

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 1st 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".

LEBANON OIL & GAS 2013 SUMMIT

BEIRUT, 22-23 APRIL, 2013

FRAMING THE ISSUE

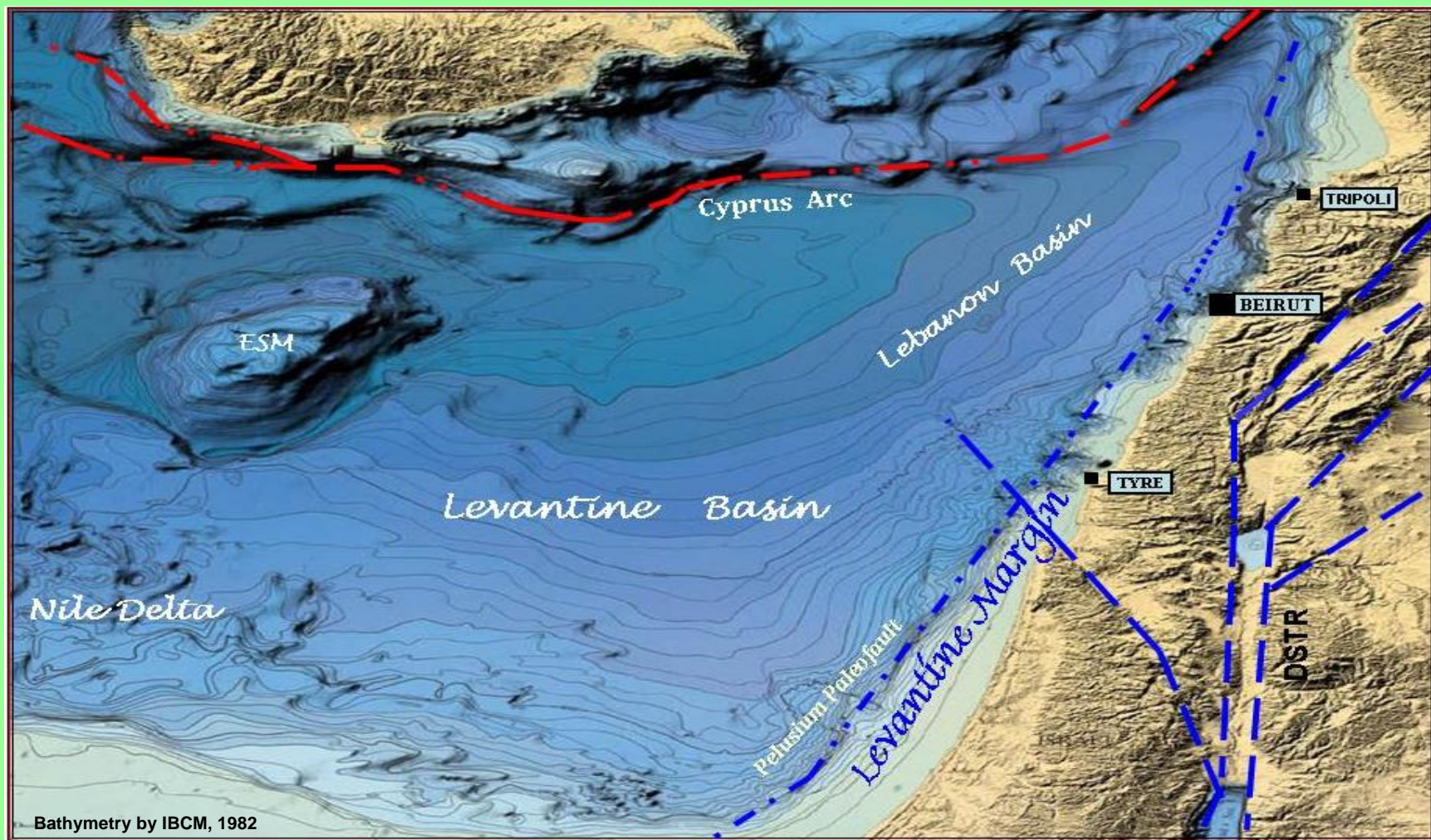
Enzo Zappaterra



PetroServ (CY) International, LLC.



