginal and Levantine Basin.

### Play analogs:

- Lower Pliocene biogenic gas fields off Gaza and SW Israel.
- Pliocene gas fields offshore Nile Delta.



## *Conclusions*

### **Prospectivity predicated on:**

- regional geologic evolution of the Levant Province
- projection of onshore stratigraphy and lithologies into the offshore
- predictive model of sediment provenance and dispersal.

### **Potential prospective plays:**

#### • **Clastic Plays:**

- .. Biogenic gas in Miocene-Pliocene turbidite sands
- .. Thermogenic gas & light oil in Lower Cretaceous sandy and calcareous turbidites

- **Carbonate plays:** Gas & oil in Miocene, Eocene, & karstified and fractured Cretaceous/Jurassic limestones.

**Sediment supply to offshore Lebanon during the Oligocene-Pliocene period took place most likely through short rivers flowing westward from uplands composed of Cretaceous/Jurassic carbonates, Lower Cretaceous coarse clastics (Chouf), and Senonian-Eocene chalks and marls (Chekka).**

**Widespread occurrence onshore of Cretaceous carbonate rocks suggests sediments supplied to the offshore during Miocene-Pliocene may contain significant amount of calcareous material derived from the weathering and erosion of these rocks.**

**Impact on reservoir quality: High percentages locally of calcareous matrix/cement may lower reservoir quality, porosity & permeability, of potential reservoir rocks.**



# THANK YOU!



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