



ISSN: 0067-2904

2D Seismic Data Reinterpretation and The Structural View of Zubair, Yamama, and Gotnia Formations in Afaq Area, Central Iraq.

Noor A. Hamza*, Ali M. Al-Rahim

Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Received: 3/3/2021

Accepted: 30/4/2021

Abstract

An interpretative study of the two-dimensional seismic data of the Afaq area was conducted using the Petrel 2017 software. 2D seismic reflection sections are used to give a structural interpretation of Afaq structure based on synthetic seismogram and well log data. Three reflectors, Zubair, Yamama, and Gotnia Formations, were selected. These reflectors are defined from well west kifl (wk-1), Where located adjacent to the study area. Structural maps of the Zubair, Yamama, and Gotnia formations are prepared and interpreted, including TWT maps, Average velocity maps, and depth maps. The studies concluded that the Afaq structure area does not contain main faults, but secondary faults with short and limited extensions. The structure of Afaq is a Monocline structure at Zubair and turns into a semi-structure (trap structure) at the Yamama and Gotnia formations. The study also showed that the structure of Afaq is plunging structure towards the east.

Keywords: 2D Seismic section, Afaq area, Zubair, Yamama, and Gotnia.

أعادة تفسير المعطيات الزلزالية ببعدين والصورة التركيبية لتكوينات الزبير واليمامة والقطنية في منطقة عفاك ، وسط العراق

نور علي حمزه* ، علي مكي حسين الرحيم

قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

تم إجراء دراسة تفسيرية للبيانات الزلزالية ثنائية الأبعاد لمنطقة عفاك باستخدام برمجيات Petrel 2017 ، تم استخدام البيانات ثنائية البعد لتفسير التركيبي لتكوينات عفاك استناداً إلى الاثر المصنع وبيانات سجل الآبار ، تم اختيار ثلاثة عواكس وهي الزبير واليمامة والقطنية . يتم تعريف هذه العواكس من البئر غرب الكفل (wk-1) ، حيث تقع في المنطقة المجاورة من منطقة الدراسة . تم إعداد خرائط التركيبية لتكوينات الزبير واليمامة وقطنية لتفسيرها وتضمنت هذه الخرائط خرائط TWT وخرائط السرعة المعدلية وخرائط عمق. وخلصت الدراسة إلى أن منطقة عفاك لا تحتوي على فوالق رئيسية ، بل فوالق ثانوية ذات امتدادات قصيرة ومحدودة ، إلى جانب أن تركيب عفاك هو تركيب احادي الميل في الزبير ويتحول إلى شبه تركيب(مصيده تركيبية) في تكوينات اليمامةوقطنية.كما اظهرت الدراسة ان تركيب عفاك تركيب غاطس باتجاه الشرق.

Introduction

The interpretation of the reflection seismic data is one of the most important elements of a successful oil and gas exploration program. [1]. The interpretation process aims to extract

*Email: noor.a.95.1a@gmail.com

geological information from the seismic stack data, explore stratigraphic changes, direct hydrocarbon detection, isochrones, structural depth maps, modern modelling (direct and inverse modelling), and computing of seismic attributes. [2]. The interpretation method can be categorized as structural, stratigraphic, and lithologic. The structural seismic interpretation aims to create structural maps of the subsurface based on the observed arrival time configuration [3].

An interpretative study was conducted for Kut – Al Hia regions and the surrounding areas using magnetic and gravitational data. This study showed the presence of several faults and anomalies. Most of these faults' trends are NW-SE, NNW-SSE, NE-SW, NNE-SSW, and some faults with trends E-W and N-S, and considered as a deep and old crossing the basement and the sedimentary cover. Some of these faults in the sedimentary rocks are inherited from old faults in the basement rock. Also, some contacts are assumed to be the result of lateral changes in basement composition and lateral changes in physical properties within sedimentary rocks.[4].

The Afaq area is located in central of Iraq within the governorates of Qadisiyah, Wasit, Babylon between the Tigris and Euphrates rivers, as shown in Figure 1. The importance of the study area is productive oil fields include Al-Ahdab-1 well, Al-Nasiriyah-3 well, Kifl-3 well, and West Al-Kifl-1 well.

This research is the first for the region and included a geophysical study by using the Seismic Reflection method; it aims to interpret of Afaq structure, the results obtained from the ministry of oil using two-dimensional data of Afaq structure area in three Formations which are the Gotnia, Yamama, and Zubair Formations.

Geological Setting

Topographically, the study area is characterized by flat agricultural nature. The height of the area range 15-20 meters above sea level [5]. The study area is divided into the alluvial flood and the northeastern parts, which are covered by Aeolian sediments [6].

Tectonically, the study area is located in the outer platform according to the tectonic map prepared by Fouad [7] (Figure 1). The study area belongs to the unstable shelf (outer platform) [8].

Gotnia Formation belongs to the Late Jurassic, which corresponds to the Late Toarcian early Tithonian tectonostratigraphic mega sequence Ap7 [6]. It is composed of anhydrite with subordinate beds of brown calcareous shales, thin black bituminous shales, and recrystallized Oolitic limestones [9].

Yamama Formation belongs to the late Tithonian-Hauterivian Sequence within the Upper Tithonian-Aptian Thamama Group, which corresponds to the Late Tithonian-Early Turonian tectonostratigraphic megasequence Ap8 [6], Bellen et al. in 1959 described a 257 m interval in Ratawi-1 as the Yamama -Sulaiy Formation. The upper 203 m, now allocated to the Yamama Formation [11], consists of 12 m of specular and brown detritus limestone with thin shale beds overlain by 191 m of micritic limestone and Oolitic limestone. The thickness of the formation is up to 400m near Najaf city and up to 360m thick in the southeast of Iraq.

While the Zubair Formation belongs to Late Barremian - Aptian sequence within the Upper Tithonian-Aptian Thamama Group, which corresponds to the Late Tithonian Early Turonian tectonostratigraphic megasequence Ap8. It was introduced and amended in the Zubair oil field by Bellen et al., (1959) in[6]. The thickness of the Zubair Formation in NE of Iraq comprises 380-400 m of alternating shale; siltstone and sandstone were reached up to 500m in southern Iraq[6]. The thickness of the Zubair Formation in the well of Afaq-1 reached more than 513 meters, and the formation in general consists of sandstone and shale rocks, where the thickness of the rocks to shale reached about 12 meters [5].

