Technical University of Crete. **Chania 29/9/2011**

Hydrocarbon Discoveries and Petroleum Systems in Greece

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H/C DISCOVERIES and HYDROCARBON SYSTEMS

The answer to the question whether or not Greece has any exploration and production potential for oil, is definitely positive. This because there are proven 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 and proper geological and migration timing 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.

ARE THE FUNDAMENTAL CONDITIONS OF HYDROCARBONS EXISTENCE IN GREECE IN EFFECT?

The Answer is YES

- **SOURCE ROCKS (quantity, quality, maturity, migration) OK**
- **RESERVOIR ROCKS (porosity, permeability) OK**
- **TRAPS OK**
- **SEAL ROCKS OK**
- **APPROPRIATE GEOLOGICAL TIME OK**

EXPLORATION ACTIVITIES IN GREECE

WELLS

INTERNATIONAL OIL COMPANIES	GREEK STATE + IFP	HELLENIC PETROLEUM	INTERNATIONAL OIL COMPANIES/ HELLENIC	PRINOS	TOTAL
1939-1974	1962-1967	1975-1995	1997-2002	1971-2009	
51	17	**74 (1)**	6	73	221(2)

(1) + Plus two (2) geothermal wells

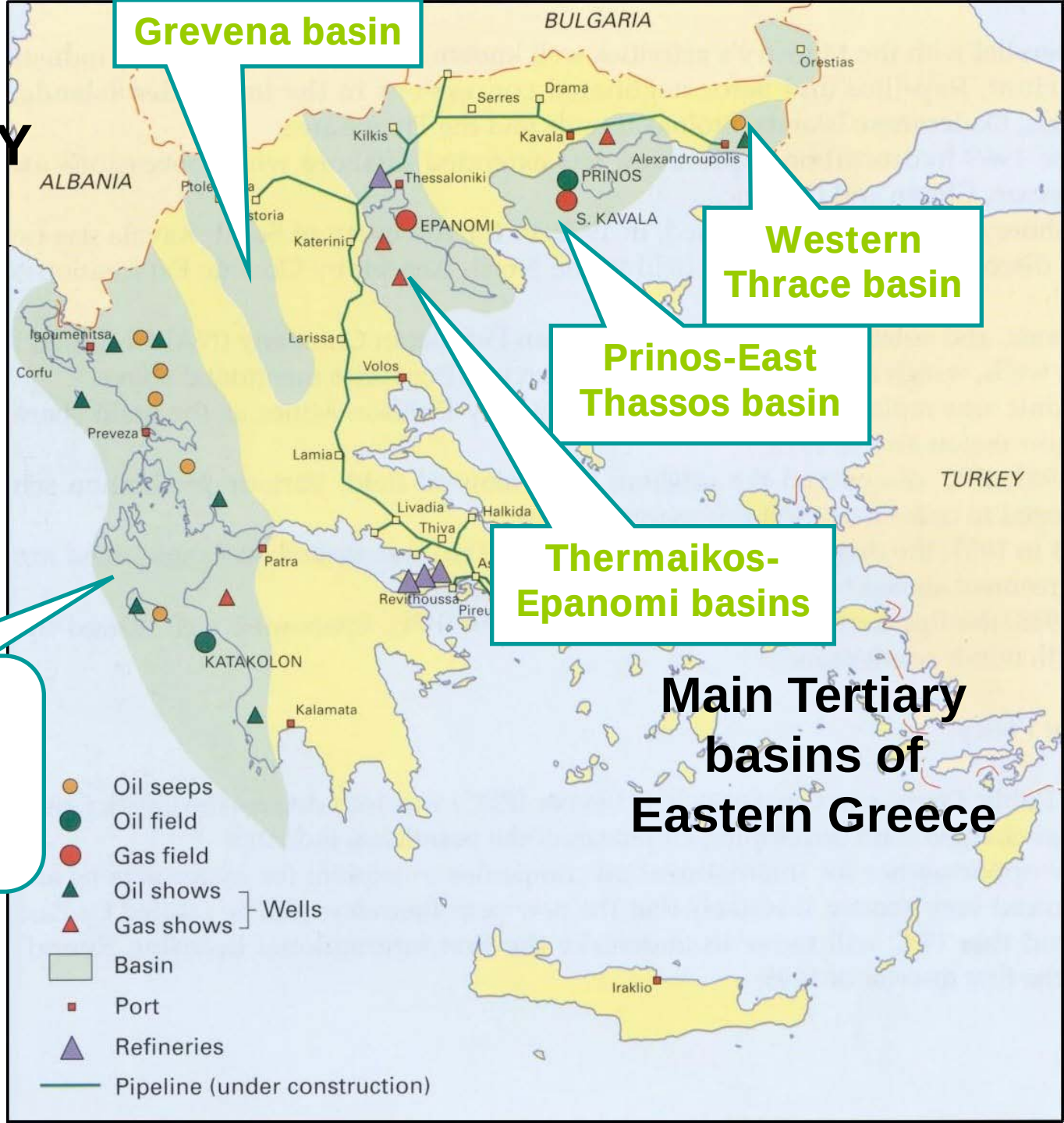
(2) 80% offstructures or very shallow depths

SEISMIC PROGRAMS (in KM)

INTERNATIONAL OIL COMPANIES	HELLENIC PETROLEUM	INTERNATIONAL OIL COMPANIES/ HELLENIC	PRINOS	TOTAL
1939-1974	1975-2000	1997-2002	1971-2009	
12200	53550 + 1 3D	2100	7765 + 2 (3D)	75615

GREECE SENTIMENTARY BASINS,

Hydrocarbon Occurrences and infrastructures



WESTERN GREECE

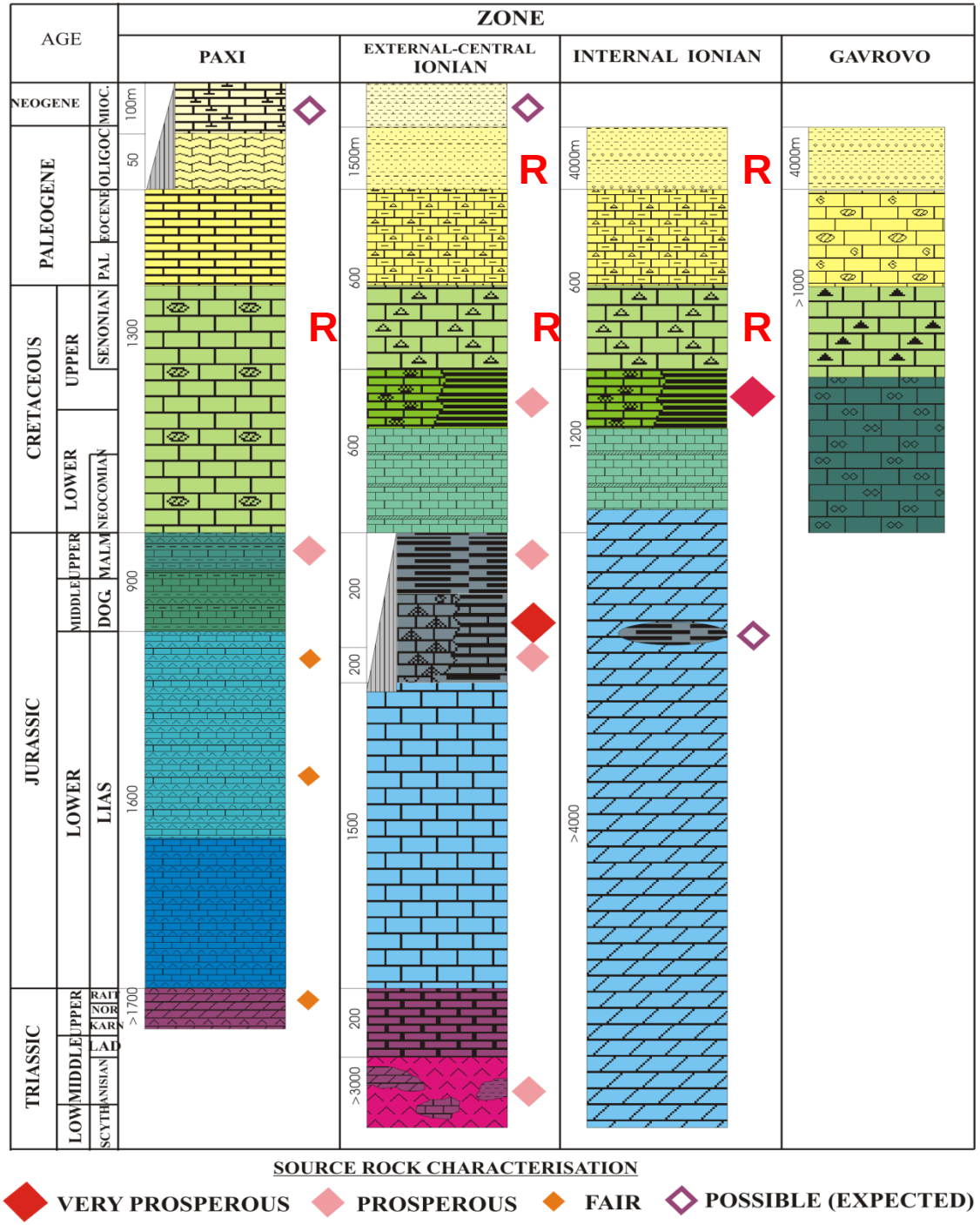
ALPINE
and
POST ALPINE BASINS

PETROLEUM SYSTEMS

Simplified lithostratigraphic columns and main source and reservoir rocks intervals, of the external geotectonic zones in Western Greece

