

Hydrocarbon Prospectivity in Apulian Platform and Ionian Zone, in Relation to Strike-Slip Fault Zones, Foreland and Back-Thrust Basins of Ionian Thrust in Greece*

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Abstract

The Greek part of the FTB in the Balkan Peninsula was taken into consideration regarding its hydrocarbon potential since it exhibits, in broad terms, similar geological history to the prolific Albanian oil and gas provinces. Likewise, the hydrocarbon potential of Italy's Apulian Platform, adjoining in the westerly offshore, may serve as an analogue. Regional analysis indicates a Mid- Mesozoic hydrocarbon system as the main system in Western Greece that compares well with that of Albania. Moreover, the so far speculative Mid-to-Late-Tertiary hydrocarbon system (equal to that of Albania) also occurs. The source rocks in the Tertiary system are mainly attributed to organic carbon-rich mudstones within the Late-Oligocene to Early/Middle-Miocene turbidites. Sand-rich deposits within the submarine fan system may serve as potential reservoirs while additionally the post-Alpine clastic succession (Neogene) and the Triassic evaporites appear to constitute cap rocks and seals. The resulting plays are similar in both countries yet not identical.

The opportunities presented herein are: (1) the Ionian thrusts' foreland basin, (2) the Ionian thrusts' back-arc (piggy-back) basin, (3) the basin north of the Borsh-Khardhiqit strike-slip fault, and (4) the Preveza Basin, north of the Cephalonia transfer fault. Fundamentally, the four basins suggested for further scrutiny all have in common that they represent sedimentary (sub-)basins of substantial thicknesses which are, in one way or another, correlated with tectonic movements, i.e. the evolution of the Hellenide FTB. Based on regional seismic lines, and on regional oil-geological considerations, locally particular opportunity areas ("scenes") have been identified. Given the limited availability of well and seismic data in Western Greece, additional activities that would be helpful in avoiding negative results in exploring those basins are needed.

Selected References

- Chamot-Rooke, N., A. Rabaute, and C. Kreemer, 2005, Western Mediterranean Ridge mud belt correlates with active shear strain at the prism-backstop geological contact: *Geology*, v. 33/11, p. 861-864.
- Holton, J., 1999, Southern Italy; 1, S. Apennines success bodes well for potential off southern Italy: *Oil and Gas Journal*, v. 97/48, p. 65-68.
- Holton, J., 1999, Southern Italy; 2, Four Geologic settings dominate oil, gas fields of Italy, Sicily: *Oil and Gas Journal*, v. 97/49, p. 81-84.
- Karakitsios, V., and N. Rigakis, 2007, Evolution and petroleum potential of western Greece: *Journal of Petroleum Geology*, v. 30/3, p. 197-218.
- Kokkinou, C.K., A. Kotronarou, P. Skitides, and G.A. Vokas, 2005, Design of an environmental inspection agency for effective enforcement in Cyprus: *IASME Transactions*, v. 4/2, p. 590-595.
- Maravelis, A., and A. Zelilidis, 2012, Paleoclimatology and paleoecology across the Eocene/Oligocene boundary, Thrace Basin, northeast Aegean Sea, Greece: *Palaeogeography Palaeoclimatology Palaeoecology*, v. 365-366, p. 81-98.
- Marvelis, A., and A. Zelilidis, 2012, Porosity-permeability and textural parameters of the Palaeogene forearc sedimentary fill on Lemnos Island, NE Greece: *Turkish Journal of Earth Sciences*, v. 21/3, p. 415-438.
- Sella, A., C. Turci, and A. Riva, 1990, Petroleum geology of the "Fossa Bradanica" (foredeep of the Southern Apennine thrust belt), in J. Brooks, (ed.), *Classic petroleum provinces: Geological Society of London Special Publications*, v. 50, p. 369-378.
- Zelilidis, A., D.J.W. Piper, I. Vakalas, P. Avramidis, and K. Getsos, 2003, Oil and gas plays in Albania; do equivalent plays exist in Greece?: *Journal of Petroleum Geology*, v. 26/1, p. 29-48.



Hydrocarbon prospectivity in Apulian platform and Ionian zone, in relation to Strike-slip fault zones, Foreland and Back-Thrust basins of Ionian Thrust in Greece



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Department of Geology, University of Patras

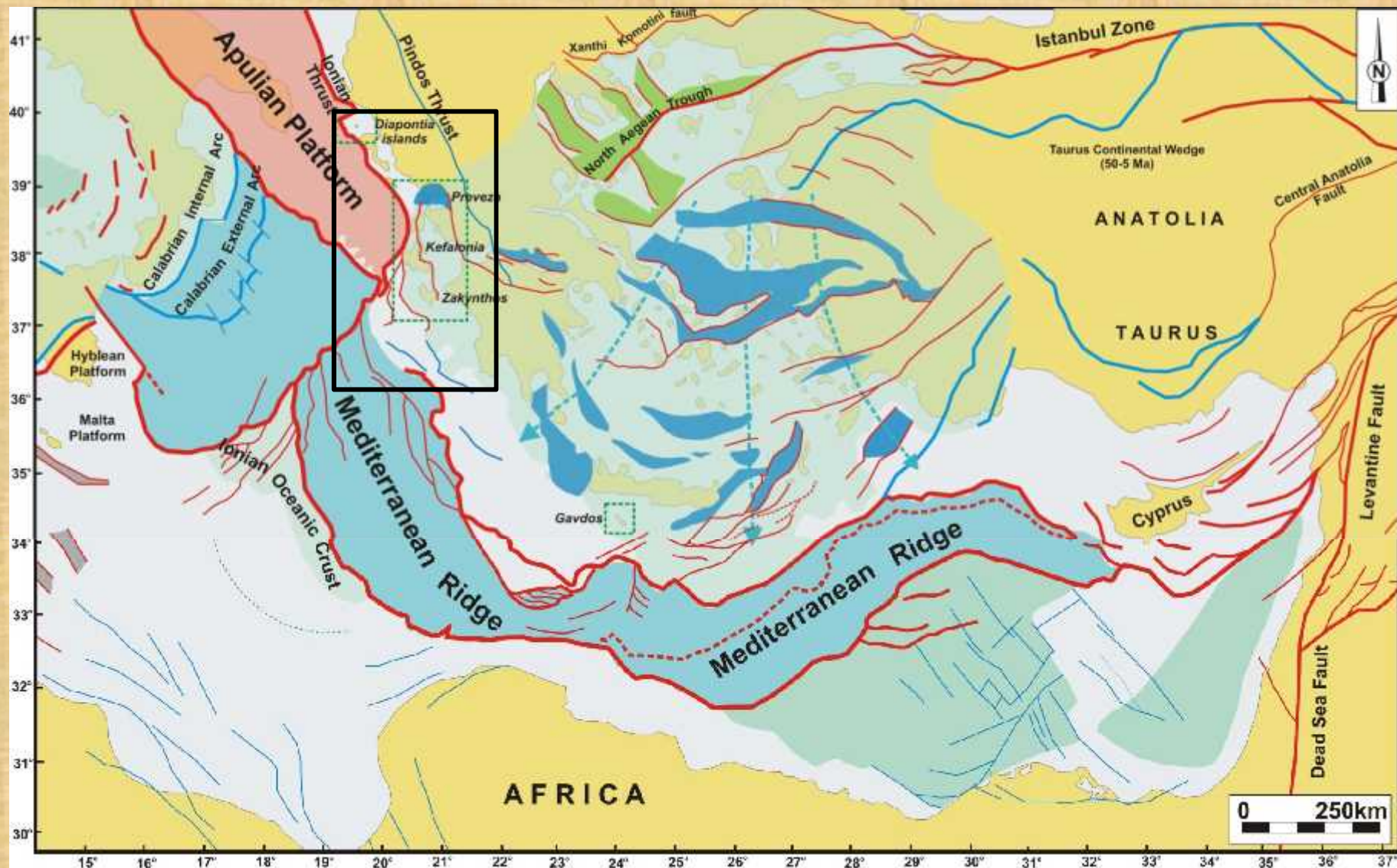


Dr. Panagiotis Konstantopoulos

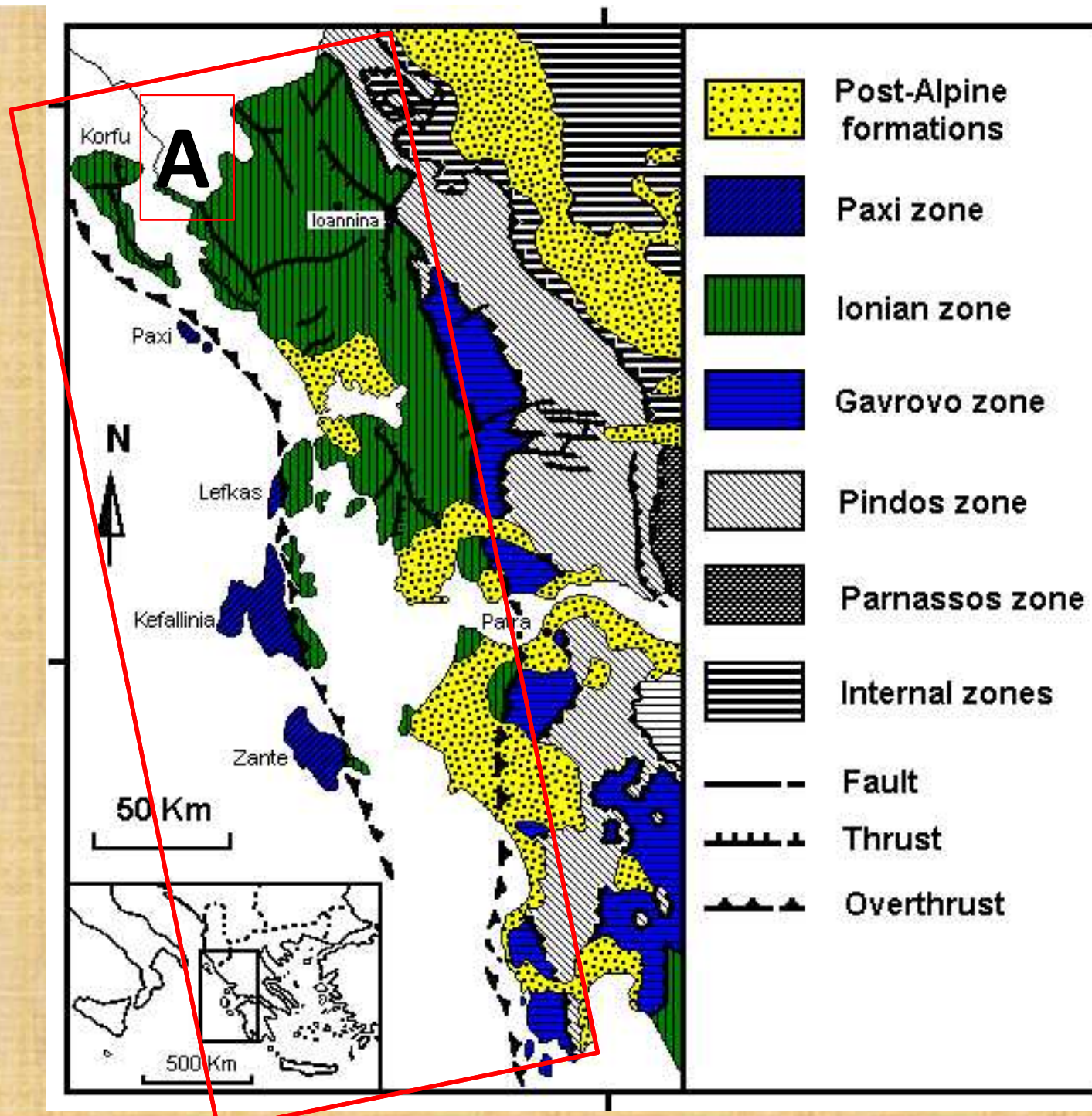


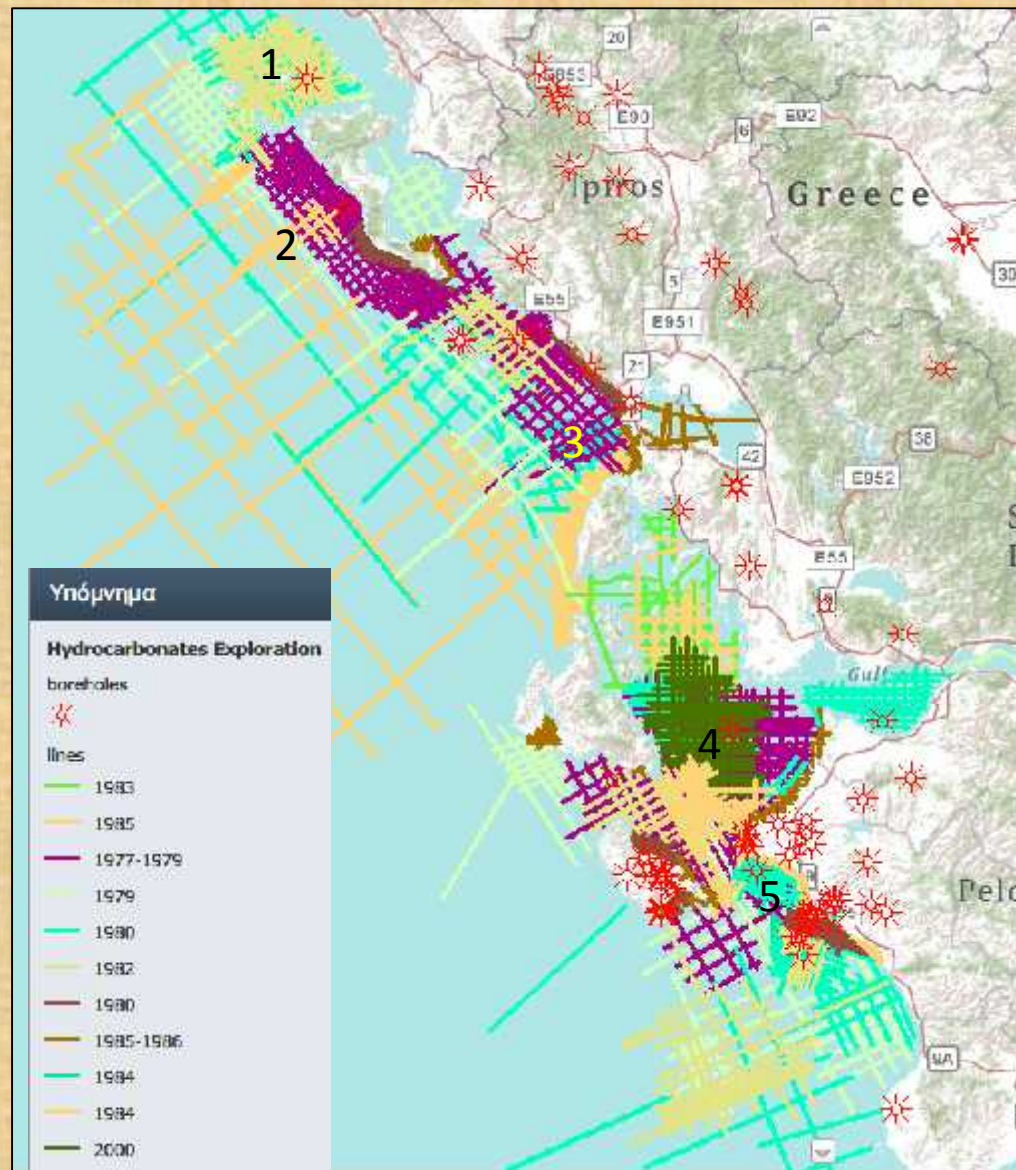
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The Northwestern part (A), with the red, shows the Apulian platform, the Southern part (B), with the deep blue, show the Mediterranean Ridge, the North Aegean sea (C) with green, show the troughs with Prinos and Epanomi hydrocarbon fields, and (D) Levantine basin with huge oil and gas fields of Cyprus and Israel(modified from Chamot-Rooke et al., 2005).





Ministry published on
4/11/2011 a Map
with seismic lines and
with boreholes

WITH DETAILS FOR

Area 1: Diapontia
islands

Area 2: west of Corfu
island

Area 3: Preveza

Area 4: Patraikos gulf

Area 5: Katakolon

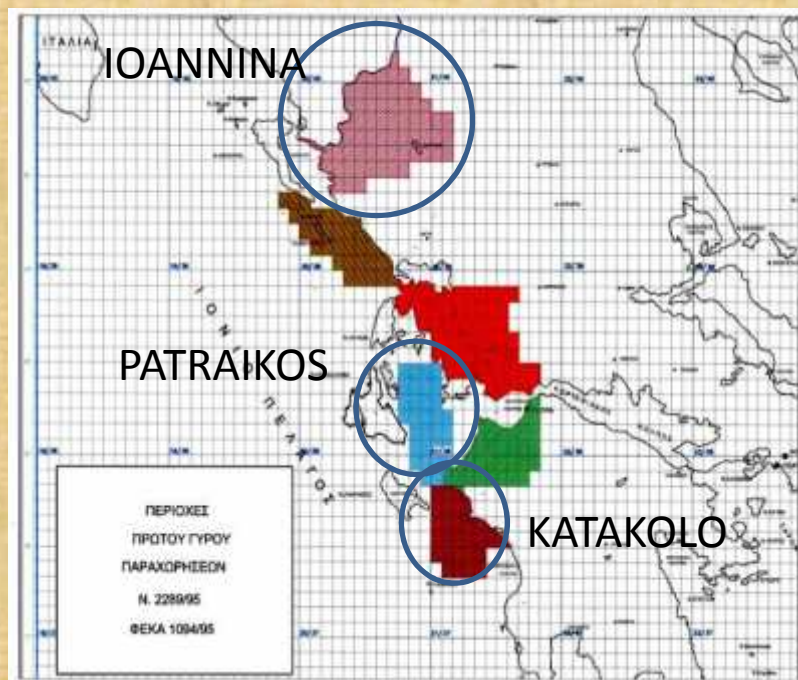


NON EXCLUSIVE SEISMIC PROJECT



4/3/2012

- 1) TGS-NOPEC GEOPHYSICAL COMPANY ASA
- 2) DOLPHIN GEOPHYSICAL
- 3) ION GEOPHYSICAL CORPORATION
- 4) SPEC PARTNERS LTD
- 5) CGGVERITAS
- 6) **PETROLEUM GEO-SERVICES (PGS)**
- 7) SPECTRUM GEO LIMITED
- 8) FUGRO MULTICLIENT SERVICES AS



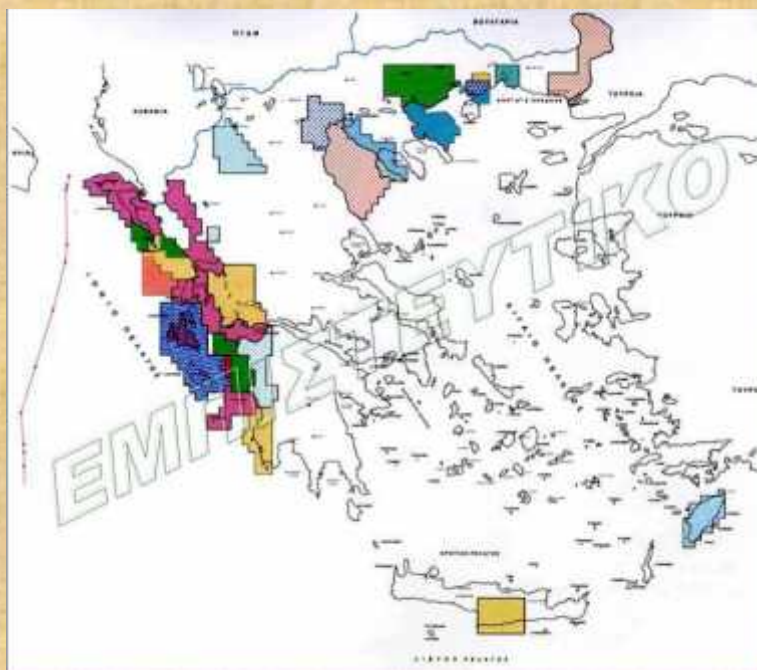
OPEN DOOR

2/7/2012

Katakolo 3-4 mb

Patraikos 200mb

Ioannina 50-80mb

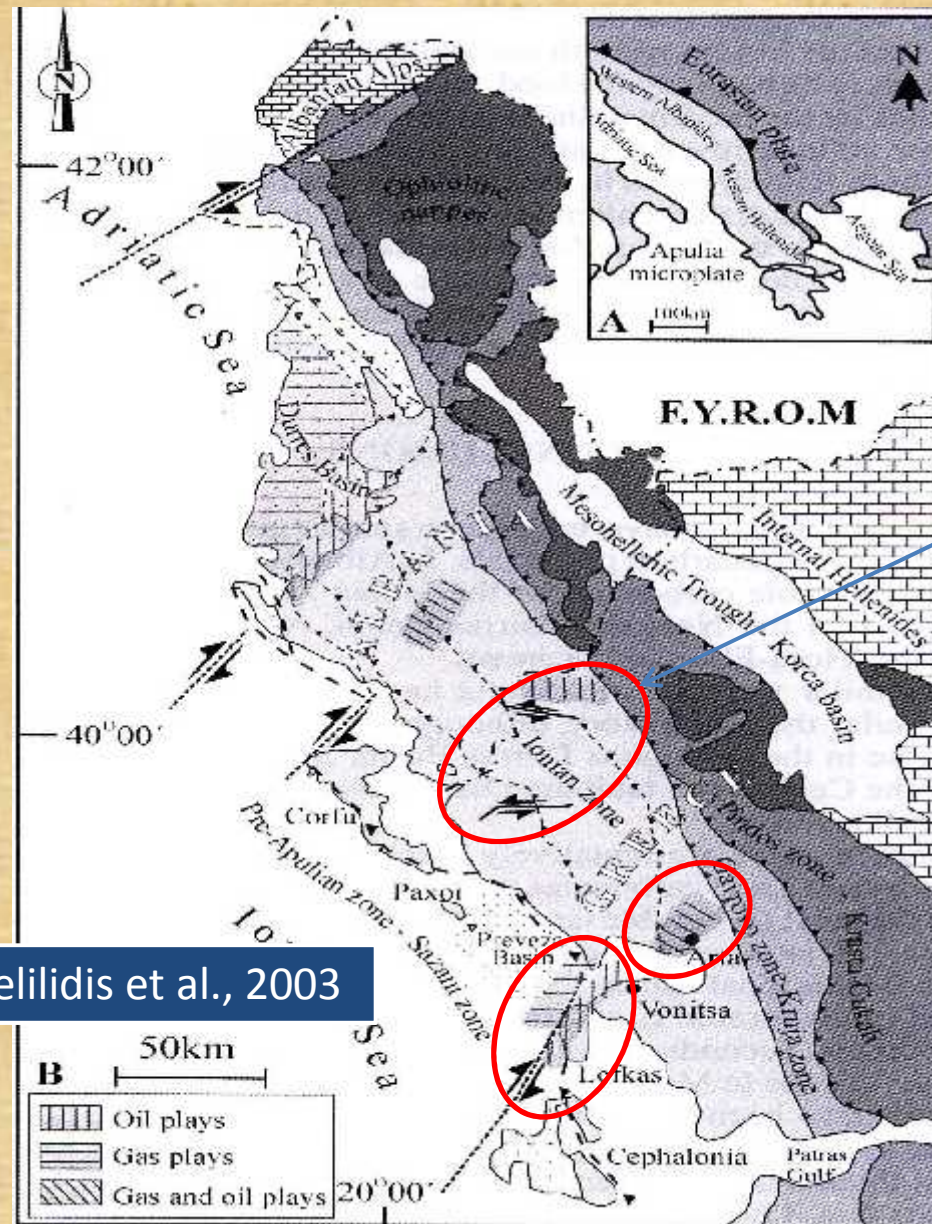


1/7/2012 ???

