

I.E.N.E. E&P Workshop Athens , April 26,27 - 2012

# **Exploration & Production of Hydrocarbons in Greece: Discoveries, Petroleum Systems and Analogues and Perspectives**

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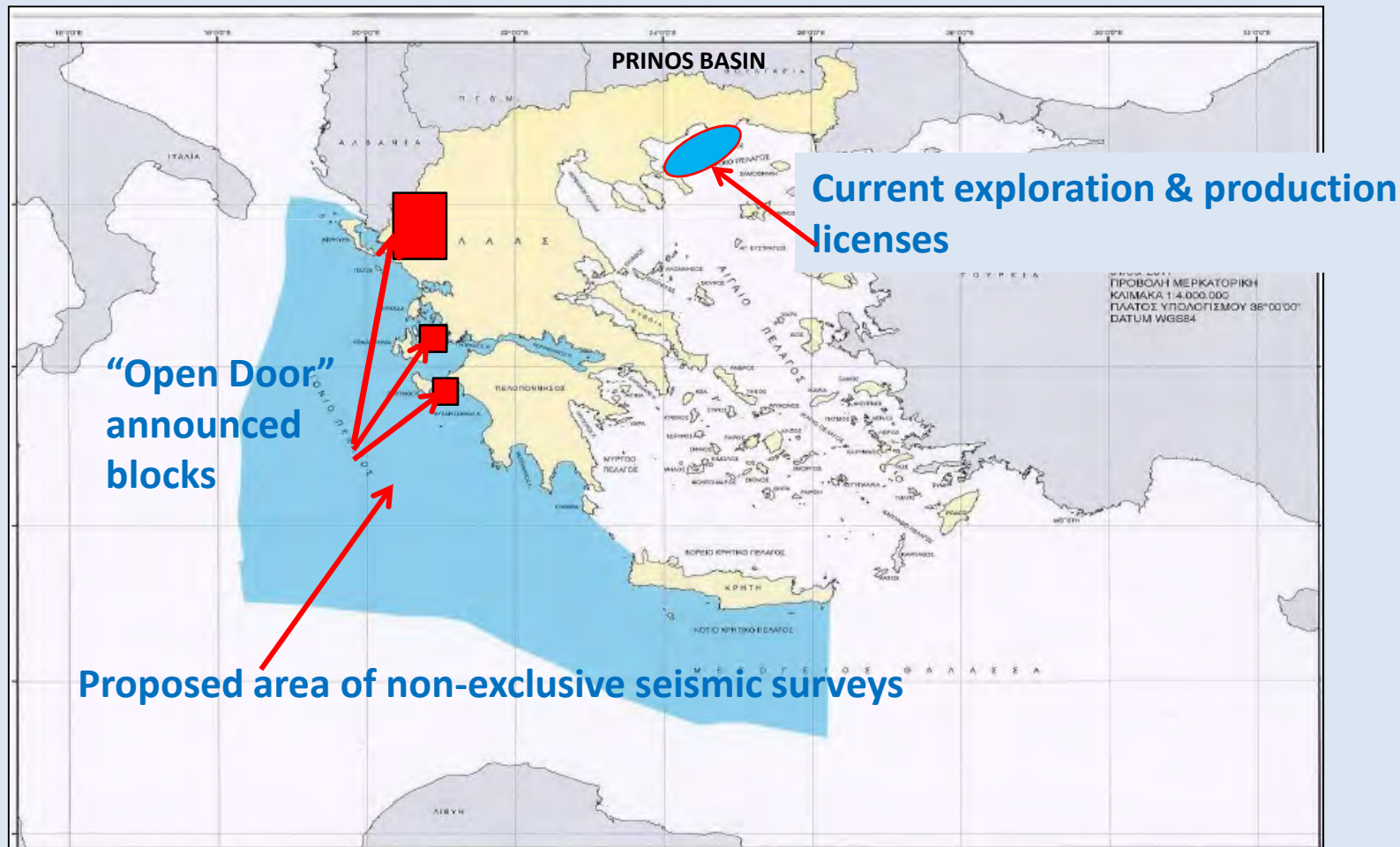
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**Ex. Technical Advisor ENERGEAN OIL & GAS**

**Ex. Technical Director of HELLENIC PETROLEUM SA**

# Exploration Activity in Greece - Current Status

- After 15 years of inactivity, re-establishment of the Hellenic Hydrocarbons Management Company S.A, 2011
- Tender for non-exclusive seismic surveys. Eight proposals have been submitted. Decision is expected within the 2-ond Quarter of 2012
- Tender for 3 areas using open door procedures



## **MAIN ISSUES NEED ANSWERS**

- **Are there proven or possible petroleum systems?**
- **Are there any credible analogues?**
- **Are fiscal terms attractive for Oil companies?**
- **Is the time enough to promote the "open door" tender?**
- **Is the business environment the proper ?**

**If the answers are positive then Greece has a chance to discover additional oil and gas.**

**SEDIMENTARY BASINS  
of GREECE,  
Hydrocarbon  
Occurrences  
and  
infrastructures**

**Western  
Greece  
basins**



# The History of Exploration Activity in Greece before 60's

1903 – Formally start of the HC exploration, initially focused on onshore areas in W. Greece driven by oil seepages. More than 40 wells in areas with gas and oil surface shows.



**ZAKYNTHOS**  
HERODOTUS, 480 bc



**KATAKOLON "Volcano" 1976**



**KATAKOLON "Volcano" 2004**



**DRAGOPSA - EPIRUS**

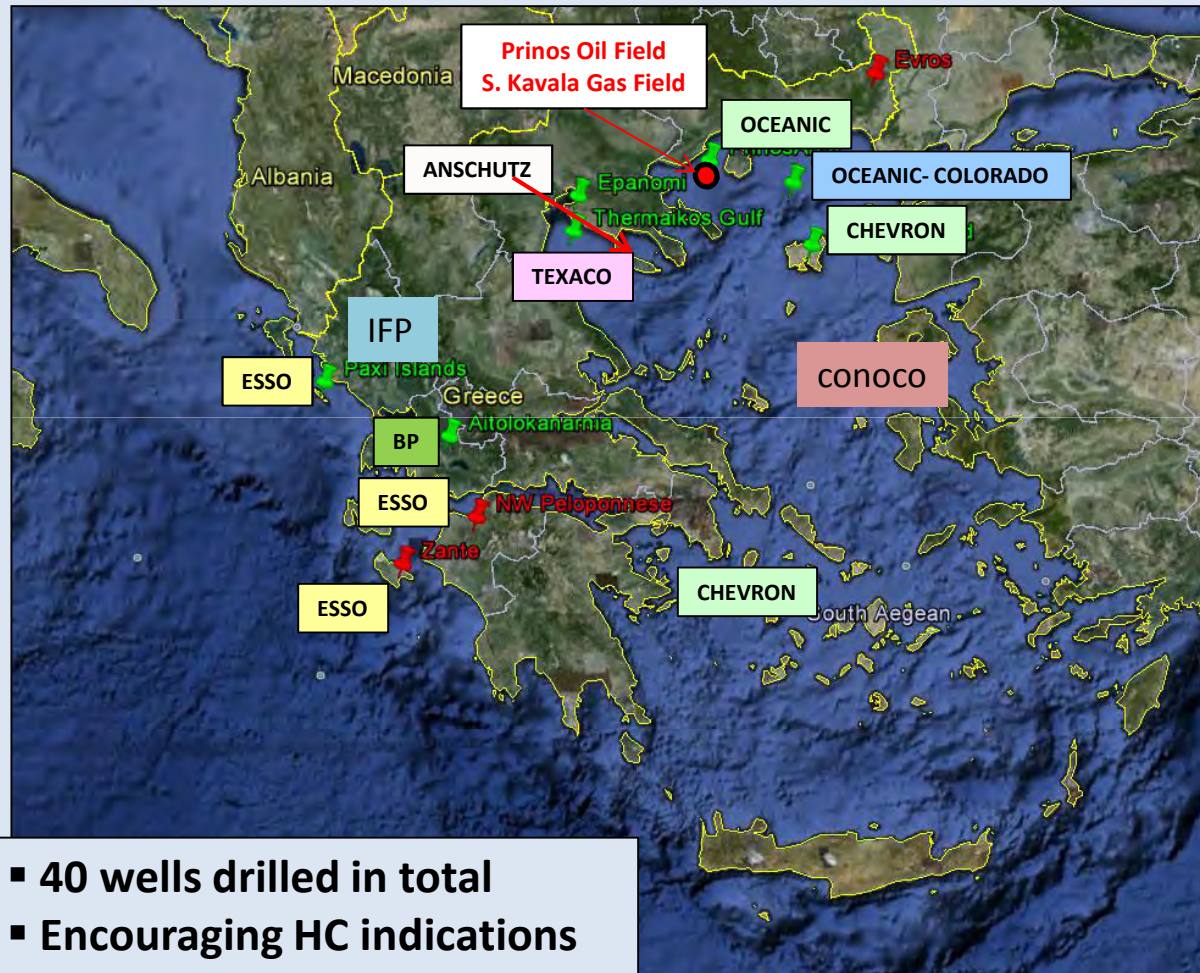


**SMOLITSAS - EPIRUS**



**LOUTRA KYLLINIS**

# The History of Exploration Activity in Greece Early 60's to mid 70's



- 40 wells drilled in total
- Encouraging HC indications
- Improvement of geological background

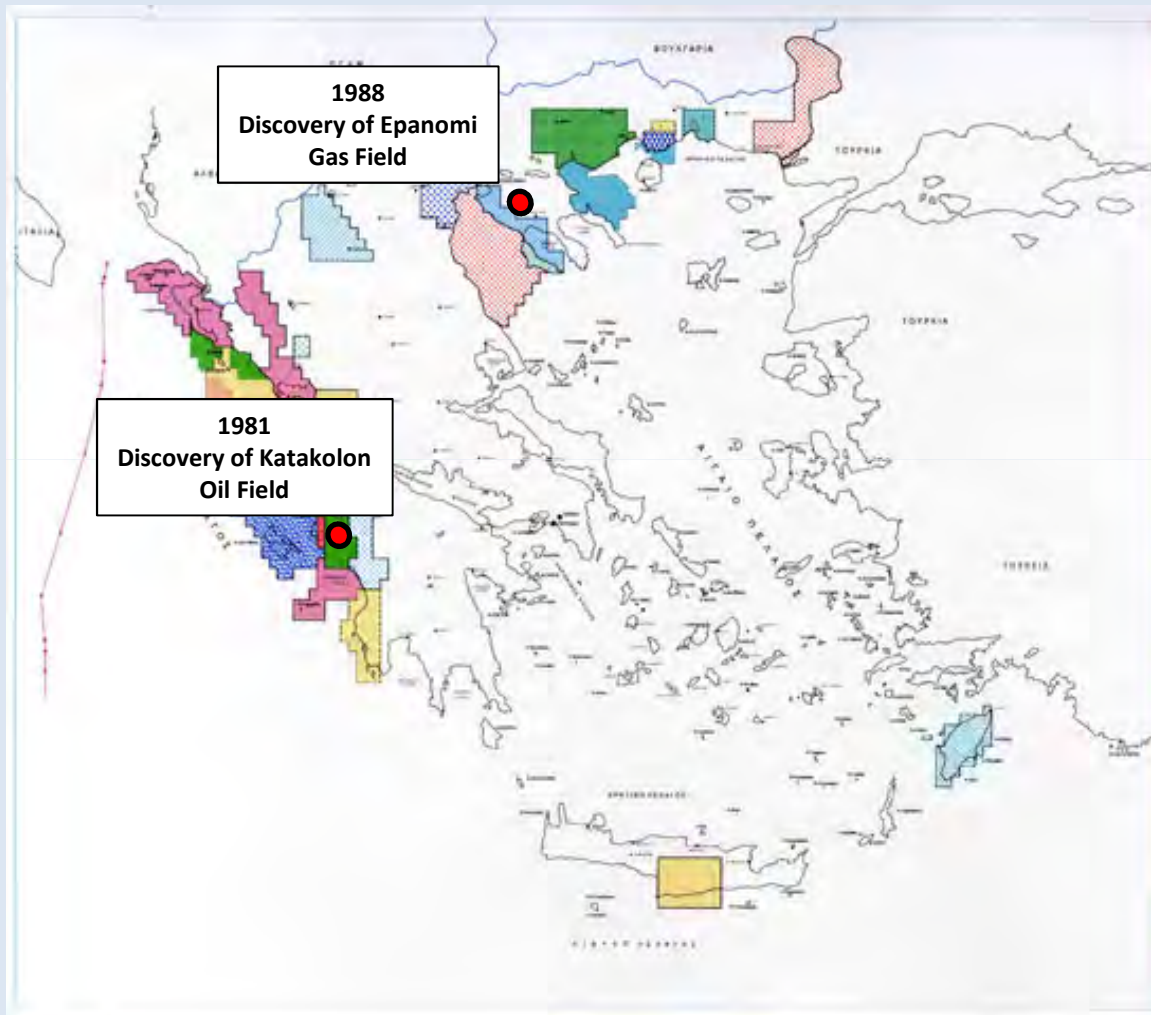
## OPERATORS

- Former Ministry of Industry
- Institute of Geology and Mineral Exploration (IGME)
- Institute Francais du Petrol (IFP)
- International oil companies

The final result of the exploration that took place during that time was the discovery of the first exploitable hydrocarbon reserves in the off-shore area of Thasos island (Prinos oil-field and South Kavala gas-field) by OCEANIC (1971-1974).



