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Seismic Structural Interpretation Study of Mishrif Formation in Nasiriyah Oil Field Southwestern Iraq

Salman Z. Khorshid, Mahmoud A. Hlelai*
Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

Seismic data interpretation study has been done for Mishrif Formation in Nasiriyah oil field at the southern part of Iraq in order to update the structural image of Mishrif reservoir which is currently the main unit bearing the oil in subsurface area covered about (447) km2. This study is achieved by using Petrel, IP, and other approval software. Seismic to well tie method in conventional qualitative interpretation used to re-identify the top and bottom of the Mishrif reservoir which converted into structural depth maps and then followed by constructing and developing 3-D structural model helped to understand the vertical and lateral thickness extensions heterogeneity of Mishrif Formation in the field. The cap rock (CRI) has thickness ranging from (4 - 14) m, it increases in (NW) and (SE), and decreases in the middle of the field. (MA) unit has thickness ranging from (53 -63) m, and it increases in (N) and decreases in the (S) of the field. The cap rock (CRII) unit has almost the same thickness in the entire field. It was ranging between (10-12) m. (MB1) unit has thickness ranging from (11 -23) m and it was increases in (W) and decreases in the (E) of the field. (MB2) has thickness ranging from (35 -55) m increases to the (E) and almost has same thickness in the entire field. Its showed that Mishrif reservoir could be a marine platform formed gradually from back reef in NW to the reef slope in SE of the field.

Keywords: Structure Interpretation, Nasiriyah oil field, Mishrif Formation.

دراسة تفسير البيانات الزلزالية لتكوين مشرف في حقل الناصرية جنوب غرب العراق

سلمان زين العابدين خورشيد، محمود عبد النبي هليلاي*
قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

تم دراسة وتفسير البيانات الزلزالية لحقل الناصرية الواقع في محافظة ذي قار جنوب غرب العراق لتحديث الصورة التركيبية لتكوين مشرف النفطي الرئيسي بالحقل بمساحة تغطي حوالي 447 كم^2. وقد انجزت هذه الدراسة باستخدام البرامج IP، Petrel وغيرها. تم عرض ومعايرة المقاطع الزلزالية المحدودة مع بيانات جس الابار في عملية التفاسير الاولية التقليدية لتعريف واعادة تحديد الحدود العليا والسفلى لتكوين مشرف ومن ثم رسم خرائط تركيبية عميقة لها تبعها بناء وتحديث موديل ثلاثي الابعاد للتركيب ساعد في فهم التغيرات الجانبية والعمودية لسمك الطبقات لتكوين المشرف. ان طبقة الغطاء الاول (CRI) ` ذات سمك يتراوح من (4−14) مترا حيث يزداد باتجاه الشمال الغربي والجنوب الشرقي ويقل في وسط الحقل. طبقة ال (MA) ذات سمك يتراوح من (53−63) مترا مع وجود زيادة باتجاه الشمال ونقصان بالجنوب. ان الطبقة الصماء (CRII) الفاصلة بين الوحدتين (MA) و (MBI) لها سمك متجانس في اغلب الاتجاهات حيث يتراوح من (10−12) مترا. وطبقة (MBI) لها سمك يتراوح من (11−23) مترا حيث تزداد في اتجاه الغرب وتقل باتجاه الشرق.

* Email: mahmoud.hlelai@gmail.com

طبقة MB2 لها سمك يتراوح من (35–55) مترا حيث تزداد باتجاه الشرق ومتجانسة نوعا ما في اغلب الاتجاهات بالحقل. كما بين الموديل احتمالية تركيب مشرف السحنية التي قد تكون عبارة عن منصة بحرية تتدرج من بيئة خلف الحيد في اتجاه شمال– غرب الى بيئة المنحدر في اتجاه جنوب–شرق من الحقل وليس نتيجة لوجود عمليات طي وذلك لغياب او قلة النشاط التكتوني في المنطقة.

Introduction:

The Mesopotamian Basin in Iraq consists of a wide asymmetric syncline and it is one of the most important productive hydrocarbons field in the world. It has variety of structures from simple to complex [1]. The Nasiriyah oil field is one of the most promising oil field in the Mesopotamian basin, which is discovered in 1976. Mishrif Formation is the main carbonates reservoir in Nasiriyah oil field. It is important in the other oil fields in central and southern of Iraq such as, Buzergan, Amara, Halfaya, Majnoon, Rumaila, and West Qurna [2]. Using 3-D seismic data supported with well logs, and coring data provide the best tools to identify the structural framework of the field. The main purpose of this paper is to interpreter the structural settings of the Mishrif Formation in Nasiriyah oil field.

