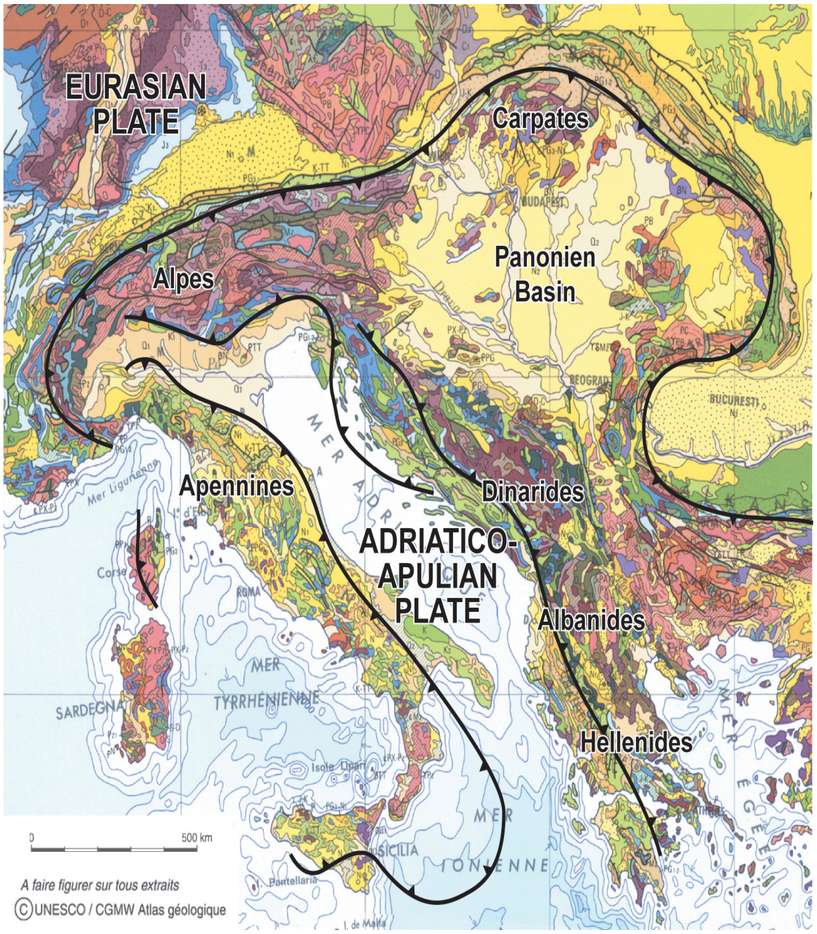
GEOLOGICAL OVERVIEW

I. REGIONAL STRUCTURAL SETTING

The relative movements of the Adriatico-Apulian sub plate, in between, the Euro Asiatic and African plates during the period of time from Mesozoic to Tertiary, mainly controlled tectonic evolution of the Albanides.



During the Jurassic and most of the Cretaceous the Adriatic-Apulia sub-plate moved in the east and northeast direction, relative to Euro Asia. At this time it was mainly affected by the extensional tectonics, thus forming a series of parallel ridges and furrows. Owing to the different depositional environments, these alterations of horst and graben structures formed a series of tectonic zones with alternating deep and shallow marine lithofacies. As result of a further Adriatic-Apulia sub plate movement towards SE during the Late Cretaceous, the tectonic style changed from **extensional** to **compression.**

During the Neogene's the northwards movement of the African Plate, enhanced compression, leading to a large scale folding and thrusting in the SW direction in Albania and NW of Greece.

Fig.2 Regional Setting of Albania

The above mentioned compression tectonics, with over thrusting towards SW, formed the southern branch of the Mediterranean Alpine thrust belt, which comprises a continuous mountain range from Dinarides in the North, in former Yugoslavia, to the Albanides, in Albania, and the Hellenides in North West of Greece.

The thrust zone complex of the Albanides comprises two major units: the Internal Albanides in the eastern part of Albania and the External Albanides in the western part of Albania

The Internal Albanides are characterized by a developed magmatism and by the intensive tectonics which has led to the over thrust and tectonic napes.

The Internal Albanides are further subdivided from East to West into the Korabi (**KO**), Mirdita (**M**) (main ophiolite bearing zone), Albanian Alps (**A**), and Gashi (**G**) zones.

The two post orogenic sedimentary basins: Burreli Basin **(U2)** in the north and Korca Basin **(U2)** in the south-eastern part of Albania, overlie transgressively the Mirdita zone and partially the Krasta-Cukali zone.

Even though, **the External Albanides** are characterized by the lack of magmatism and by more regular structural models, as in the Internal Albanides, they are highly affected by a considerable thrusting of the tectonic zones and/or structural belts westwards.

From east to west, the External Albanides comprise the Krasta-Cukali (**K-C**) zone, the Kruja platformic zone (**Kr**) and, further to the west the Ionian trough **I** and Sazani platformic zone (**S**).

Northwards the overlying Peri Adriatic Depression (**U1**) masks the Ionian and, partly Kruja tectonic zones. Westwards offshore, the Peri Adriatic Depression is unified with the South Adriatic Basin, which overlay the Preapulian (Sazani zone) and Apulia Platform.

All the above mentioned SW-NE trending thrust belts (in which the over thrusting occurred from East to west) are interrupted in the north by Shkoder–Peje [Scutari–Pec **(1)]** Lineament and the Vlore-Elbasan lineament **(2)**

In the central part of Albania, both two lineaments have a SW-NE trending.

