

# **Deep Seated Platform Carbonate Reservoirs as New Hydrocarbon Plays in the NW Albania–Montenegro Segment of the Adriatic Region\***

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## **Abstract**

The proven Ionian fertile hydrocarbon province in South Albania may not be an isolated example in the southeastern border of the South Adriatic Basin (SAB). The geological and geophysical data analyses gathered during mid-90's and early 2000 strongly support the idea of another hydrocarbon province yet to be found in the northwest Albania-Montenegro region, where deep seated structures and subthrust autochthonous platform Mesozoic units are buried underneath the frontal zones of the Kruja-Dalmatian thin-skinned thrust belt. The thin-skinned belt is thrust westward on the scale of tens of kilometres, masking various hydrocarbon potential structural and stratigraphic plays. The most important play type appears to be the structurally inverted autochthonous platform carbonates.

These deeply buried autochthonous platform carbonates resemble those in the Southern Apennines of Italy. A deep SE-NW trending anticlinorium with autochthonous platform carbonate units is interpreted in the onshore Albania-Montenegro region. The anticlinorium, which is stretched for about 140 km towards onshore Montenegro, comprises a cluster of several inverted structural closures, draping over the pre-Triassic structural high of the Apulian east-dipping foreland. The structural inversion is relatively young and it is related to post-Miocene deformations. The regional geometry of the developing thrust belts and the underlying anticlinorium is largely controlled by the preorogenic architecture of the platforms (Kruja-Dalmatian) and basins (Ionian-SAB). The famous regional tectonic zone, known as Scutari-Pec Lineament, dominates the structural pattern of the region by shaping the Mesozoic carbonate architecture.

The key source rocks of the autochthonous platform are Triassic-Cretaceous in age, analogous to those contributed to Southern Apennines discoveries. These source rock intervals are modeled to generate economic amounts of light oils, trapped in fractured shallow water carbonate reservoirs and sealed by an Oligocene regional seal. Analyses suggest that this new play could become more attractive than the traditional ones if the tectonic model better understood and additional exploration efforts are employed.

### **Selected Reference**

Dragasevic, T., 1987, Dinarides – a challenge to Yugoslav geophysicists: First Break, v. 5, No. 5, p. 173-183.

Picha, F. J, 1996, Exploring for hydrocarbons under thrust belts – a challenge new frontier in the Carpathians and elsewhere. AAPG Bulletin, V. 80, No. 10 (October 1996), p. 1547-1564.

Roure, F., E. Prenjasi and Z. Xhafa, 1995, Albania: petroleum geology of the Albanian thrust belt: AAPG International Conference and Exhibition, Excursion 7 Field Trip Notes, p. 46.

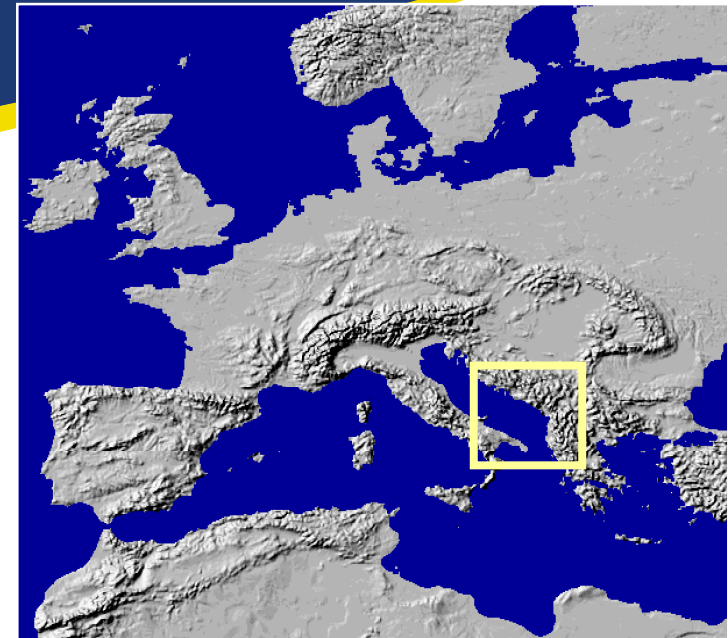
Zappatera, E., 1994, Source rock distribution model of the Periadriatic region. AAPG Bulletin, v. 78, No.3, p. 333-354.

# OMV Petrom S.A.

Deep seated platform carbonate reservoirs as  
new hydrocarbon plays in NW Albania -  
Montenegro segment of the Adriatic region.

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**Romania**

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*April 8-10, 2013*



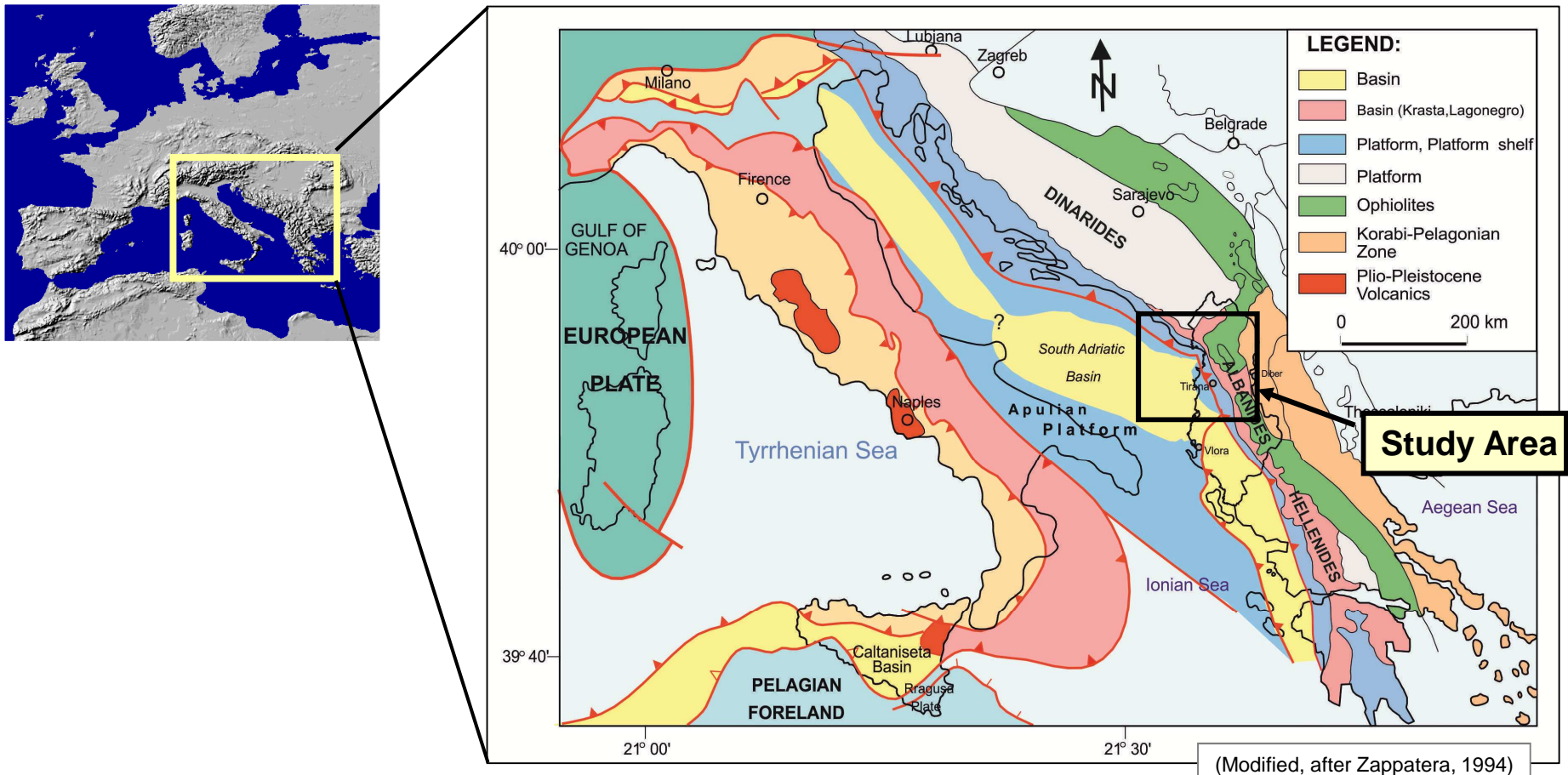
# Content

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- Regional Geological Framework
- Basin to platform observations
  - Carbonate Paleogeographic Sequences (CPS)
  - Passive roof thrusts
  - Regional cross section examples
  - Bouguer Gravity
  - The anticlinorium of sub-thrusts
- HC shows and Analogue Source Rocks
- Analogue plays and spacial target distribution
- Conclusions