◆ Source rocks

R Reservoir rocks



Oil Groups of Western Greece

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

Reservoir rocks

- **Eocene and upper Cretaceous micritic limestone and thick bedded turbititic limestone and breccias.**
- **Jurassic Dolomites in juxtaposition with Triassic Evaporites**
- **Shelf margin, chalky, rudistic and reefal limestone in Paxos zone**
- **Upper Miocene –Pliocene sands and sandstones in the post Alpine sediments**
- **Fractured and/or karstified Mesozoic limestones**

- **Matrix porosity and permeability are expected to be low**
- **Reservoir quality will be dependent on fracture intensity and in case of pre-existing erosion on Karstification .**

Seal Rocks

Ionian zone:

- **Deep marine shales of the Oligocene flysch are effective seal of the traps.**
- **Miocene or Pliocene Marls and Clays which overlie unconformably the eroded Mesozoic carbonates.**

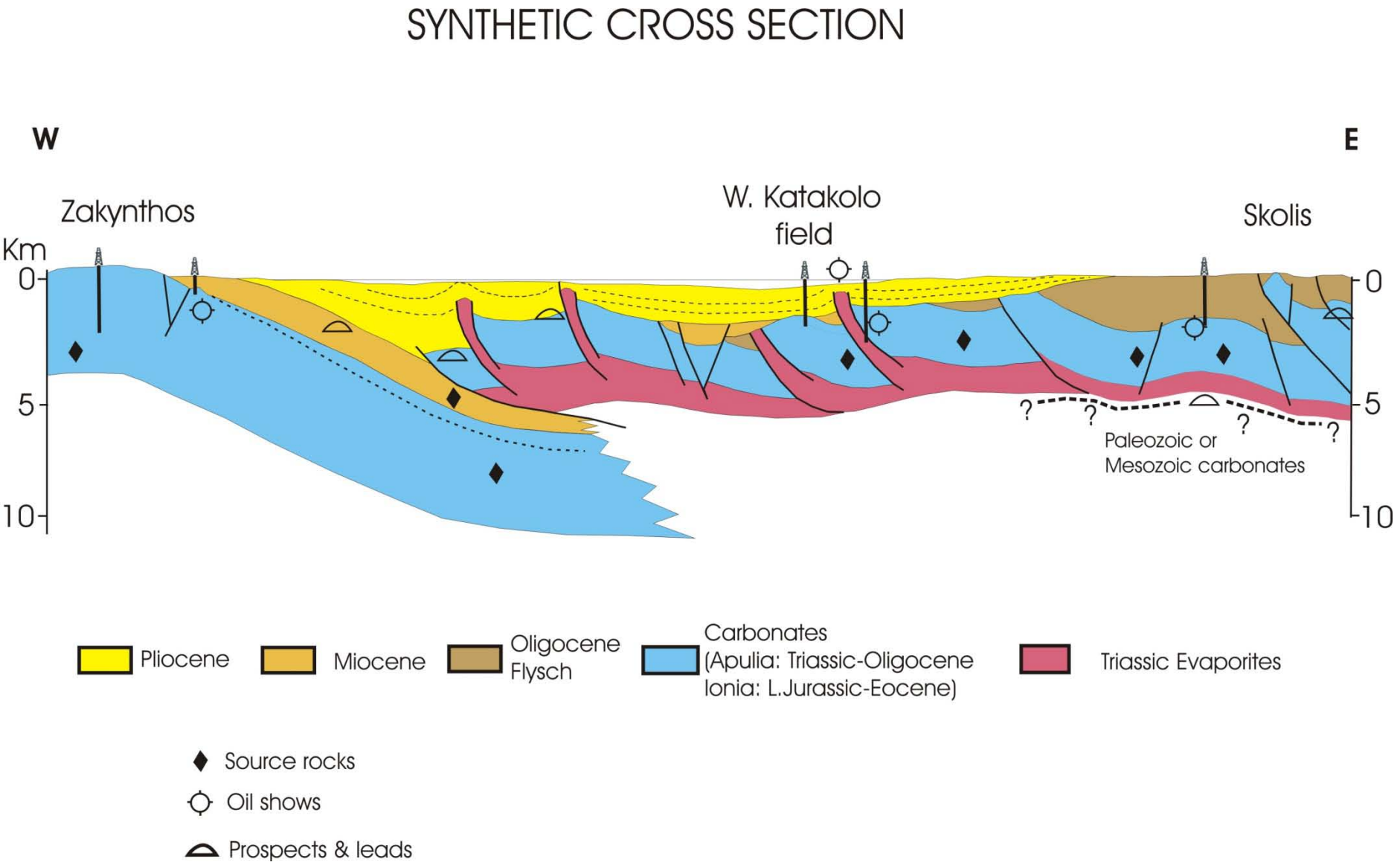
Paxi zone:

- **Miocene – Lower Pliocene marine marls and clays and shaly- marly intervals in the Mesozoic sequence**

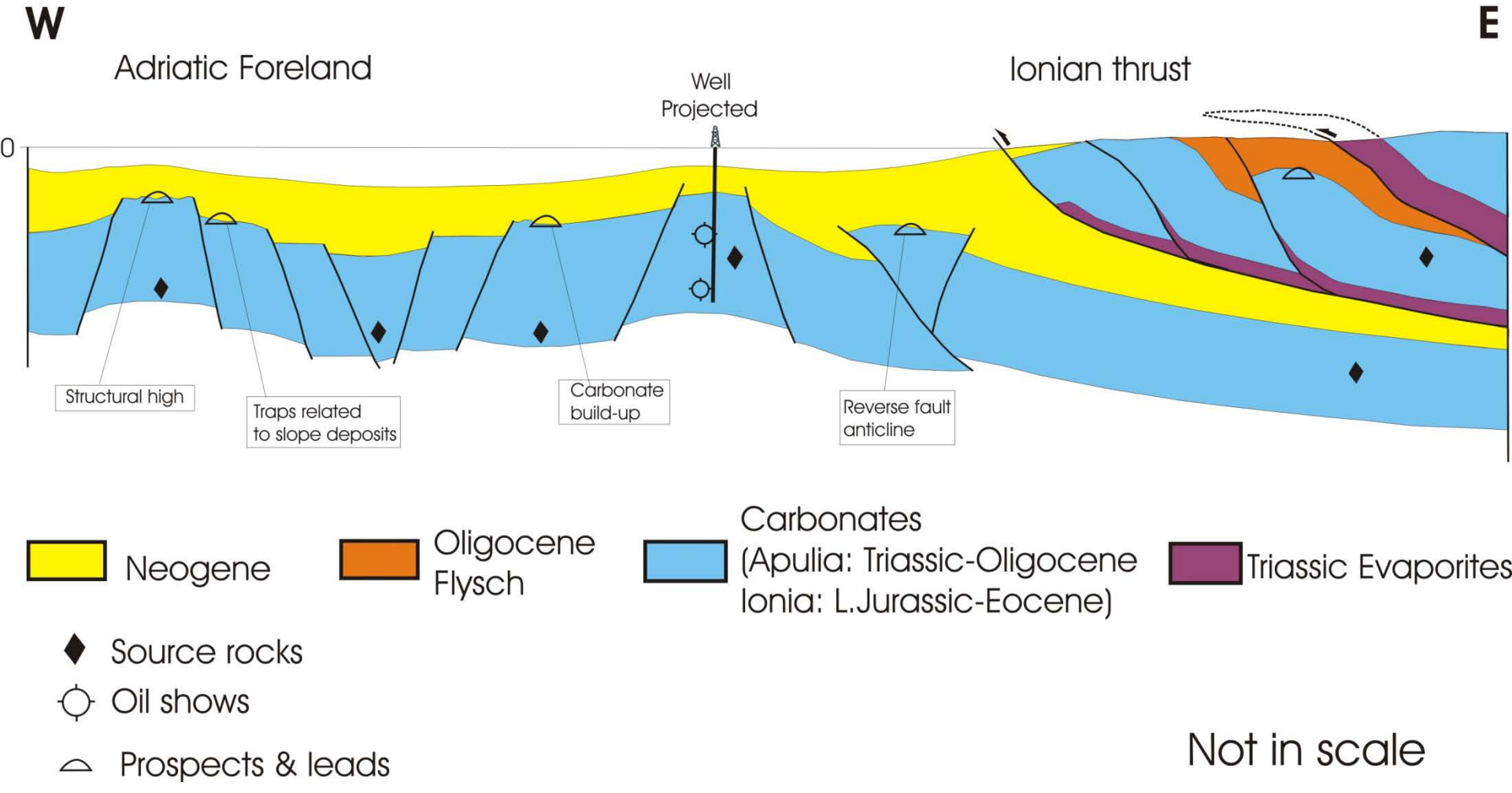
Traps

- Faulted anticlines and structures
- Eroded Paleo-highs (W. Katakolon)
- Traps related with diapiric structures
- Hanging wall and footwall anticlines
- Sub thrusts and Sub-evaporite traps
- Structures related to strike slip faults
- Reefs