10-15 onshore areas

Evros, Kavalla, Serres,
Thessaloniki, Grevena,
Aitolokarnania,
Messenia, Achaia, Kriti,
e.t.c.

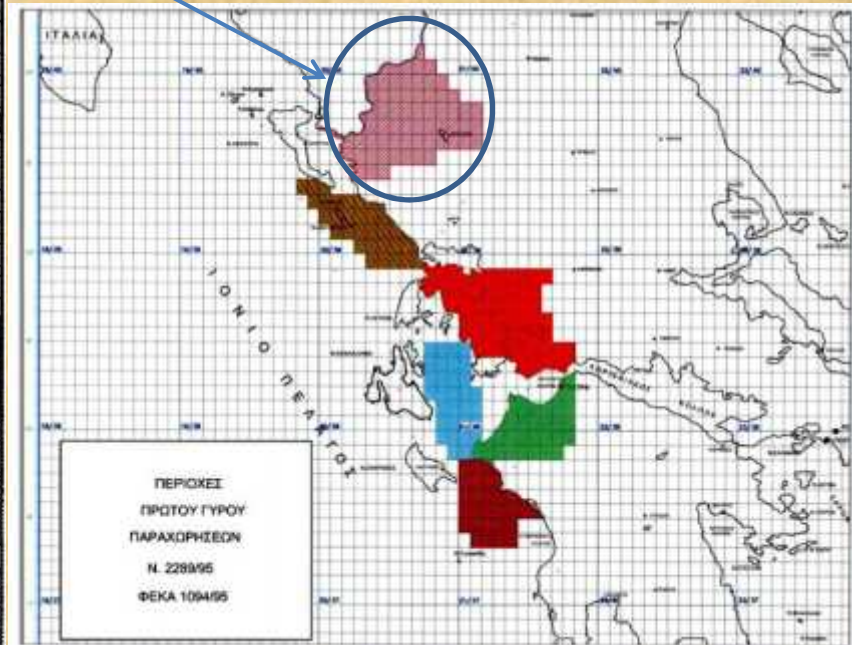
ONSHORE AREA OF IOANNINA



Zelilidis et al., 2003

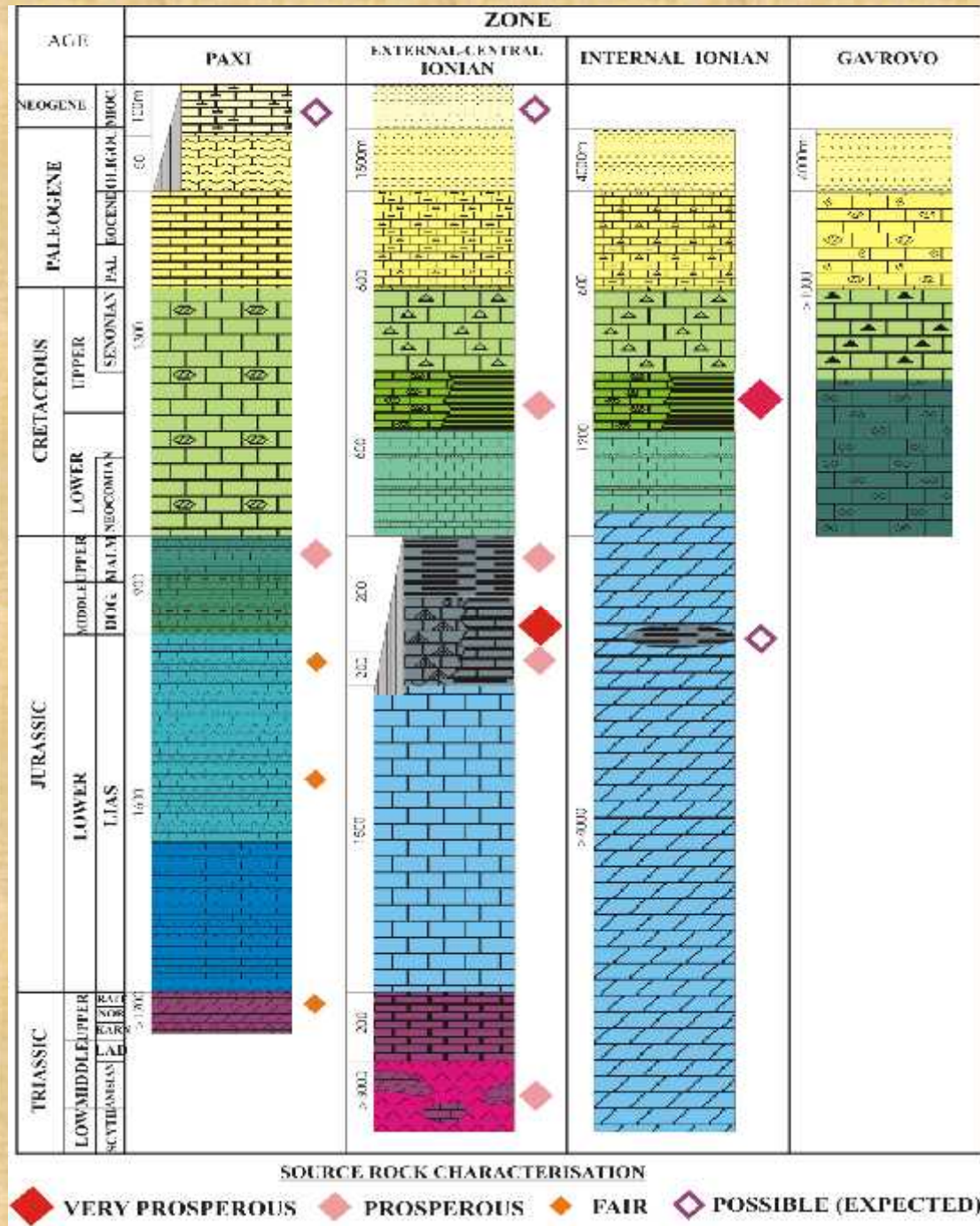
Open door: block Ioannina
With 60-80 mbo

Competition with data from 1998



GREECE				Tectonic Setting	ALBANIA			
AGE	LITHOLOGY	Source rocks	ENVIRONMENT		LITHOLOGY	Source rocks	ENVIRONMENT	
TERTIARY PALEOGENE NEOGENE	VERSIAN			POST-RIFT	DELTAIC		Shallow water	
	DELTAIC				MOLASSE			
	MOLASSE				FLYSCH			
	TRANSITIONAL MARL				INTERBEDDED LIMESTONE-CHERT			
	MICROBRECCIOUS LIMESTONES		Deep water		LIMESTONES		Deep water	
	VIGLA LIMESTONES				MARLS			
	POSIDONIA BEDS				INTERBEDDED LIMESTONE-CHERT			
	LIMESTONES				LIMESTONES			
	PANTOKRATOR LIMESTONES		Shallow water		MARLS		Deep Water	
	FOUSTAPIDIMA LIMESTONES							
CRETACEOUS	DELTAIC		Shallow water	SYN-RIFT	DELTAIC		Shallow water	
	MOLASSE				MOLASSE			
	FLYSCH				FLYSCH			
	TRANSITIONAL MARL				INTERBEDDED LIMESTONE-CHERT			
	MICROBRECCIOUS LIMESTONES		Deep water		LIMESTONES		Deep water	
	VIGLA LIMESTONES				MARLS			
	POSIDONIA BEDS				INTERBEDDED LIMESTONE-CHERT			
	LIMESTONES				LIMESTONES			
	PANTOKRATOR LIMESTONES		Shallow water		MARLS		Deep Water	
	FOUSTAPIDIMA LIMESTONES							
JURASSIC	DELTAIC		Shallow water	SYN-RIFT	DELTAIC		Shallow water	
	MOLASSE				MOLASSE			
	FLYSCH				FLYSCH			
	TRANSITIONAL MARL				INTERBEDDED LIMESTONE-CHERT			
	MICROBRECCIOUS LIMESTONES		Deep water		LIMESTONES		Deep water	
	VIGLA LIMESTONES				MARLS			
	POSIDONIA BEDS				INTERBEDDED LIMESTONE-CHERT			
	LIMESTONES				LIMESTONES			
	PANTOKRATOR LIMESTONES		Shallow water		MARLS		Deep Water	
	FOUSTAPIDIMA LIMESTONES							
TRIASSIC	DELTAIC		Shallow water	SYN-RIFT	DELTAIC		Shallow water	
	MOLASSE				MOLASSE			
	FLYSCH				FLYSCH			
	TRANSITIONAL MARL				INTERBEDDED LIMESTONE-CHERT			
	MICROBRECCIOUS LIMESTONES		Deep water		LIMESTONES		Deep water	
	VIGLA LIMESTONES				MARLS			
	POSIDONIA BEDS				INTERBEDDED LIMESTONE-CHERT			
	LIMESTONES				LIMESTONES			
	PANTOKRATOR LIMESTONES		Shallow water		MARLS		Deep Water	
	FOUSTAPIDIMA LIMESTONES							

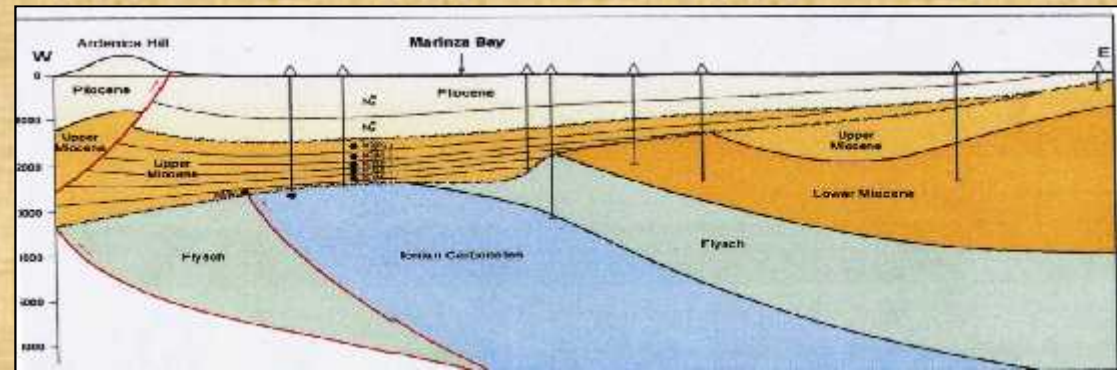
Stratigraphy of Ionian zone
Zelilidis et al., 2003



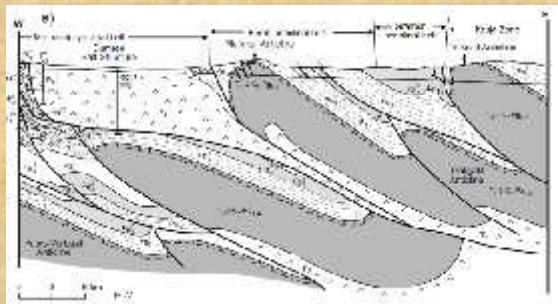
Albania



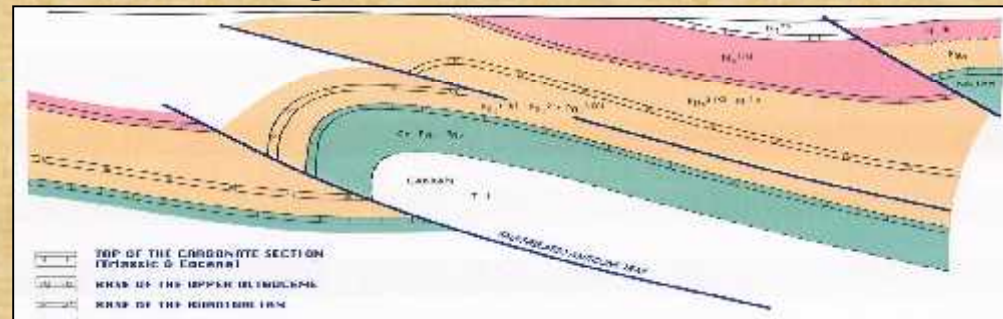
W-E Geological Cross Section- Marinza Field, onshore Albania- 5 billion bbl in place



Dumrea Structure



Schematic Geological Cross-Section of Cakran oil field



Field Area	Formation	Depth (m)	HC Column (m)	Reservoir	Recoverable Reserves BOE	API
Delvina	Carbonates	2800-3500	500-2000	Gas & Cond.	184Bcf (GIIP)	62°
Dumrea	Flysch	5700	600	Oil	110-140 MM	

Oil generated in Albania discovered as far East as Tomorrit anticline, which is within the equivalent of the Ionian zone.

Source Rocks

Formation	Age	Oil Window Time	Current HC Generation
Shale Fragments	Triassic breccia	Late Jurassic	Gas
Lower Posidonia beds	Toarcian – Aalenian (Jurassic)	Middle Miocene	Oil - Condensate – Gas
Ammonitico Rosso	Lower Toarcian (Jurassic)	Middle Miocene	Oil – Condensate – Gas
Upper Posidonia	Callovian-Tithonian (Jurassic)	Upper Miocene	Oil – Condensate – Gas
Vigla shales	Albian-Cenomanian (Cretaceous)	Miocene	Oil
Flysch (possible)	Oligocene	At 3650-5900m	Gas

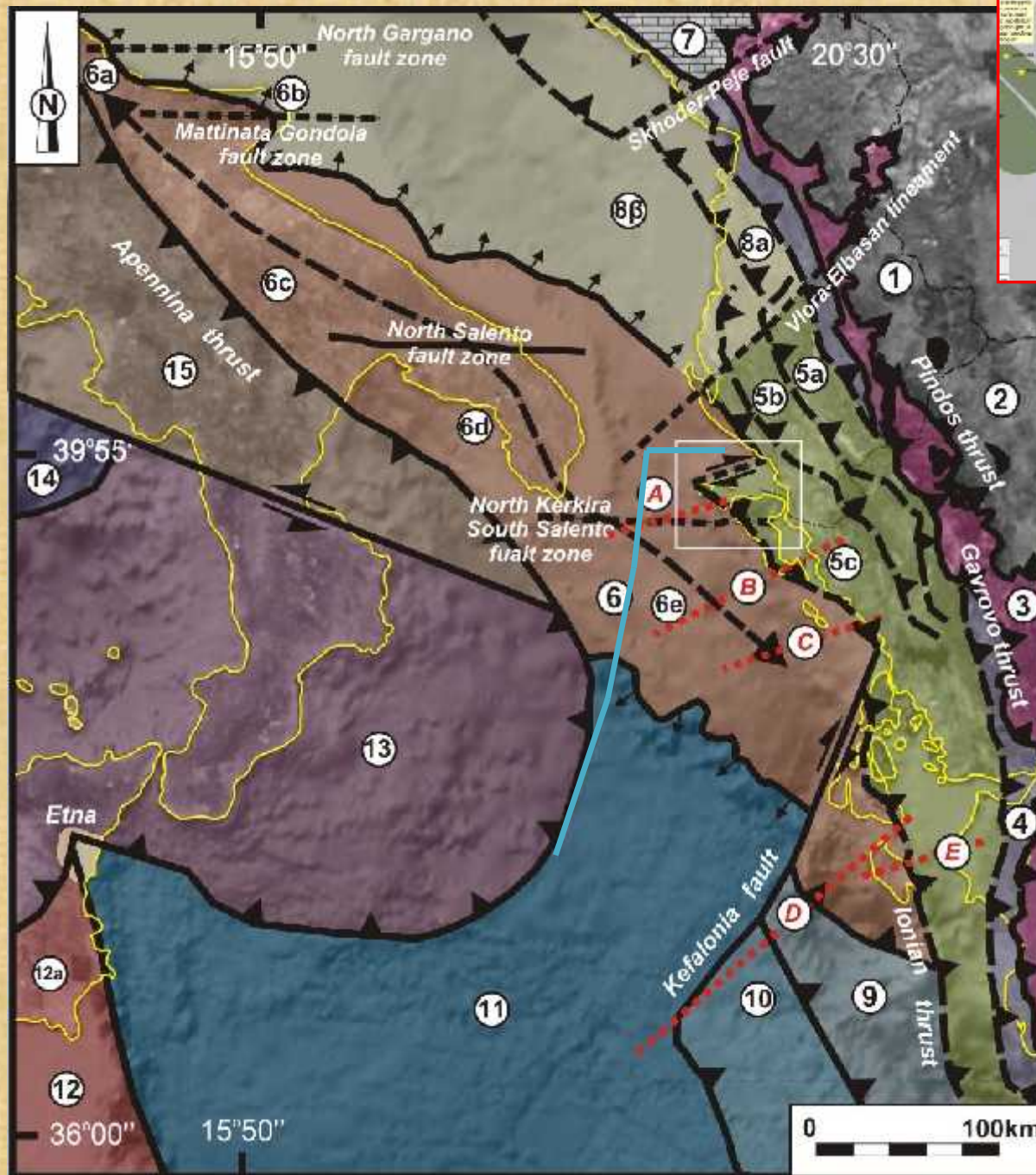
Reservoir

Reservoir Type

- **Fractured Carbonates**
- **Karstified Carbonates**
- **Strike-slip Faulted Zones**
- **Sub-marine sandstone turbidites**

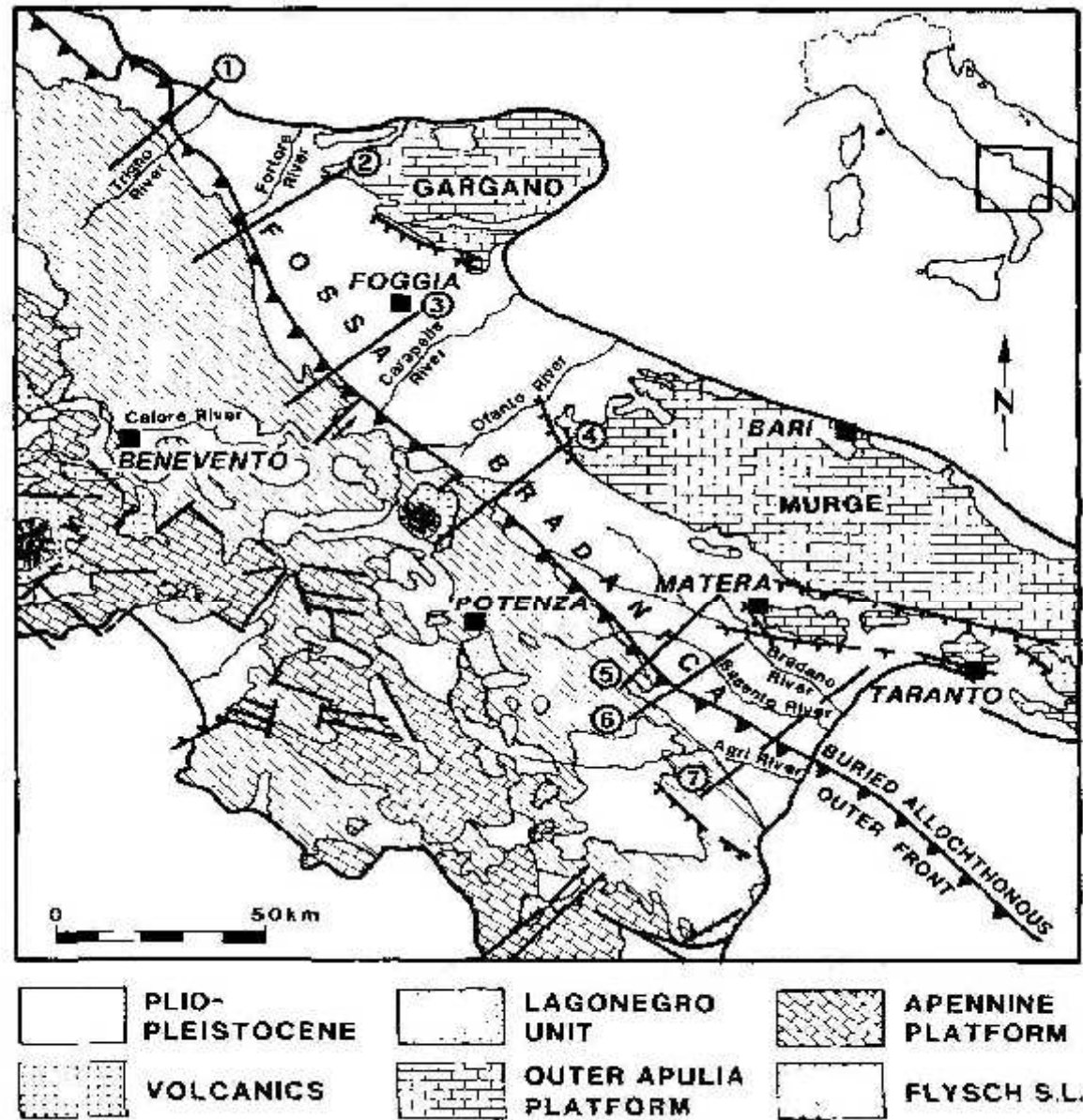
Formation	Rock Quality
Foustapidima Limestones	N/A
Pantokrator Limestones	Possible Paleo-relief
Lower Jurassic Limestones	Uplift & Erosion
Microbreccious Limestones	1-9% 0.05mD
Oligocene submarine fans	3-24% up to 10mD
Miocene submarine fans	3-15% up to 10mD