Description of Study Area:

Nasiriyah oil field lies in Thi-Qar province at southern part of Iraq close to Nasiriyah city east of the Euphrates river about (38) km northwest of the Nasiriyah center Figure-1. Gravity survey carried out between (1940-1950) by Basra oil company (BPC) for most southern areas of Iraq included studied area. In addition, magnetic survey carried out between (1973-1974) by the French Company C.G.G. The results of interpretations of both surveys have been encouraging for implementation of a detailed survey of the area where showed that there are structural enclose that have the same direction of the folds of hydrocarbon potential in other areas of the southern Iraq. First exploratory seismic reflection survey for Nasiriyah oil field was carried out between (1973- 1976) which is covered (1218) Km2 , and according to the results of the survey NS-1 well had been drilled in 1978. Between (1980 – 1981) deep seismic survey has been done. NS-2, and NS-3 wells had been drilled between (1984-1985) results to the interpretation. In (1986) reinterpretation had been done resulted to the differences in the depths of the interested formations between drilling data and seismic data. Between (1986-1988) NS-4, and NS-5 had been drilled and started a new detailed deep survey which covered (447) km^2.

Between (1994-1996) reinterpretation had been done by Italian Companies (Repsol, Agip, and Eni). Also, re-planning design for the field still under contraction by Japanese Company (JC), American Company (GXT) and Iraqi Oil Exploration Company (INOEC) [3, 4].

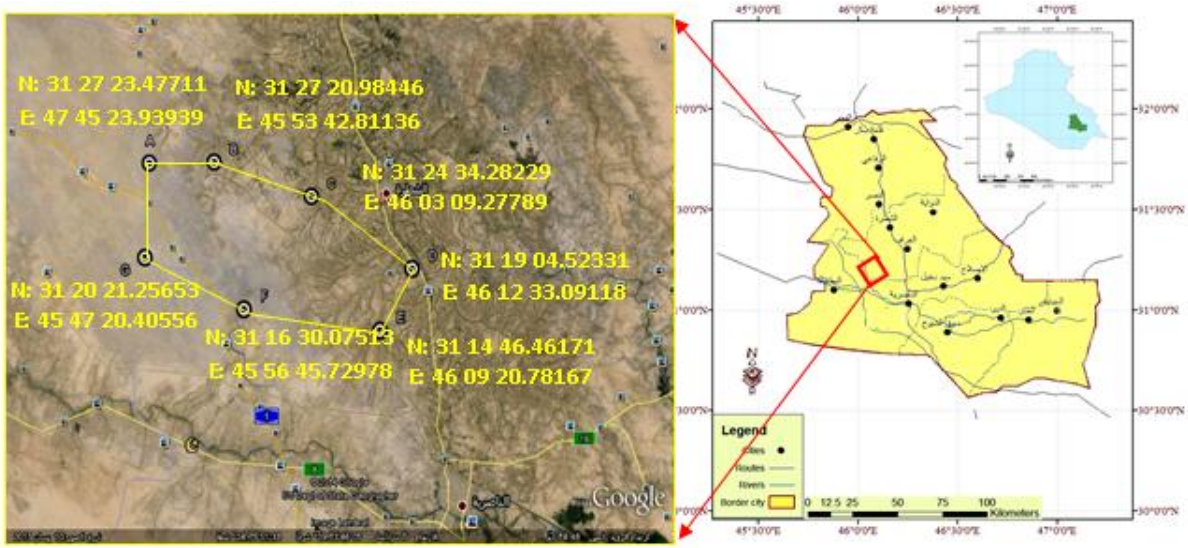

Figure 1- Shows the geographic coordinates of the study area.

Geological Setting

Surface Geology:

The area is characterized by almost a flat area covered by Holocene sediments, which consists mainly flood plain sediments presented in Hammar Formation [5]. In addition, there are moving sand dunes especially in the west and northwestern part of the area. Subsurface Geology: Iraq lies in the border area between the Arabian part of the African (Nubio-Arabian) Platform and the Asian branches of the Alpine Geo-syncline. The platform of Iraqi territory is divided into two basic units, the Stable and Unstable Shelves. Tectonically, Nasiriyah oil field is located in unstable shelf close to Arab platform in the Mesopotamian zone, which covers most of south and central parts of Iraq. It is characterized by the presence of limited sub-surface anticline and domes in variable directions NS, NW, and SE [6-8].

