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Structural Study of Basins Configuration in Mesopotamian Area

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Abstract— **Mesopotamian Zone is a foreland basin formed by a collision between Arabian and Iranian plates. A subsurface structural study made for Mesopotamian area based on the information of the oil wells, which were used in the construction of five structural cross-sections. The sections reveal information about the difference in thickness of sedimentary formations in the basin during the geological time of Mesozoic and Cenozoic Era. As well as studied the most important reasons for the formation of surface and subsurface structures, which are attributed to three main reasons: the basement rocks and their longitudinal and transverse faults, tectonic movements that happened to the region as well as the role of salt layers or structures and their rush to the top.**

Index Terms— **Mesopotamia, tectonics, structures, basement rocks, salt layers**

I. INTRODUCTION

The Mesopotamian Zone lies in central and southern Iraq between Tigris and Euphrates Rivers (Fig.1). It has a flat terrain with a gentle slope from northwest to southeast towards the Arabian Gulf. This area is considered as a part of an unstable shelf and located to the east of the stable shelf. It is bounded to the northeast by folded range of Himreen Range, and Makhoul Range, in the north, while the southwestern boundary is controlled by faults.

The Mesopotamian Zone is covered by the Tigris and Euphrates rivers sediments which belong to fluvial deposits of the Quaternary period. There are many geomorphological features in an area such as alluvial fans, floodplains, natural levees and river terraces. These features and other are very common on the surface, with the tectonic origin features such as faults and lateral migration of rivers. Mesopotamian is a mobile tectonic zone which is characterized by subsurface complex structures like faults, folds and salt domes that led to forming the oil traps. Besides these structures, it has high and complex stratigraphic columns include the deferent types of sedimentary rocks [1]. The recent tectonic activity of subsurface structures is known through their effects on the Quaternary stratigraphy and present geomorphological features.

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Fig.1: Mesopotamian Zone of Iraq (after [2], [3]).

This study is an attempt to provide information about the variation in thickness and the facies change of sedimentary deposits of different formations during the Paleozoic, Mesozoic, and Cenozoic of geological time in order to interpret the tectonic evolution of the area due to the rise of the basement rocks.

II. METHODOLOGY:

In order to accomplish the task of this research, it must be done through collecting data that is related to the study area from different sources such as previous studies, thesis, published articles, technical reports, well logs, final geological well reports, seismic sections and satellite images. The tectonic interpretation is depending on the constructed cross-sections for the study area which are obtained from drilled oil well data and many surface field observations of the area. These sections were taken because they passed by many deep oil wells and they cut many lithological formations. The data of Mesozoic and Cenozoic have been obtained on the distribution of thickness configurations through borehole information from various parts of Iraq and described with details in the tracks or cross sections on the map. Five cross sections have been taking with orientations E -W and NW-SE to get clear information about different thicknesses in the region.

III. GEOLOGICAL SETTING:

1. *Stratigraphy:*

The Quaternary sediments covered the Mesopotamian Plain and no pre-Quaternary rocks are exposed in the area. The main sediments of the Mesopotamian Plain have come from the Tigris, Euphrates, Diyala and Adhaim Rivers. The Quaternary sediments show tremendous development in the Mesopotamian Plain. These sediments consist of gravels, sands, silts, and clays that are mainly related to the cyclic fluvial sediments of the Tigris and Euphrates Rivers, with their tributaries and distributaries. The sediments form flood plains with a complex network of natural levees, channels, and terraces. Reference [4] mentioned that the Quaternary sediments are reached to 180 m thick. Reference [5] went away and pointed out that the Quaternary sediments of the Mesopotamian Plain show progressive thickening from northwest to southeast, reach the maximum thickness about 180 m sediments near Basrah city.

There are not any boreholes penetrate the complete thickness of the Paleozoic sequence in Iraq. Only very few wells in the Mesopotamian Plain have reached the upper part of the Paleozoic sequence. The Paleozoic sequence thickness estimated to be around 5 Km. by correlations with other parts of Iraq [6], [7], [8]. The average thickness of the sequence is highly variable in different parts of the Iraqi territory; it reaches about 17 Km [9].

The depth of the basement was estimated by the CGG [10] using magnetic and gravity data and the result were between 8 Km. in the western part and 14 Km. in the eastern part of the area. The area has almost a perfect sedimentary succession without any significant breaks [11].

2. *Structure:*

Folds and salt structures:

In the Mesopotamian Plain, the structural features are absent on surface because they are usually hidden beneath the Quaternary cover. It has many subsurface structures including faults, folds and diapiric structures beneath the Quaternary cover. The Mesopotamia has three types of folds are (Fig.2):

The first type is the Fault – related folds. These folds are developed by the initial fault- bounded structural troughs (graben or half-graben) because of structural inversion phenomena. Tikrit and Samara are good examples of this type.

The second type is the simple buckle folds, which formed as a result of the regional compression exerted by Arabian – Eurasian Plates collision. Such folds usually follow the trend of the Zagros Fold – Thrust Belt.