APULIAN PLATFORM
WESTERN GREECE
OFFSHORE AND
ONSHORE AREAS



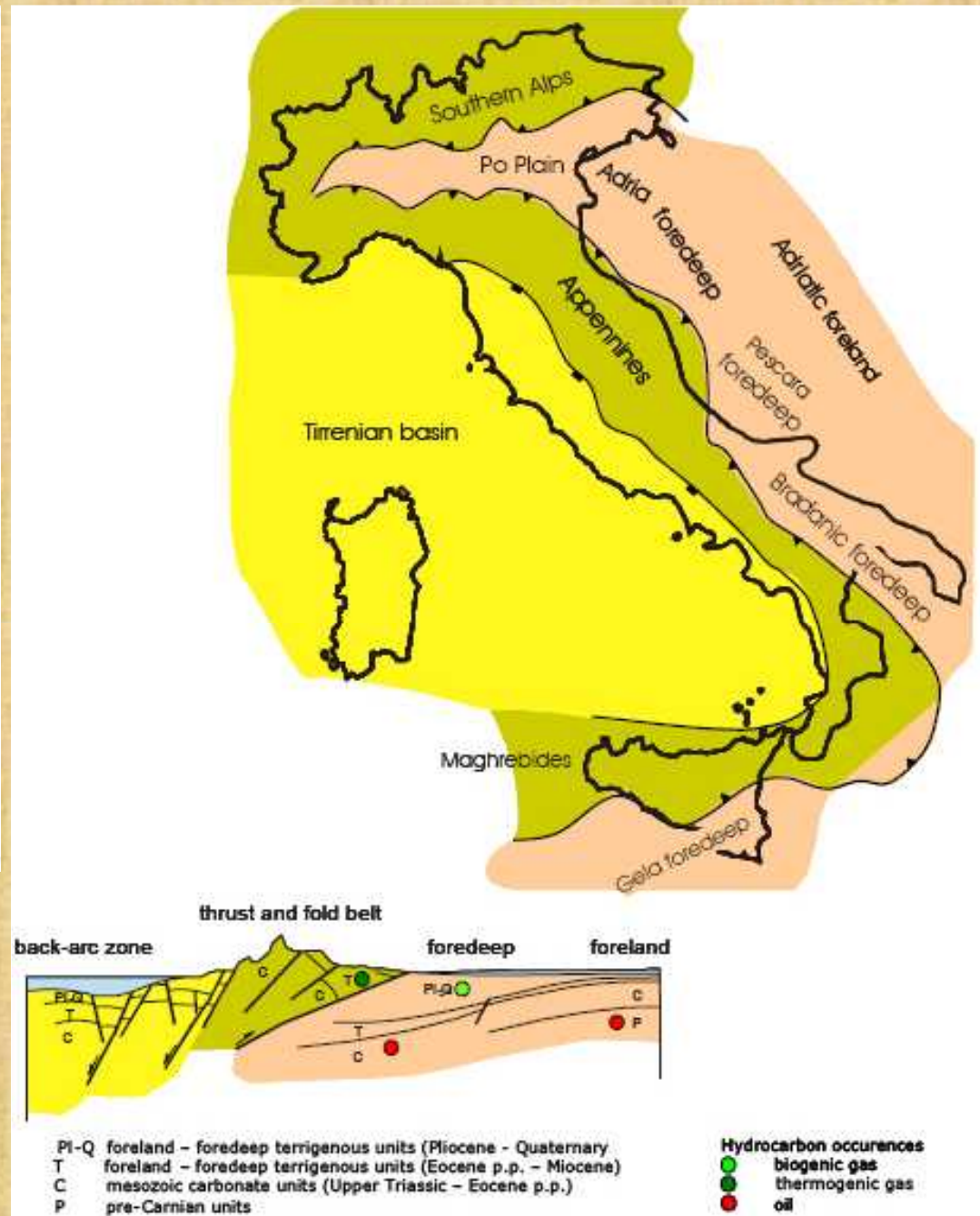
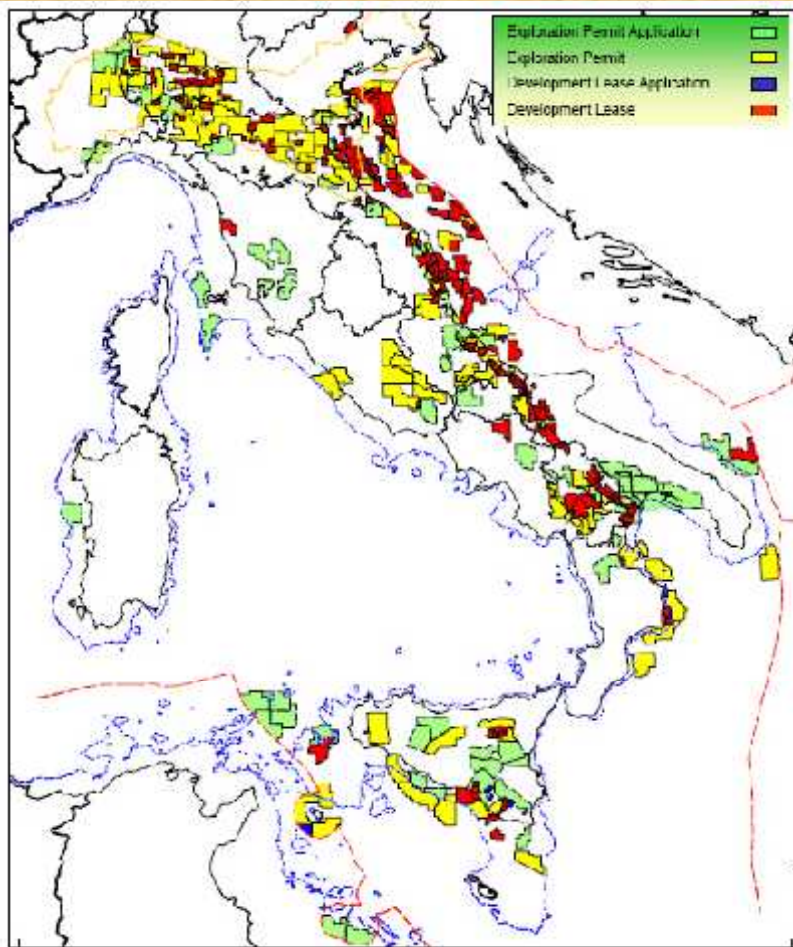
The red dashed lines are seismic lines.
The yellow line is the coastline.

1. Internal Albanides,
2. Internal Hellenides,
3. Pindos zone (Kraša),
4. Gavrovo zone (Kruja),
- 5a. Internal Ionian zone,
- 5b. Middle Ionian zone,
- 5c. External Ionian zone,
6. Apulian platform:
 - 6a. Plateau Rospo,
 - 6b. Gargano promontory,
 - 6c. Murge ridge,
 - 6d. Salento peninsula,
 - 6e. Apulia plateau,
7. Albanian Alps,
- 8a. Dures basin, 8b. Ionian-Albania basin,
9. Hellenic trench,
10. Mediterranean ridge,
11. Ionian abyssal plain,
12. Africa, 12a. Hyblean plateau,
13. Calabrian arc,
14. South Tyrrhenian sea,
15. South Apennine.

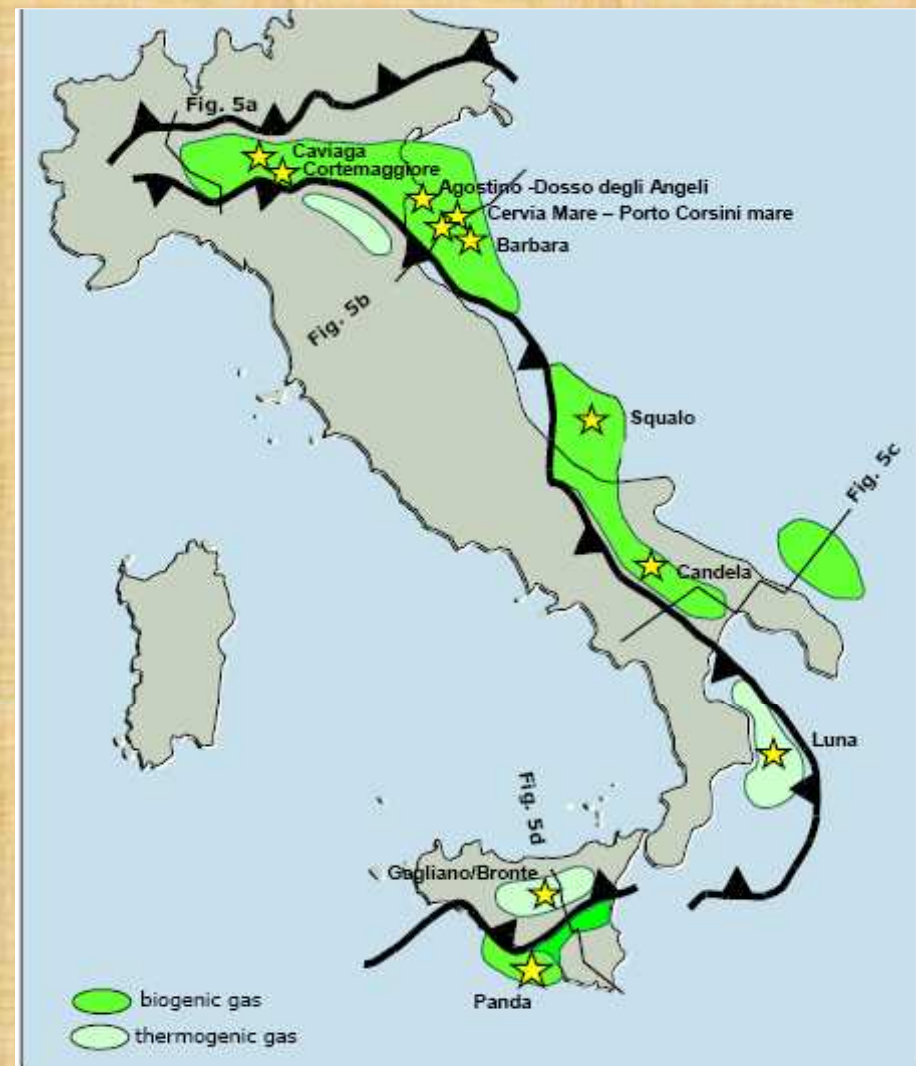


from Sella et al., 1990





from Bartello et al., 2008



Bartello et al., 2008

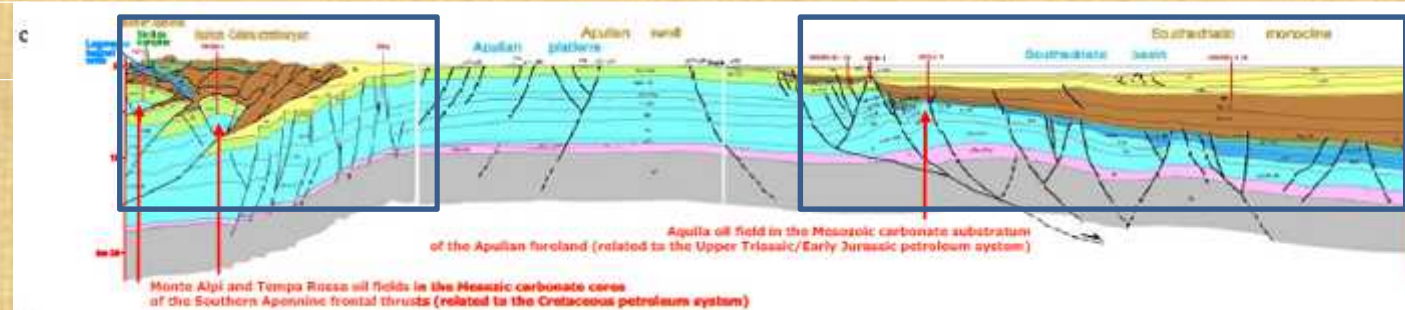


Figure 5: Internal Zone, Apennines (Val D'Agri Oil Play)

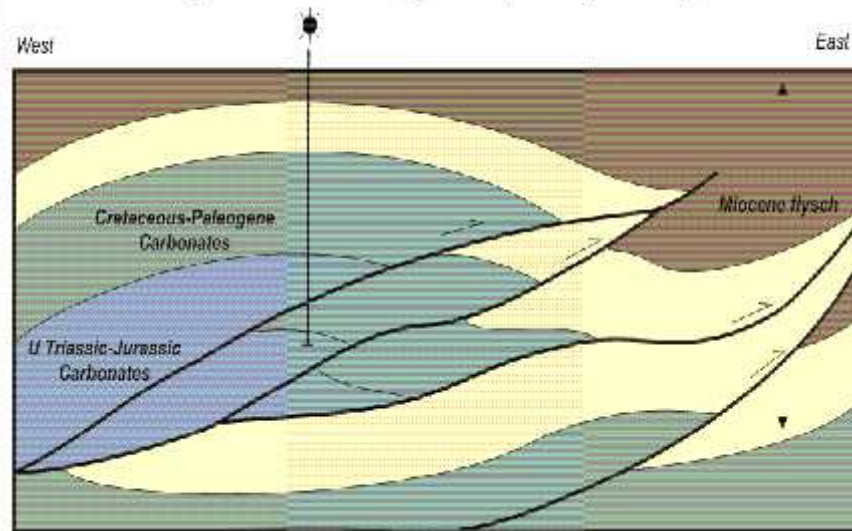


Figure 7: Luna field, Apennine external zone

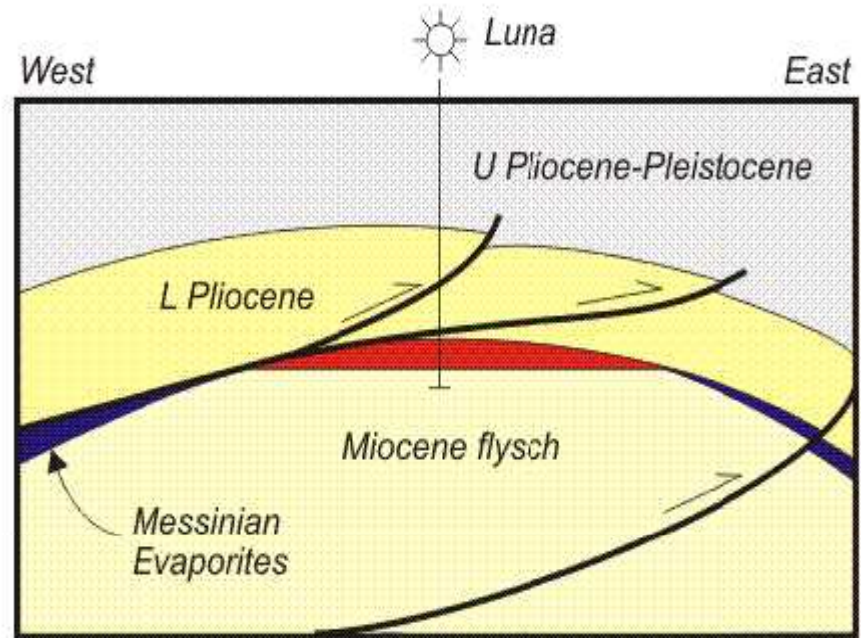


Figure 6: Pisticci field, Apennine external zone

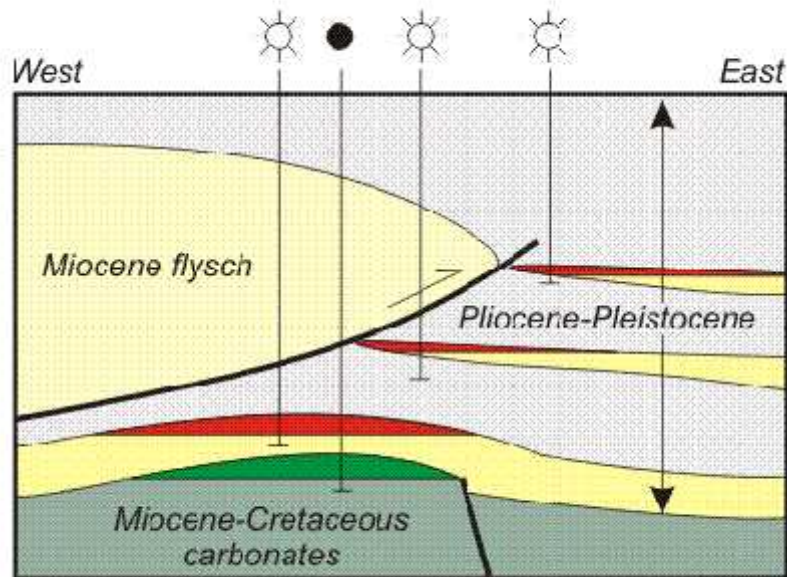
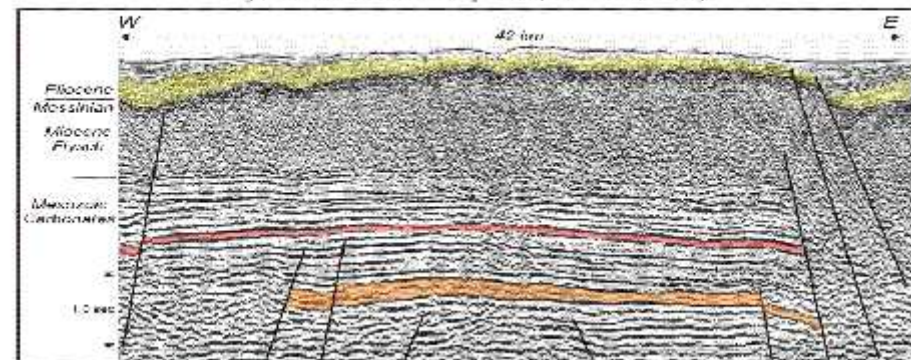
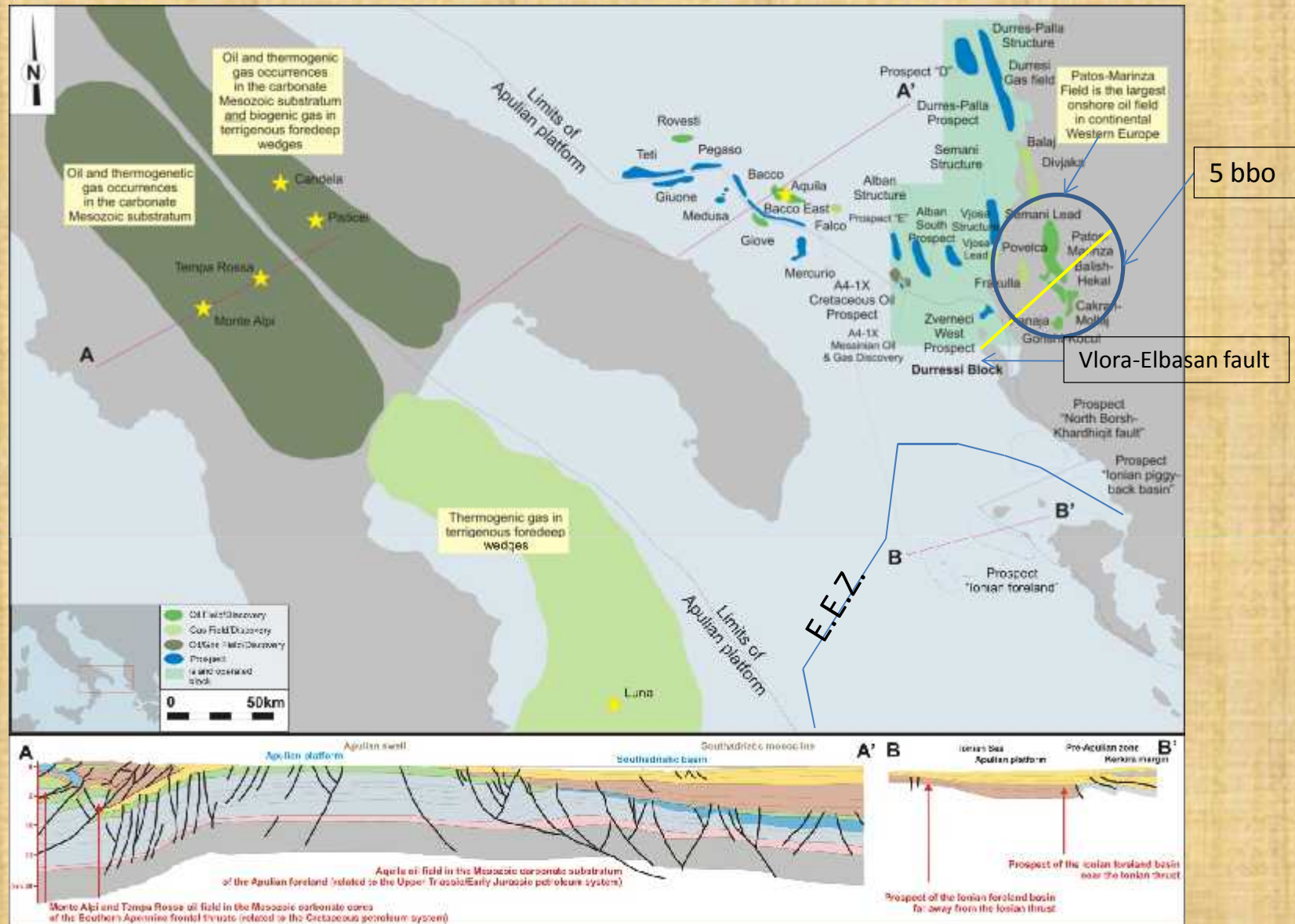


Figure 17: Miocene flysch over autochthonous forland carbonates, adjacent to Malta escarpment, offshore Sicily



