"Hydrocarbon Exploration and Production in the East Mediterranean and the Adriatic Sea"

Background Paper

Prepared for IENE's International Workshop
held in Athens on April 26-27,2012

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1. Introduction

The scope of this paper is to provide a concise review of the region's geography, geology and hydrocarbon exploration and production activity. The Adriatic Sea and its surrounding landmass of Western Balkans together with the East Mediterranean basin have a unique feature in that they combine frontier area characteristics yet they remain part of the European continent. In that sense their hydrocarbon potential although promising, remains largely unexplored and production for both oil and natural gas remains minimal. As it is mentioned in IENE's latest study of the region, in the "SE Europe Energy Outlook 2011," the region is to a very large extent energy import dependent, primarily on hydrocarbons. As it is shown in Table 1 the region in the reference year 2008 consumed on a daily basis some 1.759.050 million barrels of oil but produced only 168,650 bbl/ day. That means it is dependent to the extent of 90.42% on oil imports while the situation in natural gas is equally bad from a dependence point of view, with consumption nearing 67.0 billion cubic meters (BCM's) per year and local production of only 14.84 BCM's, again for the year 2008. Therefore, S.E. Europe as a whole is 77.84% dependent on natural gas imports. With the exception of Romania which is an oil and gas producer and covers some 42.4% of its needs from indigenous production all other countries (although some of them like Albania, Croatia, Serbia and Turkey produce limited quantities of oil and gas) are above 90% dependent on imports, while half of them are almost 100% oil imports. The same goes for natural gas with some countries including Bulgaria, FYROM, Serbia, Greece and Turkey being almost 100% dependent on imports.

In view of their large hydrocarbon dependence there is every reason for these countries not only to try and diversify their imports, e.g. by importing gas from neighbouring countries, but also for gradually increasing the portion of indigenous hydrocarbon production. Not an unrealistic proposition given the geology of the area and the high price of oil in the international markets which has been moving steadily above $100 per bbl over the last 12 months. Today, the broader Adriatic and East Med area presents considerable challenges and opportunities for hydrocarbon exploration and development in a world that remains hungry for oil and gas if we are to judge by the continuing growth in global demand and production.

According to IEA's latest Oil Monthly Report global oil demand in 2011 averaged 89.1 million barrels per day with the prospect for 2012 rising to 89.9 million barrels. While long term prospects for oil demand as outlined in IEA's 2011 World Energy Outlook, indicate that by

2030 this will have peaked at 96.9 mb/ day in the New Policies Scenarios. Hence, the potential hydrocarbon contribution of the Adriatic and East Med region is crucial in strengthening European energy security, which in a world competing for hydrocarbon resources has every advantage to see the strengthening of its indigenous oil and gas resources.

Table 1: *Oil and Gas Production and Consumption in SE Europe (2011 oil statistics, 2010 gas statistics)*

COUNTRY	OIL PRODUCTION (bbl/day)	OIL CONSUMPTION (bbl/day)	GAS PRODUCTION (bcf/year)	GAS CONSUMPTION (bcf/year)	OIL REFINING CAPACITY (bbl/day) [2009]
ALBANIA	15,500	44,000	2	1	26,000
BOSNIA & HERZEGOVINA	0	35,000	0	7	0
BULGARIA	1,000	134,000	0	77	115,000
CROATIA	13,500	113,000	67	100	250,000
CYPRUS	0	65,000	0	0	0
EGYPT	564,500	697,000	2,369	1,630	726,000
F.Y.R.O.M.	0	19,000	0	3	50,000
GREECE	1,800	336,800	0	135	423,000
ITALY	99,200	1,455,500	293	2,930	2,337,000
ISRAEL	100	237,000	114	129	220,000
LEBANON	0	88,000	0	0	0
MONTENEGRO	0	4,000	0	0	0
ROMANIA	86,900	217,000	374	455	517,000
SERBIA & KOSOVO	2,200	81,000	15	80	215,000
SYRIA	300,200	258,000	356	340	240,000
TURKEY	45,700	679,900	24	1,346	714,000
TOTAL	**1,130,600**	**4,464,200**	**3,614**	**7,233**	**5,833,000**

Source: U.S. Energy Information Administration

2· Geography

The Mediterranean Sea is an intercontinental sea, situated between Europe to the north, Africa to the south, and Asia to the east. It covers an area of approximately 2.5 million km^2.

To the west the Mediterranean Sea is connected to the Atlantic Ocean by the Strait of Gibraltar, which at its narrowest point is only 13 km wide and has a relatively shallow channel. To the northeast the Dardanelles, the Sea of Marmara, and the strait of the Bosporus link the Mediterranean Sea to the Black Sea. The Suez Canal connects it with the Red Sea to the southeast. Its deepest point is 5,267 meters (17,280 feet), called Calypso Deep, located at the Ionian Basin, 45 miles SW of Pylos, Greece.

The Mediterranean Sea is composed of two nearly equal sized basins, connected by the Strait of Sicily (a submarine ridge between the island of Sicily and the African coast). These two sub-regions are the Western Mediterranean, spanning over 0.33 million sq miles, and the Eastern Mediterranean, spanning over 0.64 million sq. miles. Each of these sub-regions is further divided into several smaller regions. The western Mediterranean has three submarine basins separated from each other by submerged ridges, including from west to east, the Alborán, the Algerian, and the Tyrrhenian basins. The Ionian Basin (northwest of which is the Adriatic Sea) together with the Levantine Basin (northwest of which is the Aegean Sea) compose the eastern part of the Mediterranean Sea. [Figure 1]

The Mediterranean was once thought to be the remnant of the Tethys Ocean. It is now known to be a structurally younger ocean basin known as Neotethys. The Neotethys was formed during the Late Triassic and Early Jurassic rifting of the African and Eurasian plates.

The sea's continental shelves are relatively narrow. The widest shelf, off the Gulf of Gabes (Qabis) on the eastern coast of Tunisia, extends 170 miles (275 km); the bed of the Adriatic Sea is also mostly continental shelf. The floor of the Mediterranean consists of sediments made up of lime, clay, and sand, under which is blue mud. The whole Mediterranean basin is tectonically active, with volcanoes and earthquakes being rather common.

***Fig. 1:** The Mediterranean Sea map. The deepest point SW of Pylos, Greece and the two basins are also shown. (Source: www.geographicguide.com, Modified by Konstantinos Oikonomopoulos)*

Many parts of the coastline are comprised of rocky shores with high cliffs. Such cliffs can be found almost in every country bordering the sea. These rocky shores are occasionally interrupted by small sandy beaches, associated with narrow valleys or small coastal plains surrounded by inland mountainous areas. Larger coastal plains with extended sandy beaches are found in regions with large rivers, such as the Rhone delta area in France, the Po plain in Italy and the entire coastline of northeast Africa.