Subsurface Geology

Subsurface geology of the Afaq structure area can be identified by studying the geological

column penetrated by the Afaq -1 well. Geological column (Figure 2) shows the age, name, thickness, and brief description of all the formations penetrated by well Aq-1.

The well Aq-1 was drilled in 1960, reaching Zubair Formation at a depth of 3386 m. It was mainly prepared as a stratigraphic test and small positive closure indicated by gravity and seismic survey.[5]

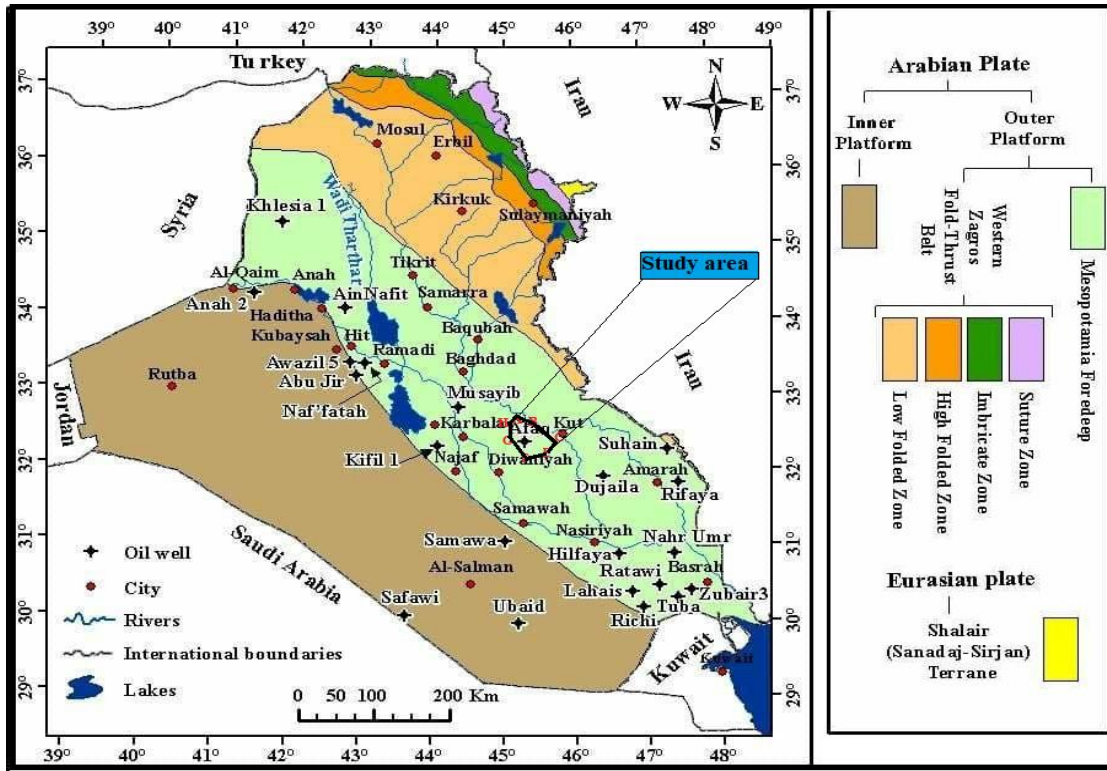


Figure 1- Tectonic map showing the study area [4] prepared by Fouad 2015.

GEOLOGICAL SECTION OF AFAQ WELL -1 (Aq-1)

PERIOD	EPOCH	FORMATION NAME	Depth (m)	LITHOLOGY	Lithological Description
QUATERNARY	RECENT	Alluvium	164.5		Gyp. Cl. w. S. f.m. gm.
TERTIARY	MIOCENE	UPPER			Mrl. w. Gyp.
		MIDDLE	629.4		Anhd. w. Mrl.
		LOWER	852.9		Lst. dol. and anhd.
CRETACEOUS	Eocene-Paleocene	Dammam	1195.4		Lst. hd. foss. glc. w. cht.
		Aaliji			Lst. hd w. cht and Mrl.
		Shirah	1654.5		Mrl. w. Lst. chk. pyr.
		Hartha	1654.5		Lst. hd. dns. det. chk. w. Lst. mrl.
		Sadi	1881.1		Lst. chk. and Mrl.
	UPPER	Tanuma	2035.6		Sh. pyr.
		Khasib	2065.9		Lst. hd. chk.
		Kifa	2143.9		Anhd. Lst. mrl. w. sh.
		Mishrif/Rumalla	2159.5		Lst. dol. chk.
		Ahmadi	2457		Lst. w. Mrl. Sah.
LOWER	Mauddud	2519.2		Lst. hd. dol. chk. w. Lst. mrl. pyr.	
	Nahr Umr	2654		Sst. f.m. gm. w. sh. pyr.	
	Shuaiba	2810		Dol. hd. pyr.	
	Zubair	2872.7		Sst. fri. f. gm. w. sh.	
			3386		

All depths are taken from R.T.K.B

Figure 2- Stratigraphic Column of well Afaq-1.[5].

I. Materials and Methods

II. 1>Loading data and base map preparation

The following information was loaded into the Petrel software:

1. Loading well data: which includes wellhead file that content (coordinates of well, Rotary Table Kelly Bushing (RTKB) and total depths), well logs (sonic and density logs), well tops, and check-shot.

2. Loading 2D seismic lines (SEG-Y format), which is a set of 2D seismic data that cover almost all the study area according to the coordinates; after that the base map was constructed (Figure 3)