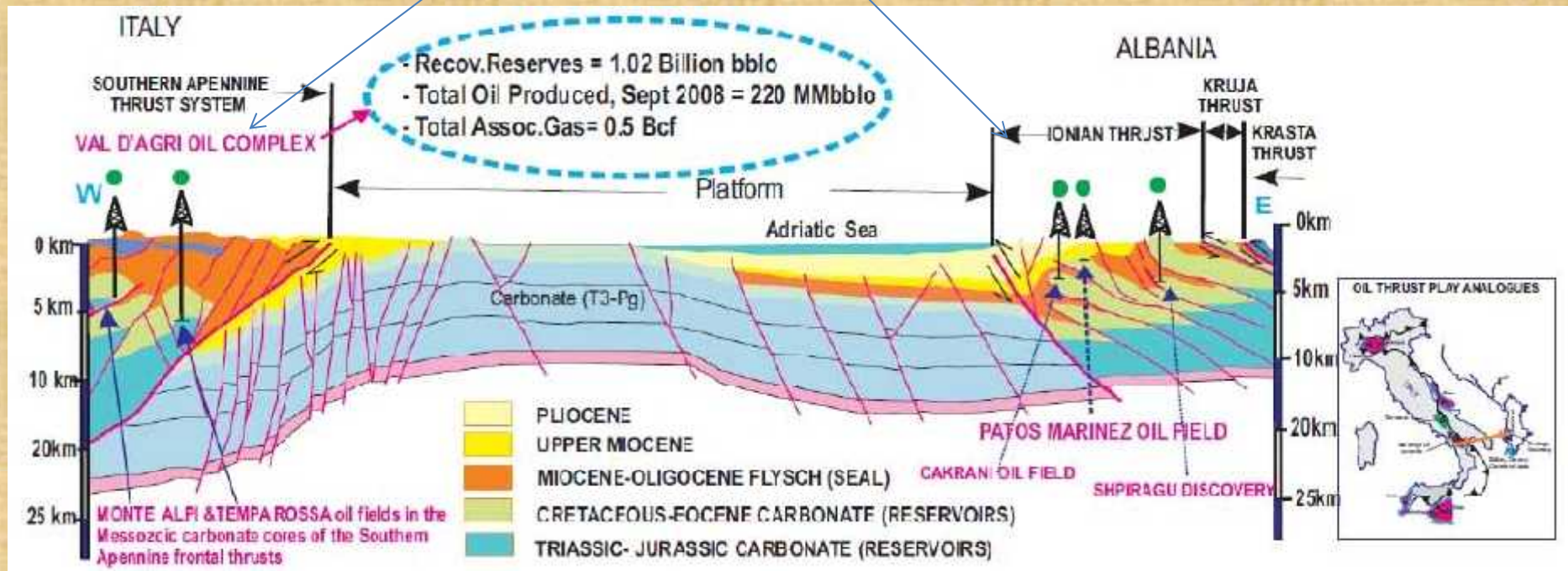
Holton, 1999

A1

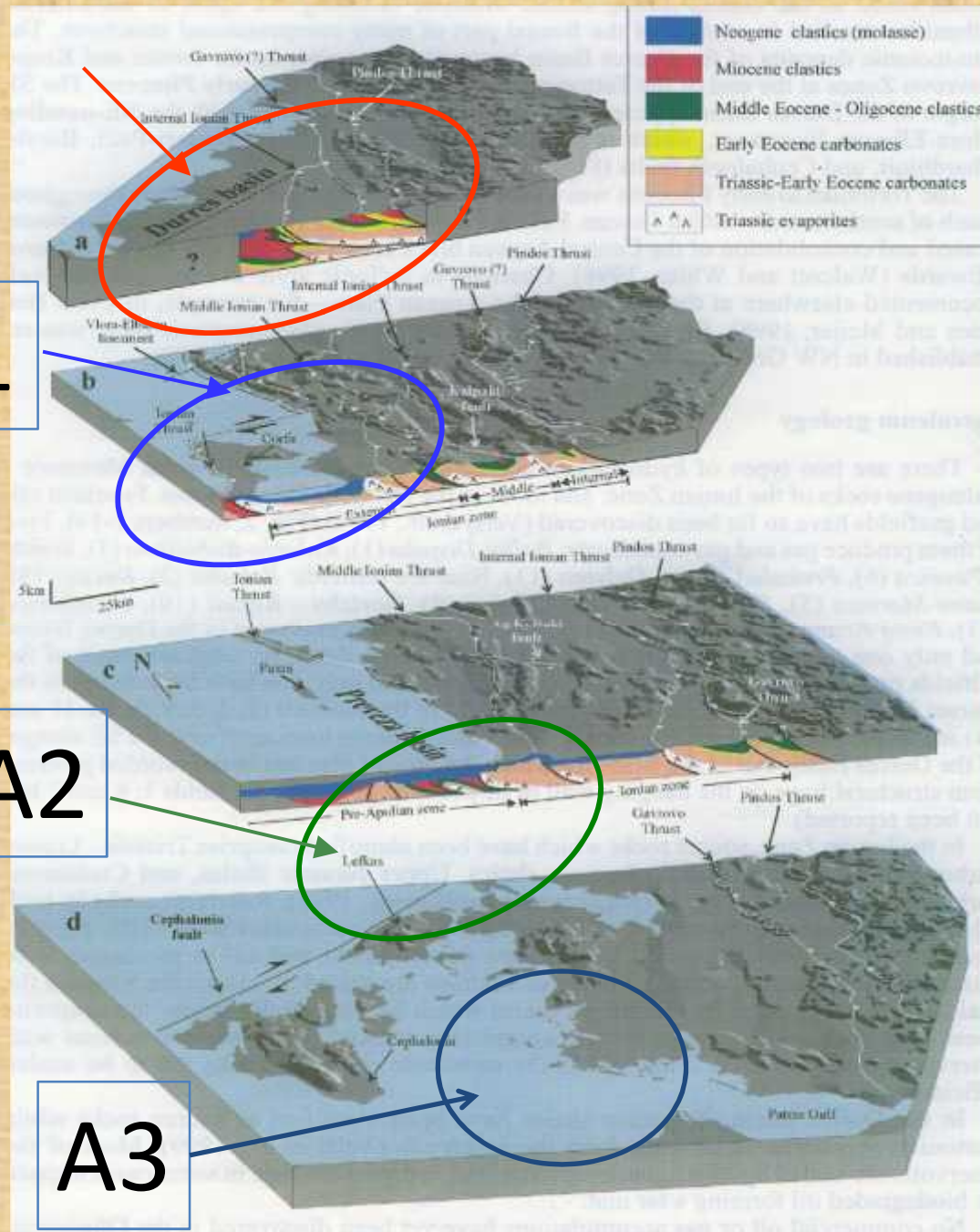


Synthetic sketch map showing Italian and Albanian hydrocarbon plays with an attempt for correlation with the northwestern part of Greece (Diapontia islands). Cross-sections AA' and BB' based on seismic data.

South Italy and Albania Analogue



Field Area	Formation	Depth (m)	HC Column (m)	Reservoir	Recoverable Reserves BOE	API
Gela	Carbonates	3000-3300		Oil		10-20°
Val D' Agri	Carbonates		600-1000	Oil	1020 MM	17-46°
Monte Alpi & Cerro Falcone	Limestones		702-760	Oil & Gas	600 MM	30-37°
Tempa Rossa	Limestones	4000	700	Oil & Gas	420 MM	17-22°

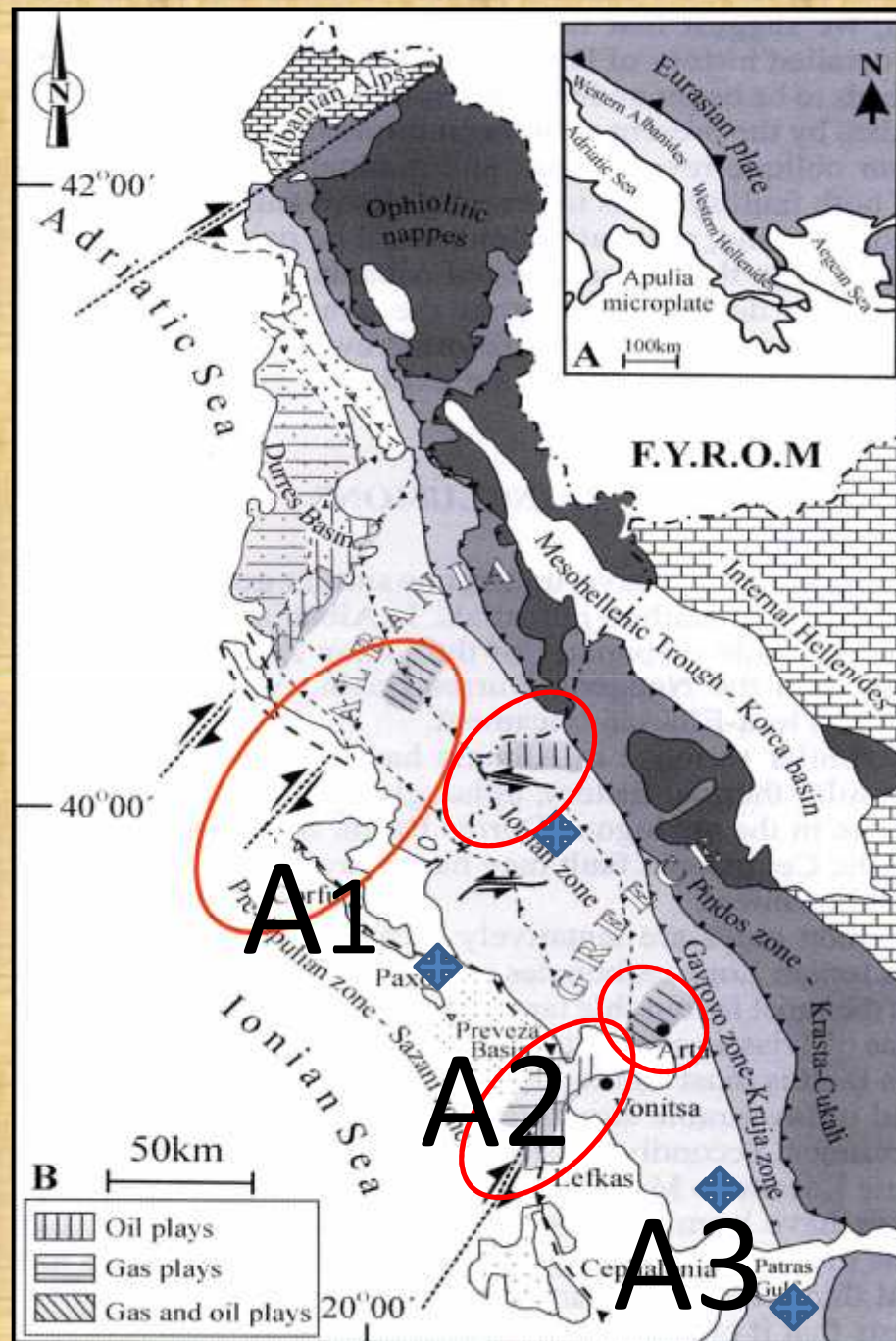


A1

A2

A3

This 3D model is divided into four blocks where the Durrës basin, the proportional basins in Diapondia Islands and Preveza, are shown (A1, A2, and A3 circles; Zelilidis et al., 2003).

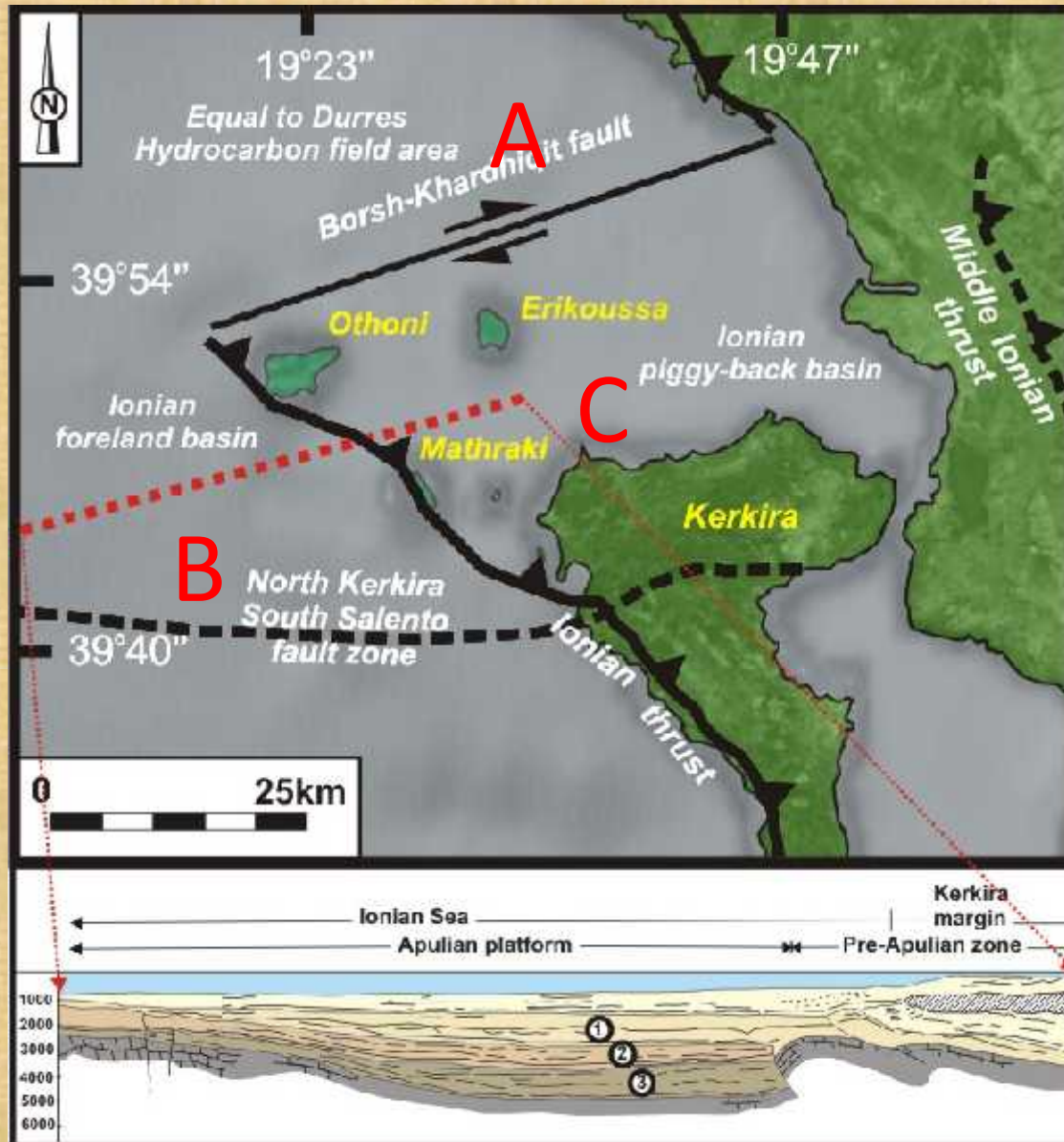


Geological map with proposed gas and oil plays. The red cycles show:

*Diapontia islands,
Kalpaki area in
Ioannina*

*Preveza-Lefkada basin
Arta area*

*(modified from Zelilidis
et al., 2003).*



Diapontia Islands with the three potential hydrocarbon regions.

- A) The first region is north to the Borsh-Khardhiqit fault,
- B) the second area is located westward to the Ionian thrust - the Ionian foreland basin. The seismic line Northern to Kerkira shows the foreland,
- C) The piggy-back basins of Ionian thrust

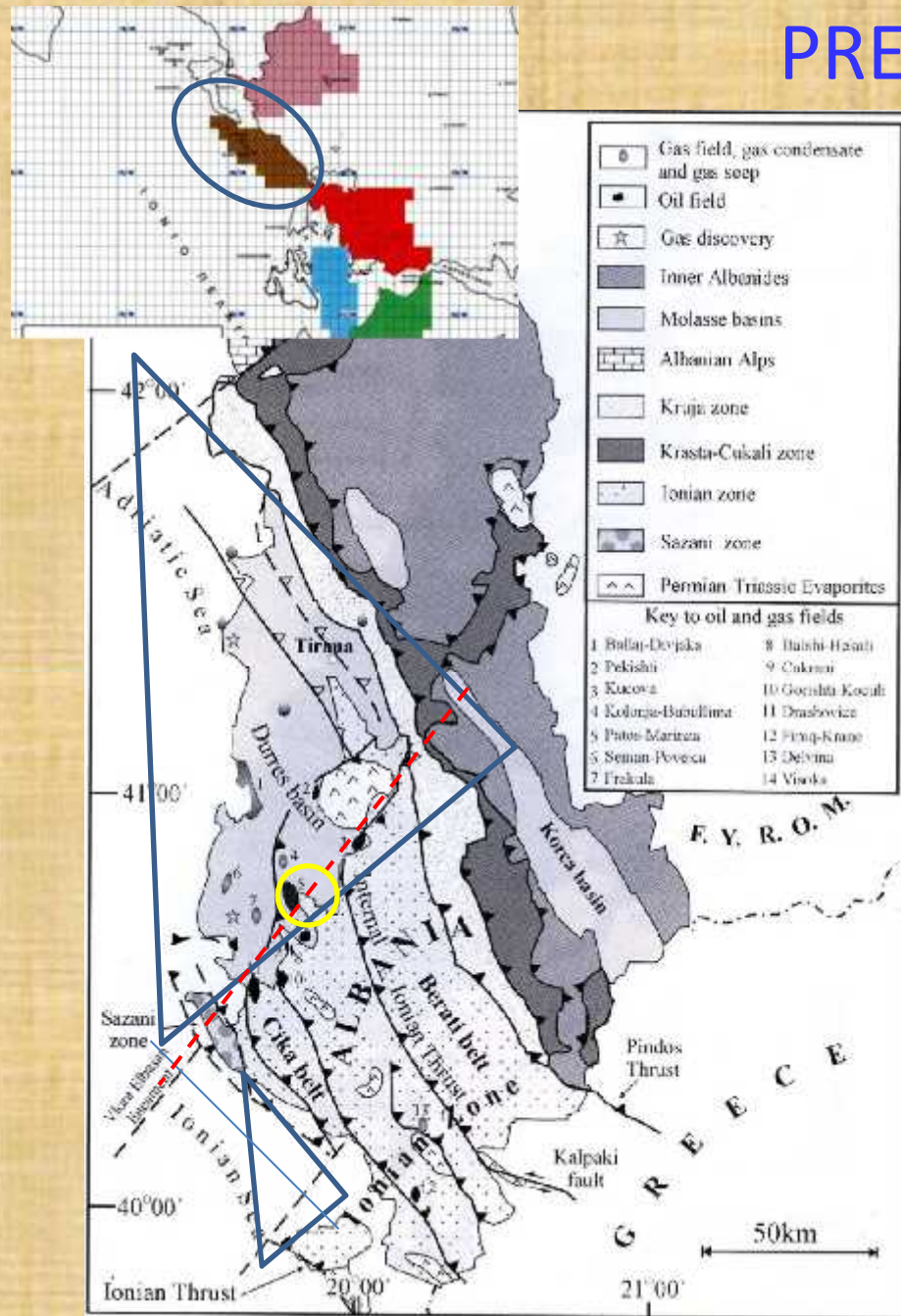
The numbers on the seismic line are:

- (1) Pliocene-Quaternary sediments,
- (2) Middle-Upper Miocene sediments and
- (3) Lower Miocene and older formations

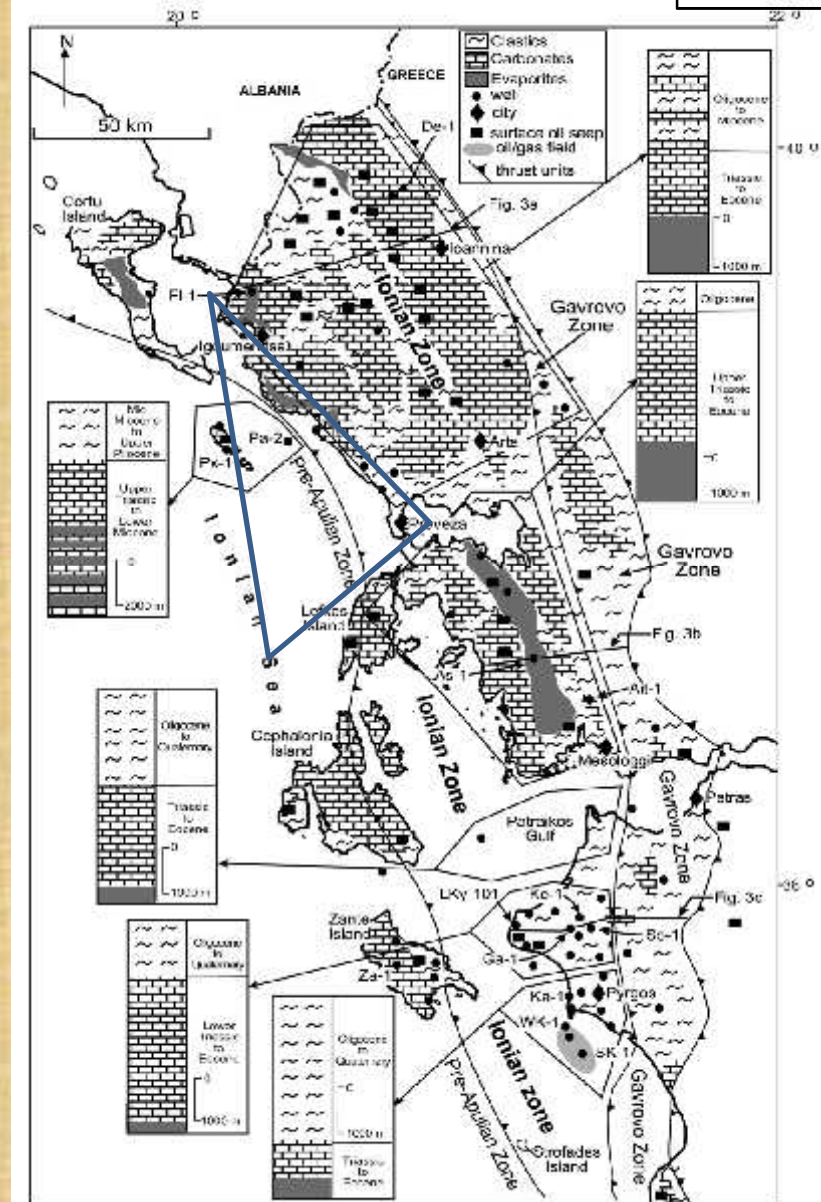
(modified from Monopolis and Bruneton, 1981).