SW GREECE H/C PLAYS



North Ionian Sea: Potential Plays



Timing of oil generation and migration

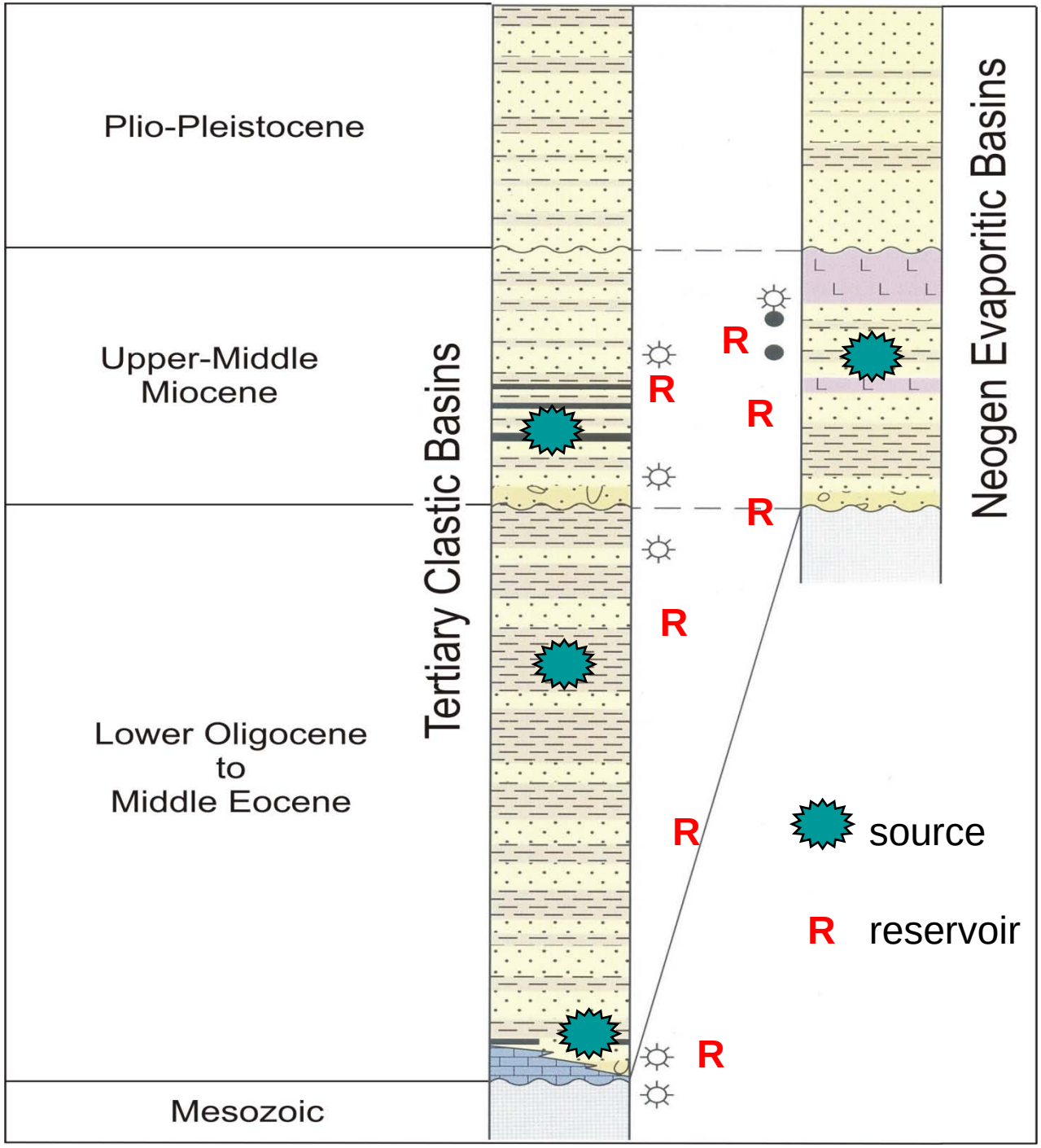
It should be mentioned that most of the oil generation took place after the main tectonic events of lower Miocene for the Ionian and early Pliocene for the Preapulian and there by after the set up of structures

EASTERN GREECE

TERTIARY BASINS

PETROLEUM SYSTEMS

Stratigraphy & source and reservoir Rocks Position of Eastern Tertiary Basins

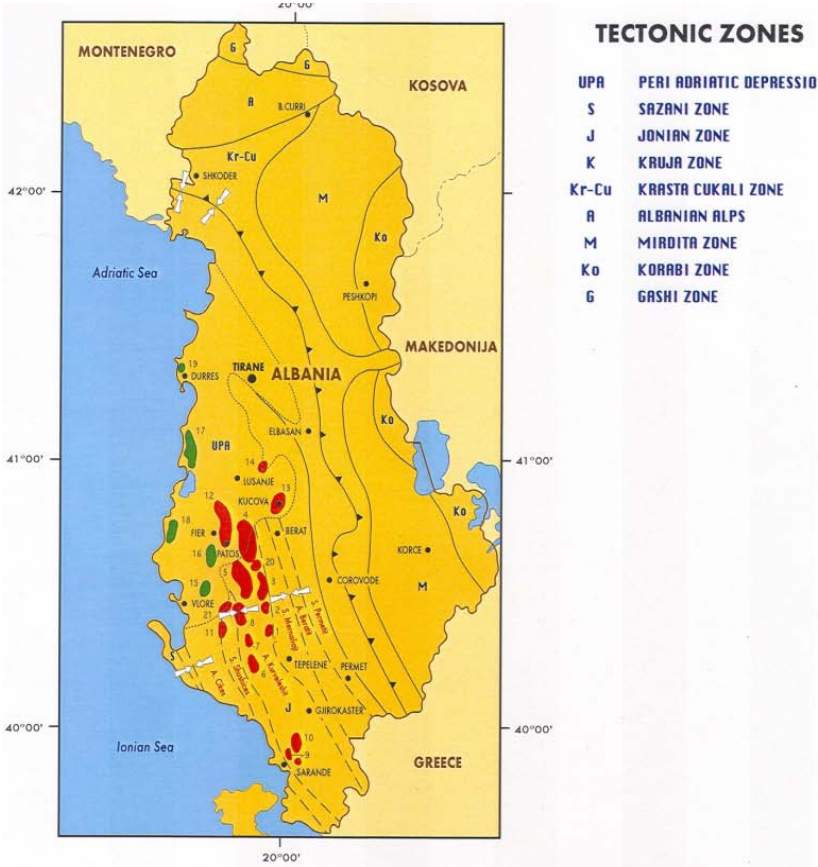


Analogs in…

Albania and Italy, Croatia and Montenegro

HYDROCARBON OCCURRENCES IN ALBANIA (OIL & GAS FIELDS)

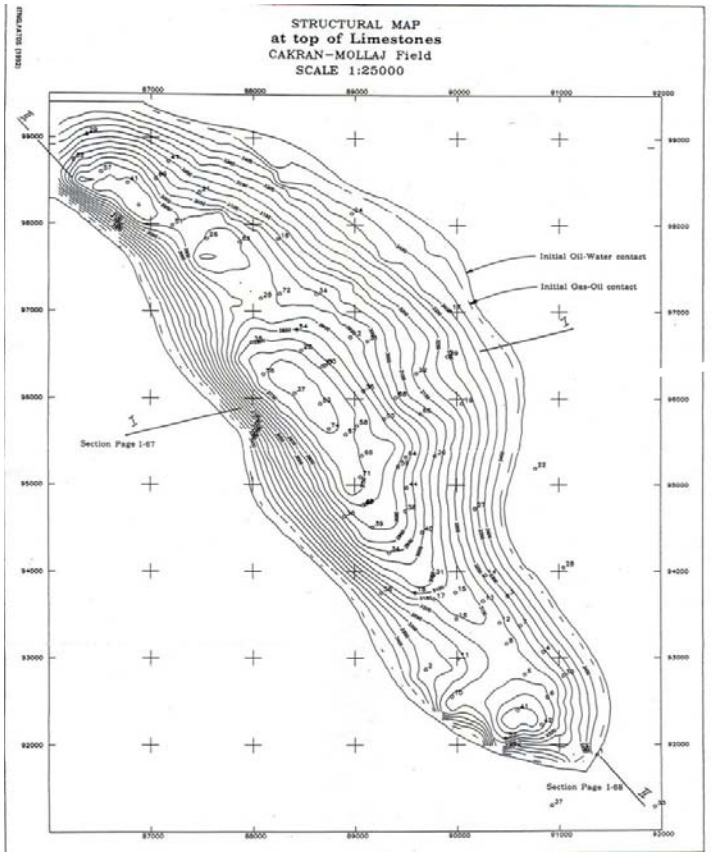
OIL/GAS FIELD	DISCOV. YEAR	RESERVOIR TYPE
Drashovica	1918	Pg3-flysch
Patosi	1927	N13-Sandst
Kucova	1928	N13-Sandst
Marinza	1957	N13-Sands
Visoka	1963	Cr-Pg2-limst
Gor-Kocul	1965	J2-Pg2-lims
Ba-Hekal	1966	Cr-Pg2-limst
C-Mollaj	1977	Cr-Pg2-limst
Finiq-Krane	1973	Cr-Pg2-limst
Delvina	1987	Cr-Pg2-limst
Divjaka	1963	N13t-Sandst
B-Kryev	1983	N2pl-Sandst
Frakulla	1965	N13-sandst
Povelca	1987	N13-sandst
Panaja	1988	N13-sandst
Durresi	1986	N13-sandst
Adriatik-4	1994	N13-sandst
Shpiragu	2001	Cr-Pg2-limst



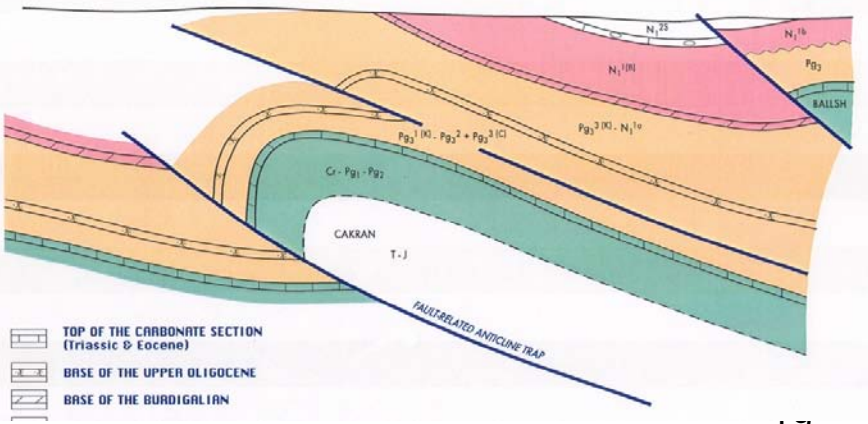
HYDROCARBON OCCURRENCES IN ALBANIA
(OIL & GAS FIELDS)