# Peri-Adriatic Circum

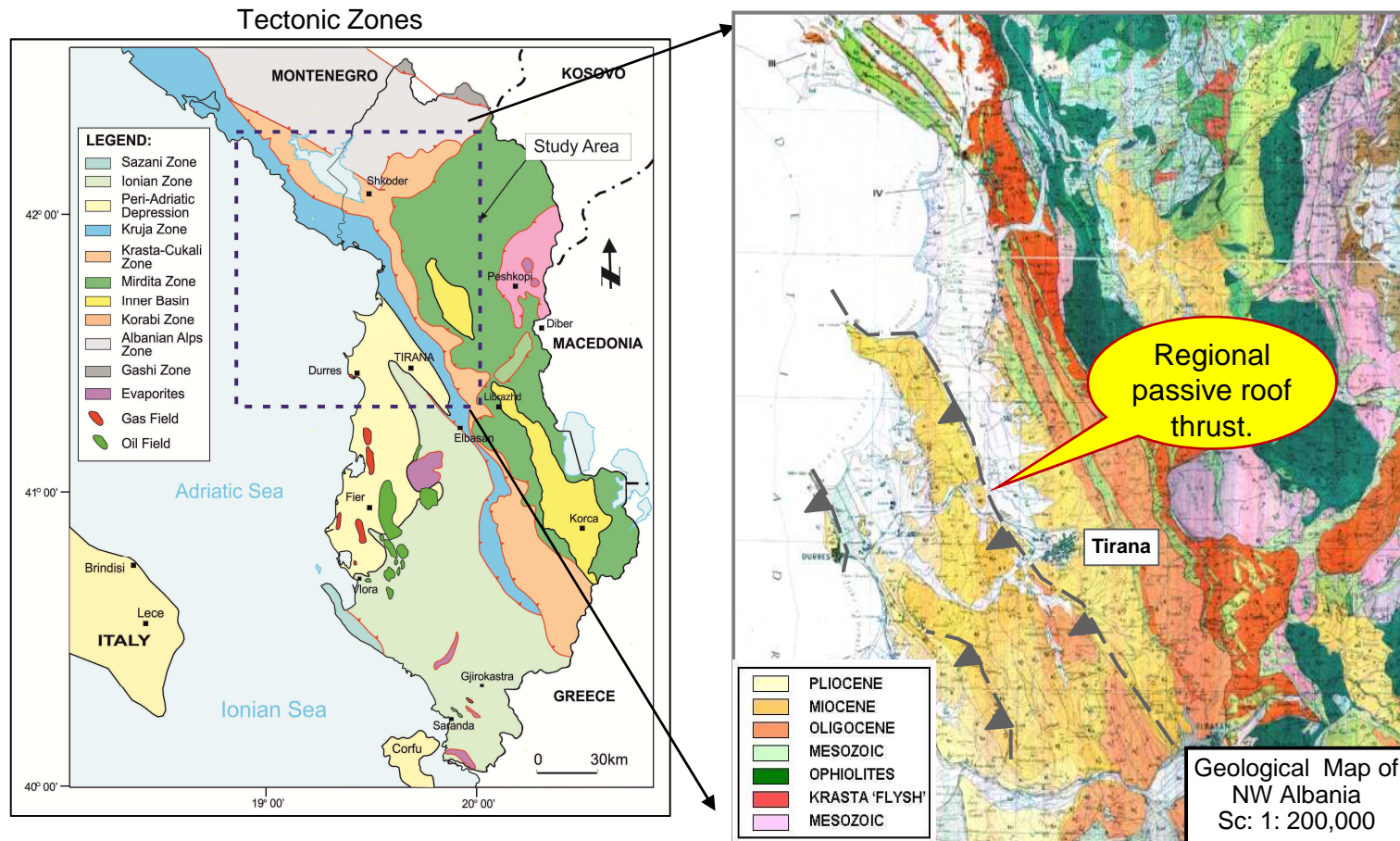
## Regional Geological Framework



- A crucial corner of the peri-Adriatic segment, where Hellenides-Albanides strike orientation switches into Dinarides orientation (Scutari-Pec Lineament).
- Part of the Alpine-Mediterranean orogenic belt: the Mesozoic/Tertiary evolution is controlled by relative movements between the Adriatic subplate and the European plate.
- Forelandward thrusting governs thin-skinned deformation since post-Oligocene.

# NW Albania

## Geological and tectonic maps



- The Study Area has undergone exploration activities for long time.
- Numerous geo-tectonic zones in the Study Area and thick Tertiary cover makes difficult to unravel the underlying Mesozoic architecture and its EoD.
- Two Plio-Miocene piggy-back basins are overlaying the area and separated by regional passive roof thrusts.
- The Mesozoic Ionian ramp setting/play has been the prevailing geological concept until now.

# Regional Data Base

## NW Albania – Montenegro regional integration

### Exploration history:

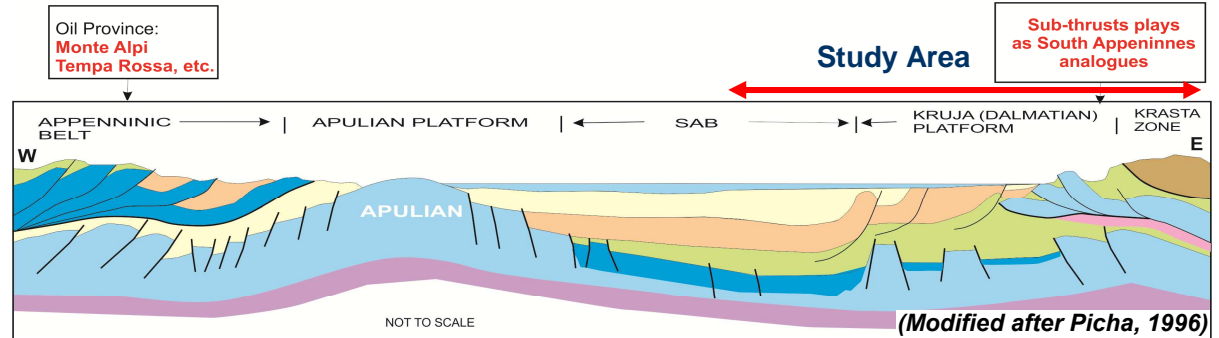
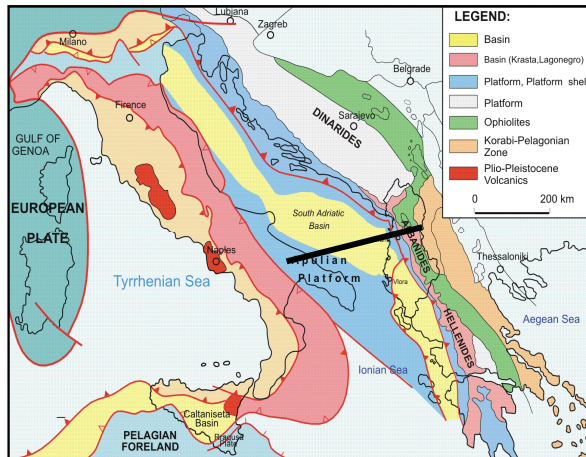
- Phase 1: more than 35 wells drilled since mid-50's of last century on-offshore: unsatisfactory well results with exception of JJ-3 well who tested noncommercial oil.
- Phase 2: intensive modern G&G data recorded during 90's, including a dense grid of 2D seismic: well results again unsatisfactory; none of them reached the proposed target.
- Why this? - a regional approach was undertaken (data integration and analysis).



Key wells data base used for regional integration.

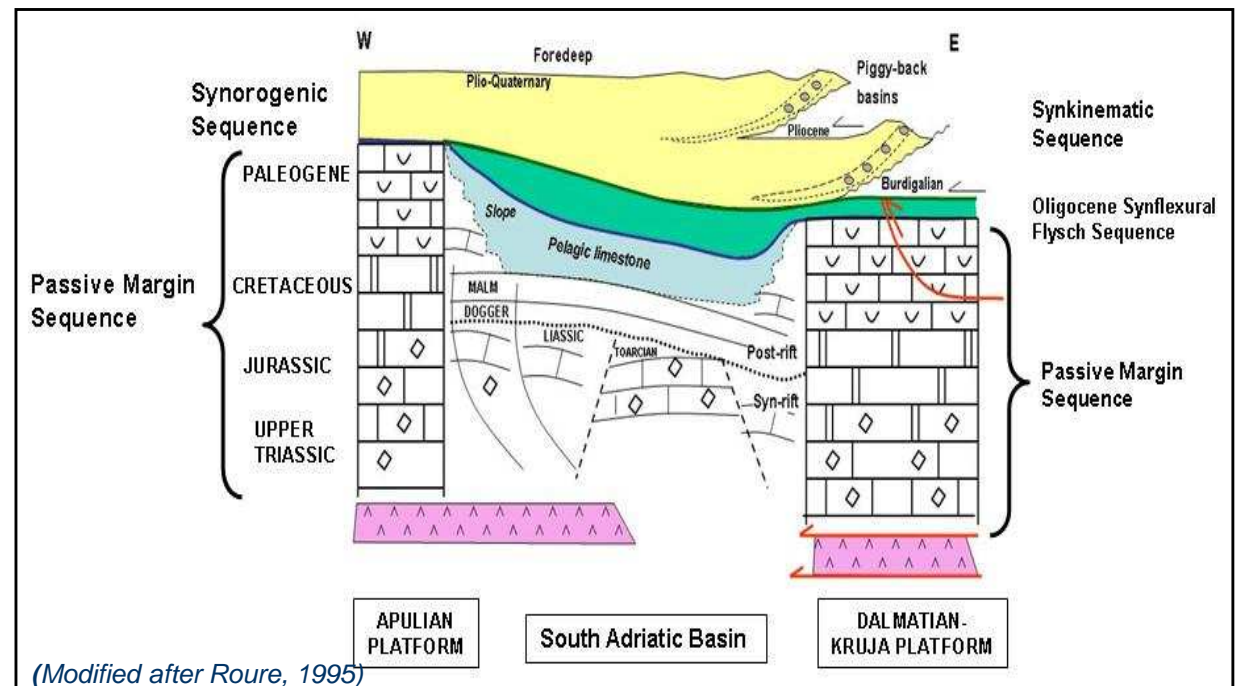
# NW Albania

## Tectono-sedimentary developments



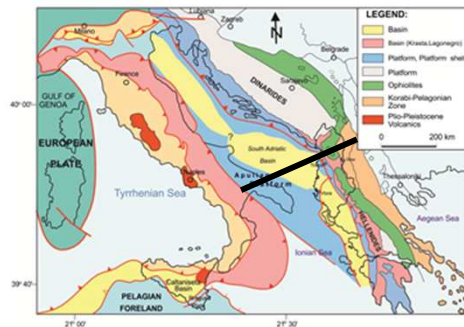
PELAGIC CARBONATES  
 PLATFORM CARBONATES  
 TERTIARY  
 EVAPORITES  
 PELAGIC SILICICLASTICS & CARBONATES

- Tilted eastward Apulian foreland
- The passive margins sequence was mapped out in NW Albania (analogue to Apulian platform).
- Thin-skin thrusting and inversion affecting passive margins during M. Miocene-Pliocene time:
  - The Kruja thin-skinned front thrust westward for at least 40 kms.
- The Neogene passive roof thrusts (piggy-back basins) are indicative of subsurface geometry.