The Cretaceous period is the most active period in the Mesozoic and it is the most important depositional environment in Iraq. Depositional environment succession of Mishrif Formation during cretaceous rocks in the lower part of Cenomanian-Early Turonian cycle has wide sediments extending start from open-shelf to fore-reef slope ,then reef flat and finally inner-shelf conditions [9, 10]. The stratigraphic of Mishrif Formation located between Kifl or Khasib and Rumaila Formations gradually. It composed from heterogeneous porous, detrital, and organic limestone rich in fossils index such as Rudest, large Foraminifera, and Algae. These lithofacies reflected wide extend of various environment sediments start with fresh water sediments in the upper of Mishrif gradually to the deep marine environment at the lower of the Mishrif [10, 11].

Data Base

Data set used in this study includes seismic digital data, fourteen digital well logs (NS-1 to NS-14), and previous geological drilling reports Figure-2. The source of the data was Ministry of oil-Exploration Company. Seismic data surveyed, acquired and processed by Iraqi National Oil Exploration Company, while logs and drilling data were by South Oil Company (INOEC), 2010 [3].

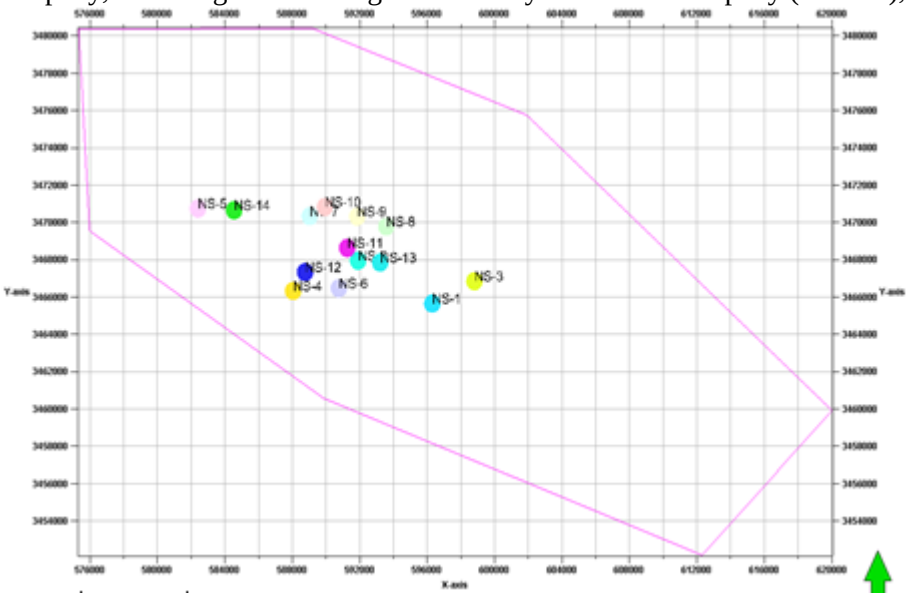

Figure 2- Shows well locations in the studied area.

Methodology

To achieve, the aim of the study and updating the subsurface image of Mishrif reservoir, which is the main interested formation in this study. The following steps are applied:

1. Selection the best wells from NS-1 well to NS-14 well that have almost all the available logs data which can be used for the lithological correlation. The logs are GR,SP,DT,RHOP,NPHI, and ILD.
2. Selection several seismic sections and the base map of the survey.
3. Editing and calibrating the selected wells logs data with seismic sections.
4. Correlation well logs in sections to illustrate the variation in reservoir thickness.
5. Determination the depths of each unit from well tie to seismic sections.
6. Creation Mishrif Formation structural maps from digital seismic depth map and well tops data supported with geological drilling data.