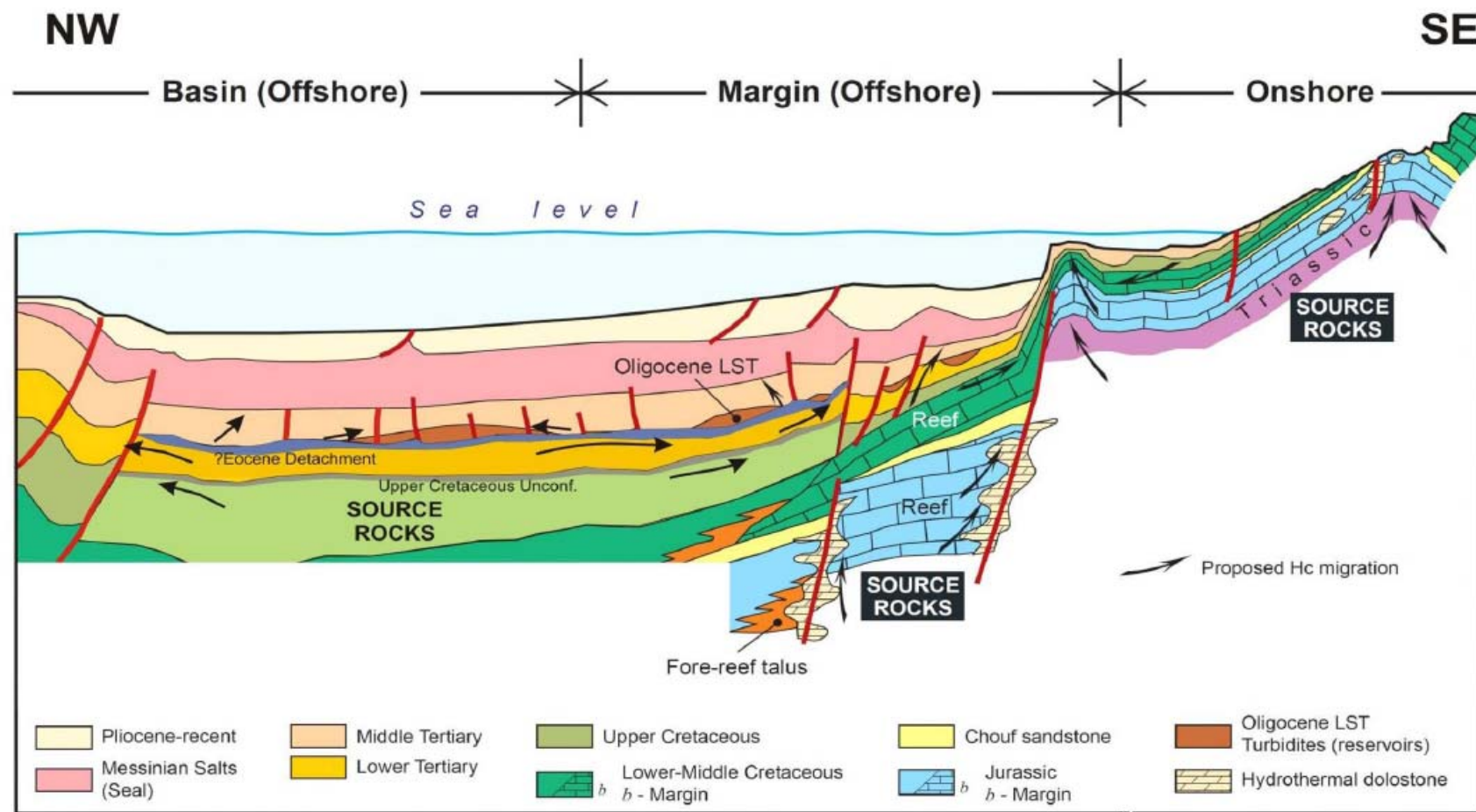
Offshore Lebanon basin





Link offshore to onshore *Conceptual Model*

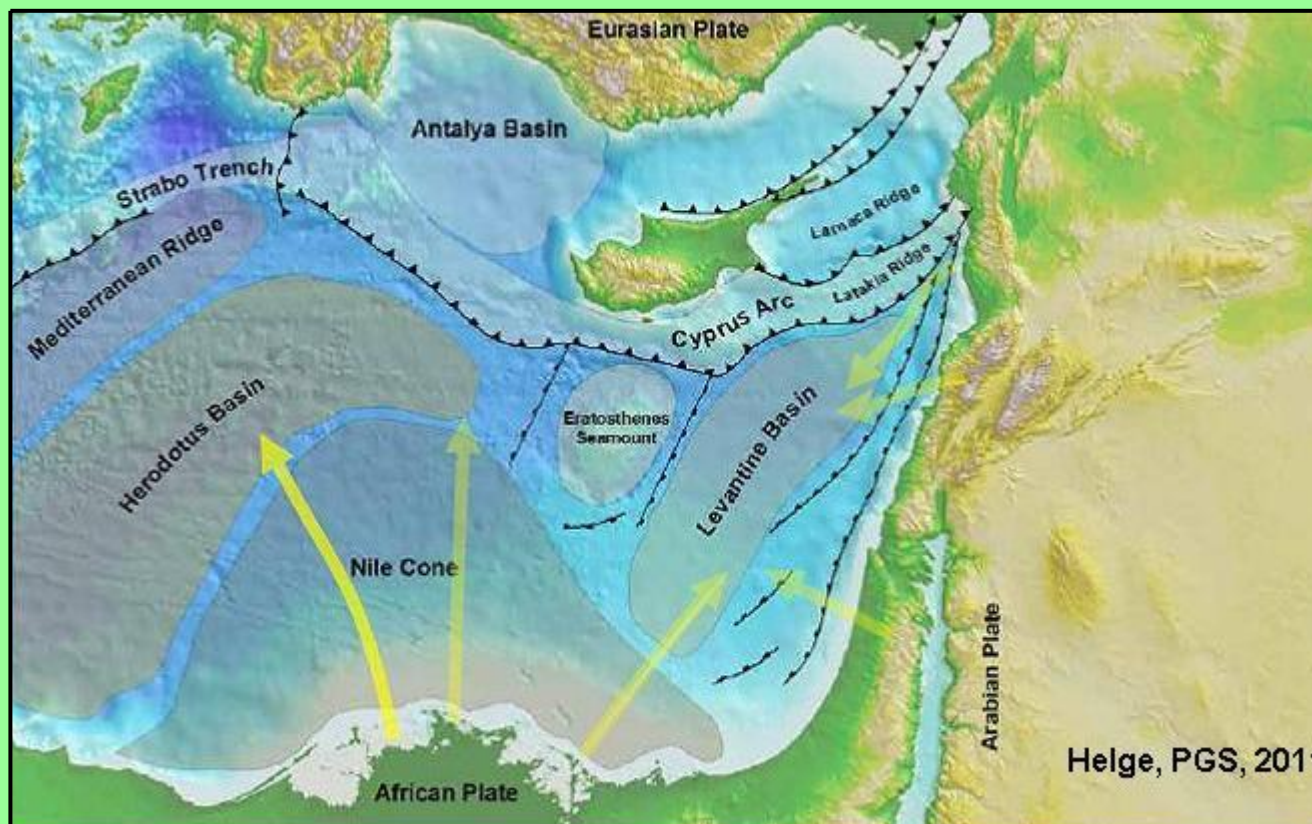
Nader, 2011/2012





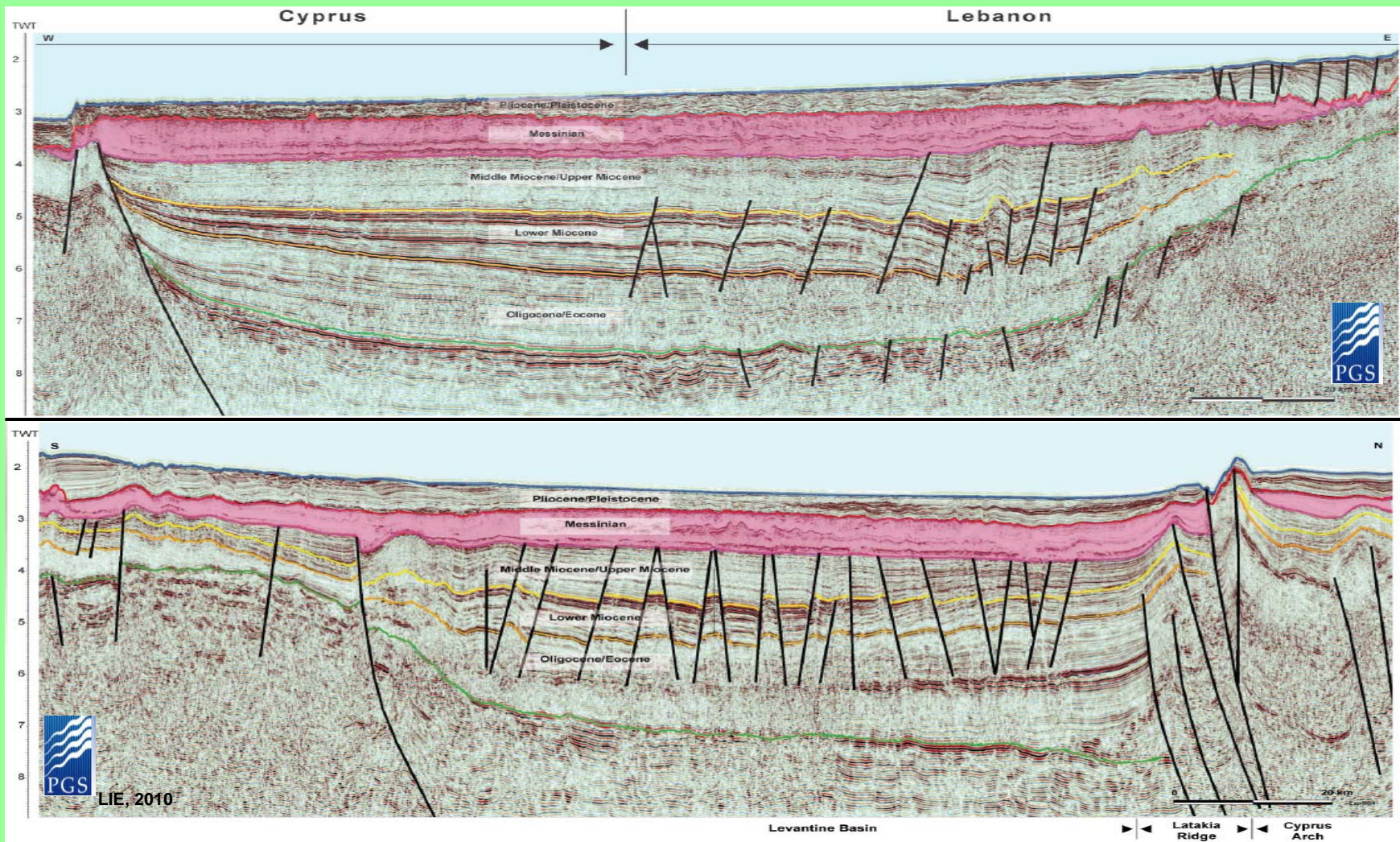
Lebanon – Sand provenance model

Helge et al, 2011





Seismic profiles offshore Lebanon



LEBANON OIL & GAS 2013 SUMMIT

