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# Integration between Petrophysical and 3D Seismic Data Analysis to Evaluate Miocene Remaining Potentiality, Temsah Field, Offshore Nile Delta Egypt

**BY**

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## ABSTRACT

*Temsah is a giant gas field located in the northern part of the Nile Delta, North East of Damietta and North West of Port Said and is about 40 km off the coast line, the extension of the field area is about 60 sq. Km, the reservoir is hosted in terrigeneous sandy rocks of middle-late Miocene (Serravallian-Tortonian) ascribed to Sidi Salem Fm. Located at depths ranging between 3500 and nearly 4000 m ssl.*

*The present study represents the integration between the well – log data and seismic data. The well – log data includes resistivity (deep and shallow), porosity tools (sonic, density, and neutron) and gamma-ray of six scattered wells (T-2, T-3, T-5, T-7, T-11, and TNW-3), using a computer program (Techlog) to evaluate quantitatively the different petrophysical characteristics Heff, Vsh, Ø eff and Shr.*

*All petrophysical characteristics that resulted from the previous steps will be represented vertically in the form of petrophysical data logs (PDL) and laterally by iso-parametric distribution maps (effective thickness, shale content, effective porosity and hydrocarbon saturation). Also, the attributes maps will be performed to show the sand distribution and lateral change in facies.*

*Petrophysical data logs (PDL) are vertical representations of all the petrophysical parameters that were deduced from the preceding processes.*

*Effective thickness, shale content, effective porosity, and hydrocarbon saturation are examples of iso-parametric maps that show the lateral fluctuations in the petrophysical parameters.*

*The petrophysical parameters of Unit C reflects the ability of this level to store and produce hydrocarbon with Effective porosity values range between 14-22%, shale content from 13.5-33.3% and hydrocarbon saturation ranges between 6-50%. While in Unit B, the effective porosity ranges between 17.9-24.5%, shale content from 8.3-35.6% and hydrocarbon saturation ranges between 50.3-53.1%.*

**KEYWORD:** Seismic, Petrophysics, Integration, Offshore Nile Delta Egypt.

## INTRODUCTION

Temsah concession is discovered by IEOC and operated by Petrobel. In four years, ten wells have been drilled, eight of which are over the Temsah field. The seismic acquisition was done for 350SqKm over the field in 1992. From 1992 to 1995 there was 2D seismic acquisition has been done for 2000Km over the field. In 1995 and 1996 a new 3Dseismic acquisition was acquired over Temsah field. The new 3D Survey has covered the northern and the central part of the concession for a total of 1200Sq Km.

In January 1996, ending the first exploratory period. The drilling of eight exploratory wells is a consequence of the difficulties IEOC encountered in trying to outline the actual structure and the reservoir setting of the field. The problem arises mainly from the following: -

- The complexity of the geological framework.
- Severe variations in the seismic velocity across the field.
- Seismic multiples caused by the presence of Messinian salt.
- Poor quality of the 3-D seismic data.

The scope of this study is to integrate Petrophysical data with Seismic data to image and delineate the subsurface features which will lead to finding the best locations for a new well.

## Methodology

The well logs have been used to evaluate and conclude the petrophysical parameters of the studied formations through the formation evaluation system. The theory of this system of well log analysis depends on the total usage of the computer through equations and formulae and pre-established charts and cross-plots for the needed petrophysical parameters such as lithology, porosity, water and hydrocarbon saturations through computer software then integrate these parameters with the attribute maps.

## GEOLOGIC SETTING

The geology of Temsah field was studied before by many researchers.

Most of these researchers agreed about the complexity of the Temsah field structure. Temsah structure is represented by faulted anticline with oriented axis northwest-southeast direction Abdel Aal. et al., 2000. The structure is dissected by strike-slip faults trending NW-SE (Temsah trend). Temsah stratigraphic column can be divided into two parts, the first part is below Rosetta section and the second part is above Rosetta section.

## Stratigraphy of the subsurface: -

### 1- General stratigraphic column of Temsah field:

The stratigraphic column of Temsah field is shown in (Fig.1).