One cannot ignore the beautiful islands of the Mediterranean when referring to the Mediterranean Sea. The Mediterranean is home to some of the major islands of the world. These include Cyprus and Crete in the eastern Mediterranean, Sicily and Malta in central and Ibiza and Majorca in the western part.

The Mediterranean Sea can be characterized as having low biomass per-unit volume, due to low nutrient levels, but high diversity, with over 10,000 marine species recorded and with a large proportion (28%) of them endemic.

Although no species disappearance has been reported in the Mediterranean Sea, changes in species composition and richness have been determined for some areas, including the introduction of exotic species (e.g. the massive introduction of tropical species from the Red Sea after the opening of the Suez Canal). Currently, there are several endangered species reported in the Mediterranean Sea, including the Monk seals, red coral, sea turtles and colonial water birds.

One of the most important habitats in the Mediterranean Sea is the large seagrass meadows that occur at depths down to 40m in the western and eastern basins. The most extensive meadows are found in Libya, Tunisia, Sicily, Sardinia, Corsica and the Hyeres Bay of France.

The main industries found in the countries surrounding the Mediterranean Sea are shipping, tourism and aquaculture and increasing hydrocarbon exploration activities.

3. Geology

The geological history of the Mediterranean is complex. It evolved in the tectonic break-up and then collision of the African and Eurasian plates and it is underlain by oceanic crust. One of the most important events during its geological history is the Messinian Salinity Crisis. It occurred in the late Miocene (12 - 5 million years ago), during which the Mediterranean Sea dried up. The beginning of this event is supposed to have been of tectonic origin; however, an astronomical control (eccentricity) might also have been involved.

The geodynamic evolution of the Mediterranean Sea was provided by the convergence of European and African plates. This process was driven by the differential spreading along the Atlantic ridge, which led to the closure of the Tethys Ocean and eventually to the Alpine orogeny. However, the Mediterranean also hosts wide extensional basins and migrating tectonic arcs, in response to its land-locked configuration. [Figure 2]

Fig. 2: *Topographic map with relief, showing Eurasian-African plate boundary. (Source: UNAVCO, 2011)*

Scientists believe that the Mediterranean Sea was mostly filled during a time period of less than two years, in a major flood that took place approximately 5.33 million years ago (Zanclean age), which ended the Messinian Salinity Crisis. Before that, the Mediterranean had undergone several cycles of drying out and replenishment of which this was the last occasion before human history.

According to this theory, when water from the Atlantic Ocean refilled the cut-off inland seas in the Mediterranean basin that had become desiccated due to increased evaporation and thus higher salinity, flooding occurred through the basin. A channel opened from the Atlantic Ocean, through the modern-day Gibraltar Strait, and carried ocean water over a distance of over 200 km.

Eastern Mediterranean

The collision between the Arabian microplate and Eurasia which led to the separation between the Tethys and the Indian Ocean took place during middle Miocene. This process resulted in profound changes in the oceanic circulation patterns, which shifted global climates towards colder conditions. The Hellenic arc, which has a land-locked configuration, underwent a widespread extension for the last 20 Myr due to a slab roll-back process. In addition, the Hellenic Arc experienced a rapid rotation phase during the Pleistocene, with a counterclockwise component in its eastern portion and a clockwise trend in the western segment. [Figure 3]

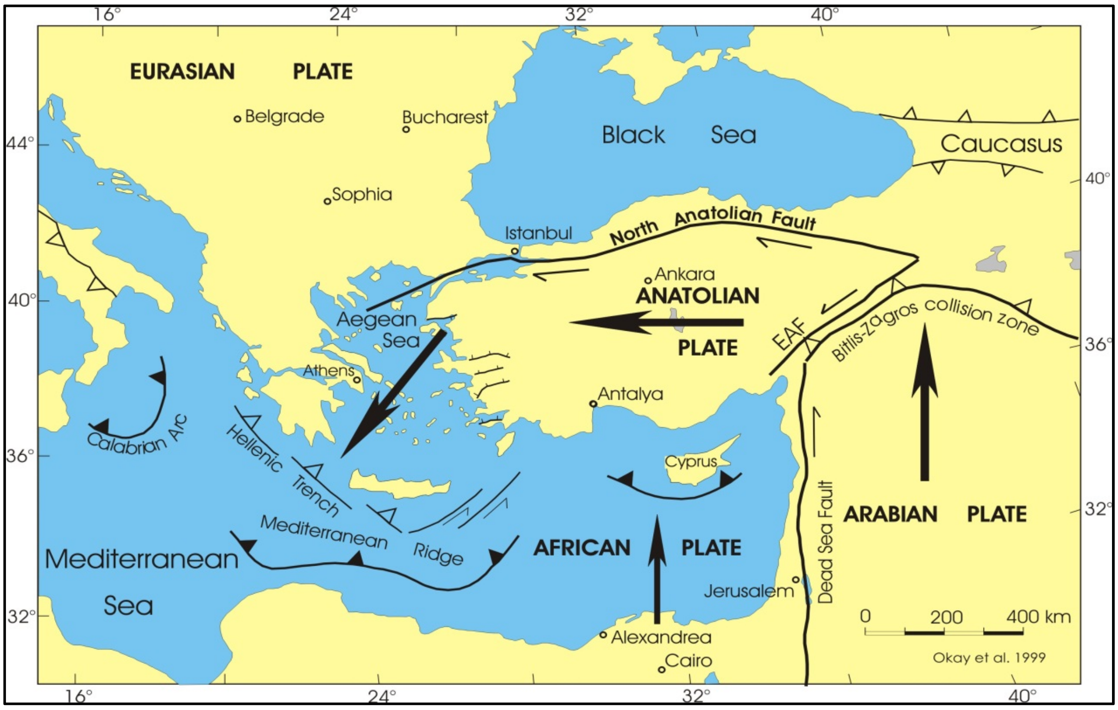

Fig. 3: *The Eastern Mediterranean Sea tectonics. (after Okay et al. 1999)*

Central Mediterranean

The opening of small oceanic basins of the central Mediterranean follows a trench migration and back-arc opening process that occurred during the last 30 Myr. This phase was characterized by the counterclockwise rotation of the Corsica-Sardinia block, which lasted until the Langhian stage (ca.16 Ma), and was in turn followed by a slab detachment along the northern African margin. Subsequently, a shift of this active extensional deformation led to the opening of the Tyrrhenian basin.