CAKANI OIL FIELD

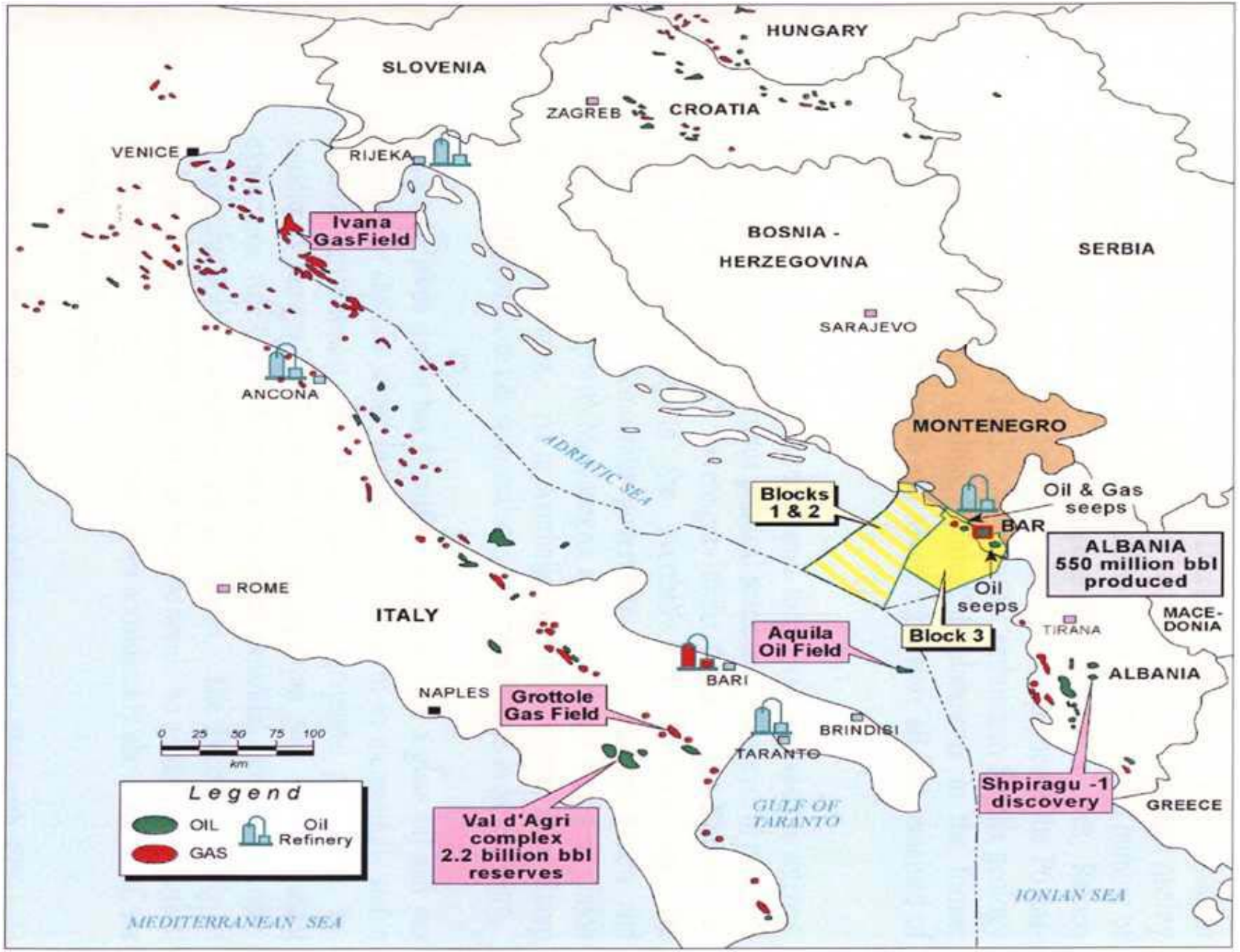
6 km West of Ballshi town

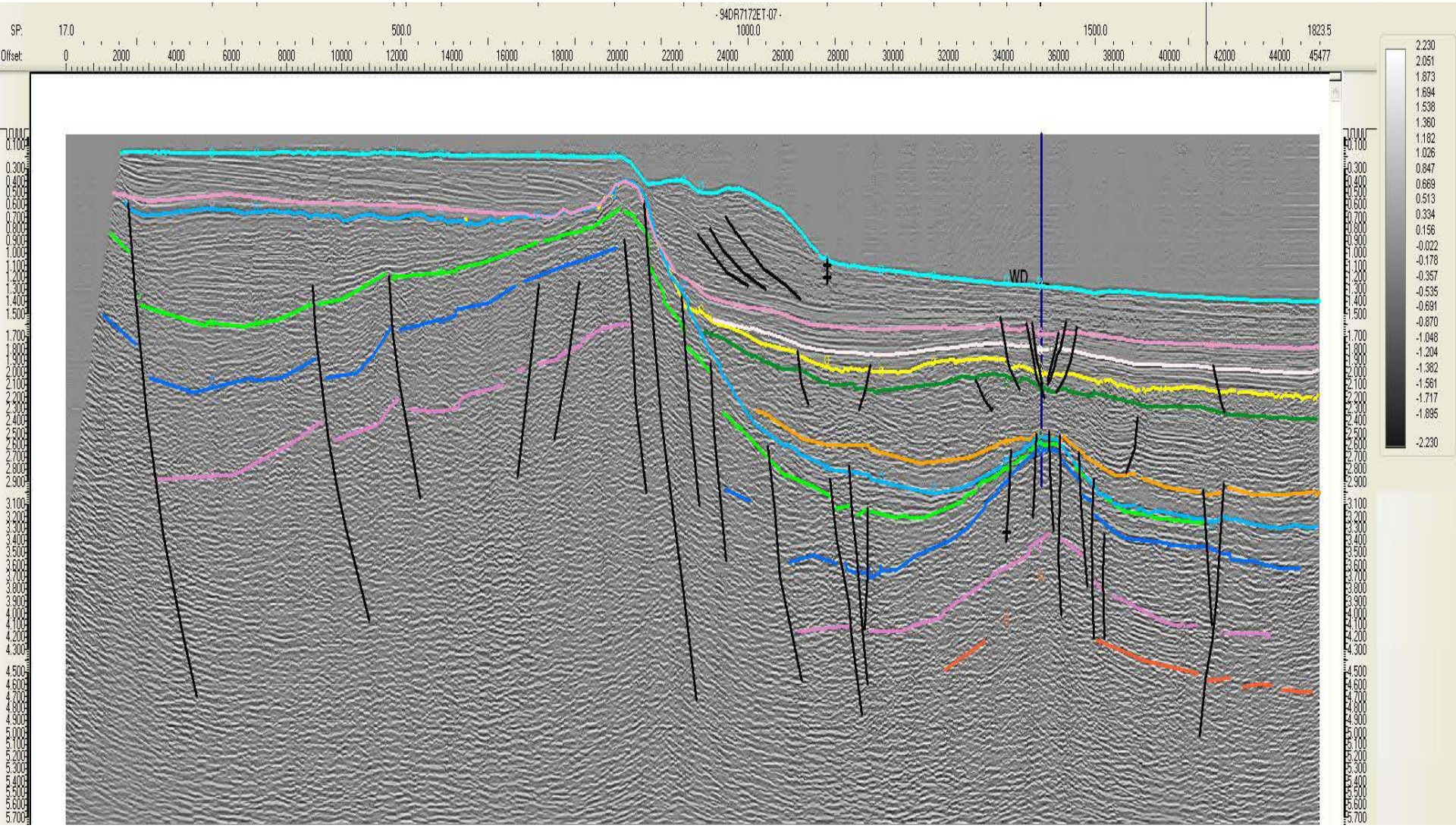


Schematic Geological Cross-Section of Cakran Oil Field



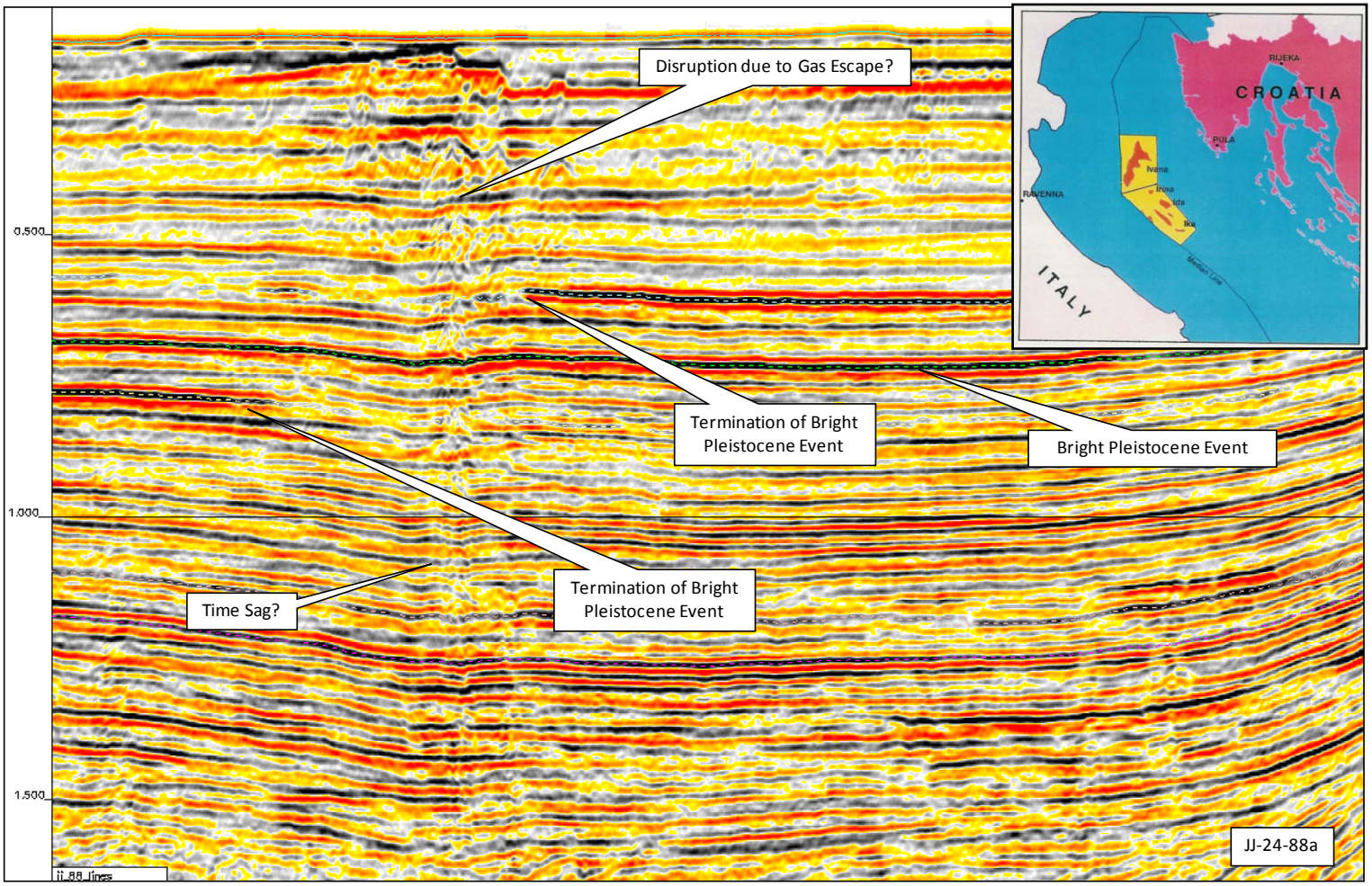
H/C Discoveries in Italy, Albania and Croatia