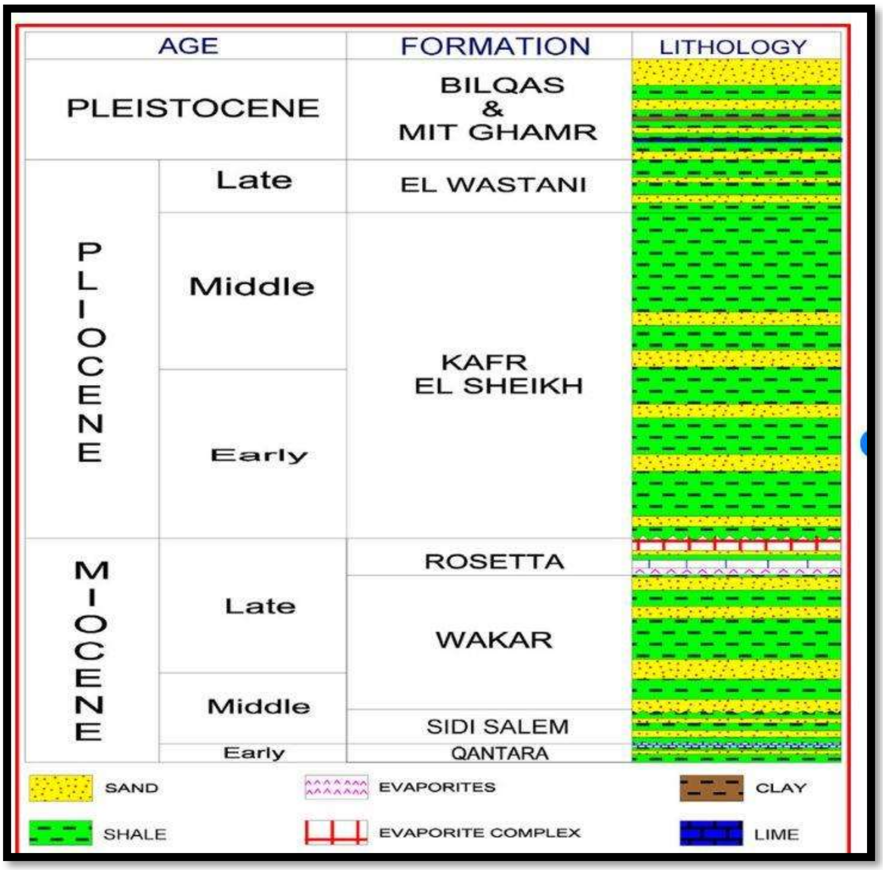


Fig. 1: Stratigraphic column of Temsah field.

## Structural setting of Temsah field: -

The Nile Delta offshore eastern area, which encompasses the fields of Akhen, Temsah, Wakar, Kersh, and Port Fouad, is situated along the Bardwil (Temsah fault trend) alignment (Fig.2) according to Kamel and Sarhan (2002).

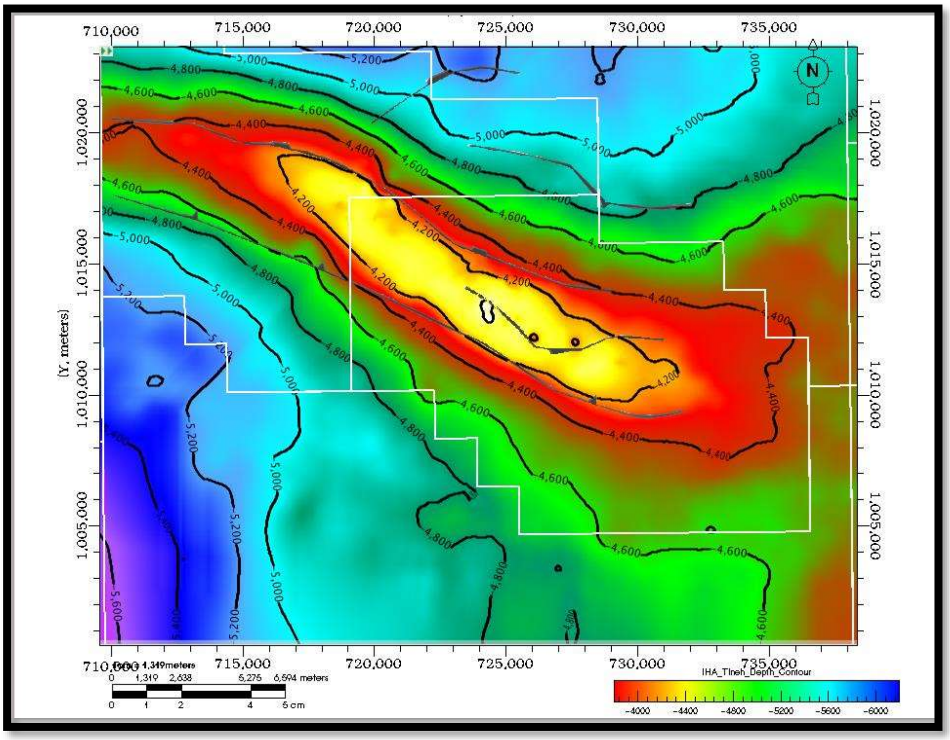


Fig. 2: Tentative regional structure contour map of top Qantara Formation, northern Nile Delta, Egypt (after Kamel and Sarhan, 2002).

Antiform features involving Miocene and pre-Miocene strata are what define these fields. These formations appear to have a flower-like shape on a vertical portion; this suggests a history of strike-slip movements.

