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Determination the depth and thickness of the Yamama Formation using the reflection seismic method in the Nasiriyah field-Southern Iraq

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***Abstract*— An interpretive study of the Yamama Formation for seismic data in the Nasiriyah oil field was achieved in this work. We choice this location for our study because of its important location between several oil fields. Using SERVPRO-10, the NS-1 well data and the seismic data were represented by time, depth, velocity, thickness, and three-dimensional mapping of the thickness distribution. The seismic interpretation of the upper and lower-time maps of the Yamama Formation showed the presence of faults towards the southwest and northeast as a result of the influence of the transverse fault system. Structural features of the Yamama Formation was also identified from the depth maps, with seven closures identified in the upper boundary and three in the lower boundary, representing the lowest occurrence of structural influence. The 3D map showed the highest value of formation thickness in the northeast direction, and that represents the distribution of formation rock units the directions of increasing sediment thickness, and the deposition location from the shelf margin to the sedimentary basin, indicates the increasing in sedimentation energy of the basin. Petrophysical properties of the Yamama Formation maps show a significant increase in the value of density and velocity and its relationship with acoustic impedance and a decrease in porosity from northeast to southwest directions.**

***Keywords*—Seismic interpretation, Petrophysical properties, Acoustic impedance, Structural analysis, Nasiriyah oil field.**

I. INTRODUCTION

The seismic method is the primary method of geophysical exploration due to its capacity for deep penetration and high resolution, which enables the detection of the physical properties of subsurface geology. Seismic exploration plays a pivotal role in resolving numerous issues about subsurface geological structures and becomes increasingly crucial in supporting engineering geological exploration. In geophysical procedures, the seismic reflection strategy is regarded as the most significant technique for identifying oil and gas reservoirs [1]Seismic interpretation is the process of obtaining geological data from seismic information. In most cases, seismic surveys consist of three main steps: data acquisition, processing, and seismic interpretation. The reflected wave is initially generated and then undergoes a processing step to form a stacked seismic section whose shape is suitable for the interpretation step [2]. The seismic interpretation of the structural analysis is based on the study of reflectors, employing techniques such as reflection time, velocity, and acoustic impedance with depth [3] In terms of oil economic value, the Yamama Formation belongs to the most important oil production reservoirs in southern Iraq and neighboring areas, which were deposited during the Cretaceous period. This formation is characterized by good reservoir specifications to contain hydrocarbon [4]. Our study used an important location between the oil fields. This location is considered as an extension for many of studies carried out by several researchers, It specializes in stratigraphy analysis to identify mounds and flat spots that were also observed in the Yamama Formation that are considered hydrocarbon indicators [5]. An analysis the reservoir units of the Yamama Formation [6]. Reservoir models that describe and estimate porosity and water saturation distributions are created by estimating the composition of petrophysical properties and calculating the content of hydrocarbons [7]. The aims of this research is to identify the tectonic influence and analyze the geological structures of the Yamama Formation in the Nasiriyah oil field, In addition, to Evaluating the petrophysical properties of the formation.

II. LOCATION OF THE STUDY AREA

Geographical location and coordinates of the study area The study area is located in the south of Iraq, including Nasiriyah, and extends eastwards to Dhi Qar Governorate as shown in "Fig.1". It is located within the Universal Transverse Mercator (UTM) (WGS-84, zone 38), and the coordinates are given in " Table. 1".

Fig. 1. Location map of the study area [8]

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III. GEOLOGY OF THE AREA

The tectonic region of Iraq shows that Nasiriyah oil field is located on an unstable shelf of the Mesopotamian Basin [9]. This location has a direct impact on the structure of the study area in terms of fracture severity and depositional conditions. The Yamama Basin took its final form from different tectonic zones, which played an important role in the development of the basin structure. The tectonics in the study area shows that the basin in the western part lies within the Arabian platform of the stable shelf Fig. 2 [10]. On the other hand, the basin lies partly within the unstable shelf in the eastern part of the Mesopotamian Valley [11].

Cretaceous deposits in Iraq are about 3000 meters thick in the AP8 and AP9 Megasequence. The Cretaceous basin of Iraq includes three major cycles: lateTithonian-early Turonian; late Turonian-early Campanian; and late Campanian-Maastrichtian [12].

