Bio- and Sequence Stratigraphy of the Pliocene Rocks in Temsah Gas Field , offshore Nile Delta , Egypt

A dissertation submitted in partial fulfilment for the requirements
of the Master degree in Geological Science

By

Zeinab El-Sayed Mohammed El-Barbary
(B.Sc., 2009)

Supervisors

Prof. Dr. Mohamed Abdel Kader El-Boukhary
Professor of Micropaleontology
Department of Geology, Faculty of Science, Ain Shams University,

Prof. Dr. Ahmed Sayed Ahmed Abu El-Ata
Professor of Seismic Methods,
Department of Geophysics, Faculty of Science, Ain Shams University,

Dr. Ahmed Niazy El-Barkooky
Associate Professor of Geology Department of Geology,
Faculty of Science, Cairo University.

Department of Geology
Faculty of Science
University of Ain Shams

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Declaration:

This project, including all of its contents and data, is entirely the work of the author (Unless otherwise indicated).

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Approval Sheet

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Professor of Micropaleontology
Department of Geology, Faculty of Science, Ain Shams University

Prof. Dr. Ahmed Sayed Ahmed Abu El-Ata
Professor of seismic Methods,
Department of Geophysics, Faculty of Science, Ain Shams University

Dr. Ahmed Neazy El-Barkooky
Associate Professor of Department of Geology,
Faculty of Science, Cairo University

Head of Geology Department

Prof. Dr. Abd El Mohsen Mohammed Morsi

Note

The present thesis is submitted to the faculty of Science, Ain Shames University in partial fulfilment for the requirements of the master Degree of Science in Geology. Besides the research work materialized in this thesis, the candidate attended eleven post graduate courses for one academic year in the following topics:

1. Field Geology
2. Geostatistics
3. Sedimentary Petrology
4. Sedimentation
5. Advanced Structural Geology
6. Geotectonics
7. Advanced Lithostratigraphy
8. Advanced Biostratigraphy
9. Micropaleontology
10. Paleoecology
11. English language

In addition, the author successfully passed the final exams of these courses in September 2011 and also successfully passed the international TOEFL test.

Head of Geology Department

Prof. Dr. Abd El Mohsen Mohammed Morsi

ABSTRACT

A high resolution, quantitative biostratigraphic analysis for the foraminiferal microfossils and semi-quantitative analysis for the calcareous nannofossils of the Pliocene sequence provided from El-Temsah Concession, that located in the northeastern province of the Nile Delta region, between **Latitudes** 31° 57’ 00’’ N & 31° 45’ 00’’ N and **Longitudes** 32° 18’ 00’’E & 32° 00’ 00’’E , have been investigated.

The microfossils recovered from the three boreholes penetrating the Pliocene rocks revealed the identification of 47 planktonic and 113 benthic foraminiferal species which are biostratigraphically evaluated and allowed the delineation of four standard planktonic foraminiferal biozones. These planktonic zones are arranged from top to bottom as follows: *Globorotalia crassaformis* (in partim), *Globorotalia puncticulata*, eq. *Globorotalia puncticulata⁄Globorotalia margaritae* and eq. *Globorotalia margaritae* Zones. The equivalent benthic zones have also been recorded along the same successions. These include: *Articulina tubulosa, Bulimina elegans marginata* plexus*, Bulimina marginata, Anomalinoides helicinus* and *Cibicides italicus⁄ Uvigerina rutila* Zones.

In addition, a semi-quantitative calcareous nannofossil analysis was carried out on all samples, where 24 nannofossil species were also identified. The nannofossil species allowed the subdivision of the studied Pliocene succession into 7 standard biozones, from top to bottom, are as follows: *Pseudoemiliana lacunose* (NN19), *Discoaster brouweri* (NN18), *Discoaster surculus* (NN16), *Reticulofenestra pseudoumbilicus* (NN15), *Discoaster asymmetricus* (NN14), *Ceratolithus rugosus* (NN13) and *Amaurolithus tricorniculatus* (NN12) Zones. This study enables to construct a bio- and chronostratigraphic correlation for the Early-Late Pliocene Kafr EL-Sheikh Formation and delineate the occurrence of pronounced hiatuses along the Pliocene rocks in the studied area.