The origin and timing of these structures are still up for debate because they are not fully understood, and the alignment is really not perfect-there is a tiny offset or obliquity. Shear displacements along the major Qattara-

Eratosthenes and pelusium lines may have contributed to the general shear

Displacements observed along the Bardwil line (Temsah trend) during the Middle Miocene. Along the line, en echelon will have been created as a result of this shear Dolson, J.C. et al. (2001).

## Sedimentology of Temsah field: -

In Temsah field the stratigraphic sequence (Fig.3) during Miocene time indicates the presence of three main depositional sequences ranging from Serravallian up to the upper Miocene (Tortonian-Messinian): Sequence1 (SQ1), Sequence 2 (SQ2), and Sequence 3 (SQ3). Temsah reservoirs (Sidi Salim Fm. – SQ 1) and (Wakar Fm. – SQ2 and 3). Are related consequently to the Middle Miocene submarine gravity – driven flows in a deep – water environment and to the late Miocene Tortonian deposits consequently.

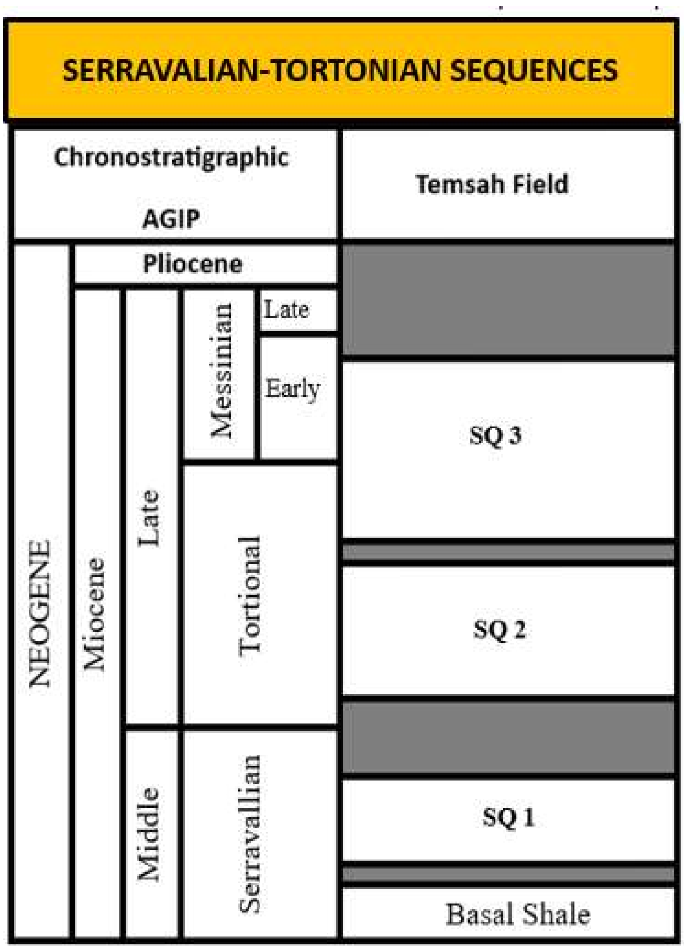


Fig. 3: Stratigraphic scheme during Miocene of Temsah field (After Petrobel, 2003).

The original paleo-flow direction is NE-SW and the depositional model presents a series of crosscutting channels, a system of subparallel sandy depocenters, with terminal lobes that can be incised by younger channels Betello, F. et al.,1996.

The coarse sediment availability is due to a relative sea level fall that induces gravity slides of shelfal sands. With time, the gradual decrease of the volume and density of the gravity flows leads to mudder turbidity currents that accumulate progressively.
Finer Sandstone bodies, vertically separated by equivalently thick muddy units.

In the field the main reservoir is composed of three Sequences (Unit A, B and C from the base), which constitute part of the Serravallian SQ1. Sequence1 is characterized by an overall fining upward trend, furthermore, within each unit there is an upward change from sand rich to mud rich. The argillaceous and silty sections may be the record of the time of coarse sediments starvation in the basin, or represent the lateral and distal deposits of the high-density sandy flows (high gamma ray and sonic values).

## Seismic Interpretation

Seismic data highlighted the structures that were affecting on Serravalian levels (A, B, C) either 3D seismic highlighted the Sand distribution by Seismic attributed maps.

### 1- Conventional Seismic Interpretation

Seismic interpretation is divided into two main steps, the first one is fault detection, and the second one is the Seismic picking. After that perform Structure Contour maps and Seismic attribute maps which helps in detection of the gas bearing sand.

In this study we preformed the interpretation on Unit C, and the result was a depth structural contour map but not calibrated with the well tops.