Western Mediterranean

Since Mesozoic to Tertiary times, during the convergence between Africa and Iberia, the Betic-Rif mountain belts developed. Tectonic models for its evolution include: rapid motion of Alboran microplate, subduction zone and radial extensional collapse caused by convective removal of lithospheric mantle. The development of these intramontane Betic and Rif basins led to the onset of two marine gateways which were progressively closed during the late Miocene by an interplay of tectonic and glacio-eustatic processes. [Figure 4]

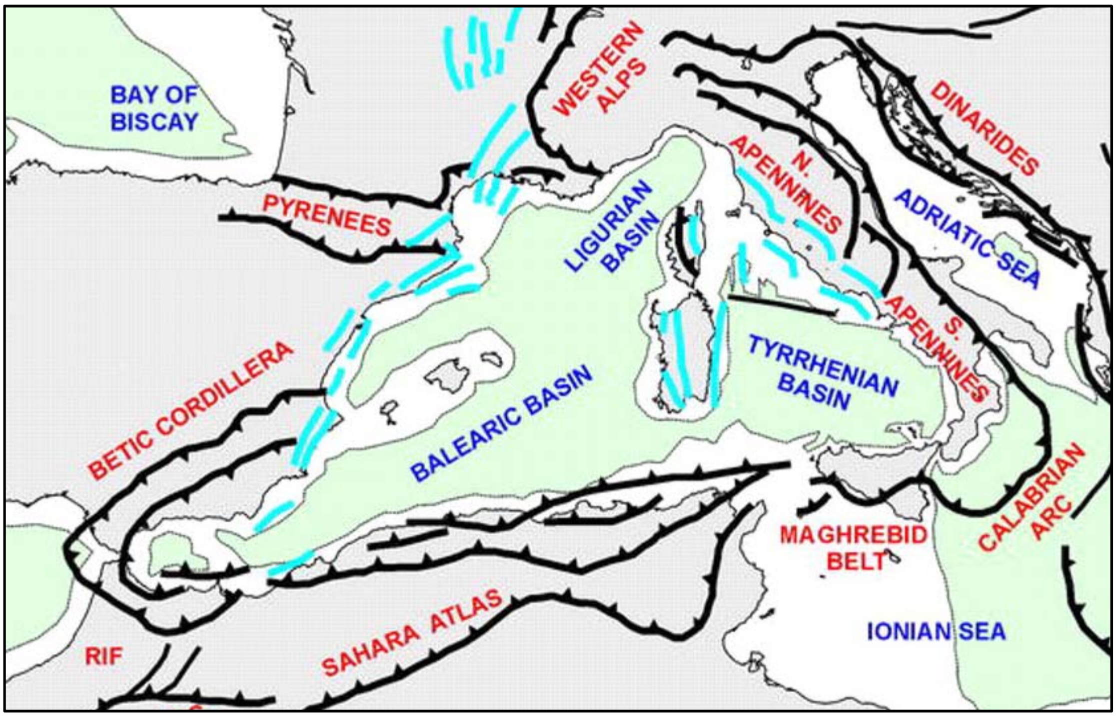

Fig. 4: *Central and Western Mediterranean Sea tectonics. (after Oldow et al 2002)*

Paleoenvironmental Analysis

Its semi-enclosed configuration makes the oceanic gateways critical in controlling circulation and environmental evolution in the Mediterranean Sea. Water circulation patterns are driven by a number of interactive factors, such as climate and bathymetry, which can lead to precipitation of evaporites. During the Messinian Salinity Crisis, evaporites accumulated in the Red Sea Basin (late Miocene), in the Carpathian foredeep (middle Miocene) and in the whole Mediterranean area (Messinian). In the Mediterranean basin, diatomites are regularly found underneath the evaporitic formations, suggesting a possible connection between their geneses.

The Strait of Gibraltar was formed during the early Pliocene. However, two other connections between the Atlantic Ocean and the Mediterranean Sea existed in the past: the Betic Corridor (southern Spain) and the Rifian Corridor (northern Morocco). The former closed during Tortonian times, thus providing a "Tortonian Salinity Crisis" well before the Messinian one; the latter closed about 6 Ma, allowing exchanges in the mammal fauna between Africa and Europe. Nowadays, evaporation is more relevant than the water yield supplied by riverine water and precipitation, so that salinity in the Mediterranean is higher than in the Atlantic. These conditions result in the outflow of warm saline Mediterranean deep water across Gibraltar, which is in turn counterbalanced by an inflow of a less saline surface current of cold oceanic water.

Paleoclimate

Because of its latitudinal position and its land-locked configuration, the Mediterranean is especially sensitive to astronomically induced climatic variations, which are well documented in its sedimentary record. Since the Mediterranean is involved in the deposition of eolian dust from the Sahara during dry periods, whereas riverine detrital input prevails during wet ones, the Mediterranean marine sapropel-bearing sequences provide high-resolution climatic information. These data have been employed in reconstructing astronomically calibrated time scales for the last 9 Ma of the Earth's history, helping to constrain the time of past Geomagnetic Reversals. Furthermore, these paleoclimatic records have improved our knowledge of the Earth's orbital variations in the past because of their exceptional accuracy.

3.1. Adriatic Sea

The Adriatic Sea is an elongated, semi-enclosed basin that includes three distinct morphological domains. The northern part has a shallow and low gradient continental shelf. The central Adriatic, the mid-Adriatic basin reaches a depth of 250 meters and it is a steeper and narrower shelf. On the other hand, the southern part is a deep basin of about 1,200 meters.

Geophysical and geological information indicate that the Adriatic Sea together with the Po Valley in Italy, are associated with a tectonic microplate that separated from the African Plate during the Mesozoic era; the Apulian or Adriatic Plate [Figure 5]. This separation began during Middle – Late Triassic, when limestone deposition commenced. From Norian to Late Cretaceous, the Adriatic and Apulia Carbonate Platforms formed as a thick series of carbonate sediments (dolomites and limestones), up to 8,000 meters. Remnants of the former are found in the Adriatic Sea, as well as in the southern Alps and the Dinaric Alps, and remnants of the latter are seen as the Gargano Promontory and the Maiella mountain [Figure 6]. In the Eocene and early Oligocene, the plate moved north and north-east, contributing to the Alpine orogeny (along with the African and Eurasian Plates' movements) via the tectonic uplift of the Dinarides and the Alps. In the Late Oligocene, the motion was reversed and the Apennine Mountains' orogeny took place. An

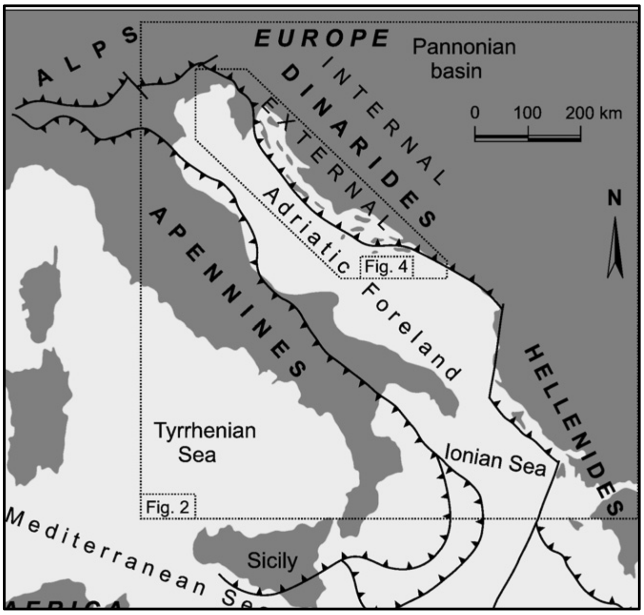

Fig. 5: The association of the Adriatic Sea microplate and the Po Valley. (after Korbar, 2009)