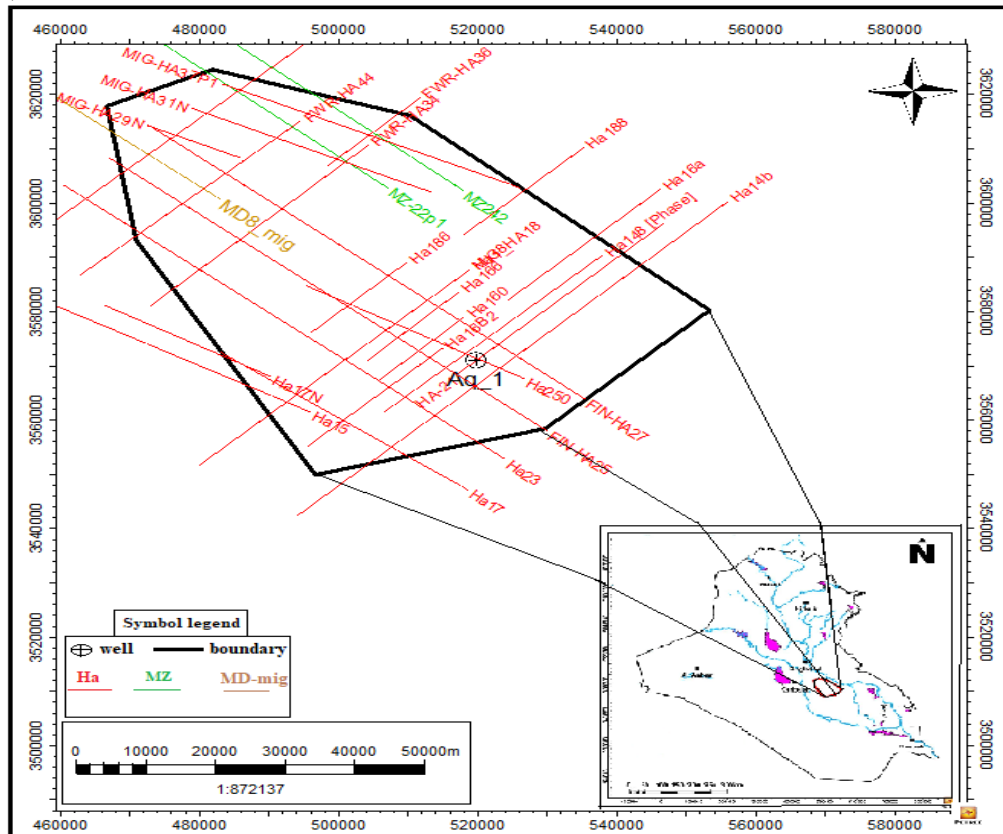


Figure 3- The base map of the study area.

III. 2. Synthetic Generation of West Kifl -1(wk-1) well.

Synthetic seismograms are the ties between geological and geophysical information subsequence, it is helpful for picking reflectors correctly for target Formations, the Time-Depth Relationship (TDR) from velocity and density logs, and a wavelet to create seismogram are required.[2]

Synthetic generation involves the following steps according to lindseth (1979)[11]:

1. Time converting the wells using a sonic log or Check-shot information, establishing a time-depth relationship (TDR).

2. Calculate acoustic impedance (Z), which was achieved based on the following equation:
 $Z = \rho \cdot V$ Where: ρ : density, V: seismic velocity (p-wave velocity).

3. Calculate the Reflection Coefficient (R.C), which was achieved based on the following equation:

$R.C = R.C. = (Z2-Z1)/(Z2+Z1)$ where; Z1 is the acoustic impedance above the interface while Z2 is the acoustic impedance below the interface.

4. Construct a wavelet.

5. Convoluting reflection coefficients with a seismic wavelet series is the last step in creating a synthetic seismogram.

The traverse seismic sections passing through the well location and synthetic traces of reflectors are presented in Figure 4.

In this study, the reflectors Zubair, Yamama, and Gotnia have defined from a nearby a well west kifl-1 which Penetrates the Formations that was the target of the study but, the well Afaq-1 that located in the area study do not penetrates these Formations, so, used the synthetic seismogram generation from well west kifl-1 (wk-1). Figure 4.

3. Composite line

To make accurate two-way time maps through the seismic sections, we must link the seismic lines in the region with each other for the picking process to be exact. And this linking process is called composite lines; as shown in Figure 5, seismic lines were linked for mapping to Zubair, Yamama, and Gotnia Formations.

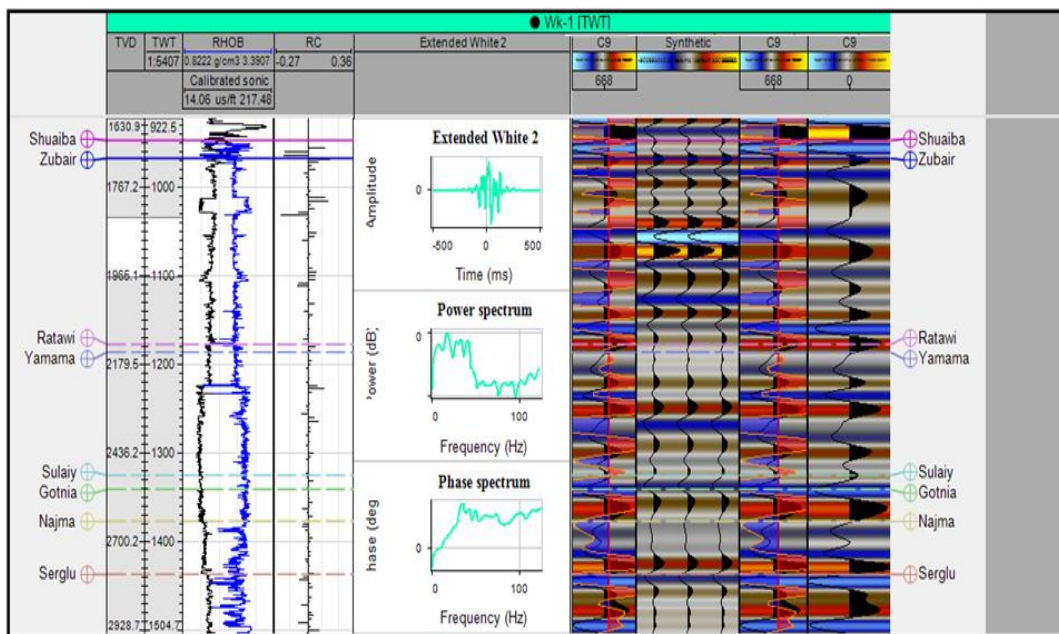


Figure 4-Synthetic seismogram of well West kifl-1.