BEIRUT, 22-23 APRIL, 2013

SEDIMENT PROVENANCE & DISPERSAL A MODEL

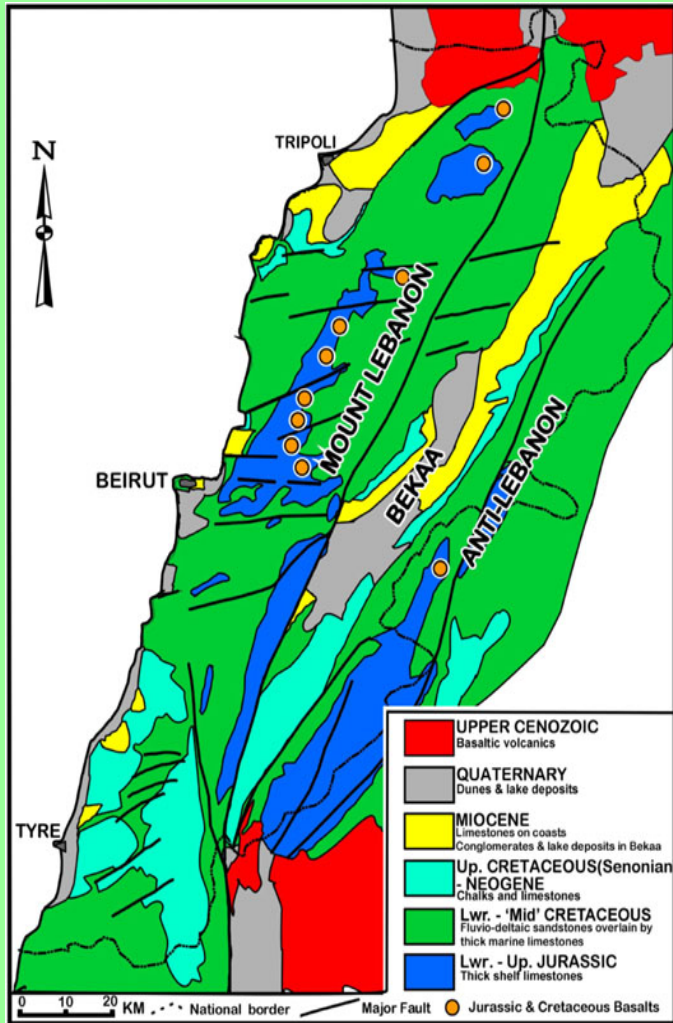
Enzo Zappaterra



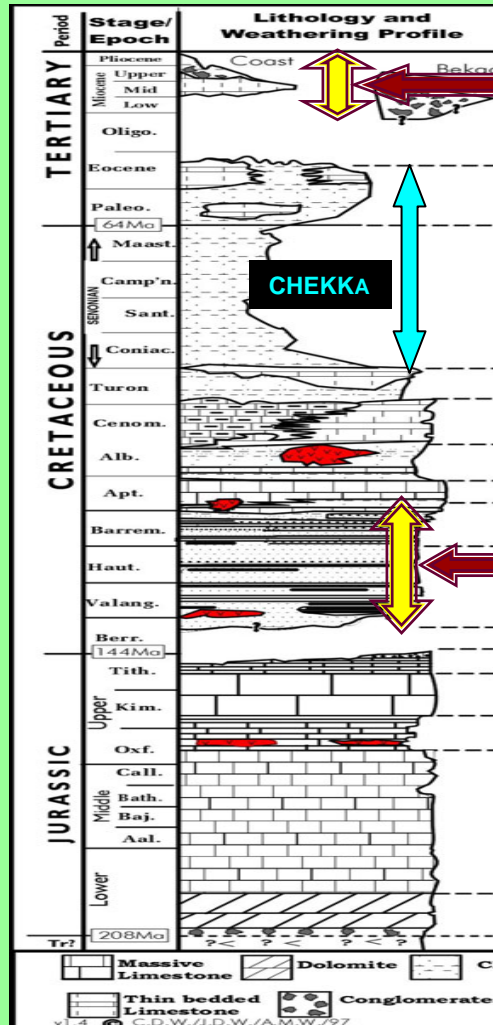
PetroServ (CY) International, LLC.



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



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.