The Lithostratigraphic approach capability for predicting the lateral facies changes, as well as the chronostratigraphic concept for subdividing and correlating the stratigraphic time rock units are emphasized. This study focuses on the linkage between lithostratigraphy and chronostratigraphy in subdividing the stratigraphic sucession into genetically related rock packages, using the seismic stratigraphic and biostratigraphic data.

The Paleoecolological interpretation of the foraminiferal assemblages and sedimentary facies have been carried out on Kafr El-sheikh and Wastani Formations, suggests that Pliocene rock unit in the study area into several transgressive and regressive cycles correlative with Hardenbol et al scheme, (1998). The sequence stratigraphic subdivision obtained in the present study is depend on the integration between biostratigraphic analysis,

well log motifs and seismic stratigraphy interpretation and allowed the recognition of key stratigraphic surfaces as SB 's, MFS 's and TS 's on the well seismic sections.

In the study area, nine sequence stratigraphic units are identified with three major MFS 's and interpreted on the seismic well sections, they are arranged from bottom to top as: Za 2, Pia 1, Pia 2, Ge 1, Ge 2, Cala 1, Cala 2, Io 1 and Io 2.

The distribution of sand reservoirs in the Nile Delta linked with the low stands of the relative sea level, in which the high- density sand channel deposits were slumping by gravitational force erosively baypassing the delta slope. In this thesis the controlling factors affected these slumps are highlighted for hydrocarbon prospectivity.

Keywords: Foraminifera; Calcareous Nannofossil; biostratigraghy; Sequence stratigraphy; Seismic stratigraphy; Pliocene; Nile Delta; Egypt.

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CHAPTER 1

Introduction

1.1. Generalities:

The Nile Delta is not only the oldest known delta in the world, but it also the largest and most important depositional system in the Mediterranean Sea. It is the unique site in Egypt favoured for accumulation and preservation of Quaternary sediments (Said, 1981). The Nile Delta, once the largest depocenter in the Mediterranean, with lobe shape structure is now essentially a main altered coastal plain, which has stopped building out into the Mediterranean and locally is receding.

The Nile Delta lies on the northern margin of the African Plate, which extends from the subduction zone adjacent to the Cretan and Cyprus arcs to the Red sea, where it rifted apart from the Arabian Plate.

The geological development of the Nile Delta and its submarine extension is a recent phenomenon, when compared with other major deltas. Although an ancestral Nile existed in the region of the present Delta in the Middle-Late Miocene, the true deltaic pro-gradation of the present Nile Delta only began in the Late Pliocene.

The Egyptian Nile Delta is one of the most classical Deltas of the world, as it plays an important role in the Egyptian life. It is considered now as a major gas province and one of the most promising areas for future petroleum exploration in North East Africa (Badawy, 2006).

During this long period, the Nile River contributes very large quantities of sediment to the Mediterranean Sea. This fluvial deposition builds delta gradually

outward, while the marine processes transport some of these sediments in cross-shore and along-shore directions on the continental shelf, as far as the Levant Basin.

The Nile Delta was subdivided into the following structural-sedimentary provinces:

- The South Delta province
- The North Delta basin
- The Nile cone
- The Levant platform

The study area is located in the eastern part of the North Delta basin, offshore Nile Delta and around the edge of the Nile cone that represents the deep-water area of the Plio-Pleistocene sediments that accumulated toward the northeast. This study scope on the turbidite feeder channels that occupied the Temsah concession, due to the prograding setting of the Nile Delta during Plio-Pleistocene age after the Messinian salinity crisis.

