FOUNDATION FOR RESEARCH AND TECHNOLOGY – HELLAS
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ΕΠΙΣΤΗΜΟΝΙΚΗ ΗΜΕΡΙΔΑ
25.10
ΟΙ ΥΔΡΟΓΟΝΑΝΘΡΑΚΕΣ ΣΤΗΝ ΕΝΕΡΓΕΙΑΚΗ ΜΕΤΑΒΑΣΗ
ΔΕΔΟΜΕΝΑ ΚΑΙ ΠΟΛΙΤΙΚΕΣ

ΤΟ ΔΥΝΑΜΙΚΟ ΥΔΡΟΓΟΝΑΝΘΡΑΚΩΝ ΤΗΣ ΕΛΛΑΔΑΣ, ΜΕ ΕΜΦΑΣΗ ΣΤΟ ΑΕΡΙΟ ΩΣ ΤΟ ΚΥΡΙΟ ΚΑΥΣΙΜΟ ΤΗΣ ΕΝΕΡΓΕΙΑΚΗΣ ΜΕΤΑΒΑΣΗΣ

The hydrocarbon potential of Greece, focusing on Gas as the main fuel of the energy transition

Dr. Spyros Bellas,

Principal Researcher at IPR/FORTH

ΧΑΝΙΑ, ΑΙΘΟΥΣΑ ΚΑΜ, 25 ΟΚΤΩΒΡΙΟΥ 2021

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PRESENTATION STRUCTURE

- Hydrocarbons, EU green goal and Greece
- The necessity of Gas
- Analogues in the wider region
- Hydrocarbons Potential > *in GREECE*
- GAS: Onshore & Offshore Greece
- What to expect? Catagenic *vs.* Biogenic
- Hydrocarbon shows (Wells)

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The Press just a few days ago!

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IENE ITE

OCTOBER 1 2021

FT Alphaville **Natural gas**

A natgas Cassandra speaks out

Continued commitment to a net zero carbon policy will drive energy poverty and a potential humanitarian crisis, industry insider warns.

Financial Times publishes letter by IENE Chairman on the fragility of Energy Transition Oct., 13th 2021

FINANCIAL TIMES

The Economist

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Finance & economics
Sep 25th 2021 edition ›

Boiling over

Natural-gas prices are spiking around the world

Unusual weather and supply outages are to blame

Ξεκινάει μάχη στην Ε.Ε. για την ενεργειακή κρίση

Οι προτάσεις Ελλάδας, Ισπανίας και Πολωνίας για την αντιμετώπιση του

Oil

Oil prices rise above $80 a barrel for first time in three years

Coal and European gas prices rally to record peaks as traders brace themselves for winter crunch

FINANCIAL TIMES

HOME WORLD US COMPANIES TECH MARKETS CLIMATE OPINION WORK & CAREERS LIFE & ARTS HOW TO SPEND IT

Latest on Oil & Gas industry

Memo to countries going green: don't be like the UK

UK energy suppliers quoting deals more than £700 above price cap

Why oil producers won't stop the rally Premium

Oil & Gas industry + Add to myFT

Record gas prices hit bonds as investors fear wider damage

Cost of Europe's natural gas contracts soar 23%, prompting UK government gilt sell-off

ΟΙΚΟΝΟΜΙΚΗ

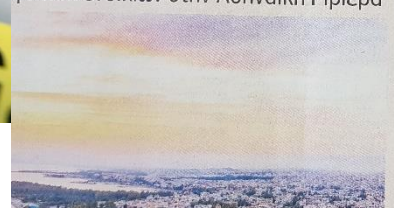
Η ΚΑΘΗΜΕΡΙΝΗ

ΑΘΗΝΑ, ΚΥΡΙΑΚΗ 24 ΟΚΤΩΒΡΙΟΥ 2021

ΣΗΜΕΡΙΝΗ ΜΕΡΑ
ΔΙΚΤΥΟΣ
ΔΙΑΙΤΗΣΗΣ
ΟΙΚΟΝΟΜΙΚΗ
ΑΡΧΗ ΤΗΣ ΕΚΤ

ΤΟ ΜΗΝΥΜΑ
Η εξέλιξη δείχνει το βαθύ ρήγμα μεταξύ ΕΚΤ και Bundesbank

Η ΕΛΛΑΔΑ
Η παροχή ρευστού προς τη χώρα μας μπορεί να γίνει πιο εύκολη



γείωση ενοικίων στην Αθηναϊκή Ριβιέρα

Το ράλι τιμών αναθερμαίνει το ενδιαφέρον για τα κοιτάσματα

Οικονομικό και γεωστρατηγικό όφελος του αερίου στα ελληνικά «οικόπεδα»

No 218| ΟΚΤΩΒΡΙΟΣ 2021

IENE INSTITUTE OF ENERGY FOR SOUTH-EAST EUROPE

ΔΕΛΤΙΟ ΕΝΕΡΓΕΙΑΚΗΣ ΑΝΑΛΥΣΗΣ

Περιεχόμενα

Dr. S. Bellas, Principal Researcher at IPR/FORTH

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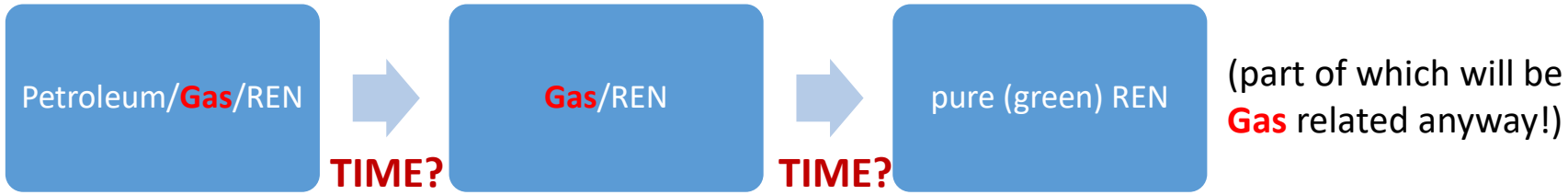
HYDROCARBONS, EU goal and GREECE

- The Energy Transition needs adequate TIME, no matter how well prepared is believed to be
- This holds for our case (Greece) as well as for Europe
- The real fact is that Greece energy sector depends by 78 to 80% on fossil fuels (2021), 98% of which is imported!
- How long will it take to decrease its dependence down to 50%? Is 2030 or even the 2050 a reliable and affordable time to achieve the EU's carbon free goal? And which will the consequences be?
- Anyway, a (viable) desirable transition will have to go through an energy mix differentiation:



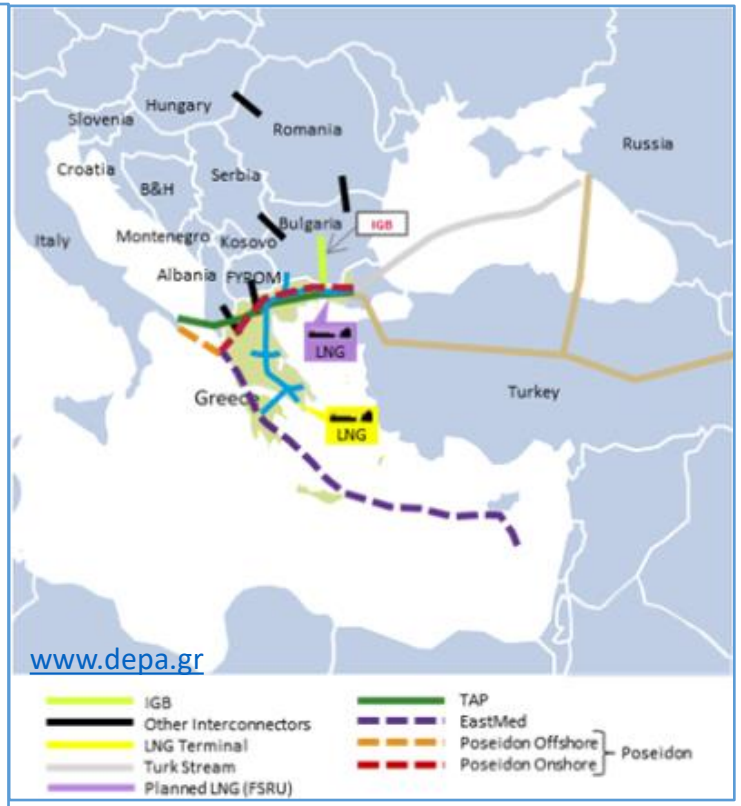
- **Therefore, in a realistic way we should proceed with H/C Exploration, focusing particularly on Gas**

REN: Renewable energy sources

Is there a real need for Gas?