After that the correction is performed to match between the depth grids and well tops, then the result will be a depth structure contour map (Fig.4).

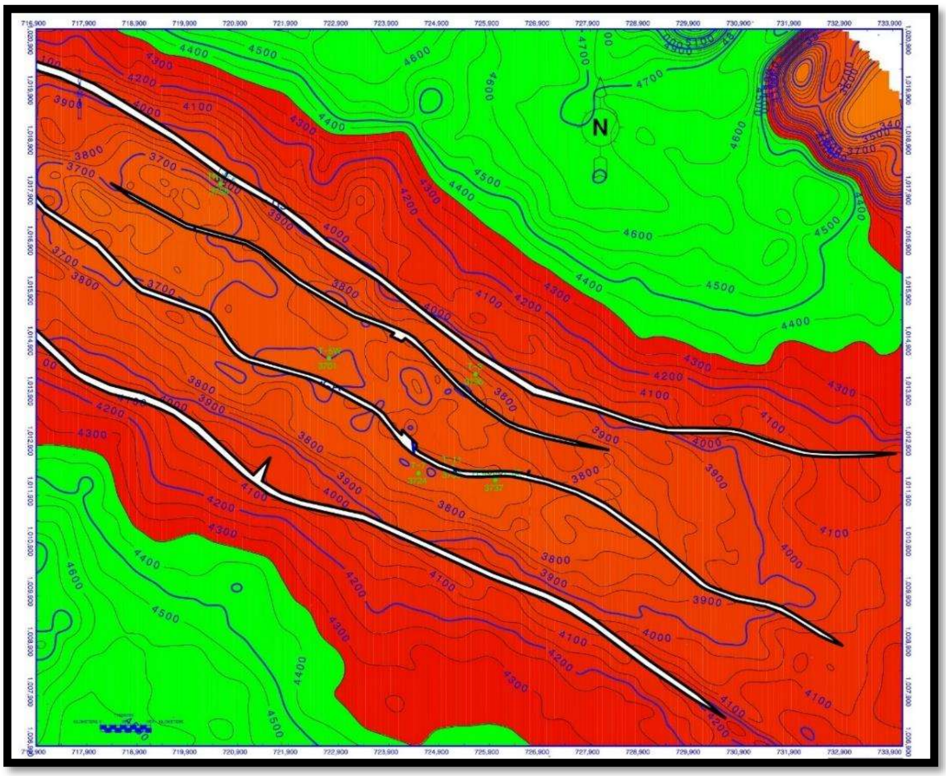


Fig. 4: Depth structure contour map for top Unit C.

## 2- Spectral Decomposition

Is a technique used to help interpret seismic data, although there are several attributes to which spectral decomposition can be applied (such as azimuth, dip, and frequency), frequency is the most commonly used? It can be applied to time migration data, generating a tuned frequency in hertz (Hz) units. Spectral decomposition generates two components: frequency and phase. The frequency component directly represents the relative seismic amplitude within a certain frequency range.

The main Use of spectral decomposition is helping in seismic interpretation by improving thin bed resolution and showing temporal bed thickness variability.

The method of performing the spectral decomposition is by converting the seismic data from time domain to frequency domain by using Fourier transform. The frequency sections at 18, 20, 23 HZ which represents the geological features and RGB color blending were performed to get better image of Unit C (Fig.5) which shows the geometry of the sand bodies and channel of Unit-C, but it was impossible to apply spectral decomposition on Unit-A and Unit-B due to the both unit thickness being below the Seismic resolution.