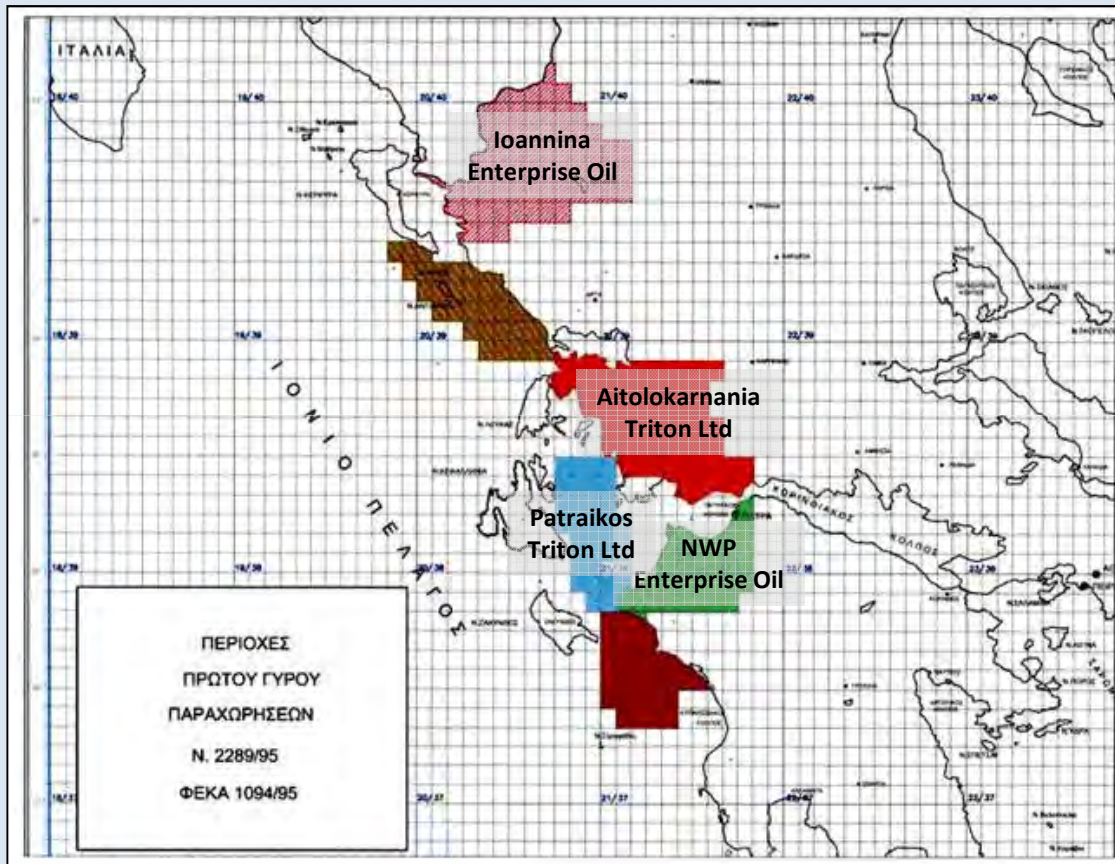
## The History of Exploration Activity in Greece - Mid 70's to mid 90's



- 1975 - foundation of the Public Petroleum Corporation (DEP)
- 1985 – foundation of (DEP EKY (*subsidiary company to DEP*))
- The Greek government granted to the aforementioned two companies 24 on-shore and off-shore areas for HC prospecting, exploration and production
- Total of 73.000 Km of 2D and 300 km<sup>2</sup> of 3D seismic surveys
- 74 exploration wells were drilled
- 1998-99 foundation of Hellenic Petroleum



# The History of Exploration Activity in Greece Mid 90's to mid 00's



- 1996- **1<sup>st</sup> International Licensing Round**, involving 6 concession areas

- 4 licenses were granted for the areas:

- NW Peloponnese & Ioannina (*Enterprise Oil*)

- Aitolokarnania & off-shore Western Patraikos Gulf (*Triton Ltd*)

- Total amount of investment in seismic surveys and drilling reached up to 85 M€.

- All wells were P&A with minor HC shows.

- Acquisition of Triton Ltd by Amerada Hess and acquisition of Enterprise Oil by Shell and the companies withdrew in 2000-2001. (low oil prices)

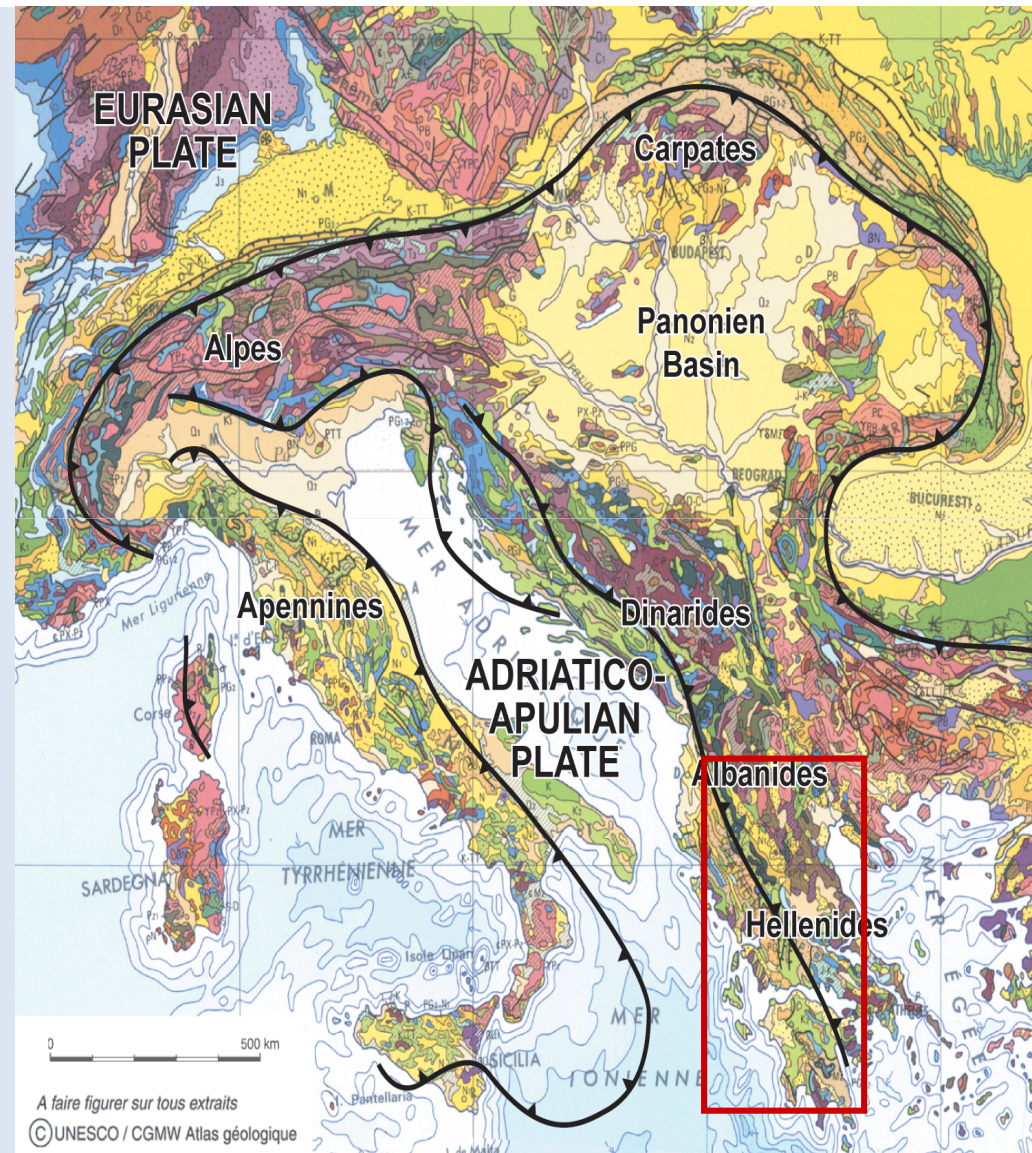
# **GR: HYDROCARBON FIELDS & DISCOVERIES**

- **PRINOS (oil field) Thracian Sea**
- **SOUTH KAVALA (gas field) - Thracian Sea**
- **NORTH PRINOS (oil field)-Thracian Sea**
- **EPSILON (oil field)- Thracian Sea**
- **EPANOMI (gas field)- Chalkidiki**
- **WEST KATAKOLON (oil field)- Ionian Sea**
  
- **ALYKES(Asphalt discovery) – Zakynthos**
- **Athos (oil discovery)- Thracian Sea**
- **AMMODIS (Heavy Oil Discovery)- Thracian Sea**
- **EAST THASSOS (Heavy Oil Discovery )-Thracian Sea**
  
- **Interesting biogenic gas accumulations were discovered while drilling Neogene layers.**
  
- **More than 200 oil /gas shows on the surface or in wells**

# WESTERN GREECE REGIONAL GEOLOGICAL SETTING

**- WESTERN GREECE IS A PART OF THE ALPINE MEDITERRANEAN OROGENIC BELT AND IS LOCATED SOUTH OF THE ALBANIDES AND DINARIDES BELTS.**

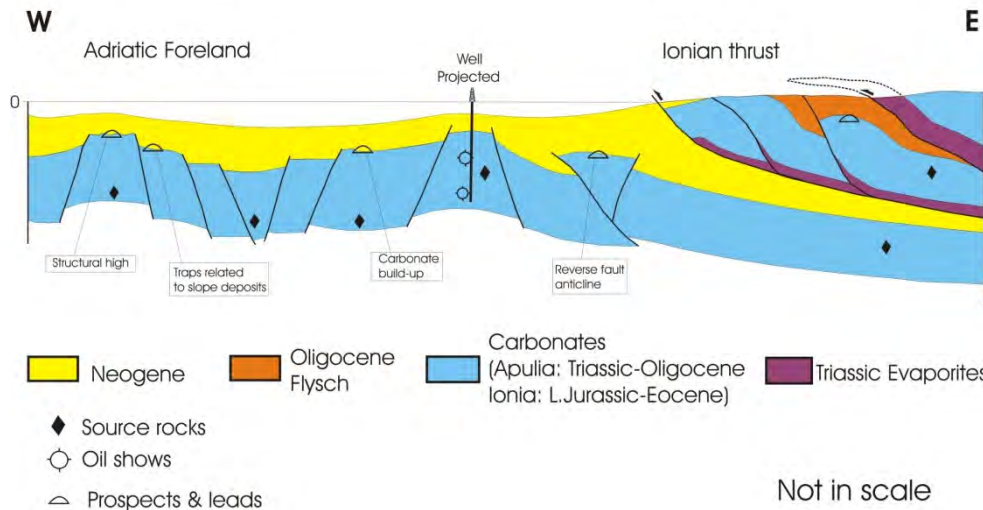
**- MESOZOIC AND TERTIARY EVOLUTION WAS CONTROLLED BY RELATIVE MOVEMENTS BETWEEN AFRICA AND EURASIA PLATES**



