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MAPPING PALEOCHANNELS IN ABU MADI FORMATION AS HYDROCARBON (GAS) RESERVOIRS USING SEISMIC DATA INTERPRETATION, BALTIM FIELD, OFFSHORE NILE DELTA, EGYPT

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تفسير البيانات السيزمية لدراسة الخزانات الهيدركربونية في قنوات تكوين أبو ماضي،

حقل بلطيم البحري ، دلتا النيل، مصر

الخلاصة: يدور هذا البحث حول دراسة و متابعة تكوين أبو ماضي، الذي يعتبر الخزان الأساسي بمنطقة الدراسة في حقل بلطيم البحري الكائن في دلتا النيل بمصر. تعتمد هذه الدراسة علي تحديد إمكانية وجود الهيدروكربون (الغاز) في الحقل ودراسة خصائص الخزان عن طريق استخدام البيانات السيزمية المتاحة. يتكون حقل بلطيم من مستويين للخزان، III أساسي و III سفلي في المسيسيني العلوي لتكوين أبو ماضي ، أعتمد تفسير البيانات علي ربط بيانات تسجيلات الآبار بالبيانات السيزمية، ومن ثم متابعة الأسطح الجيولوجية المعنية في البيانات السيزمية الثنائية الأبعاد واستخراج خرائط هذا الأسطح في نطاق الزمن والعمق. ساهمت الخرائط الكنتورية للعمق في دراسة كيفية تحسين إنتاجية الكربوهيدون و تحديد أماكن وجوده عن طريق البيانات السيزمية.

ABSTRACT: *The main objective of this context is to delineate and map Abu Madi Formation which is the main reservoir in this study area in Baltim gas field located in the Nile Delta to evaluate the hydrocarbon (gas) potentiality in this field and study the reservoir properties based on the available seismic data.*

Baltim field comprises two reservoir levels named III main and III lower within the Upper Messinian Abu Madi Formation.

The seismic interpretation started with creating the synthetic seismogram which is used for the well to the seismic tie followed by picking the desired horizons in all the provided 2D seismic lines, then two-way time maps were generated for each top of these reservoirs after that the average velocity calculated from the time-distance curves acquired from the check shot data are used to provide the structural depth maps to study the areal extension.

Finally, depth-structure contour maps are constructed to enhance the hydrocarbon productivity based on the interpretation of the available seismic data.

1. INTRODUCTION

Baltim East was discovered in 1993 and the production started in April 2000. It includes ten wells BE-1 – BE-10 with good field performance as well as key workover occurred during past years emphasizes possibility of additional potential to Baltim North area.

Baltim North was discovered in 1995 and the production started in November 2005. Five wells have been drilled in Baltim North named BN-1 & BN-5.

The seismic data is provided as PSTM 2D seismic lines exported from 3D PSTM marine seismic cube. The number of lines is 19 in lines and 18 cross lines. The available seismic surveys were acquired at Baltim North and Baltim East fields and adjacent areas as shown in figure (1).

The study area was covered by 37 2D seismic lines of about 1560 km length. In general, the good quality of the migrated post-stack seismic data can be used in structural interpretation. Four seismic horizons were picked namely:

1. Top of Abu Madi Formation
2. Abu Madi Middle (level 3 main)
3. Abu Madi Middle (level 3 lower)
4. Bottom of Abu Madi.

Four Time and Depth structural maps were created for these horizons. The 2D marine seismic data reaches in general up to (8) seconds. The 2D seismic grid spacing varies over the study area ranging between 1 to 4.5 km maximum.

2. GEOLOGICAL SETTINGS (Stratigraphic Column)

Abu Madi Formation is the most important formation through all sections where it is represents the main gas producing reservoirs in the Nile Delta. Rizzini et al. (1978) and Barber (1981) considered the Abu Madi Formation to be mainly transgressive as it is formed mainly of reworked Qawasim and pre-Qawasim sediments.

It consists mainly of thick sandstone layers varying in thickness between 217m and 340m, the sandstone is intercalated with siltstone and shale interbeds which become thicker and more frequent in the upper part of the sequence. The sand is quartzose, quit variable in grain size almost loose conglomeratic.

The stratigraphic sequence of Abu Madi Formation was established by Dalla (1991) who divided the Abu Madi Formation into four depositional sequences starting