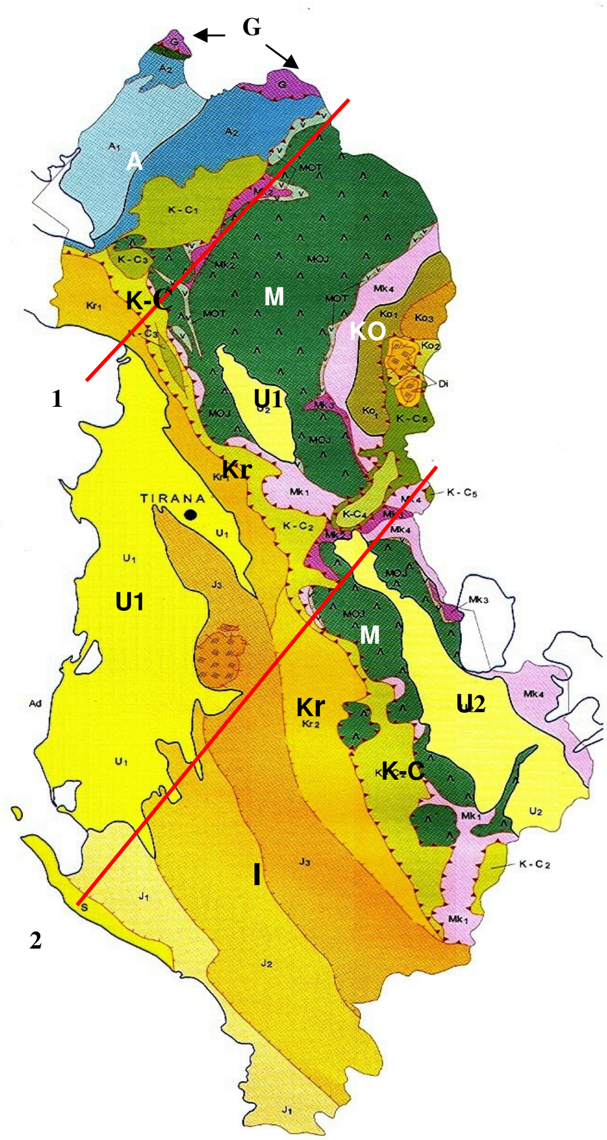


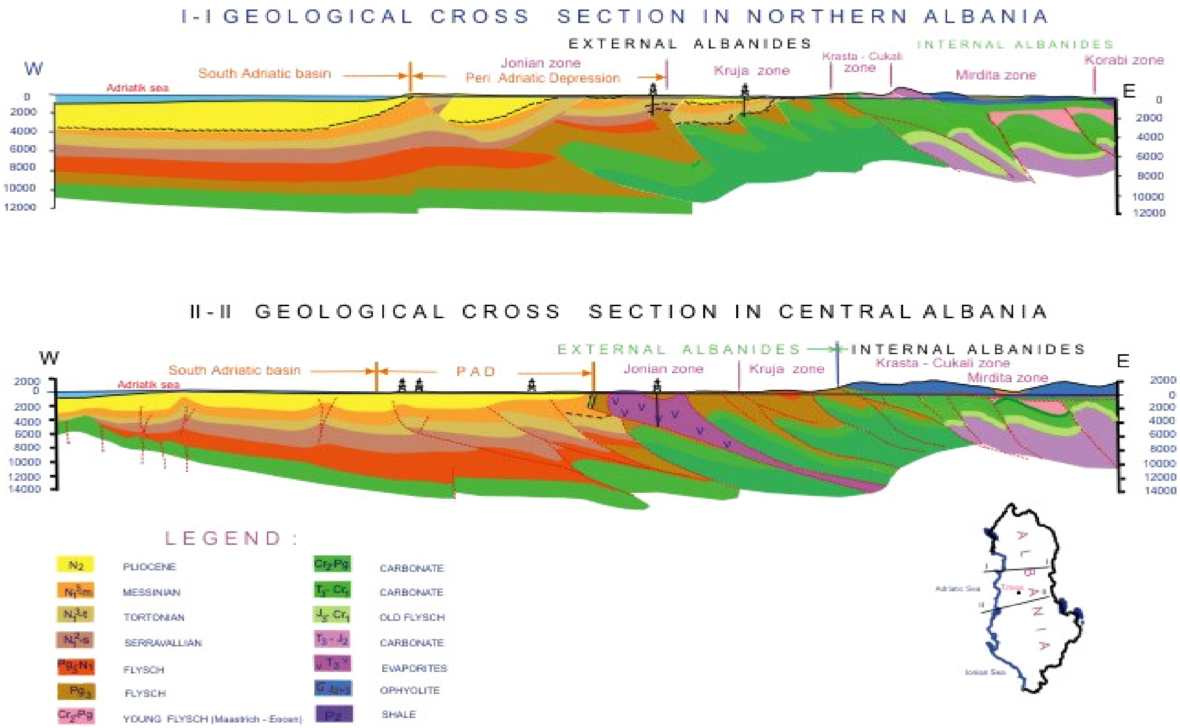
Fig.3 The structural-tectonic units in Albanides

II. TECTONIC STYLE IN ALBANIDE

The subduction of the thinned continental crust at the margins of the Apulia-Adriatic plate resulted in a large amount of horizontal shortening by the formation of thrust belts.

Except for over thrusting in the SW direction, some differential horizontal displacement occurred, causing local rotation of the mountain fronts and thus to the formation of mountain arcs. The Triassic evaporates formed the main gliding planes for over thrusting.

Locally the thick Triassic evaporate did not only played the role as a gliding plane, but pierced as a salt domes into flysch and/or molasses and eventually reached the surface as it is the case in Dumrea salt dome or in some other places in the south of Albania.
The mountain front and fold belts in Albanide and especially in the External Albanides comprise the main features of a thrust system, including, back thrusting and triangle zones,



see fig.4 & 5 .

Fig. 4 Geological Cross sections in the Northern and Central part of Albania

Thrusting of tectonic zones (and their structural belts or individual structures) on one another westward, represents one of main tectonic features in Albanides. There are some evidences on the surface showing thrusting westward. The flysch deposits of Okshtuni window (Krasta Cukali zone) in the Peshkopi region (Mirdita zone) indicate for a relative thrusting amplitude of the Mirdita zone about 40 km westwards.