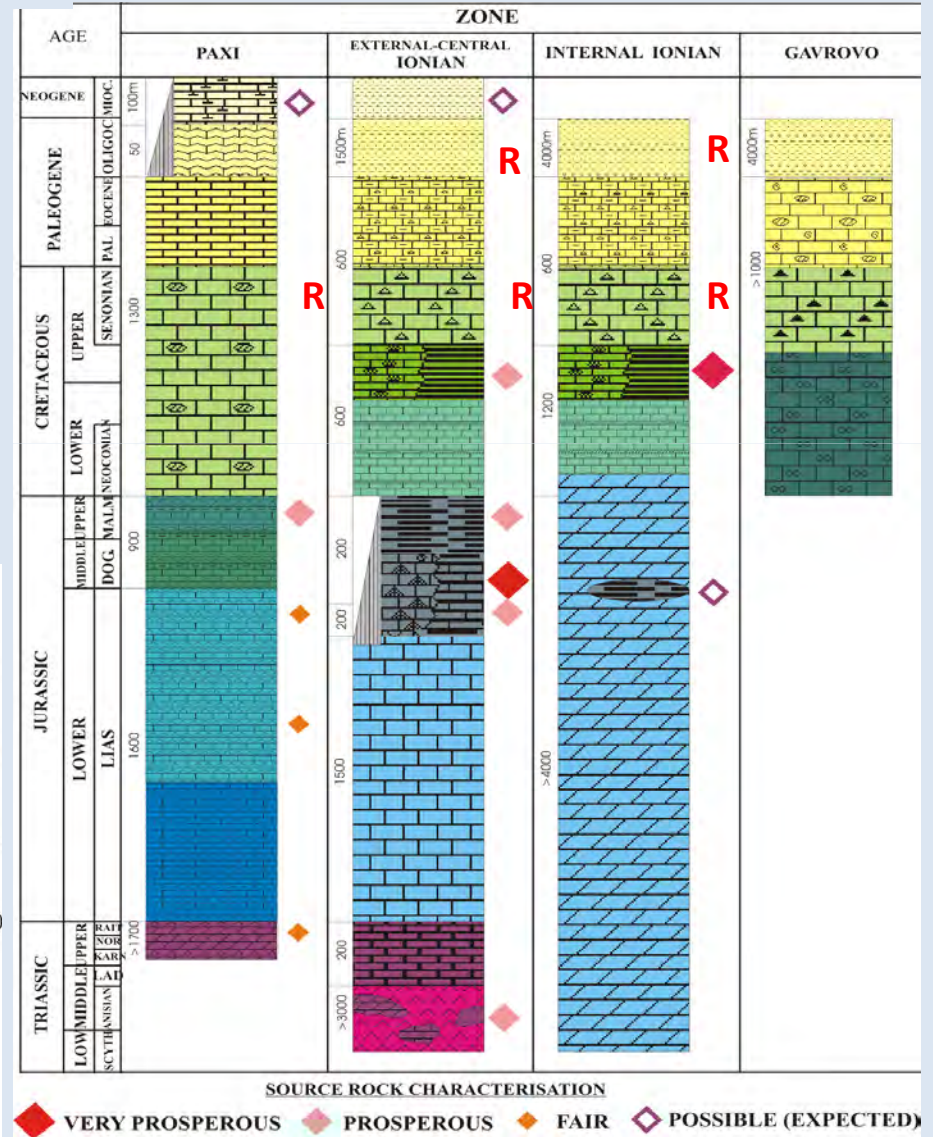
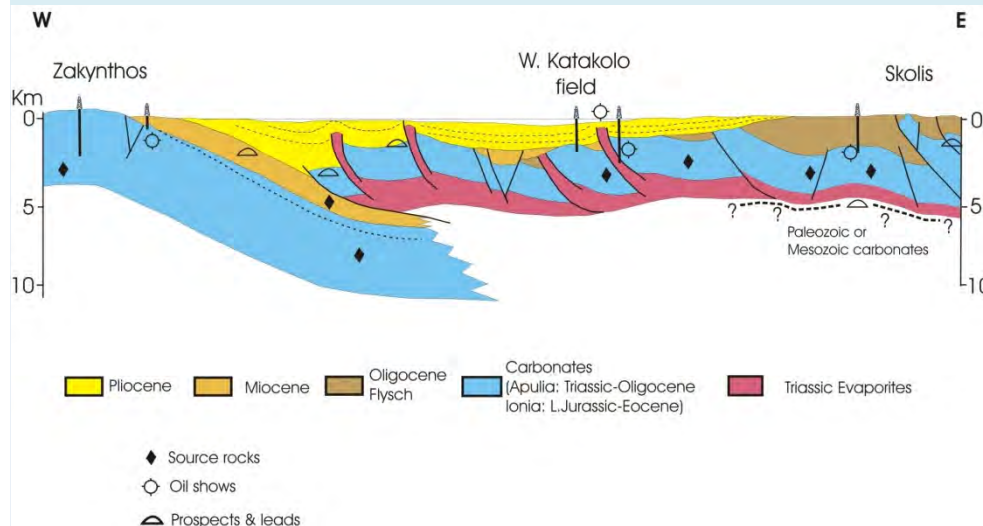
# Greece: Geological Summary of the External Geotectonic Zones of W. Greece

## Northern Ionian cross section and potential plays

## Simplified lithostratigraphic column with main reservoir & source rocks



## Central Ionian cross section and potential plays



# Oil Groups of Western Greece

# Source Rocks and oil seeps in Western Greece

GROUP	GEOTECTONIC ZONE	AREA	SOURCE ROCK	AGE	OILWINDOW
<b>A (A1-A2)</b>	CENTRAL IONIAN	EPIRUS (BOTSARA)	POSIDONIA BEDS	MIDDLE JURASSIC	3750-5800 m
<b>B</b>	CENTRAL IONIAN	TRIFOS KYLLINI W. KATAKOLO	VIGLA SHALES	LOWER CRETACEOUS	3450-5600 m (Internal Ionian)
<b>C</b>	CENTRAL IONIAN	DELVINAKI S. KATAKOLO ETOLIKO-1	TRIASSIC BRECCIAS	TRIASSIC	1000-3600 m
<b>D1</b>	PAXI	ZANTE	CLASTIC SEDIMENTS	MIOCENE	5800-7850 m
<b>D2</b>	GAVROVO	FILIATRA	EVAPORITES		
<b>E</b>	PAXI	PAXI ISLAND	APTICI SHALES	M-U JURASSIC	5600-7250 m

**Lower Posidonia beds**



**Lower Posidonia beds**



**Loutra Kyllinis oil seep**



**Zakynthos: Miocene source rocks**



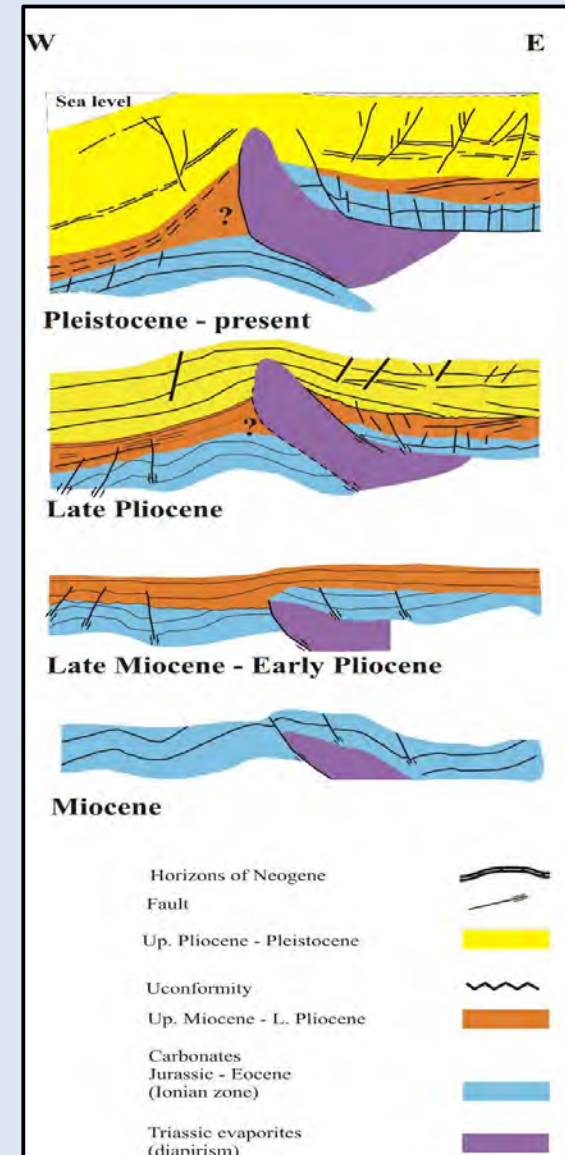
**HERODOTUS OIL SEEP**

**Dragopsa Oil Seep**

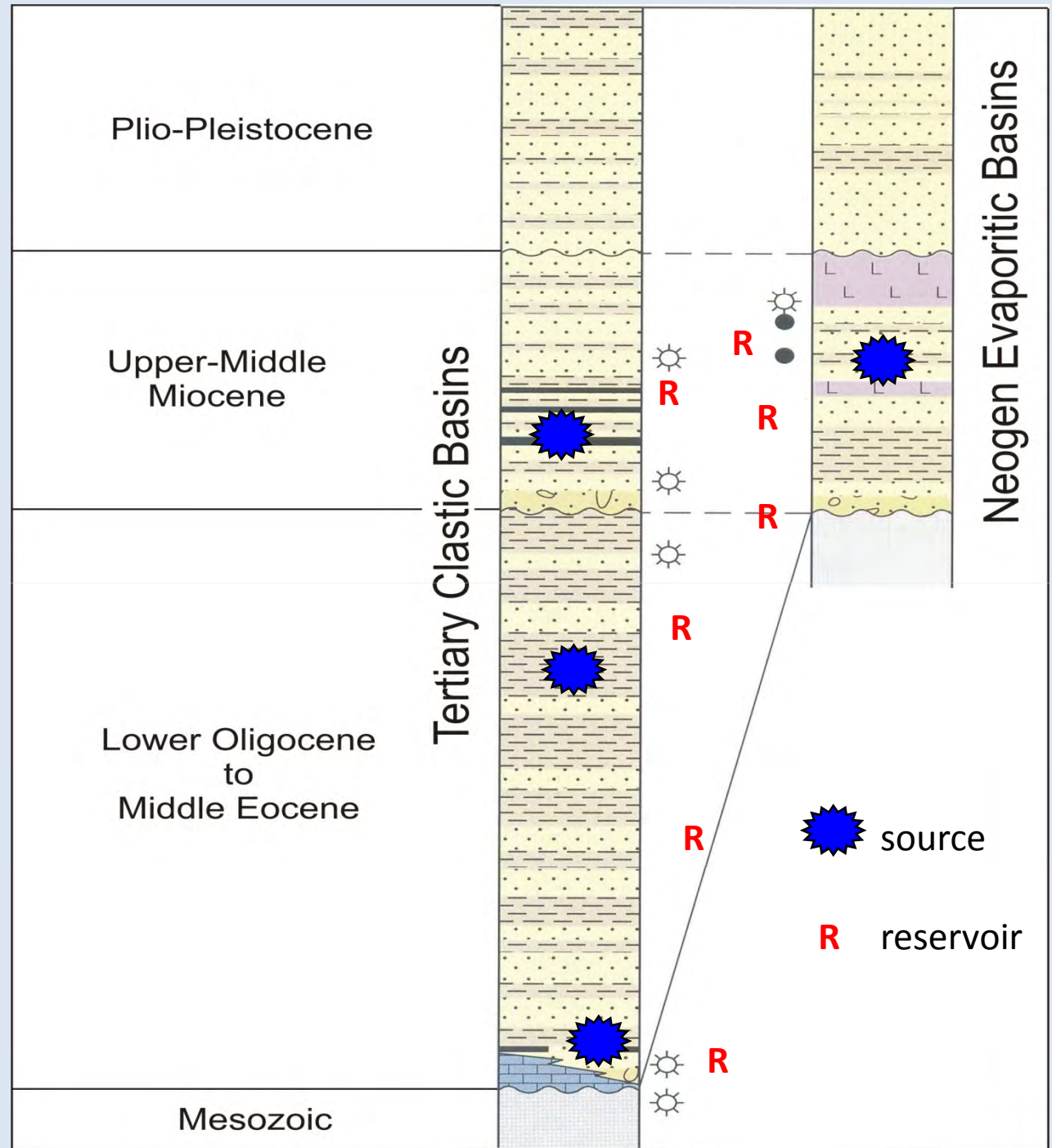


# Significance of Triassic Evaporites

- The evaporites played a significant role in the palaeo-geographic evolution and sedimentation of the Ionian zone generally , since the Pleiostocene.
- Diapiric movements further deformed the alpine rocks (carbonates) and the overlying Neogene sediments and acted locally as cap rock since the Late Pleiostocene.
- The evaporites facilitated the migration of hydrocarbons in carbonate reservoirs at a latest stage.