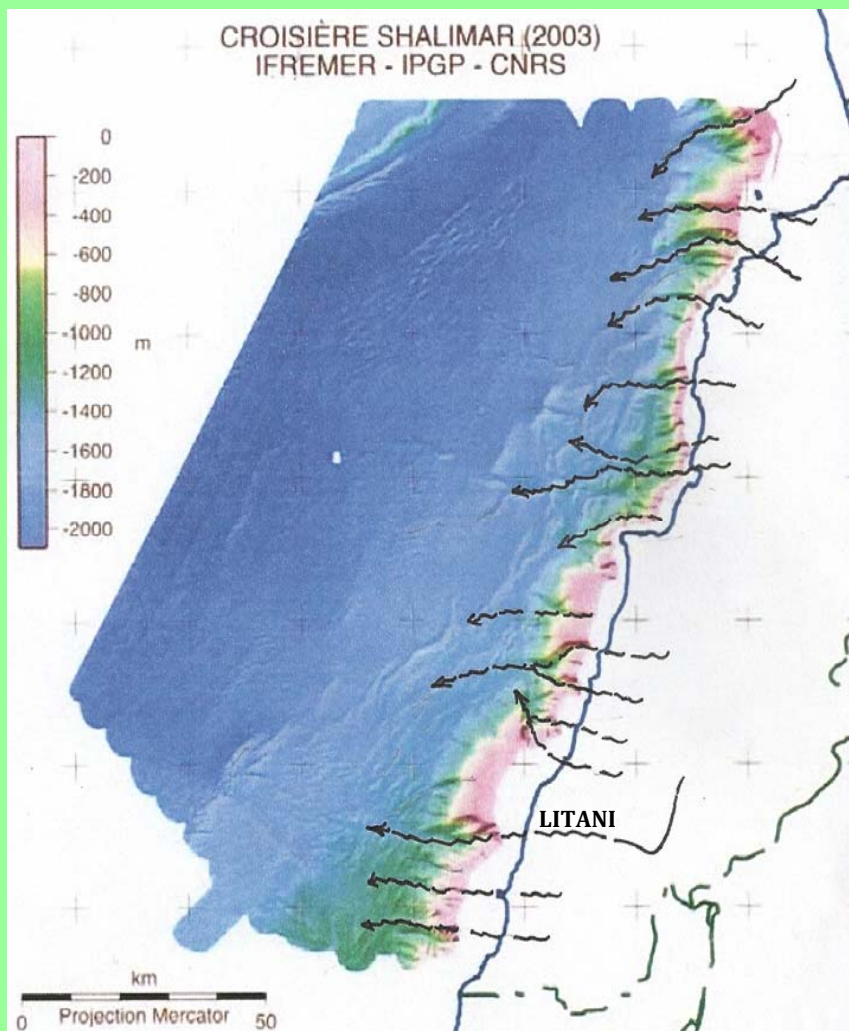
Longitudinal system of rivers with a NNE-SSW direction restricted to the Bekaa Valley.

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

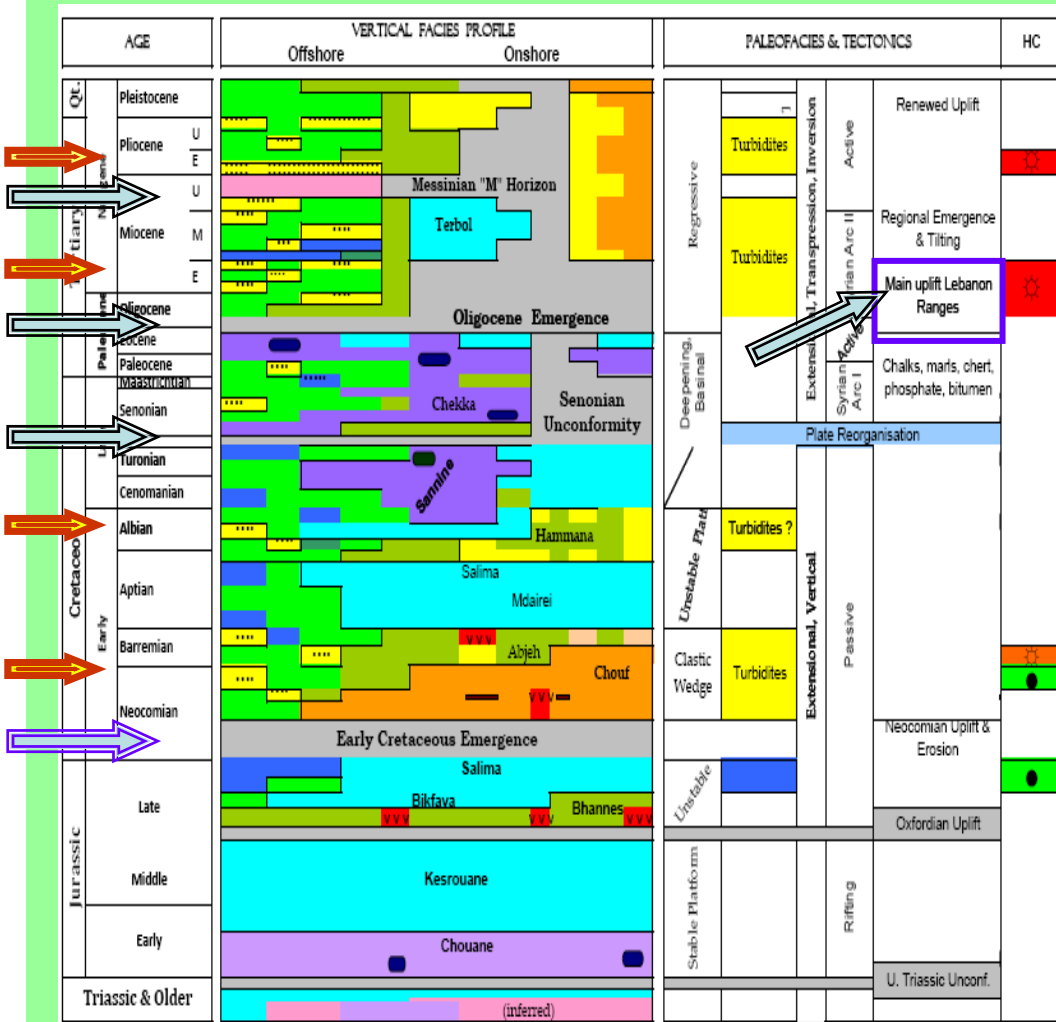


Offshore canyons vs onshore rivers





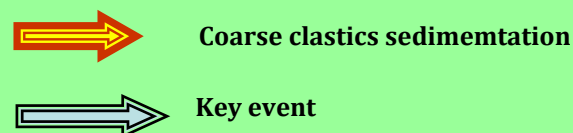
Lebanon geological model



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.