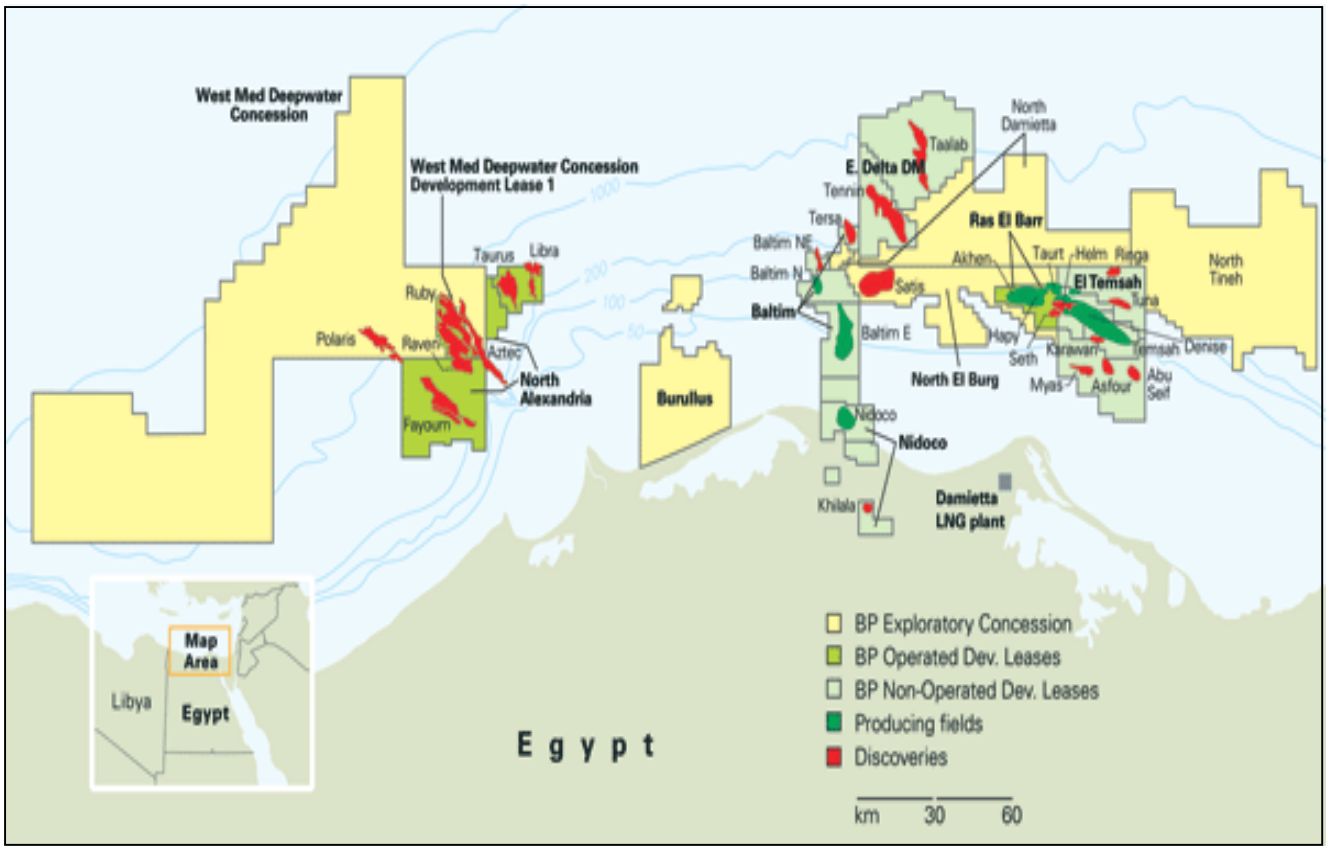

Figure1.1. Northern Egypt Location map of BP, 2010, showing the position of the study area.