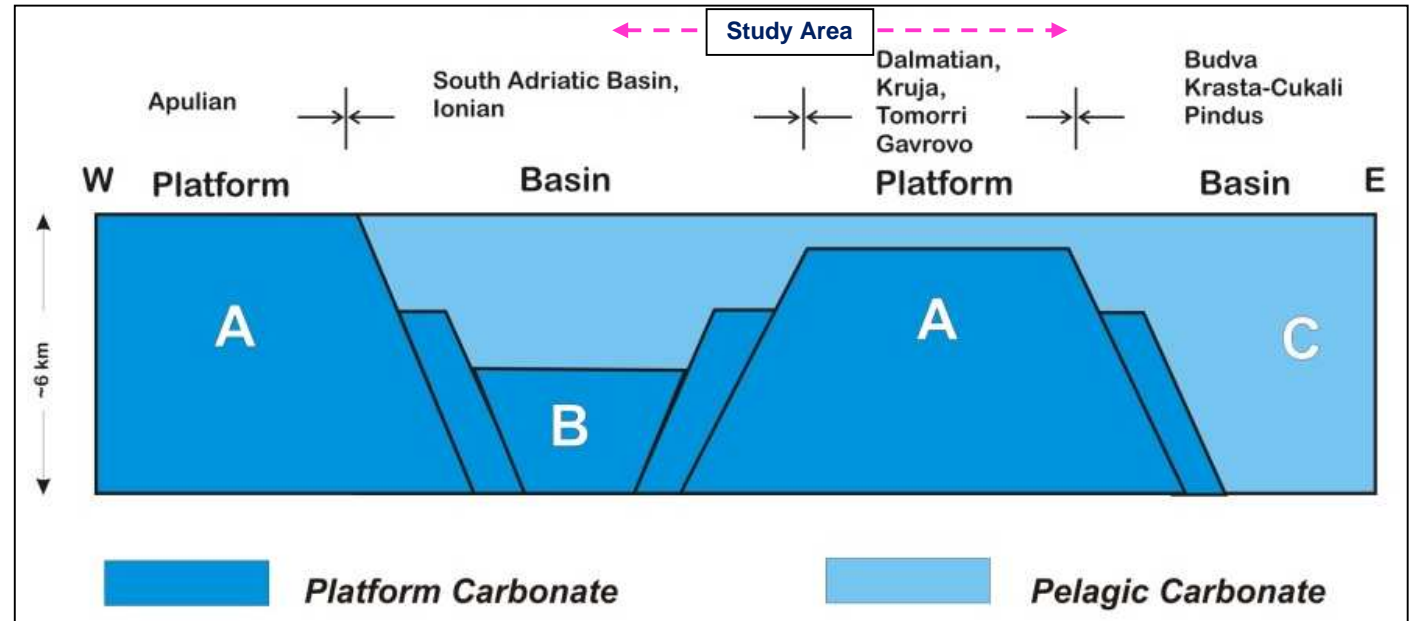


# Carbonate Paleogeographic Sequences

## *Mesozoic platform vs basinal architecture*



Carbonate paleogeographic sequences (CPS) during the rifting stage (modified after Zappatera, 1994)



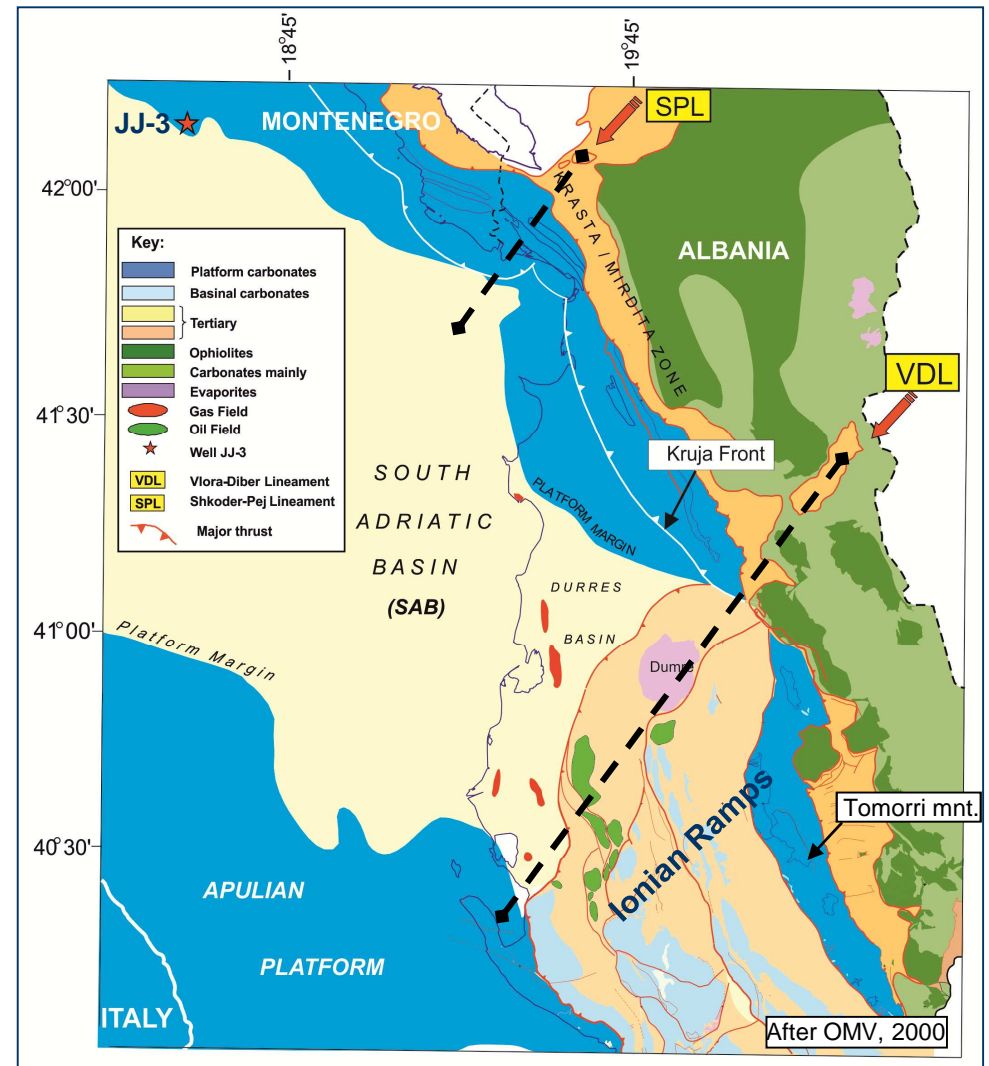
The tilted Apulian foreland is composed by intercalation of basins and platforms

- Sequence “A” – Thick platform carbonates of T3-N1. Evaporites occur in the lower part. Stable sedimentation and platform growth under uniform environmental conditions (~ 5-7 km thick).
- Sequence “B” – The platform to basin sequence of T3-Pg. Lower platform unit of tidal-subtidal carbonates of T3-Liassic age and upper basinal unit of pelagic carbonate muds, marls and cherts of Liass – Pg. Sequence “B” reflects the break up of a new paleogeography (~ 3 km thick).
- Sequence “C” – The basinal sequence of T3-J. Pelagic carbonates, siliceous rocks deposited in deep water basins that persisted from T3 – Early Tertiary (thickness unknown?).

# Top Mesozoic carbonates

## *Platform vs basin architecture*

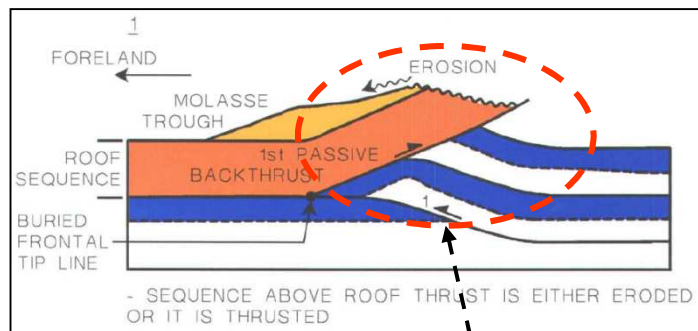
- Current map results from integration of G&G data on a regional scale.
- For the first time the autochthonous platform carbonates are mapped out in the Albanian territory (**JJ-3** well is the only one reaching the platform carbonates on Eastern passive margin).
- **SAB** is sandwiched between passive margins and not deformed at all.
- The Albanian platform margin seems to conjugate with the SE corner of Apulian (an ACW rifting).
- Platform carbonates constitute primary play types in this area.
- **Ionian** carbonate ramps are bound by VDL.
- Both lineaments (**VDL**, **SPL**) are foot prints of pre-orogeny (rifting) architecture, blended with post-orogeny ones.