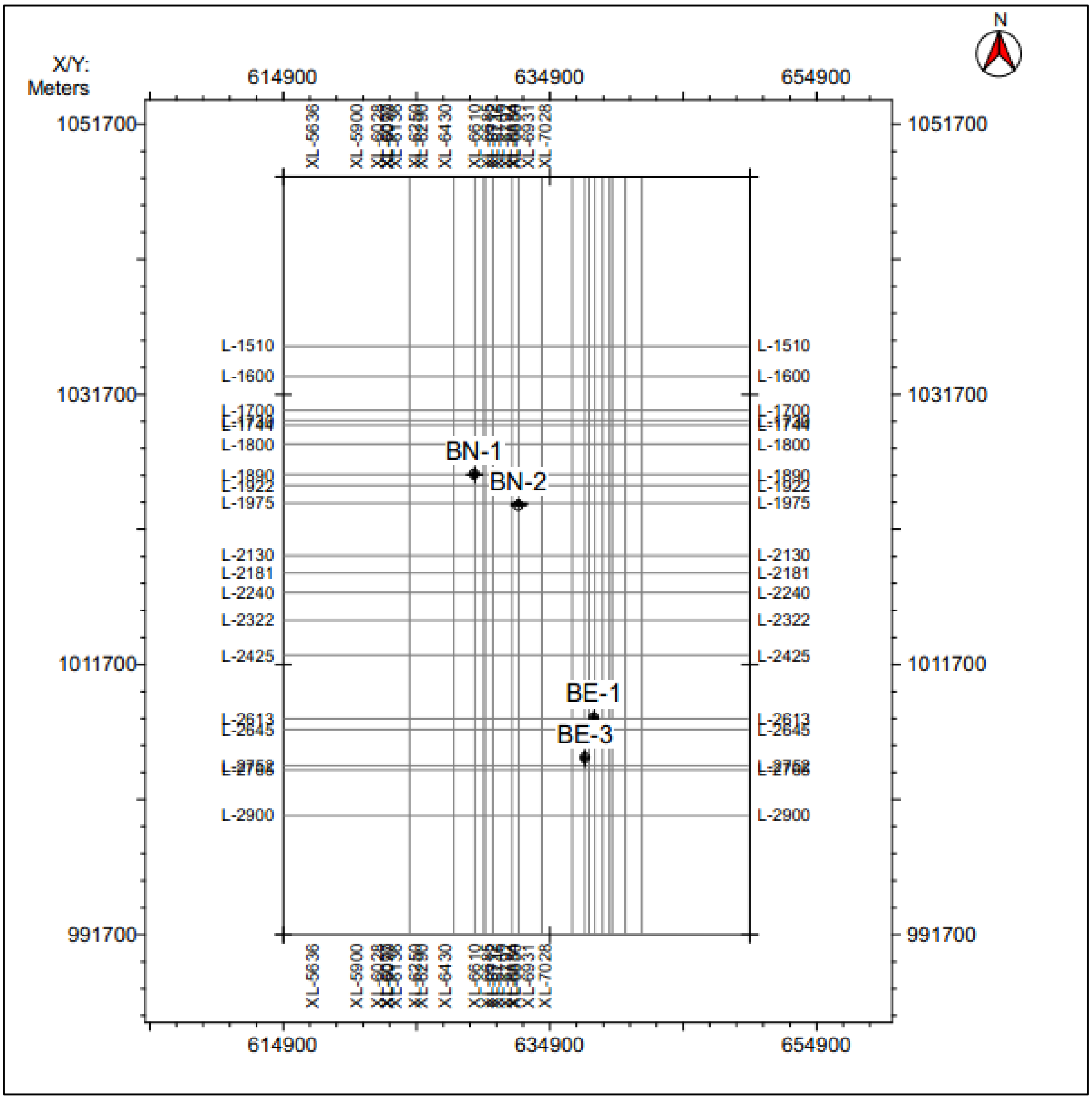

Fig. (1): Base map of the interpreted 2D seismic lines.

from the bottom, UM1, UM2A, UM2B, and UM3. The classical lithostratigraphic layering of Abu Madi Formation comes from the Abu Madi/El Qara fields where the reservoir sandstone levels have been named, starting from the bottom, as follows; Level III lower, Level III main, Level III upper, Level III-A and Level II respectively.

Regionally the last sequence correlated from East Delta field to Baltim, all of them have shown similar internal organization and evolution. The only major difference was related to the more prospective fluvial to fluvio-deltaic facies (Dalla et al., 1997). Baltim fields comprise two reservoir levels named III main and III lower within the Upper Messinian Abu Madi Formation. The stratigraphic correlation between these two levels at El Qara and Baltim fields are shown in figures (2 and 3).

The sequences UM-3 and UM-2 (reservoir levels II, IIIA and III-upper) in Baltim gas fields are shale-out (Fig. 4) and the other sequence UM-1 and the lower part of UM-2 (two reservoir levels III main and III lower) are deposited due to the increase of the major subsidence rate than the one in the Abu Madi/El Qara field's area causing an increasing accommodation space in the Baltim region.

This study focused on levels III main and III lower. The last one represents the upper part of the sequence UM-1 in the Baltim fields.

3. METHEDOLOGY

The quality of seismic data has moderate to good seismic continuity at the different picked seismic horizons from the top of Abu Madi down to the top of Qawasim figure (5).

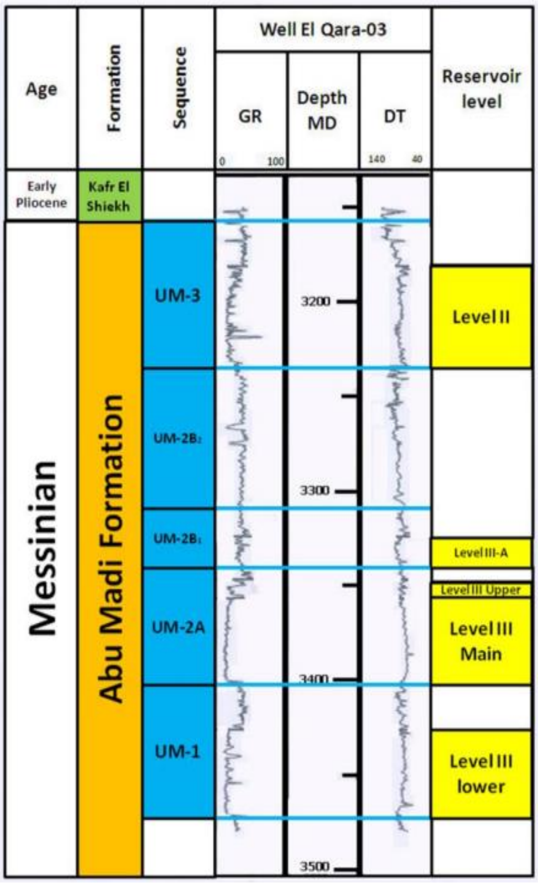

Fig. (2): Sequence stratigraphy of Abu Madi Formation in El Qara field deduced from EQ-3 reference well.