Early Miocene paleodrainage network



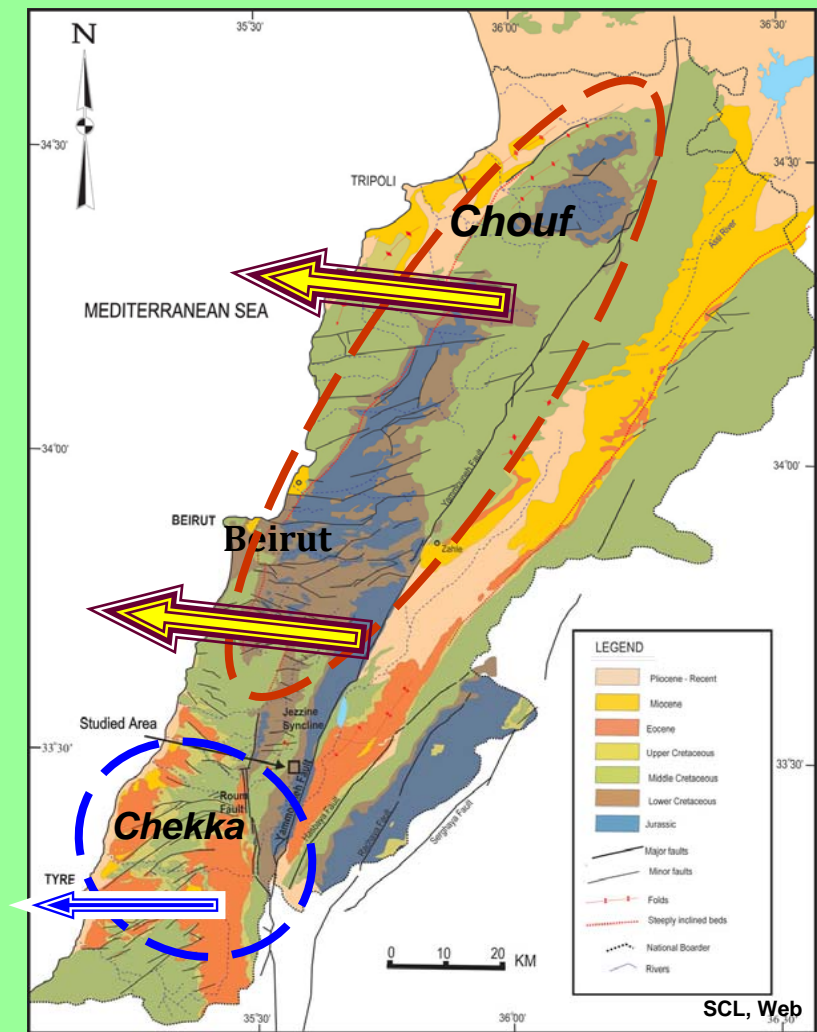
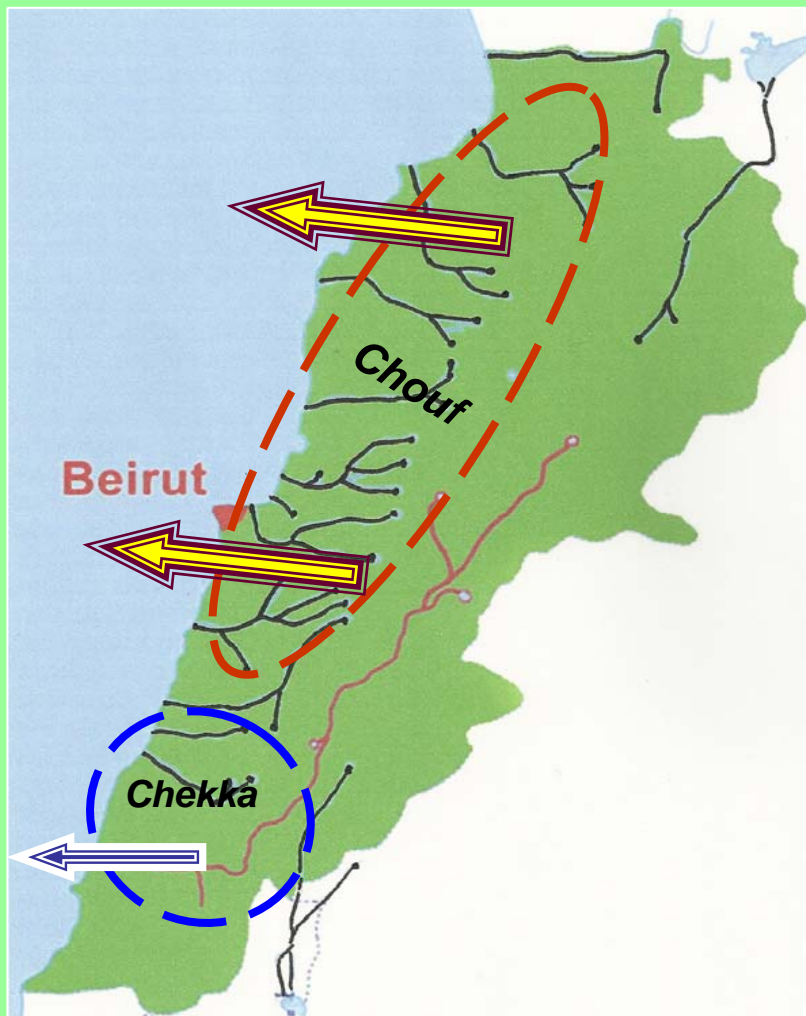
Early Miocene and Pliocene paleodrainage network is assumed to be similar to the present-day network.