A series of energy facts delivered by the EU strategy plan, including Greece, dictate the long-term prediction (decades) for the use of Natural Gas (N.G.)

1. **New Investments of Ship-owners in LNG carriers**
2. **Development of existed and future LNG Stations**
    1. *Increase the Capacity of Revythoussa (Isl.)*
    2. *FSRU Alexandroupolis (Port)*
    3. *FSRU Volos (Port) + CNG*
    4. *Corinth LNG Station*
3. **Pipeline Construction**
    1. *NORD STREAM 2*
    2. *TAP + interconnections*
    3. *IGB + Gas Distribution Network Expansion*
4. **South Kavala Underground N.G. Storage**
5. **EU – looking for new Geo-Storage locations**
6. **Geostrategic-geopolitic status**



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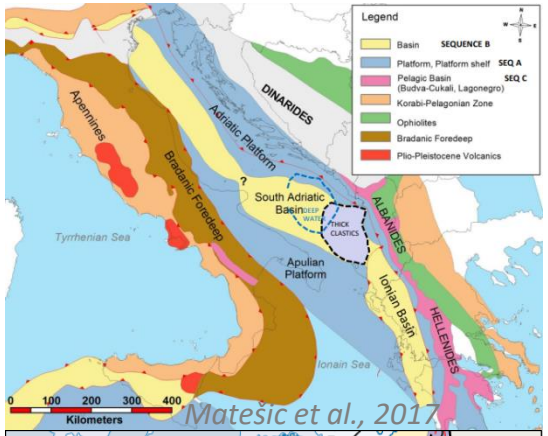
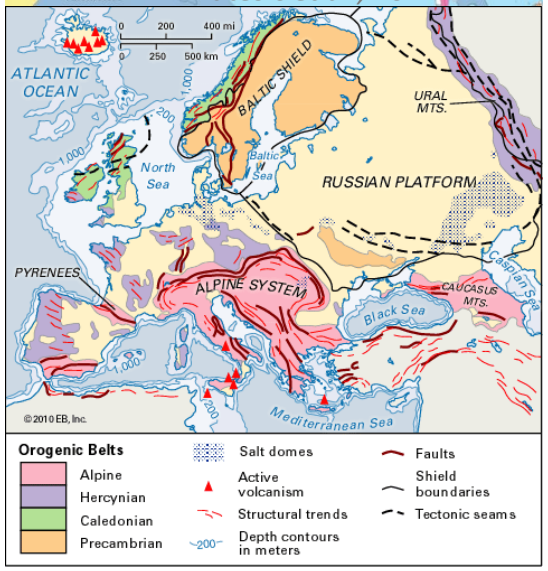
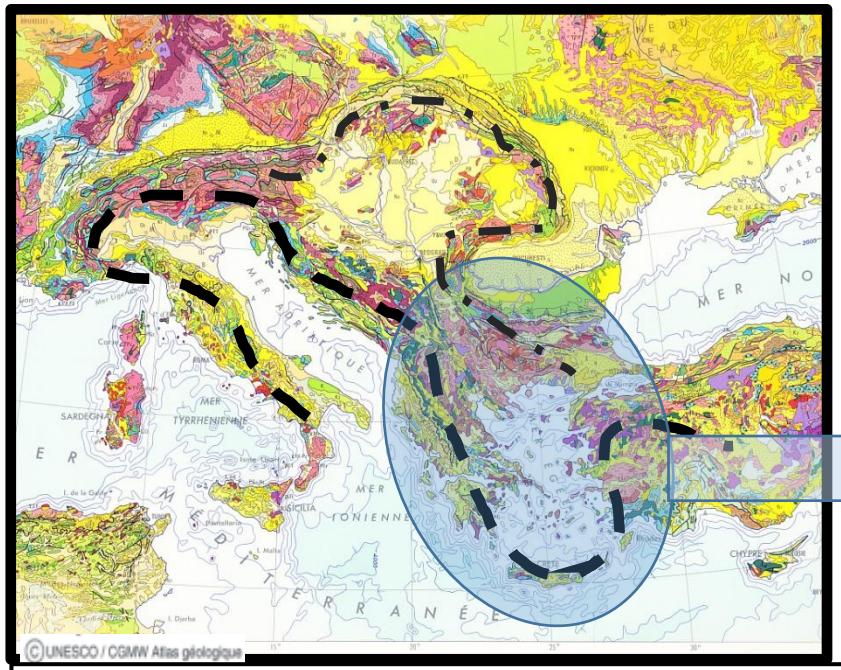
WHAT IS THE GEOLOGY BEHIND HYDROCARBON ENERGY RESOURCES?

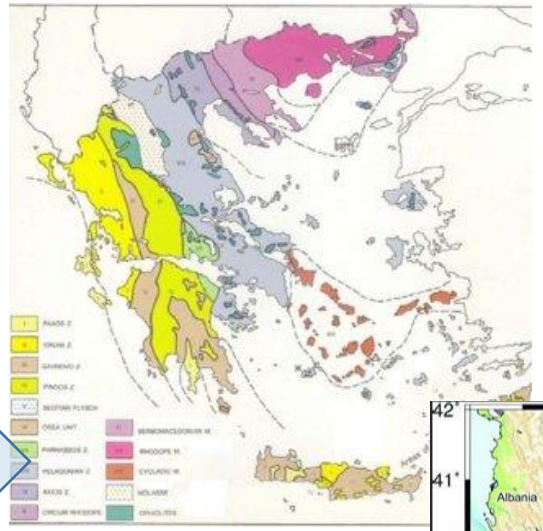
Hellenides, the Fold and Thrust Belt (FTB) sector of the Alpine FTB

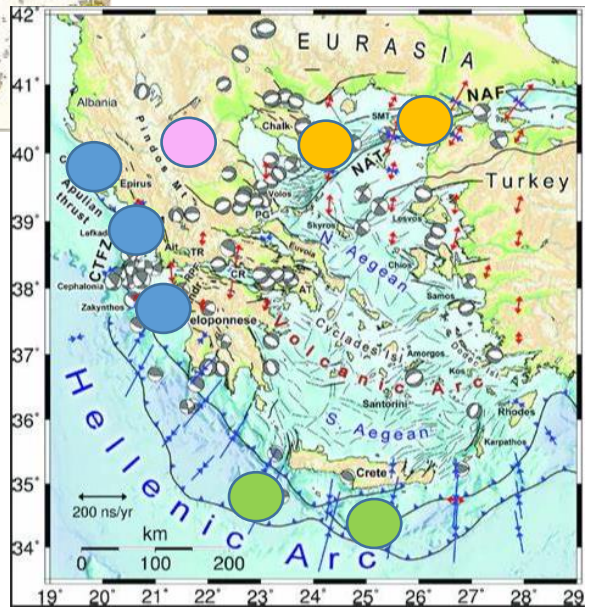


Matesic et al., 2017









- FTB & CTF affects the western part of Greece
- NAF/NAT the north-eastern part,
- Strike-slip/Piggy-back Basin the N.–Central GR
- Active Plate tectonics - the southern part