This period was characterized by differential subduction across transverse faults and the shifting of the inner shelf basin axis towards an eastern region The drift of the narrow subcontinent was the result of the opening of South New Tethys, a new negative margin created along the northeastern margin of the Arabian Plate [13].

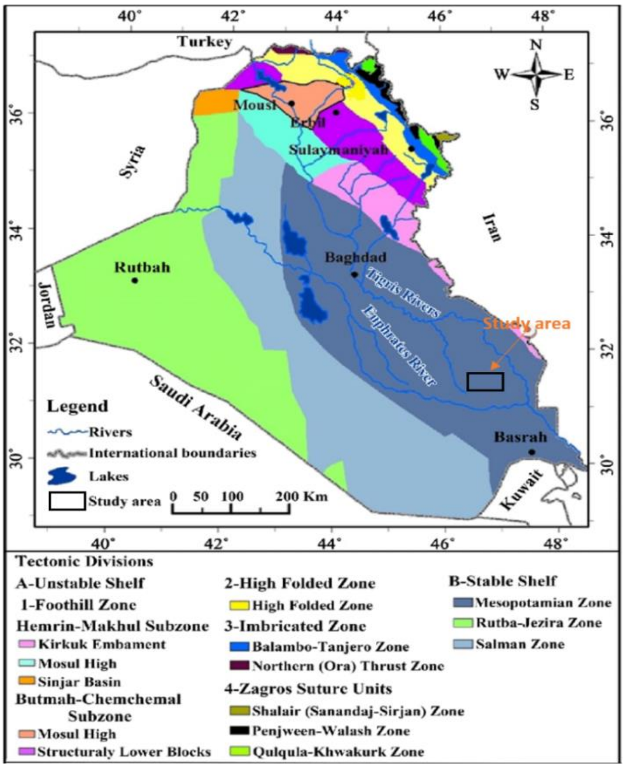


Fig. 2. Divisions of the Iraqi tectonic map the yamama formation [14]

The Yamama Formation is a carbonate-dominated corridor that overlies the Sully Formation. It is 400 metres thick in the Zubair area [12,14]. The formation comprises three sedimentary cycles: The upper part of the cycle contains inner-slope facies of oolitic rocks, which pass downward into fine-grained faces and an intermediate bioclastic/coral surface. The Formation is made up mainly of limestone, but some dolomitic limestone and shale were reported. In the southwestern part of Yamama basin, some well contain anhydrite within the Yamama section [15].

TABLE I. *COORDINATES OF THE STUDY AREA*

NO.	N (UTM)	E (UTM)
A	720000	356000
B	720000	336000
C	480000	336000
D	480000	356000

IV. METHODOLOGY

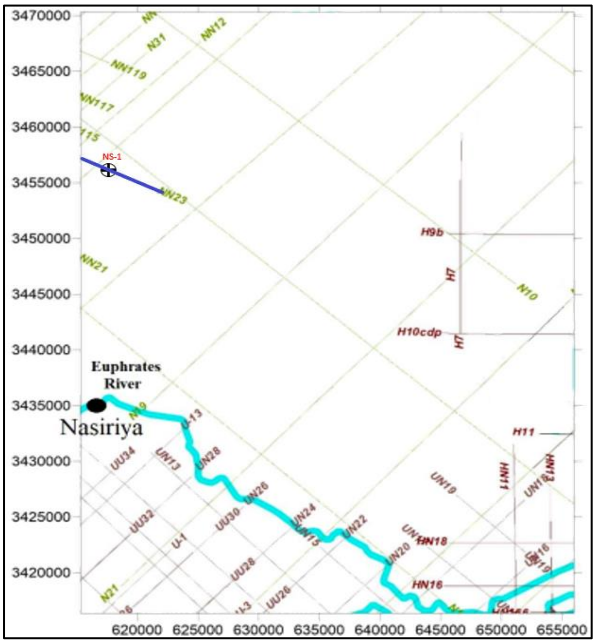
The work method included obtaining data from Dhi Qar Oil Company for the study area of the Nasiriyah oil field, NS-1 well information, and seismic survey data for the study area, and the data were processed in EXCEL through SURFER10 software. The base map is shown in Fig. 3. The seismic survey lines covering the study area and the location of the NS-1 exploratory well, where the seismic data was defined with the well data to identify the Yamama formation along the area where the upper and lower boundary of the formation was identified, as shown in Fig. 4. Therefore, seismic interpretation is to create seismic contour maps, which shows the time, depth, velocity, thickness, acoustic impedance, and 3D mapping of the thickness distribution.