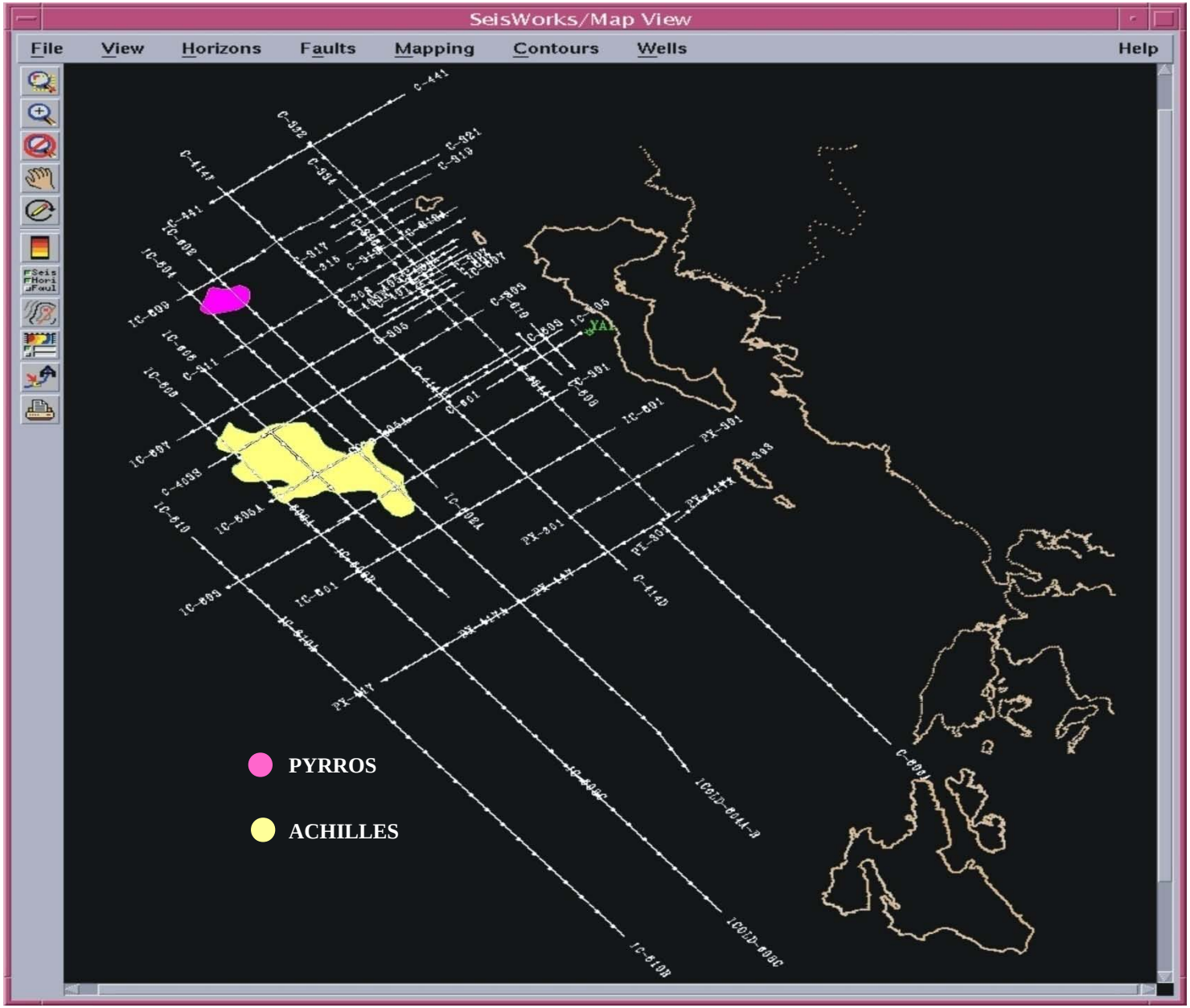


Rovesti-1 -Discovery

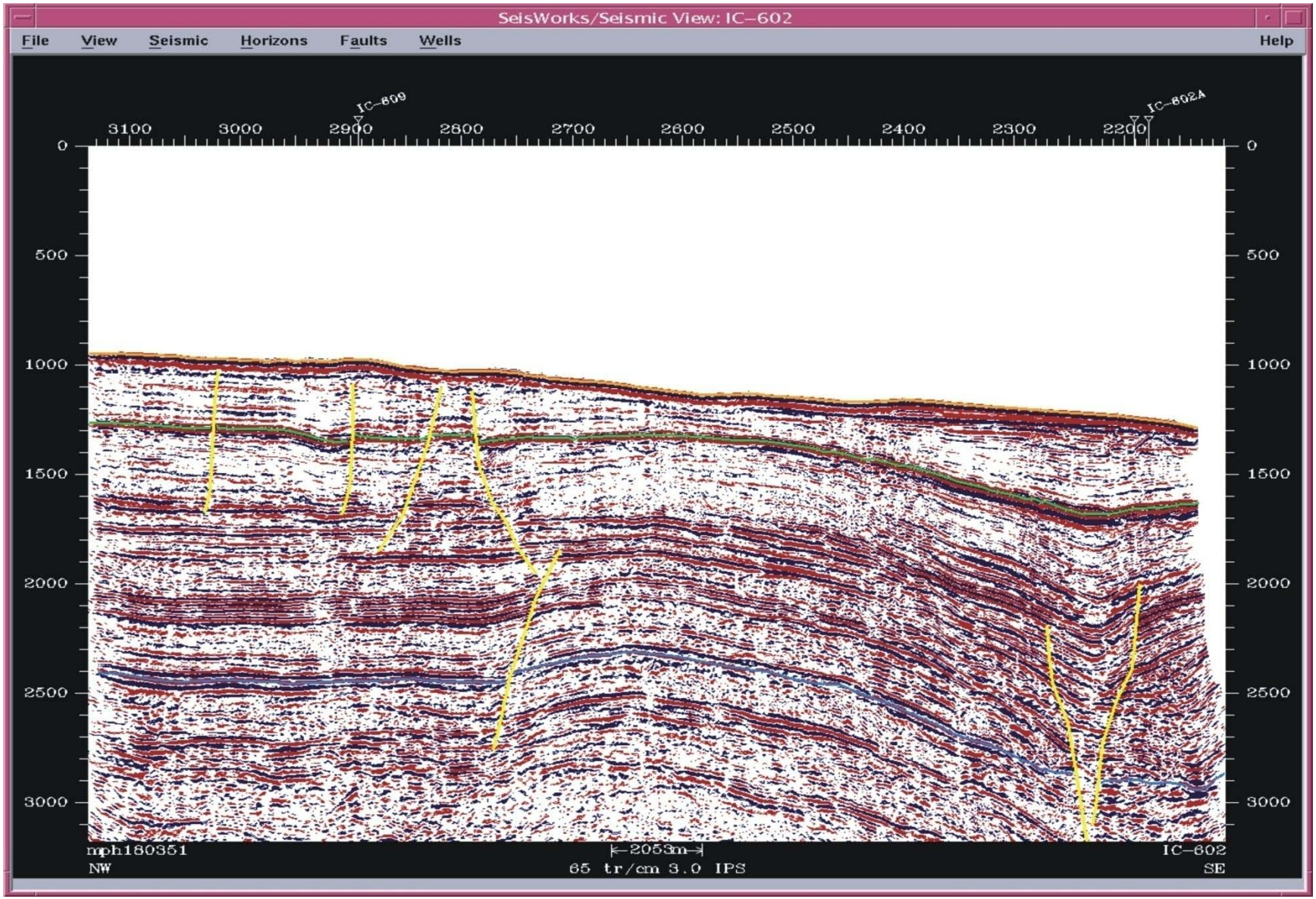
Ivana Field, Croatia



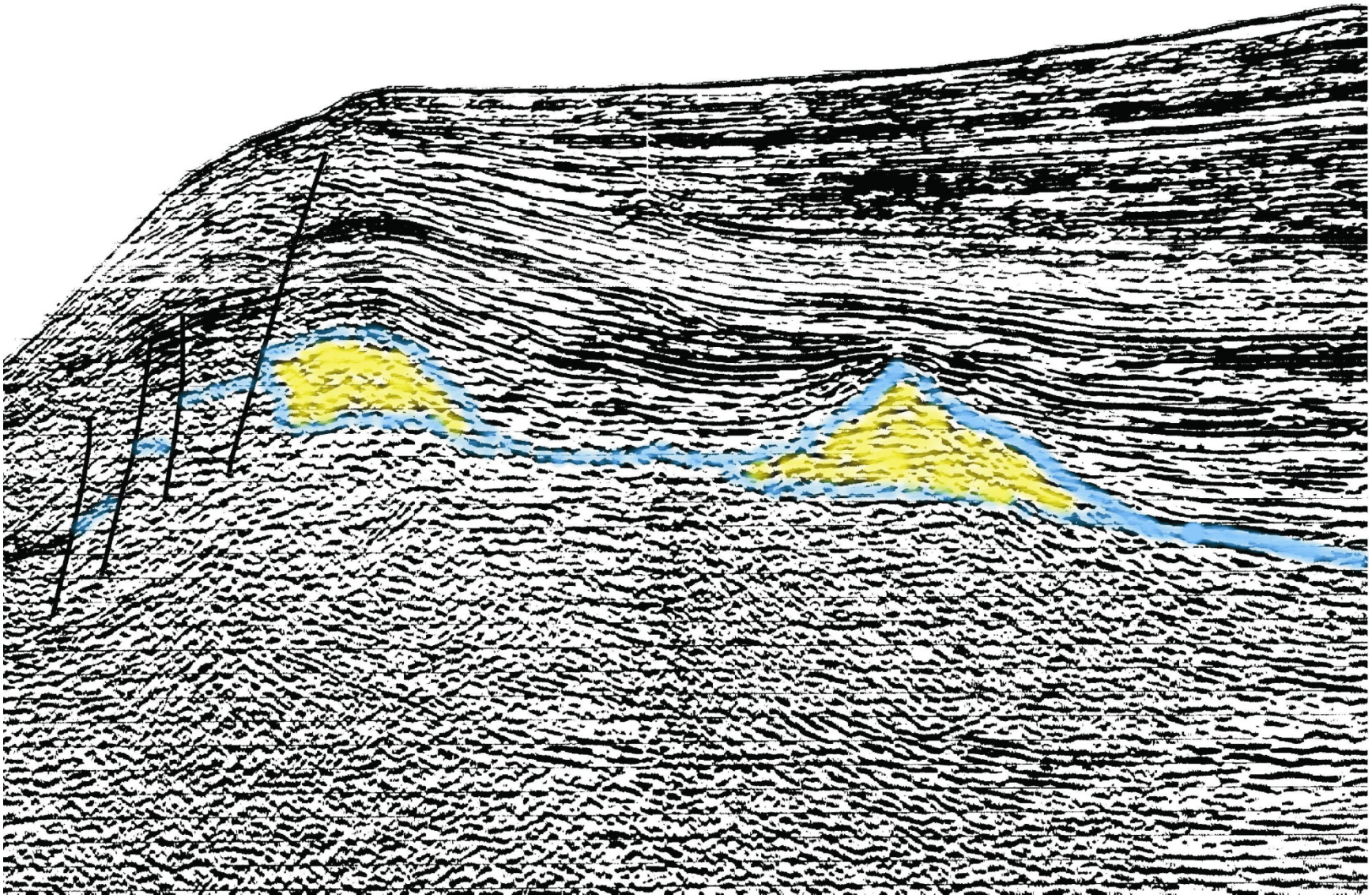