PREVEZA

A2



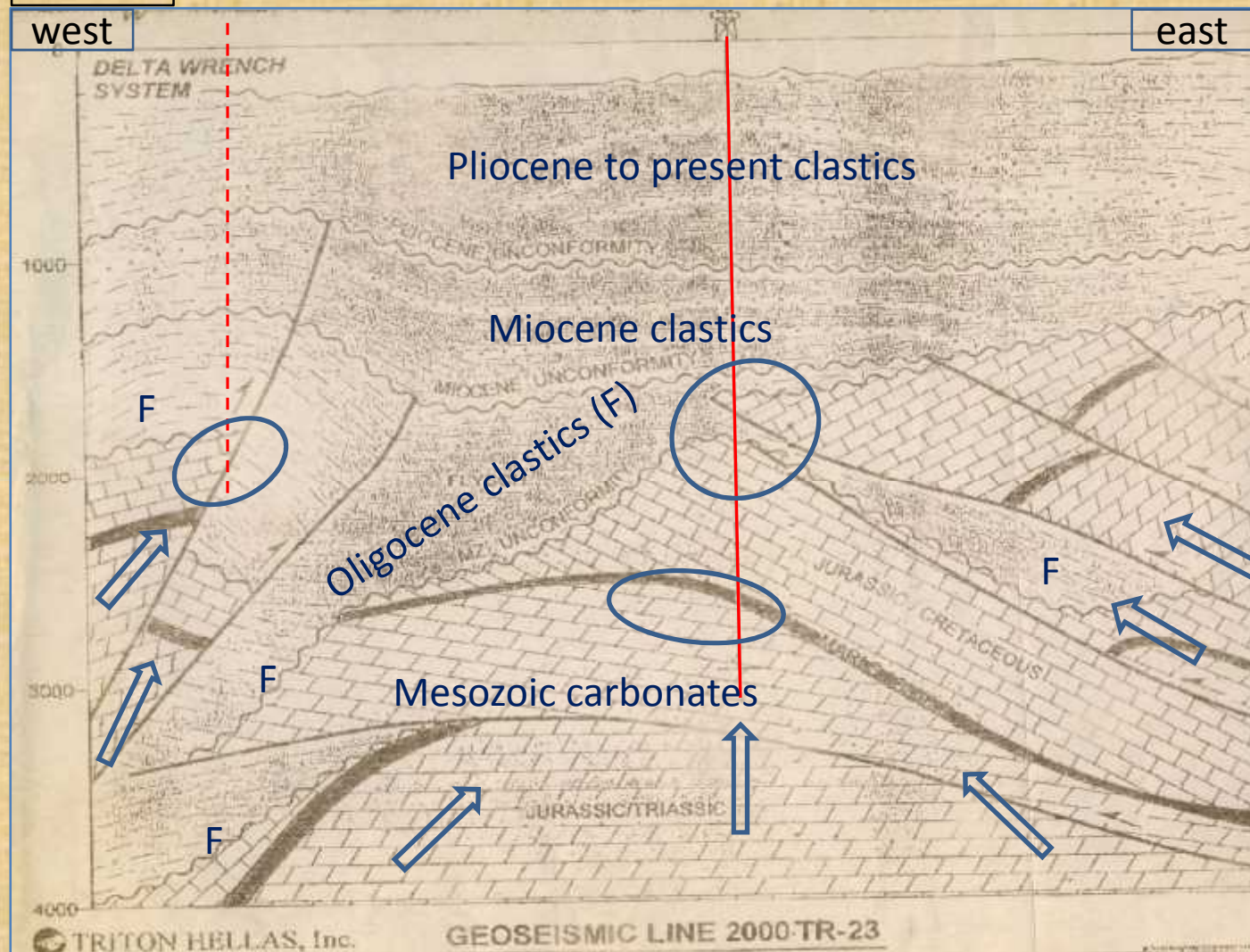
Zelilidis et al., 2003



Mavromatidis 2009

A3

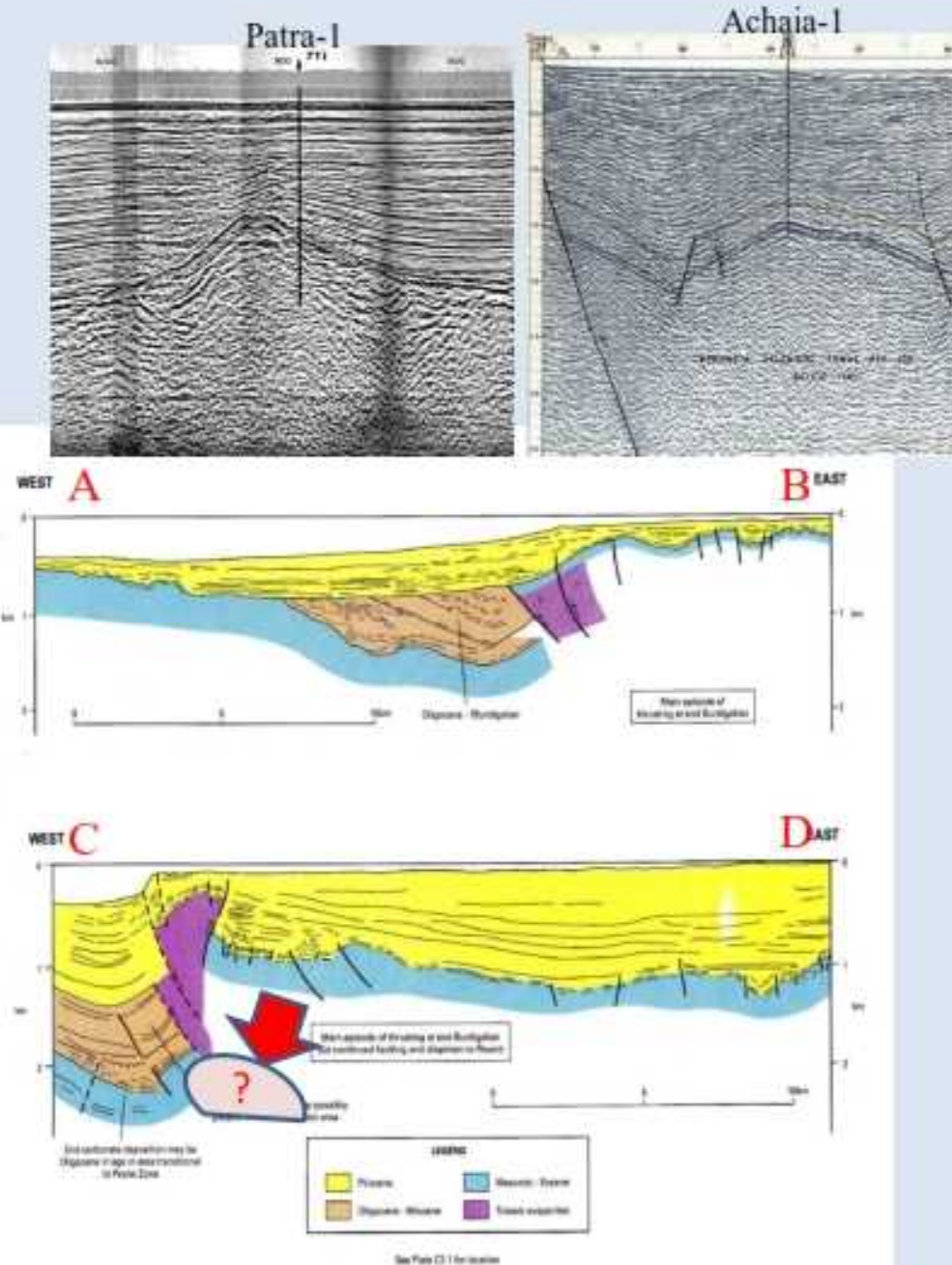
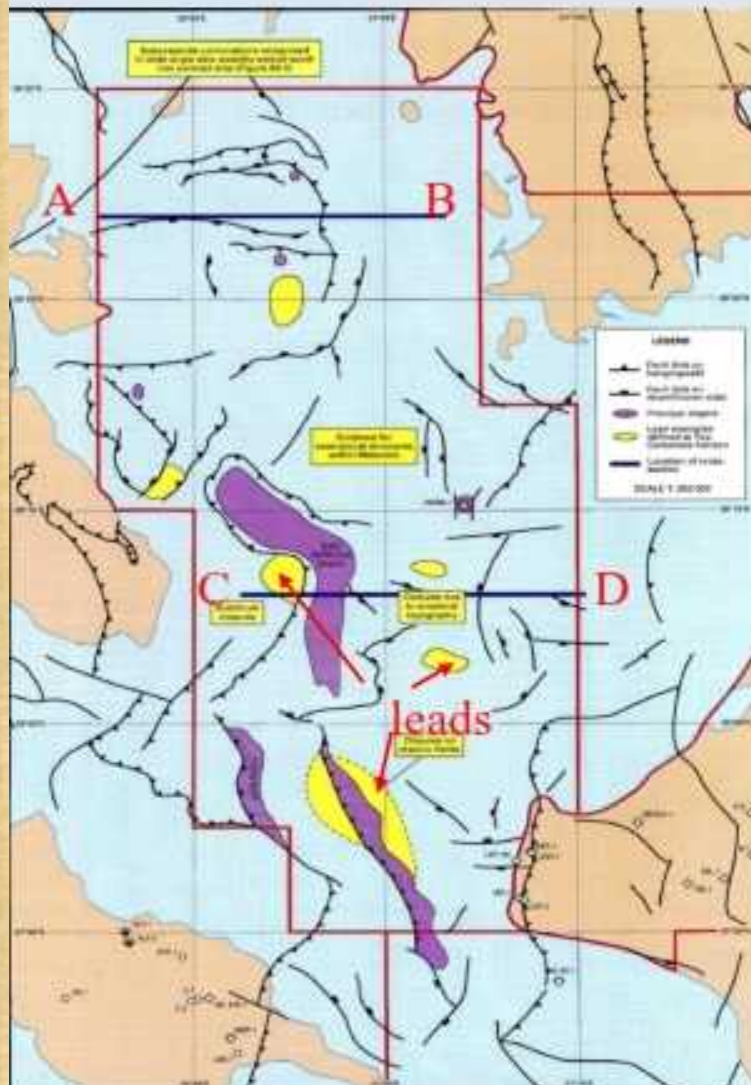
GULF OF PATRAS



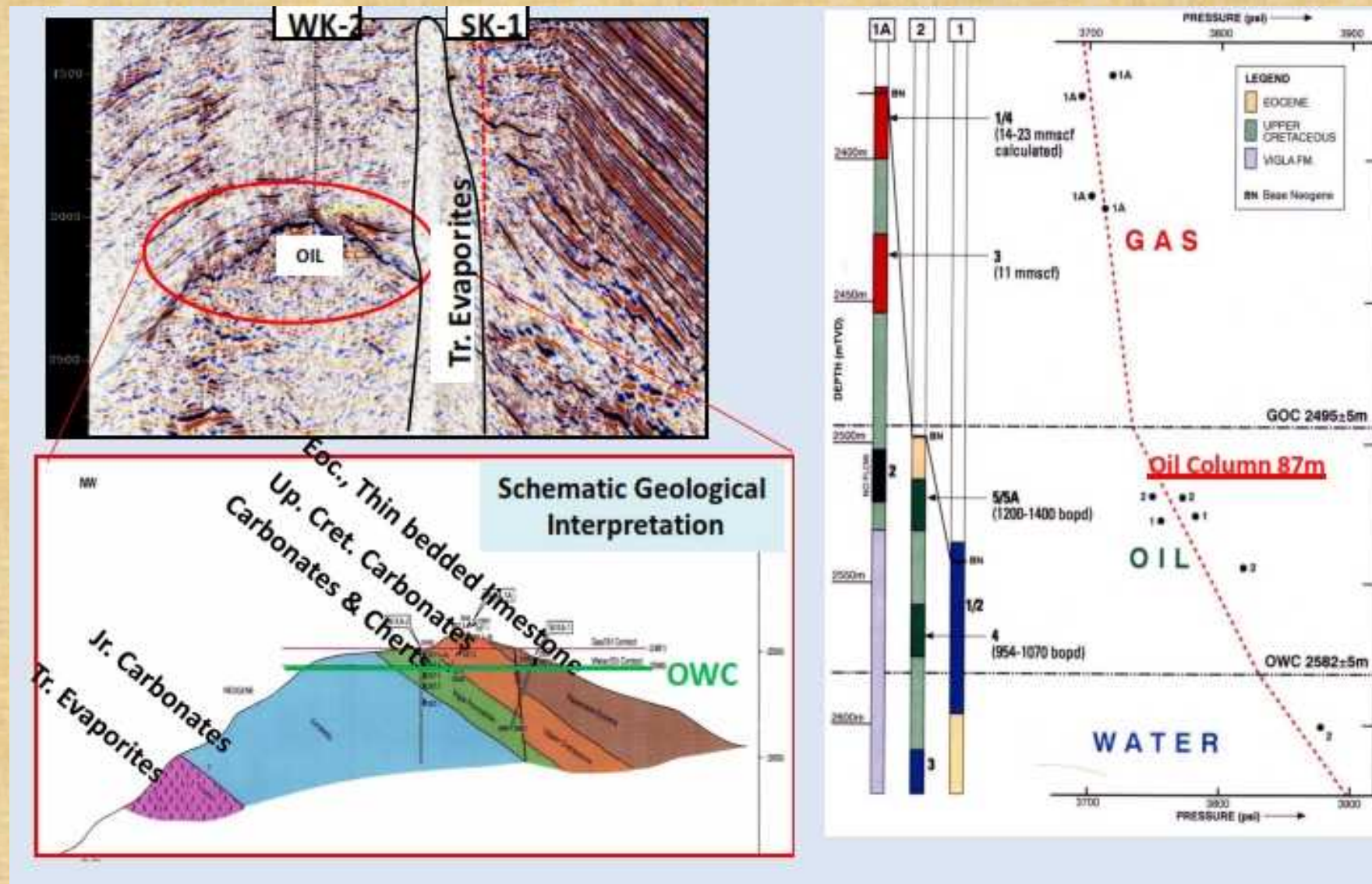
200 million
barrels of oil,
according to
ministry
information
based on the
Triton results
from 1998.

PATRAIKOS GULF

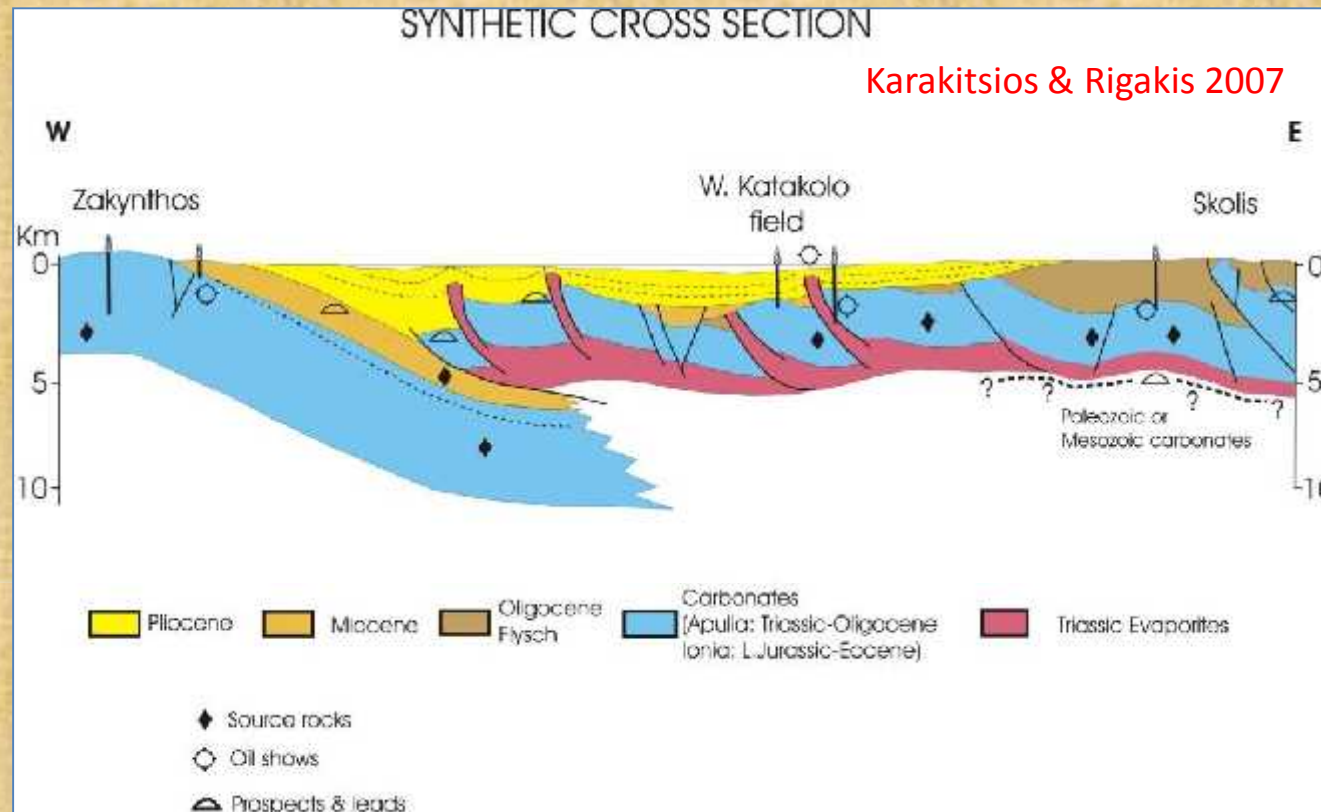
PLAY CONCEPT(II)



OPEN DOOR: KATAKOLO

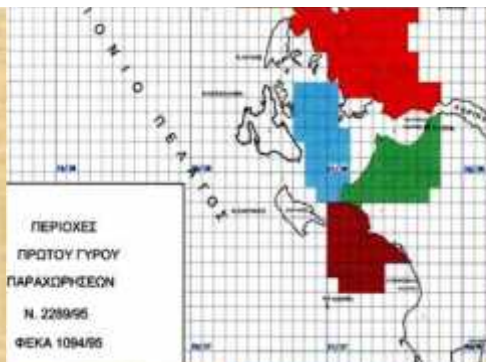


KATAKOLO



- Gas flow: 11-12 million cubic meter/day for each zone
- Oil flow: 1000-1500 barrels/day
- Reservoir depth: 2400-2600m
- Water depth: 200-350m
- Distance from the land: 3.5km
- 2D seismic data: 6000km
- 3D seismic data: 100 square km

PREVEZA- PATRAIKOS - KATAKOLO



PREVEZA

PATRAIKOS

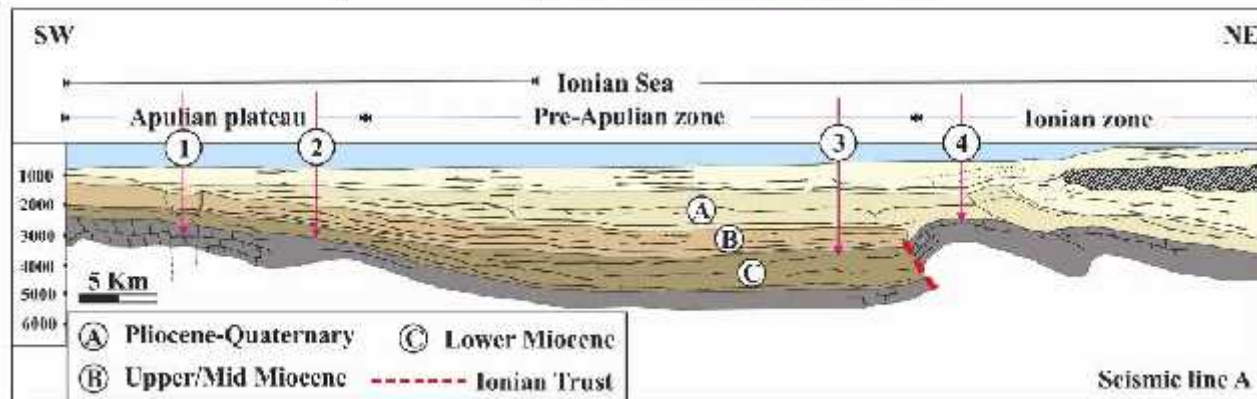
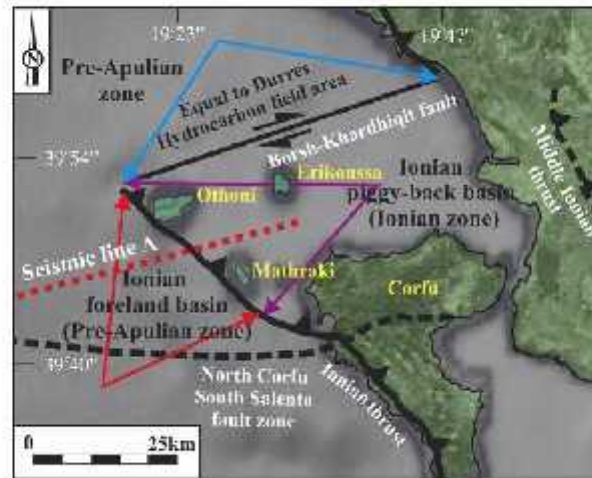
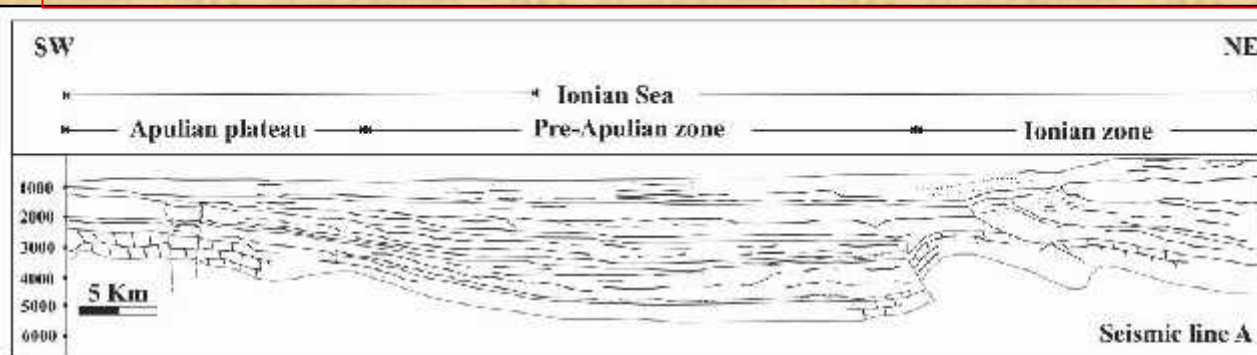
KYPARISIAKOS
GULF -
STROFADES