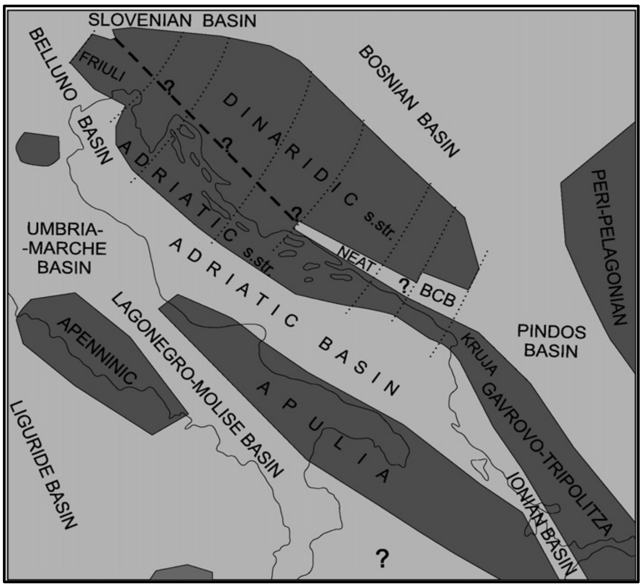

Fig. 6: The Adriatic and Apulian Carbonate Platforms. (after Korbar, 2009)

unbroken zone of increased seismic activity borders the Adriatic Sea, with a belt of thrust faults generally oriented NE–SW on the east coast and the NE–SW normal faults in the Apennines, indicating an Adriatic counterclockwise rotation. An active 200-kilometer fault has been identified to the northwest of Dubrovnik, adding to the Dalmatian islands as the Eurasian Plate slides over the Adriatic microplate. Furthermore, the fault causes the Apennine peninsula's southern tip to move towards the opposite shore by about 0.4 centimeters per year. If this movement continues, the seafloor will be completely consumed and the Adriatic Sea will be closed off in 50–70 million years. In the Northern Adriatic, the coast of the Gulf of Trieste and western Istria is gradually subsiding, having sunk about 1.5 meters in the past two thousand years. In the Middle Adriatic Basin, there is evidence of Permian volcanism in the area of Komiža on the island of Vis and the volcanic islands of Jabuka and Brusnik.

3.2. Eastern Mediterranean

The eastern Mediterranean is a small ocean basin known for its unusual tectonic complexity. It includes a short segment of the convergence boundary between Africa and Eurasia. Subduction in this segment is along two very small arcs, the Hellenic and Cyprean arcs. In both arcs subduction has been documented using bathymetric, earthquake and other data. The Hellenic arc is associated with back-arc basin and volcanism, while the Cyprean arc is not. The bathymetric and seismic patterns in the eastern Mediterranean seem to be significantly more complex than in most simple “pacific type” subduction zones. This apparent complexity has resulted in numerous tectonic models for this region [Figure 7].

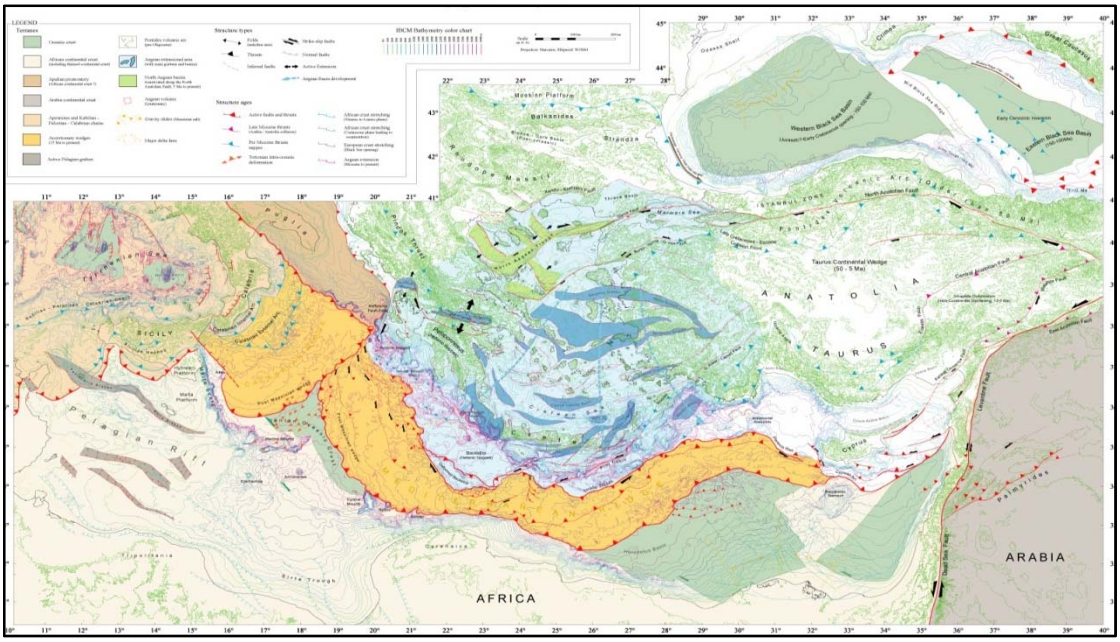

Fig. 7: *Structural map of the Eastern Mediterranean. (Source: Mémoire de la Société géologique de France2005)*

Virtually all subduction arcs are characterized by a subduction trench, a single and mostly continuous ocean deep which marks the flexure of the descending oceanic lithosphere. In the eastern Mediterranean, however, the situation is markedly different. Subduction has been documented in this region, particularly in the Hellenic arc, yet a single continuous trench cannot be traced.

The Hellenic arc is characterized by multiple, parallel and en echelon ocean deeps which follow the arc; in addition, numerous short deeps which are perpendicular to the trend of the arc are also present. Separate elevated blocks appear to be the elements causing the fragmentation of the longer deeps parallel to the arc. Generally, in the Hellenic arc, instead of one long subduction trench there are several deeps which could, probably, qualify as subduction trenches. This non-typical pattern is, probably, tectonically related and warrants an explanation. Several other bathymetric observations are of interest, For example, the different trenches are not equal in depth; in fact the outer, Strabo, trench is but a cleft in the ocean floor, whereas the one next to it, the Pliny trench, is much more distinct [Figure 8].