The Nile Delta basin is a hydrocarbon – rich province that has hydrocarbon generated from clastic reservoirs ranging in age from Pleistocene to Early Cretaceous. Currently, the Nile Delta /Offshore Mediterranean is the most active exploration and development province in Egypt. The Temsah gas field was discovered in 1977-1981 by MOBIL with the drilling of the first two wells Temsah 1 and Temsah 2 in the southern part of the structure. The Temsah concession is operated by the International Egyptian Oil Company (IEOC) in partnership with Amoco (BP now) that having a participating interest of 50% since early 1992. IEOC drilled the well Temsah 3 in 1993, which gave the best results ever seen in the Nile Delta region till that timein 2001. The field began production of gas and condensate in 1999.

The study area lies within BP and Petrobel offshore concession, located in the eastern off shore part of the Nile Delta, Egypt, in 73.5 m of water, 37 km NNE of the port of Damietta, approximately 65kms NNW of Port Said, Mediterranean Sea.

This study area is concerned with the north eastern Nile Delta region, between lat. **Latitudes** 31° 57′ 00′′ N, 31° 45′ 00′′ N and **Longitudes** 32° 18′ 00′′E, 32° 00′ 00′′E. The extension of the study area is about 60 square kilometers in water depths ranging from 80 to 90m.

1.2. Scope of the Study

The main target of the present study is to illustrate the relation between the structural & tectonic evaluation, depositional setting and stratigraphic aspects of cyclic, genetically related strata bounded by surfaces of unconformity on the reservoir evaluation of Temsah gas field during Plio-Pleistocene age in term of sequence stratigraphy by integrating the biostratigraphical, well logs, seismic facies and paleoenvironmental data taken from the study area.

Focusing on the reservoir configuration and its extension by using the 4th order sequence stratigraghy (parasequences and system tracts) and constructing a structural and static facies model to build the geologic history of the area. The following steps have been covered to complete the study as work flow:-

- Reviewing the general geologic setting of the Nile Delta area, with particular emphasis on the studied area.
- Identifying the microfossils, which will be yielded from the drilled cuttings to delineate the chronostratigraphy of the studied sequence.
- Interpreting the seismic reflection data in terms of seismic reflection characteristics, lithofacies and depositional environments.
- Constructing the geo-seismic sections and correlation panels and interpreted to delineate the main depositional packages and geometries.
- Deducing the depositional cycles of the Pliocene-Upper Miocene sequence in the study area in relation to the causative tectonics.
- Delineating the sequence boundaries, using the integrated bio-stratigraphic data, as well as the seismic reflection data.
- Deducing the geologic history of the study area, with special emphasis on the sea level changes, by establishing the seismic-sedimentational model of the considered area.