Prospects

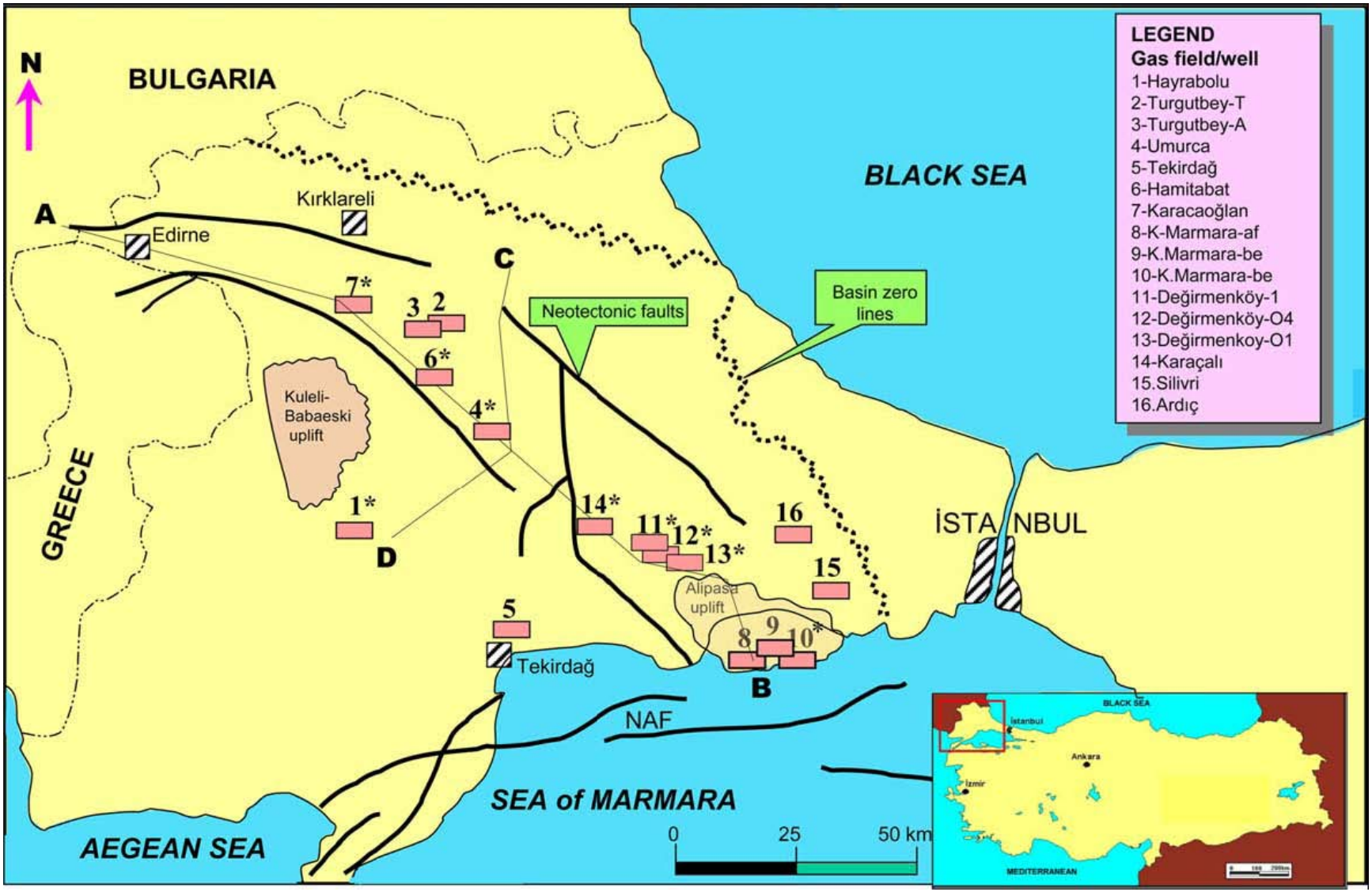

SeisWorks/Map View
File
View
Horizons
Faults
Mapping
Contours
Wells
Help
PYRROS
ACHILLES