# Stratigraphy & source and reservoir Rocks Intervals of Eastern Greece Tertiary Basins



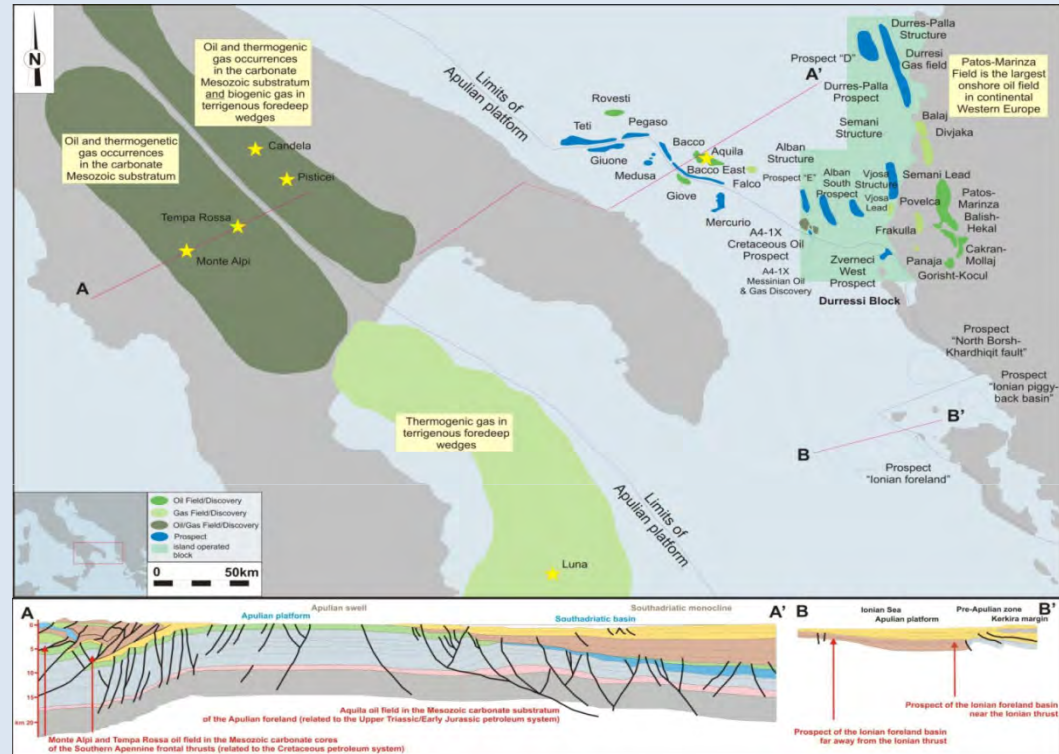
# **Analogues**



# H-C Discoveries in East Thrace Basin in Turkey



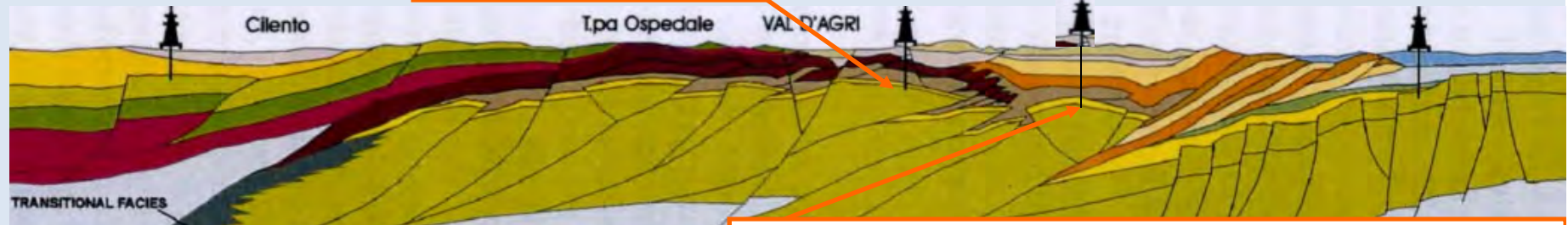
# H-C fields in Italy and Albania



M. Alpi trend

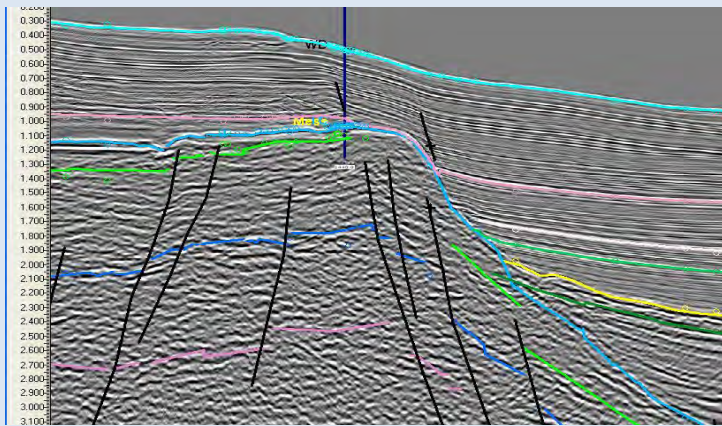
A

B

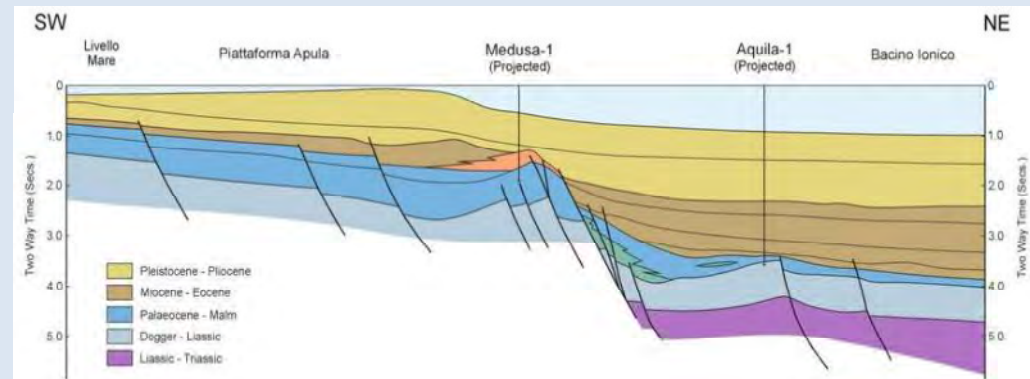


Tempa Rossa (Monte Grosso) trend

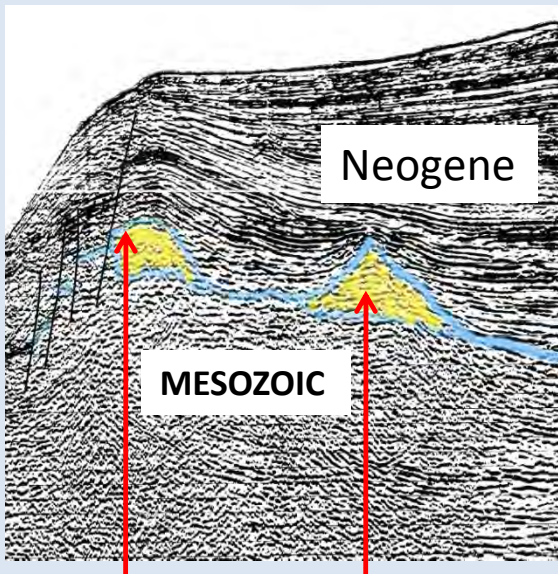
# Analogue : South Adriatic in Italy and North Ionian in Greece



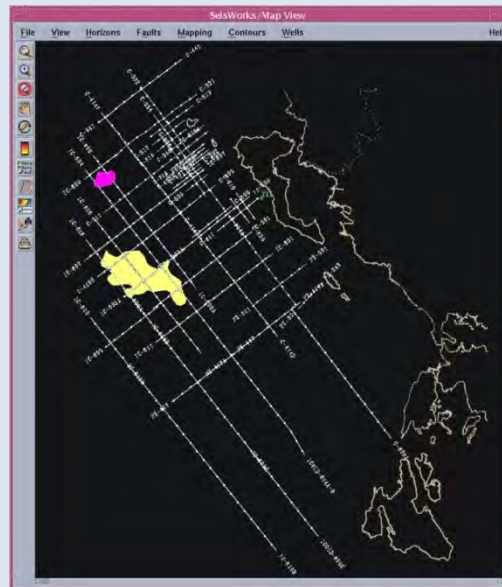
Carbonate platform margin “build-ups” in the Adriatic Sea in ITALY



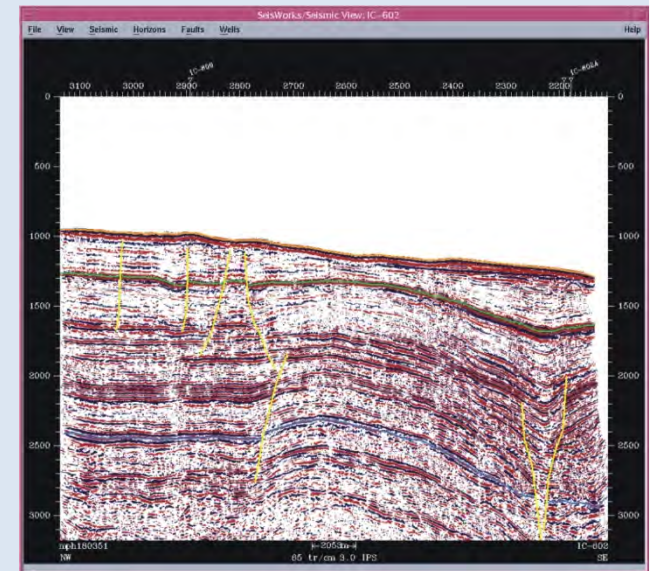
1. Platform margin build-ups (Giove, Medusa discoveries)
2. Pelagic Carbonates -Paleo-structures (Rovesti discovery / Aquila field)
3. Proximal Talus Slope Play
4. Platform Rotated Fault Blocks (Cretaceous/Jurassic)
5. Distal Calcarene Turbidites (re-sedimented platform carbonates – Aquila field)