7. Reconstructing the 3-D structural model.

Theoretical Review

Reflection seismology (or seismic reflection) is a technique (echograph) works by sending artificial elastic waves in 3D direction by controlled energy source such as dynamite explosion or vibrators ranging from (10 – 100) Hz into the earth and recording the strength (intensity) and time required for the return of any reflected signals to the surface. Reflection is produce whenever the energy pulse enters into a material with different elastic property. Some of the energy pulses reflect back to the receivers, some energy also keeps traveling through the materials until it dissipates or lost (attenuation), and the other waves scattered. If the velocity of the elastic waves through the ground is known and the travel times two ways time (TWT) of the energy pulses are measured, distance (or depth in the ground) can be accurately measured. [12-17]. The total travel time (TWT) of any reflected signals recorded at the earth surface by receivers can be determined according the cases below:

Case 1:

When the subsurface reflector is flat and homogeneous medium of constant velocity, the depth can estimate as in the equation below [18, 19] Figure-3:

$$t = 2z / v \quad (1)$$

Where, Z = the depth of the reflected boundaries, t = recorded two way travel time, V = estimated velocity of seismic waves.

Case 2:

When the subsurface reflector is dipping and homogeneous medium of constant velocity, the depth can estimate as equation blew [17, 18] Figure-3:

$$t = [t0^2 + x^2 \cos^2\alpha / v^2]\ 1/2 \quad (2)$$

Where: α: represents the component of the reflector dip angle. Thus, the normal movement out **(NMO)** has the same as horizontal layer case, but the apparent velocity is v/cos α.

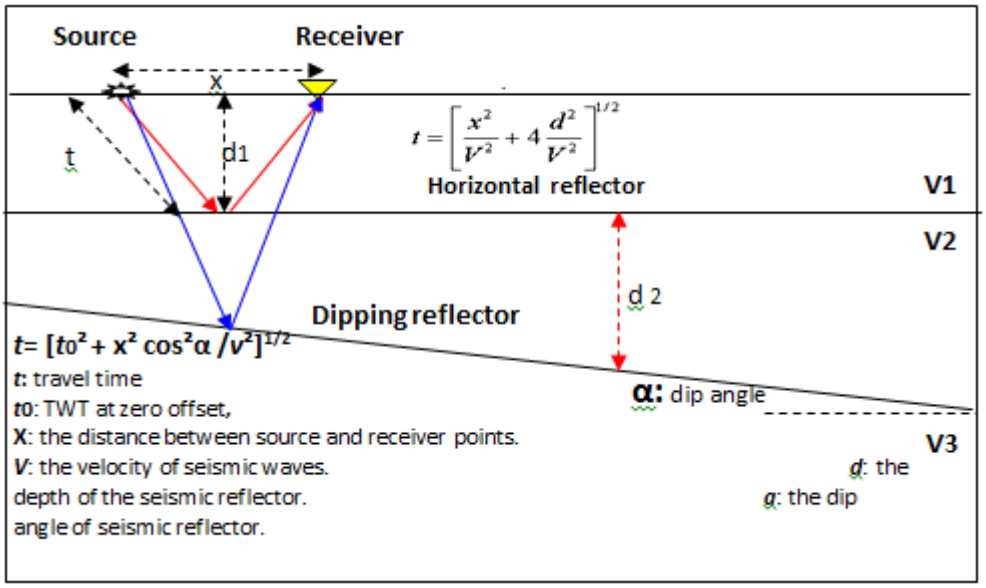

Figure 3-TWT in case of dipping & horizontal reflector [18]

Data Interpretation

The primary aim of geophysical data interpretation in this study will be qualitatively (conventionally) to map the geological structure settings and estimating the best geological model of the Mishrif reservoir which derived to optimize new well locations or to improve petroleum recovery. Both data (seismic and logs) in the current study achieved by using a special software established for this purpose such as Petrel, IP, which authorized from Geology Department – Basra university.

Quality Control of the Interpretation Data

Preparation and calibration of seismic and logs data are the primary essential step of the interpretation. To achieve this job following steps are applied:

1. Loading and identifying the base map of the studied area, which includes the geometry of the seismic survey (shot point locations).

2. Loading and jointing the acquired digital seismic data inline and crossline in (SEG-Y) format to the base map
3. Viewing, checking, and editing the digital seismic data.
4. Calibrated the top and bottom of the Mishrif Formation in the well logs data responses and drilling geological data with seismic sections Figure-4. This calibration can determine accurate depth of seismic reflectors, identify (separates) different lithologies boundaries in the seismic sections.

