Abstract

Recent large gas discoveries off-shore Israel, Cyprus, and Egypt highlight the Eastern Mediterranean area as a hot spot for global exploration. Zohr is not the only gas field in Egypt, but West Nile Delta (WND), Nooros, and Atoll are all important gas fields that add to the national gas production. The source of this poster is a graduation project that aims at developing the student’s ability to search for the required data through published researches, websites, and companies to get the answers for the following questions:
1 - Can Egypt become main energy hub in Middle East?
2 - Can Israel compete in natural gas race?

Published data covering the complex geology and hydrocarbon potential of the main gas fields in the study area have been collected and analyzed. Global LNG prices have risen to a level that makes exports via the Egyptian LNG facilities economic once more. Egyptian companies have already stuck $15 billion deal for the import of Israel natural gas. Egypt intends to attract additional resources such as Cypriot gas to become the energy and LNG hub of the region.

Egypt is qualified to be a regional hub for energy and LNG hub due to its liquefying plants, pipeline grids, warehousing, transportation, trading of petroleum and gas products, and ports overlooking the Mediterranean and the Red Sea and refineries.

Selected References


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Mekawi, H., 2018, BP Begins Production from Egypt’s Atoll Gas Field Seven Months Ahead of Schedule: Regional President, BP North Africa.


Selected Websites


Exploration and Development of Siliciclastic and Carbonate Reservoirs in The Eastern Mediterranean

By

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ABSTRACT
Recent large gas discoveries off-shore Israel, Cyprus and Egypt highlight the Eastern Mediterranean area as a hot spot for global exploration. Zohr is not the only gas field in Egypt, but West Nile Delta (WND), Nooros and Atoll are all important gas fields that add to the national gas production. The source of this poster is a graduation project aims at developing the student’s ability to search for the required data through published researches, websites and companies to get the answers for the following questions:
1- Can Egypt become main energy hub in Middle East?
2- Can Israel compete in natural gas race?

1) Zohr Gas Field
Eni is an Italian multinational oil and gas company headquartered in Rome. An agreement was signed in January 2015 with the Egyptian Ministry of Petroleum, the Egyptian National Oil Company (ENOC) and ENI following a competitive field discovery release in Egypt and in the Mediterranean Sea. At the end of August 2015, Eni announced to have achieved through its subsidiary IEOC a outstanding gas discovery in the Shorouk Concession, situated in the continental waters of the Egyptian Mediterranean sector. From the geological point of view, the Shorouk Concession is located at the intersection of the Nile Delta Basin and of the Levantine Basin. The Zohr structure is located in about 1,500 m of water depth. Zohr 1 NFW was drilled to a total depth of 4,321 meters and hit 630 meters of hydrocarbon column in a carbonate sequence of Miocene age with excellent reservoir characteristics (430 meters pore space of net pay). According to the well and seismic information available, the discovery could hold a potential of 30 trillion cubic feet of lean gas in place.

Exploration and Development in the Eastern Mediterranean in Egypt and Israel

Petroleum System of Zohr Gas Field
Source Rock:
Thermogenic gas and oil from Oligocene and deeper SR (Fig. 7). Reservoir:
The reservoir rocks are carbonate platform interpreted as ramps with bioclastic sediments (Fig. 5). Seal (Cap rock):
A regional cap shales of Miocene age (Fig. 6).
Structure and Stratigraphic traps provide the main trapping style (Fig. 6).

Production
The huge Zohr gas field offshore Egypt has increased its production six fold since it started production in January 2016, Egypt’s Petroleum Minister Tarek el-Molla said.
Production at Zohr in the Mediterranean has increased to 2 billion cubic feet per day (bcfd) in January 2016. Eni and its partners aim to reach plateau production in excess of 2.7 bcfd by 2019, the Italian company says.

2) Baltim Gas Field
Baltim area lies on the north of the Nile Delta about 25 km of the Egyptian Coast. It covers an area of about 500 km2, with a length of 25 km and a width of 18.75km. Baltim area is considered as the northwest extension of Abu Madi. Baltim East was discovered in 1993 and the production started in April 2000. Baltim North was discovered in 1995. The production halted only in November 2005. The Baltim gas field’s natural gas reserves are estimated to be 1 trillion cubic feet (tcf).

Petroleum System of Baltim Gas Field
Source Rock:
Hydrocarbon fields discoveries are proved at all levels. Oligocene is the main source rock in the Nile Delta. Significant biogenic gas potential mainly within the Focene–Paleocene interval. Few penetrations of the Pre-Tertiary sequence. The Deepsea outcrops well penetrated the Upper part of Jurassic Sequence. Reservoir:
Shaly carbonate build-ups (Fig. 9).
Seal (Cap rock):
A regional cap shales of Miocene age (Fig. 7).
Trap:
Structure and Stratigraphic traps provide the main trapping style (Fig. 7).

Production
Baltim gas field is located about 25 km off the Egyptian Coast. The field is operated by the Egyptian Natural Gas Holding Company (EGAS) and ENI following a competitive field discovery release, (after Paolo Esestime, Ashleigh Hewitt and Ned Hodgson, 2016).