West Lefkas - Reefal build-ups In Greece

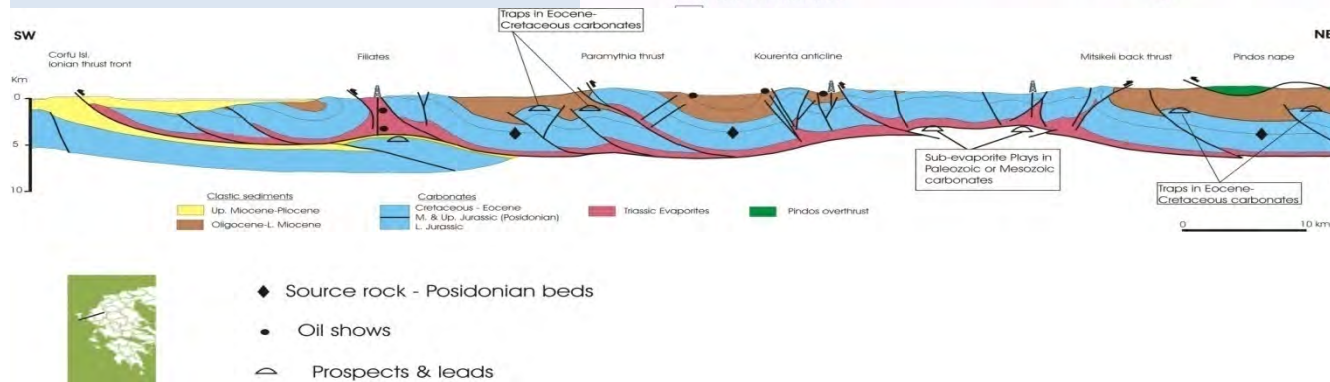
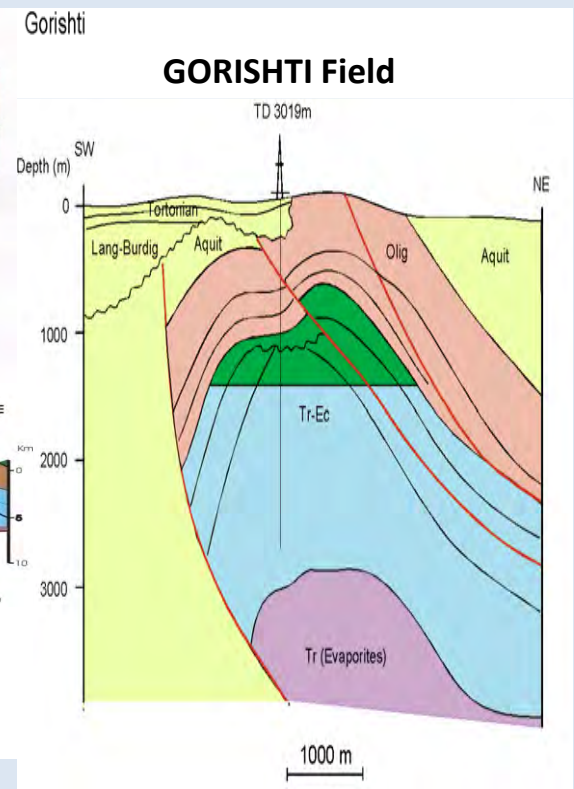
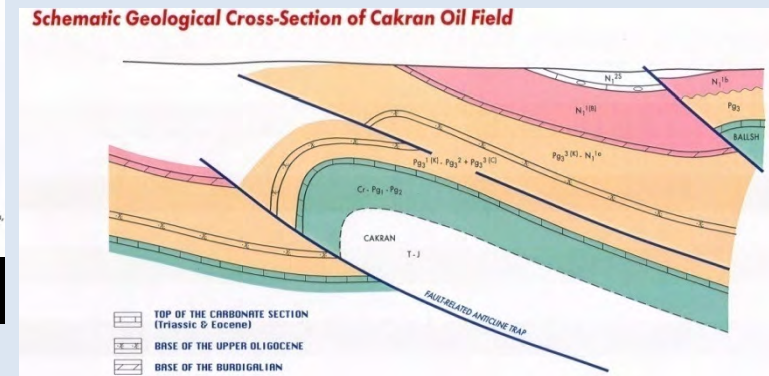
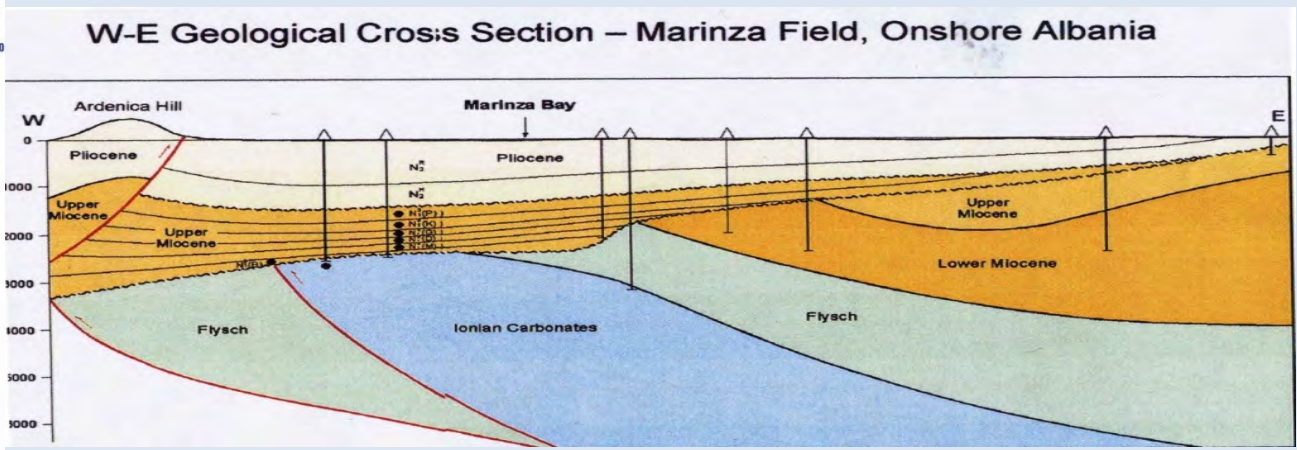
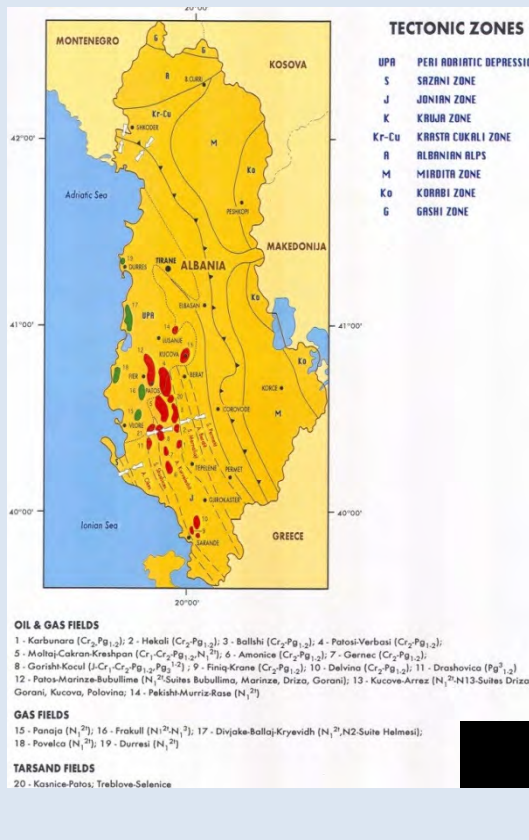


West CORFU: 400 sq. Km structure



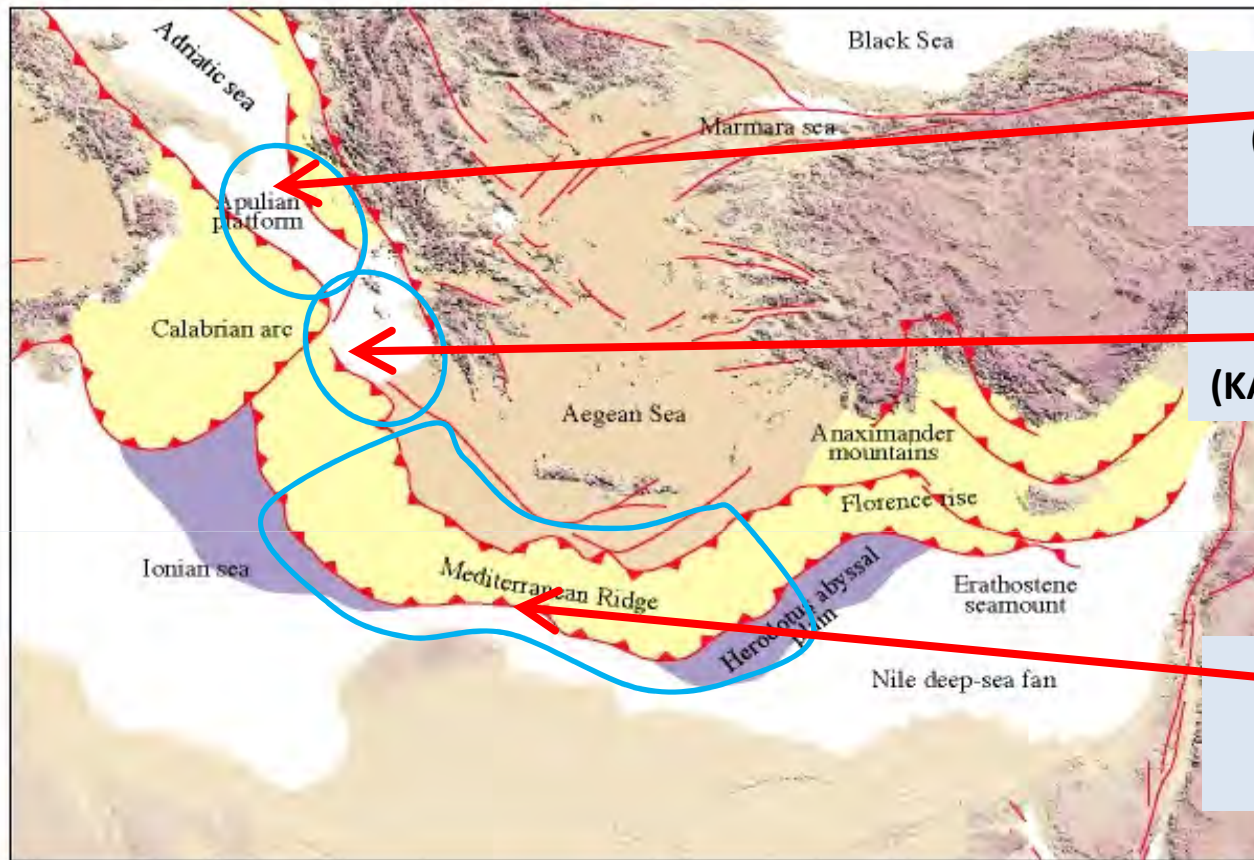
West CORFU: Faulted Block (possible “paleo-high”) N-S directed seismic line

# ANALOGUES and HYDROCARBON OCCURRENCES IN ALBANIA (OIL & GAS FIELDS)



**Structural section across NW. Greece**

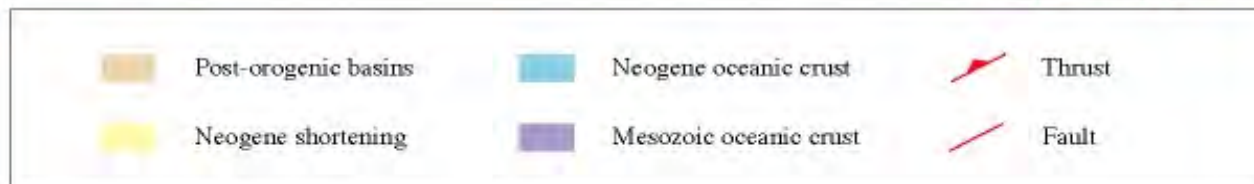
# TECTONIC SKETCH OF EASTERN MEDITERRANEAN



**NORTH IONIAN SEA  
(SOUTH ADRIATIC/APULIAN  
PLATFORM)**

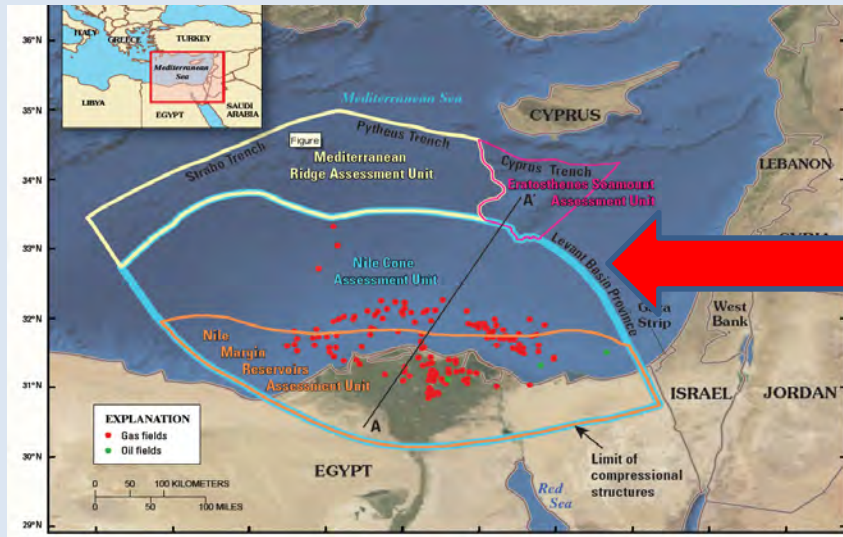
**CENTRAL IONIAN SEA  
(KATAKOLON - PATRAIKOS GULF)**

**SOUTH IONIAN and  
SOUTH CRETE AREA  
???**

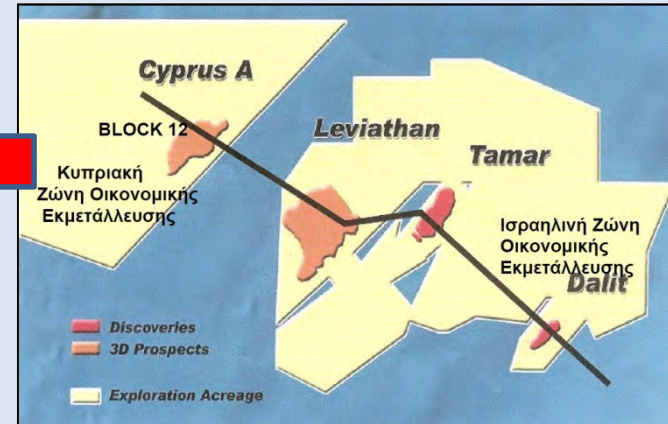


*Tectonic sketch of the Eastern Mediterranean  
(adapted from Barrier, E., Chamot-Rooke, N. and Giordano, G., 2004,  
Geodynamic Map of the Mediterranean, Commission for The Geological Map of the World, CCGM)*