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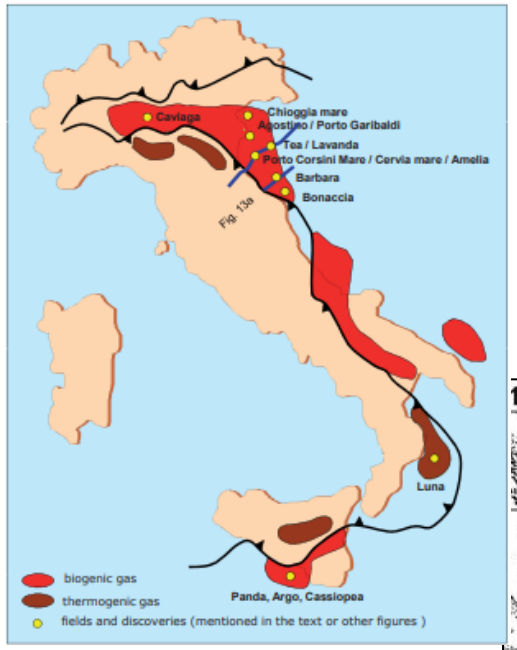
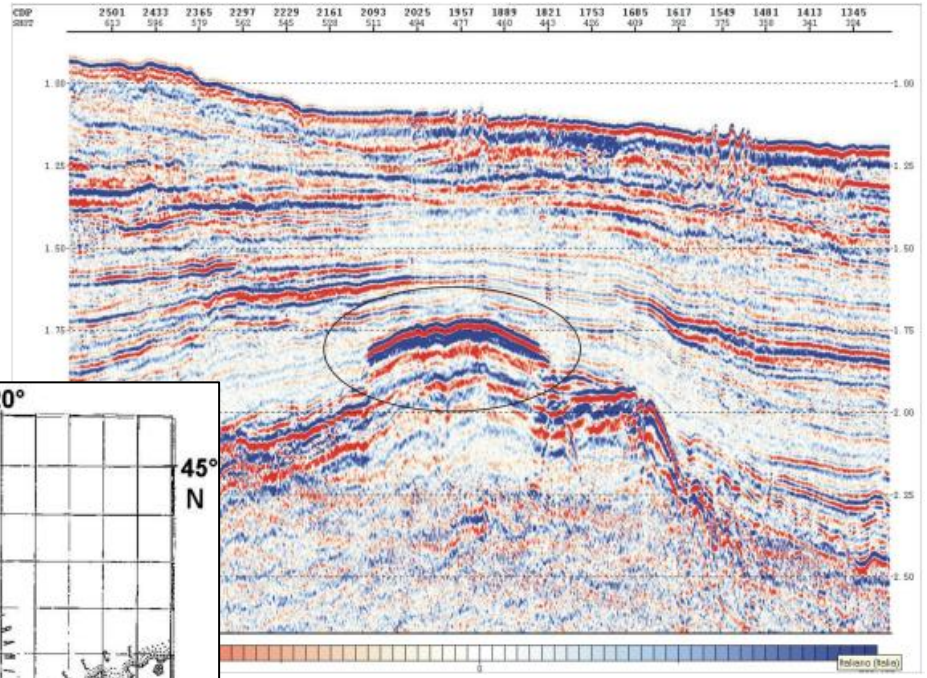
(Offshore-) Gas Analogues, S. Adriatic/N. Ionian

Looking for what?

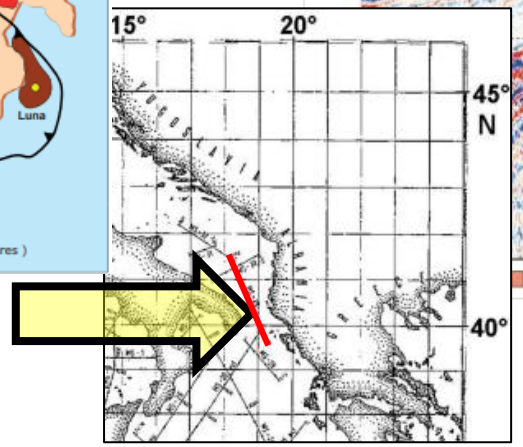


Gazzini et al. (2015)

MS-29 Offshore 2D line



Mocnik, 2008; Del Ben et al. (2010)



- Bright Spot, Otranto channel
- North of Corfu Island
- Plio-Quaternary deposits (gas saturated)
- Located between Italy and Albania, NW of Greece

The Plio-Pleistocene biogenic gas system is considered one of the two main proved petroleum systems in the Adriatic (Matešic et al., 2017)

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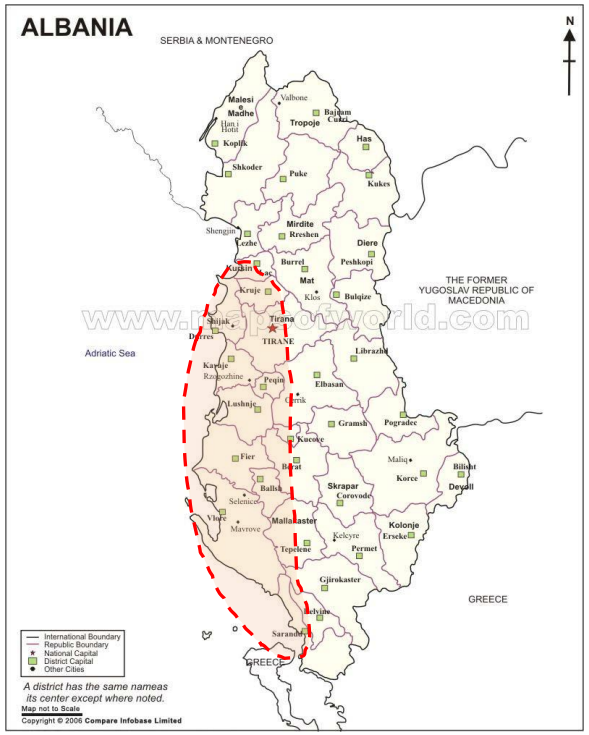
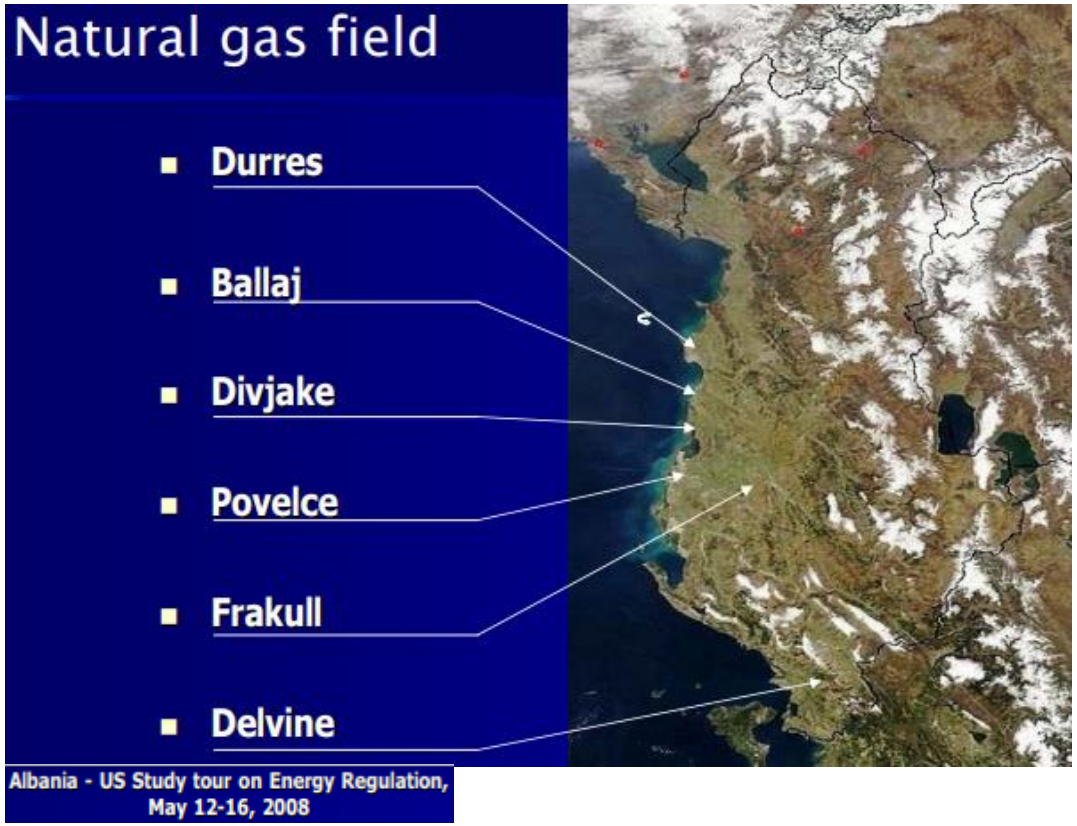
Just have a look around…

(Onshore-) Gas Analogues, Albania





- 1968: Divjaka gas field first production
- About 20 natural gas wells
- Production of ca. 12 Mcm/yr (previously 70 Mcm/yr)
- Cumulative production ≥ 3.3 Bcm
- All fields developed within the Ionian zone!