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



LEBANON OIL & GAS 2013 SUMMIT

BEIRUT, 22-23 APRIL, 2013

OFFSHORE LEBANON PROSPECTIVITY

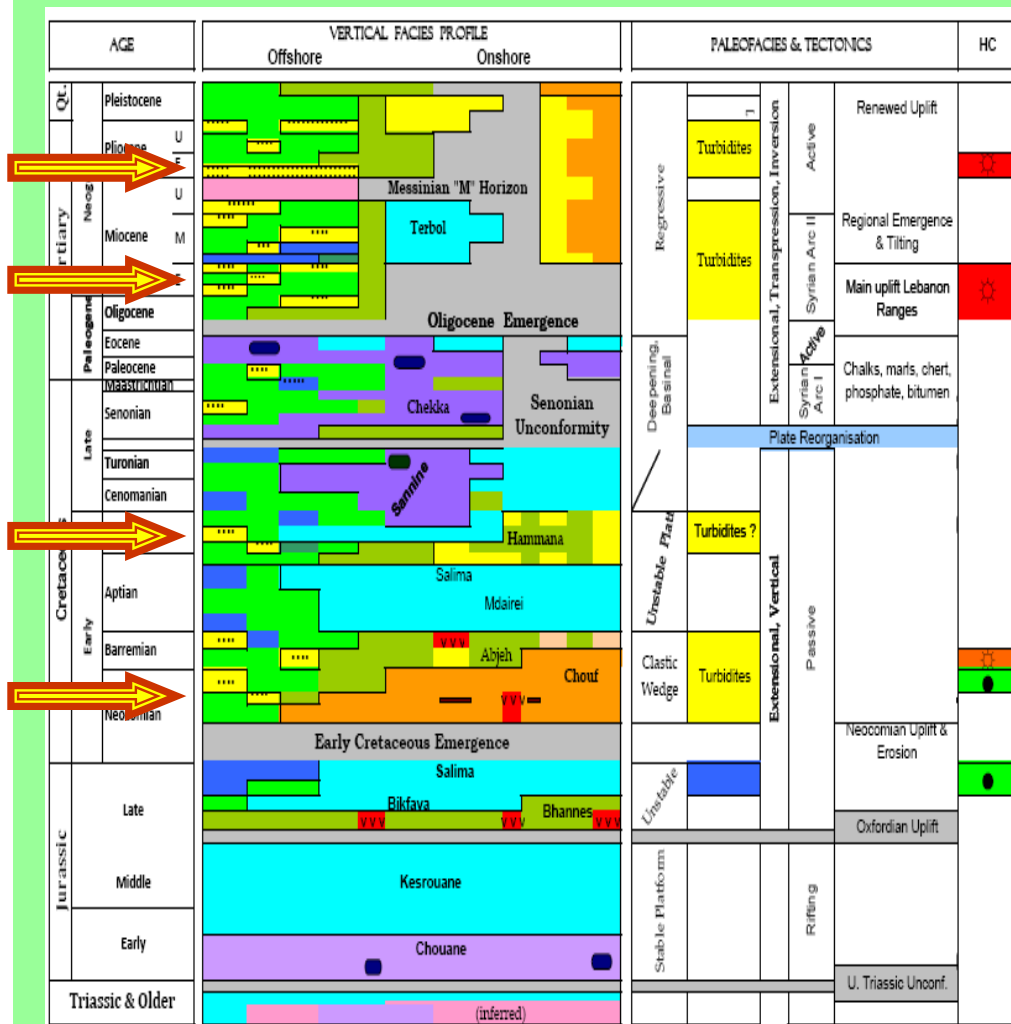
Enzo Zappaterra



PetroServ (CY) International, LLC.




Potential sand-rich pay-zones & offshore prospectivity



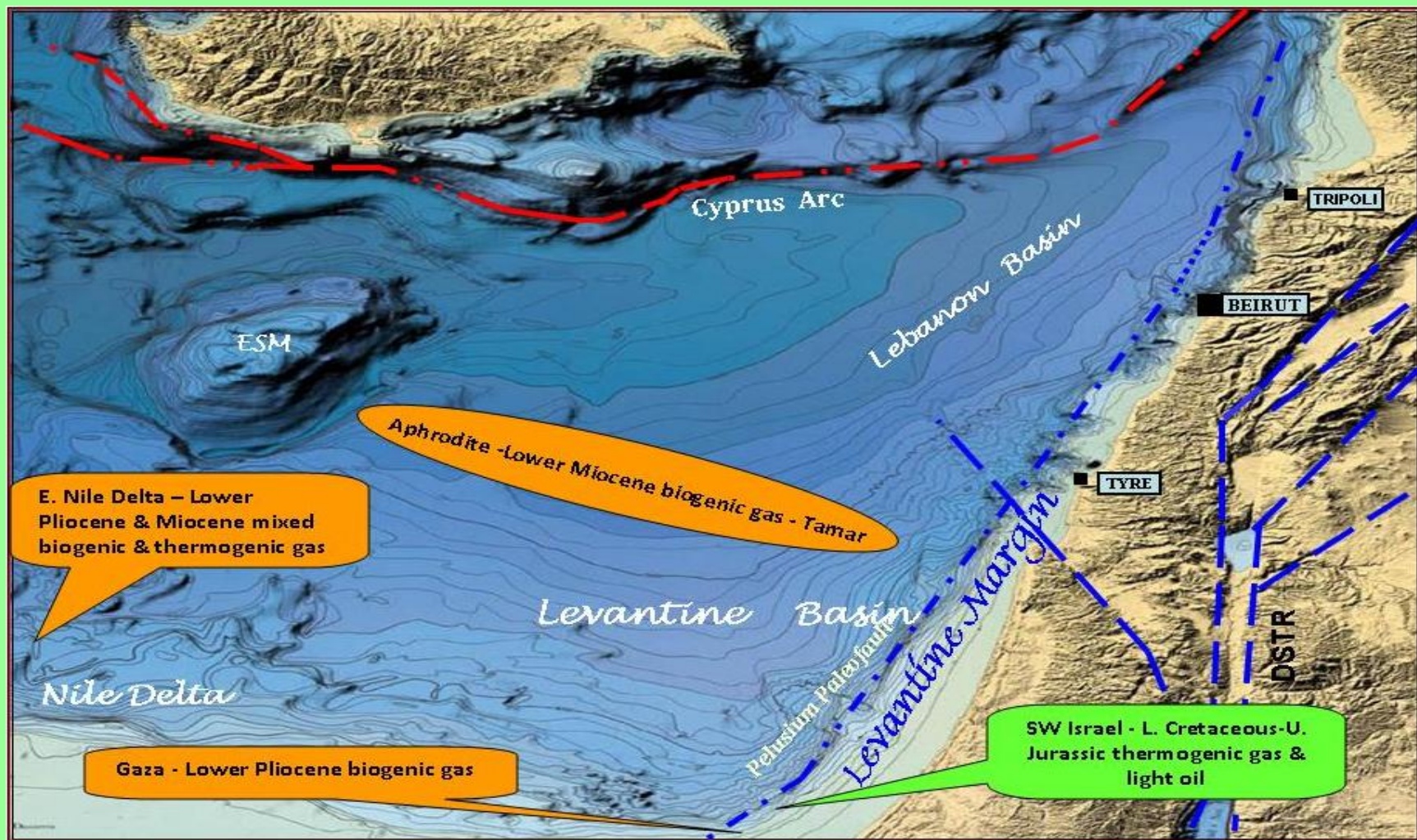
Regional setting - shelf carbonates in the east, deeper marine facies to the west - has persisted during most of the Mesozoic and Early Tertiary, determining overall prospectivity of the offshore Levant Margin & Levantine Basin.