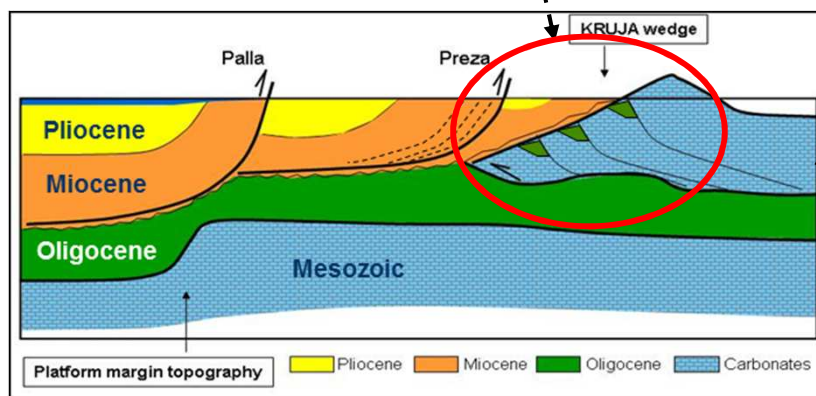
Simplified Top Mesozoic carbonates map  
(South Adriatic Basin region)

# Passive roof thrusts

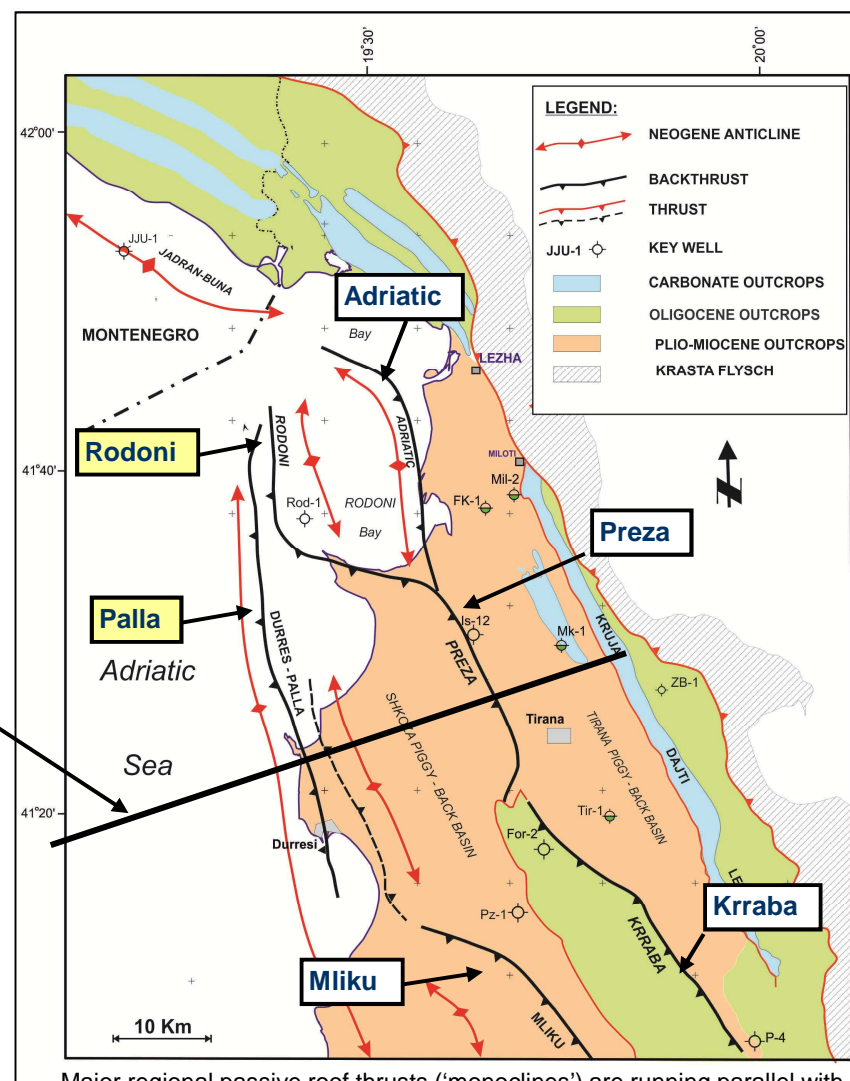
## *Indicative to sub-surface morphology*



(A) - Development of Preza (Krraba, Adriatic) passive roof thrust is due to buried carbonate wedges with westward progressing (NPA, 1994)



(B) - Palla backthrust is due to a combination of stepping geometry between pelagic and platform carbonates and also as a result of Plio-Miocene subsidence and westward vergence (OMV, 2000).

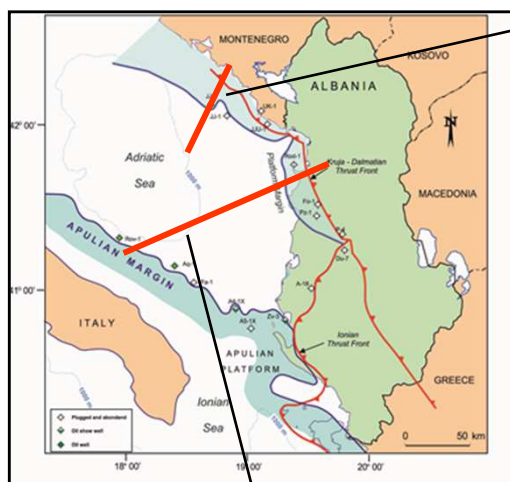


Major regional passive roof thrusts ('monoclines') are running parallel with Kruja-Dalmatian thrust fronts in the NW part of Albania. The individual length of each segment is in the range of 40-60kms.

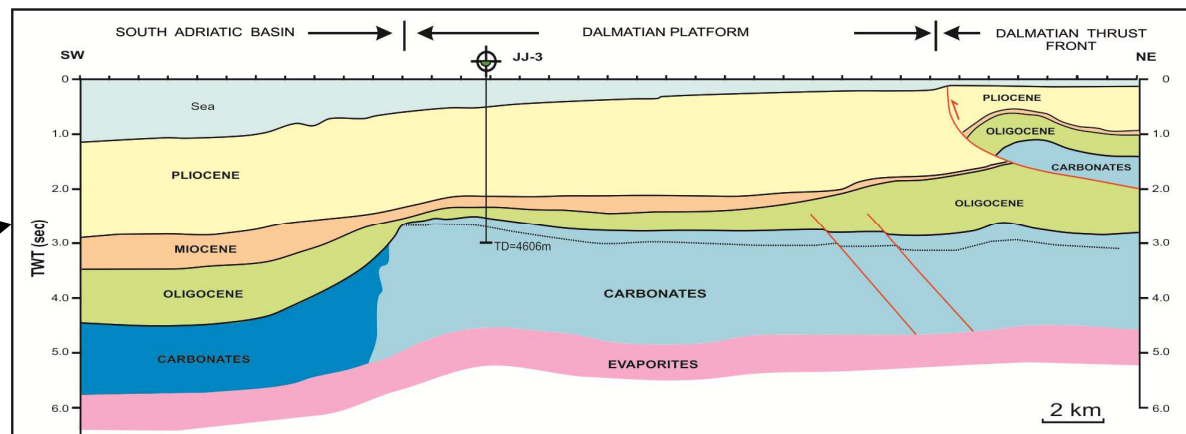
# Montenegro & Albania offshore-onshore

## *Basin to platform observations*

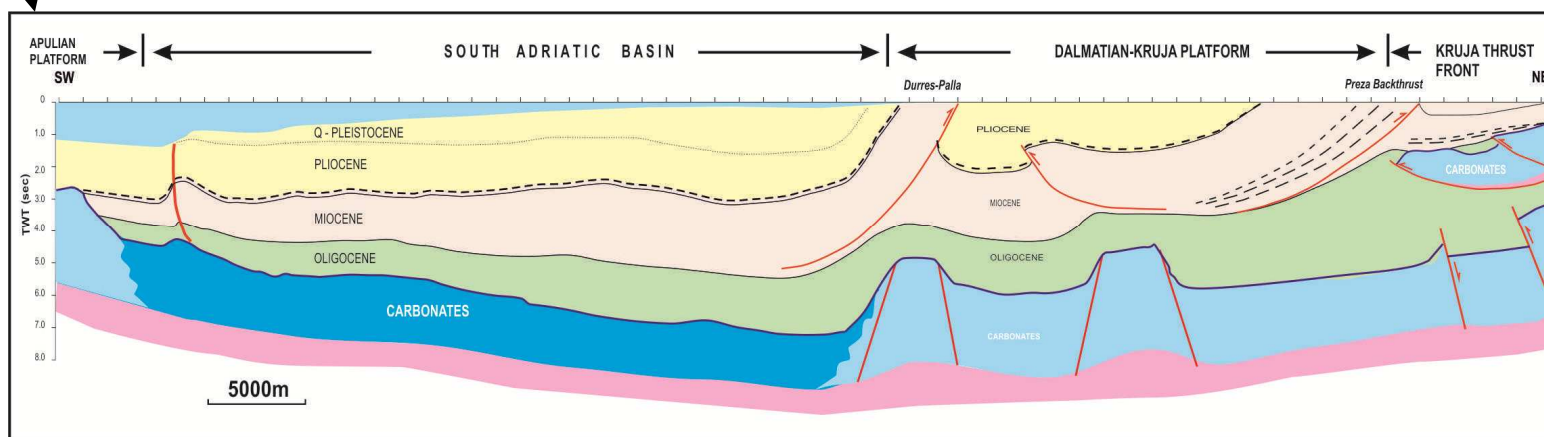
- Well JJ-3 drilled in mid-80's by Chevron; tested oil at platform margin.
- Key risks: top seal and charging.