(Nepravishta, 2008)

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GR's Hydrocarbons Potential: The Gas

In the sedimentary basins of Greece hydrocarbon gases are distinguished in five categories:

- Surface gas seeps (i.e. in Epirus, Kyllini, Patraikos-Amvrakikos Gulf, etc.)
- Subsea mud volcano gas seeps (Ionian GT zone & south of Crete)
- Shallow water-well gas shows (i.e. in Zakynthos, Grevena, Crete, Argolis, etc.)
- O&G Exploration well gases in exploration wells
- Pure hydrocarbon gas fields (i.e. Epanomi, South Kavala, etc.).

The W. and SW. parts of Greece are the main areas in which methane & higher H/C degas (Daskalopoulou et al., 2019)

geo-chemo-classification/per occurrence

- **Biogenic** gases (*i.e. Katakolo onshore gas-field & shallow exploration well gases*).
- **Catagenetic** (*i.e. offshore Katakolo oil field gases, Epanomi and South Kavala gas fields & deep exploration well gases)*
- **Metagenetic** gases (i.e. *Delta of Evros river & West Thermaikos Gulf, NE and N. Greece*).

H/C: Hydrocarbons
GT: Geotectonic

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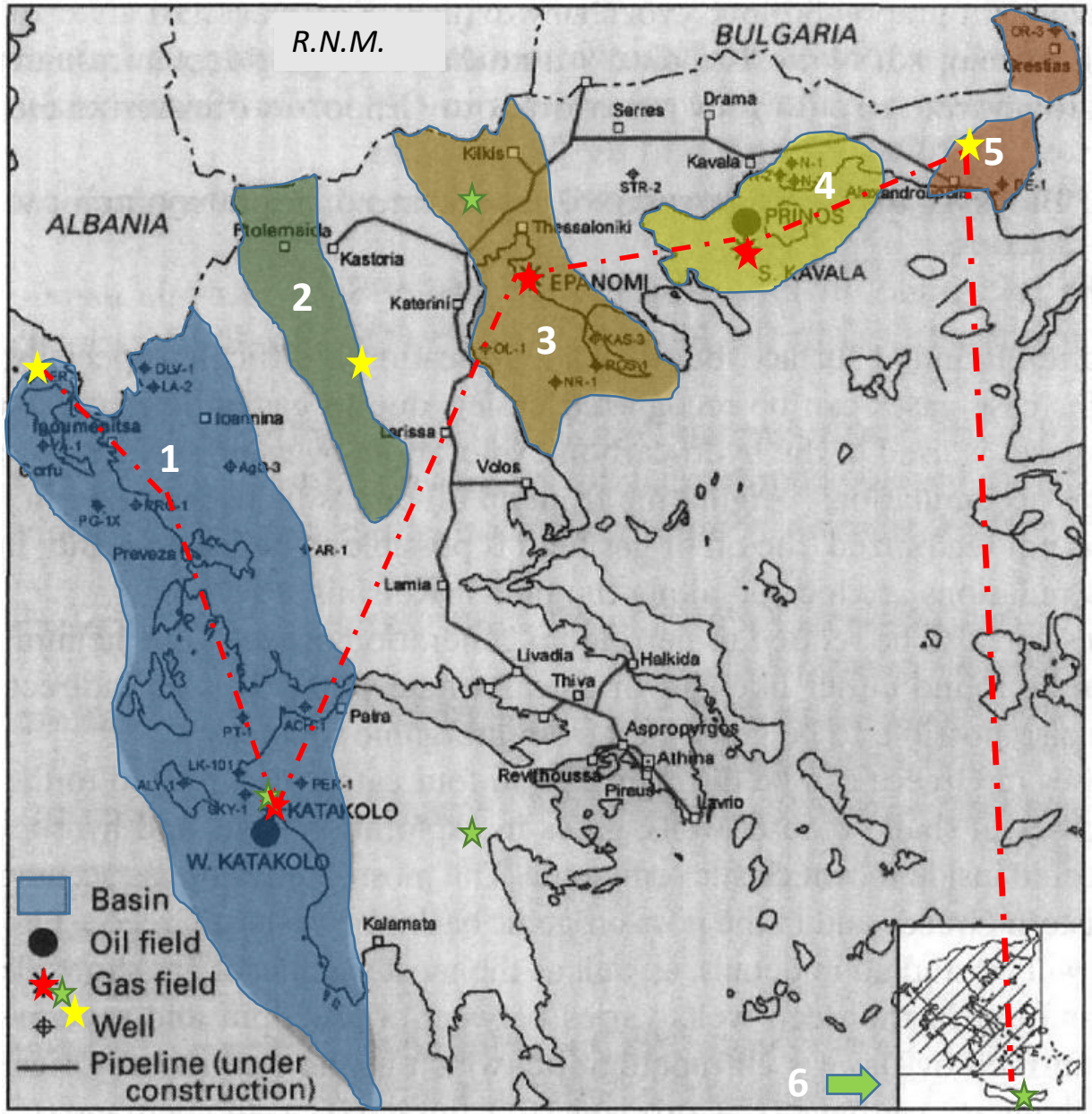
Where in Greece?

Main sedimentary basins of Greece with hydrocarbon potential relevant to Gas accumulations



Basins/Regions

1. Ionian (mostly Mesozoic)
2. Mesohellenic (Cenozoic, Eoc-Mioc)
3. Axios-Thermaikos, (Meso/Cenozoic)
4. Prinos (Neogene)
5. Thrace (W) (Cenozoic & *Mesozoic in Turkey*)
6. Crete (Cenozoic and ?)

modified after Rigakis *et al.*, 2001

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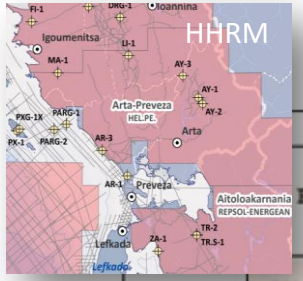
On- and Off-shore Cases with gas shows/accumulations, #wells #Ionian Zone of Greece



Ag. Georgios#3 well

AGE		FORMATION	SOURCE ROCKS	THICKNESS (m)
PERIOD	EPOCH			
QUATERNARY	HOLOCENE	DEBRIS		210
PALEOGENE	OLIGOCENE	FLYSCH A		840
				450
		FLYSCH B		460
	MIDDLE-UPPER EOCENE	EOCENE LIMESTONES		140
CRETACEOUS	LOWER EOCENE-UPPER SENONIAN	SENONIAN LIMESTONES		580
	TURONIAN-LOWER CRETACEOUS	VIGLA	✸	1280
JURASSIC	UPPER JURASSIC	POSIDONIA SHALES	✸	250
	LOWER JURASSIC	PANTOKRATOR		77+

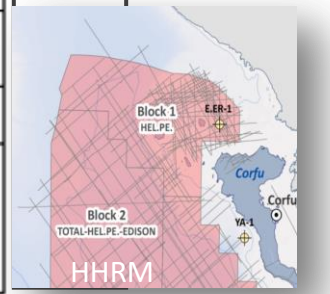
POST-RIFT; SYN - RIFT; PRE - RIFT

Gas ★ ★

E. Erikoussa#1 well

RIFT PHASE	AGE		FORMATION	SOURCE ROCKS	THICKNESS (m)
	PERIOD	EPOCH			
POST-RIFT	QUATERNARY	HOLOCENE	ALLUVIAL		69
	NEOGENE	PLIOCENE	LOWER PLIOCENE		440
		MIOCENE	MIOCENE		810
	PALEOGENE	OLIGOCENE	FLYSCH		390
		EOCENE	EOCENE LIMESTONES		220
	CRETACEOUS	UPPER CRETACEOUS	SENONIAN LIMESTONES		185
			VIGLA	✸	100
SYN - RIFT	JURASSIC	LOWER JURRASIC	SINIAIS - PANTOKRATOR		107+
PRE - RIFT					