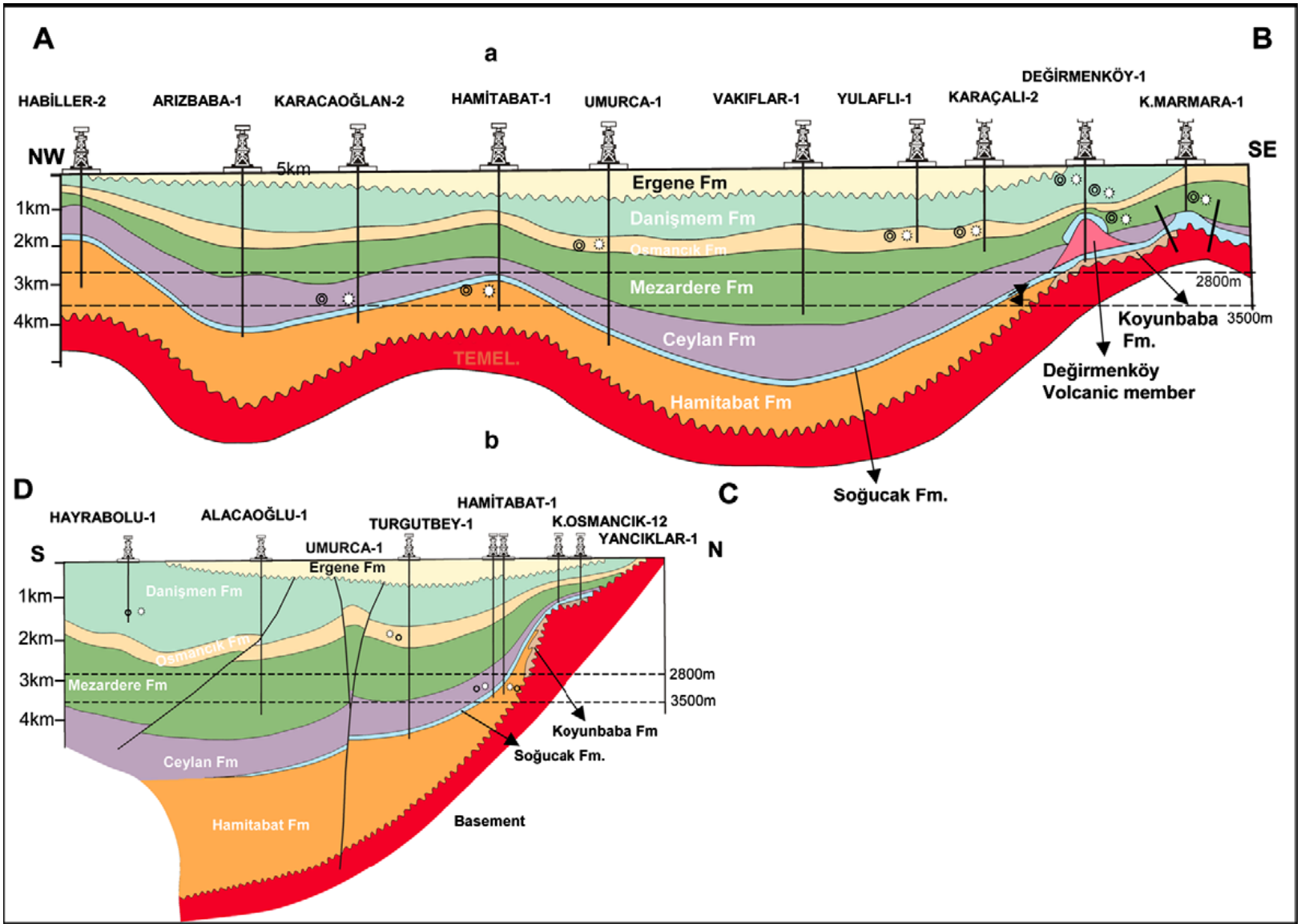
Faullted Block (possible “paleo-high”)
N-S directed seismic line



West Lefkas - Reefal build-ups




N
BULGARIA
BLACK SEA
GREECE
AEGEAN SEA
SEA of MARMARA
İSTANBUL
Kırklareli
Edirne
Tekirdağ
A
B
C
D
NAF
Neotectonic faults
Basin zero lines
Kuleli-Babaeski uplift
Alipaşa uplift
7*
3
2
6*
4*
1*
14*
11*
12*
13*
16
15
5
8
9
10*
0
25
50 km
LEGEND
Gas field/well
1-Hayrabolu
2-Turgutbey-T
3-Turgutbey-A
4-Umurca
5-Tekirdağ
6-Hamitabat
7-Karacaoğlan
8-K-Marmara-af
9-K.Marmara-be
10-K.Marmara-be
11-Değirmenköy-1
12-Değirmenköy-O4
13-Değirmenkoy-O1
14-Karaçalı
15.Silivri
16.Ardıç
BLACK SEA
İstanbul
Ankara
İzmir
MEDITERRANEAN


A
a
B
HABİLLER-2
ARIZBABA-1
KARACAOĞLAN-2
HAMİTABAT-1
UMURCA-1
VAKIFLAR-1
YULAFLI-1
KARAÇALI-2
DEĞİRMENKÖY-1
K.MARMARA-1
NW
SE
5km
1km
2km
3km
4km
Ergene Fm
Danişmem Fm
Osmancık Fm
Mezardere Fm
Ceylan Fm
TEMEL.
Hamitabat Fm
2800m
3500m
Koyunbaba Fm.
Değirmenköy Volcanic member
b
C
Soğucak Fm.
D
HAYRABOLU-1
ALACAOĞLU-1
TURGUTBEY-1
HAMİTABAT-1
K.OSMANCIK-12
YANCIKLAR-1
UMURCA-1
S
N
Ergene Fm
Danişmen Fm
Osmancık Fm
Mezardere Fm
Ceylan Fm
Hamitabat Fm
2800m
3500m
Koyunbaba Fm
Soğucak Fm.
Basement

HELLAS E&P

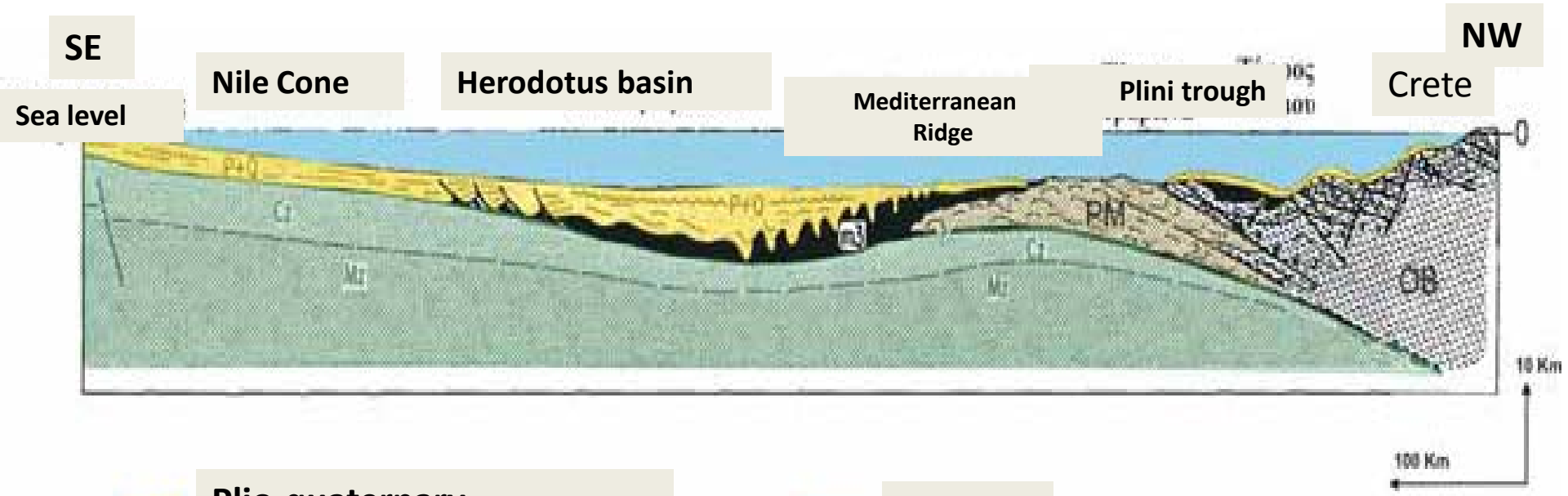
HYDROCARBON

SHOWS

Loutra Kyllinis

South Crete
Deep offshore areas

Geological Cross Section CRETE-NORTH EGYPT (Nile Cone)
Herodotus and Plinios Basins



P+Q — Plio-quaternary

PM — Messinean evaporites

Pre Messinian sediments

Sea

OB — Orogenic Zone

C M — African Platform

GREEK

H/C

DISCOVERIES

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

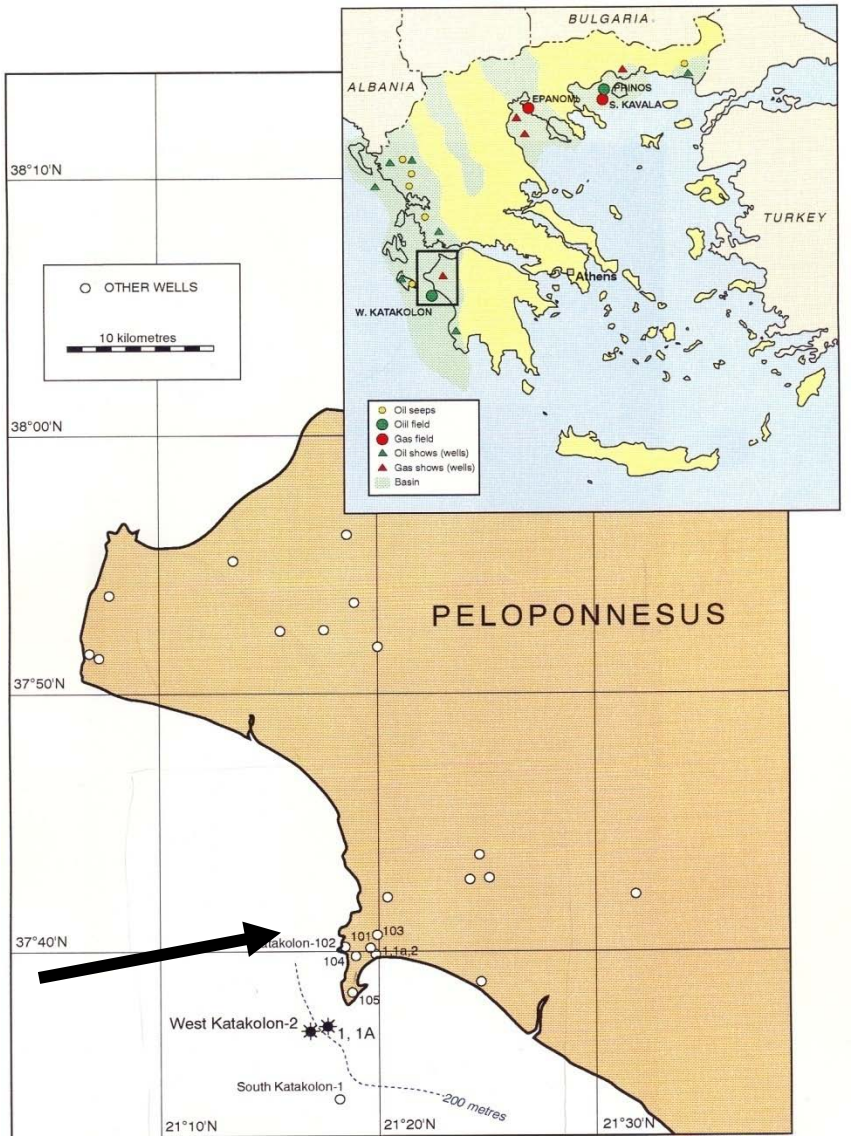
- **WEST KATAKOLON (oil field)- Ionian Sea**