2

OPEN DOOR – BLOCK PATRAIKOS
200 MILLION BARRELS OF OIL

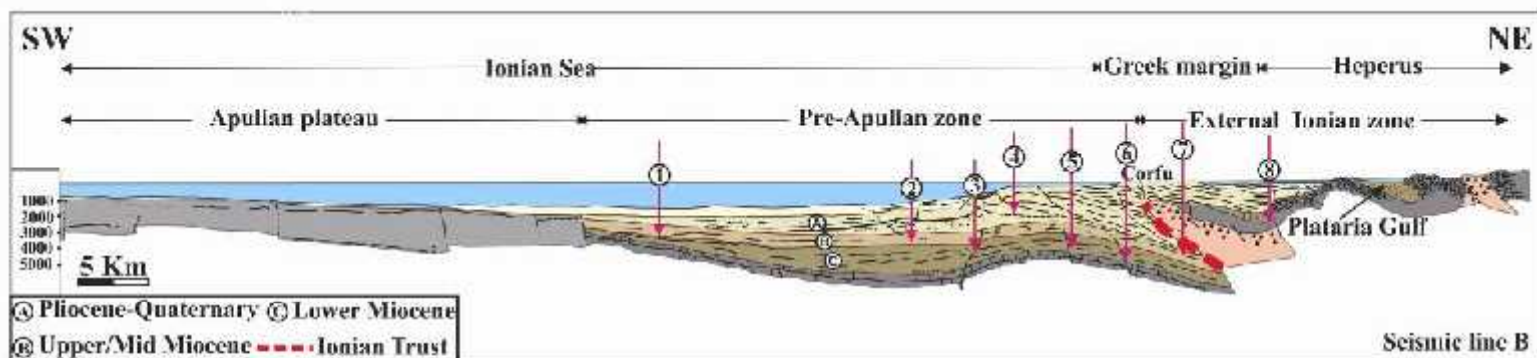
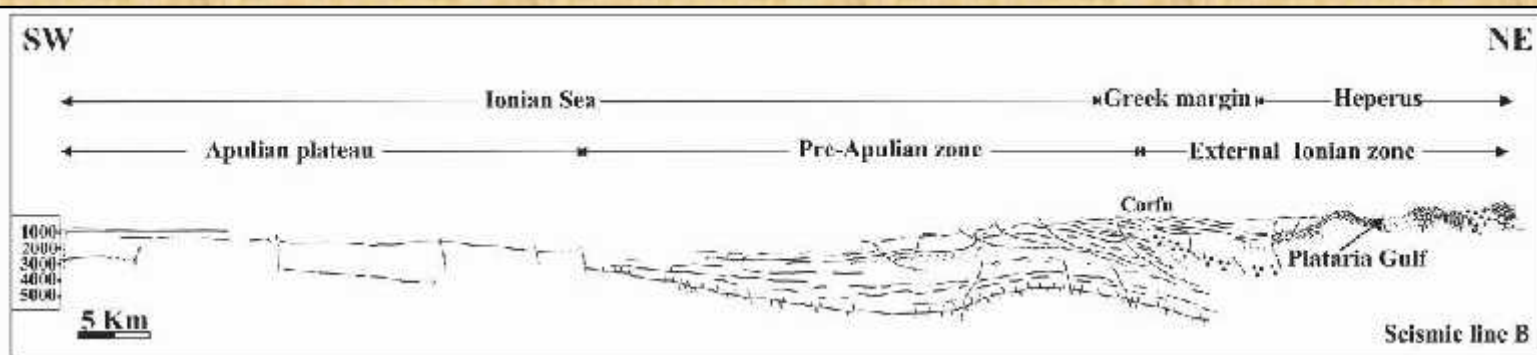
OPEN DOOR – BLOCK KATAKOLO
3 MILLION BARRELS OF OIL

WHAT WE SUGGEST FOR THE APULIAN PLATFORM



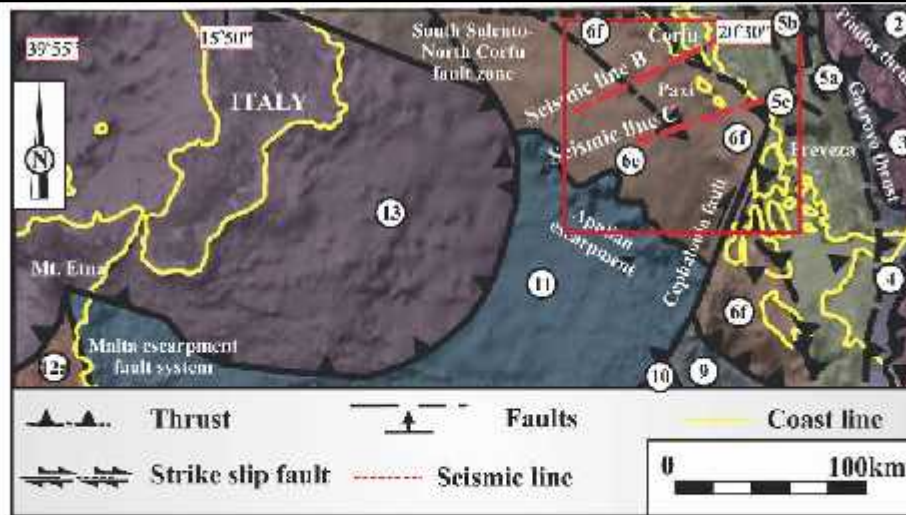
1. Diapontia islands

Maravelis et. al., 2012

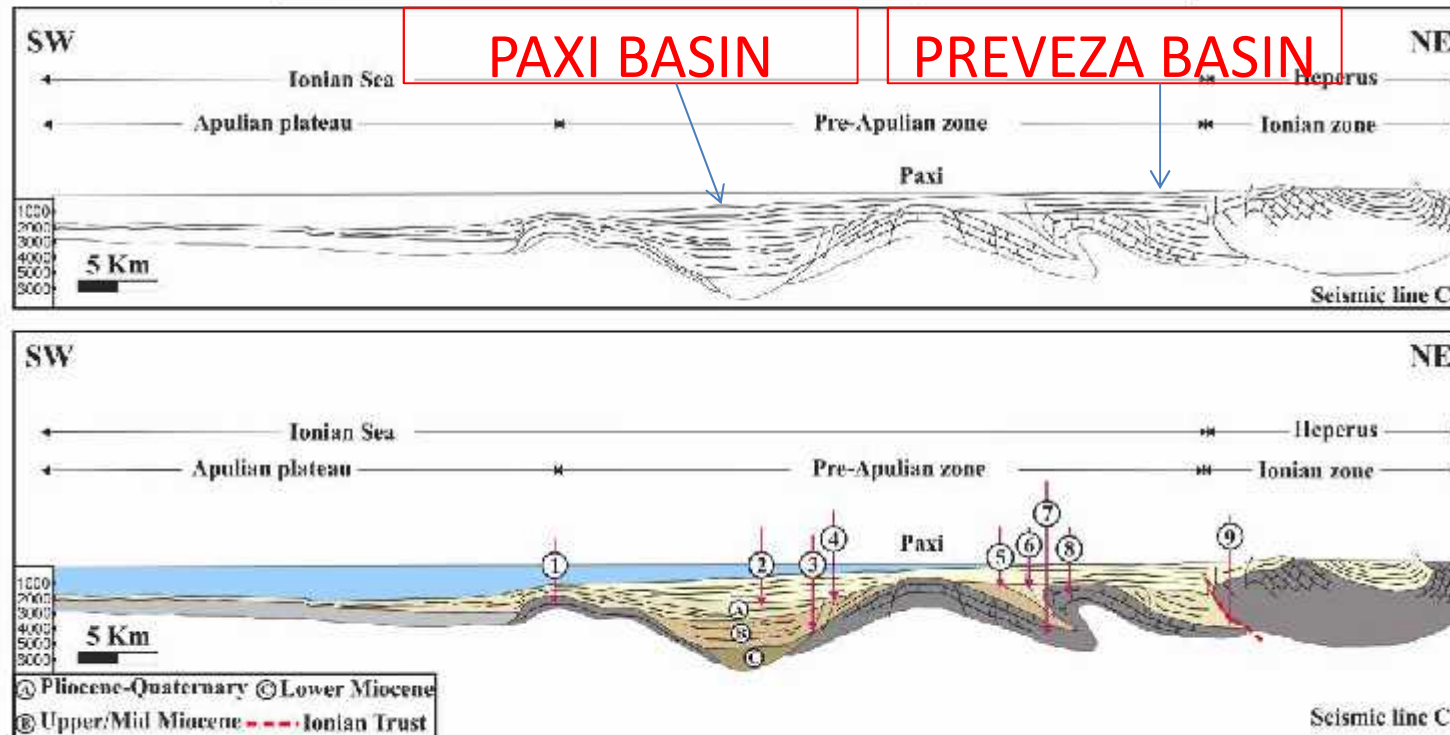


2. West of Corfu


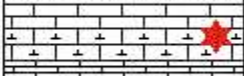

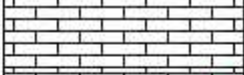
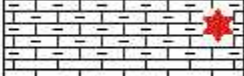
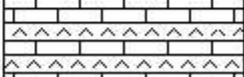
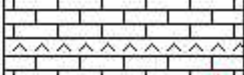
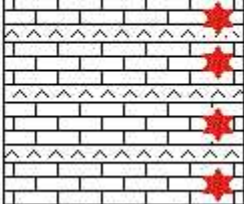
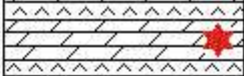
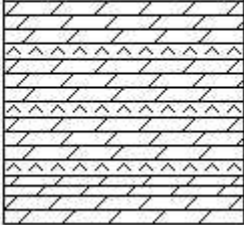
3. Paxi Basin



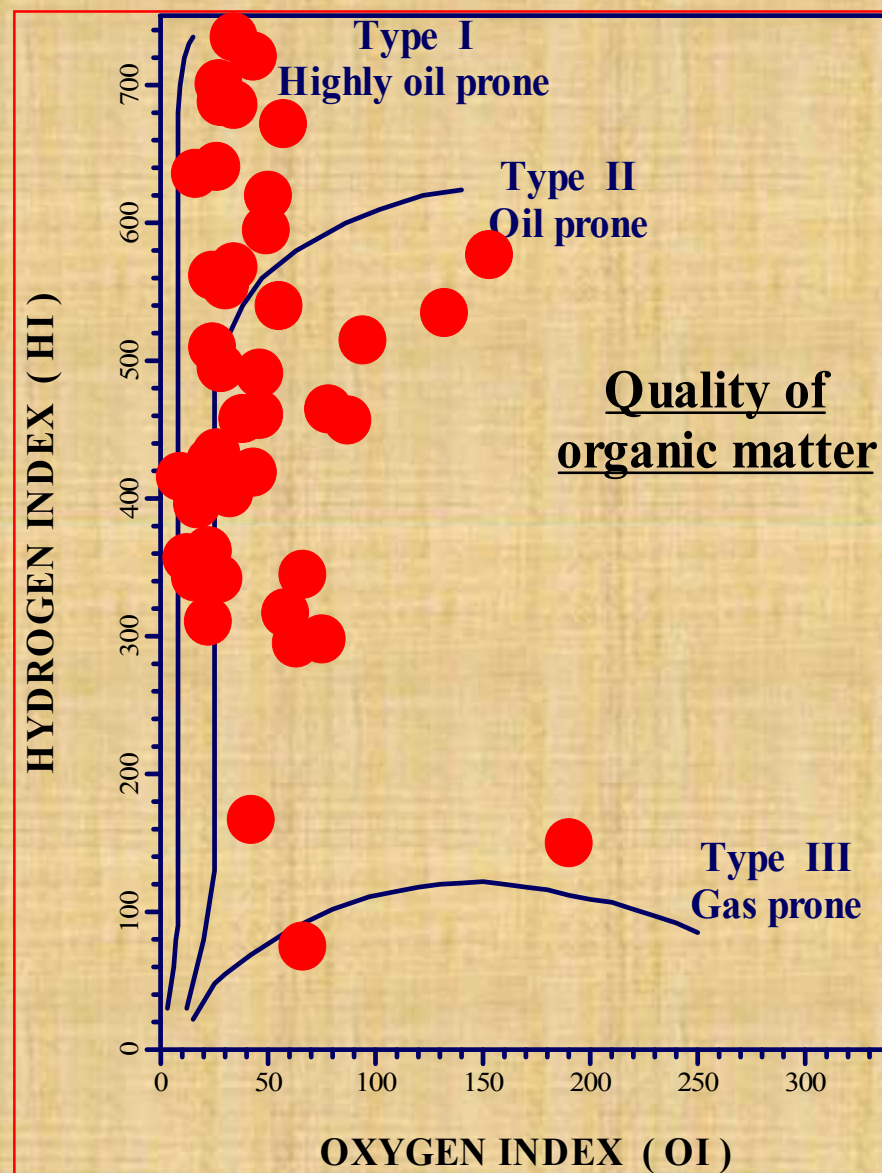
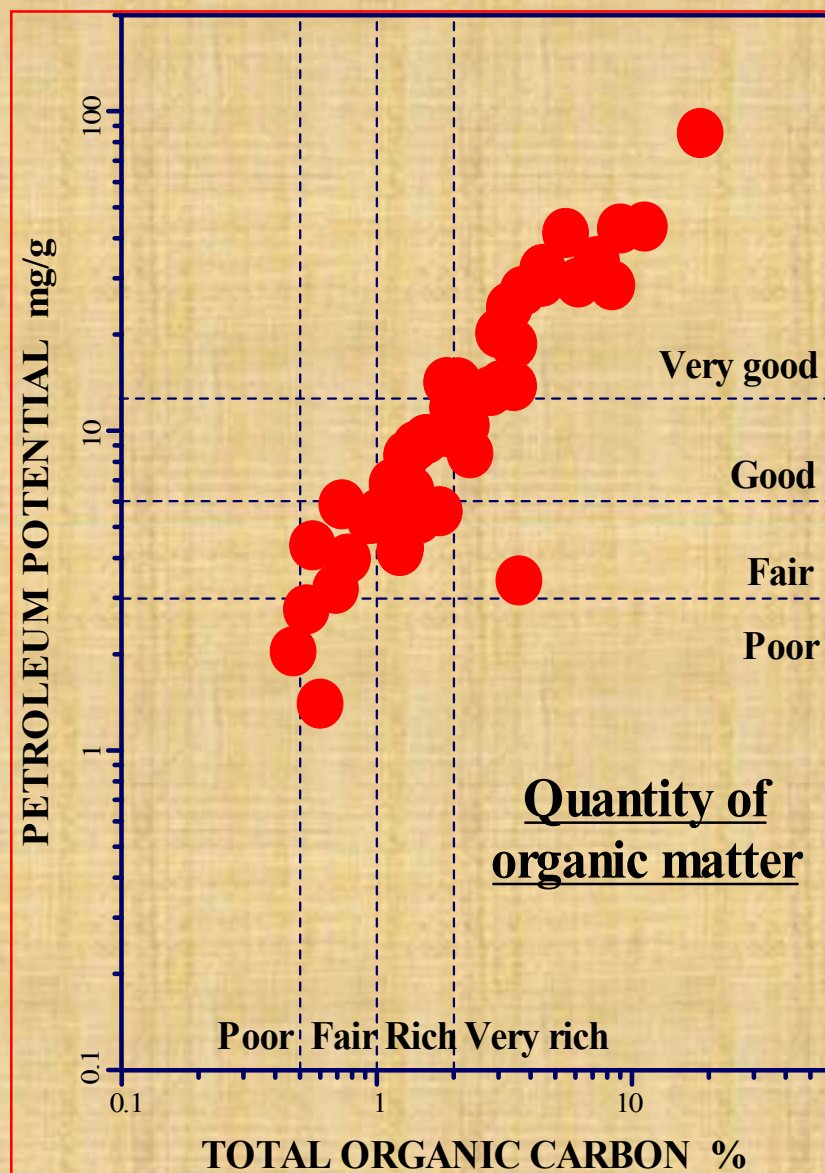
4. Preveza Basin



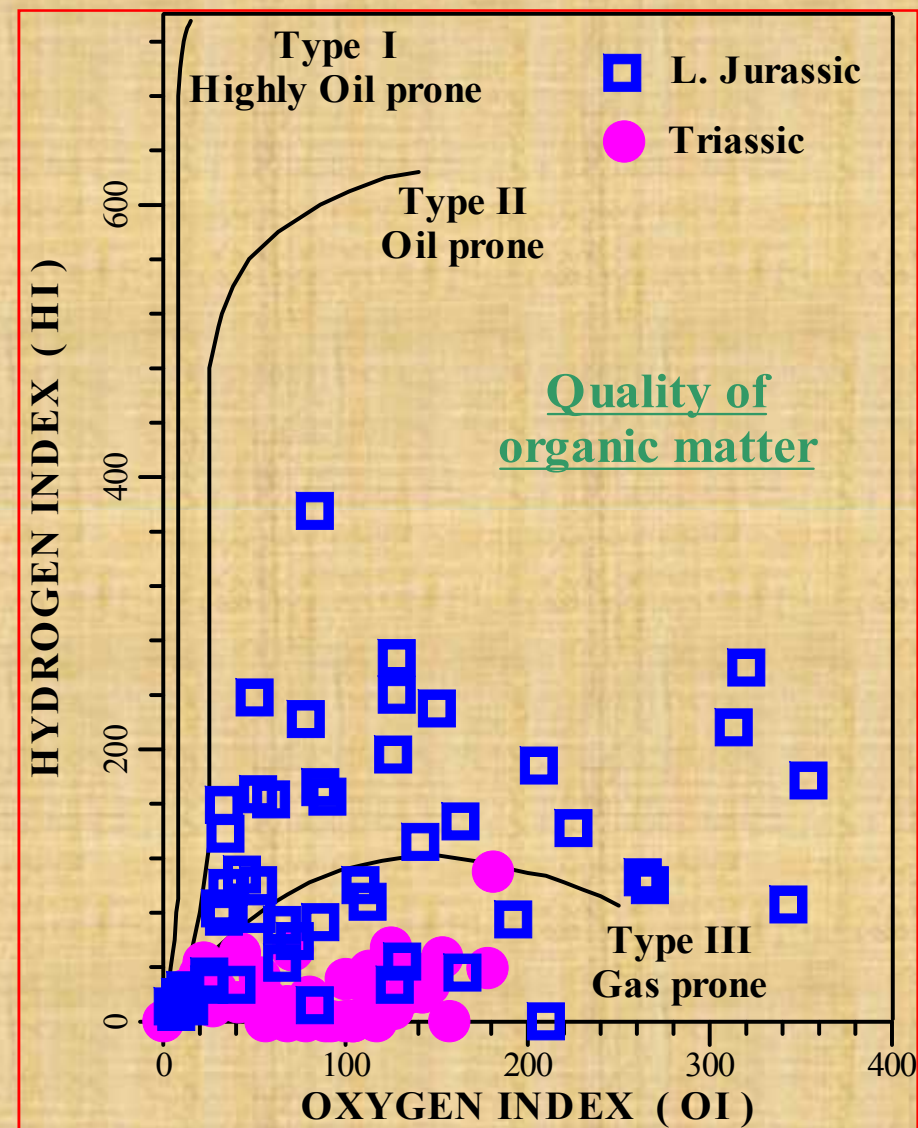
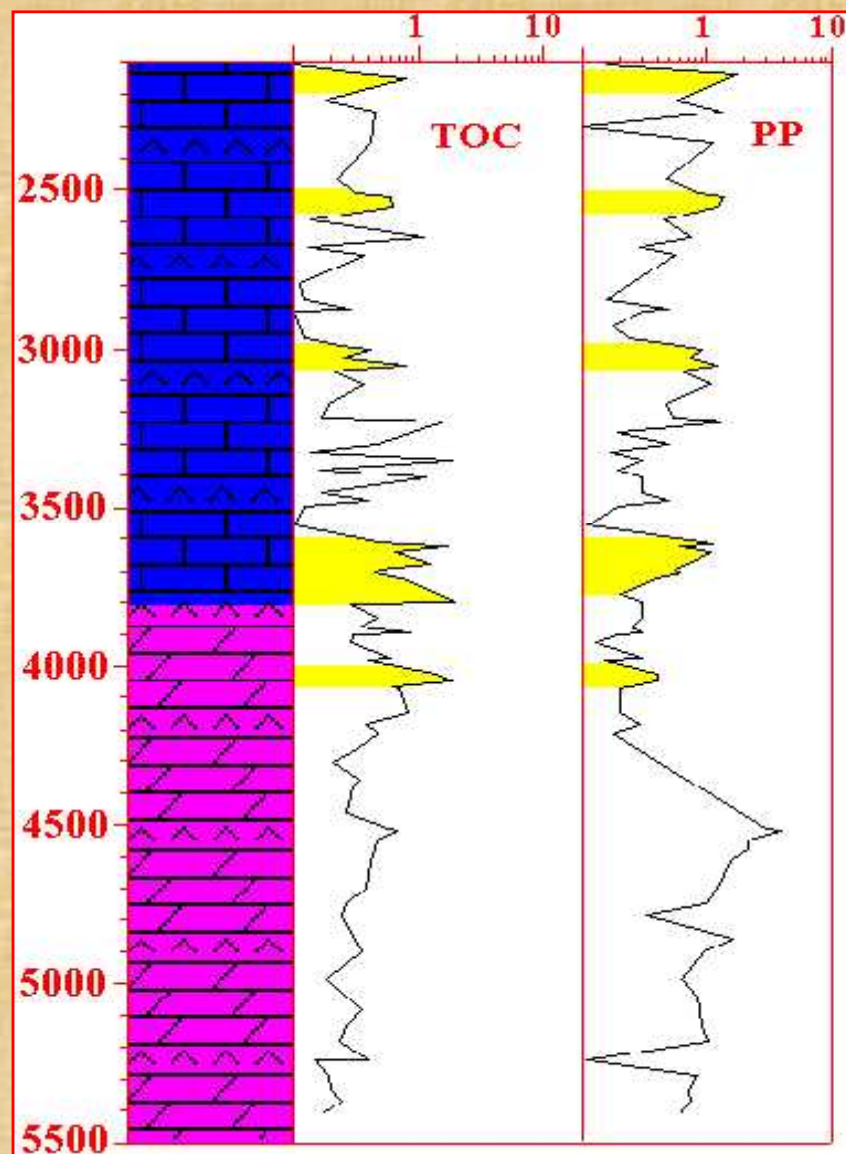
WE KNOW the stratigraphy of Pre-Apulian source rocks

Pliocene			Gas prone source rocks
Miocene			Gas prone source rocks
Eocene	Scaglia		
Cretaceous	Maiolica		
M.-U. Jurassic	Aptici		Rich source rock horizons
	Complesso Anidritico		
			