Geological cross section (seismic line Y-80-10E) offshore Montenegro



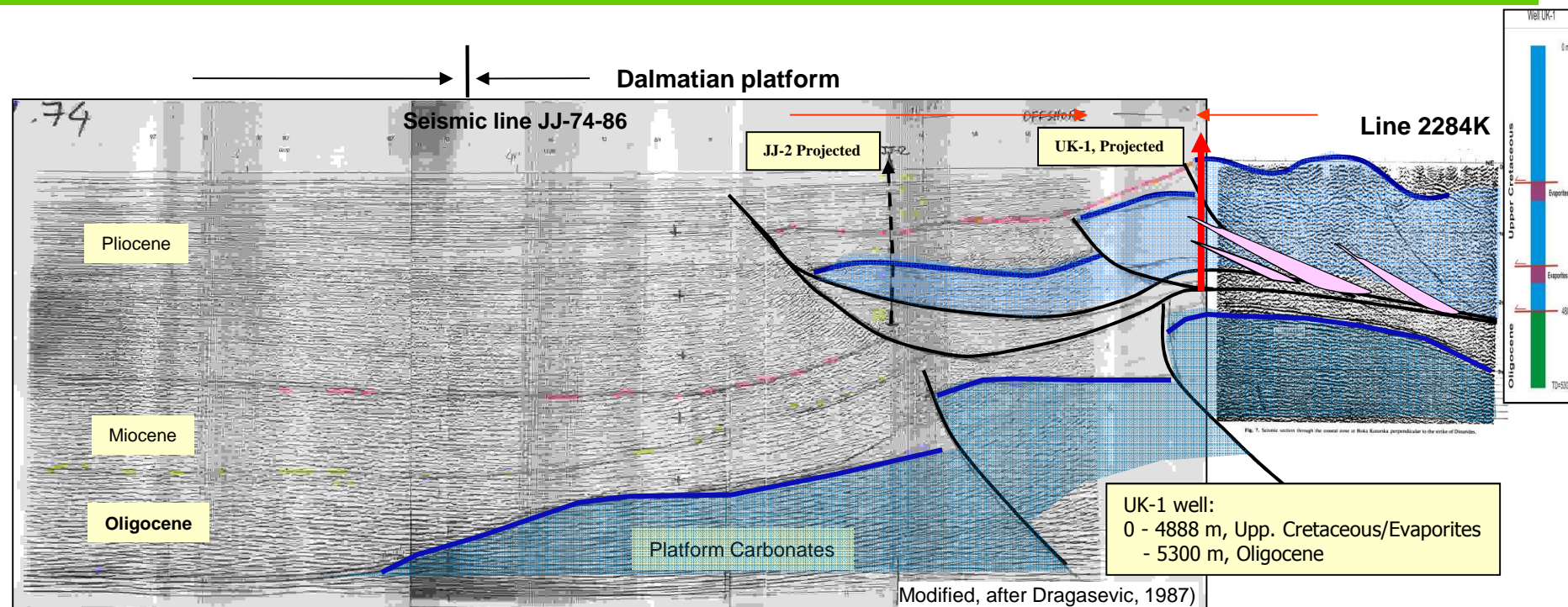
- Western part: undeformed South Adriatic Basin; any HC generation is migrating updip towards West (Aquila, Falco).
- Eastern part: autochthonous platform setting, extensional tectonics throughout.
- Potential intra-platform basins surround the structural highs in onshore Albania.



•Regional cross section through off-onshore Albania (seismic lines: OXAB-91-09+RO-91-168+417/89+341/91+15/88)

# Montenegro off-onshore

## *Inverted platform carbonates masked by Dalmatian thin-skinned*

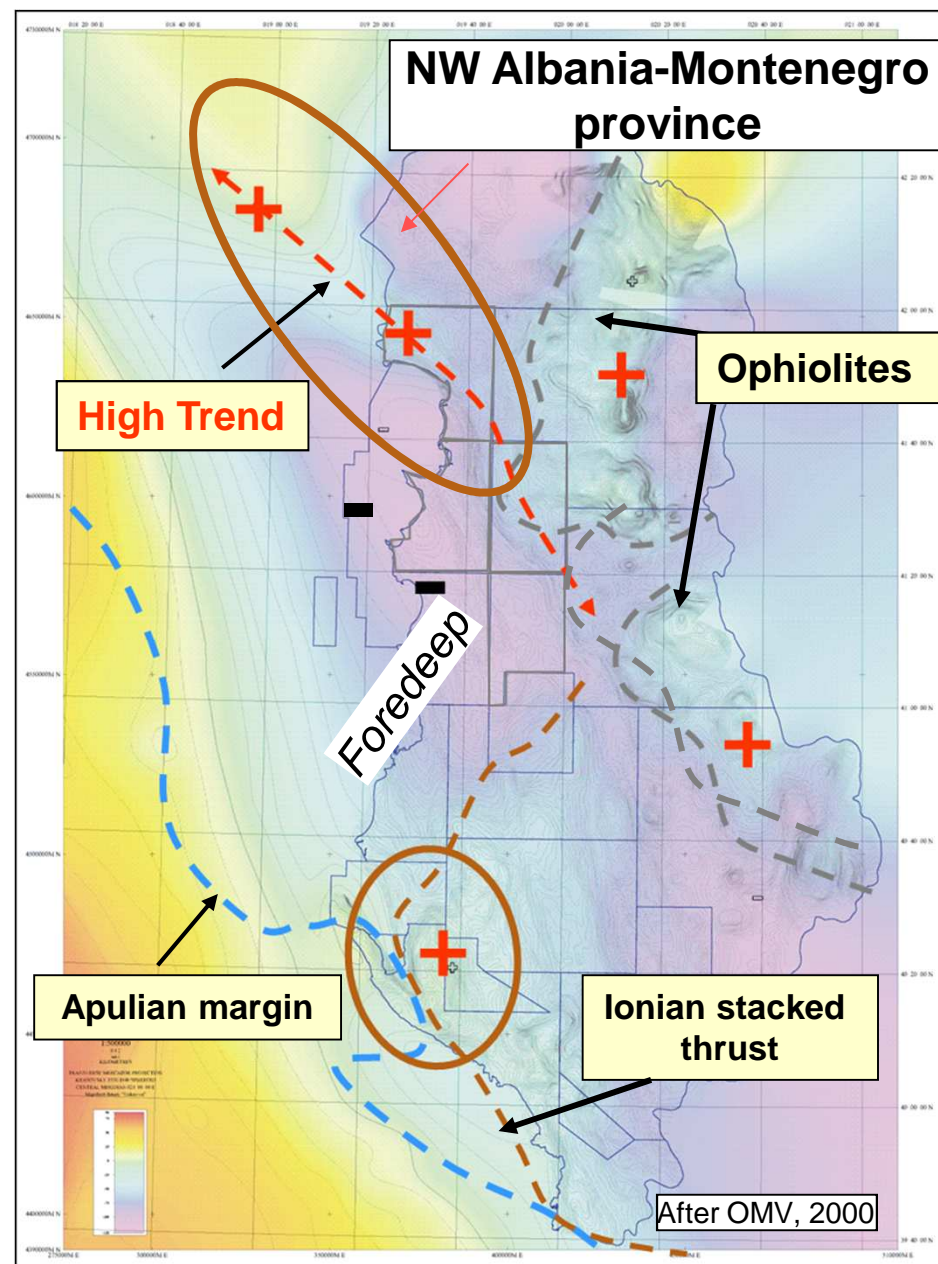


- First evidences of inverted autochthonous carbonates.
- Well UK-1 (P&A in 1997, onshore Montenegro) was TD at Oligocene after penetrated through the thin-skinned U. Cretaceous platform carbonates.
- Strong reflector at around 2.2-2.3 sec (TWT) are likely to be top Mesozoic reservoirs sealed by Oligocene shales.
- Dalmatian thin-skinned carbonates are draping over the inverted autochthonous carbonates.
- Key play in the region.