It can be seen that the velocity and intensity (ρ) depend on the wave propagation through the layers with depth. From this a mathematical expression can be used equation (1), to calculate the acoustic impedance value (AI) [16], [17], as in [18]:

$$AI = V_i \rho_i \text{ for the i the layer i.e} \quad (1)$$

From this, petrophysical properties can be determined, and porosity changes can be characterized based on acoustic impedance and density maps.

Fig. 3. Map of the locations and directions of the seismic recording lines implemented in the study area.



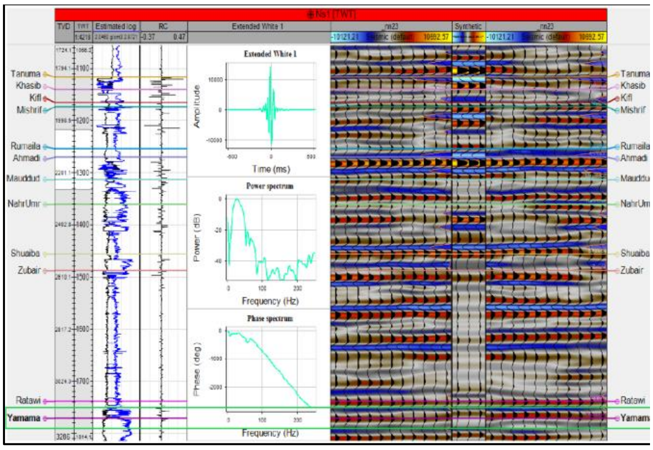


Fig. 4. Synthetic generation of well Ns-1 with to seismic line NN23.

V. Interpretation of Seismic Structural

The seismic maps were obtained and interpreted through the server program and identified the structures of the Yamama Formation, the tectonic influence and thickness of the formation along the Nasiriyah oil field and the location of the sedimentary basin, through maps of the time, depth, velocity, density, acoustic impedance and thickness.

A) Time maps

The maps of the upper boundary of the Yamama Formation were interpreted. We noted that in the time map in Fig. 5, the change of time from southwest to northeast direction and a gradual change from -1120 ms to 2500 ms,and the addition of identifying faults along the study area and the change of time values were in the direction of southwest-northeast of the region. The map of the lower boundary of the Yamama Formation changes the time values from (-28900 ms), to (-38500 ms) from the NE-SW direction and with the identification of faults towards the northeast of the region as in Fig. 6.

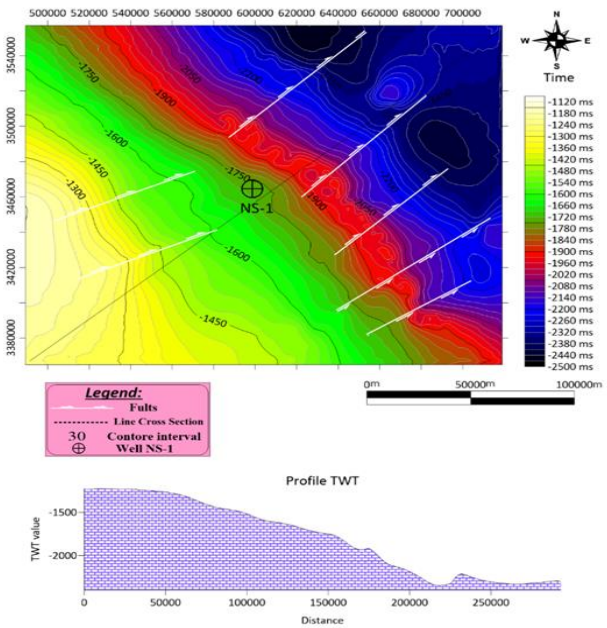


Fig. 5. Time map of the upper boundary of the Yamama Formation.