L. Jurassic			Four horizons / fair organic matter
			
Triassic	Burano		Horizon with residual organic matter

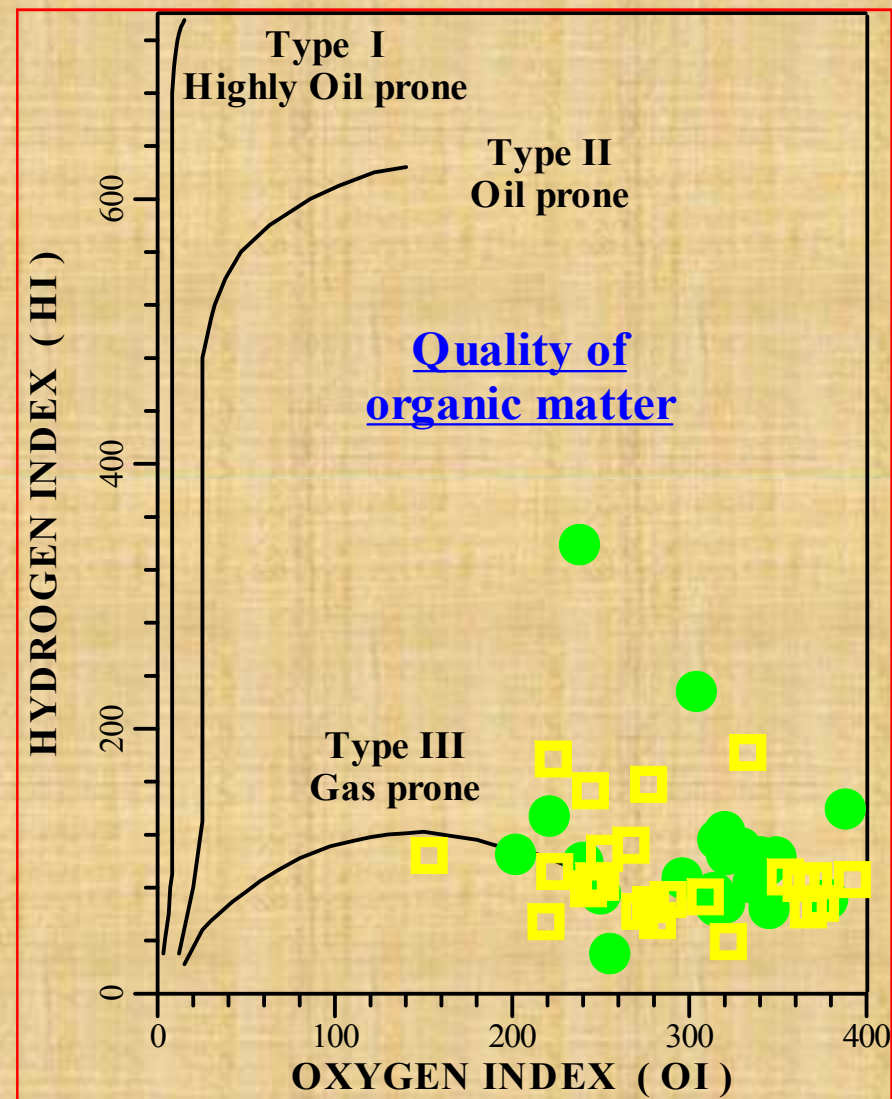
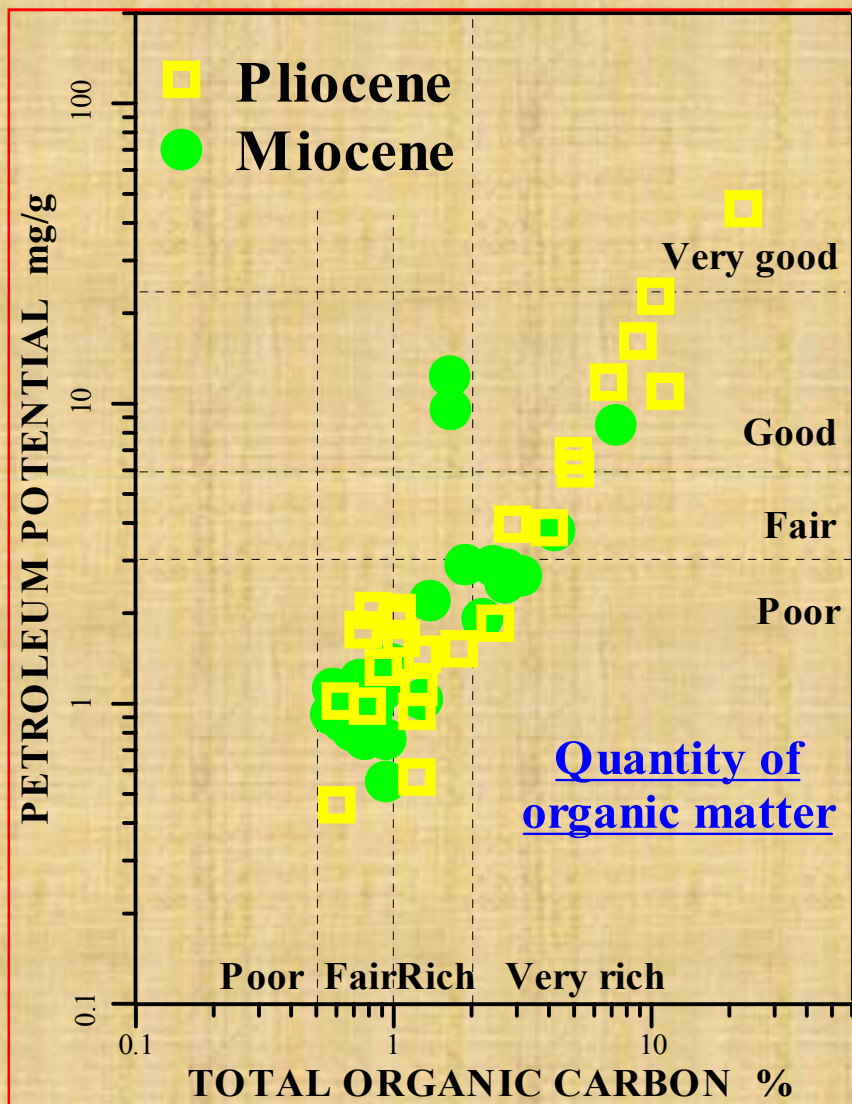
UPPER TRIASSIC

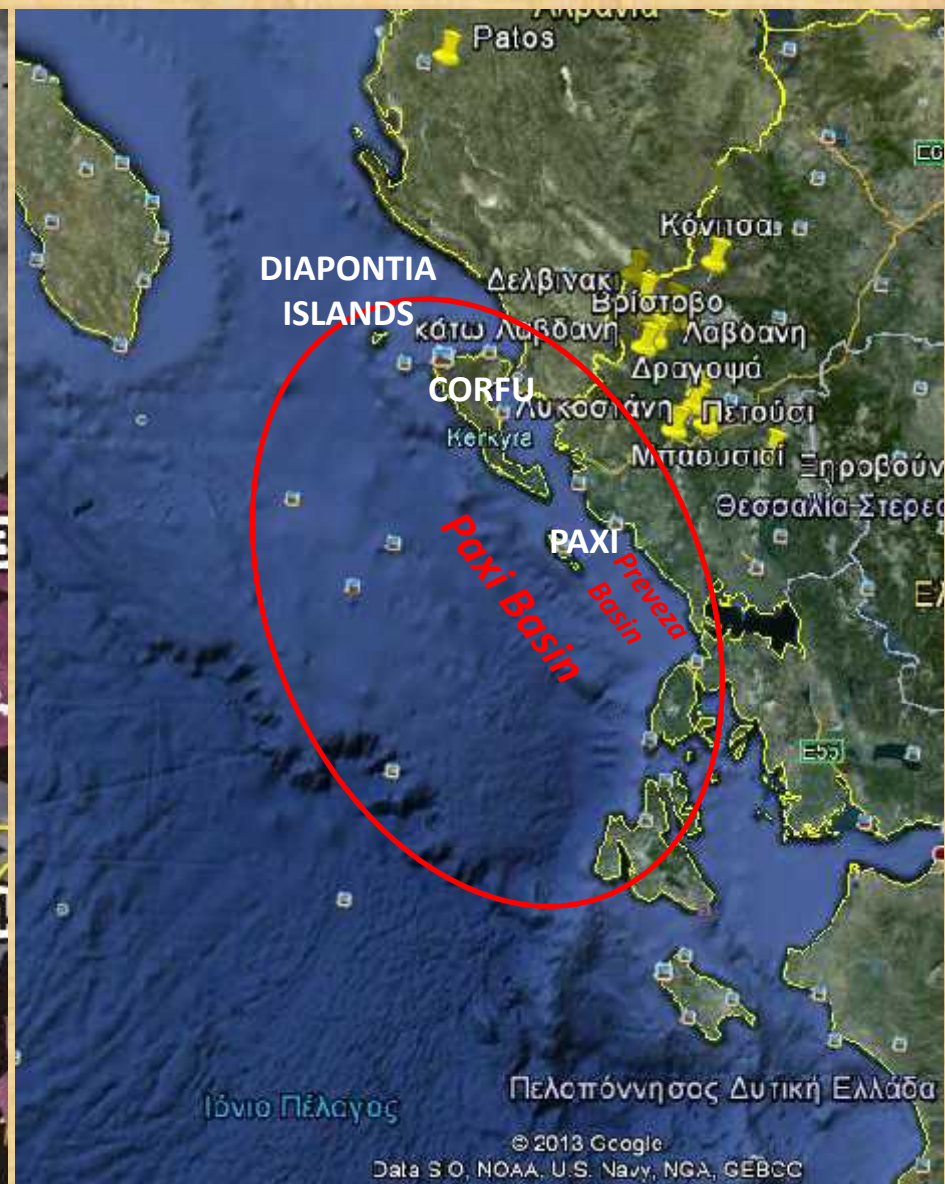
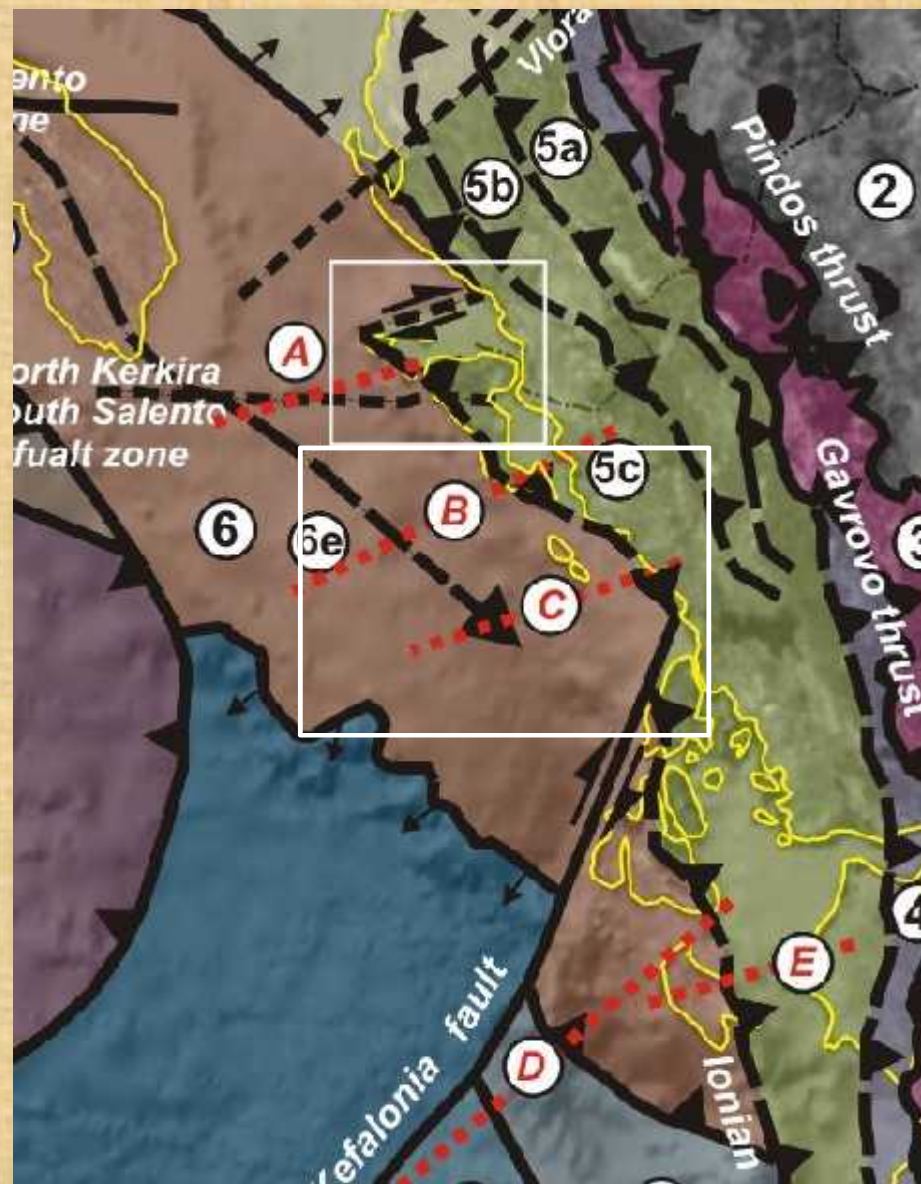


LOWER JURASSIC - TRIASSIC

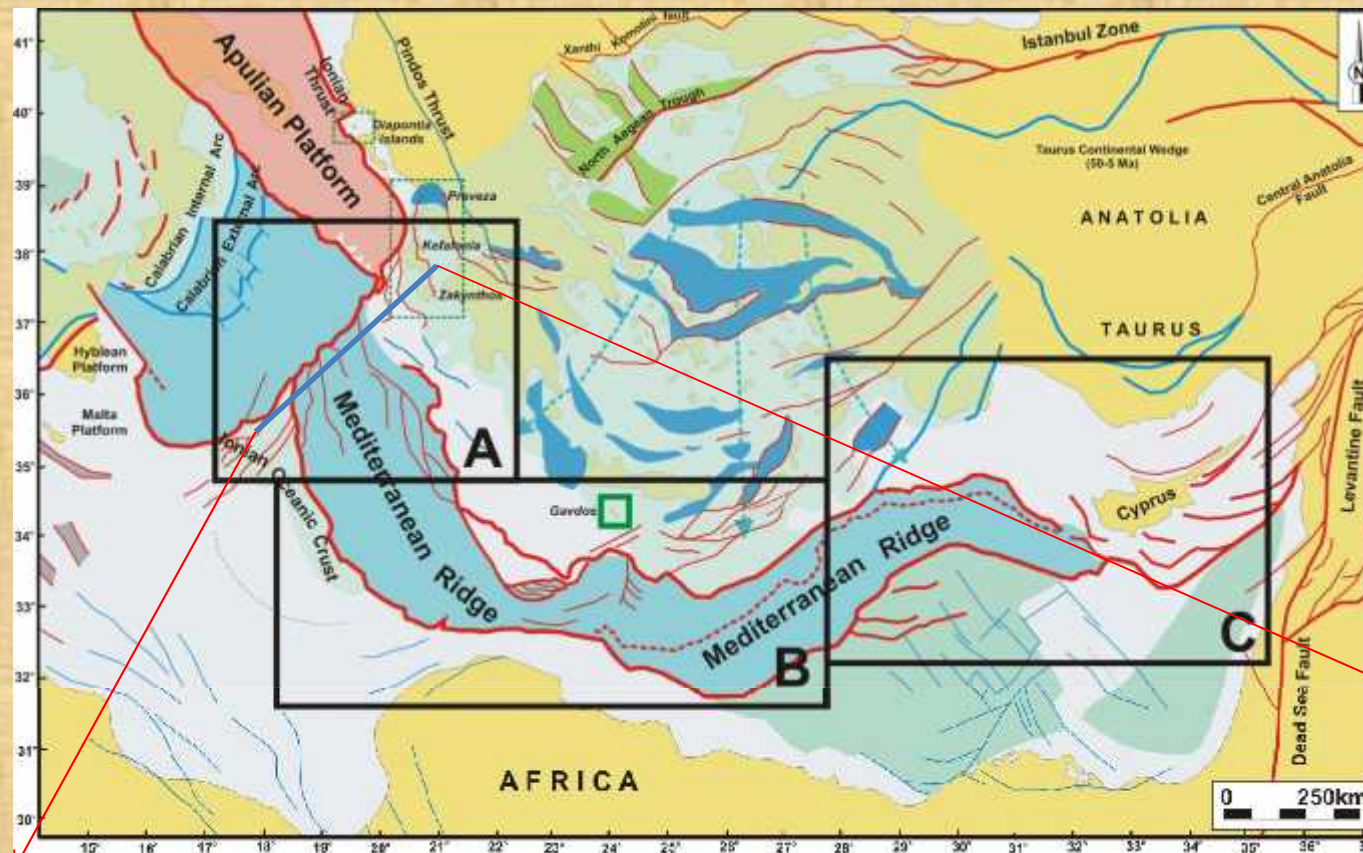


Clastic deposits of Miocene and Pliocene

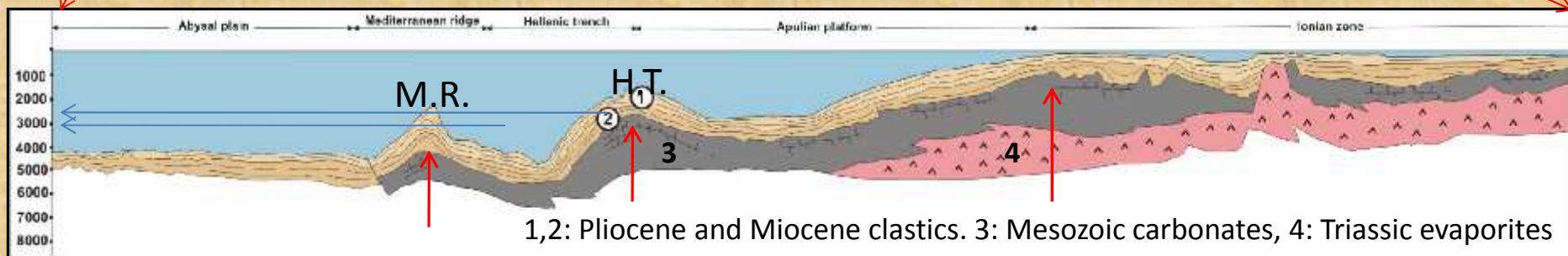




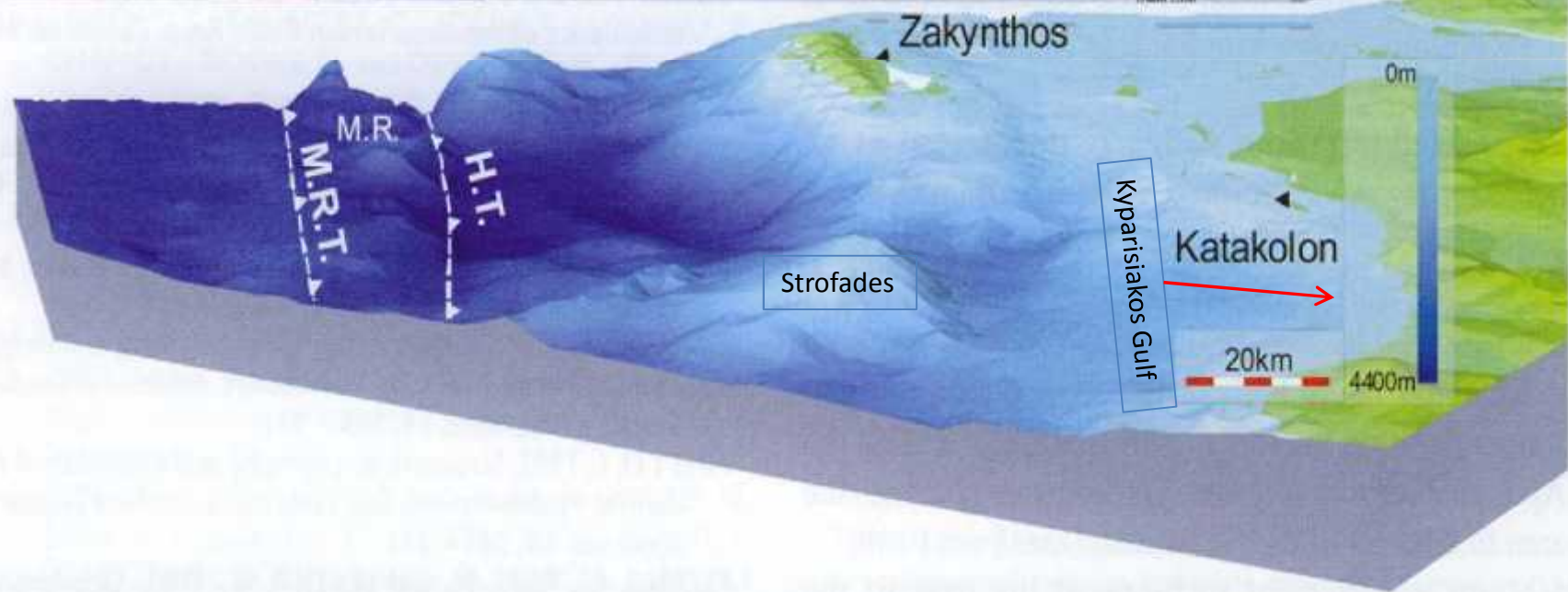
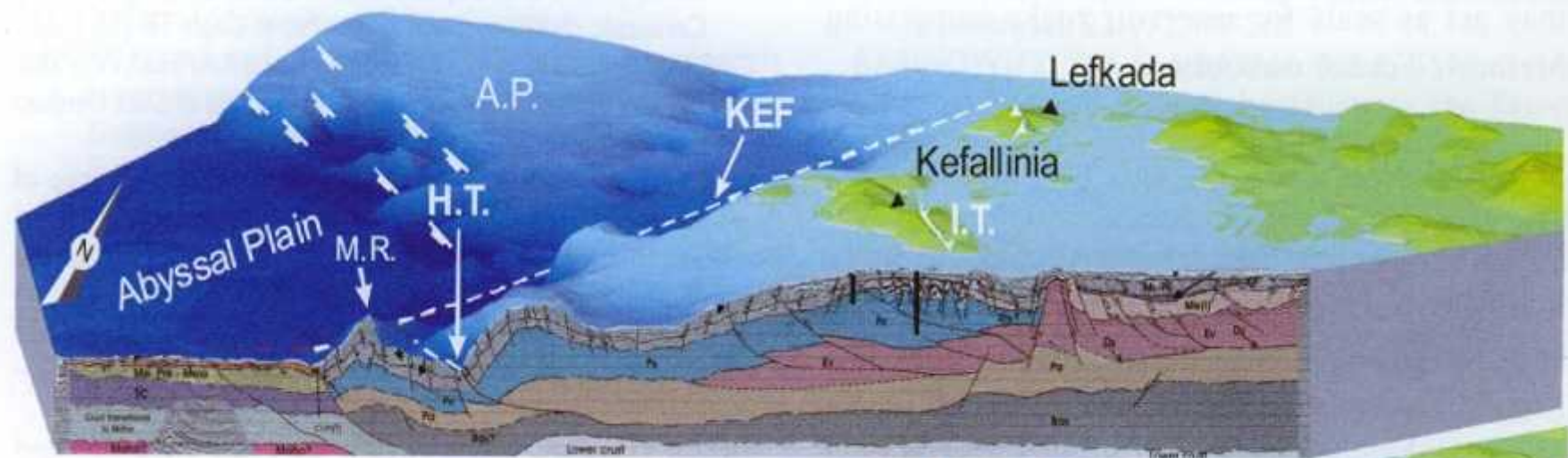
MEDITERANEAN RIDGE IN WESTERN GREECE OFFSHORE AREAS