Supplementary Information

Exploration and Development of Siliciclastic and Carbonate Reservoirs in The Eastern Mediterranean

1) Nile Delta Stratigraphy
Hydrocarbon fields discoveries are proved at all levels. Oligocene is the main source rock in the Nile Delta. Significant biogenic gas potential mainly within the Focene–Paleocene interval. Few penetrations of the Pre-Tertiary sequence. The Deepsea outcrops well penetrated the Upper part of Jurassic Sequence. 2) Explored Plays and Zohr Play Concept

Figure 1: Location map of the Eastern Mediterranean, showing the location of the study area (after Wood Mackenzie 2018)
Figure 2: Nile Delta Tertiary stratigraphy main plays (modified after Mahmoud Khaleel et al., 2010)
Figure 3: Offshore Nile delta explored plays and Zohr play concept (after Francesco Bertello, Hamed Harby and Stella Brandelisie 2016)
Figure 4: Seismic section of Zohr 1 NFW, showing petroleum system of well (after Francesco Bertello, Hamed Harby and Stella Brandelisie 2016).
Figure 6: Geological sketch of the Zohr Discovery reprinted from ENI press release, (after Paolo Esestime, Ashleigh Hewitt and Ned Hodgson, 2016)
Figure 8: Halim and his team of students, Geology Department, Faculty of Science, Cairo University, Egypt.

Figure 9: Schematic cross section illustrating the sequence stratigraphic framework of the Zohr Field (after Francesco Bertello, Hamed Harby and Stella Brandelisie 2016).
Figure 10: Lithostratigraphic column of the Nile Delta area in the Zohr field, Egypt modified after Reference 1. Abdella-Fatat, Ahmed Yousef Tawfik, 2010.
The Nooros field was discovered in July 2015 in the Nile Delta offshore area and put into production in record time the following month. It is currently Eni’s main gas producing field in its Egyptian asset portfolio and as well as an example of the success of the company’s model. The discovery perfectly exemplifies Eni’s “near field” exploration strategy, aimed at locating additional potential discoveries located in proximity to already existing upstream infrastructure.

In the Nile Delta Concession, where Nooros is located, Eni holds a 73% stake through its affiliate IEOC Production BV, while BP holds the remaining 27%.

**Petroleum System of Nooros Gas Field**

**Source Rock:**
Oligocene shales have values of TOC ranging from 0.8 to 2.2%, with low-medium hydrogen index 100-300 (0.4 to 0.8% Ro, type III – low oil and gas prone kerogen). Detrital shales represent a fair - good source rocks, mainly of type III, gas prone kerogen. Mixed kerogen type II-III oil and gas prone was reported in certain areas. The TOC values up to 2%, with low-medium hydrogen index.

**Reservoir:**
Reservoir rocks concerned of late Miocene are constrained by sand & siltstone in the Qawasm and Salamat Fms., which showed good petrophysical characteristics.

**Seal (Cap rock):**
Seal is provided by intra-formational shale of Qawasm and post-rift megasequence. Thick shale intervals present at the lowermost portion of the kafir el shikh Fm., provide the seal for Abu Madi and Atoll gas fields. These seal rocks are age late Miocene to early Eocene.

**Trap:**
The sedimentary section in the Nile Delta area with gas potential seems to be limited to the Neogene formations trapped against listric faults or draped over faulted blocks. However pre-Miocene basement of the base of this Neogene sequence may also be considered as future exploration plays.

**Production**

The reserve of the field reaches 2 trillion cubic feet of gas. Its production rate is 1.2 billion cubic feet per day of gas. The first production of the well was in August 2015 at the rate of 350 million cubic feet. The number of wells reached 14 wells at 1.2 billion cubic feet per day.

4) **Atoll Gas Field**

The Atoll field was discovered by BP in March 2015 by drilling the Atoll-1 deepwater exploration discovery well. The trap is defined using the sixth generation semi-submersible rig Maersk Discoverer to a depth of 1237m. The drilling site is located 15km north of the Salamat discovery, 620km north of the city of Damietta, and 45km northwest of Temsah offshore facilities.

The exploration well was drilled to a depth of 6,400m and encountered approximately 50m of gas pay in high-quality sandstones. It is the operator’s second most significant Oligocene discovery in the area after the Salamat discovery of 2013. The field is estimated to contain approximately 0.6 trillion cubic feet (tcf) of natural gas and 31 million metric tons (mmt) of condensate.

5) **Levitation Gas Field**

Located in the eastern Mediterranean Sea area off the coast of Israel, Levitation Natural Gas Field was discovered in December 2012. The discovery is situated in 1,450m of water. Noble Energy commenced drilling on the Levitation-1 well in October 2014. In the first stage, the well was drilled to a depth of 6,500m. It encountered a minimum of 12 of clean natural gas pay. The Levitation gas field’s natural gas reserves are estimated to be 18 trillion cubic feet (tcf).