Gas ★



NW Peloponnesus Case; On- and Off-shore wells & seeps

Katakolo map & cross section

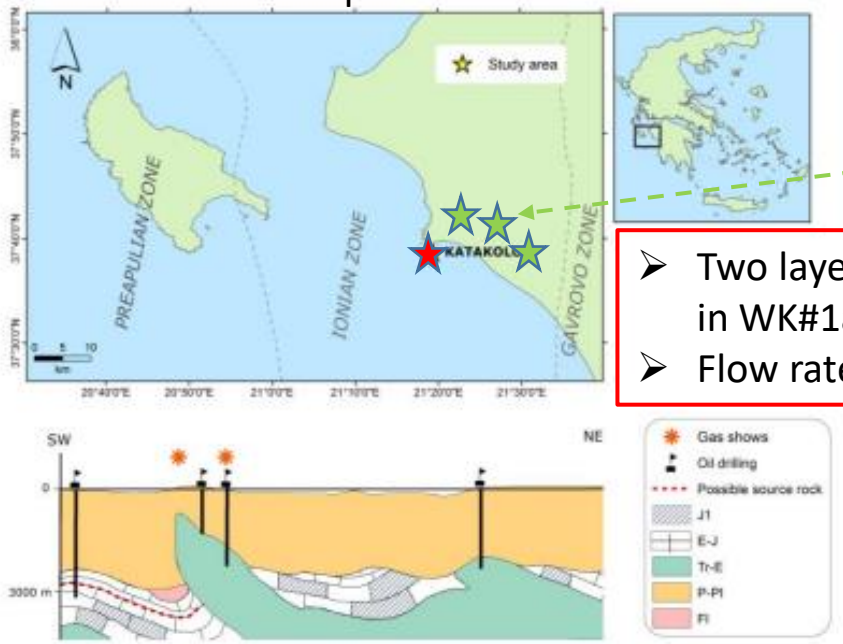
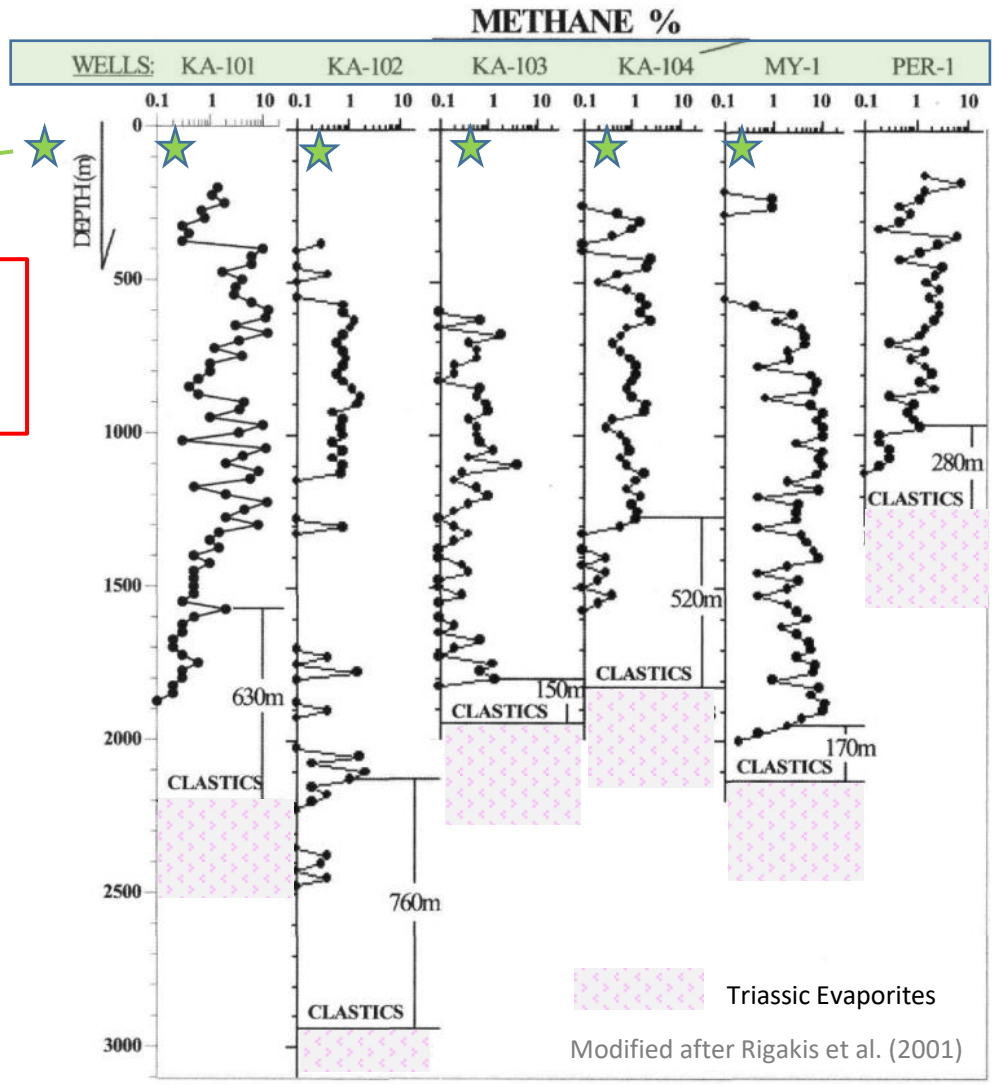


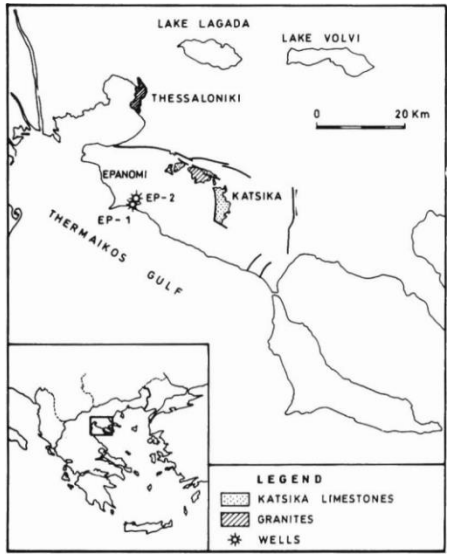
Fig. 3.3 (a) General map showing the location of Katakolo, one of the study areas and the three external tectonostratigraphic zones of the Hellenides fold-and-thrust belt; (b) Simplified cross section showing the structural evolution of Neogene basins (modified from Nikolaou, 2001), Key: P-PL: Pliopleistocene; Fl: Flysch; J1: Lias; Tr-E: Triassic; E-J: Eocene- Upper Jurasic. Kordella (2021)

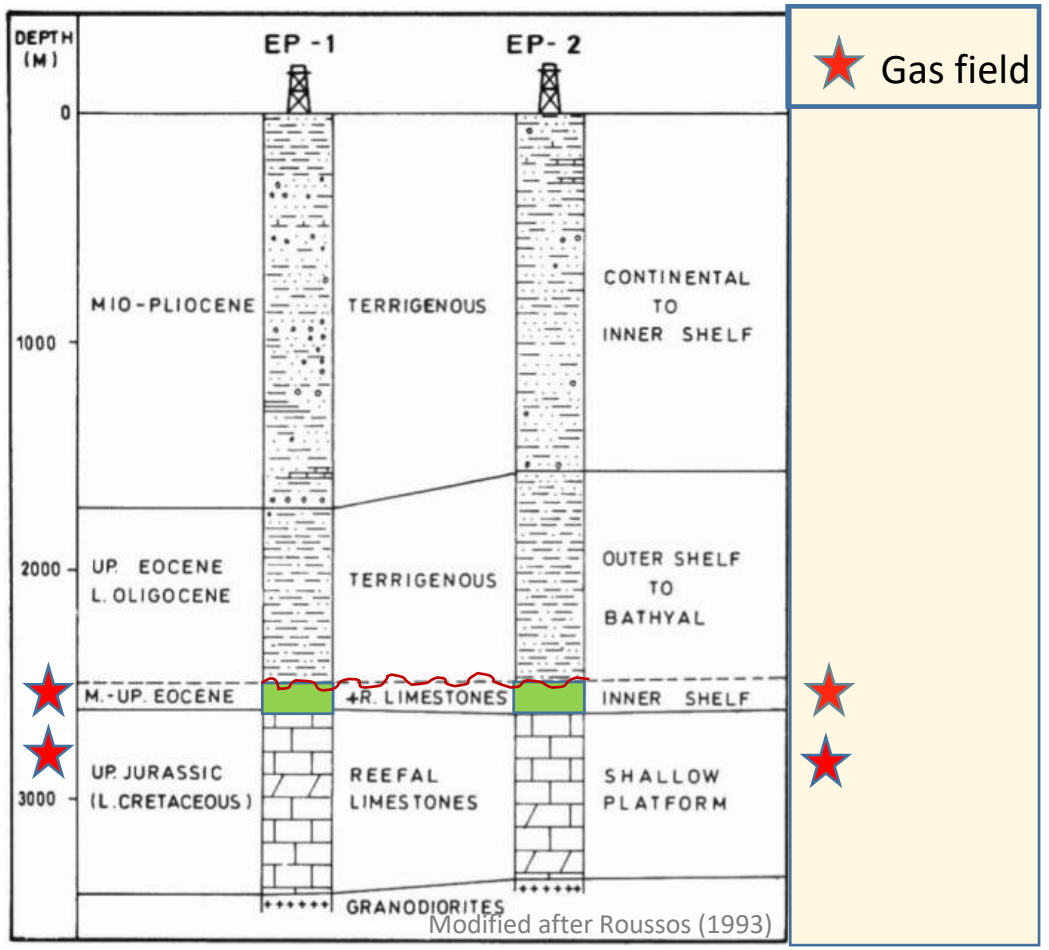
- Two layers of Gas documented in WK#1a well
- Flow rates up to 11MMSCFD