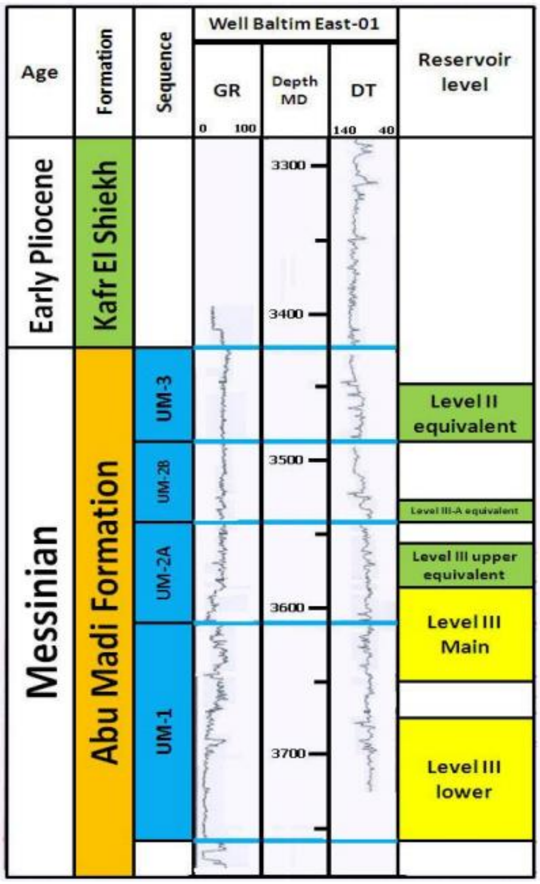

Fig. (3): Sequence Stratigraphy of Abu Madi Formation in Baltim area deduced from BE-1 reference well.

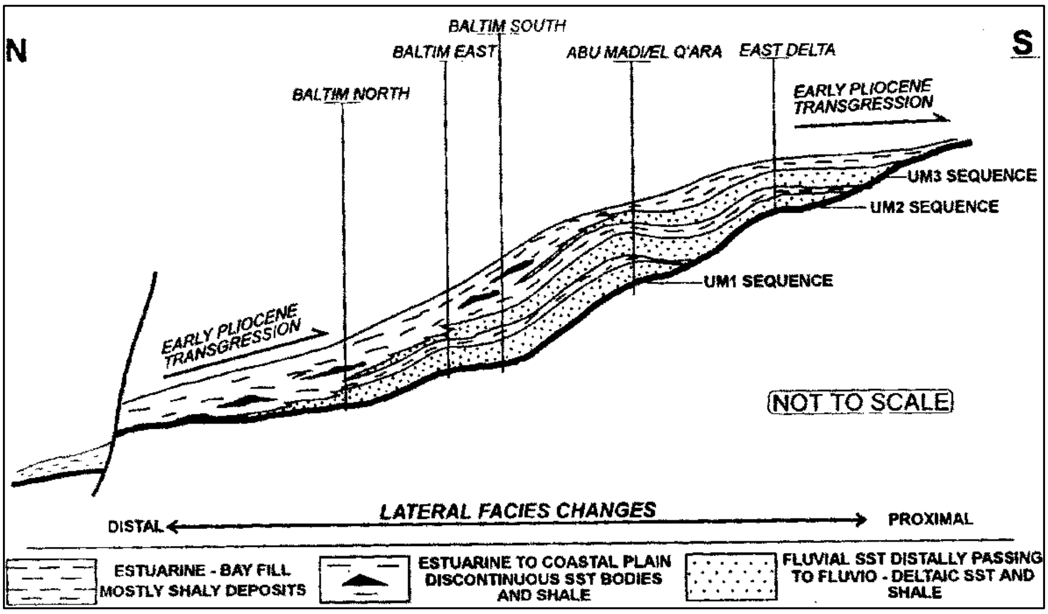

Fig. (4): Sketch showing the physical stratigraphy of Abu Madi sequences (Palmieri et al., 1996).

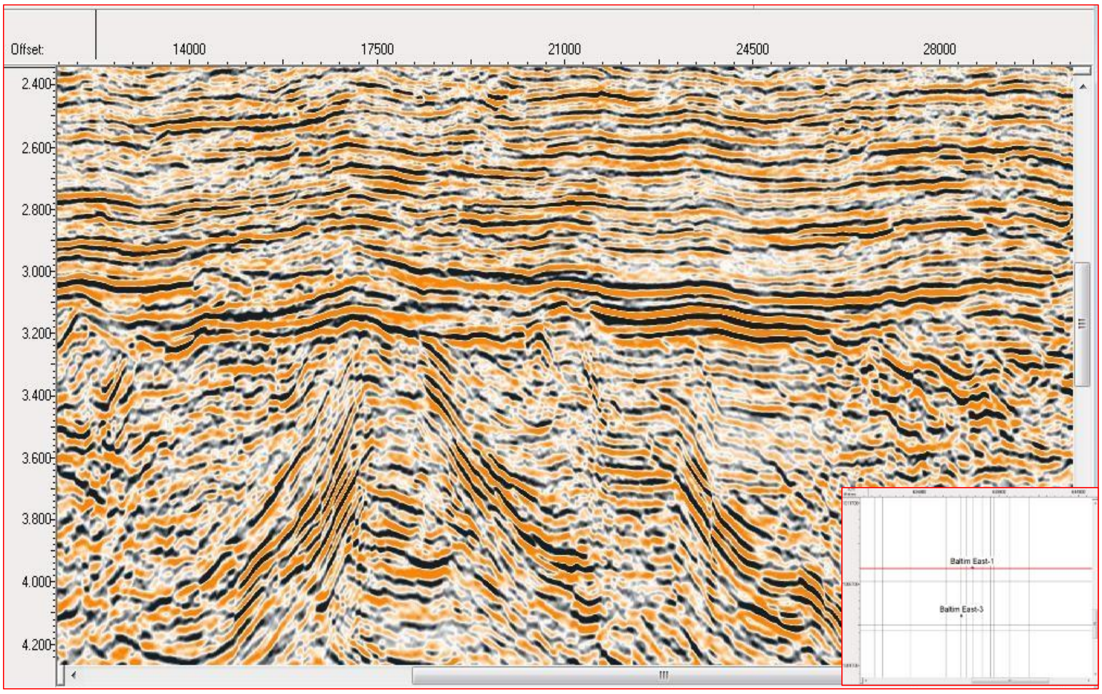

Fig. (5): Cross line 2613 showing the high quality of the recorded seismic data.