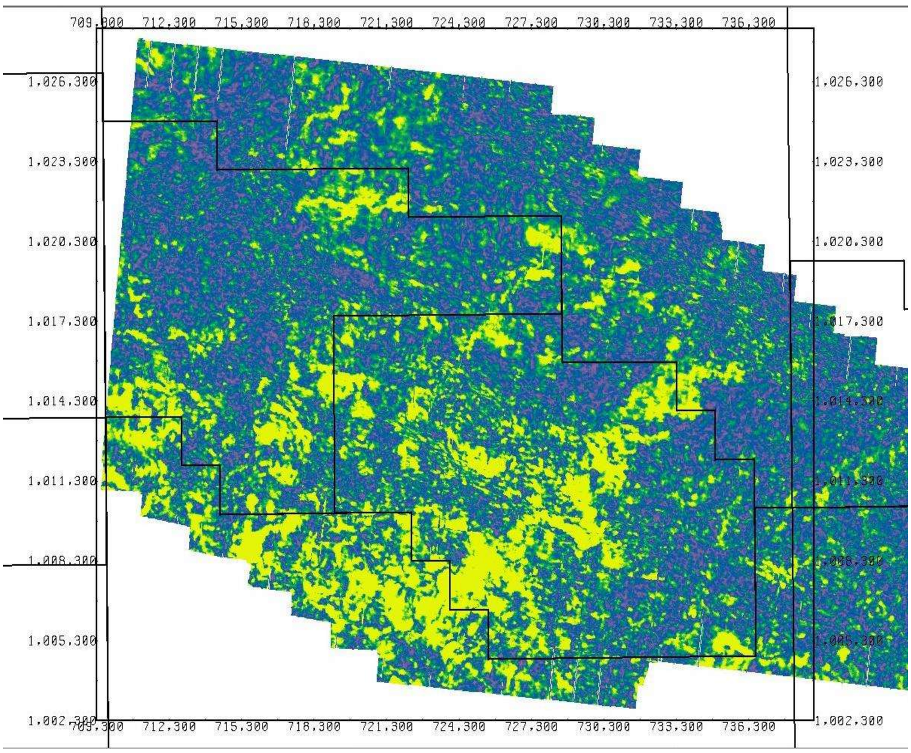


Fig. 5: Spectral Decomposition for top Unit C.

## Reservoir Evaluation: -

The main aim of the well log interpretation is estimating the volume Shale content, the total and effective porosities, and fluid saturations. All of these data are evaluating the reservoir vertically and horizontally by constructing the different types of maps.

It's very important to make a correlation between Temsah wells and show the results of thinning and thickening.

### 1- Computer processed interpretation (CPI)

One of the modern log interpretation methods is the systematic use of computer software. This performs a quick integration of several logging measurements, so the detection and evaluation of the hydrocarbon bearing zones can be achieved rapidly after the logging operation. The well logging instruments give the chance for a more accurate evaluation of lithology, porosity and water saturation. In this evaluation, Techlog petrophysics software constructed by Schlumberger, used for evaluation of the petrophysical parameters of the studied wells.

### 2- Reservoir output data

The end results include net pay thickness, average and maximum porosity, shale volume and water saturation. (Fig.6) represents an example constructed from Techlog Petrophysical Software for Temsah-2 well. From left to right the following tracks are found:

1- Zone units.

2- The first track: GR log.

4- True vertical depth

5- Resistivity logs. (Shallow and deep curves).

7- Sonic log.

8- Water saturation.

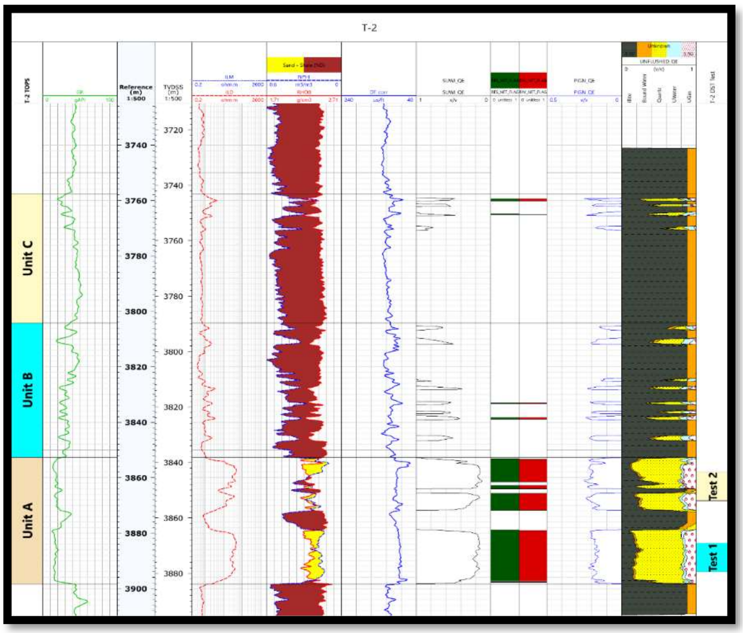


Fig. 6: PDL after ELAN Software for T-2 well.

## Horizontal variation of petrophysical parameters: -

The horizontal variation maps show the lateral change in petrophysical parameters, such as gross thickness, average porosity, shale volume and water saturation. So, the integration between these maps can indicate the best location to drill more wells in the study area.

## 1- Effective porosity Distribution variation

Effective porosity is one of the most important petrophysical parameter in petrophysical evaluation. (Fig.7) represents the effective porosity of Unit C, and it shows the effective porosity increasing toward east and west directions especially at wells Temsah-3 in the east direction and at Temsah-5 in the west direction then decreasing toward north and south direction at wells TNW-3 in the North-West direction and Temsah-2 in the south-east direction. The maximum effective porosity is 22% and the minimum effective porosity is 14%.