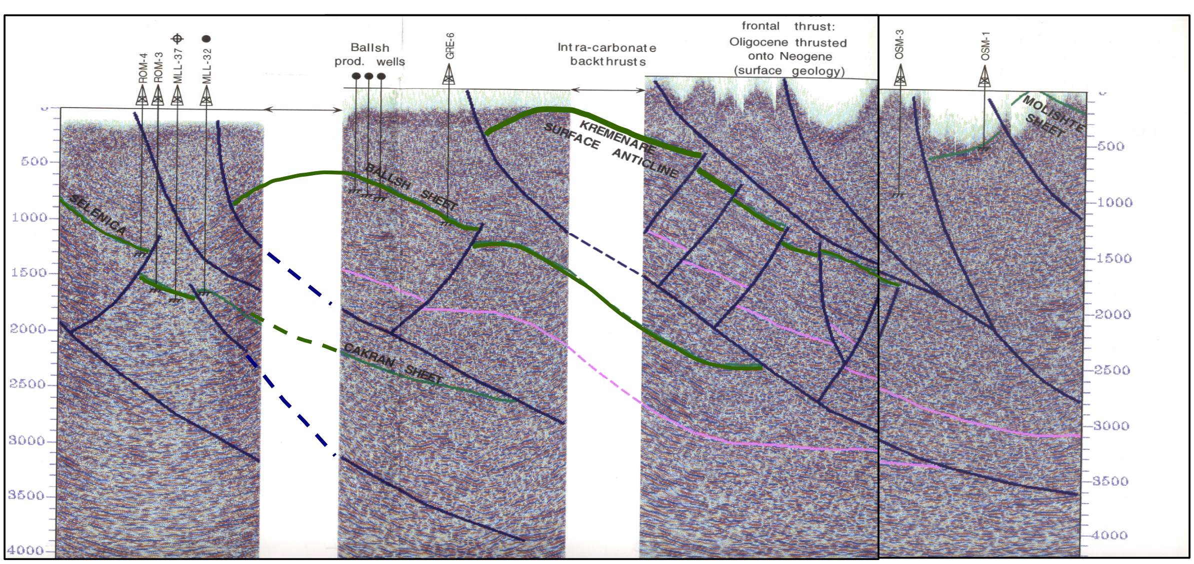


Fig. 5. Cross Section through Ballshi Oil Filed (Block 3 Onshore)

The presence of Mirdita, Krasta Cukali and Ionian zones at the same place in the Leskoviku region shows an horizontal thrusting amplitude of the Internal Albanides over the External ones at the range of 50-60km. Thrusting westward is proved as a common geological model in Albania in most of the oil fields discovered in Albania as it shown in the figure-4

In the following figures clearly can see relation between *Apennines and Albanides, by Carminati et al., 2004*

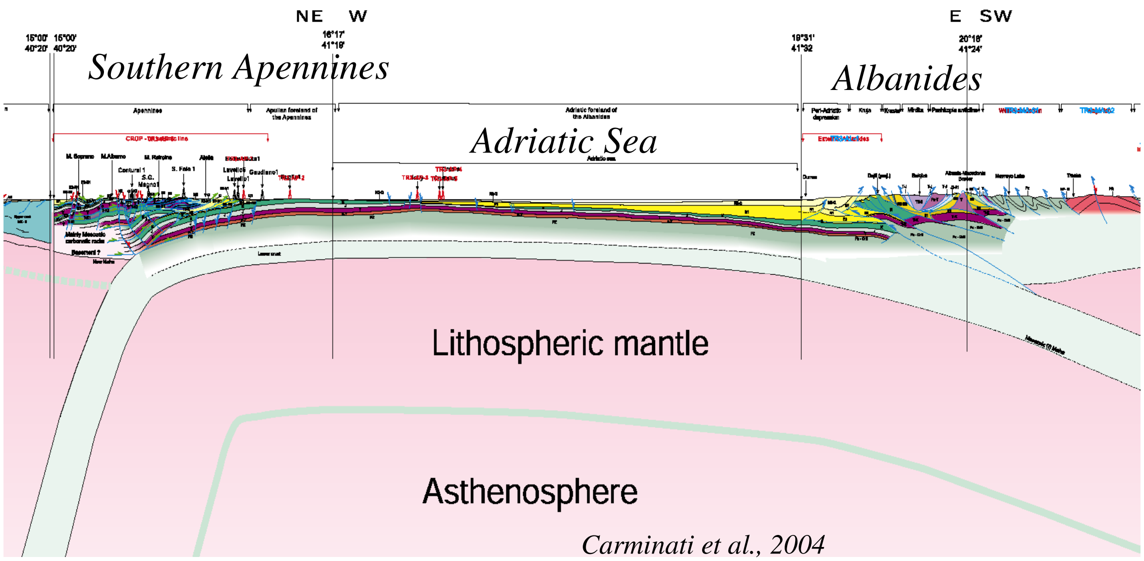


Fig. 6. Relation between Apennines and Albanides

III. STRATIGRAPHY

The sediments ranging in age from Paleozoic to Quaternary included are encountered in Albanides.

The metamorphic rocks, consisting of terrigenous, effusive and rare carbonate rocks are encountered in the Internal Albanides (Korabi Zone) and they belong to the Paleozoic age.

The evaporate formation which consists of salts, anhydrites etc, belong to Permian–Triassic ages is mainly encountered in the Korabi and Ionian tectonic zones.

The ophiolit formation, which consists of plutogenic and volcanic faces, belongs to Middle Upper Jurassic age and is widely spread in the Internal Albanides, especially in the Mirdita tectonic zone.

The carbonates sediments are widely spread in the External and Internal Albanides. This formation is related to the Mesozoic (Upper Triassic to Oligocene) age and is represented by limestone of different kinds and dolomites. The carbonate formation in the external Albanides (Ionian zone) is of Upper Triassic-Eocene and belongs to pelagic faces. Its thickness varies between 2100-2850m.

The flysch formation is identified with the so-called **Early flysch** which belongs to the Upper Jurassic-Lower Cretaceous is encountered in Krasta-Cukali and Mirdita zones, while the ***Young Flysch*** (of Mastrichtian–Eocene age) was formed in Krasta-Cukali and Albanian Alps.

In the External Albanides and particularly in Kruja and Ionian tectonic zones the flysch formation is of Oligocene age and is widely spread on the surface with a total thickness varies 1000-3000m which is reduced from east to west.

The Pre-molasses formation, consisting of marls, marl clays, sandstone, and lithotamnic and organogenic limestone belongs to Acquitanian-Burdigalian- Early Serravalian in age and is encountered in the External Albanides especially in the western part of the Ionian zone and Sazani as well. The thickness of Pre-molasses formation varies from 850m in the East up to 2300-2500m in the West.