3.1: Synthetic seismograms

Synthetic seismograms are artificial reflection records made from velocity logs by conversion of the velocity log in depth to a reflectivity function in time and by convolution of this function with a presumed appropriate wavelet or source pulse (Dobrin and Savit, 1988).

The created synthetic seismograms displayed a good correlation between the seismic data and created for those wells that showed a good correlation to the seismic data. Samples of the synthetic seismogram are shown in figure (6).

Well to seismic tie:

The final step to tie all these wells is to perform a 2D analysis for them with synthetics using the geological information of the well tops and logs. At this stage, several lines were selected that have two or more wells, synthetics, cyclo-sequence stratigraphic tops, and wireline logs to illustrate the continuity and correlation between the wells.

Four seismic horizons were picked, namely:

- Top of Abu Madi, moderate peak.
- Abu Madi Middle (level 3 main), moderate peak.
- Abu Madi Middle (level 3 lower), moderate to weak peak
- Bottom of Abu Madi, moderate to weak trough

3.2: Seismic interpretation

Seismic interpretation usually takes place against a background of continuing exploration activity and an associated increase in the amount of information related to the subsurface geology (Kearey et al., 2002)

Conventional seismic interpretation implies picking and tracking laterally consistent seismic reflectors for the purpose of mapping geologic structure, stratigraphy and reservoir architecture (Avseth, 2005).

The seismic interpretation was carried out through the Schlumberger Software (Petrel) and SMT Kingdom software. Seven selected dips and one strike section were presented to illustrate the interpreted horizons in the area as shown in figure (7), Interpretation of the 2D seismic data was based mainly on the available 37 seismic lines.

3.3: Time to depth conversion:

Four time and depth maps were constructed for the horizons from the top of Abu Madi down to the Sidi Salem Formation. Time to depth conversion of the time maps was carried out using the Time/Depth curve of Baltim North-1 well. The velocity curve of Baltim North-1 well, figure (8), displayed a normal gradient of increased velocity function with depth.

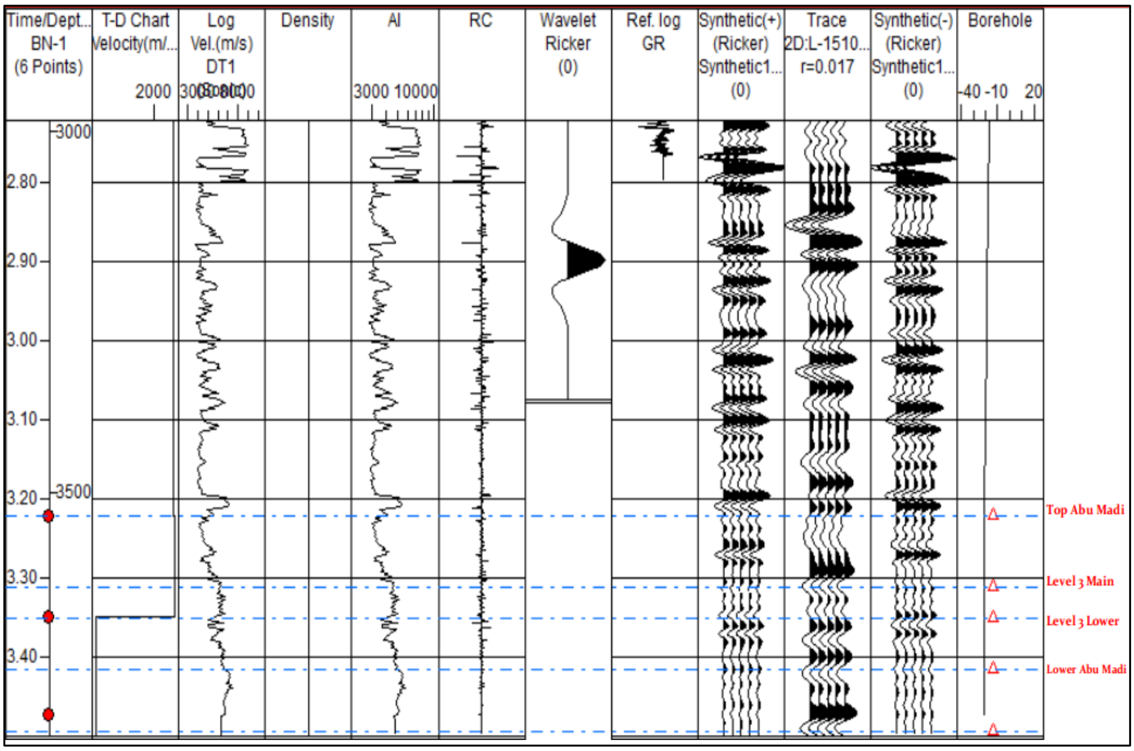

Fig. (6): Baltim North-1 well synthetic seismogram montage.