- **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**
- **11 working petroleum systems Offshore and Onshore**

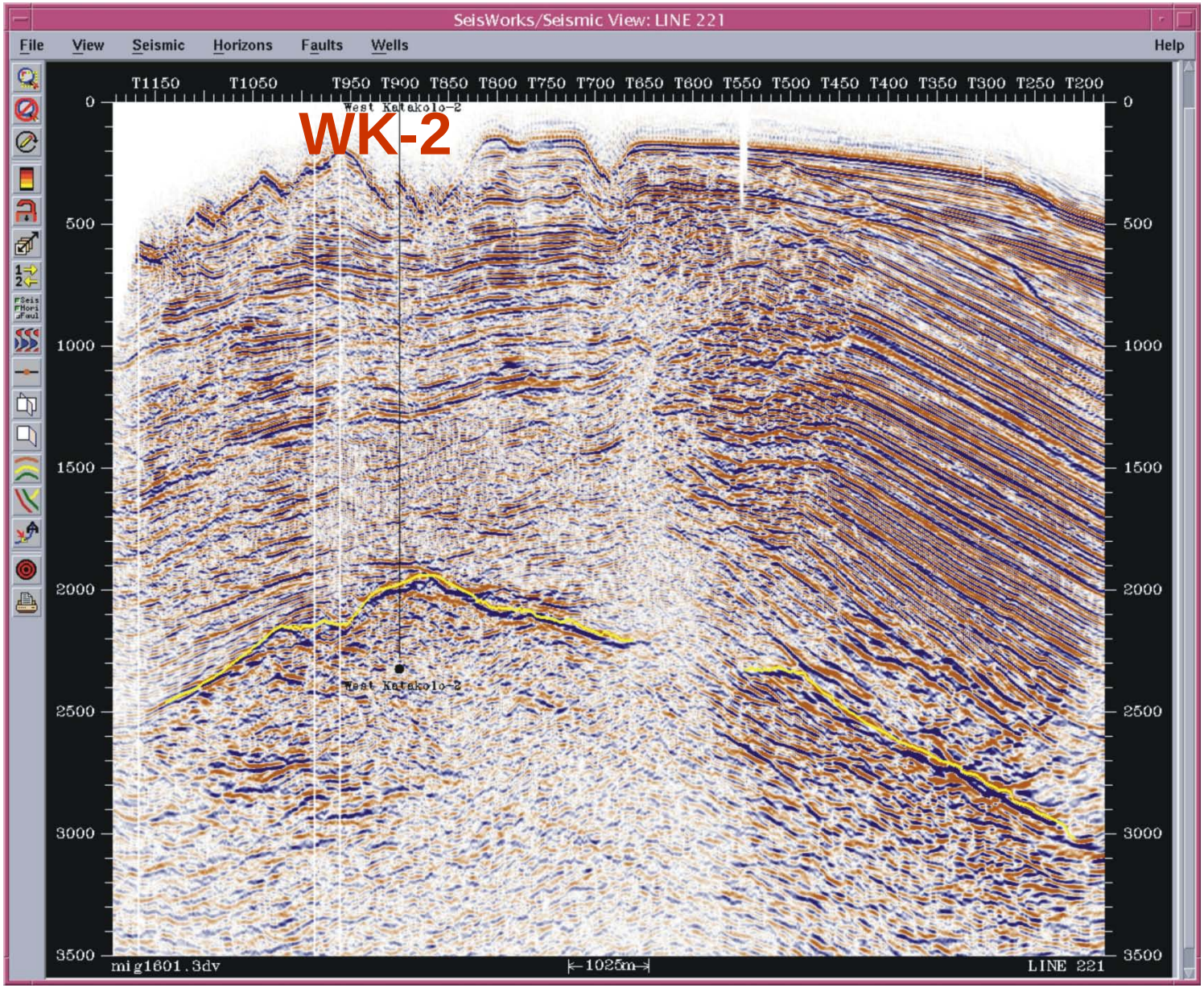
OFFSHORE WEST KATAKOLON FIELD

AS A KEY CASE



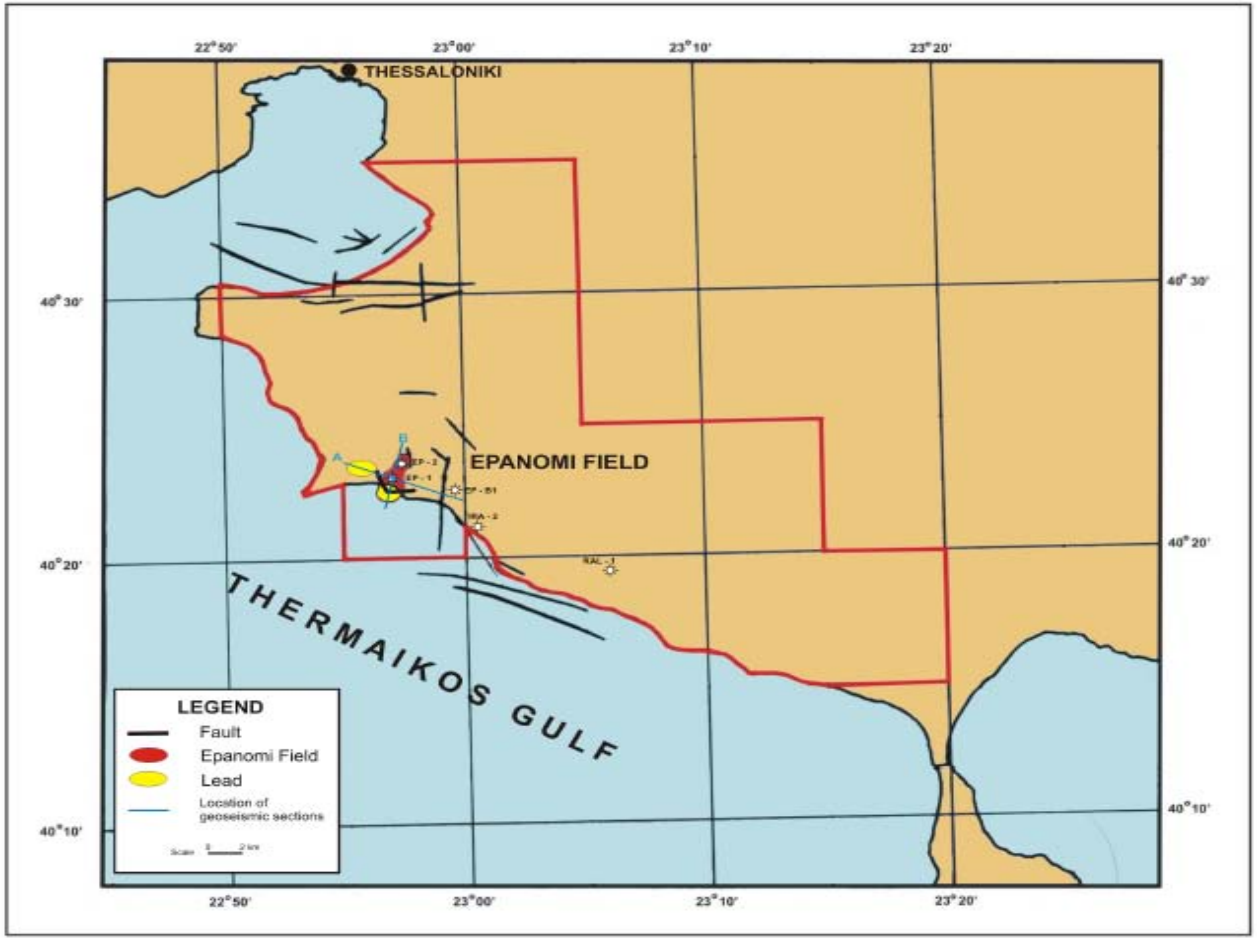
WEST KATAKOLO BASIC CHARACTERISTICS

- Two wells and one deviated well from the first one
- Gas flow from two intervals, 11-12 million cubic feet/day from each one
- Oil flow in WKA-2 well, 1000-1500 barrels/day
- Reservoir depth: 2400-2600 m
- Sea depth: 200-350 m
- Small distance from the nearest shore



Seismic Line 221

Epanomi Gas discovery



EPANOMI GAS FIELD
BASIC CHARACTERISTICS

- ✓Recoverable reserves: 450 million m^3 of Gas
- ✓Gas flow 16 million cubic feet/day
- ✓Small distance from natural gas pipeline
- ✓Small distance from Thessaloniki
- ✓Some more leads in the neighborhood area

EPANOMI STRUCTURE & PRODUCTION TEST