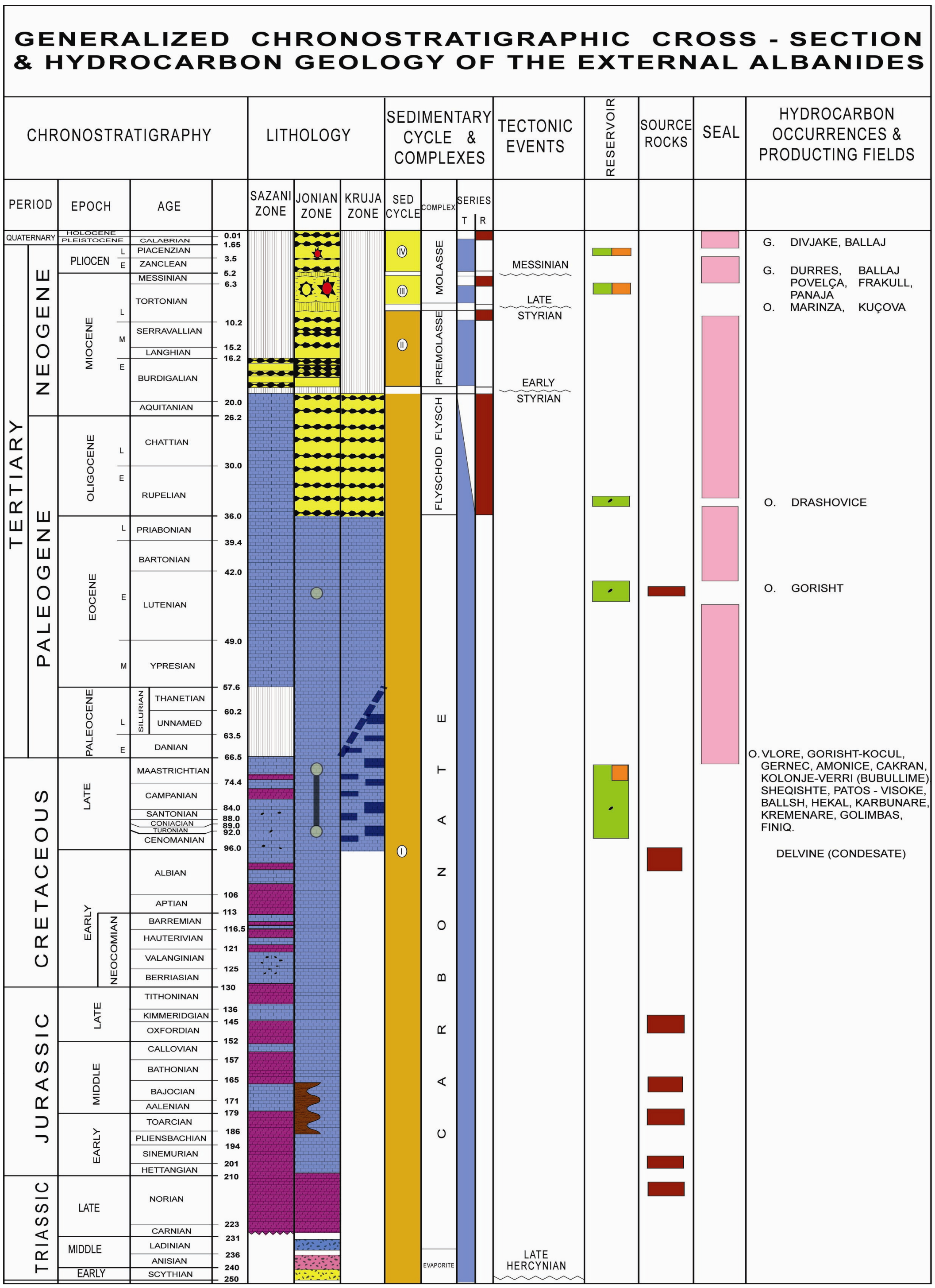


Fig. 7. Generalized Chrono-stratigraphic Section -External Albanides

IV. PETROLEUM GEOLOGY

IV.1. SOURCE ROCK LEVELS

Several source rock levels have been observed in outcrops of different zones in Albanide.

In the Ionian zone: black shale intercalations of Late Triassic from thin centimeters to thick organic–rich layers, comparable to those of Burano formation (Early Triassic) in Southern Italy, have been encountered.

In Cika belt Early Triassic source rocks have a gross thickness of up to 15m. Based on the outcrop samples TOC=0.1-38% have been recorded for these source rocks. In the basal Jurassic similar intercalations with higher TOC values (up to 52%) have been recorded. the Sazani zone only one Triassic level has been recognized. The Toarcian limestone comprises a somewhat thicker and locally more organic–rich interval, corresponding to the widespread Posidonia Shale's. **(Table 1).**

In the Shpiragu-1 well a 600m gross interval was recorded with posidonia shale interlayer. In Middle and Jurassic and also in the Late Jurassic some further thin, organic- rich shale intercalations with maximum TOC =9% have been evidenced. A couple of thicker bituminous shale/limestone intervals are known from the Lower Cretaceous with maximum TOC =27% have been recorded. They probably correlate with similar organic-rich deposits from Peri Adriatic carbonate platform of Former Yugoslavia.