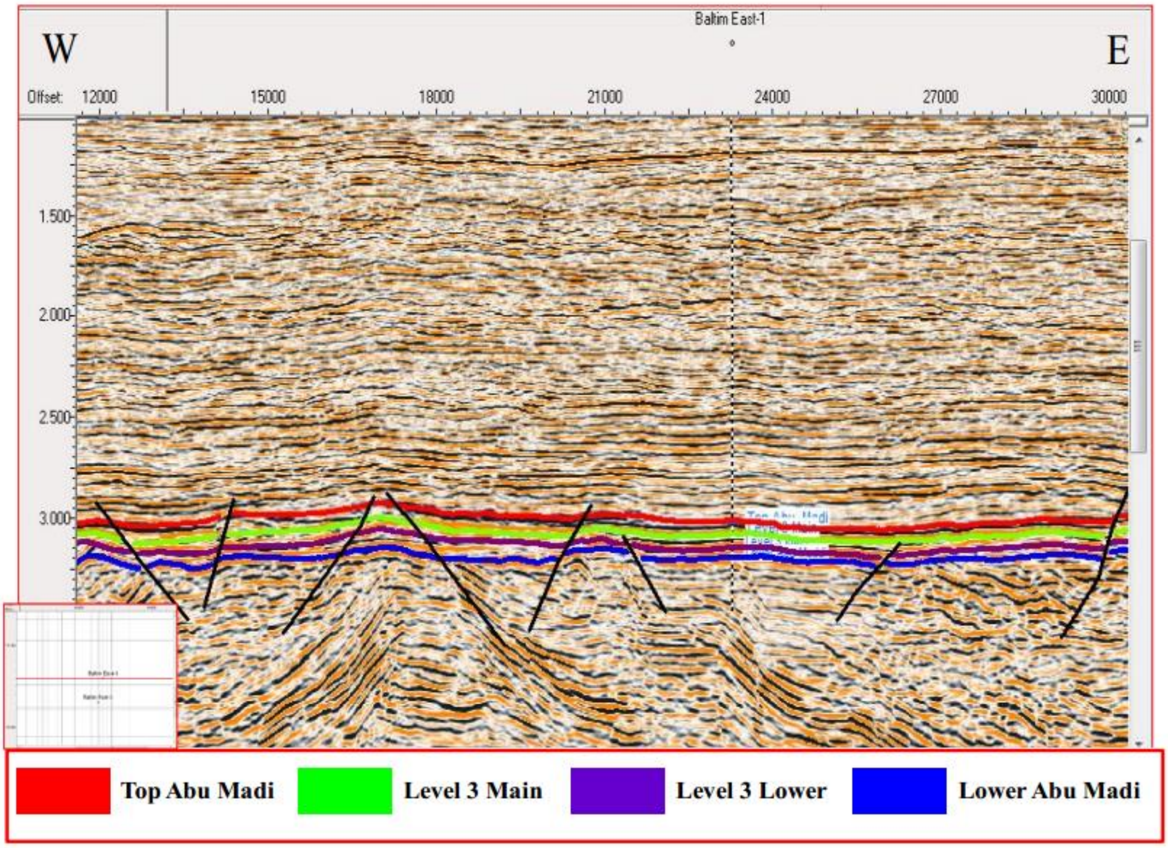

Fig. (7): Interpreted cross line 2613 showing the picked seismic horizons.

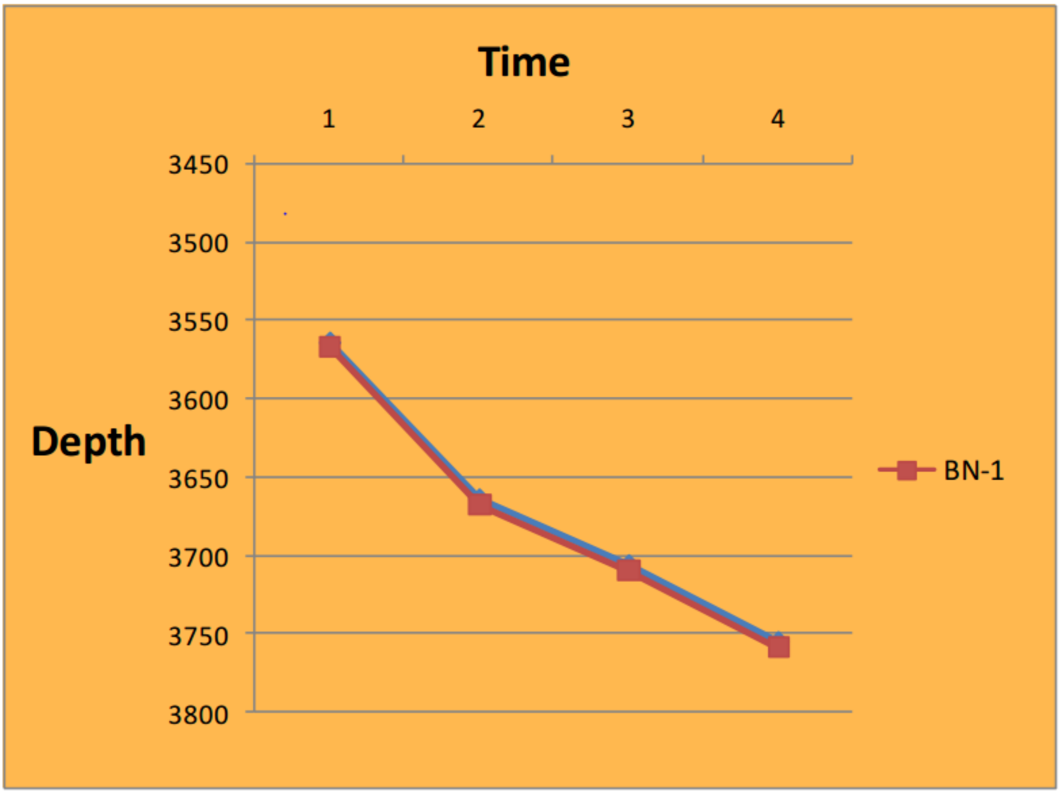

Fig. (8): Time - Depth Curve of Baltim North-1 well.

3.3.1: Abu Madi (Level 3 Main) Two-way Time and Depth maps:

The upper Pliocene channels can be traced in map and seismic sections.

The structure contour maps on the top of level III main were adjusted by well logs data on the top of level III main.

Abu Madi reservoir (Level III main) was sealed, laterally by sharp facies changes due to the main channel boundary. It is revealed that, the area was dissected by two main faults, the first one is a great high angle E-W normal fault dipping northward in the southern part of Baltim area between Baltim South field and Baltim East field.

The second fault between Baltim North field and Baltim Northeast field which are in NE- SW direction and dips to the north, displacing all the levels more than 80 m.