## Egypt: Offshore discoveries in Eastern Mediterranean



## ISRAEL: Offshore Discoveries in Levantine Basin

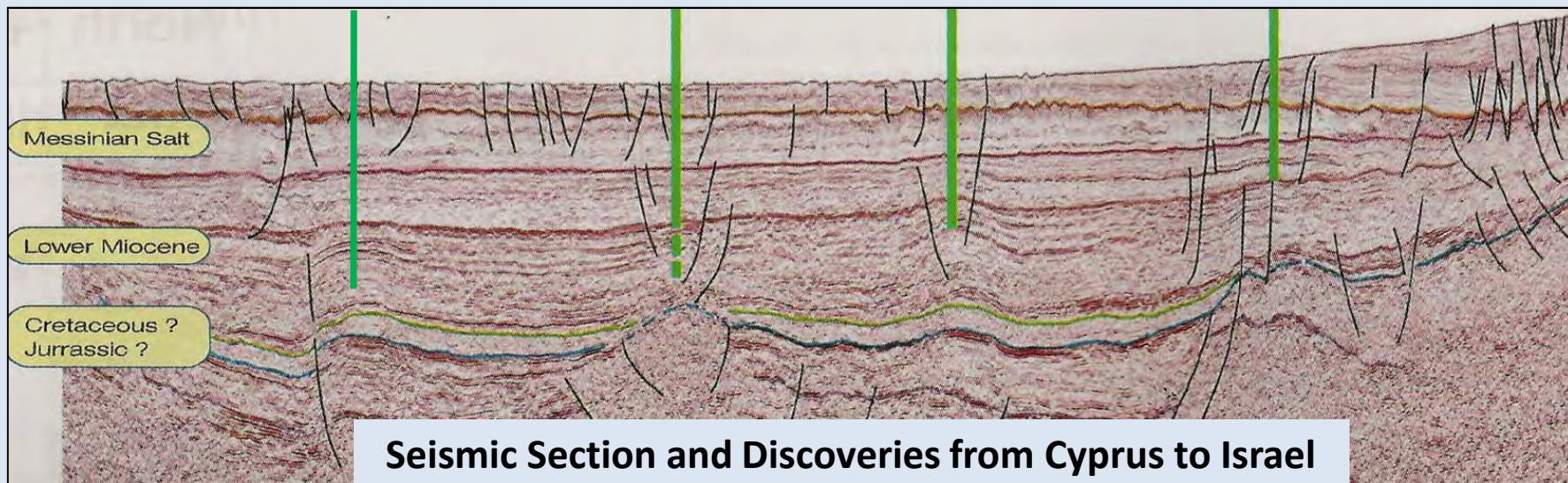


Cyprus A  
7 + Tcf

Leviathan  
≈ 16 + Tcf

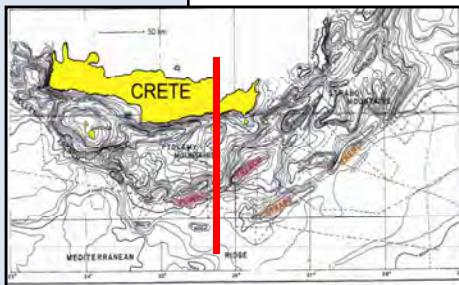
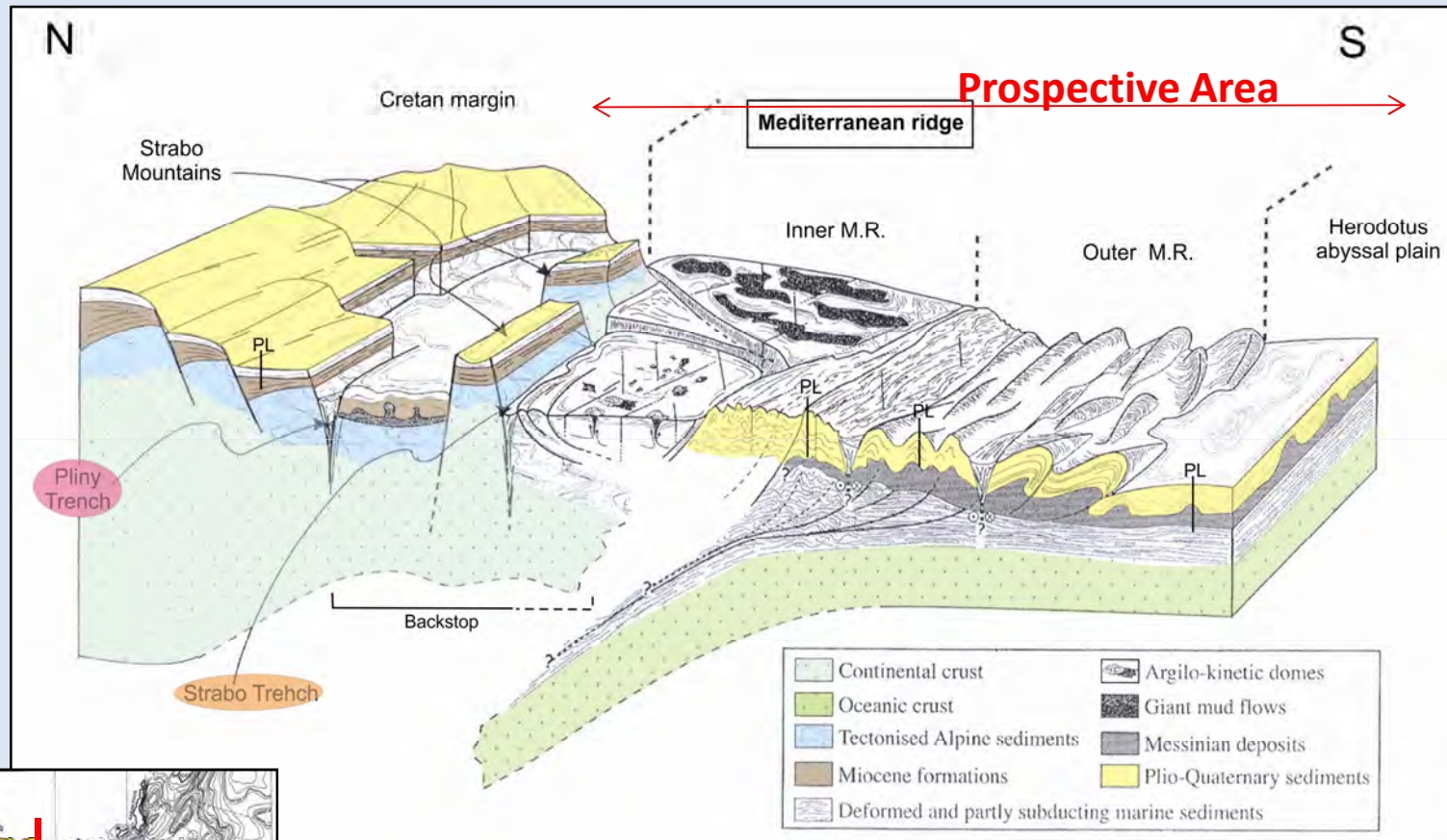
Tamar  
≈ 8+ Tcf

Dalit  
≈ 0.5 Tcf



# Greece : Exploration Potentiality of Southern Crete

## General Geological Model



*Huguen et al (2001)*

# Greece: First “Open Door” Exploration Areas

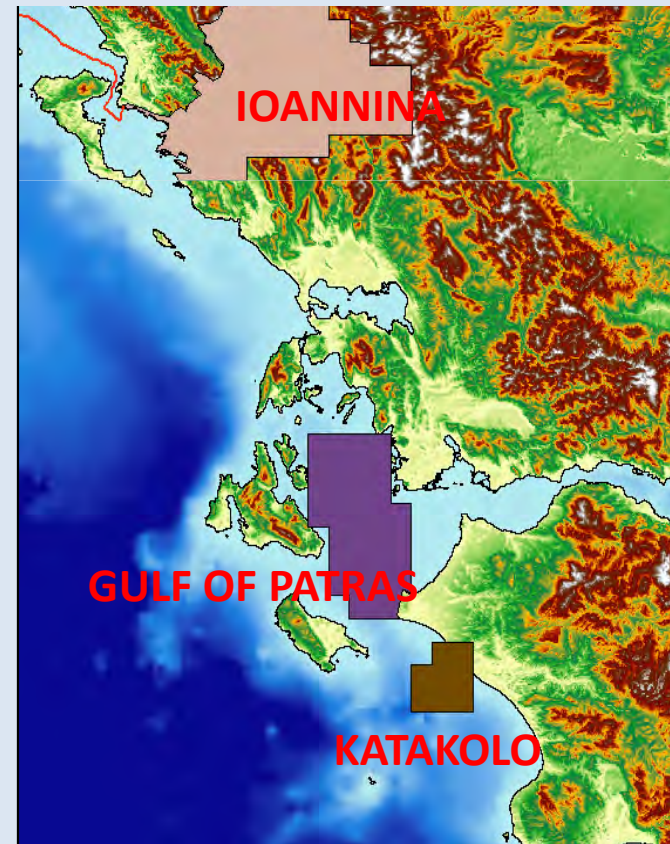
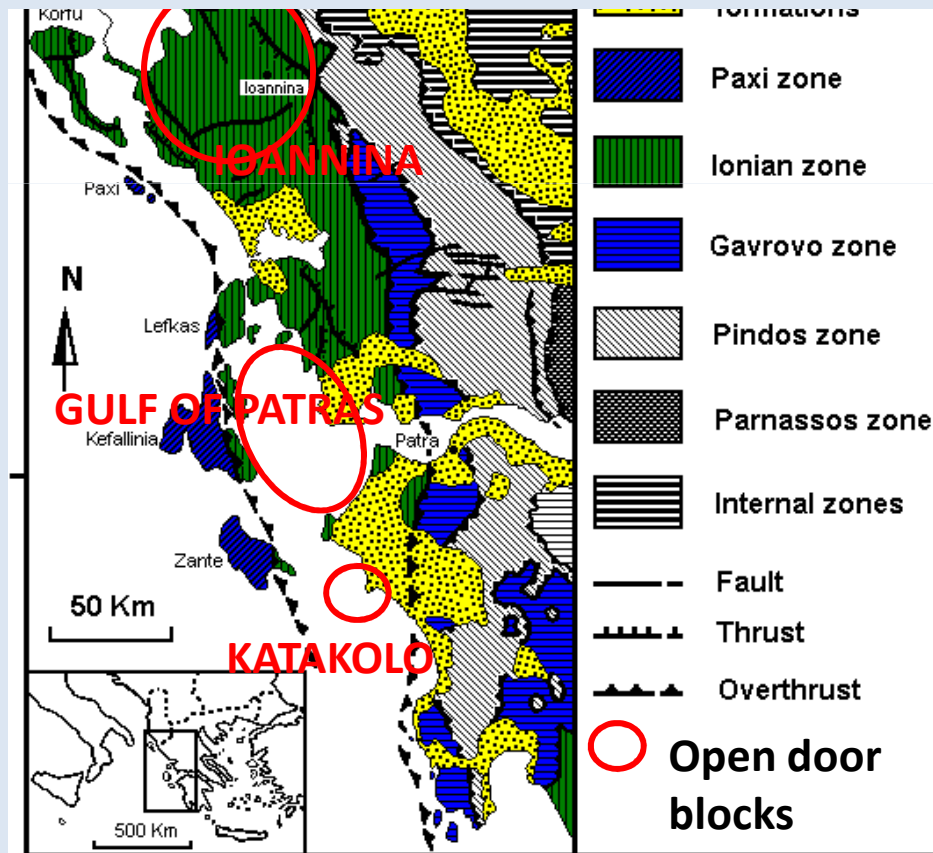
Areas integrated in the process “open door”

- *Gulf of Patras*
- Epirus – Ioannina
- Western Katakolo



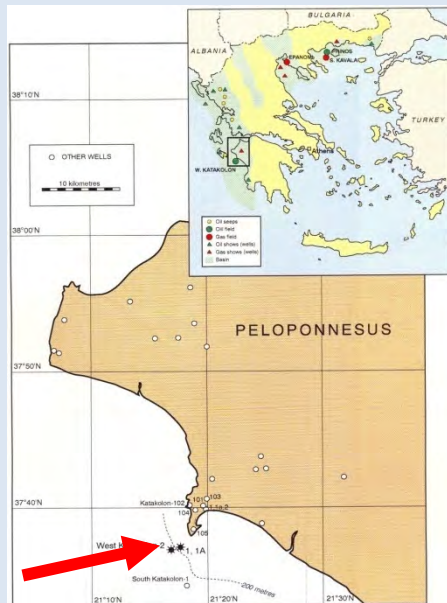
Offers are expected on July 2, 2012

External Hellenides geotectonic zones





# OFFSHORE WEST KATAKOLON FIELD AS A KEY CASE



Depth map of the top of Carbonates, showing the WOC and OGC levels, based on 2-D seismic



▪The field discovered in 1981, and the producing horizon is the Eocene-Cretaceous carbonates of a paleostructure, unconformably covered by clastic Neogene sediments with an estimated 20-25 million bbl oil in place .