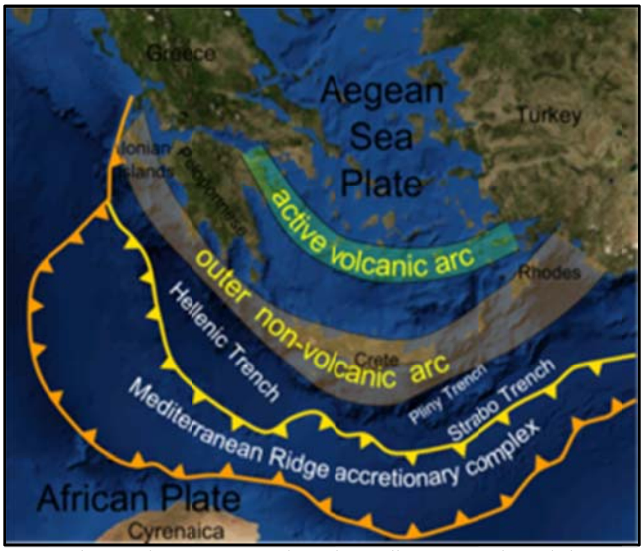

Fig. 8: *The Mediterranean Ridge, the Hellenic Trench and the volcanic arc. (Source: www.wikipedia.org)*

Equally important may be the observation of a halo of small and, in places, deep basins north of the subduction zone of the eastern Mediterranean. It could possibly be argued that some of these, particularly the shallow ones around Cyprus are equivalent to back-arc basins. The deep Finike and Rhodes basins, on the other hand, are much more difficult to account for.

Finally, the eastern Mediterranean includes a large number of elevated terranes particularly in the Ionian basin and the Hellenic arc complex. Some of the more distinct elevated terranes in the Ionian basin are the Medina Ridge, Medina Bank and the Cyrene, Epicharmos and Archimedes seamounts. Other prominent elevated terranes also appear within the Hellenic arc complex; however, whereas in the Ionian basin the elevated blocks are spread throughout the basin, in the Hellenic arc a large number of blocks crowds a small area causing the complex pattern of bathymetric highs and lows.

3.3. Mediterranean Ridge

The prevailing feature in the region is the Mediterranean Ridge (>80,000 km^2, 60-80×1,200 kms). It covers the area south, west and east of the island of Crete. Its main characteristics are very different to the Levant basin, due to collision between the Eurasian and the African plates. This ridge is forming an accretionary prism complex, whose rate of increase is the fastest in the world [Figure 9].

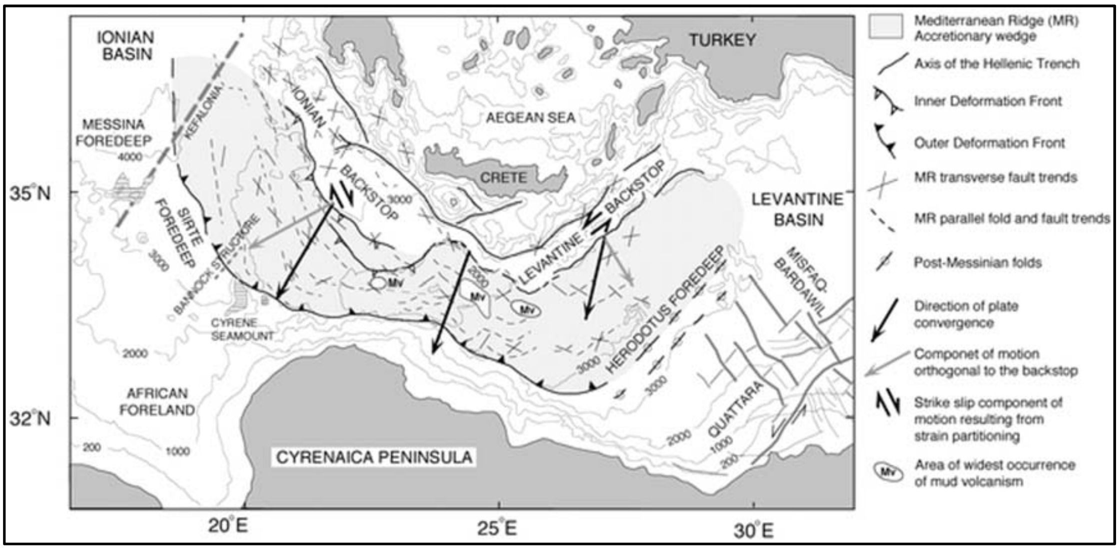

Fig. 9: *The Mediterranean Ridge and other features. (After Costa et al, 2004)*

There are geological models for the area; some of them quite promising concerning hydrocarbon exploration, provided of course it is all proven by future exploration efforts. It is characterized by the existence of mud volcanoes and thermogenic gas leakage. However, the fact is, the area is not thoroughly covered by seismic surveys and the water depth is rather obstructing. Future seismic is expected to deliver results regarding the sediment thickness, quality and the tectonic deformation elements [Figure 10].

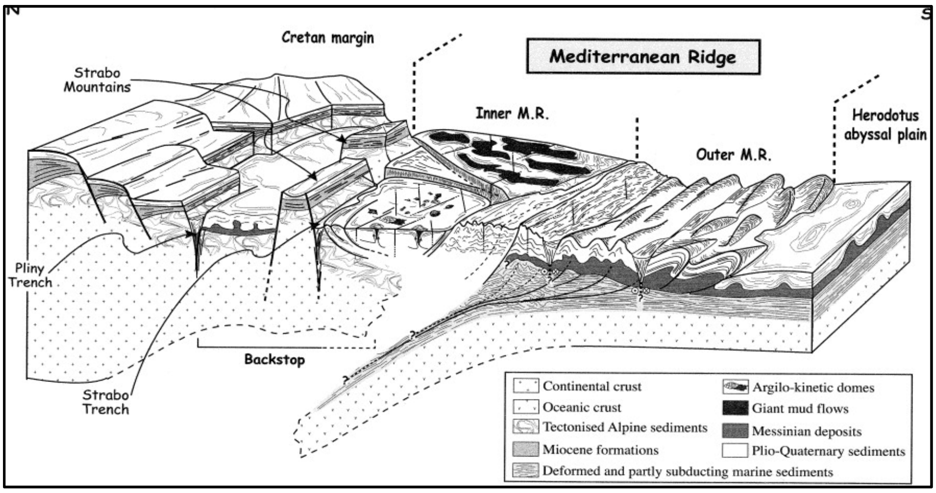

Fig. 10: *The Mediterranean Ridge structure, south of Crete. (after Huguen et al, 2001)*

4. Hydrocarbon Exploration and Production

The East Mediterranean is considered to be an under-explored area. With the exception of Egypt and Syria, for which exploration and production is a primary industry sector, (producing in total approximately 1.1 million bbl/day), most of the countries have yet a long way to go. However, recent exploration successes in offshore areas have drawn attention to the hydrocarbon potential of this region. Significant discoveries offshore Egypt, Cyprus and Israel have opened new basins and new plays for petroleum exploration, particularly in deep water. New seismic data, the results of the recent and upcoming exploration wells and license activity will all redefine the industry's future in the region.