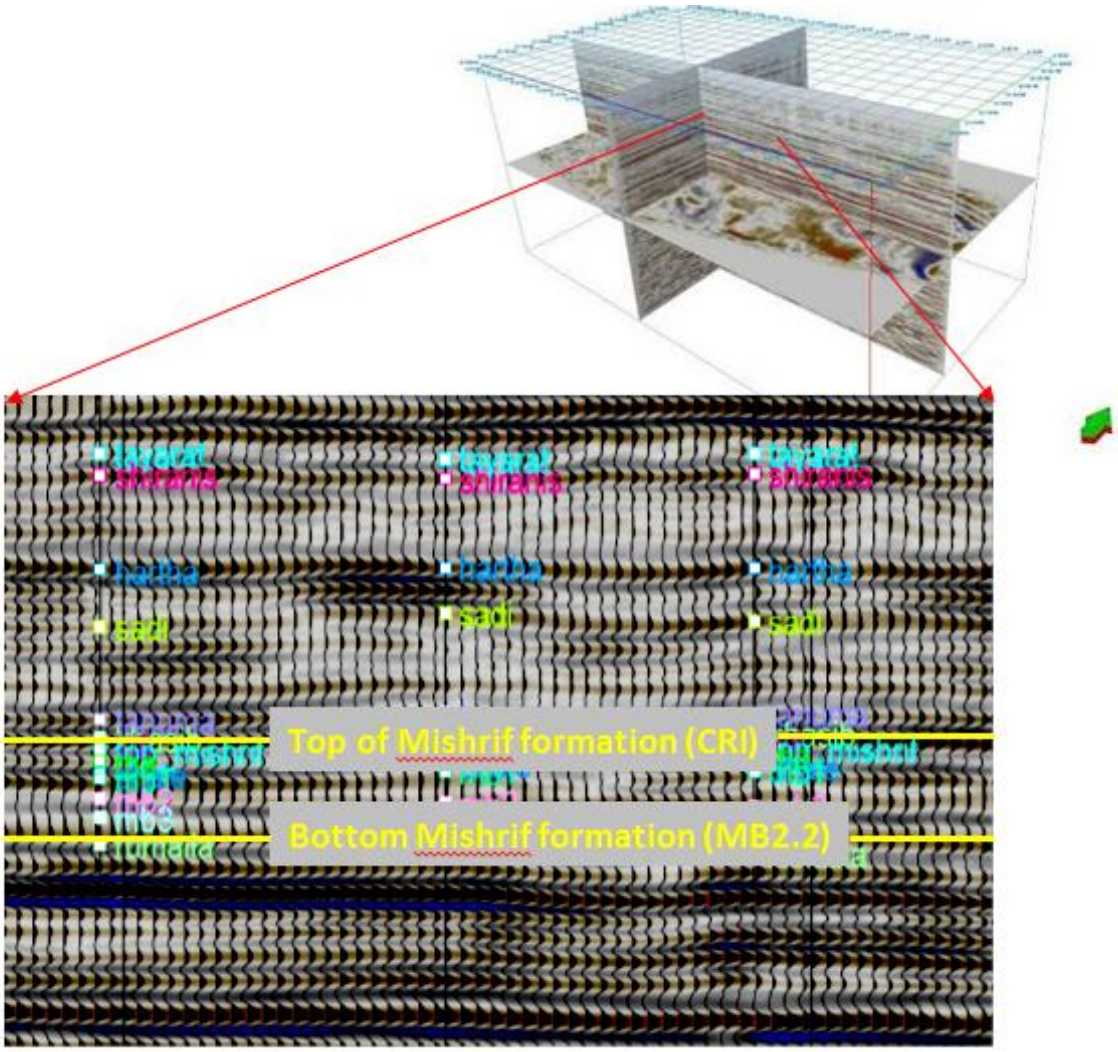

Figure 4- Shows the picking tops seismic reflectors tied with well logs responds for Mishrif Formation units in Nasiriyah oil field

5. Created a well log correlation section Figure-5 to support the calibrated and identify the alteration of the thickness for Mishrif Formation units. This section is depending on the direct analyses of the logs data responses on behavior of GR, SP, DT, RHOP, NPHI, ILD, ILM.