•West Katakolon oil field has been proved by 3 wells WK-1 , WK-1a and WK-2 (1981-1982)

▪Different production performance was recorded

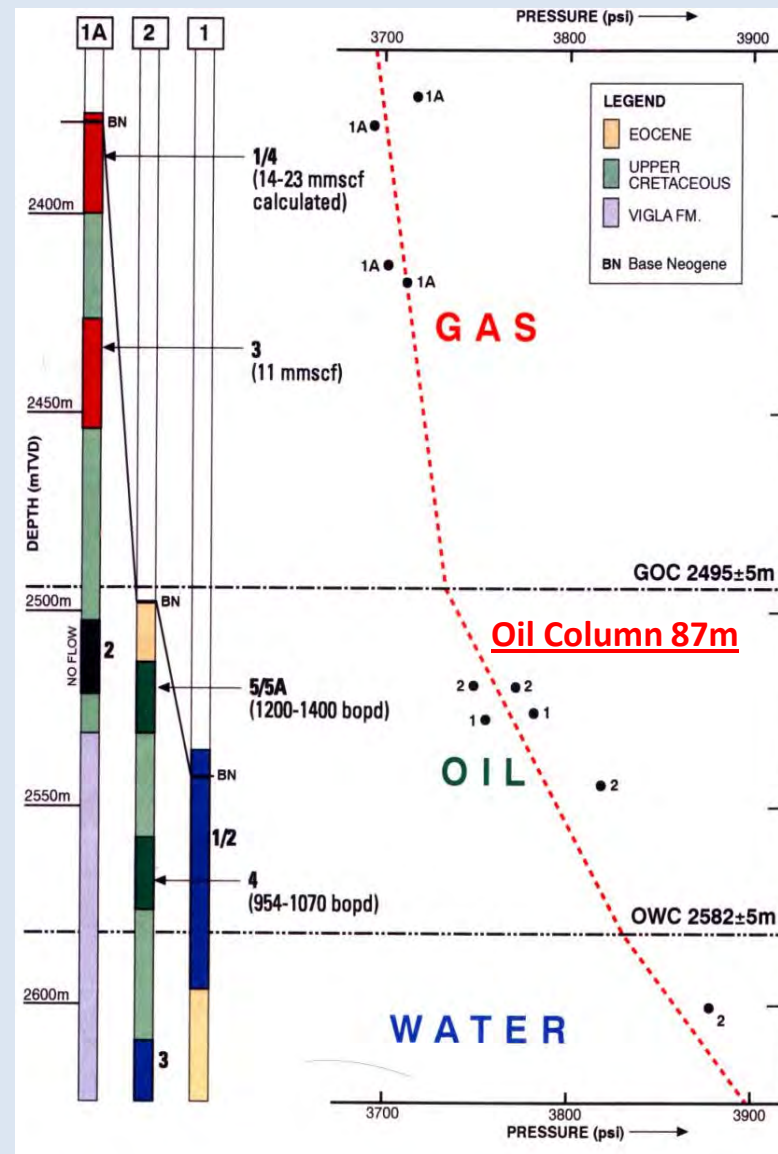
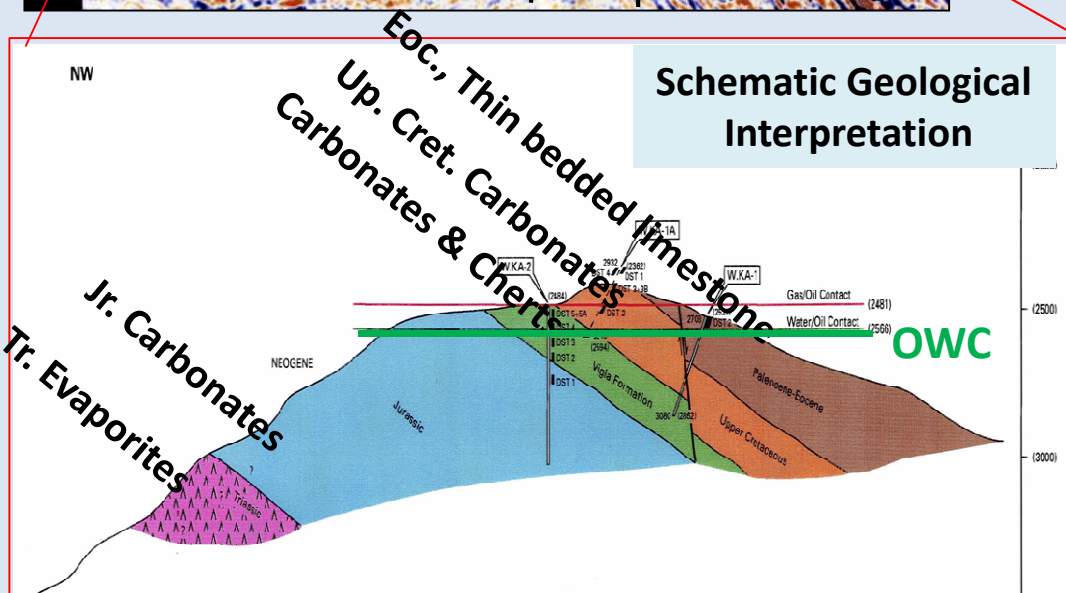
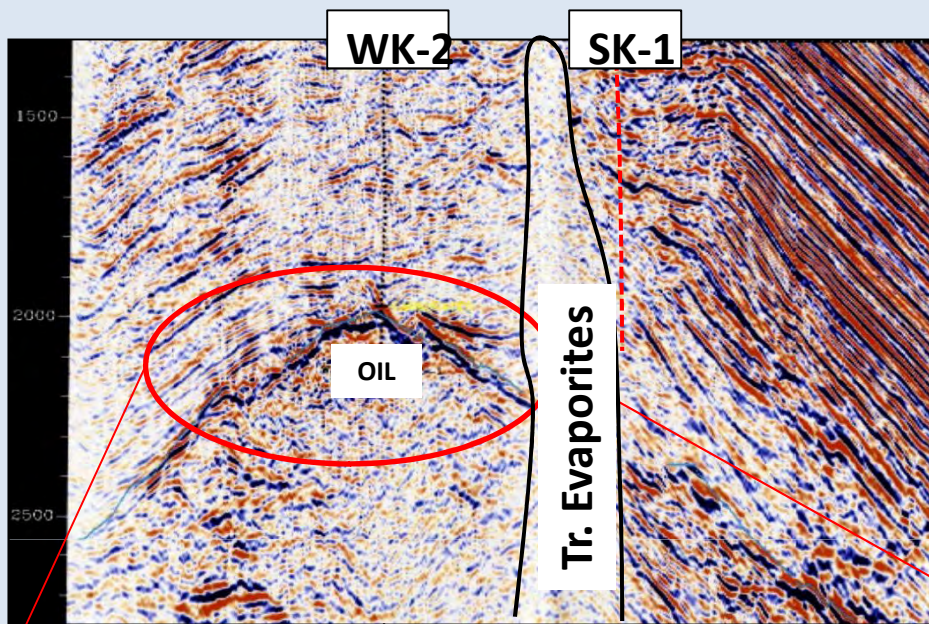
▪In WK-1a Gas flowed from two layers in the Gas Cap with flow rates up to 11MMSCFD from each zone.

▪In WK-2 oil flowed from two zones with flow rates between 1000-1400 bbl/day each. Gas zone was not reached at this position

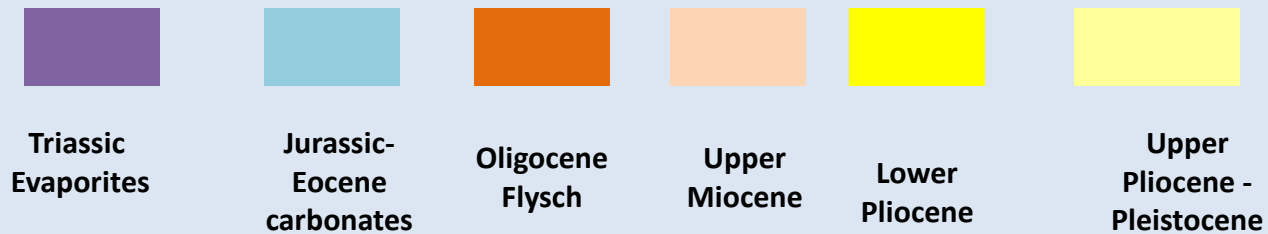
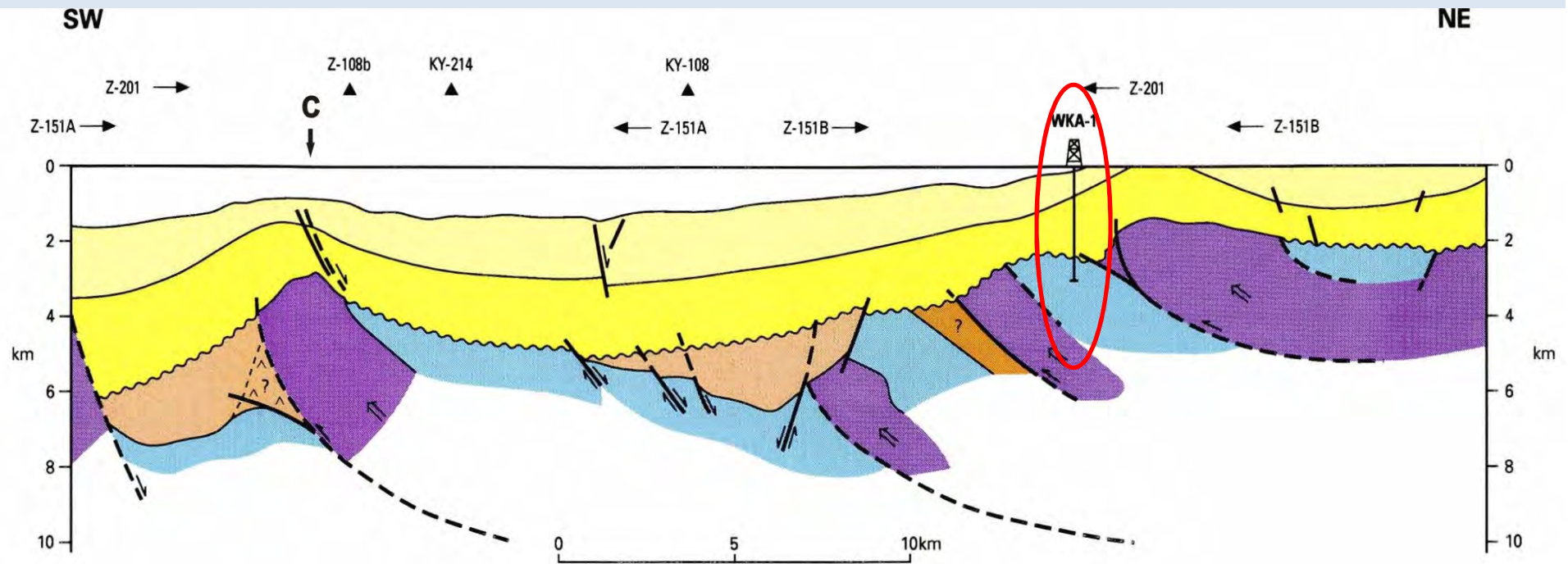


**W. Katakolo - 2,  
1982 , DST,**

# Exploration Data from Katakolo Oil Field



# W. Katakolo As a key case [field geoseismic section (based on 2D profiles)]



# KATAKOLO: GAS SHOWS

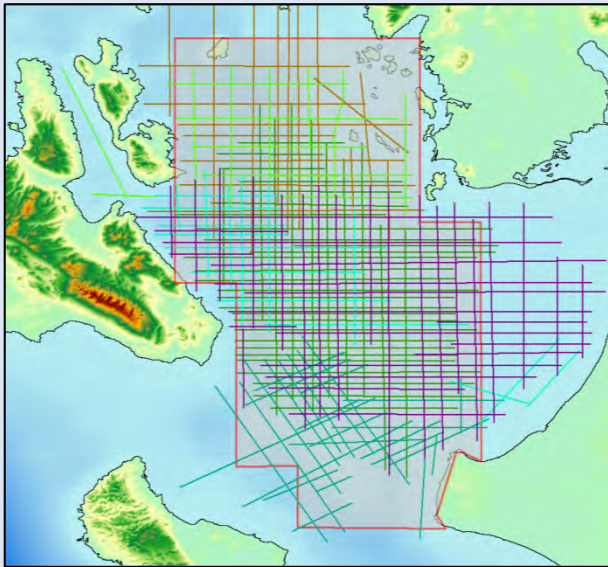


# Katakolon Port as Cruise Destination for Ancient Olympia

> 400 Cruise Vessels, > 1.000.000 tourists every year .