This chapter provides an overview of the exploration and production activities taking place in this emerging region of the planet. A number of general historical facts and figures are presented in order to give a better understanding of the area and its hydrocarbon potential.

4.1. Albania

The surface occurrences of bitumen in the southern part of Albania have already been known since ancient Roman and Greek times. The bitumen's existence in the Selenica region had been merely forgotten up to 1875, when French Company was granted the right to exploit and export it to France as asphalt for road construction, until 1918.

Oil seepage observed at Drashovica, led to the first oil well in Albania in 1918. The well was producing approximately 20-30 bbl/d for two years from a depth of 100 meters.

Thenceforth, Albania attracted worldwide attention which, together with intensive and systematic exploration and drilling, resulted in the discovery of the Patozi oil field (1928). It was reported to contain one billion barrels of oil, which would make it one of the largest onshore oil fields in Europe. Its normal production commenced in 1939 and is currently operated by Bankers Petroleum Ltd, which also has concession rights for the Patos-Marinza oil field.

Seismic surveys were initially introduced in the country in 1951, by Russian experts, which led to the Marinza oil field discovery in 1957, generating increased oil production. In the early 1960s a stronger picture of the subsurface structures in Albania was made possible benefiting from the seismic methods, which in turn brought new discoveries on stream and the maximum oil production in 1974 rose to 2,250,000 tons/year. That is when oil production peaked in Albania and hence declined until 1982 when a more rapid decline began due to lack of funding for field development and technical expertise.

According to the World Bank, 4,666 oil wells have been drilled in Albania, of which 3,123 wells are operating and 981 wells are shut in or have been abandoned. Of the 500 gas wells drilled in the country, only 255 have produced gas.

Oil production in 2010 was in the order of 11,000 bbl/d., while natural gas production is currently around 500 Mcf/d.

4.2. Croatia

Approximately 104 million cubic meters of oil (from 39 fields), 7 million cubic meters of condensate (from 11 fields), and 65 billion cubic meters of gas (from 52 fields), were recovered in the Croatian part of the Pannonian Basin System from 1942 until 2005. The production peak was attained during 1980–1989, when exploitation began in 12 new fields.

Crude oil production has faced major decline since 1994, reaching 15,000 bbl/d. in 2009, while gas production in 2010 was around 67 Bcf.

4.3. Cyprus

Hydrocarbon exploration in Cyprus commenced in 1938, when the Iraq Petroleum Company Ltd conducted geological and geophysical surveys on the island. These surveys lasted until 1948, and later on from 1949 until 1970, four exploration wells were spudded onshore Cyprus in depths between 1,250-3,295 m. The local company Oil Prospectors Ltd drilled two wells at the Moni and Tseri areas, while the Forest Oil Corporation followed with other two wells in Archangelos and Lefkoniko areas. All these wells were dry holes.

The first seismic surveys offshore Cyprus were conducted by Delta Exploration Inc. during 1970-1974 in the shallow waters up to 200m depth. In 1975, Sefel Geophysical Ltd proceeded in the acquisition of 8,000 km seismic survey in the Eastern Mediterranean (most of its survey in the Cypriot waters).

Ten years later (1985-1987) the Soviet Academy of Scientists carried out geological and geophysical studies offshore Cyprus. The findings also showed a moderate potential for hydrocarbons onshore and in the shallow waters.

In 2008, following the first licensing round, Noble Energy Inc., was granted one exploration license and in 2011 the Cypriot Government together with the grantee jointly announced the discovery of a major gas find, in "Block 12", with an estimated gross resource range between 5 to 8 Tcf, with a gross mean of 7 Tcf.

There is no hydrocarbon production at present. However, a second licensing round is underway.

4.4. Egypt

The beginning of the oil industry in Egypt goes back to 1883. M. de Bay, a Belgian specialist, along with the Egyptian Government were exploring in the Eastern Desert (Ras Gemsah) for oil, but operations began two years later, in 1885. The drilling operations led to a production of 10 bbl/day from the first well. Unfortunately, the drilling operations of the second and third well were not fruitful.

In 1886, the Egyptian Government was able to dig oil from Ras Gemsah, which marked the beginning of the country's oil industry. During this same year, an American team was appointed to develop a survey on the area, based on which, the team recommended resuming the drilling operations, not only in the Ras Gemsah but also at the Ras Dhib to the north and Abu Durba on the east side of the Gulf of Suez. However, the government stopped supporting the drilling in these areas in 1888.

At the beginning of the 20th century, and specifically in 1904, the Egyptian government had authorized Cairo Syndicate to explore oil in Sinai and Quena. At that time, foreign companies began exploration activities in the country for the first time.

Three years later, in 1907, the Egyptian Oil Trust Ltd was registered, with the objective of receiving concessions, developing, drilling, purifying, supplying, reserving, distributing and handling petroleum products. The next year, Egyptian Oil Trust Ltd started drilling operations and in 1909 the first amount of oil was produced from Ras Gemsah at depth of 1,287 ft. The well was producing two barrels of oil per minute and in 1911, the first oil refinery was established.

In the year 1912, the total number of wells was 23. By time, the oil production began to decrease until operations were stopped in 1927. However, before that, there was another important exploration made in the Hurghada field in 1911. The Anglo Egyptian Oilfields Ltd

(50% Shell and 50% BP) struck oil in 1913. Unfortunately, exploration activities stopped due to World War I and in 1931 the field's production rate reached 1.8 million barrels per year.

In 1934, the Cooperative Petroleum Association Co. was established in Egypt in order to link cooperatives for the exchange of goods and services and support cooperation in Egypt. Over the next few years, five major international companies were authorized to undertake exploration work. These included the Anglo Iranian Oil, Royal Dutch /Shell including Anglo Egyptian, Socony-Vacuum Oil Co. Inc., Standard Oil Co. of California and Standard Oil Co. of New Jersey. The government could only authorize 40 licenses, so these five companies through their subsidiaries bid for the available blocks, which resulted in the presence of around 23 companies exploring in the search of oil between 1935 and 1940.

The year of 1938 symbolized a new era for oil production in Egypt, as the first commercial oilfield was discovered. The Anglo Egyptian Oilfields was able to discover an oil field in Ras Gharib, located between Hurghada and Suez. The well was producing 1,200 bbl/day, which was a boost in the oil production. The production rate later increased and reached its peak of 5.1 million barrels in 1939.