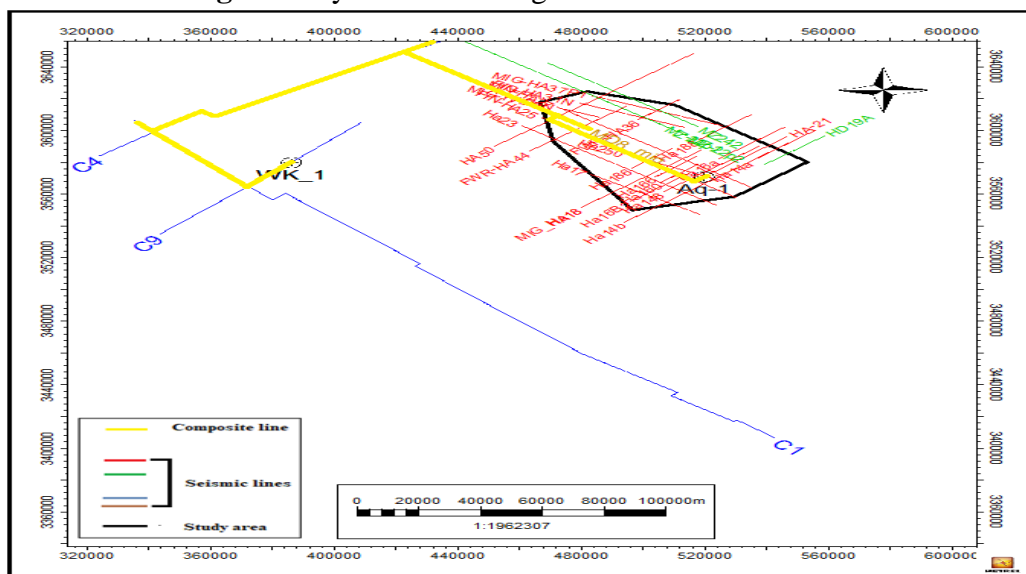


Figure 5-The Composite lines in the study area.

4. Description of the Picked Reflectors

This study focused on three Formations, Zubair, Yamama, and Gotnia, to clarify the situation structure for the Afaq structure area and because they are the most important reservoirs in the region. The Zubair reservoir in the Afaq Structures area showed excellent reservoir sands (from cutting). The following is a brief description of each reflector considered in this study. Figure 6 shows the picked horizons and Afaq structure :

1. The top of Zubair is though, this reflector is represented by sandstone interbedded with shale, and the continuity in the study area of reflectors are good.
2. The top of the Yamama Formation is between trough and peak and has intermediate continuity.
3. The top of the Gotnia Formation is peak and has bad continuity.

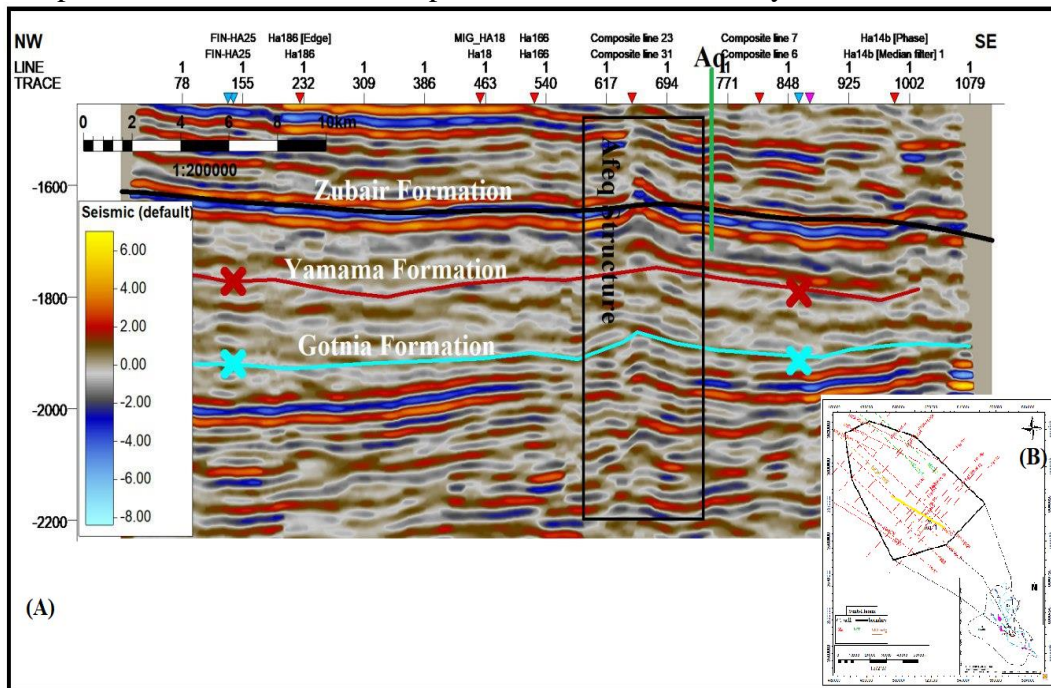


Figure 6 A- Part of the seismic line Ha250 showing formations top and Afaq structure B- base map shows the location of the line Ha250 marked by the yellow arrow.

Structural Mapping of the picked reflectors Time Structural Maps (TWT).

General, the time structural maps, as shown in Figures 7, 8 and 9 as tops of Zubair, Yamama, and Gotnia Formations respectively indicate that the lowest value of the time in the west and southwest of study area with northeast ward strip of low value that represent Afaq Structure, while the highest value is in the east and northeast. The structure of Afaq in the three formations is described as the following: In TWT, Afaq Structure appears in the top Zubair map as a monocline with SW-NE direction with a length of about 30 km and a width of about 5 km.

In TWT, the dimensions of the structure in the top Yamama map are similar to what is present in the Zubair Formation with a 30-millisecond closure with the appearance of two structural located to the northwest of the Afaq structure named A(nose structure) and B(nose structure with close about 30-millisecond). In TWT of top of Gotnia Map, the Structure of Afaq is monocline with two close about a 30 millisecond. The study also showed the presence of several secondary faults that affect a region within the studied formations within the sedimentary cycle Late Jurassic (Gotnia Formation), and lower-Mid Cretaceous (Yamama

and Zubair Formations) are shown in the map of TWT in Figures 7, 8 and 9 respectively, the type of these faults is strike-slip faults developed due to reactive of Transversal Fault System, the Transversal System was reactivated from Late Jurassic times onwards [6].