- The CH4-dominated gas emissions (gas-seeps), suggest a thermogenic origin, derived from a Jurassic carbonate reservoir (Etiope et al., 2013)

N. Greece (Epanomi Gas Field Case); On-shore wells





Modified after Roussos (1993)

Geo-history in short

- Discovered in 1988
- EP#1 TD= 2,605m
- Below an erosional unconformity (clastic/carbonate sequence)
- Highly fractured limestone Reservoir (*increased secondary porosity*)
- Lateral migration is postulated
- Max. vertical closure = 200m (EP#1)
- Area at the closure = ~4 km^2
- Estimated reserves ~ 500Mcm
- Never developed
- Potential presence of more sites

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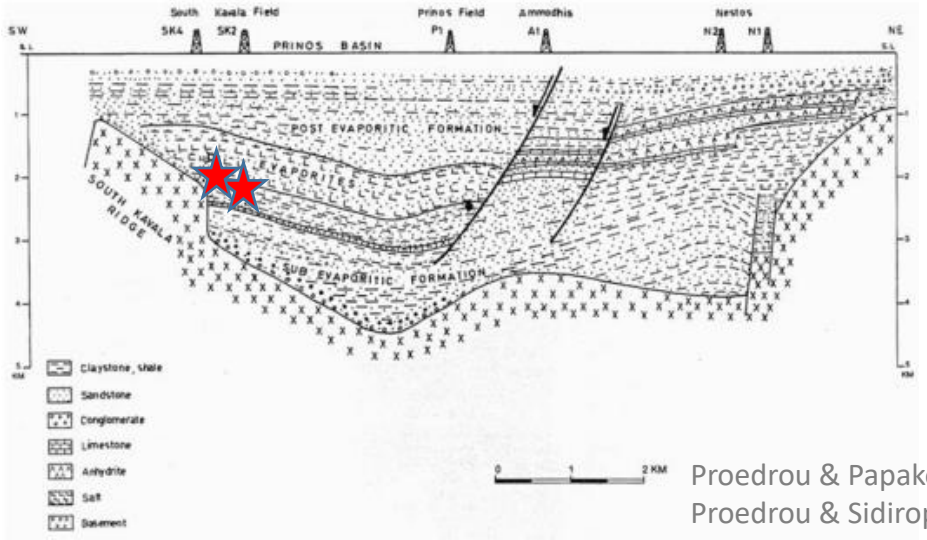
The South Kavala Gas Field Case; Off-shore wells

Energean web site

- S. Kavala Gas field (SK#) developed to the south of the Prinos Basin, evolved during E. Paleogene on a metamorphic basement
- **Reservoir:** Clastic origin
- **Seal**: Evaporitic layers alternating with marine sandstones & shales (Messinian)
- **Source**: Coal deposits? Gas generation potential
- S. Kavala Gas condensate & Nestos gases (sub-basin) are free from H_2S and CO_2
- Presently is a depleted field, planned for NG geo-storage

SW-NE section



Proedrou & Papakonstantinou (2004)
Proedrou & Sidiropoulos (1992)

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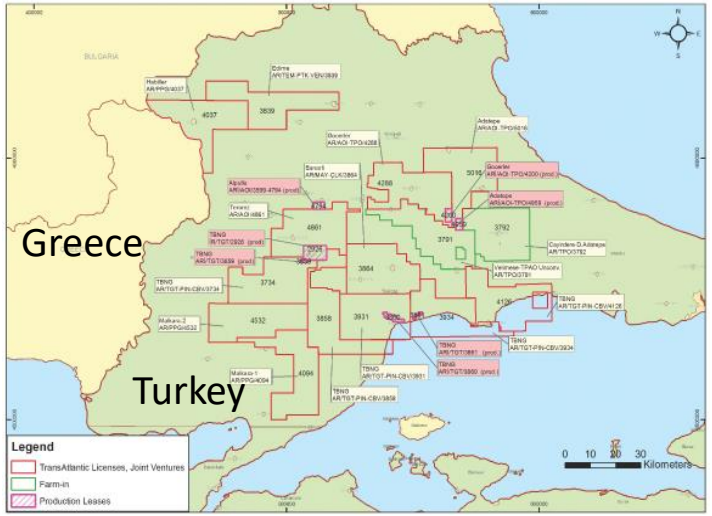
NE Greece Cenozoic basins Case; On- and Off-shore wells

Analogues: The case of H/C licenses & prod. Fields - E.Thrace basin



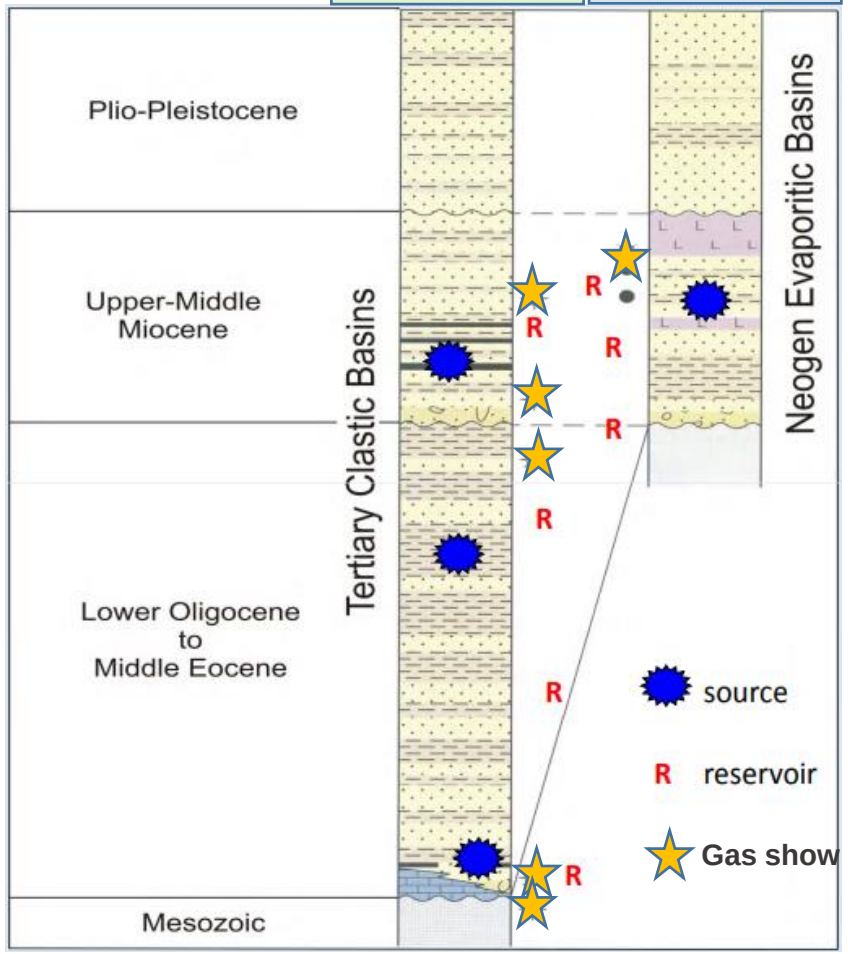
US SECURITIES AND EXCHANGE COMMISSION

https://www.sec.gov/Archives/edgar/data/1092289/000119312512128943/d283613d10k.htm

- NW Turkey: Oligocene petroleum system. (Mid-)Eocene reservoirs are mostly productive (Derman, AAPG, 2014). *[not unconv.]*
- 12 Gas fields (data of Gurgey, 2009)