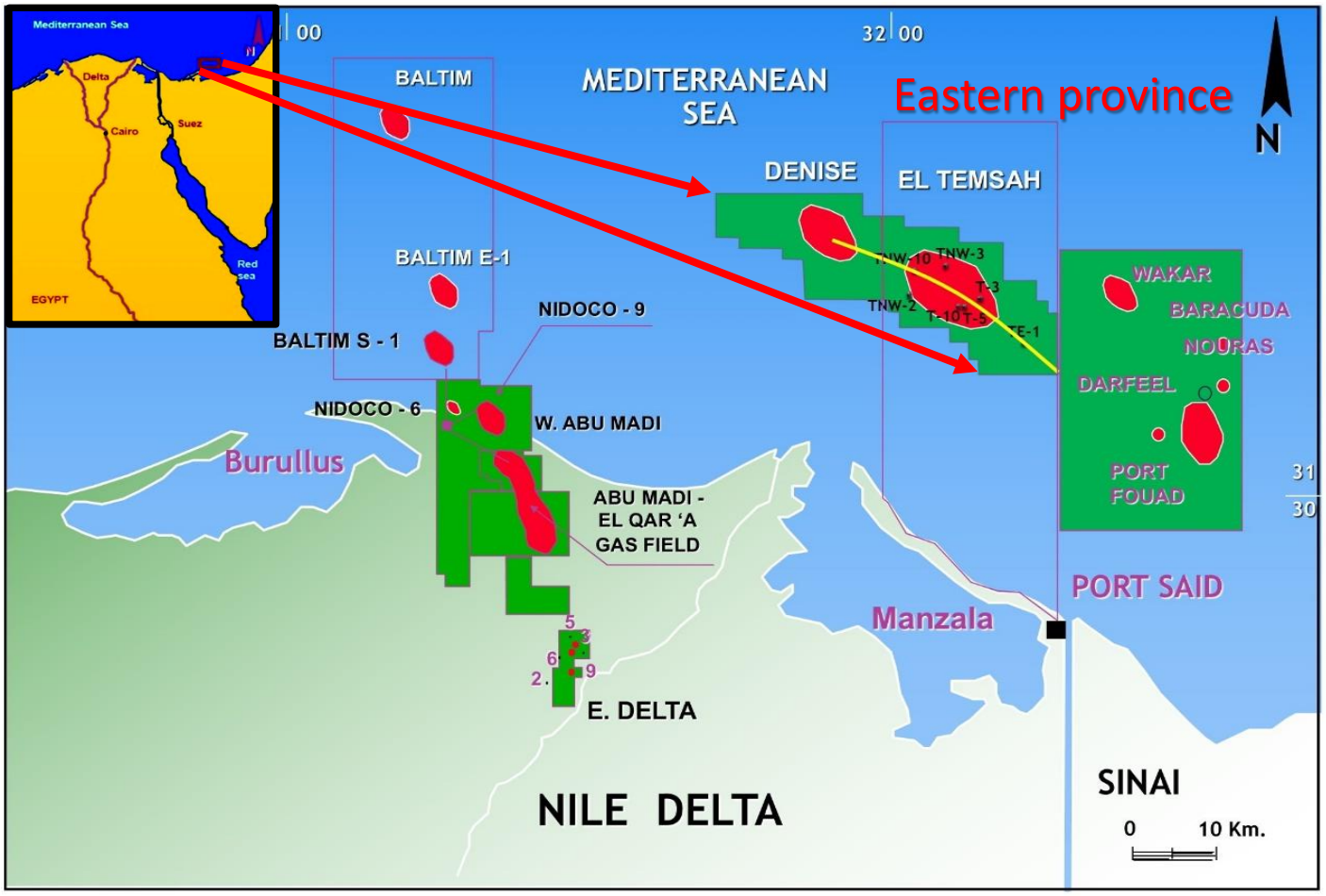

Figure 1.2. Location map of the Temsah area showing correlation line between the selected wells.