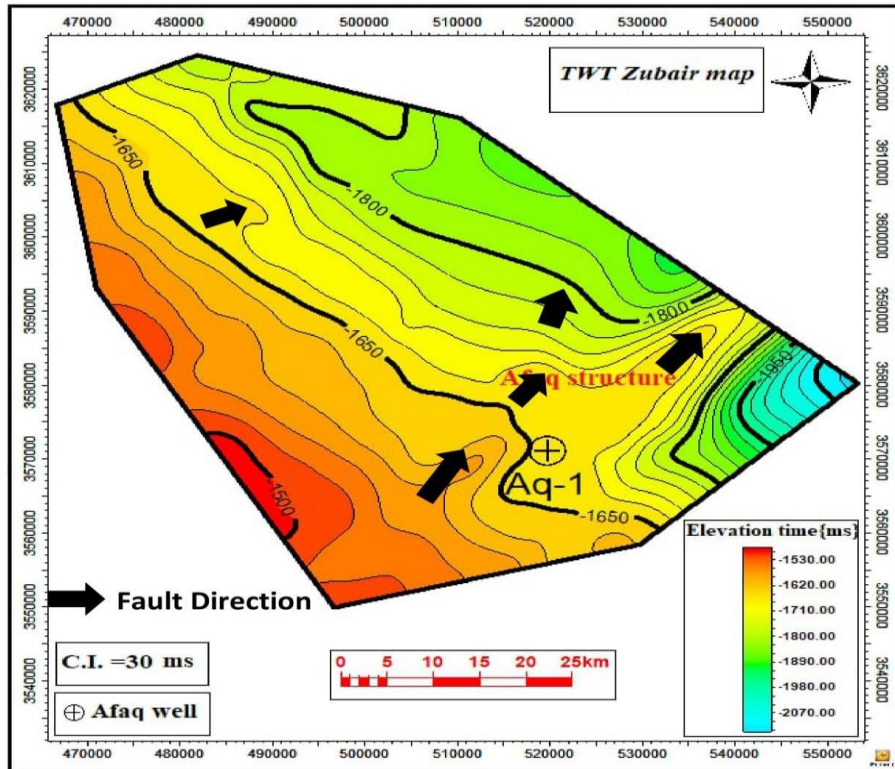


Figure 7- TWT map of the top of Zubair Formation

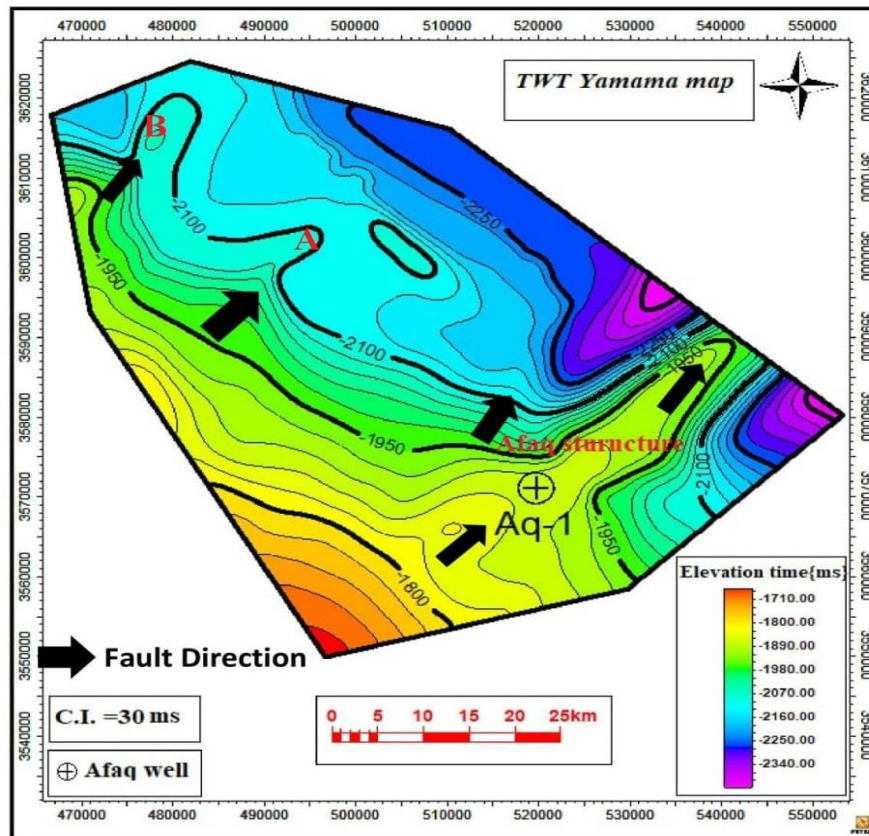


Figure 8- TWT Map of top of Yamama Formation

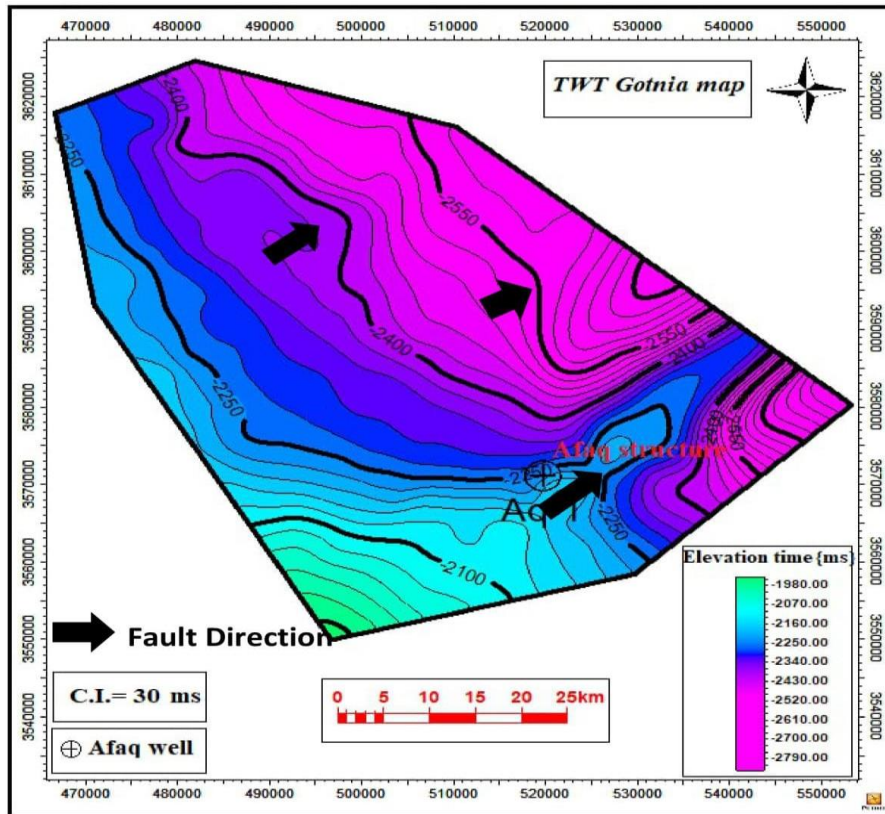


Figure 9-TWT map of the top of Gotnia Formation

Average Velocity Maps

The average velocity value of Zubair, Yamama, and Gotnia Formations increases toward the east and northeast direction and decreases toward the south and southwest directions Figures 9, 10 and 11. These velocity maps were used to convert two-way time maps measured in milliseconds into depth maps measured in meters to show a more accurate structural image of the area.