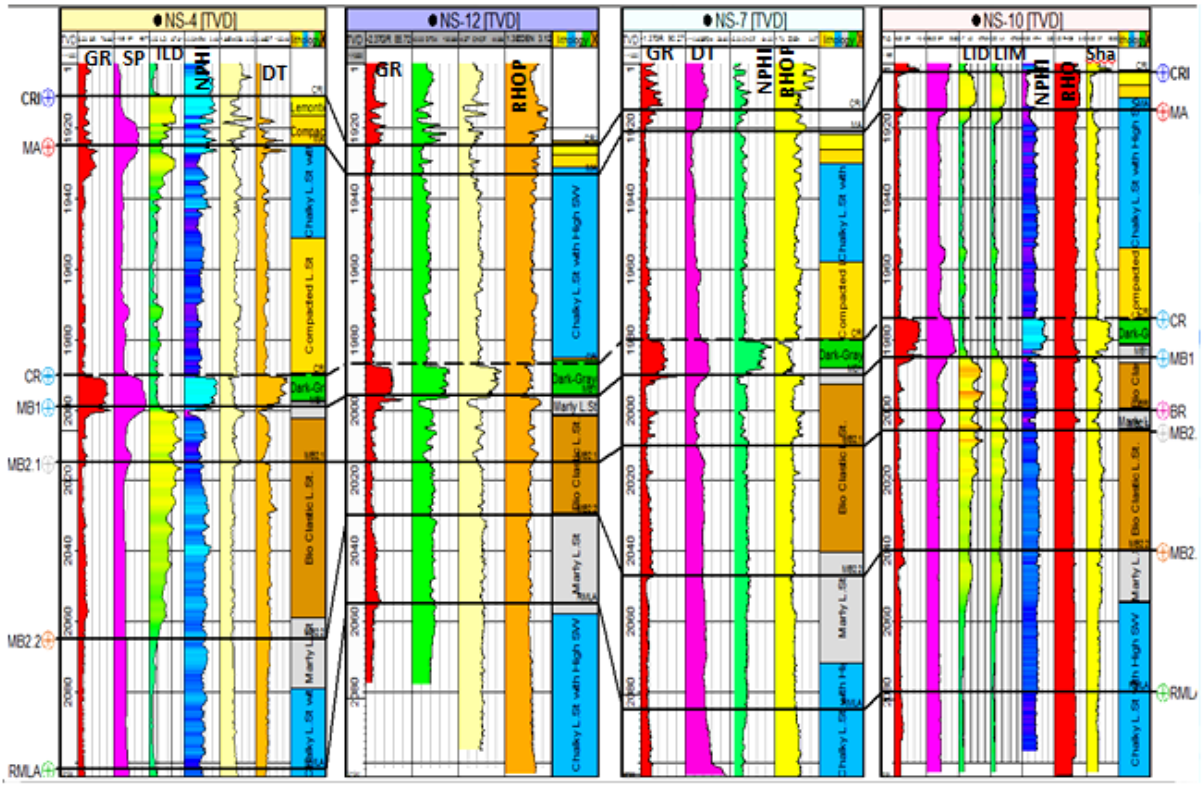

Figure 5- Shows the lithological correlation through various logs types NS-4, NS-12, NS-7, and NS-10

Qualitative Interpretation

The structure or qualitative interpretation of Mishrif Formation used in this study depended on the digitalization of the seismic depth maps for MB unit as reference and calibrated the units reflectors by log data and drilling geological reports Figure-3.15. The horizons of Mishrif Formation units have been created in Figure-3.16. Figure-6.A, B, C, D, E, F, G, H included current well locations.

The first top unit of Mishrif Formation is the cap rock I (CRI) which consists of longitudinal structure extended with NW-SE. The second unit is MA which is structurally discussed. The third unit is the cap rock II (CRII) which consists of two main platforms in the middle of the field. The fourth unit is MB1 which is the main produces unit trapped the oil, its consists of the main structure platform that included secondary domes in the middle of the field. The fifth unit is the barrier rock (B.R) which is consists of main the longitudinal thin structure layer. The sixth units is (MB2.1) which consists of unsymmetrical platform structure centered in the middle of the filed and its structure has less longitudinal extension. The seventh unit is (MB2.2) which consists of unsymmetrical platform structure centered in the middle of the filed and its structure has less longitudinal extension.

In general, the length of Mishrif Formation structure is about (18) km and its width is about (4.5) Km. The northeastern limb of Nasiriyah structure tilts about (2.4^0) and the western limb about (2.1^0).