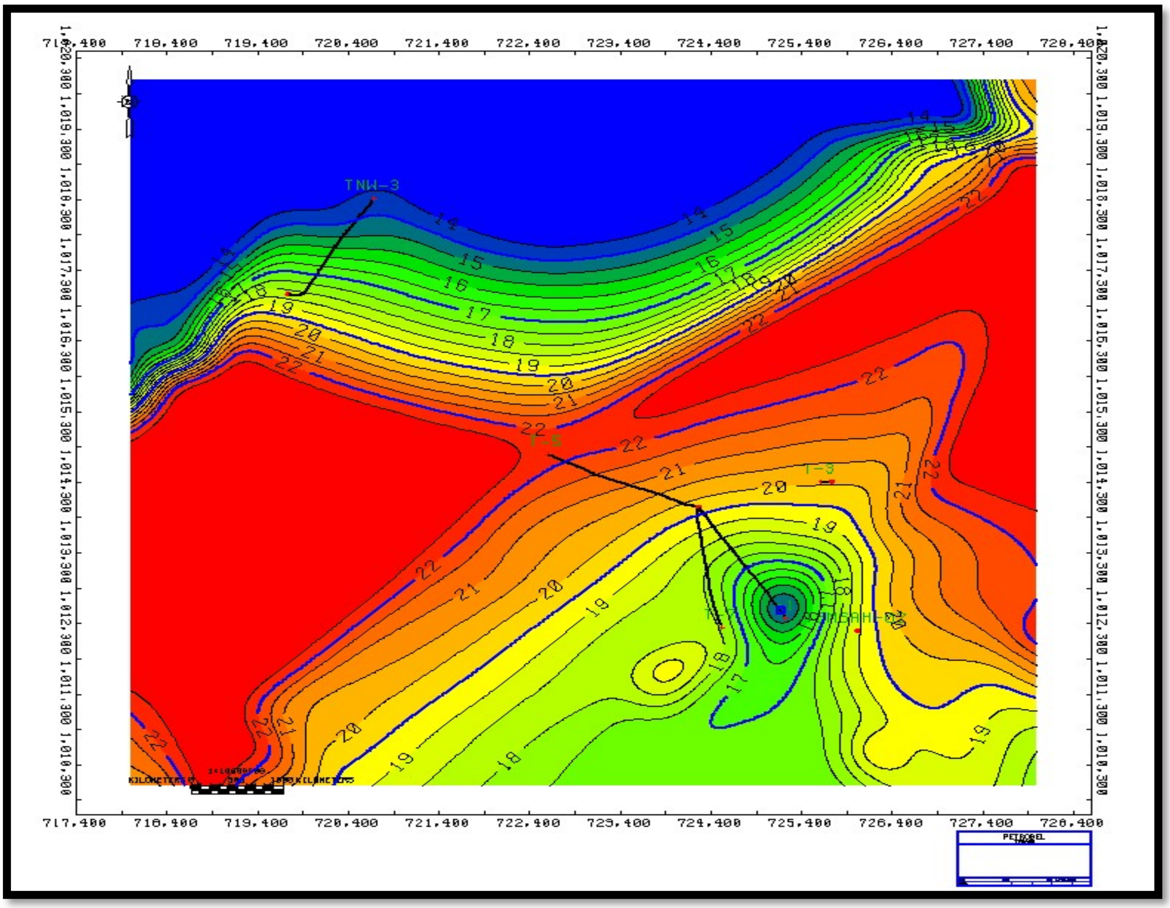


Fig. 7: Effective porosity map for Unit C.

## 2- Hydrocarbon Saturation variation

Hydrocarbon saturation estimation is one of the important petrophysical parameters in petrophysical evaluation. (Fig.8) represents the hydrocarbon saturation variation along Unit C. And shows that hydrocarbon saturation increases toward the east direction at well Temsah-3 also toward the west direction, and decreases toward the south direction at well Temsah-7, The maximum hydrocarbon saturation is 50% and the minimum hydrocarbon saturation is 6%.