# Regional Bouguer gravity

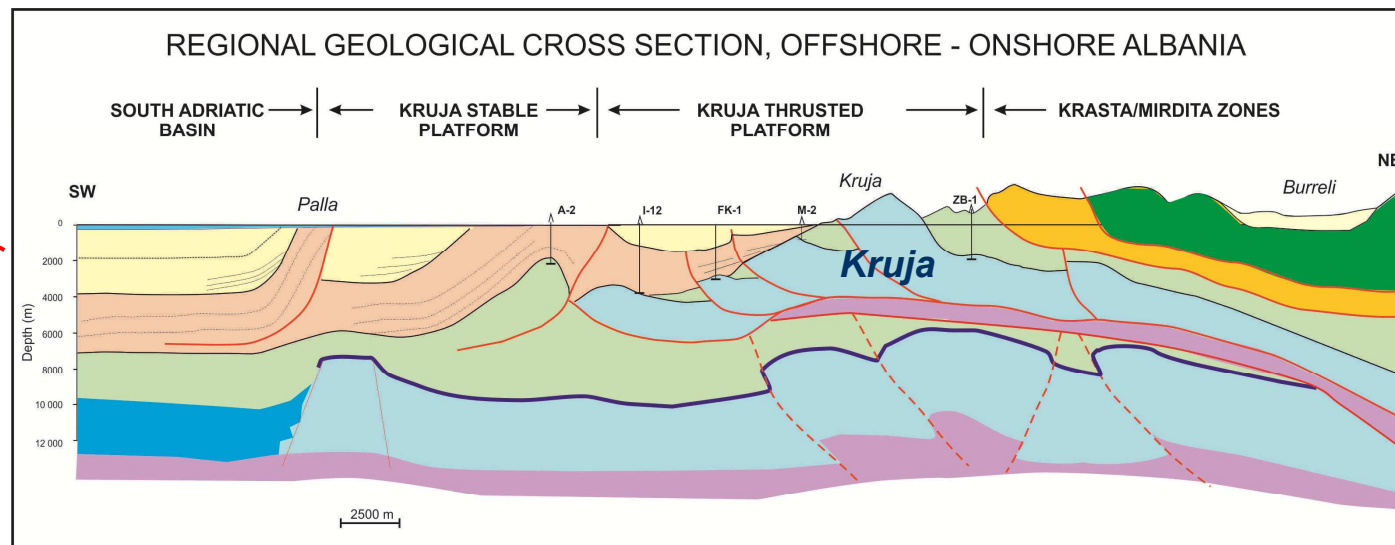
## *Evidence for sub-thrust high trend*

- Benefits of using potential methods.
- Bouguer gravity data are more or less a resemblance of passive margins and high density stacked rocks.
- A high trend, evident in Montenegro and entering NW Albania in SE direction is supporting the basement high, thus the anticlinorium trend.
- The gravity modelling suggests that internal part of Albanides are comprising thick ophiolites and basinal sediments, allowing us to assume deepening of autochthonous platform units eastward.

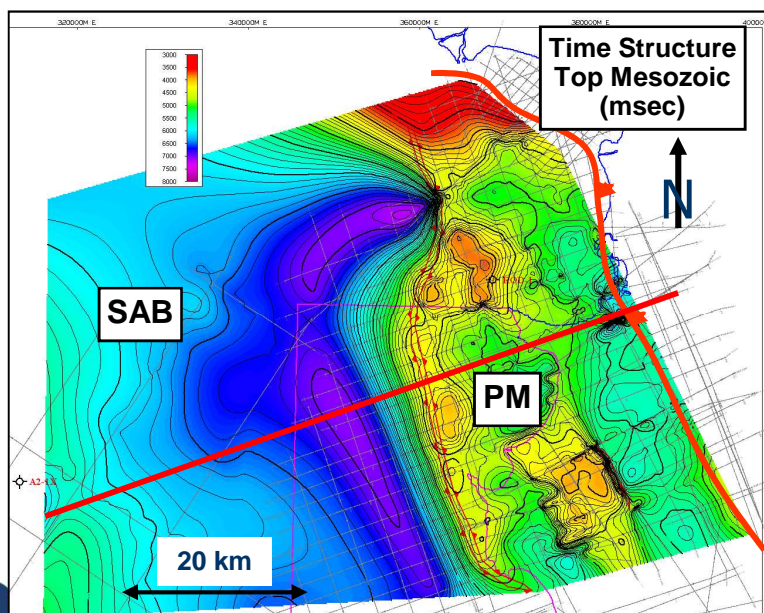


# Onshore Albania

## *Buried autochthonous subthrust*



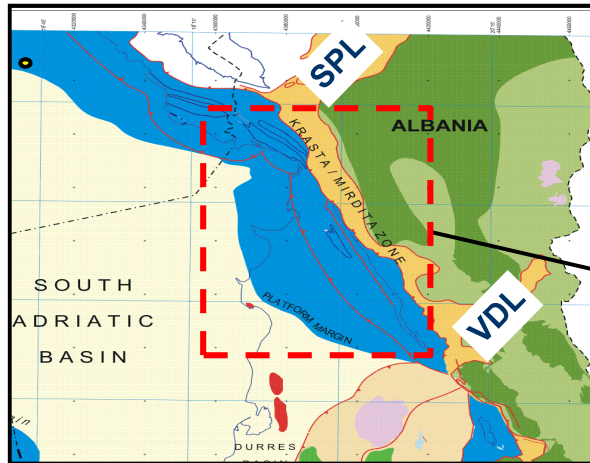
Pliocene
  Miocene
  Oligocene
  Carbonates (Basinal)
  Carbonates (Platform)
  Evaporites
  Krasta/Mirdita Zones



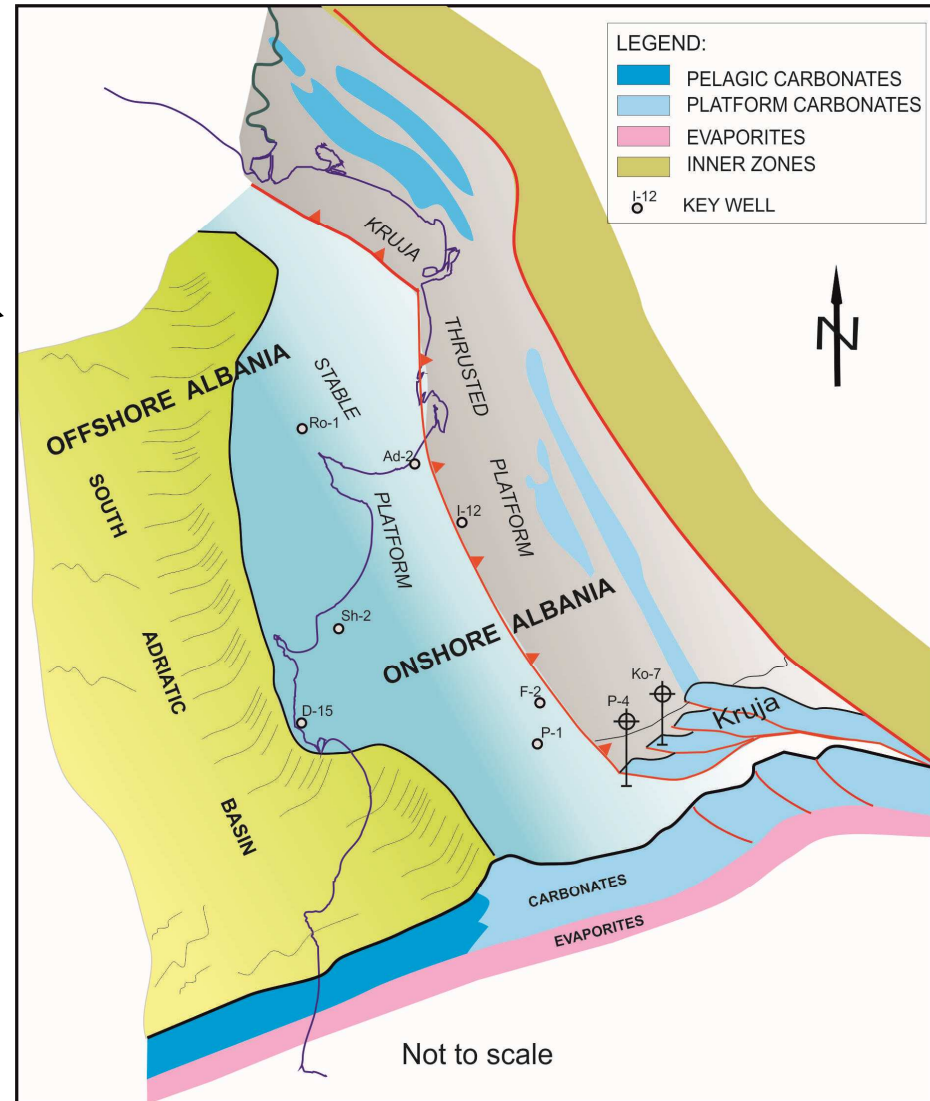
- Likewise in Montenegro, inverted sub-thrust autochthonous carbonates are predicted in NW Albania
- Kruja wedge structural model is well constrained (wells and 2D seismic) and is forming an undulation with the peak along the Kruja ridge.
- Kruja behaves like a single thrust sheet with back limb plunging eastward.
- The autochthonous platform inversion is a result of progressive thrusting westward during M. Miocene/Pliocene

# Onshore-offshore Albania

## *3D view of autochthonous subthrust ('anticlinorium')*



- The sub-thrust highs are forming an 'anticlinorium' with lateral ramps controlled by VDL and SPL.
- Regional geology is suggesting east-dipping back-limbs (lack of seismic data to the East).
- The thin-skinned Kruja thrust is draping over the anticlinorium and mimicking its underlying morphology.
- The anticlinorium is following the general strike trend (SE-NW) and several sub-thrust closures are predicted along the strike.
- The anticlinorium is still a model driven.