TABLE 1. Source Rocks in Albanide

No	ZONE	AGE	LITHOLOGY	SAMPLE LOCATION	TOC (%)	HI MgrHc/gr	Tmax	KEROG TYPE	VR/E
1	Sazani	Upper Triassic	Dolom/ Shale	Well	0.16-1.72	162	424	II/III	0.87
1	IONIAN	Upper Triassic	Shale/Clay/limes	Outcrop	0.02-38.5	617	416	I	0.54-0.88
2		Lower Jurassic	Dolomite Shale	Outcrop	0.0.1-52	450	434	I/II	0.55-0.75
3		Toarcian	Possidonia Shale	Outcrop	0.09-3.7	588	432	I/II	0.5-0.6
4		Middle Jurassic	Clay	Well	2	505	424	II	0.57
5			Shale	Outcrop	0.04-9.4	508	432	I	0.52
6		Upper Jurassic	Shale	Outcrop	0.03-5.9	520	430	I	0.45-0.57
7		Lower Cretaceous	Shale	Outc/ Well	0.02-27	521-700	413	I/II	0.45-0.54
1	KRUJA	Upper Cretaceous	Dolomite/shale	Outcrop	0.18-4.2	540	427	I/II	0.3-0.403
1	IO,KR,SA PAD	Aquitan/Burdigal	Clastic	Outc/ Well	0.19-1.72	71	434	III	0.4-0.5
2		Tortonian-Pliocene	Clastic	Well	0.05-1.62	34.8	431.5	III	0.330-0.28
1	KRASTA CUKALI	Triassic - Jurassic	Shale	Outcrop	7.48	85.27	463	III	0.64

2		Cretaceous-Paleogene	Shale	Outcrop	0.5	16.28	455	III	0.52
1	KORABI	Silurian	Black Shale	Outcrop	2.48	0	548		2.747

In Sazani the upper part of the Triassic carbonates includes organic-rich dolomites /shale with TOC up to 1.72%.

In Kruja zone some Maastrichtian and Eocene organic rich dolomites/shale have been observed in the outcrops. No rocks older than Upper Cretaceous have been encountered in the Kruja zone but additional deeper and older source rock levels cannot be excluded in this zone.

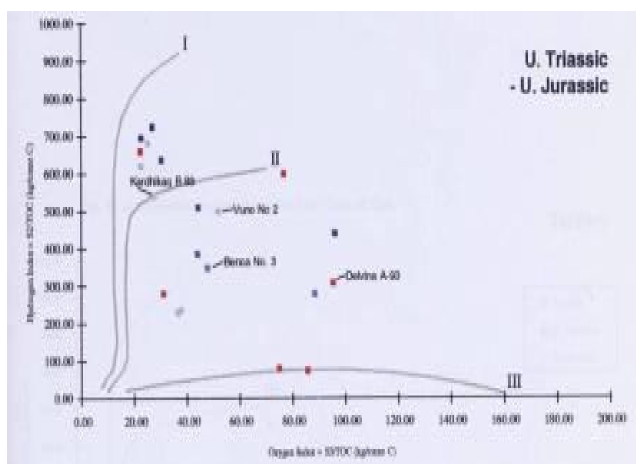
In Krasta Cukali zone two source rock levels are proved. The first level is related to bituminous shale of Triassic-Jurassic (TOC=7.48 %), while the second one is related to the bituminous shale of Cretaceous-Paleocene (TOC=0.5 %).

In Internal Albanides the only source rock level is related to the black shale within Silurian deposits in Korabi zone (TOC=2.48 %).

In Tertiary section, a dispersed organic matter throughout the entire section has been recognized. Some lignite's and brown coals levels have been identified in the Ionian zone and Peri Adriatik Depression. They mainly occur below the evaporates, in the deltaic sediments of the Early Messinian, and also in the similar deposits of the Pliocene. Regarding the dispersed organic matter, the geochemical analysis indicates that Aquitanian/Burdigalian section is slightly richer than the upper part of clastic section from Serravalian to Pliocene included.

IV.2. SOURCE ROCK QUALITY

Good to excellent quality, of type I/II source rocks are present in the Upper Triassic, Lower Jurassic and Lower Cretaceous of the Ionian Zone. The Toarcian, Middle Jurassic and Upper Jurassic of the Ionian Zone and the Upper Cretaceous of the Kruja zone, contain poor to good quality type I/II source rocks for oil. (Fig .8)



In Krasta-Cukali type III source rocks are able to generate gaseous hydrocarbons.

The Tortonian to Pliocene Terrigenous section of the Peri Adriatic Depression is of poor to very poor type III source rock for gas. The Aquitanian/Burdigalian is slightly better than the Serravalian/Tortonian to Pliocene sequence.

Fig.8. Upper Triassic-Jurassic S.Rocks(Ionian Zone)

IV.3. SOURCE ROCK MATURITY

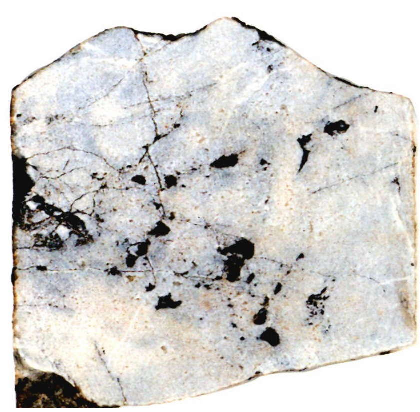


Fig.9 Core sample from Porcellanous limestone (Gorishti Oil field)

The outcrops Upper Triassic and Lower Jurassic source rock levels in the Ionian zone show mature for oil generation (VR/E 0.53-0.88)

In Krasta Cukali, the source rocks with VR/E=0.64-0.52 %, have reached the maturation stage.

The source rock related to the black shale within Silurian deposits in the Korabi zone (VR/E =2.47 %), show that this source rock has generated its entire hydrocarbon potential.

The presence of gas, bitumen and very rarely oil shows encountered in the Internal Albanides (Block 8, 7, 1) indicates the presence of the source rocks that have generated gaseous and liquid hydrocarbons.

IV.4. Reservoir

Oil and Gas reservoirs have been proved in both the deeper marine carbonates of the Ionian zone and in the clastic section of Peri-Adriatic Depression.

The limestone reservoir in Albania range in age from Cretaceous to Eocene, it is virtually clay-free, massive and represented by micritic and clastic limestone. The main type of reservoir consists of fractured carbonates, going deeper from the Eocene-Paleocene to Cretaceous is noted that the reservoir storage capacity, is largely improved, because increasing of the secondary porosity, which consists of fracture, and vuggy porosities. From some well cores analysis of Cakran oil field, the matrix porosity result to be mainly 2,5% going up to a peak 6% for a couple of samples.

Also, from the well core measurements in of the Paleocene reservoirs belonging to the Ionian zone (Kurveleshi belt), the fracture porosity resulted to be at a range between 2, 4-2.5%.