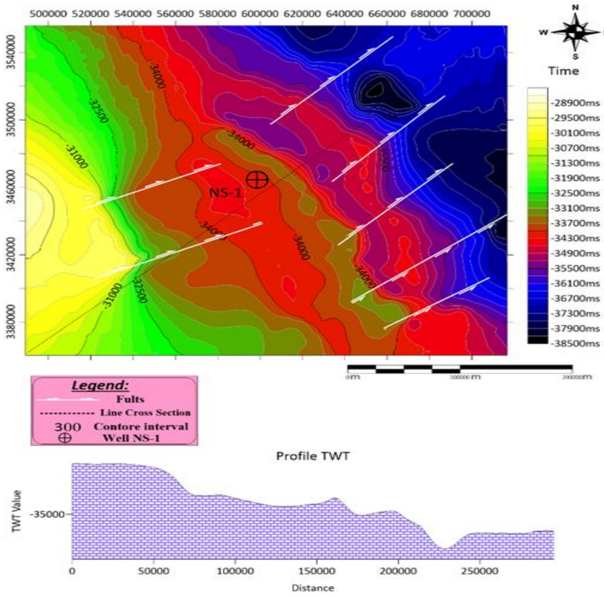


Fig. 6. Time map of the lower boundary of the Yamama Formation.

B) Depth maps

From the depth maps, we identified the depth of the formation and identify the structures, where we noticed an increase in the depth of the Yamama Formation from 28,500m to 38,500m, that is, from the southwest to the northeast direction of the upper boundary. Geological structures were identified along the region, where structural closures in the map represent them. As shown in “Fig. 7”, For the lower boundary of the Yamama Formation, we observed an increase in the depth of the Yamama Formation towards the northeast with a value of(-43000m) and decreases towards the southwest with a value of (-23000m) As shown in Figure (4-5). in addition to identifying the geological structures in the region. Through the map of the distribution of faults, the impact of the transverse fault system affects the plate in general and the region in particular, as shown in “Fig. 8”.

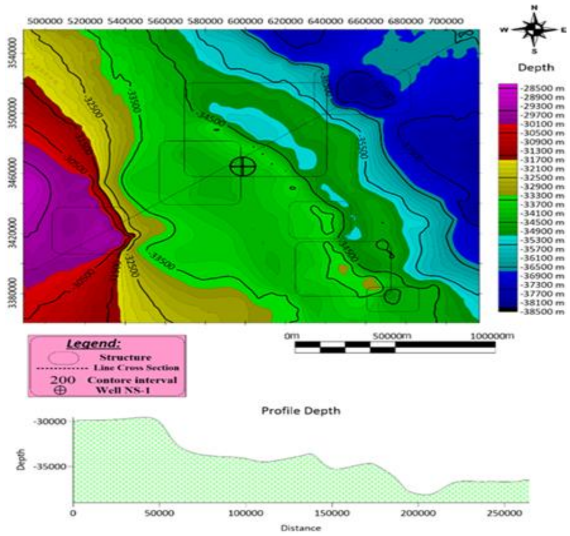


Fig. 7. Depth map of the upper boundary of the Yamama Formation.