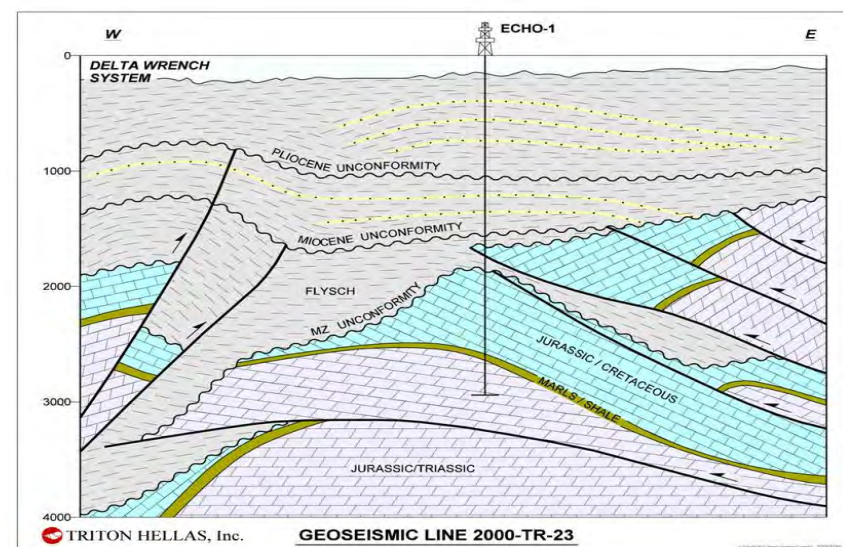
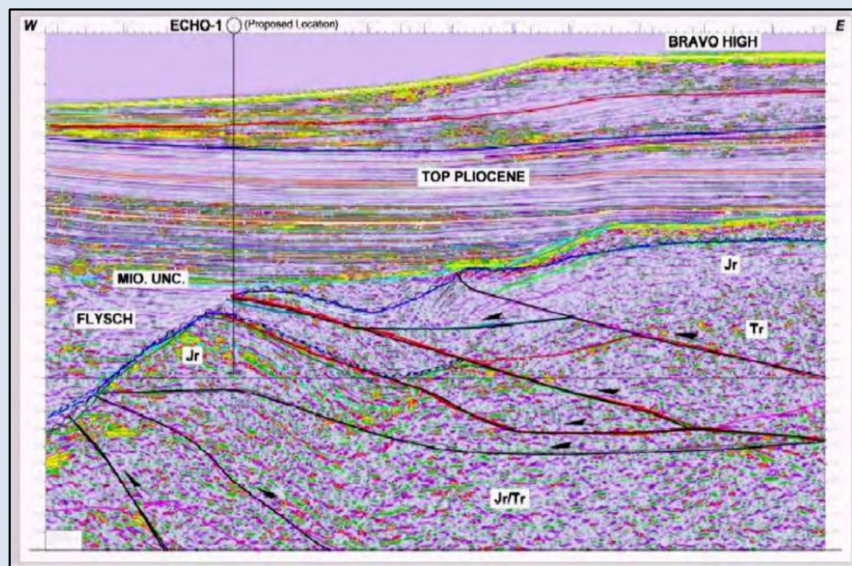


# Gulf of Patras



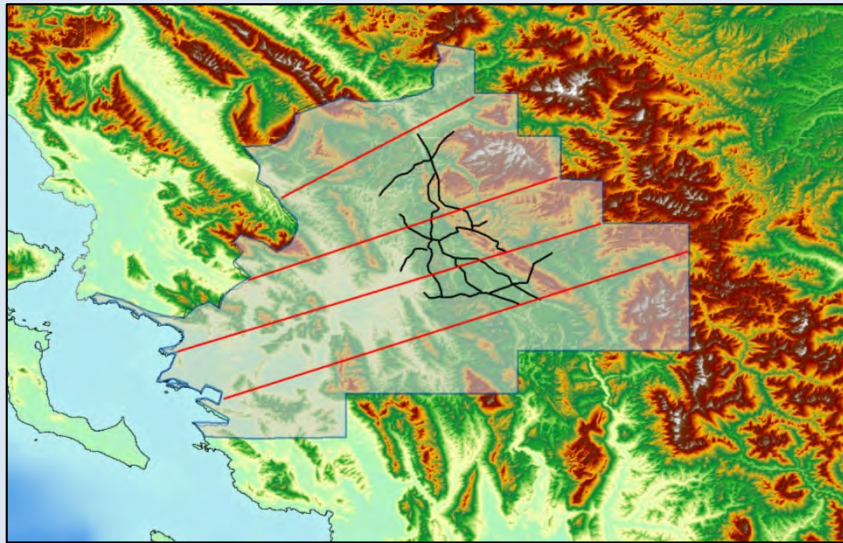
## Block History

- 2D seismic data were acquired before 1982
- Modern seismic data acquired in 2000 by Triton Hellas
- Both surveys have been reprocessed
- 3 shallow (around 1200m) wells drilled within the concession area





# IOANNINA BLOCK



## Available Data

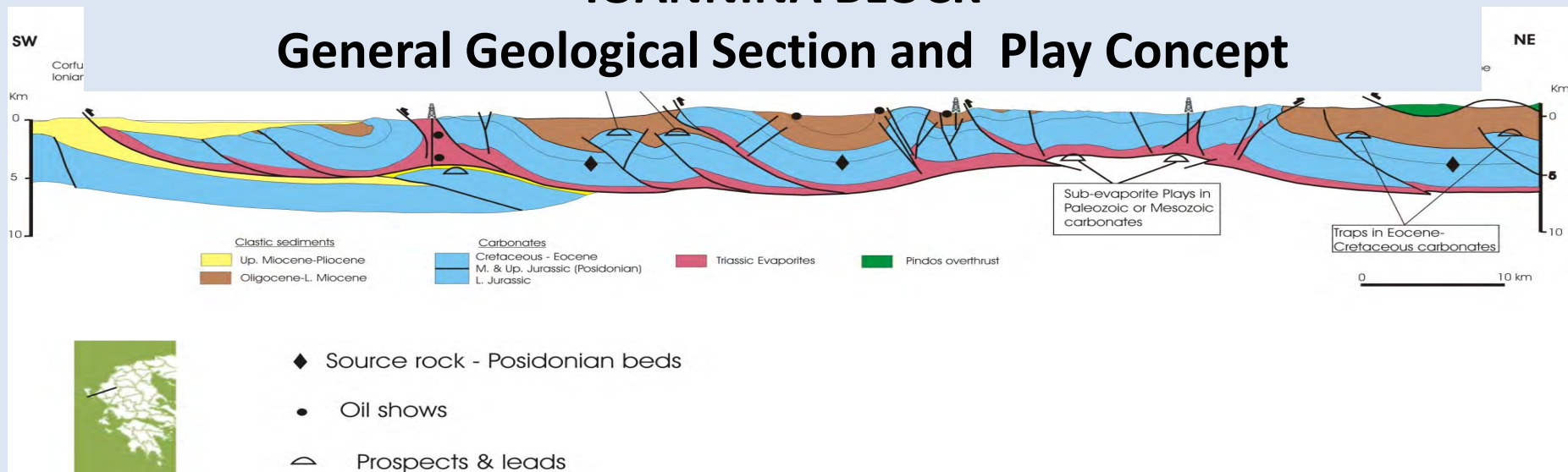
2 D Seismic 1015 km, (408 km by Enterprise Oil).

Wells: 11 (Enterprise Oil 1 and 1 side track)

(Demetra # 1, 3966  $\mu$  and 1 site track till 3600  $\mu$ )

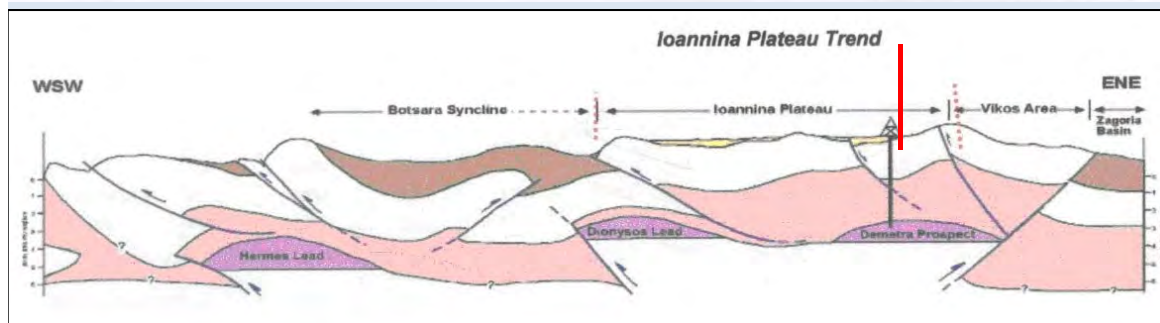
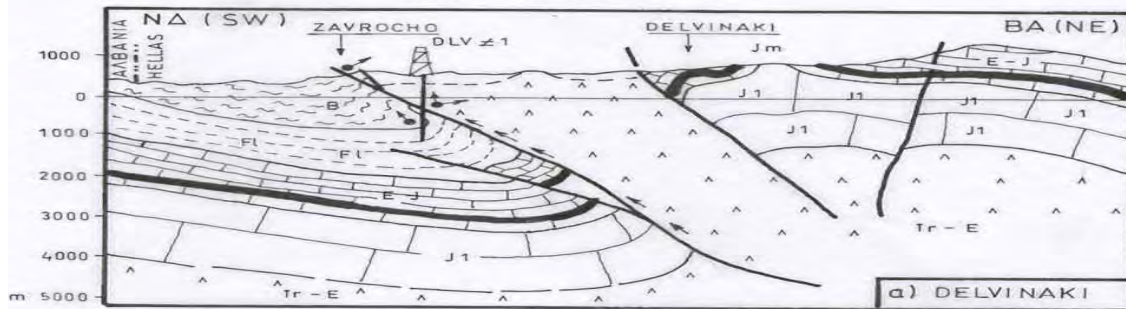
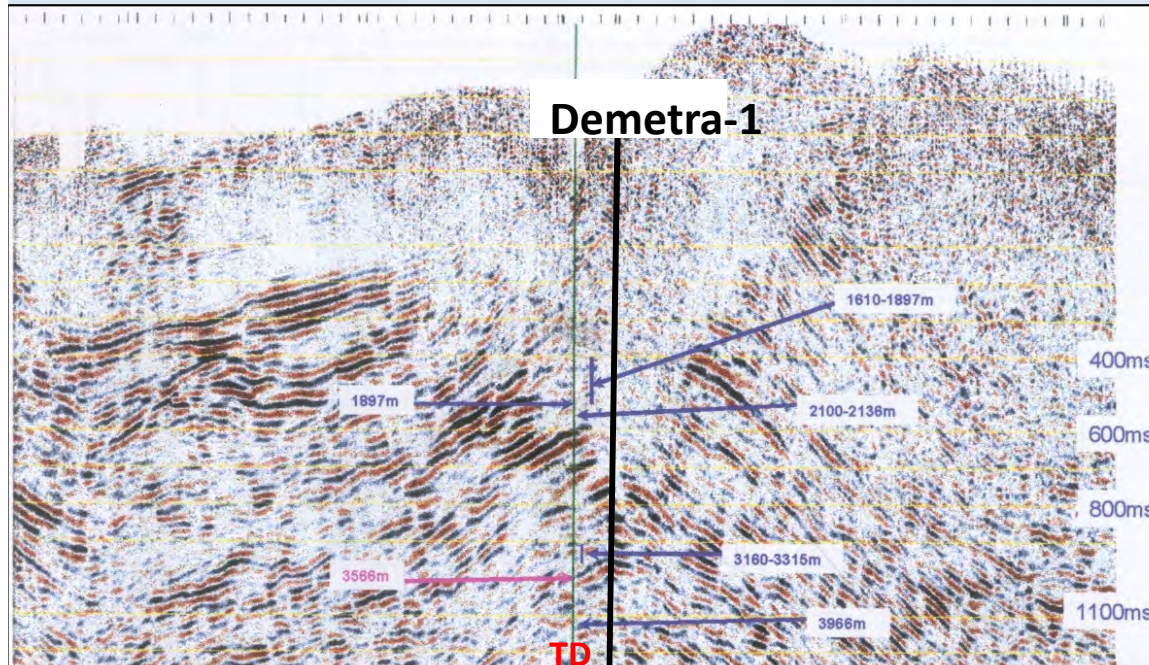
# IOANNINA BLOCK

## General Geological Section and Play Concept





# Ioannina Block: Demetra-1 & -1z



## Summary of Demetra-1

- Drilling started 8/9/2001
- Top of Evaporites was @ 1897m
- Drilling through the evaporitic sequence up to 3996m (85 days) where really high pressures occurred (kick, 16.5 ppg).
- Due to technical reasons (increase of mud weight) , drilling stopped, well cemented up to 3.076m and sidetracked

## Summary of Demetra -1z

- well was sidetracked from 2807m
- @ 3566m high pressures occurred (17.5ppg)
- Increase of mud weight at 17,9 ppg
- Drilling stopped @ TD of 3600m after 162 days

## DLV-1

- Analogue well with high pressures in the region

## H/C DISCOVERIES and HYDROCARBON SYSTEMS

The **answer** to the question whether or not Greece has any exploration and production potential for H/C, is definitely **positive**. This because there are proven and active petroleum systems in the alpine and Post-alpine basins of Western Greece, as well as, in the molassic and post-alpine tertiary basins of Eastern Greece, where source rocks, reservoirs, cap rocks, traps and proper geological and migration time **co exist**. The **active hydrocarbon seeps and shows** and hydrocarbon discoveries, found in both Western and Eastern Greece, attest to the existence of active hydrocarbon systems. Commercial exploitation of hydrocarbon accumulations in the Thracian Sea and in **analogues systems** to the ones of Greece, such as in Italy, Albania, Croatia, as well as discoveries in East Thrace in Turkey, all advocate to high hydrocarbon potential of the similar sedimentary basins of Greece.