The Upper Cretaceous reservoir in Kruja zone, consisting of dolomites and dolomites limestone, has not been penetrated by any well, thus they are described from outcrops. Considering the fact those reservoirs in Kruja belonging to neritic platformic facies, good to excellent reservoir properties are expected to be found there.

From the well cores of the Upper Triassic-Lower Jurassic reservoir in Sazani zone, the effective porosity consisting of: intercrystalline, fracture, and vuggy porosities range from 2-10.5%. In the Lower Cretaceous reservoirs (Sazani zone) the fracture and intercrystalline porosity ranges from 2.6-7.9%, whereas for the Paleocene–Eocene reservoirs fracture porosity varies from 09-1.3%.

The matrix porosity and vuggy porosity of the Upper Cretaceous reservoirs as measured In A4-1x well cores are respectively 4.3 -10% and 6-7%. In the Upper Cretaceous (Apulia Platform) reservoirs consisting of dolomites limestone of A5-1x well (Block JONI-5) the total porosity are 13.6%

Reservoir in some oil fields in the central part of Albania is related to Miocene deltaic sandstones with porosities ranging between 10-30% and permeability's 200-2000md, such as in Marinza, Patos and Kucova fields. Reservoir in the gas fields of Peri Adriatik Depression is related to molasses sandstones of Late Miocene of Tortonian-Messinian in age or in turpitude sandstones of Pliocene age, with porosities ranging between 12 - 37%.

IV.5. SEALS

Flysch and flyschoidal deposits of Oligocene-Miocene are proved to be as an excellent seal in the existing oil fields in the Ionian zone.

Considerable clayey thickness of Tortonian-Pliocene is proved to be a good seal for the gas and oil fields in Peri-Adriatic Depression.

The following can also predicted as a good seals:

Clayey-marl shale of Toarcian, cherty packets of Jurassic and clayey shale of Lower Cretaceous within carbonate formation in the Ionian zone.

The Old flysch of Jurassic-Cretaceous in Mirdita and Krasta zones and the Young flysch of Mastrichtian-Eocene in Krasta-Cukali and Albanian Alps zones.

IV.6. HYDROCARBON OCCURRENCE IN ALBANIA

Albania was established as a Hydrocarbon bearing province as early as Roman times, when heavy oil and asphalts of Selenica mine were used for lamps.
The first oil Discovery in Albania happened in 1918, in Drashovica Oligocene flysch.

In 1927, 1928 **Kucova** and **Patosi** oil fields were discovered, followed by **Marinza** oil field (the biggest oil field in Albania) which was discovered in **1957(Fig. 10)**

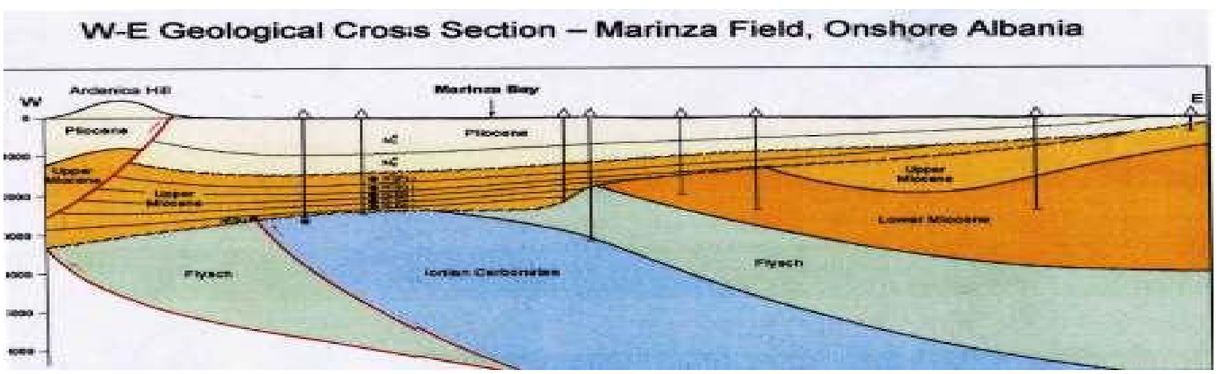


Figure 10

In these fields the oil was found to be reservoir in the sandy layers of the Upper Miocene, and was charged from the underlying Ionian Mesozoic limestone of Kucova and Visoka.

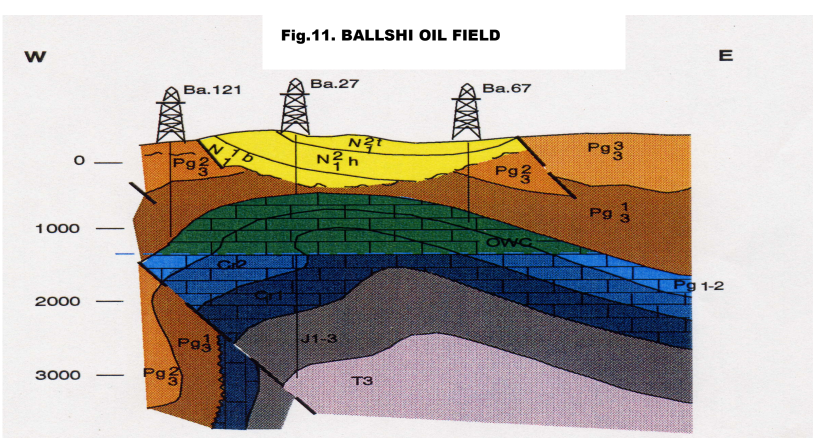
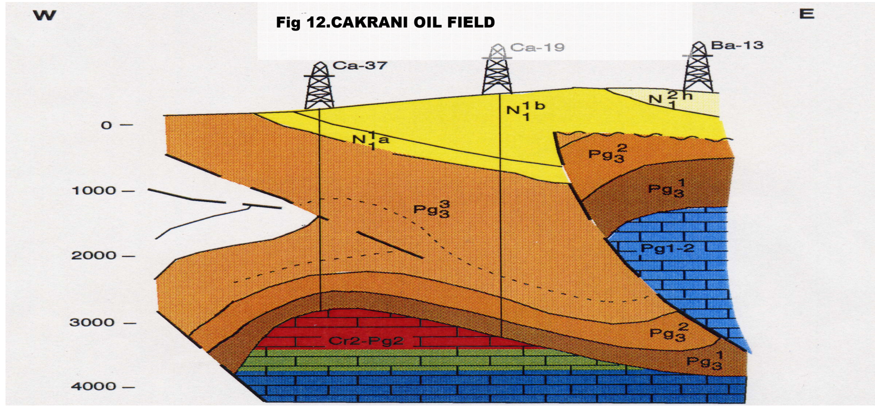


Fig.11. BALLSHI OIL FIELD

During the early 1960's when the seismic survey began to reveal a more realistic picture of the subsurface structures under the Patos-Marinza complex and other areas, significant discoveries within deeper seated carbonate reservoirs were brought on stream.