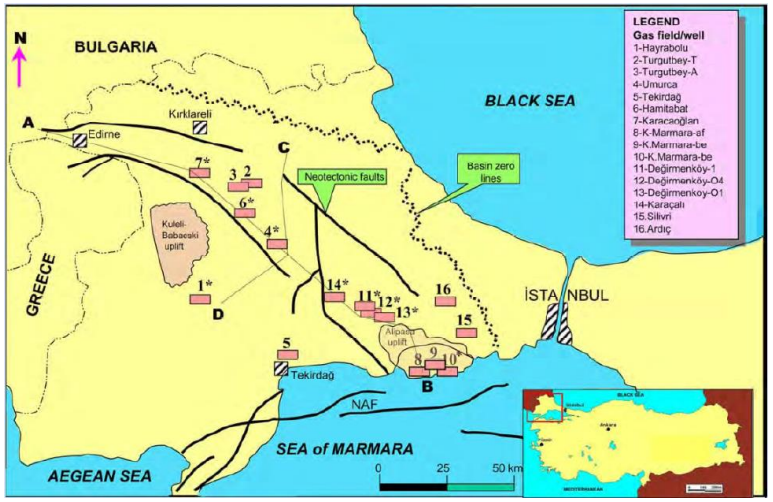
https://archproductiveives.datapages.com/data/specpubs/memoir106/data/469_aapg-sp1960469.htm

On-shore analogue | "Prinos" analogue



Modified from Nikolaou, 2012

Analogues: Gas prod. Fields E.Thrace basin



Nikolaou, 2012

- 16 Gas fields!
- Follow two main fault systems
  - a. NNW-SSE (11-12/16)
  - b. NAF… (4-5/16)

➢ Both affect NE Greece!

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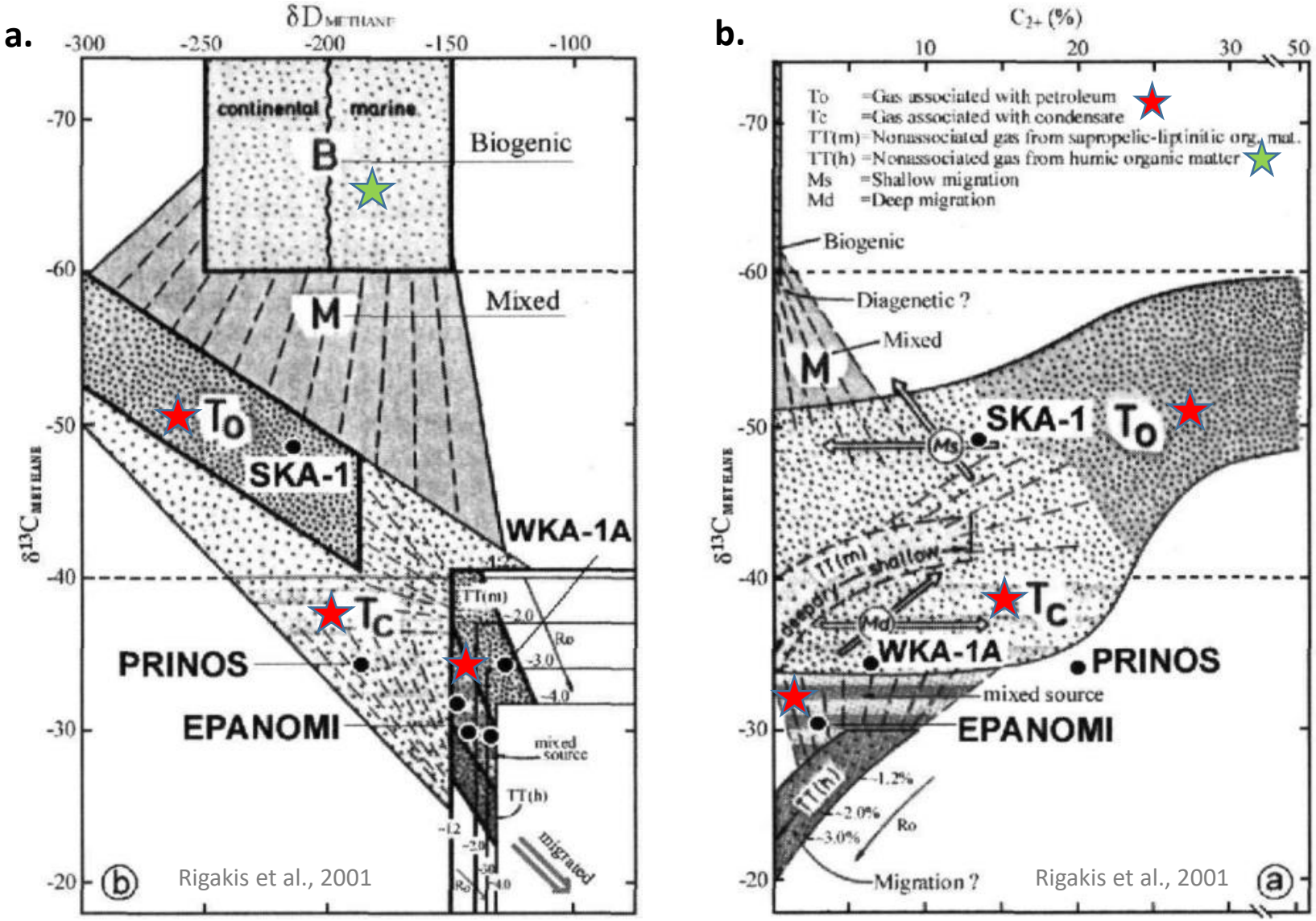
Classification of Greek hydrocarbon gases



Classification based on compositional and isotopic variations.
(*evolution paths after Schoell, 1983*).

a. Methane isotopes, δ13C vs. δDmethane (deuterium)

b. C2+ hydrocarbon gases vs. δ13C of methane

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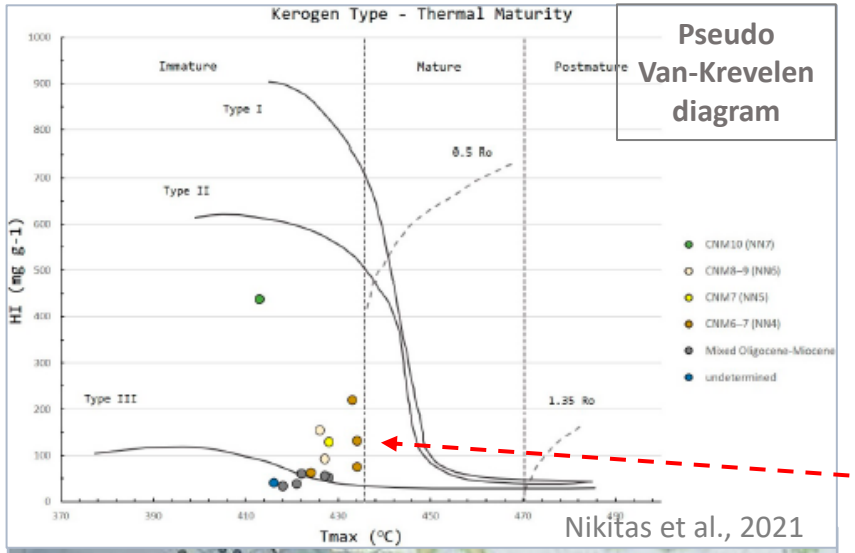
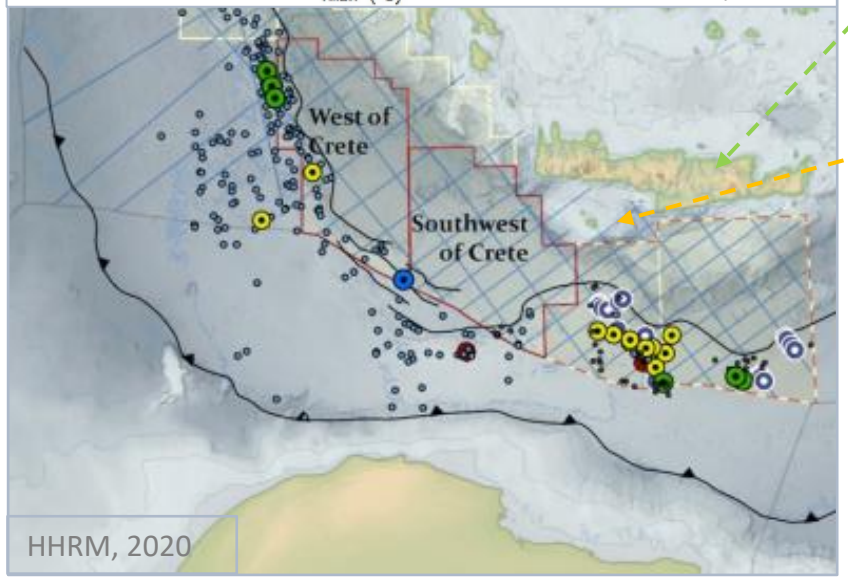
The Case of Crete