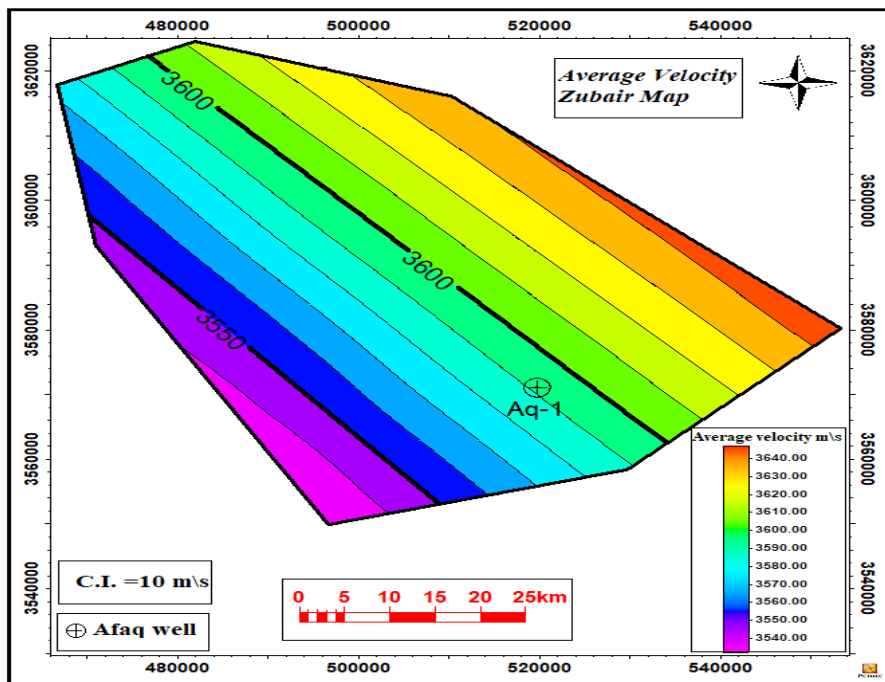


Figure 10- Average Velocity map of Zubair Formation

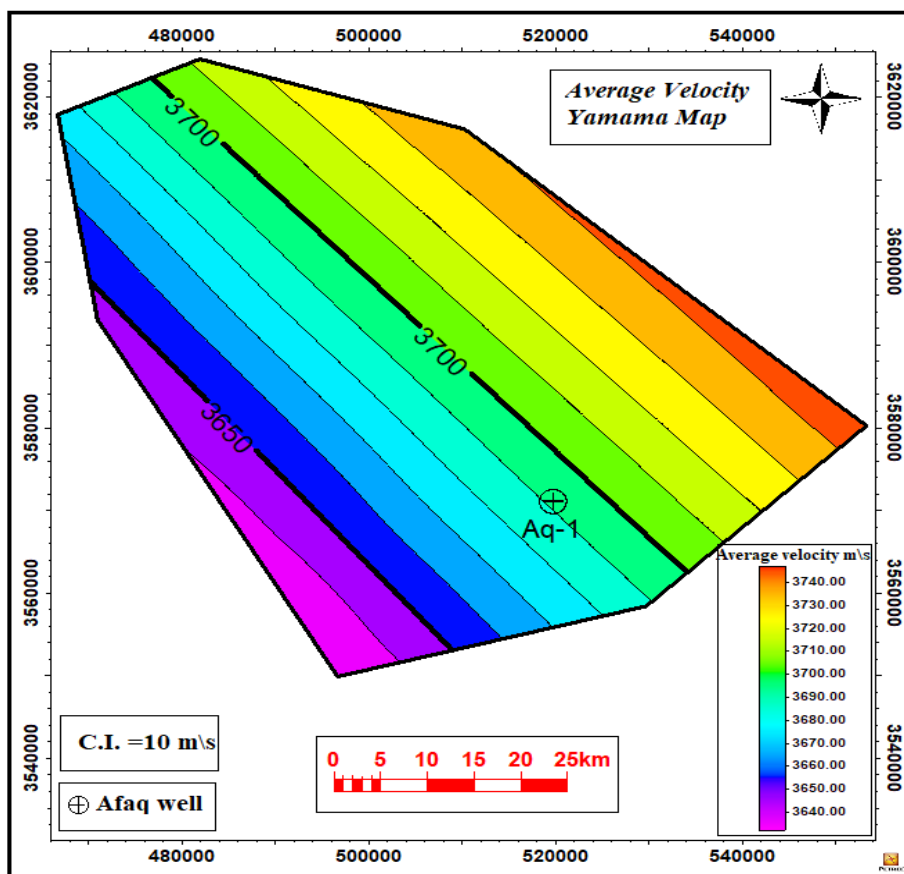


Figure 11-Average Velocity map of Yamama Formation

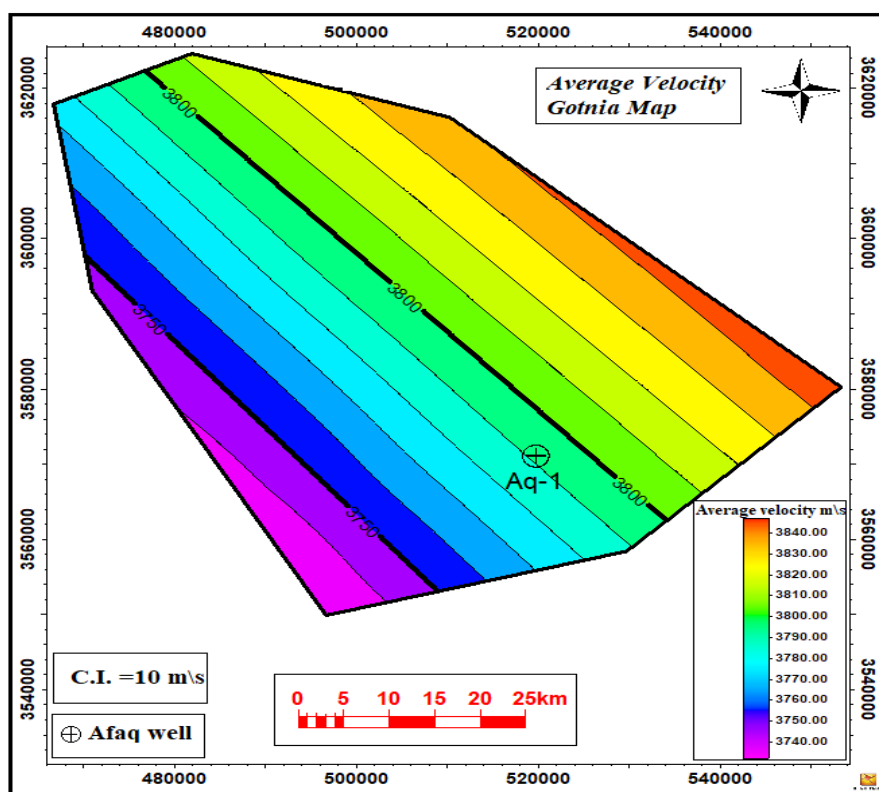


Figure 12- Average Velocity map of Gotnia Formation

Depth Structure maps

The depth map is calculated from a given reflector's time map with an average velocity map at the same reflector, as follows: depth at any point = (velocity * one-way time) at this point [10].