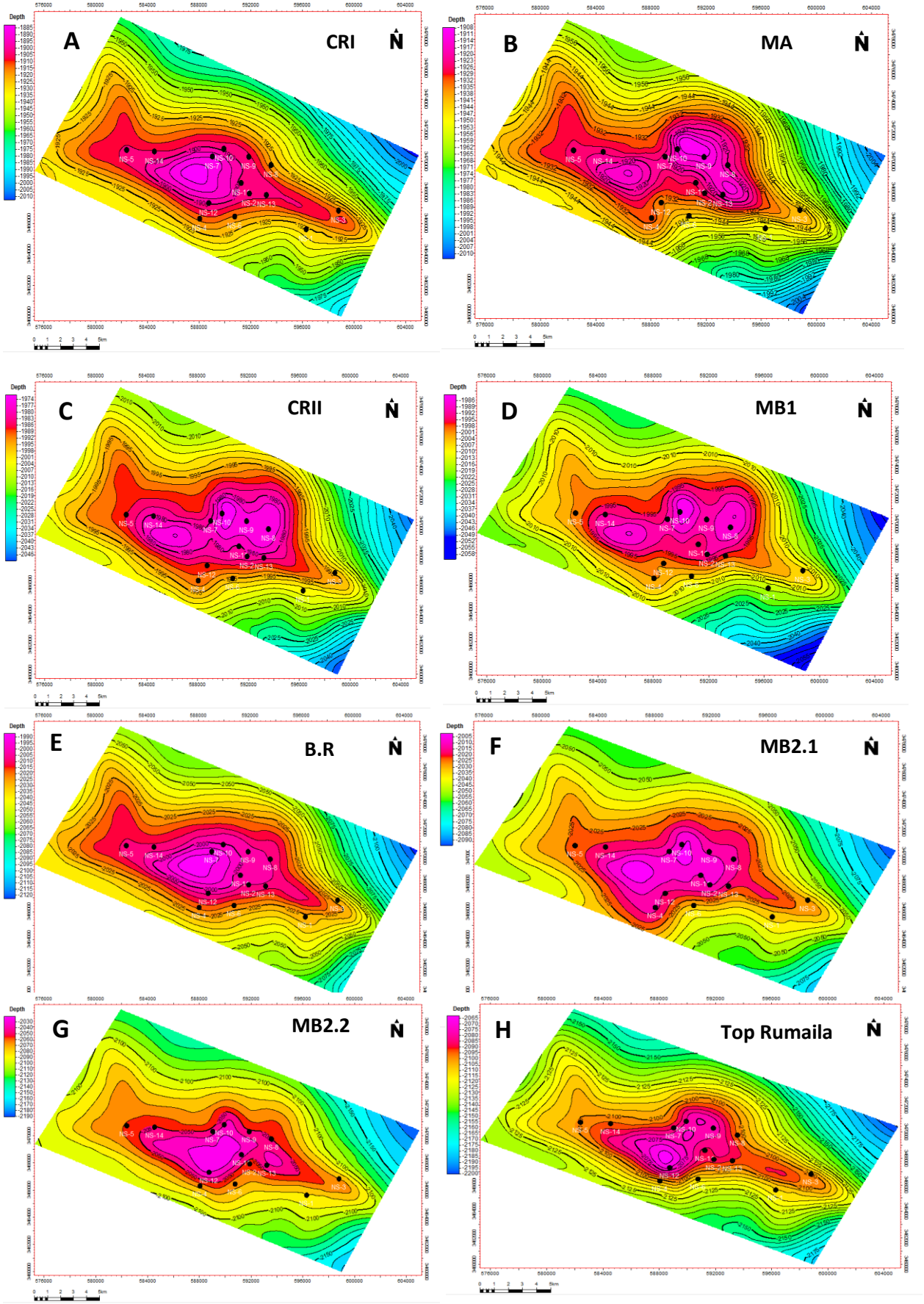

Figure 6- Shows the structural depth maps of Mishrif Formation units.

Figure-7 illustrated the variation of the thickness in the three dimension trends for Mishrif Formation units, the barrier rock (B.R) layer doesn't shows the continuity of the thickness in all the field. Its disappeared in the south and west of the field and its increased in the NE trends of the field while the other layers have continuity in all directions.