Figures (9) and (10) displays Abu Madi (level III main) TWT contour map and Abu Madi (level III main) depth structure contour map.

3.3.2: Abu Madi (Level 3 lower) Two-way Time and Depth maps:

The upper Pliocene channels can be traced in map and seismic sections. The structure contour maps on the top of Level III lower were adjusted by well logs data on the top of level III lower.

Abu Madi reservoir (Level III lower) was sealed, laterally by sharp facies changes due to the main channel boundary. It is revealed that, the area was dissected by two main faults, the first one is a great high angle E-W normal fault dipping northward in the southern part of Baltim area between Baltim South field and Baltim East field.

The second fault between Baltim North field and Baltim Northeast field which are in NE- SW direction and dips to the north, displacing all the levels more than 80 m.

Figures (11) and (12) display Abu Madi (level III lower) TWT contour map and Abu Madi (level III lower) depth structure contour map.

Baltim gas field structurally belongs to the central subbasin which separated from the eastern and western subbasin by set of faults trending NW-SE & NE-SW directions (Rosetta and Barduwil or Misfaq fault zones),

Abu Madi reservoir was sealed, laterally by sharp facies changes due to the main channel boundary, and vertically by mud blankets of Kafr El Sheikh Formation which uniformly covers Abu Madi Formation.

Figures (13) and (14) illustrates top Abu Madi TWT Contour Map and top Abu Madi depth structure contour map, respectively.

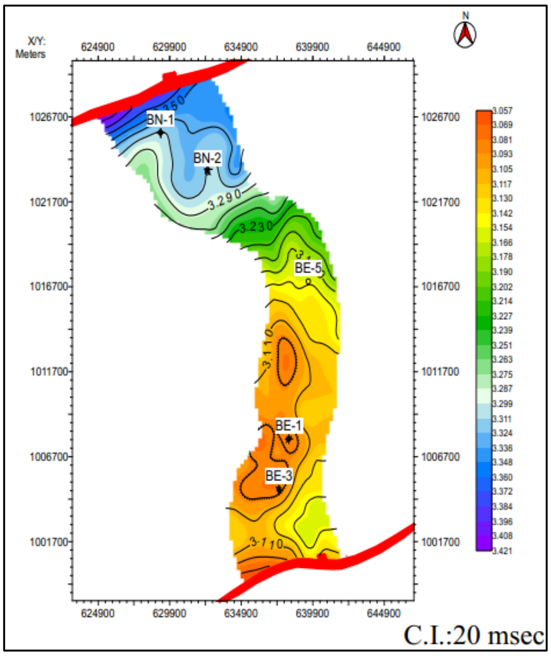

Fig. (9): Abu Madi (level III main) TWT contour map.

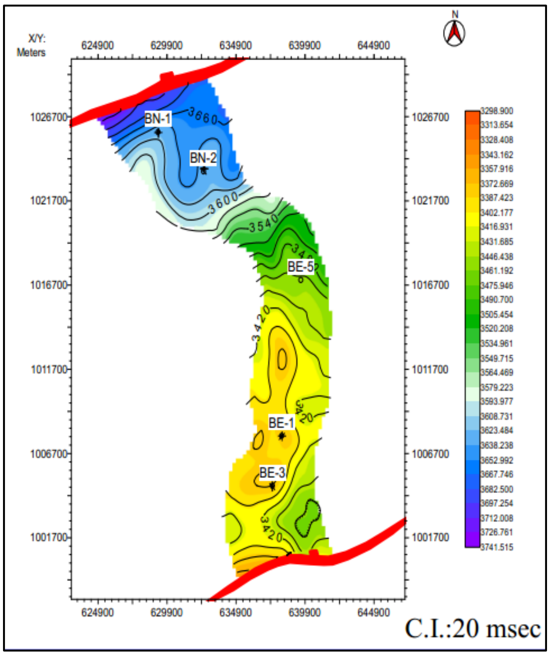

Fig. (10): Abu Madi (level III main) depth structure contour map.

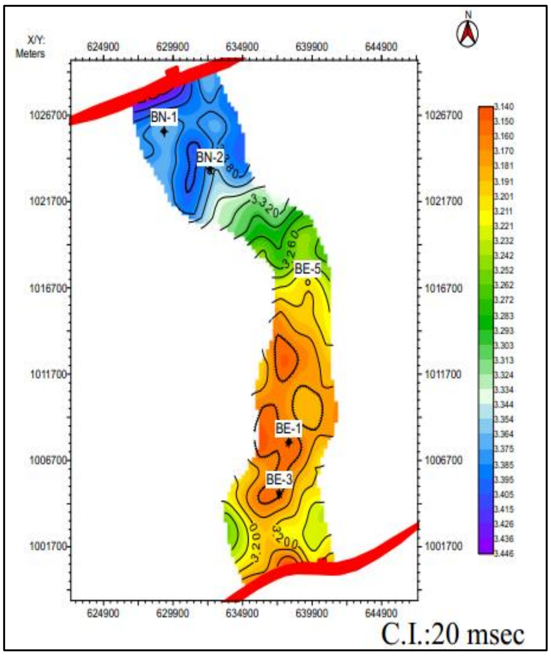

Fig. (11): Abu Madi (level III lower) TWT contour map.