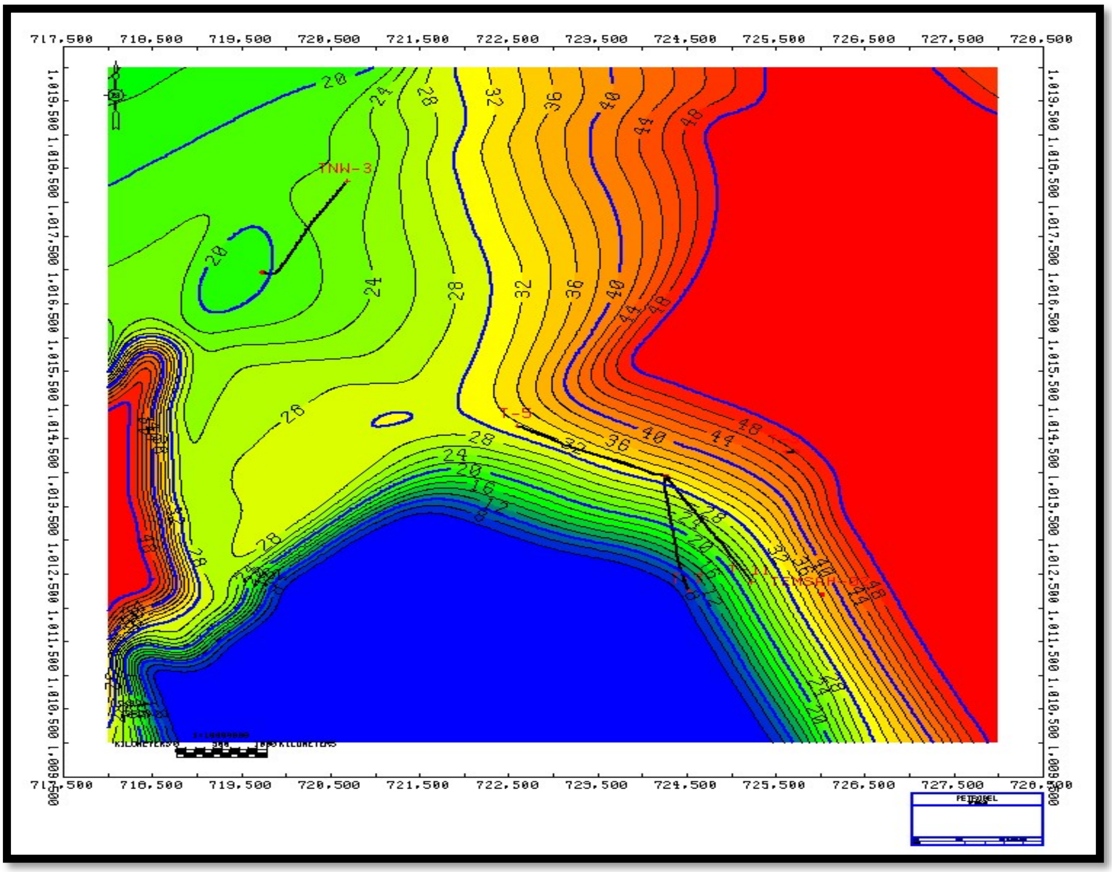


Fig. 8: Hydrocarbon saturation variation map for Unit C.

## Integration between different petrophysical maps and spectral decomposition:

It’s very important to integrate between different petrophysical maps like (porosity, gross thickness) and spectral decomposition to get the best locations for a drainage point, for example (Fig.9) and (Fig.10) which represents the integration between spectral decomposition, porosity and thickness maps which give the best location for drilling the wells in the area of interest.

From the integration between porosity and spectral decomposition map (Fig.9). There is an increase in porosity with increase in the amplitude in the Spectral decomposition map so, there is a positive relationship. For example, porosity increases toward the west with increasing amplitude.

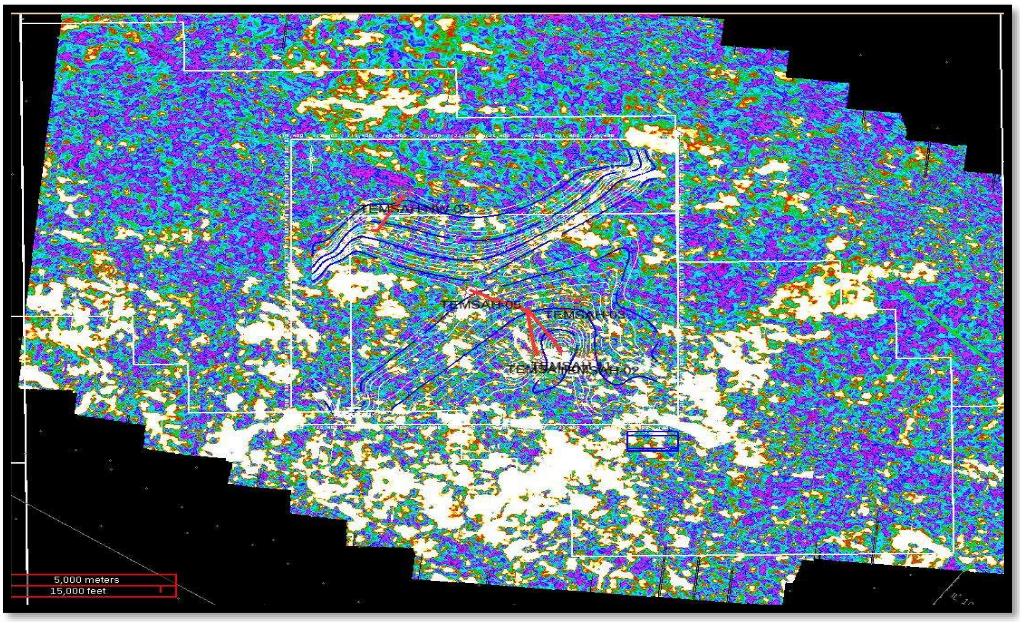


Fig. 9: Integration between Effective Porosity and Spectral Decomposition maps.