Pseudo Van-Krevelen diagram

Nikitas et al., 2021



HHRM, 2020

On-shore: Biogenic gas
Location: Central Crete (a few sites)
Geology: Neogene formations, developed on the preneogene basement (carbonates *or* metamorphic)
Reservoir Depth: deeper than 400m

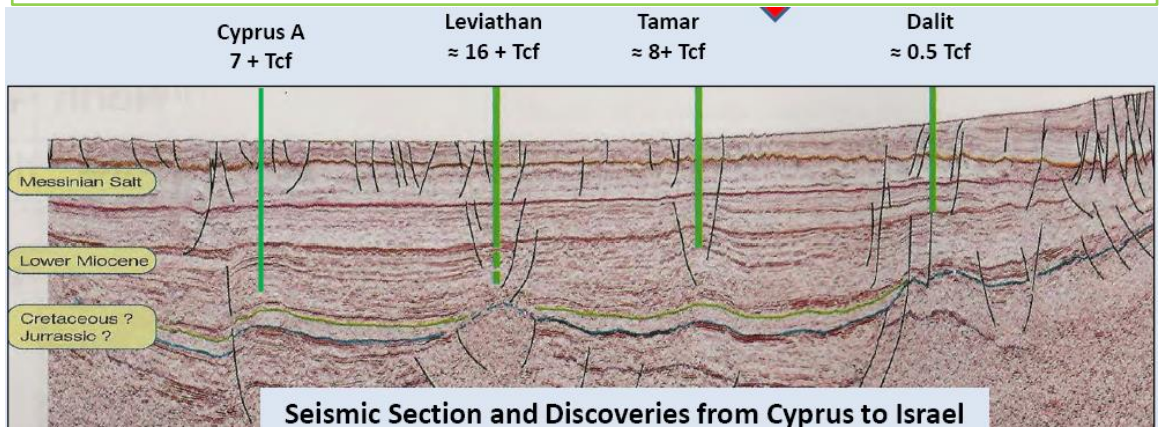
Other (Offshore indications)
1. Mudvolcanoes (Olimpi Field)
2. Gas leakages (buble-type) in the sea column (between Gavdos and Crete)

Bruneton et al. (2012)
Konofagos (2018)

MVs Geologic Ages *(mud breccia)*
Miocene
Oligocene
Cretaceous
Jurassic
Uknown

The Case of Crete; Surrounded by Analogues

Offshore E-Med. pot. analogues to Onshore Crete



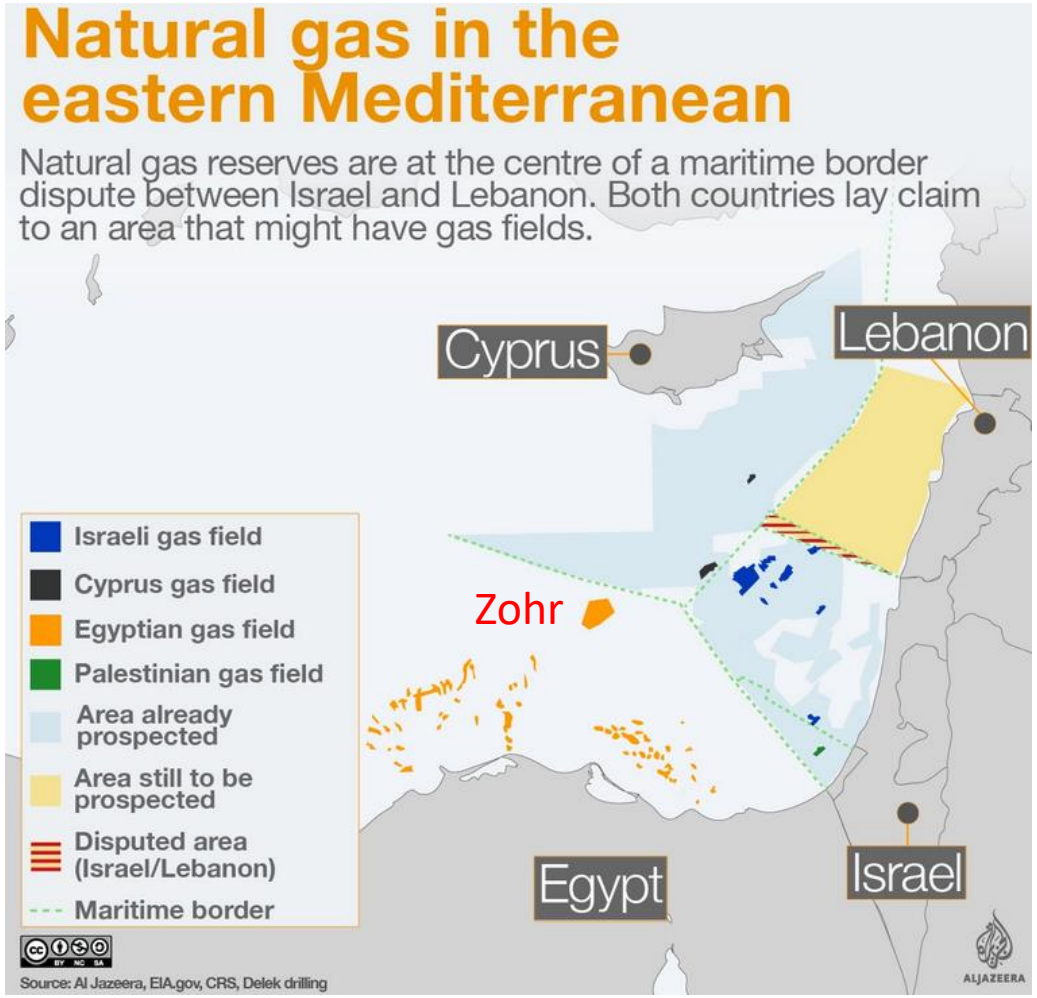
Nikolaou, 2012

Off-shore: Biogenic gas

Producing Fields

- Israel
- Cyprus
- Egypt

- Greece?



A Geo-Classification of the "gas" accumulations in Greece

Reservoir Type

Siliciclastic Fms.			Carbonate Fms		
Catagenic	Biogenic	Uknown	Catagenic	Biogenic	Uknown
Ag. Georgios (on) Mesohellenic (on) S. Kavala (off, F) Thrace Basin (on) Gas-seeps, W.GR (on) MVs (off)	E.Erikoussa (off) Katakolo (on) Crete (on) Gas-seeps (off) MVs (off)	Mesohellenic (on) S.Crete (off)	Epanomi (on, F) Katakolo (off, D) Gas-seeps (off) MVs (off)	Thrace Basin? Crete (off)? MVs (off)	Mesohellenic? Gas-seeps (on) MVs (off)

Legend: on=onshore, off=Offshore, F=Field, D=Discovery

SUMMARIZING

- In view of a viable & safe Energy Transition and the high-level goals set by EU, Gas exploration (the so-called "bridging energy source") should be a top priority.
- Commercial Gas has been discovered in western, central (north) and northeastern Greece.
- More than 200 gas/oil shows have been documented, including a few oil seepages.
- Many wells included gas shows yet lack of data complicates further evaluation.
- Biogenic gases are also documented in many places including Crete.
- The existing Gas fields, additional geological indications for prospective sources and the (producing) analogues (Albania, Cyprus, Egypt, Turkey), suggest that Greece has the potential and should be explored for Gas.
- The Institute of Petroleum Research of the Foundation of Research and Technology (IPR-FORTH), can provide its services and technical experience for all those purposes.

Further research is a must. So, Keep Exploring Greece!

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Σας ευχαριστώ για την προσοχή σας!

Thank you for your attention!

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