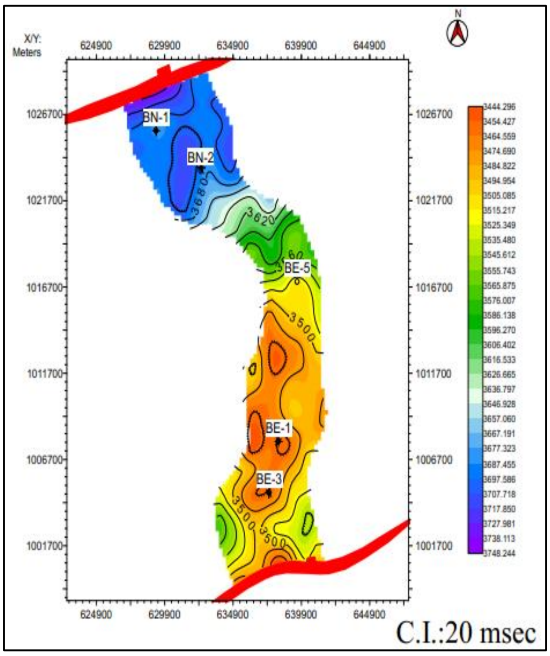

Fig. (12): Abu Madi (level III lower) depth structure contour map.

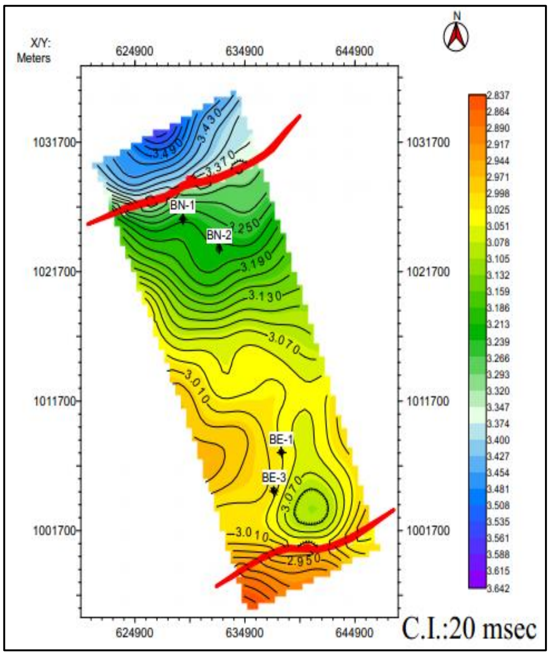

Fig. (13): Top Abu Madi TWT contour map.

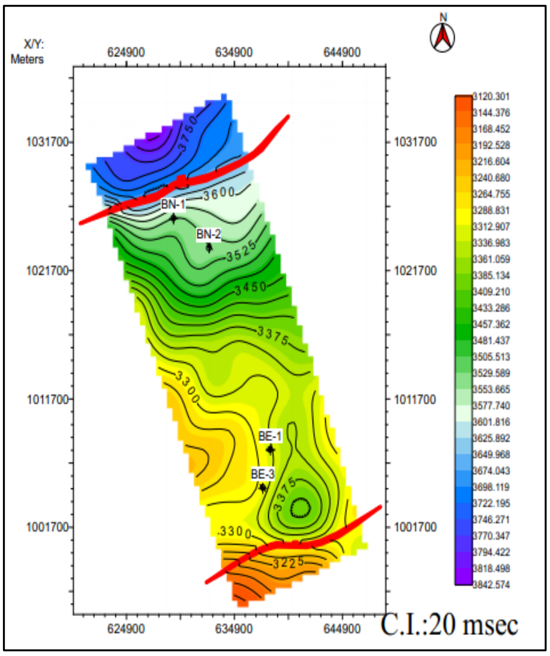

Fig. (14): Top Abu Madi depth structure contour map.

At the bottom of Abu Madi (Qawasim Formation); an angular unconformity exists between the Abu Madi series and the underlying formations.

Also the dip meter measurement can help in defining such contact, which is often marked by angular unconformities.

Also this formation was dissected by two main faults, the first one is a great high angle E- W normal fault dipping northward in the southern part of Baltim area between Baltim South field and Baltim East field.The second fault between Baltim North field and Baltim Northeast field which are in NE-SW direction and dips to the north, displacing all the levels more than 100 m.

Figures (15) and (16) illustrates Bottom Abu Madi TWT contour map and Bottom Abu Madi depth structure contour map.

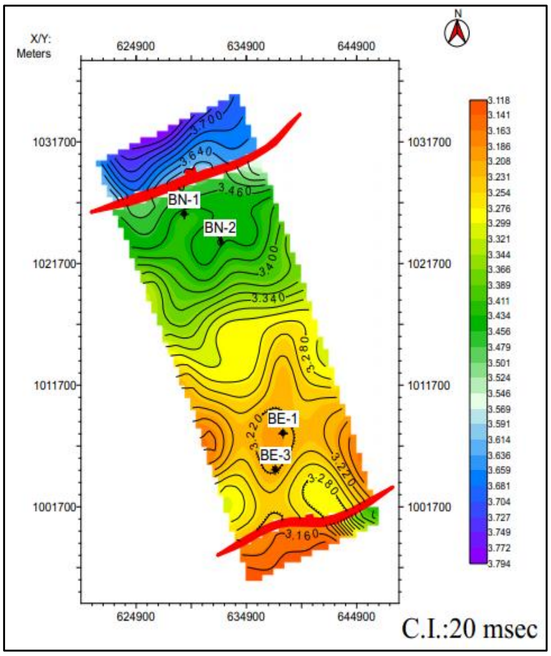

Fig. (15): Bottom Abu Madi TWT contour map.

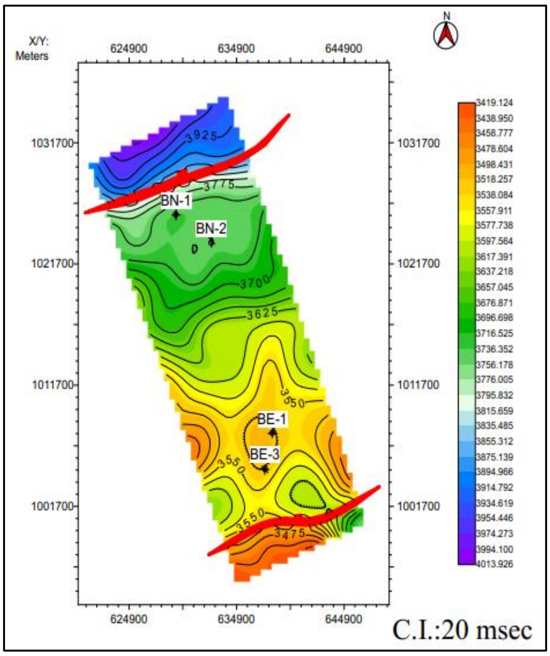

Fig. (16): Bottom Abu Madi depth structure contour map.