Also, from the integration between thickness and spectral decomposition map (Fig.10) there is an increase in thickness with an increase in amplitude in the Spectral decomposition map so, there is a positive relationship. For example, effective thickness increases toward the west and south east with increasing amplitude.

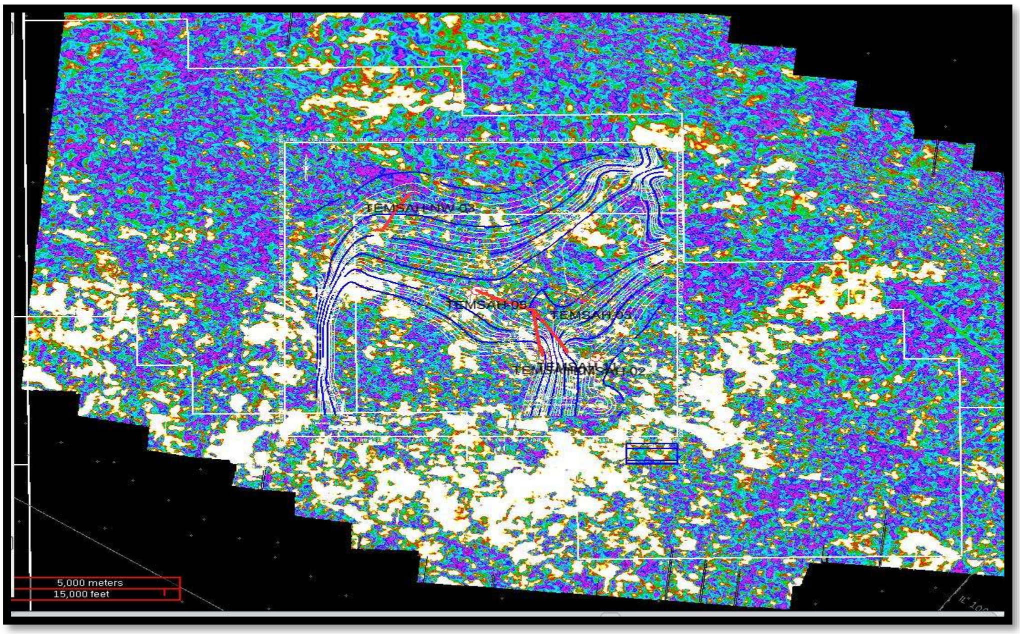


Fig. 10: Integration between Effective thickness and Spectral Decomposition maps.

It's very important to show the integration between the petrophysical evaluation results and seismic interpretation results. The petrophysical parameters displayed vertically and laterally (horizontal iso-parametric maps). These maps help to detect the lateral change in petrophysical parameters such as gross thickness, average porosity, water saturation and volume of shale.

These maps will help in indicating the best locations for hydrocarbon potentialities. Especially if it was integrated with Seismic attribute and structure contour maps.

### Discussions

In Temsah field, a complex structure system is the characterization of the Miocene section. Such complex structure system is resulted from complex tectonic activity, such as extensional and compressional forces that affecting the Miocene section and tend to have complex structures associated. The pre stack time migration (PSTM) is important to show such complex structure, it is also important to perform different type of attributes such as spectral Decomposition which can play a big role in delineating stratigraphic feature distribution. Spectral decomposition uses the frequency content of seismic and shows the channel features clearly. Spectral decomposition was integrated with the petrophysical parameter map, such as effective porosity to get the best results.

## Summary and Conclusion

In Temsah field, the Gas production comes from units A, B and C (Serravalian reservoir) in Miocene (Sidi Salem formation). The shale, which present in Tinah and Qantara formations, is considered a source rock for such field.

In order to illustrate the Miocene's hydrocarbon potential, the current work primarily focuses on the quantitative interpretation of the digital well log data that is now accessible for six wells spread over the research area. The petrophysical features of such well log data, including effective thickness (Heff), shale content (Vsh), effective porosity (Phi eff), and hydrocarbon saturation (Shr), have been assessed and computed using the Techlog computer software.

All of the previous petrophysical characteristics are represented vertically in the form of petrophysical data logs (PDL). Effective thickness, shale content, effective porosity, and hydrocarbon saturation are the iso- parametric maps that show the lateral variations of the petrophysical features for each level.

The effective porosity of such formation ranges from 14% to 22%, and the effective porosity increase toward the east at well Temsah-3 and also toward the west at well Temsah-5, but decreases toward north and south directions.

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