General, the depth maps for the studied reflectors, as shown in Figures 13, 14 and 15 respectively, show that the deepest point appears in the east and southeast direction of the study area, and the depth shallowest appears in the west and southwest direction, while the Afaq is described as follows in the three reflectors;

The depth map of the top of the Zubair Formation shows the Structure lies between contours (-2750m to -3250), and it appears as a monocline with a small structural close of about 20 m. The depth map of the top Yamama Formation shows the structure lies between contours (-3250m to -3750m), and it appears as a monocline, and other nose structure is located to the northwest the study area, it contains a closure of 50m each. While the depth map of the top of the Gotnia Formation shows the structure lies between the contour (-3750m to -4500m), and it appears as a monocline structure that contains a closure of 50m.

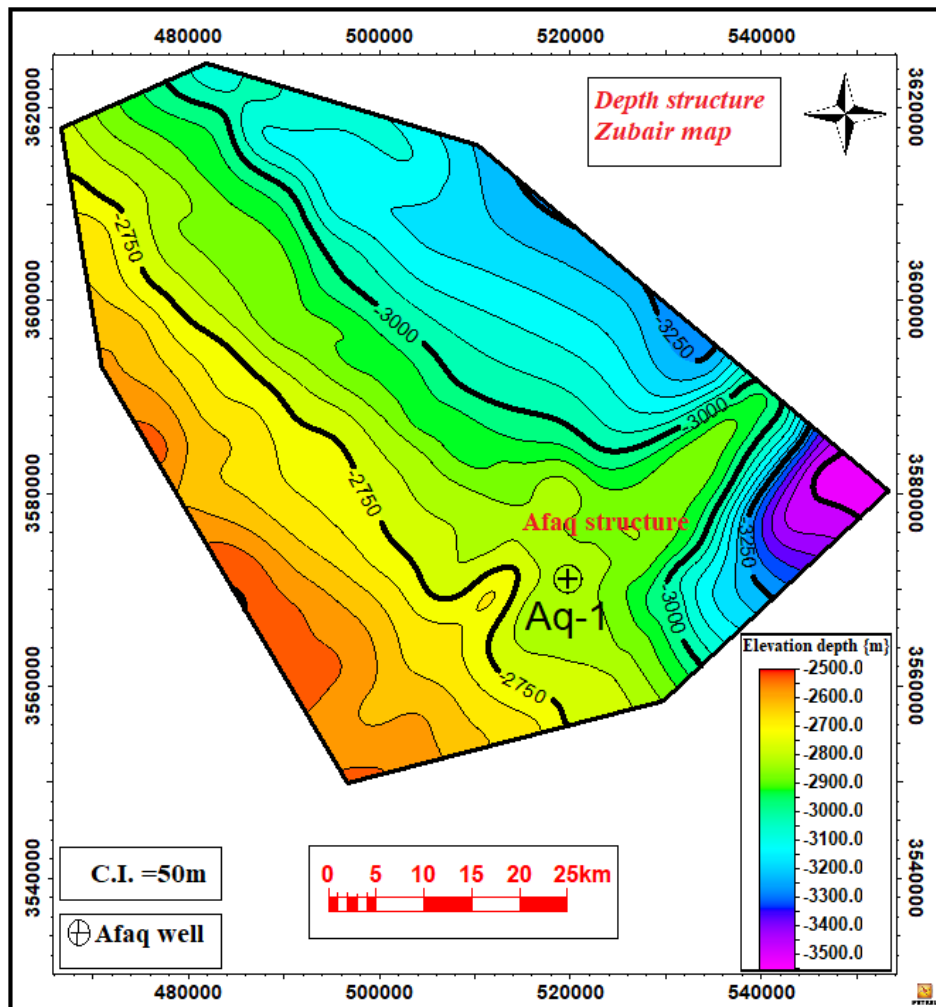


Figure 13-Depth map of the top of Zubair Formation

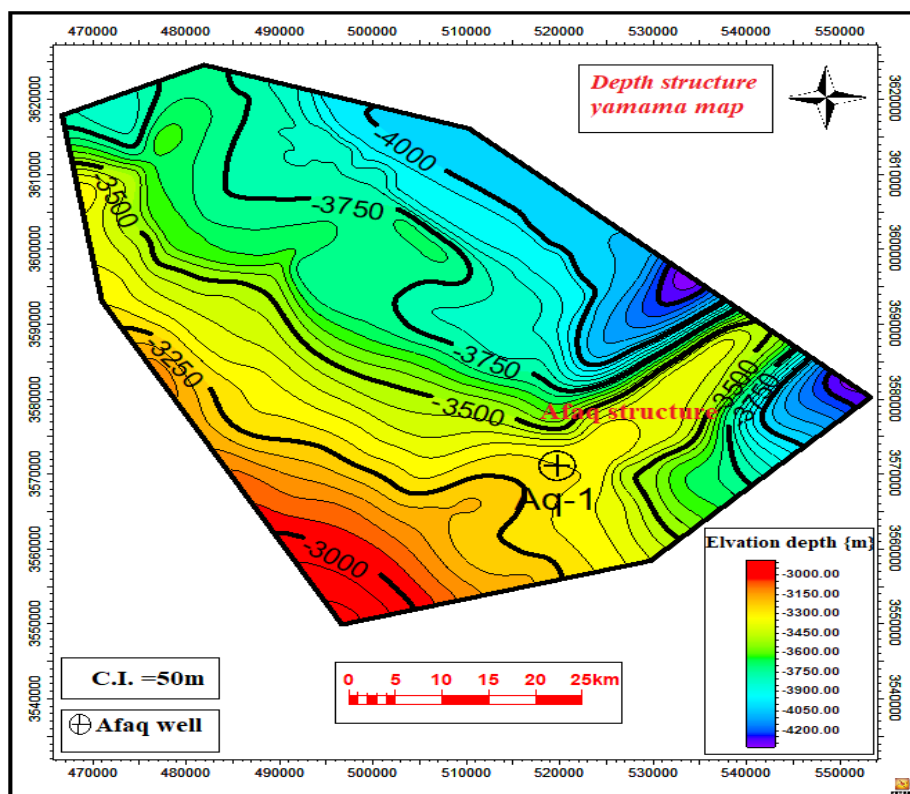


Figure 14-Depth map of the top of Yamama Formation

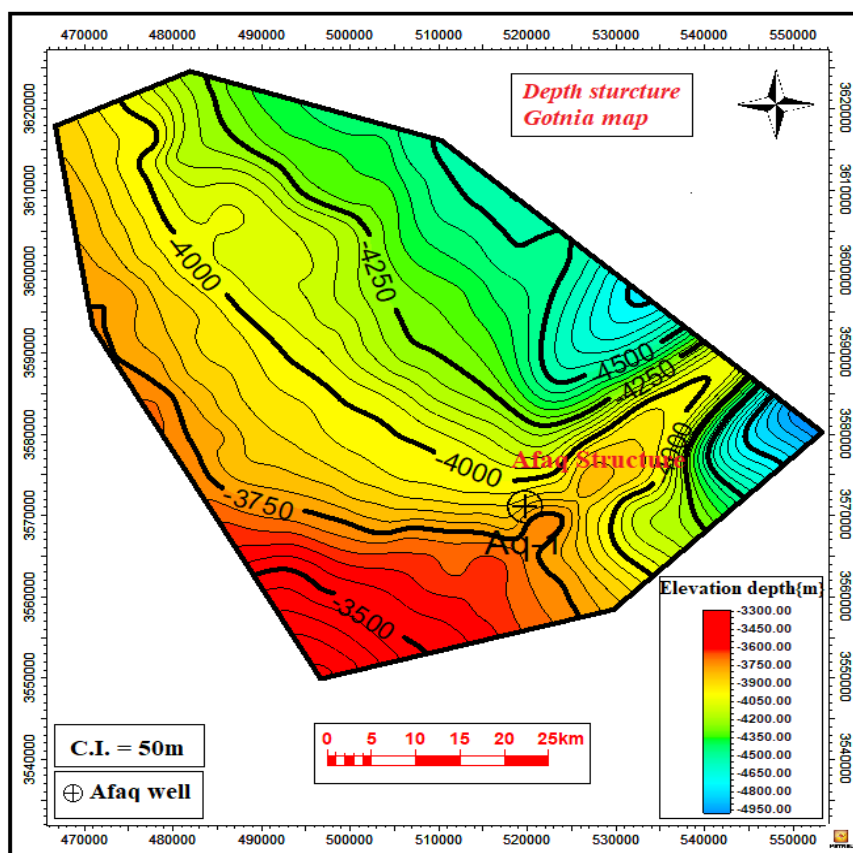


Figure 15-Depth map of the top of Gotina Formation

Conclusions: The study concludes the following

Three reflectors, Zubair, Yamama, and Gotnia Formations are defined using synthetic seismogram in the time domain for WK-1 well in West Kifl field, wavelet of three Formations appeared as the following Zubair as a trough, Yamama between trough and peak, while the Gotnia as Peak.

The TWT, average velocity and depth maps were used to interpret the structure pictures of the select horizon and show the following result:

The presence of several secondary faults with short and finite spans and these faults is strike-slip faults developed due to reactive of Transversal Fault System, the Transversal System was reactivated from Late Jurassic times onwards.

The TWT maps of three Formations demonstrated a higher value of TWT in the northeast and east, which indicates that the reflector is slopping towards the northeast of the area. The structure of Afaq appears like a monocline takes a NE-SW direction in Zubair Formation, while in Yamama and Gotnia, it appears as Sami-structure(trap structure), with two nose structures one of which contains a closure of 30ms and the other without closure.