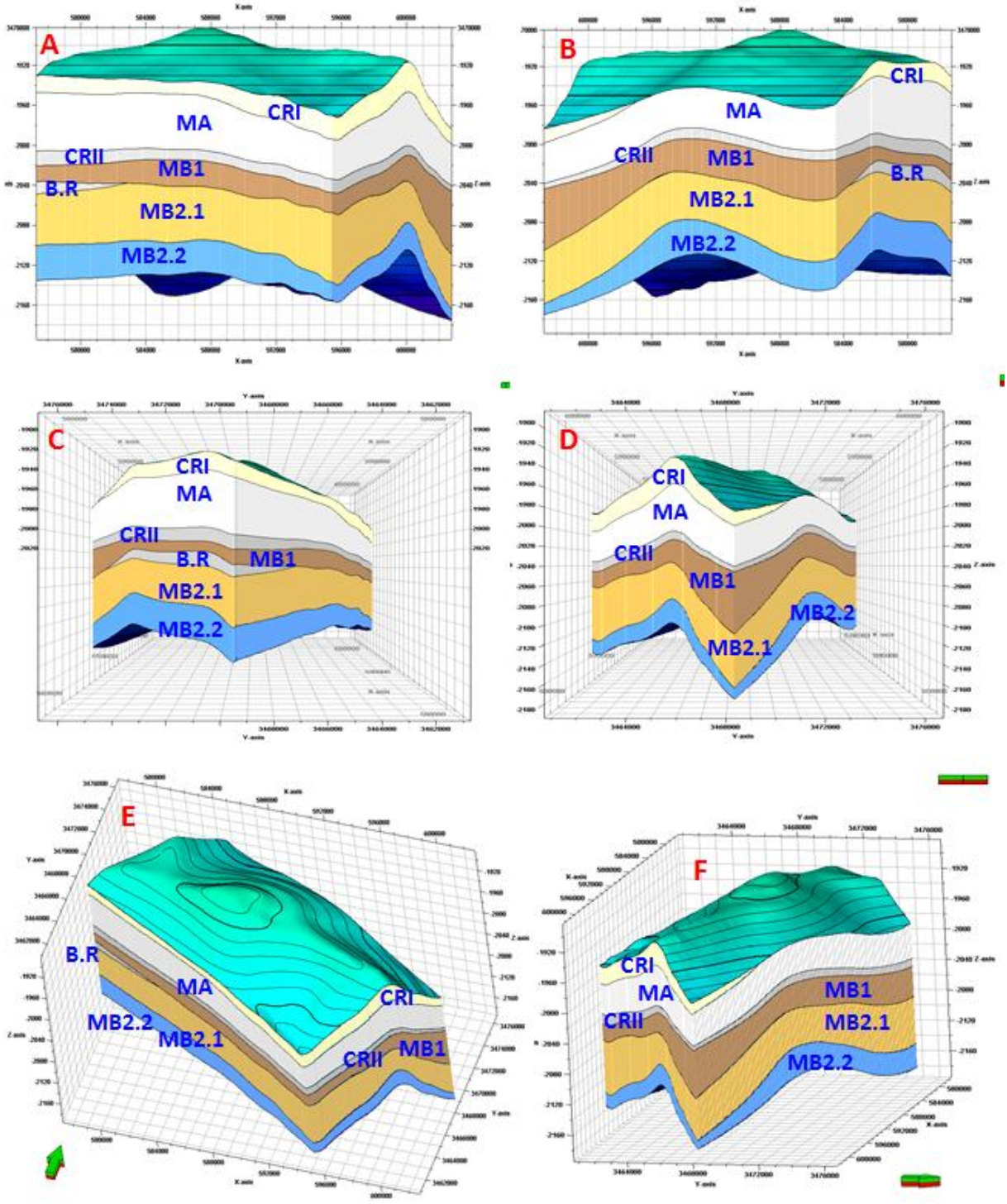

Figure 7- Shows the 3-D structural models for Mishrif reservoir in different sides A) south side , B) North side, C) West side, D) East side, E) Random side 1, F) Random side 2 .

Conclusions

1. 2-D and 3-D structural model created for Mishrif Formation units in Nasiriyah oil field depended on the seismic and well logs data.
2. The current study illustrated the vertical and horizontal thickness alteration of the Mishrif Formation units which reflect the oil stock in the field. MB1 unit has a thickness ranges between (11-23) m in different wells. Its increases in NW, SE, and E, directions such as in NS-5 well, and decreases towered the W and at some of the middle of the area such as in NS-2, and 13 wells.
3. The variation in the structures of the Mishrif Formation for each unit are reflected the changes in the environmental deposition facies (lithology stratigraphic) due to the nature of the marine environment which is carbonate reservoir consists of limestone, while the cap units consist of shale, marly compacted limestone.

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