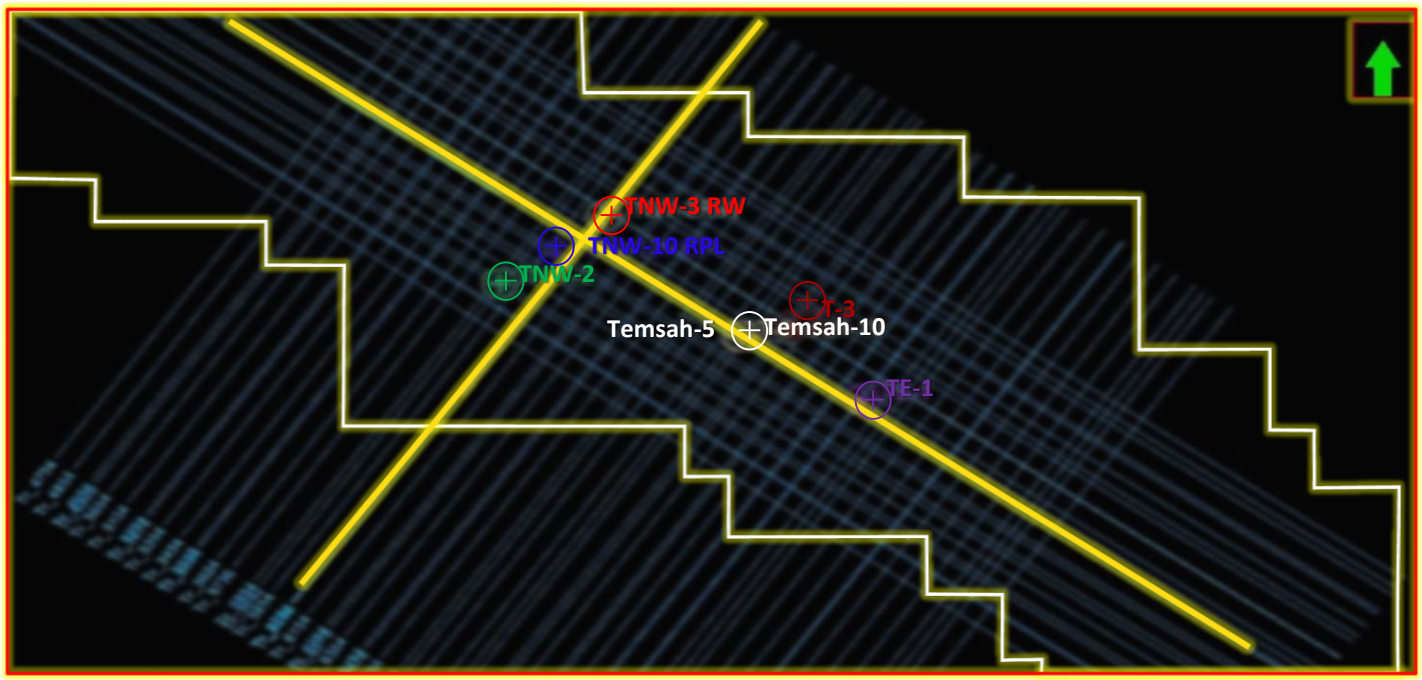

Figure 1.3. Location map of the 3D seismic coverage (2004).

1.3. Exploration History of the Nile Delta and the study area

The Nile Delta “offshore Mediterranean area” is the most active exploration province in Egypt. The earliest exploration activity in the Delta started in forties, when the first gravimetric and seismic acquisitions were carried out in the central onshore area of the Nile Delta (EGPC, 1994). The Nile Delta was a subject of seismic acquisition – first time – in 1964 by IEOC Company. Many oil and gas fields were discovered, based on seismic surveys, as the first onshore gas discovery in the Nile Delta is Abu Madi gas field in 1967 that operated by IEOC when the exploratory well Abu Madi-1 encountered gas and condensate-bearing sands of Abu Madi Formation. The first offshore one in the Delta is Abu Qir gas field, northeast of Alexandria, discovered by Phillips in 1969 (first phase of exploration). In seventies and eighties, the exploration spread allover the Onshore Delta and Offshore Mediterranean, but only few gas discoveries were made with similar potential (second phase of exploration) (EGPC, 1994).

In 1977-1980, MOBIL discovered EL-TEMSAH gas field by drilling Temash-1 and 2 wells in the northeastern offshore part of the Nile Delta. IEOC discovered Tineh gas field in 1981 by drilling Tineh-1 exploratory well in the Offshore Mediterranean region. In 1982 and 1983, Port Fouad, Wakar and Kersh, in the Offshore Mediterranean were tested gas by IEOC, then followed by the discovery of EL Qar,a gas field (north of Abu Madi gas field) in 1985 (second phase of exploration). In the third phase of exploration in the Nile Delta, ELF AQUITAN Company discovered the Naf gas field in 1987, and the seismic acquisition continued in Onshore and Offshore Delta through the operating companies CONOCO, IEOC, PETROBEL and WEPCO. Mango and Abu Zakn fields in 1985 were discovered by TOTAL in the offshore North Sinai concession. The fourth phase of exploration started in 1987-1993 by IEOC and EGPC that adopted intensive exclusive and nonexclusive seismic programs in the deep water areas

of the Mediterranean. Also, the onshore East Delta -1 gas discovery was made by IEOC in 1990. 1993-1994, exploration activity was concentrated in the Offshore Mediterranean as in Port Fouad concession the offshore Baltim E-1 gas well was discovered by IEOC. The fourth exploration phase has a great effect on the acquisition of the Nile Delta, as the 3D seismic survey was introduced in the Offshore Mediterranean in 1993. After that, the Pliocene prospect was defined and Denise-1 was drilled in the North west side of Temsah concession by the partnership IEOC-AMOCO in 1995. The previous exploration activities in the Nile Delta achieved 28 gas and condensates discoveries at the end of 1995.