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



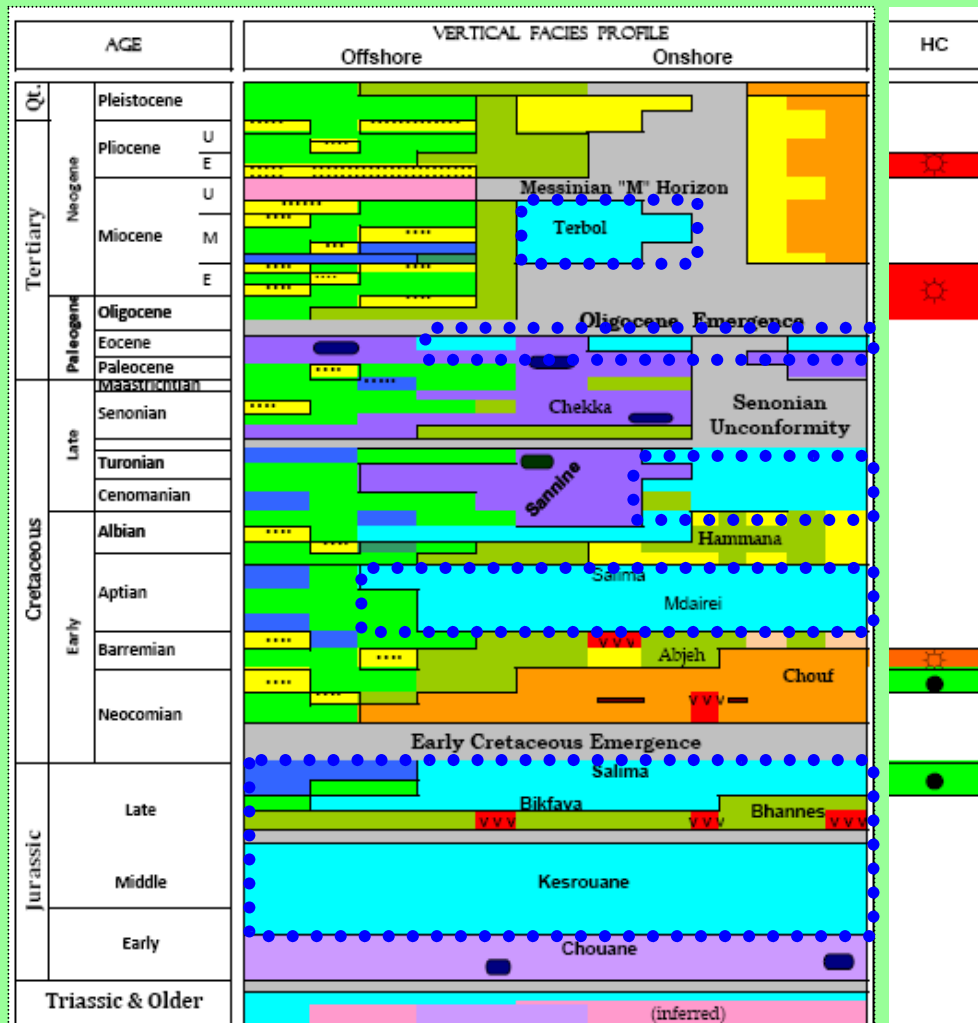
Hydrocarbon discoveries





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).

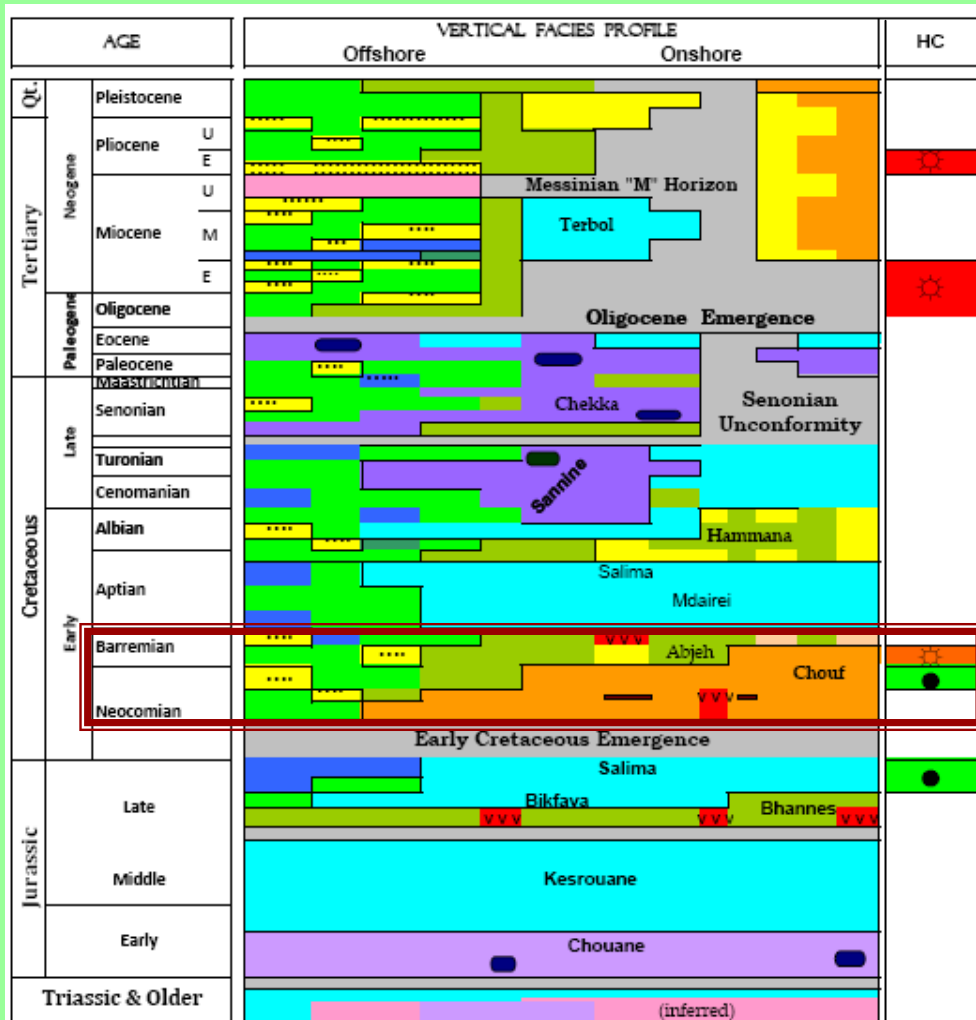
Play analogs:

- 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.