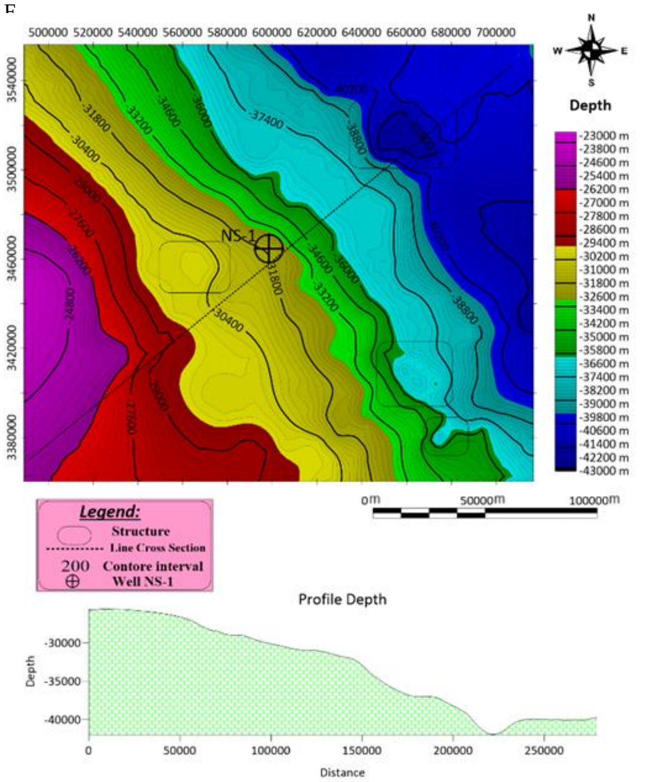


Fig. 8. Depth map of the lower boundary of the Yamama Formation.

C) *Velocity map*

The velocity changes from southwest with a value of (2500m¬/s) to northeast with a value of 5100m¬/s) as shown in Figure (4-6), as a result of the inverse relationship with the time data, as shown in “Fig. 9”.

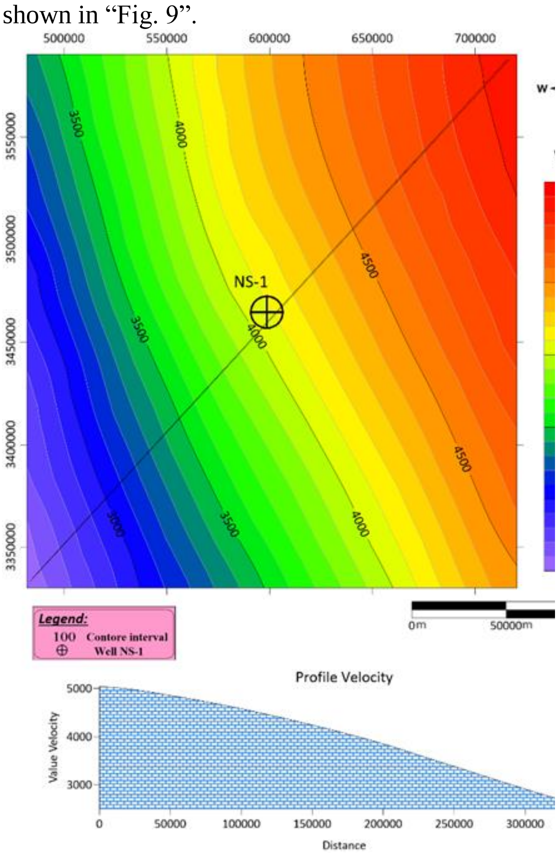


Fig. 9. Velocity map of the Yamama Formation.

D) *Density map*

The density changes from the southwest (2 kg/m3) to the northeast (2.9 kg/m3) “Fig. 10”.

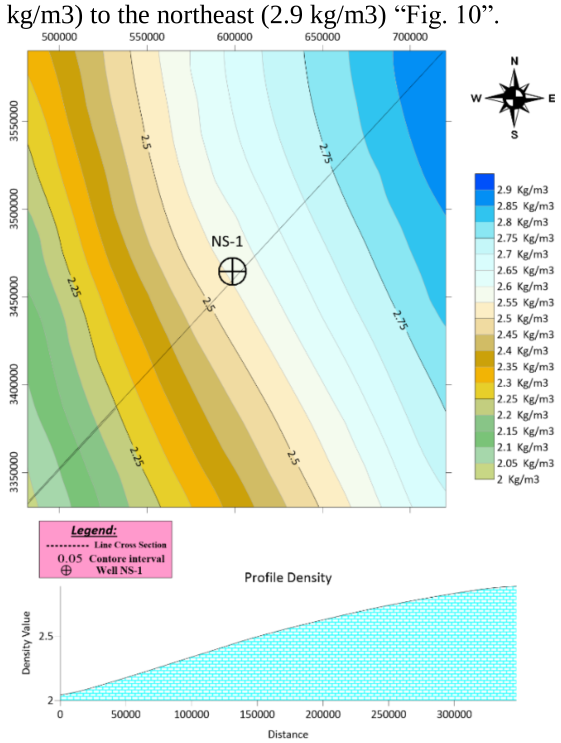


Fig. 10. Density distribution map of the Yamama Formation.