Visoka oil field (1963,) was the first discovery, which proved a **new HC play type** to be related to the fractured carbonate reservoirs of Cretaceous-Eocene age, underneath the clastic section.

Visoka Discovery was followed by other discoveries in the fractured carbonate reservoir such as: Gorishti-Koculi (1965), Ballshi-Hekal (1966), Finiq-Krane (1974), Cakran-Mollaj (1977), Amonica (1980) and Delvina (1987).Fig 11,12.



With the first Gas Discovery (1963) in the Tortonian sandstone layers of Divjaka, other gas fields respectively: Frakulla (1972), Ballaj 1983, Povelca and Panaja gas fields in 1987 and Durresi (1988) were discovered in the Peri Adriatic Depression .Fig 13

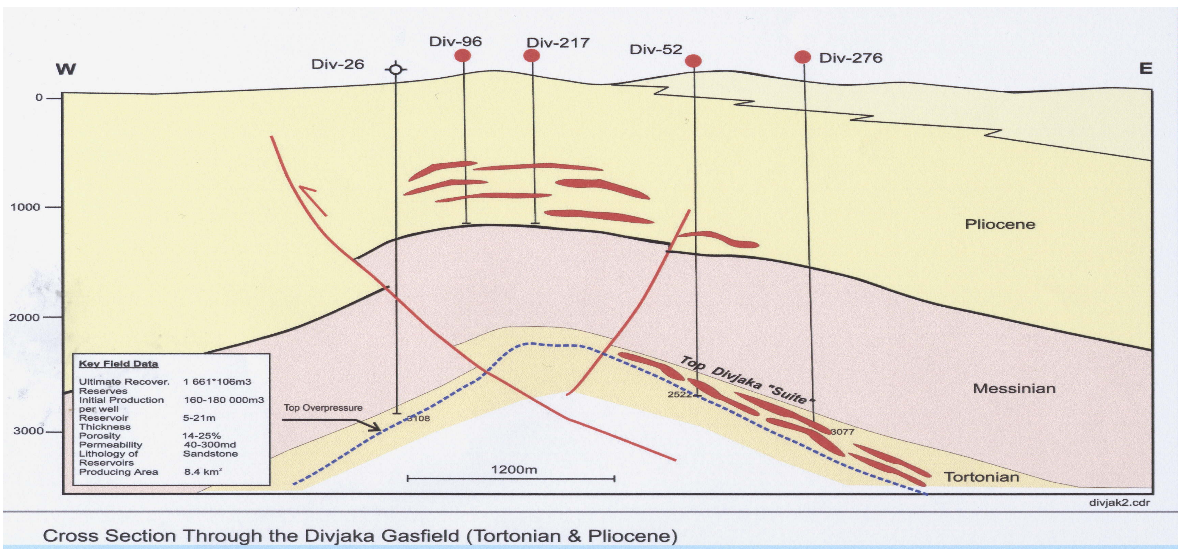


Fig 13. Cross section through Divjaka gas field

The A4-1x well drilled (1993 by AGIP and Chevron in offshore Albania (Adriatiku-4) proved to be as a light oil (condensate) and gas bearing in Messinian clastic reservoir.

The first oil discovery onshore Albania was made by OCCCIDENTAL of Albania in the year 2001, after the first drilling (Shpiragu-1well) into the Sqepuri structure located in the Block 2 onshore. Fig.14