By 1946, Sinai had become an important area for exploration. Two years later, the Egyptian Government forbade the exporting of crude oil which triggered a downslope in the oil production until 1953. The government allowed that only refined products be sold in Egypt. Later oil was discovered in Ras Bakr, Khreim and Ras Gharib by the 1960s, during which there was a total of 90 wells in new fields and in 1961, the first offshore oilfield was discovered in North Balayim. In 1962, The Egyptian General Petroleum Corporation was formed, operating in the form of joint ventures with foreign companies.

In 1964, two partnerships, American Co. (later Amoco) and Philips Petroleum Co., were founded to work on new areas. In 1965, the Gulf of Suez Petroleum Company (GUPCO) was established as the Egyptian American Corporation. It discovered El-Morgan, the oldest and biggest oilfield in the Egyptian petroleum history. GUPCO operated and drilled around 12 oil wells and one dry well, but the company's production started in 1967.

The 1967 war affected the oil industry and operations were slow. In 1972, Egypt has joined the Arab Petroleum Exporting Countries and in 1973, the first Ministry of Petroleum was formed in order to carry out all the responsibilities related to the oil industry.

In 1977, October field was discovered, the third largest oilfield in Egypt, located 21 miles from the west shoreline in the Gulf of Suez. Since its discovery and until 1991, it produced more than 420 million barrels of oil. By 1998, the country's total production had reached an average of 866,000 bbl/d of crude oil.

More than 176 petroleum agreements and laws were established to develop and increase the country's production rate until 2010. By that time, the total number of discoveries had reached 489 in the Mediterranean, Gulf of Suez, the Eastern and Western Deserts, Sinai, Delta and Upper Egypt. Out of these, 311 discoveries were crude oil.

According to the Oil and Gas Journal's January 2011 estimate, Egypt's proven oil reserves stand at 4.4 billion barrels. In 2010, Egypt's crude oil production was approximately 540,000 bbl/d. Despite the new discoveries and the enhanced oil recovery (EOR) techniques at mature fields, production continues its decline.

On the other hand, the country's natural gas sector is expanding rapidly with production quadrupling between 1998 and 2009. Estimated proven gas reserves stand at 78.0 Tcf (2011), an increase from 2010 estimates of 58.5 Tcf and the third highest in Africa after Nigeria (187 Tcf) and Algeria (160 Tcf). In 2009, Egypt produced roughly 2.3 Tcf.

4.5. Greece

Hydrocarbon exploration in Greece dates back to the beginning of the 20th century, in 1903. However, some evidence exists on earlier efforts having taken place in the early second half of the 19th century (1860). The first wells were drilled by companies which included London Oil Development, Hellis, Pan-Israel, Deilman-Ilio in the areas of Keri (Zante), NW Peloponnese and Evros in NE Greece.

Exploration efforts were discontinuous up to the early 60s mainly focusing on onshore areas, especially in Western Greece and areas where oil seepage existed.

During the 1960s and the mid 1970s, exploration becomes more systematic and the decision for the establishment of the first public body, oriented to the exploration of hydrocarbons, came as a consequence of the achieved results.

A systematic and methodical exploration effort started in the early 60s by the former Ministry of Industry, in close collaboration with the Institute of Geology and Mineral Exploration (IGME) and with the Institute Français du Petrol (IFP) acting as consultants.

Extensive geological research was carried out at the time, especially in continental Greece, and 17 shallow depth wells were drilled. At the same time, concessions were granted to major companies, such as BP (Aitoloakarnania area), ESSO (NW Peloponnese, Zante and Paxi islands), Hunt (Thessaloniki), TEXACO (Thermaikos gulf), CHEVRON (Limnos island), ANSCHUTZ (Thessaloniki-Epanomi) and OCEANIC-COLORADO (Thracian sea). These companies drilled, in total, more than 40 wells onshore and offshore. Most of the former wells penetrated geological targets that gave, in some cases, encouraging hydrocarbon indications. The most important discovery was the Prinos oilfield, offshore Thasos island in 1971-1974 by OCEANIC. Commercial production of Prinos started in 1981 with production peaking in 1985 (28,000 bbl/d). Today Prinos field produces some 1,200 bbl/day, operated by Energean Oil & Gas S.A. Until today Prinos has produced some 116 million barrels of oil, whereas initial estimates totaled 60 million barrels of oil, which is indicative of the hydrocarbon potential of the area.

In 1975, the Public Petroleum Corporation (DEP) was founded, in order to boost exploration activities in the country. DEP's activities ended in 1995. During this time, a total of 73.000 Km of 2D and 2,500 km^2 of 3D seismic survey lines were carried out and 73 exploration wells were drilled. The result was the discovery of oil in the offshore Katakolo area in NW Peloponnese, gas in Epanomi, an area adjacent to Thessaloniki, and, in some cases, biogenic gas accumulations.

The country carried out its first International Licensing Round, involving 6 concession areas, in 1996, resulting in 4 licensees for the areas: NW Peloponnese and Ioannina to Enterprise Oil and for the areas of Aitoloakarnania and offshore Western Patraikos Gulf to Triton Ltd. Unfortunately the efforts were not fruitful and these companies withdrew in 2000-2001.

Following that, exploration activity almost ceased for a whole decade. However, since 2007, certain reforms took place and Greece has announced granting rights of exploration and exploitation in three areas (Patraikos Gulf, Ioannina and Western Katakolo) through an "open door" procedure, while at the same time the government has invited international bids for non-exclusive seismic surveys in offshore western Greece and south of Crete.

4.6. Italy

Oil and gas seeps were known and exploited during the Middle Ages, when oil was sought for medicinal purposes. Active exploration for oil began in the second half of the 19th century, but the results were generally poor. The first consistent and important discoveries were made when reflection seismic techniques were introduced in 1940, the first year of World War II. However, upon the war's outbreak, field work and drilling of exploratory wells was hampered and the first sizeable gas field was discovered in 1944 in the Po Plain.

After an initial boost with the discoveries in Sicily in the late 1950s (Ragusa, Gela), no significant successes were attained until the early 1970s when discoveries were made in the deepest carbonate succession of the Po Plain (Malossa) and in the Pescara offshore (Rospo). Two other significant boosts occurred in the 1980s (Villafortuna-Trecate, Aquila, Vega) and in the late 1980s-early 1990s (Val d'Agri, Tempa Rossa). However, hydrocarbon exploration in the country has not reached a mature level and some further potential is believed to be left in more complex and deep structures.

Proven oil reserves for 2011 are estimated at 1 billion barrels of oil and 3 Tcf of gas, while crude oil production was 106,000 bbl/d for 2010.