The Temsah concession was awarded to the International Egyptian Oil Company (IEOC) since 1992. ENI was entitled to operate the field through the Operation Company Petrobel under the El Temash concession agreement. Amoco Egypt Oil Company (BP now) is a sole partner having a participating interest of 50%. The concession expires on 24th March 2026.

The Temsah field was previously under the operation of MOBIL in December 1973. MOBIL drilled the second wildcat El- Temsah-1 well in the Damietta concession, offshore Nile Delta after the acquisition of 2D seismic data over the concession. The location of T-1 was chosen on a structural high, which was identified as approximate Middle cretaceous anomaly (EGPC, 1994). The target anticlinal structure was believed to have formed during the Late Cretaceous to Early Tertiary Syrian Arc tectonic event (Bertello et al., 1996). The well was abandoned before reaching the Cretaceous anomaly, because of drilling problems. The well stopped drilling in the Oligocene level at 14254 feet, but the Middle Miocene (Sidi Salim Formation) tested gas at two sandstone lobes on Nov. 1980. MOBIL drilled El-Temsah-2 in 1980-1981to test an elongated anticlinal prospect (the Cretaceous objective) and failed again, because of drilling problems. The well encountered a thick gas bearing sandstones of Sidi Salem formation and tested gas in a commercial quantities. In spite of the large gas discovery in the

concession, the area was relinquished by MOBIL on 1982, because MOBIL was searching for gas and their concession agreement did not allow the sale of gas. The concession remained an open area until 1992, when IEOC in a partnership with AMOCO (now BP) acquired the area (internal reports) and the concession agreement included a gas sales clause.

The exploration was supported by the acquisition, in 1992, of 3D seismic survey of 350 sq. km over the field and, from 1992 to 1995, by 2000 km of 2D lines over the rest of the concession. In 1995 and 1996, a new and very large 3D survey was acquired over Temsah and its concessions: in Temsah the 3D survey has covered the northern and the central part of the concession for a total of 1200 sq km.

In 2002, ENI carried out a fundamental study: “ARAB REPUBLIC OF EGYPT, TEMSAH & AKHEN FIELDS - Integrated Geological Studies of the Sidi Salim Fm.” which used to generate the reservoir 3D Model.

In April 2004, ENI-E&P (Milan) and ENI-LTE (London) released the reservoir study “Temsah Field Stochastic Modeling Study – An updated reservoir model for Temsah Field area”. An additional review on the seismic-structural interpretation was conducted during the early spring of 2008, as the results of the 2007 reprocessing, were made available.

Only 7 wells were chosen from the Temsah concession, for the present study to cover the whole structure of the area, Temash E-1 (TD= 4029m \ Sidi Salim Fm.), Temsah-3 (TD= 4054m \ Sidi Salim Fm.), Temsah-5 (TD= 4486m \ Sidi Salim Fm.), Temsah-10 (TD= 4033 \ Sidi Salim Fm.), Temsah NW-2 (TD= 4162m \ Sidi Salim Fm.), Temsah NW-3 R.W. (TD= 3798m \ Sidi Salim Fm.), Temsah NW-10 (TD= 3874.7m \ Sidi Salim Fm.).

Temsah-3 Well (Ji 72-3)

The Temsah-3 well is located on the intersection of Latitude 31° 50′14.790″ N and Longitude 32° 10′ 11.031″E. The well approximately lays 2.8 km north of the discovery well (Temsah-3). The well was drilled as a vertical exploration well by