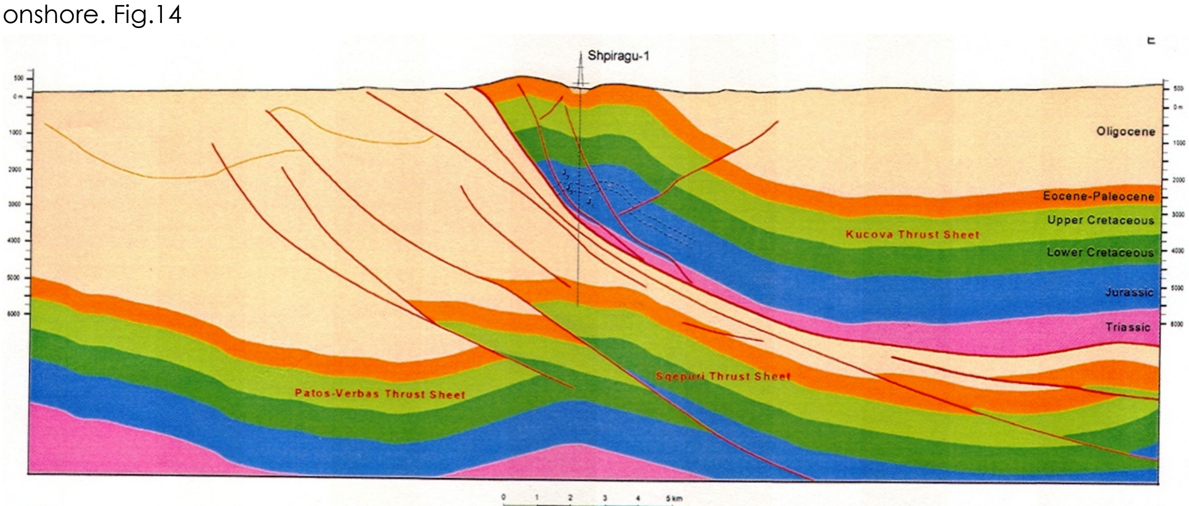
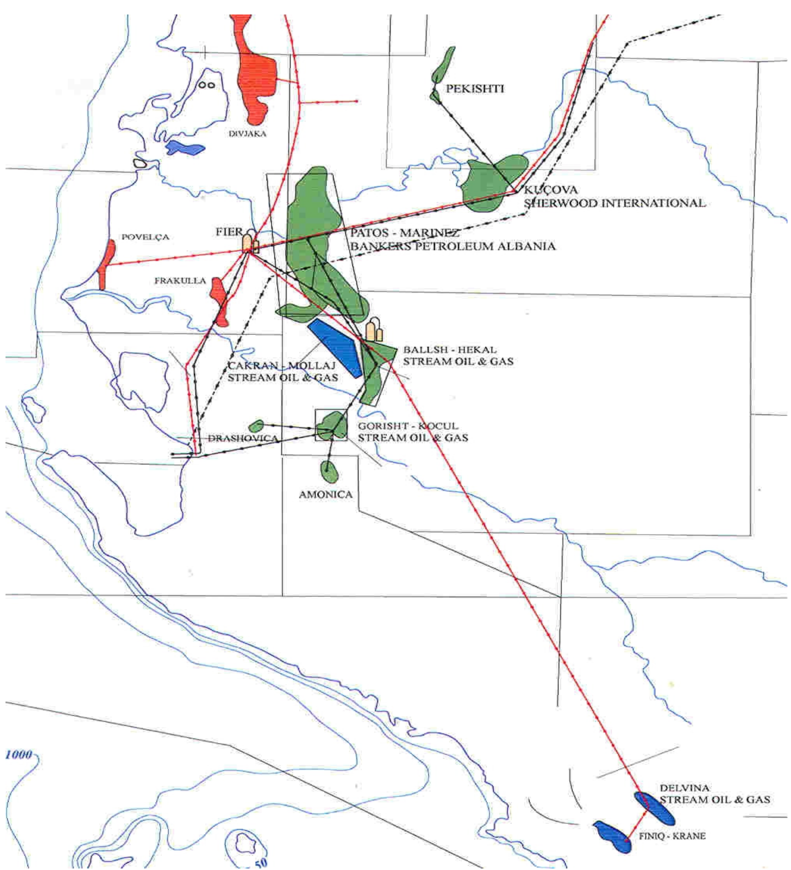


Figure 14, Cross Section through Shpiragu structure

A summary of the Exploration History in Albania is represented in the TABLE 2, while the Oil and gas filed location map is presented on figure 14

TABLE 2

FIELD	DISCOVERY YEAR	RESERVOIR TYPE	RESERVOIR DEPTH (m)	O/G GRAVITY (API)	SULPHUR CONTENT (%)
Drashovica	1918	Oligoc.flysch	100-200	Oil<10^o	?
Patos	1927	Mess-clastics	Surf. To 1200	Oil (12-24^{o}API)	2.5-6
Kucova	1928	Mess-clastics	Surf. To 1500	Oil (13-16^{o}API)	4
Marinza	1957	Mess-clastics	1200-1800	Oil (12-35^{o}API)	4-6
Visoka	1963	Cret/Eoc.Carb	800-1000	Oil (5-16^{o}API)	5-6
Gorisht–Kocul	1965	Cret/Eoc.Carb	1000-2500	Oil (17^{o}API)	6
Ballsh-Hekal	1966	Cret/Eoc.Carb	1000-3000	Oil (12-24^{o}API)	5.7-8.4
Cakrran-Mollaj	1977	Cret/Eoc.Carb	3000-4500	Oil (14-37^{o}API) Cond, 52^{o}API	0.9
Finiq-Krane	1973	Cret/Eoc.Carb	800-2000	Oil (<10^{o}API)	3.7-4.3
Delvina	1989	Cret/Eoc.Carb	2800-3400	Oil (31^{o}API) Cond, 53^{o}API	0.7
Divjaka	1963	Tort/clastics	2400-3000	Gas &Condens	Na
Ballaj-Kryevidh	1983	Plioc/clastics	300-1700	Gas	Na
Frakulla	1965	Mess/clastics	300-2500	Gas	Na
Povelca	1987	Mess/clastics	1800-3500	Gas & condens	Na
Panaja	1988	Mess/clastics	2500	Gas	Na
Ad-4 (offshore)	1994	Mess/clastics	2500-3100	Biogenic Gas & Cond, 54.3^{o}API	Na
Sqepuri	2001	Cret/Eoc.Carb	4950	Oil (37^{o}API)	2,3



IV.7. TRAP FORMATION

The main trap formation mechanism in Albania is linked to the compression tectonic regime of Alpine Orogeny, and the resulting over thrusting. This mechanism is valid not only for the carbonate reservoir fields in Albania such as Visoka, Ballshi-hekali, Cakran-Molla, Gorisht-Kocul, Delvina, Finiq-Krane, and Shpiragu Discovery recently made(2001), but as well as for the most traps concerning the clastic sandstone reservoirs proved in Albania such as Patosi-Marinza, Kucova etc.

The main folding phases responsible for trap forming in Albania are related to the geological times as follows:

- The Late Eocene/Early Oligocene
- The Burdigalian
- The Tortonian
- The Pliocene to recent

In the Dumrea region, around the salt dome, traps are also partly linked to the diapirism of Triassic evaporates, forming among others, some salt dome flank traps and traps sealed by evaporates such as proved in Pekisht-Murriz.

IV.8. CHARGING HISTORY

As generally observed in the areas dominated by thrust tectonic world wide (e.g. in Italian Apennine Fore deep) also in Albania, the geothermal gradients (around 20^0/km) and heat flow values are low.

Depending on the burial history, oil or gas/condensate has been generated.
In Albania the three main periods of expulsion occurred:

Heavy oil formed during Langhian
Heavy oil formed duringTortonian,
Light oil and /or condensate formed during and after Pliocene.

The above mentioned phases of folding and trap forming have also conditioned the respective periods of main Hydrocarbon Migration. Migration is thought to have started during the Acquitanian, but generally reached its peak during Tortonian times, and is still taking place.