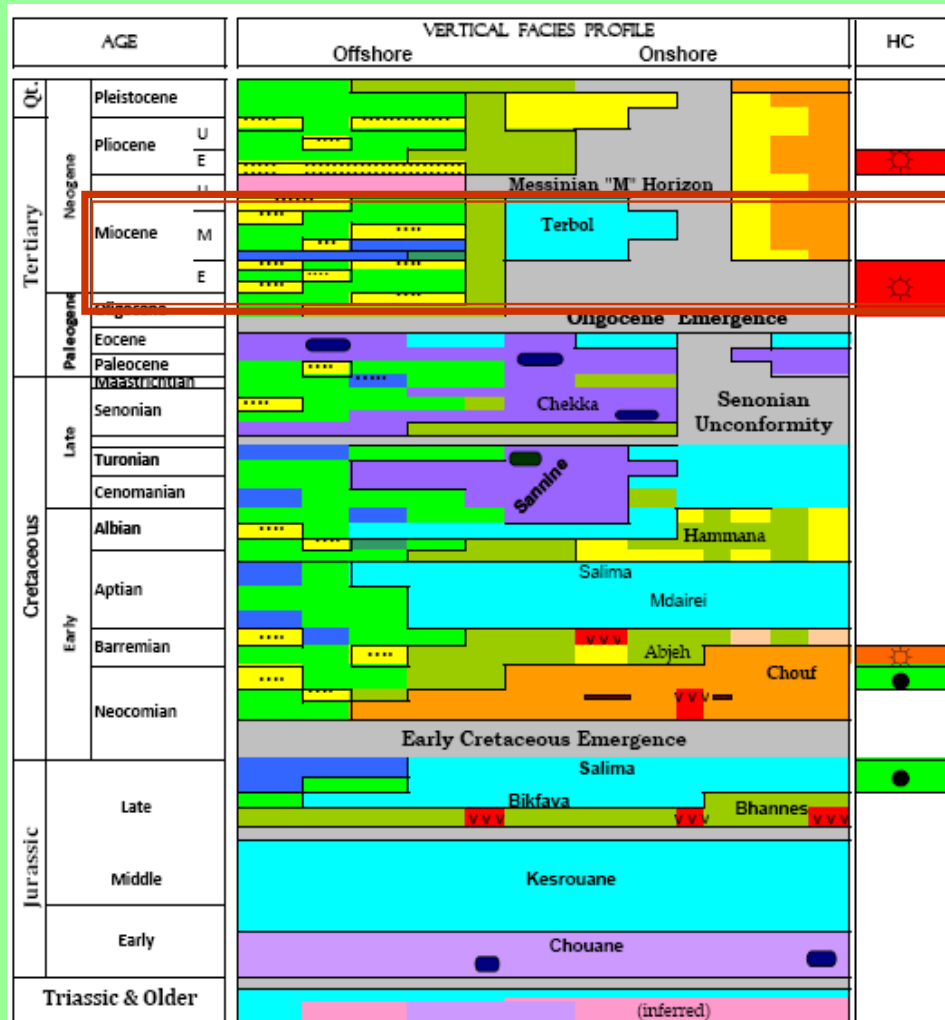
Play analog:

- 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.

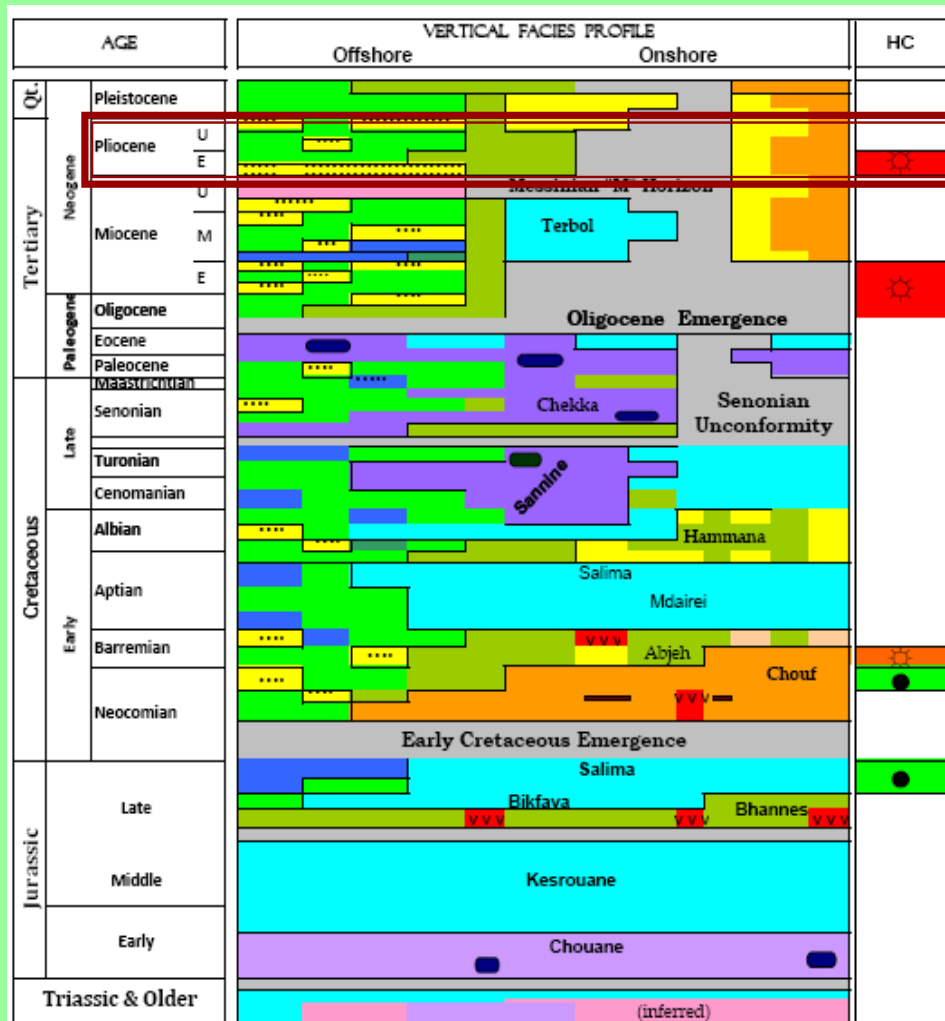
Play analogs:

- 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!



PetroServ (CY) International, LLC.

54 Nicolaou Demetriou – Kyriakon Tower, Suite # 101 – Larnaca 6031, Cyprus

Tel-Off: + 357 24 625666

Private: + 357 24 626777

E-mail: fuad@petroservint.com

E-mail: enzo@petroservint.com

Mob/Int'l: + 35 797 885511

Mob/UK: + 44 7 500 777 288

For general information: Fuad L. Jawad, Larnaca, Cyprus

For technical, geological assistance: Enzo Zappaterra, London, UK