6) **Tamar Gas Field**

The Tamar field is a natural gas field located roughly 50 km west of Haifa, at an over depth of about 4,875 meters below sea level, and is waters that are 3,700 meters deep. The Tamar field is considered to have proven reserves of 300 billion cubic meters (1.7 trillion cubic feet) of natural gas.

**Petroleum System of Tamar Gas Field**

**Source Rock:**
The Lower Miocene (or Oligo-Miocene) contains the main biogenic gas of shale.

**Reservoir:**
The Oligocene-Miocene reservoir section in levitation field is a sequence of Deep-water turbidite sandstone interbedded with variable amounts of silts and mudstone. Clean and interbed sands are quartz arenites (>= 80%), with porosity> 15%, with permeability> 100 md.

**Seal (Cap rock):**
Regional seal of Miocene Evaporites in upper Miocene. This sequence is an important event in the Mediterranean. The thick evaporite deposits up to 200m thick, that were deposited during a Late Miocene of the Mediterranean Sea.

**Trap:**
The trap is of Syrian arc fold and uplifted structures and normal fault.

**Production**

The Tamar field gas field’s natural gas reserves are estimated to be 18 trillion cubic feet (tcf). Besides natural gas, the field is said to contain 600 million barrels of oil and millions of barrels of condensate. The field is currently producing 1.2 billion cubic feet per day (Bcf/d) of natural gas, the field is said to contain 600 million barrels of oil beneath the gas layer.

**Leviathan Gas Field**

Located in the eastern Mediterranean Sea area off the coast of Israel. Leviathan Natural Gas Field was discovered in December 2012. The discovery is situated in 1,450m of water in the Levantine Basin. Noble Energy commenced drilling on the Leviathan-1 well in October 2014. In the first stage, the well was drilled to a depth of 6,500m. It encountered a minimum of 12 of clean natural gas pay. The Leviathan gas field’s natural gas reserves are estimated to be 350 billion cubic feet (tcf).

**Petroleum System of Leviathan Gas Field**

**Source Rock:**
The Lower Miocene (or Oligo-Miocene) contains the main biogenic gas of shale.

**Reservoir:**
The Oligocene-Miocene reservoir section in levitation field is a sequence of Deep water turbidite sandstone interbedded with variable amounts of silts and mudstone. Clean and interbed sands are quartz arenites (>= 80%), with porosity> 15%, with permeability> 100 md.

**Seal (Cap rock):**
Regional seal of Miocene Evaporites in upper Miocene. This sequence is an important event in the Mediterranean. The thick evaporite deposits up to 200m thick, that were deposited during a Late Miocene of the Mediterranean Sea.

**Trap:**
The trap is of Syrian arc fold and uplifted structures and normal fault.

**Production**

The Leviathan field is a natural gas field located roughly 50 km west of Haifa, at an over depth of about 4,875 meters below sea level, and is waters that are 3,700 meters deep. The Leviathan field is considered to have proven reserves of 300 billion cubic meters (1.7 trillion cubic feet) of natural gas.

**ISRAEL-EGYPT GAS EXPORT DEAL**

Israel-Egypt沢山 steps have been taken that could eventually gas from Israel’s offshore to be piped to Egypt.

Israel’s Delek, the US-based firm Noble and Egypt’s East Gas have established a company (Emed) to buy 90% of the 28 in. 90 km East Mediterranean gas pipeline for $163 million. This investment, combined with a transportation agreement, will provide Egypt with a massive commercial pipeline and gas sales.

Of the $116 million, the Levanion and Tamar offshore gas field partners will each pay $125 million, while Delak and Noble will each pay another $50 million. Most importantly, the East Gas company, which owns the pipeline from Ashqelon in Jordan to Arish in Egypt, will invest $146 million, which is a considerable amount for Egypt. This strategic partnership, with a leading Egyptian infrastructure company, with the “skin in the game” and an Egyptian umbrella for the entire transaction to sell Israeli gas to Egypt.

Global demand for gas is growing. Bloomberg New Energy Finance predicted that global demand for natural gas would increase from 284 m tones a year in 2017 to 450 m t/y in 2030, while analyst forecasts for global gas demand growth.”

**CONCLUSIONS**

1) Zohr is the only gas field in Egypt, but West Nile Delta (WND), Nooros and Atoll are all important gas fields that add to the national gas production.

2) Egypt had reached self-sufficiency in natural gas production during 2014, as a result of a six-fold increase in Egypt’s Eastern Mediterranean Zohr Field’s production. The country’s gas output is expected to reach peak production in 2015, as it is expected that Zohr will produce 3 billion SCFD in 2015.

3) Egypt is qualified to be a regional hub for energy due to its liquefying plants, pipeline grids, Warehousing, transportation, trading of petroleum and gas products and ports overlooking the Mediterranean and the Red Sea.

4) Egyptian companies have already start $15 billion deal for the import of Israeli natural gas. Egypt intends to attract additional resources such as Cypriot gas to become the energy and LNG hub of the region.

5) Israel is aware of the competing and more favorable Egyptian offer compared to its relatively expensive and technically challenging proposal.