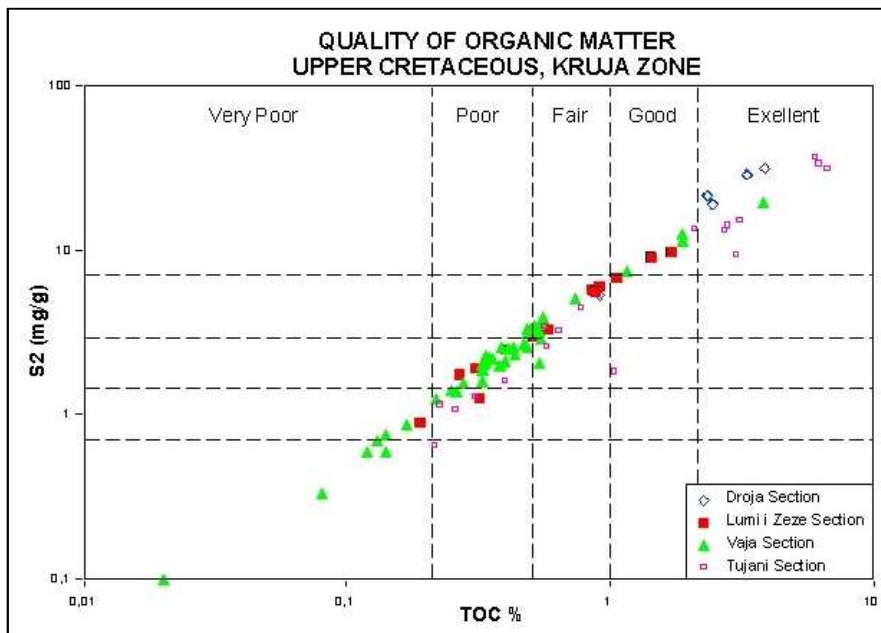


Tectonic sketch model: 3D view of the autochthonous carbonates ('anticlinorium') and the thin-skinned thrusts.

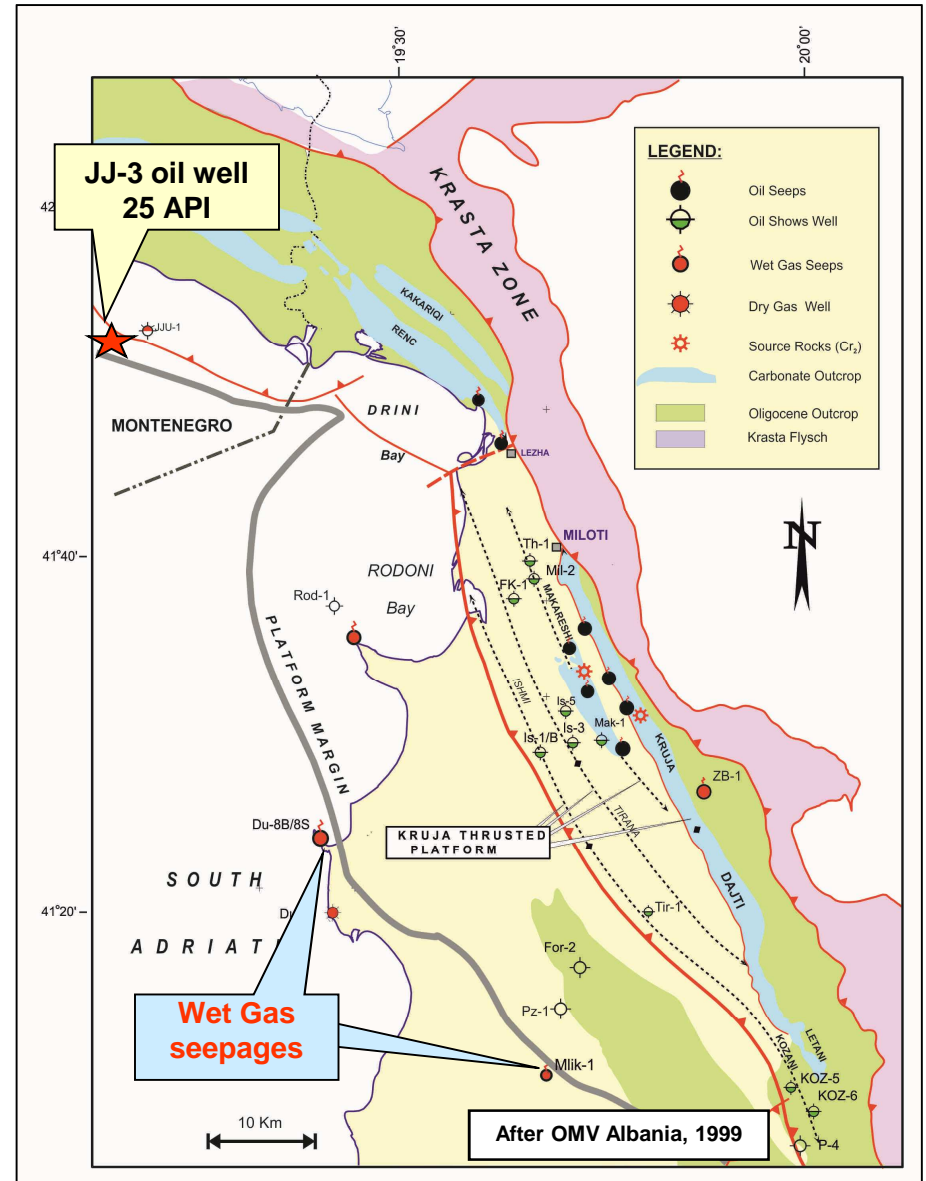
# HC shows

## Correlative to U. Cretaceous SR

- Abundant oil and wet gas shows in the study area; the key reason for exploration although they had lean TOC and immature.
- All oil shows in onshore NW Albania/Montenegro are correlative to Upper Cretaceous SR.
- JJ-3 well – tested oil 25°API
- Wet gas seepages are related to deep rooted passive roof thrusts. The origin is assumed to be related with Oligocene shales SR (Rupelian age).

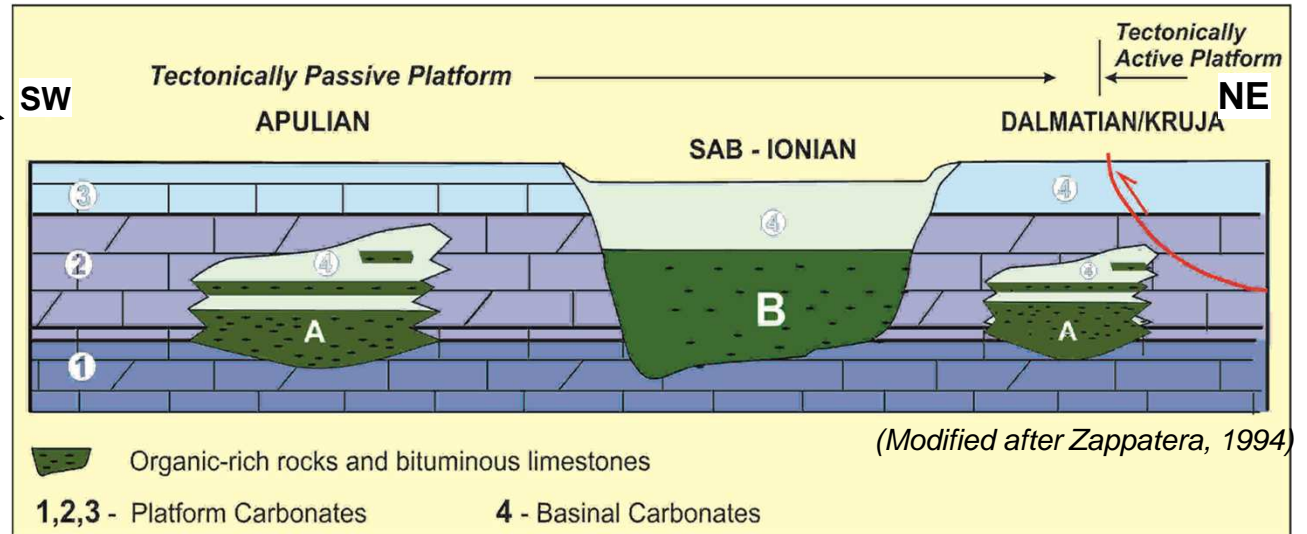
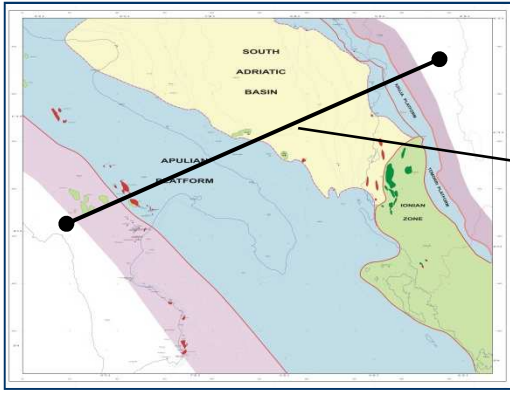


The encountered Cretaceous SR show lean TOC.