4.7. Israel

Drilling in Israel began in 1947 in the Heletz area. In 1955 the original well was deepened and an oil field was discovered. At that point, several small North American and Israeli government oil companies drilled the surface structures in the area with the hope of making a major find. These attempts centered upon drilling the Cretaceous formations primarily in the Negev desert. Later the exploration centered upon the Upper and Middle Jurassic formations resulting in the discovery of the first gas fields (Zohar, Kidod and Hakanaim near Arad) and a further oil discovery in Kokhav, near Heletz. There was also a non-commercial oil discovery at Gurim, near Arad. In 1962, Lewis prepared a report for the Israeli government that estimated 500 million to 2 billion barrels of oil would ultimately be recovered in Israel.

Several deep wells in northern Israel were drilled prior to 1986 and then, the government suspended all drilling operations and Oil Exploration Investment, Ltd was directed to carry out a comprehensive basin analysis study for all of Israel.

Since the early 1990´s, the bulk of exploration activities have been conducted by a number of small Israeli publicly-traded limited partnerships, generally managed by Israeli industry professionals without significant outside assistance. At the end of the decade, several large international oil and gas companies acquired rights in exploratory prospects and became involved in exploration activities primarily offshore. These included British Gas, Enserch, Reading & Bates, and Samedan (now Noble Energy.)

During the 90s e a small discovery at the Zuk Tamrur field was made near the Dead Sea, producing 150-200 barrels of light oil per day. During the past few years, significant amounts of natural gas have been discovered off the coast of Israel. Trillions of cubic feet (Tcf) in proven gas reserves from several Israeli and Gaza fields have been discovered.

The Mari and Noa fields are large natural gas fields, with estimated reserves of 1.7 Tcf of gas.

In 2000, the British Gas-Isramco group announced that it had discovered a large gas field 12 miles offshore at its Nir-1 well. The well reportedly contains gas reserves of 274 Bcf.

In January 2009, Noble Energy announced a major natural gas discovery, offshore Israel, at the Tamar #1 well, about 56 miles off the Israeli northern port of Haifa, located in approximately 5,500 feet of water. The well was drilled to a total depth of 16,076 feet and the gross mean resources were estimated to be 5.0 Tcf (Trillion cubic feet) of natural gas.

In March 2009, Noble Energy announced a natural gas discovery, offshore Israel, at the Dalit prospect well, about 30 miles off the coast of Hadera, located in approximately 4,500 feet of water. The well was drilled to a total depth of 12,000 feet and the gross mean resources were estimated to be 500 Bcf of natural gas.

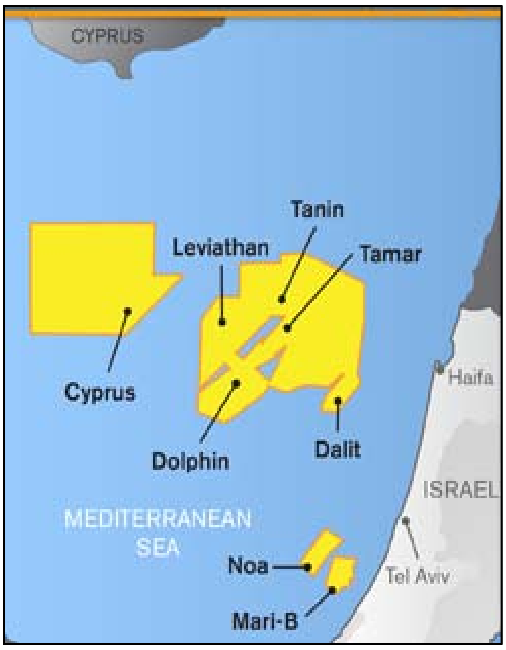

Fig. 11: *The major gas discoveries in Israel. (source Noble Energy Inc)*

In June 2010, Noble Energy announced the discovery of Leviathan, one of the world's largest offshore natural gas fields. It is located 81 miles west of Haifa, deep in the Levant basin with gross mean resources of 17 Tcf of natural gas. At the time of discovery, the Leviathan gas field was the largest find, ever discovered in the under-explored area of the Mediterranean Sea and the largest discovery in the history of Noble Energy.

Crude oil production in Israel in 2009 was insignificant while natural gas in 2010 was around 55 Bcf [Figure 11].

4.8. Lebanon

There are no wells drilled in the area offshore Lebanon. However, seven wells have been drilled onshore between 1947 and 1967 all with traces of gas and/or bitumen giving some indications to the country's hydrocarbon potential. In the offshore region within close proximity to Lebanon, there are indications of oil and gas existence in wells. As yet there is no hydrocarbon production, however.

4.9. Montenegro

In Montenegro hydrocarbon activity commenced after the Second World War. Between 1949 and 1966, 16 onshore wells were drilled ranging from 900 to 4,600 meters.

Offshore, 5 wells have been drilled from mid 1970's to mid 1990's. Their total depths ranged from approximately 3,700 to 4,900 meters. Onshore, 10 wells were drilled at a total depth of around 5,200 meters.

Seismic surveys cover much of the exploration blocks in the country. There is a total length of 6,500 kms of 2D seismic and 311 km^2 of 3D seismic.

Some plays, mainly offshore Montenegro have been identified, concerning biogenic gas, thermogenic gas as well as oil.

Currently Montenegro has opened a Data Room and the country's first bidding round is expected to commence in 2012.

4.10. Syria

Syrian oil exploration first began in 1933 during the French Mandate and the first commercial discovery was made in 1956. The industry took off in 1968, when Syria's first commercial oil field began production, although Syria did not begin exporting oil until the mid-1980s.

Syria is the only significant crude oil producing country in the Eastern Mediterranean region, which includes Jordan, Lebanon, Israel, the West Bank, and Gaza. According to the U.S. Energy Information Agency, Syria's proved oil reserves in 2011 were 2.5 billion barrels. That same year, production was around 400,000 bbl/d. Performance has stabilized after falling for a number of years (in 1996 production reached 582,000 bbl/d) and is poised to turn around as new fields come on line. In 2010, Syria produced 316 Bcf of natural gas, having 8.5 Tcf of proved gas reserves (2011).

4.11. Turkey

More than 3,000 wells have been drilled in Turkey since 1935, mainly on onshore areas. In the offshore areas, a total of 35 exploration wells have so far been drilled. As a result of all these activities 103 oil and 28 gas fields, in different sizes have been discovered.

Most of Turkey's 270 million barrels of oil reserves (2011) are located in the eastern part of the country. In addition, Turkish Petroleum Company (TPAO) has increased its exploration activities in the Black Sea, which according to the company could hold 10 billion barrels of oil. A number of foreign companies are involved in the exploration of the Black Sea in joint ventures with TPAO, including ExxonMobil and Chevron. ExxonMobil is planning to begin drilling its first exploration well in the Turkish sector of the Black Sea in the first half of 2011.

Crude oil production reached 46,000 bbl/d in 2009, while natural gas production stood at 23.9 Bcf in 2010.

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