E) *Acoustic Impedance Map*

The acoustic impedance changes from the southwest with a value (5000 kg/m^{2}s) to the northeast with a value of (15000 kg/m^{2}s) “Fig. 11”, resulting from the product of velocity times density.

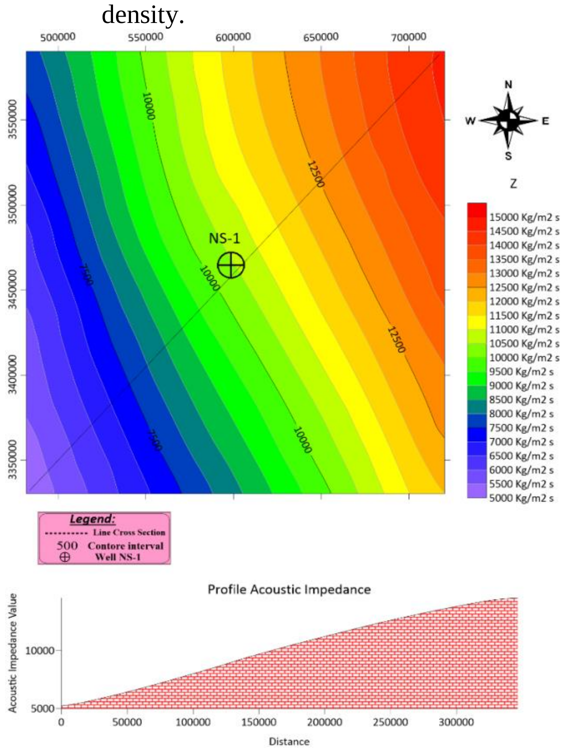


Fig. 11. Acoustic impedance distribution map of the Yamama Formation.

F) Thickness map

The thickness of the Yamama Formation changed and increased towards the northeast with a value of (650m) and gradually decreased towards the southwest until it reached a value of (50m), which what we observed in the map in “Fig. 12”.

From the thickness map of the Yamama Formation in “Fig. 13”, we noticed that the thickness of the formation increased towards the northeast.