# Source Rock

## *TR-Liassic as key Mesozoic SR in Adria plate*

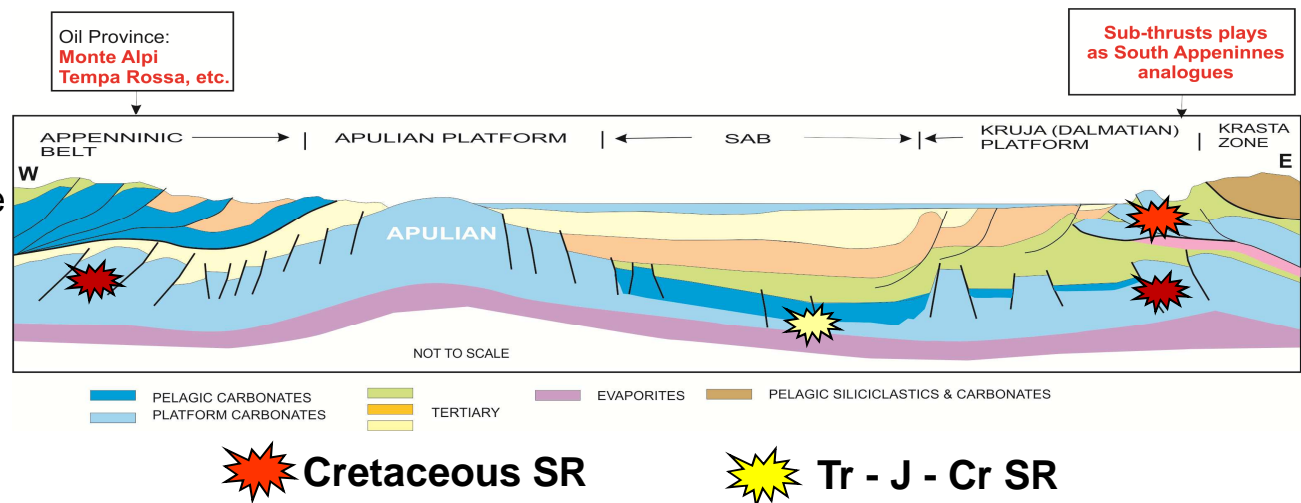


### ➤ Two major SR episodes:

- Tr-Liassic and J – Cr
- Organic rich SR, on Western ramp of Apulian platform sealed off by platform carbonates, are source of oil generation for large discoveries in Southern Apennines.

### ➤ Analogue SR are assumed to develop on the Eastern ramp of the Apulian plate (NW of Albania, Montenegro, JJ3 well).

### ➤ The Cretaceous SR are at oil window at 6 km depth (low geothermal gradient of 16o/1000m or less).



# Analogue Plays

## NW Albania-Montenegro vs South Apennines

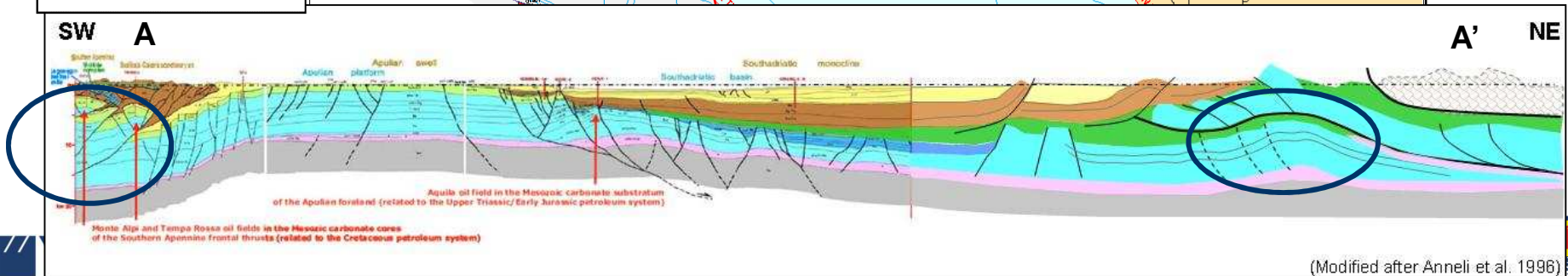
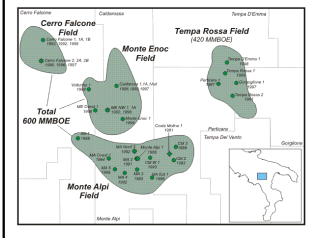
**Southern Apennines** discoveries;  
> 2,000 MMboe in place, stretched  
over an area approx. < 1,000 km<sup>2</sup>.

**NW Albania-Montenegro** as mirror  
image of Southern Apennines.

- Share the same reservoirs;
- Same mechanism of inversion;
- Oligocene excellent top seal
- The area of interest ~3,000 km<sup>2</sup>.

**Ionian Production Province**  
> 7,000 MMboe barrels of  
heavy/light oil in-place.

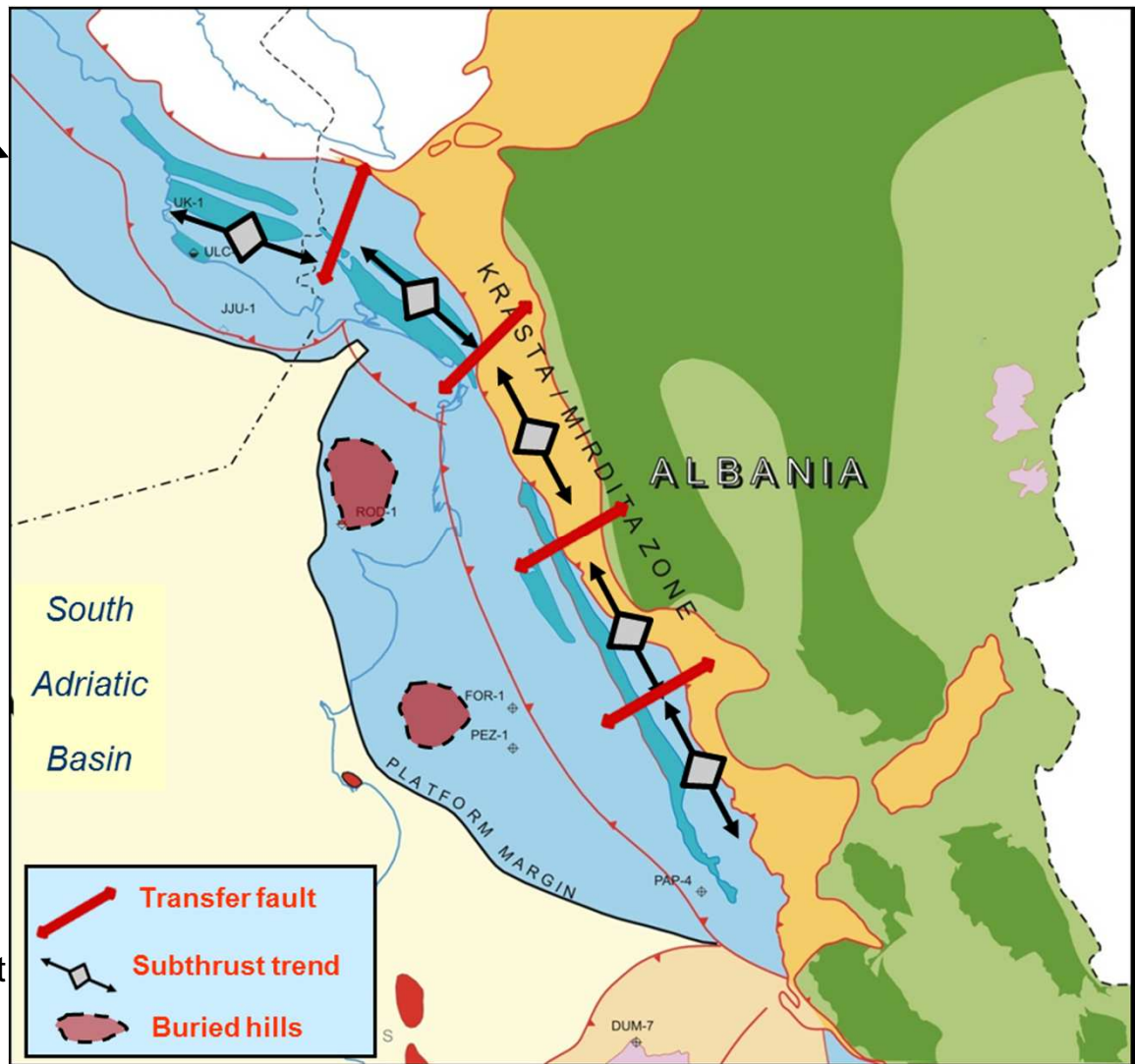
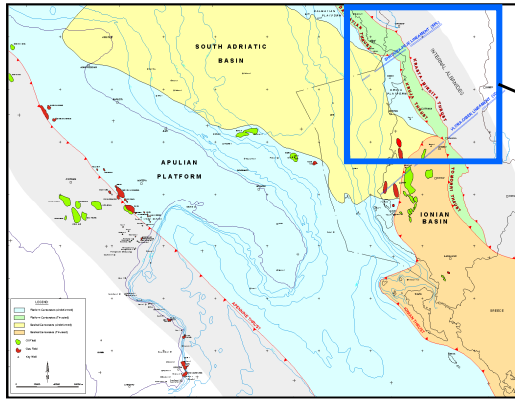
Figure 4: Val D'Agri Area Wells



(Modified after Anelli et al. 1996)

# Buried hills and subthrust targets

## *Spatial distribution along anticlinorium*



- Existing G&G data allows prediction of the spatial distribution of subthrusts along the anticlinorium.
- Potential sub-thrusts follows:
  - the SW-NE strike orientation
  - transfer faults accommodate their distribution along strike
  - avg. depth of top reservoir: ~ 5 - 6 km
- The predictive work will help mitigate cost and risk related to future exploration activity.

# Conclusions

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- The Dalmatian-Kruja thin-skinned geometry is largely controlled by the pre-orogeny Mesozoic architecture. Exploration of this play type is of high risk, mainly due to low/immature SR presence and lack of top seal.
- In contrast, the deep-seated, inverted and thrust platform carbonates are structural analogues to the large discoveries in the Southern Appenines and could become key plays for HC exploration in the region.
- The proposed model can incorporate further refinements for the target depths and spacial distribution of possible traps along the 'anticlinorium' through additional exploration efforts.

# Thank you!

Thanks to OMV A.G, Austria for allowing me to share the results with you!