The average velocity of the three Formations in the Afaq area increases in the northeast and east.

The depth maps of the three Formations show that the deepest part is in the east, which indicates that the Afaq structure is plunging to the east of the study area.

References

- [1] Herron, D. A., *First Step in Seismic Interpretation, Society of Exploration Geophysics*, 193 p, 2011.
- [2] Al-Sadi, H. N. *Seismic hydrocarbon exploration: 2D and 3D Techniques, springer international publishing, Switzerland*, 331p, 2017.
- [3] Nester, D. C. and Padgett, M. J. Geophysical Methods-Seismic Interpretation. In D. M. Thompson, & A. M. Woods (Eds.), *Development Geology Reference Manual* (p. 379). Tulsa, Oklahoma: AAPG, 1992.
- [4] AL-Banna, A. S., Daim, F. M., & AL-Zubaidi, A. A. "The Deep Faults in Kut-Hai and Surrounding Area Inferred from Gravity and Magnetic Data". *Iraqi Journal of Science*, vol. 58, no. (3A), pp. 1235-1245, 2017.
- [5] Oil Exploration Company, *Reinterpretation of seismic data of Afaq Structure Area, O.E.C Library*. (Arabic interior report), 2001.
- [6] Jassim, S.Z. and Goff, J.C. *Geology of Iraq, Dolin Prague and Moravian Museum, Brno*, 341p, 2006.
- [7] Fouad, S. F. "Tectonic map of Iraq, Scale 1:1000000, 3rd edition, 2012",. *Iraqi Bull. of Geo. and Min*, vol. 11, no. 1, pp. 1-7, 2015.
- [8] Al-Banna, A. S. and Ali, K. K. The transition zone between two parts of the platform in Iraq: A review study , vol. 59, no. 2c, pp. 1086-1092, 2018.
- [9] Buday T. and Jassim S.Z. The regional geology of Iraq. vol. 2. Tectonism, Magmatism and Metamorphism edited by Kassab I.I. and Abbas. M.J, Baghdad 352p, 1987.
- [10] Sadooni, F. N., "Stratigraphic Sequence, Microfaciesand Petroleum Prospects of the Yamama formation, Lower Cretaceous, Southern Iraq". *AAPG Bull*, vol.77, pp. 1971-1988, 1993.
- [11] Lindseth, R. "Synthetic sonic logs – a process for stratigraphic interpretation": *Geophysics*, vol. 44, pp. 3-26, 1979.