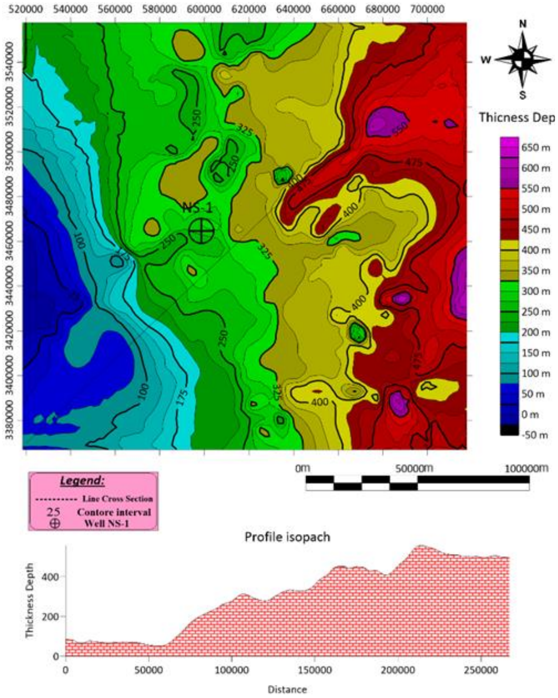


Fig. 12. Thickness Map of Al Yamamah Formation

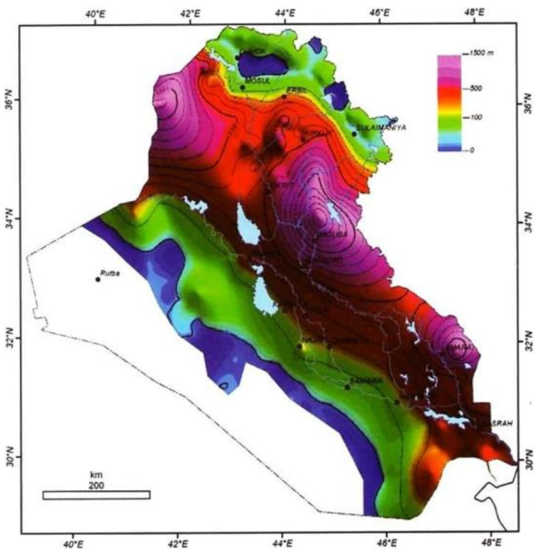


Fig. 13. Map of the thickness changes of the Yamama Formation [12].

G) Three-dimensional map of the thickness

The thickness increased from the northeast with a thickness of (-600m). In addition to the presence of geological structures, including enclosures and noses, was identified in the northern and western regions of the study area, which are situated within the Yamama Formation. This thickness was increased in the map in “Fig. 14”, as a result of the deposition of the Yamama Formation in the inner edge of the depositional basin and the distribution of the ancient environments of the formation “Fig. 15”.

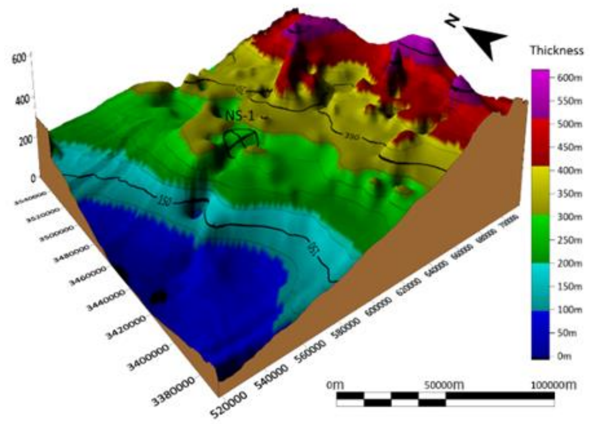


Fig. 14. 3D thickness map of the Yamama Formation

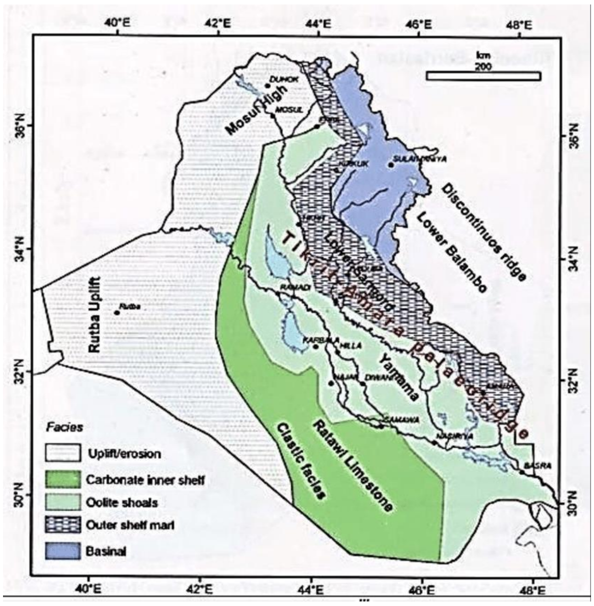


Fig. 15. Distribution of ancient environments for the formation of Al Yamamah [15]

VI. CONCLUSIONS

We observed an increase in the time of the Yamama Formation in the upper and lower boundary in the northeast direction with a value of (-2500 ms) and an increase in the depth of the Yamama Formation in the upper and lower boundary in the northeast direction. The faults in the region was identified in the northeast direction with a value of (-38500 m). In addition to increasing velocity and density towards the northeast and increasing the acoustic impedance of the boundary and the Yamama Formation from southwest to northeast with a value of (1500 kg / m2).

We noted the increase in thickness from the southwest direction to the northeast, where the thickness reaches (650 m) and the geological structures represented by enclosures and noses have been identified as extending formations in the northern and western regions of the study area. Seismic maps showed the location of the deposition of the Yamama Formation at the edge of the basin, which is towards the northeast, and the region is affected by the growth of transverse faults.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

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