The upper Pliocene channels can be traced in Level III main & lower maps and seismic sections.

Figure (17) and (18) illustrates the channel boundary of level III main depth structure contour map and interpreted lines and the channel boundary level III lower depth structure contour map and interpreted lines.

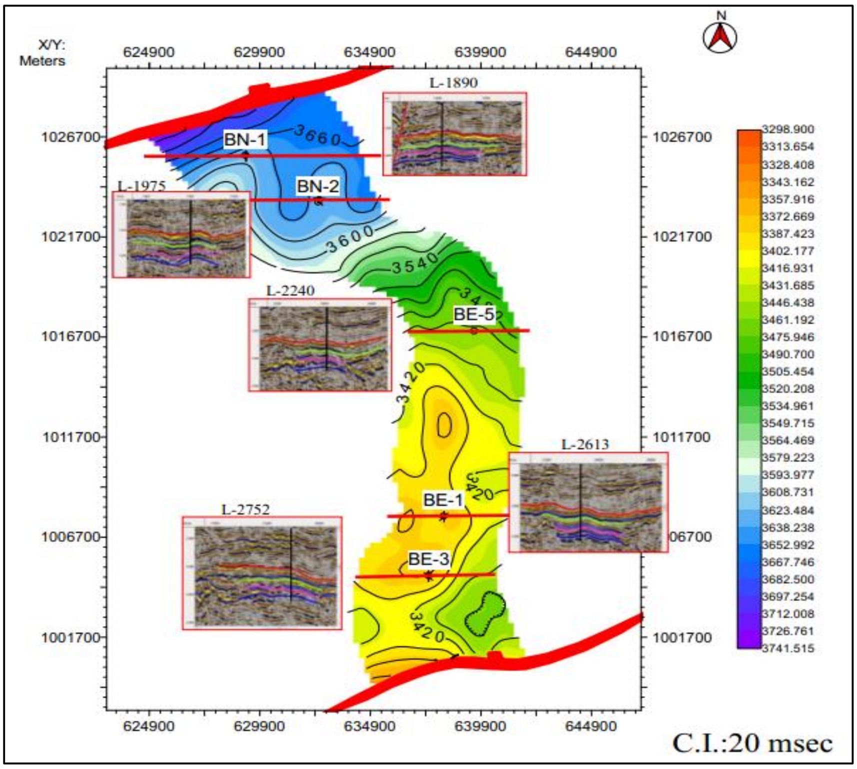

Fig. (17): Channel boundary of level III main depth structure contour map and interpreted lines.

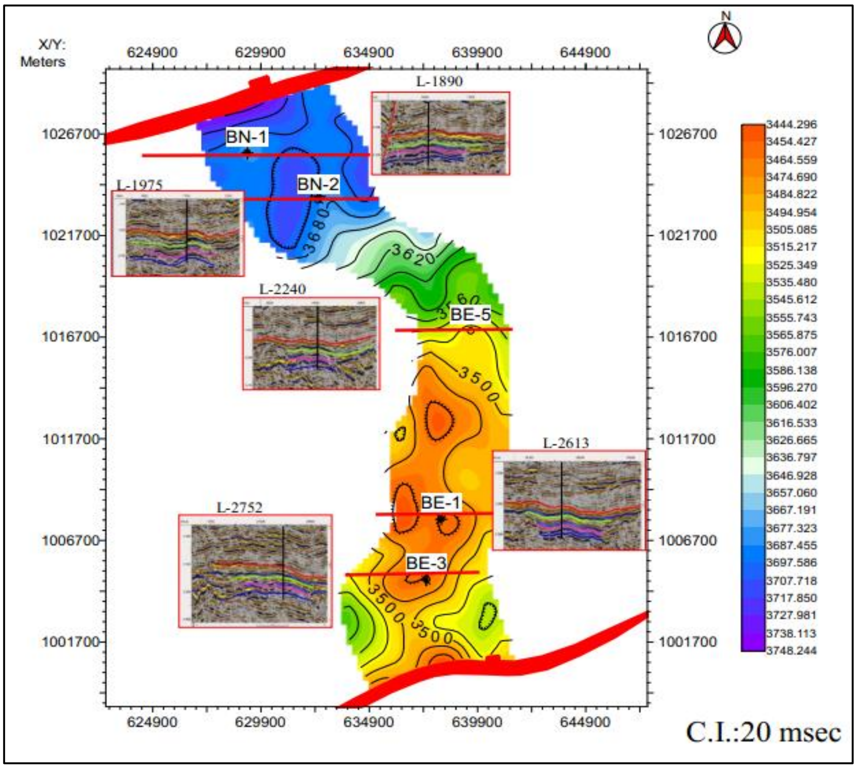

Fig. (18): Channel boundary level III lower depth structure contour map and interpreted lines.

4. SUMMARY AND CONCLUSION

Detailed seismic interpretation workflow has been applied to delineate the subsurface structure and extension for the paleo-channels in the Baltim Field, Offshore Nile Delta of Egypt. The workflow started by generating a synthetic seismogram from the logs of Baltim North-1 well. Four levels within the Abu Madi Formation has been identified and picked on the seismic sections. Two-way time structure contour maps were then generated for the interpreted horizons. Time to depth conversion of the time maps was carried out using the Time-Depth curve of Baltim North-1 well. The generated depth maps revealed the channels boundaries as well as faults affecting the Abu Madi Formation which led to better identification of the possible hydrocarbon traps.

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