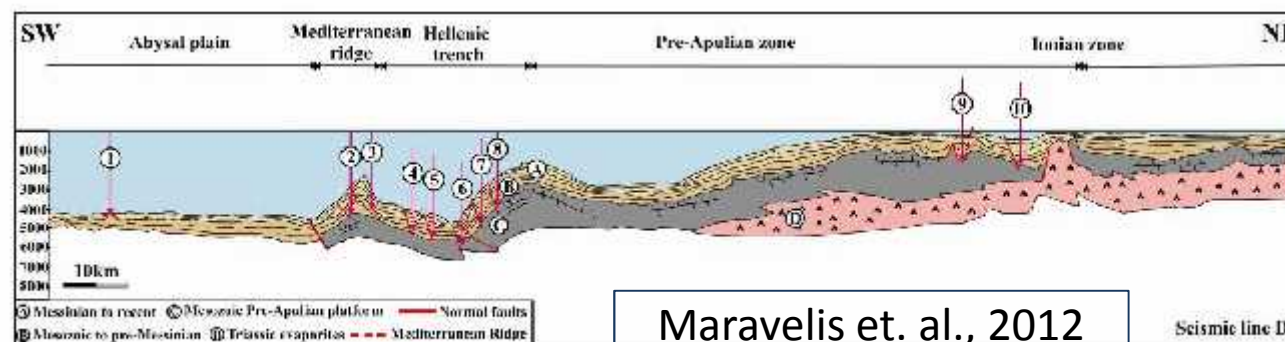
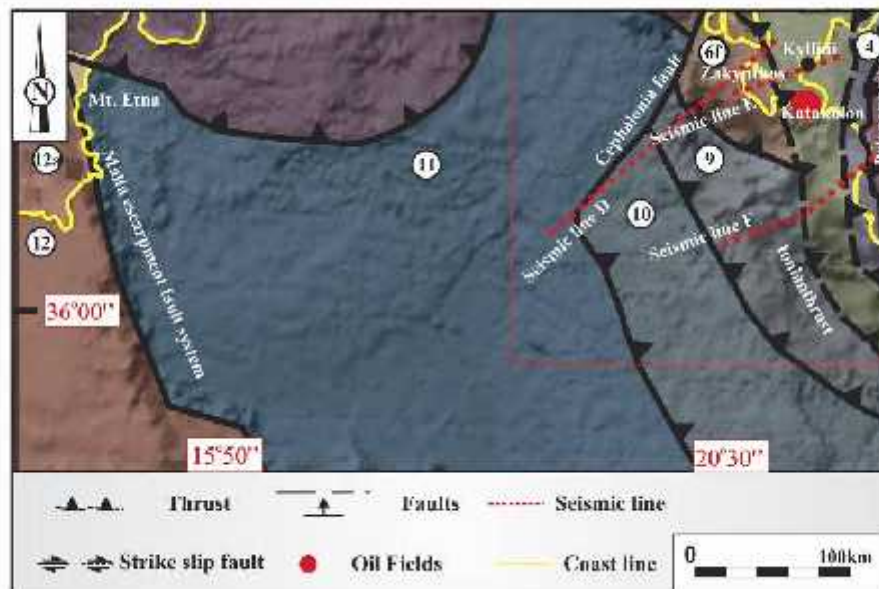
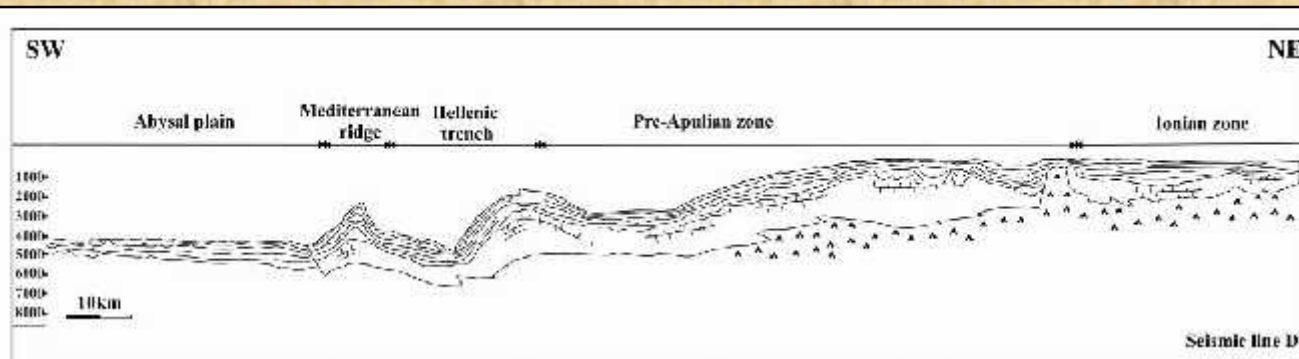


*Southern part:
Mediterranean
Ridge (modified
from Chamot-
Rooke et al.,
2005),
separated into
three distinct
areas.*



AREA A: Example from seismic line between Cephalonia and Zakynthos Islands (modified from Kokkinou et al., 2005). *The red arrows show the possible hydrocarbon fields*





Maravelis et. al., 2012

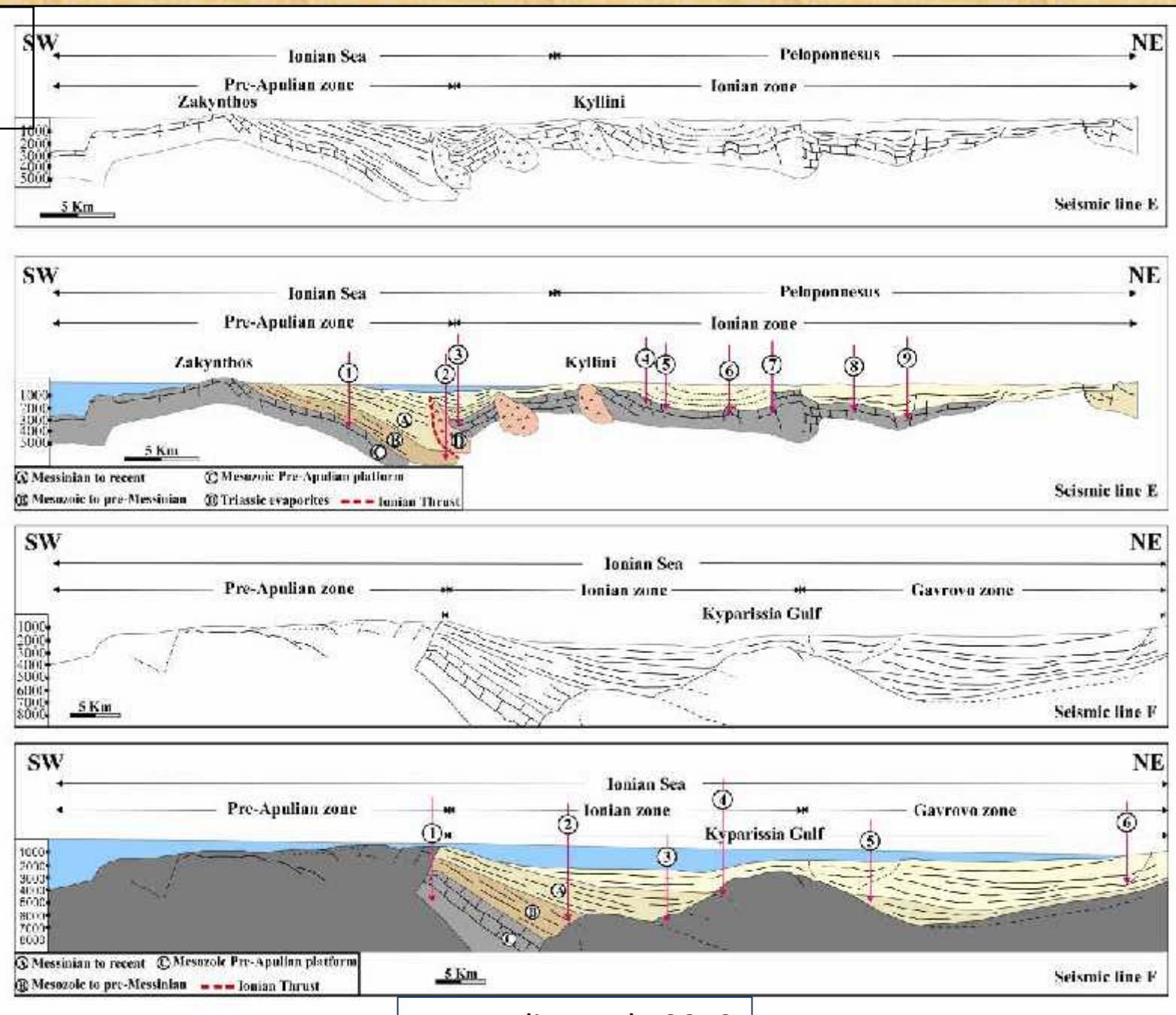
AREA A:

Possible hydrocarbon plays:

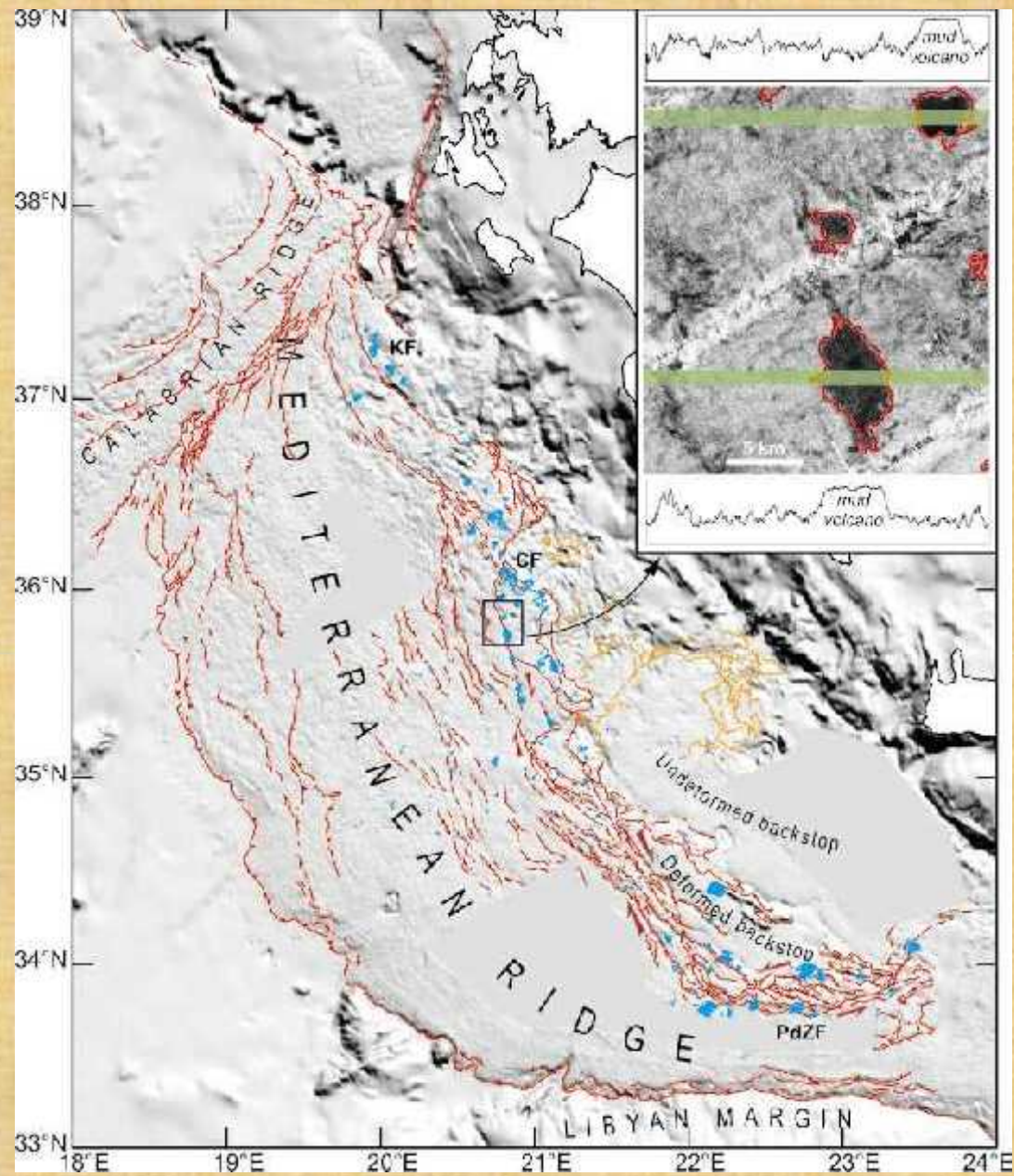
1. Two major anticlines:
Medit. Ridge
and
Hellenic Trench,
2km under sea-
level.

2. Abyssal Plain,
4km under sea-
level
(Maravelis et
al., 2012)

B1

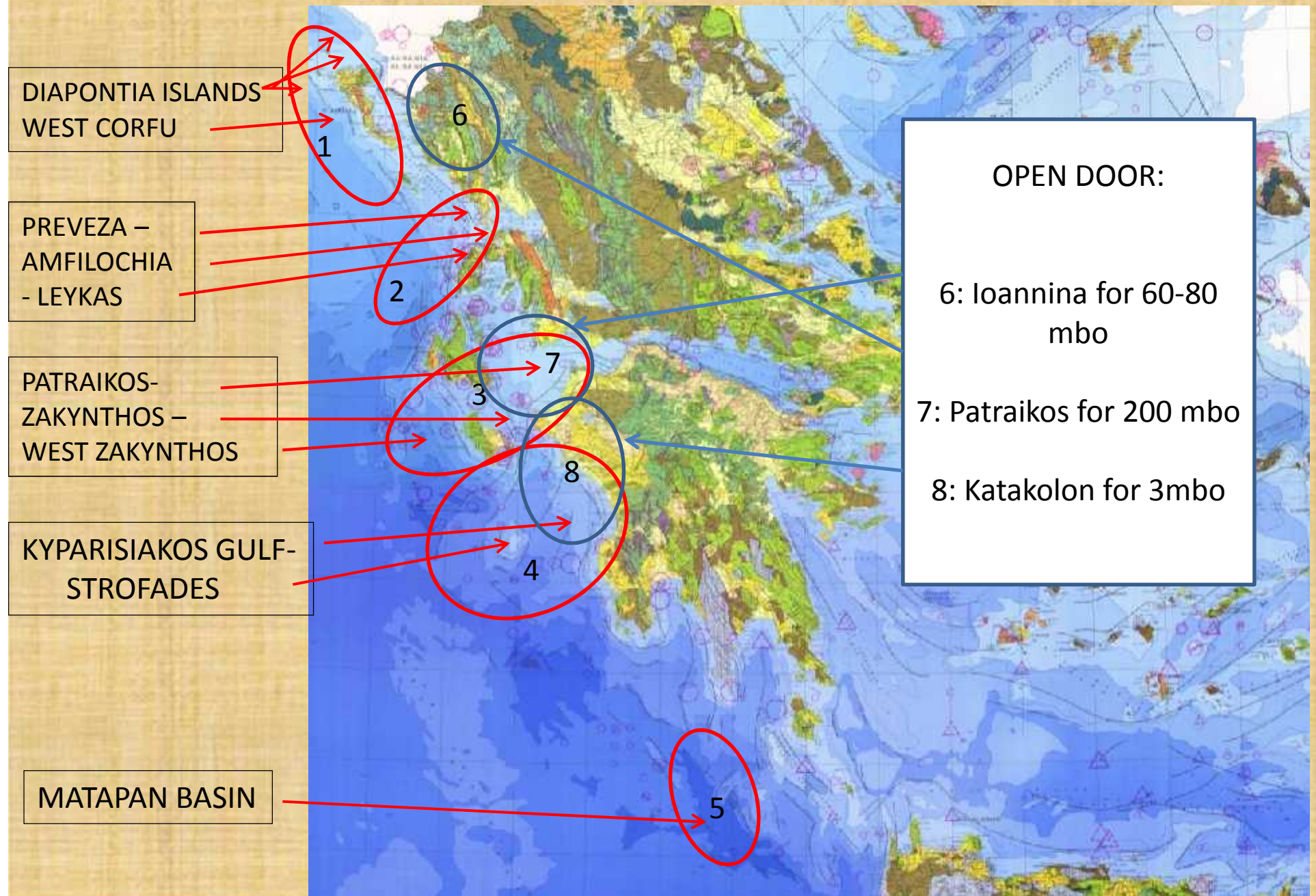


Maravelis et. al., 2012



Modified from Chamot-Rooke et al., 2005

CONCLUSION



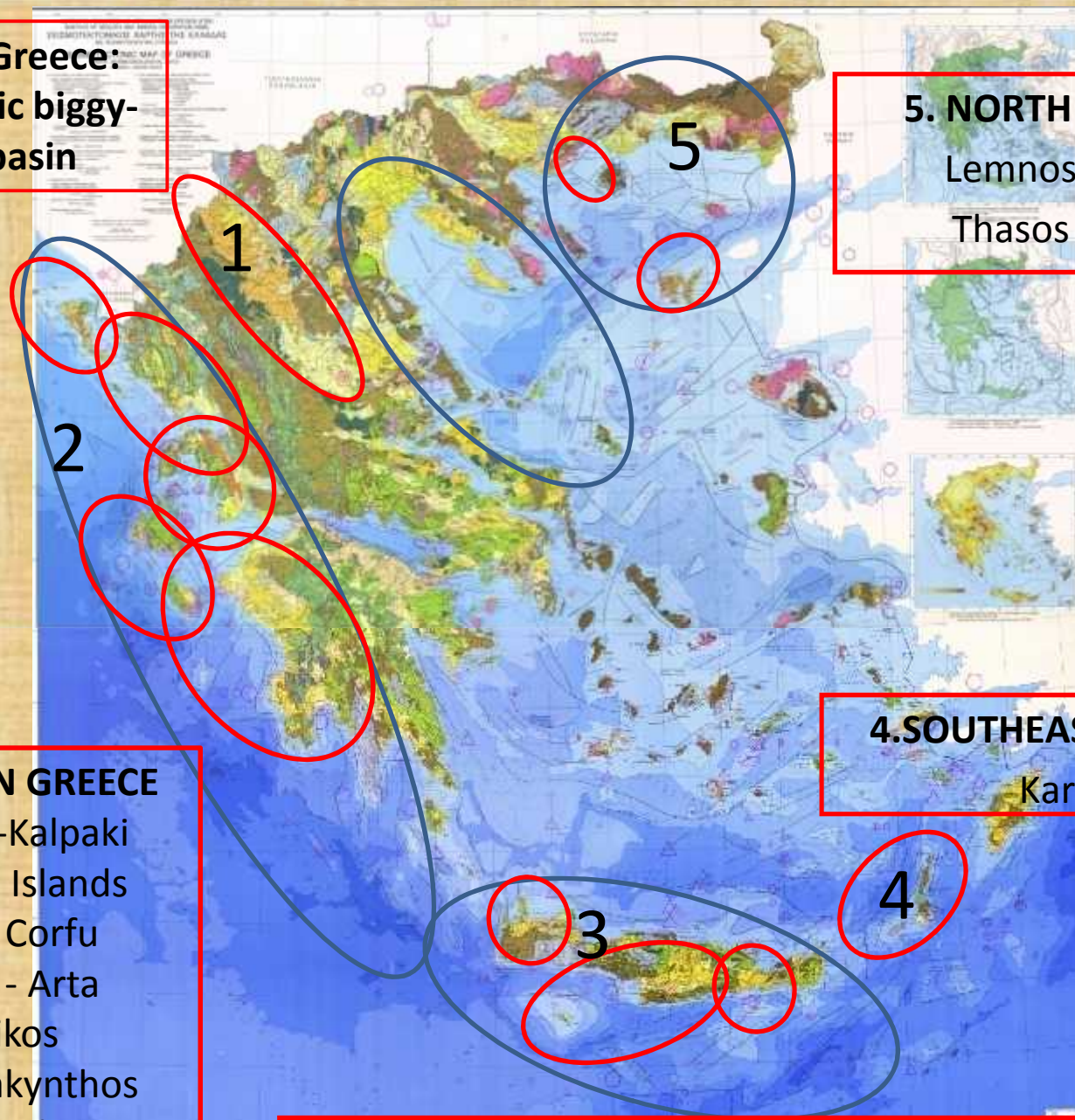
1. Central Greece:
Mesohellenic biggy-
back basin

5. NORTH AEGEAN
Lemnos Island
Thasos Island

2. WESTERN GREECE
Ioannena-Kalpaki
Diapontia Islands
West of Corfu
Preveza - Arta
Patraikos
West of Zakynthos
Kyparissiakos
West of Strofades

4. SOUTHEAST AEGEAN SEA
Karpathos

3. CRETE: NW Basins (Platanos-Kasteli-Maleme), Onshore
Messara & Ierapetra Basins, Offshore Gavdos Basin



Thank you for your attention