The third type is the least common and known to the south of Iraq, the folds are N-S in orientation following the old inherited fractures of the N-S Arabian trend. These folds are usually long, broad with low amplitude such as Zubair, Rumaila. The movement of basal salt of Early Cambrian late-Permian Hormuz salt is the main reason to create these folds and its active movement in the north of the Gulf region, which reaches the surface only in one location, to the south of Basrah city known as Jabal Sanam [12].

Balad, Samarra, Tikrit and Baiji subsurface anticlines are still rising up [13]. These anticlines with other surface features like the drainage pattern, shifting of the main river courses, abandoned river channels, active and inactive fans are good indicators for the neotectonic movements. Surface folds are almost absent in Mesopotamian plain, NW – SE trending Anah, Tikrit and Samarra folds are the only excluding. The surface features are hardly recognized because of the Quaternary cover sediments, which are uplifted along these surfaces with about 10–15 m relief in comparison with the surrounding.

Salt structures have an economic importance as they form oil and gas traps. These salts represent by Hormuz salts which extended over the basement rocks and under the thick sedimentary column in the south of Iraq playing a major role in the generation of many subsurface anticline structures that led to forming oil fields in the south of Iraq such as fields of Zubair, Rumaila, Ratawi and Nhr Umr…etc. The rushing of these salts is the main reason to change the direction of oil field from NW-SE in the north of Iraq to N-S in the south of Iraq.

Fig.2: Structural Map of Mesopotamia Foredeep (after [14]).

Faults:

A network of normal fault systems present in northern part of the area between south Baghdad and south Mosul with the orientation of NW – SE, and ENE – WSW (Fig.2). These fault systems are;

1. *The first fault system* is normal faults of NW – SE trend that forming a difficult series of grabens, half grabens, and single faults. Some of these grabens have been fractional reverse to form anticline folds or structural noses above them, while other grabens have not.

2. *The second fault system* is normal faults of ENE – WSW trend that present in northwestern part of the area and containing a set of troughs as grabens and half grabens including Anah, Tayarat, Khlesia and Tel Hajar. Some of these structural basins have been fractional reverse to form fault-propagation folds above them [15], [16].

The Mesopotamian Zone contains longitudinal and transversal faults [11]. The major longitudinal faults in Mesopotamian Zone are Makhul-Hemrin Fault, Tikrit-Amara Fault, Ramadi-Musayib Fault and Euphrates Boundary Fault, while the major transversal faults in Mesopotamian Zone are: Sirwan Fault, Kut-Dezful Fault, Takhadid-Qurna Fault and Al Batin Fault (Fig.3).

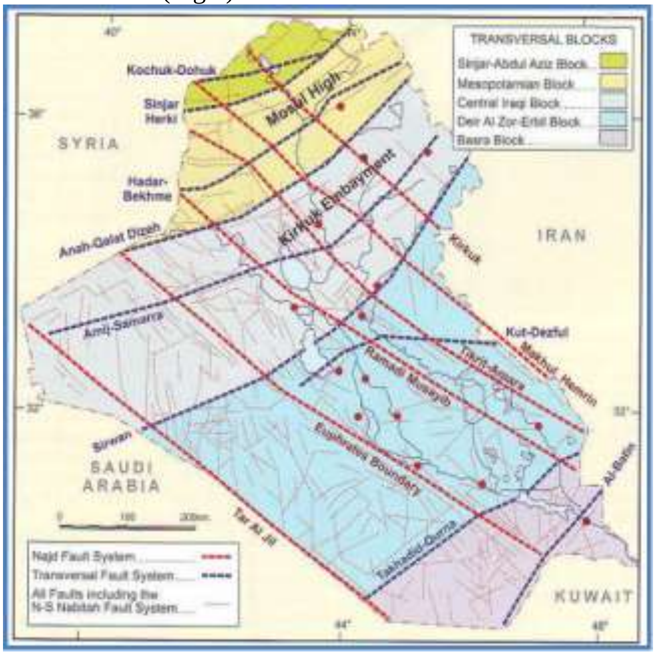

Fig.3: Tectonic zones of Iraq (after [11]).

The basement rocks are considered as important reason to form surface and subsurface structures. In Iraq, the basement rocks are not revealed and there was not borehole penetrated all sediment cover to the basement rocks. Therefore, our information about structure and depth of the basement are resulting from some indirectly studies, such as the surrounding countries in the Middle East. Primarily, depending on gravity data to identify the faults and complementary to the magnetic data and satellite images. Trending fault systems include the northwest-southeast trending (Najd Fault System), the northeast-southwest trending (Transversal Fault System) and the north-south (Nabitah Fault System). These fault systems were formed during Late Precambrian Nabitah Orogeny [17].

Geological evolution of Iraq has been associated with Arabian plate movements during geological time. Najd and Hejaz are the first movements that built mountains which has an active role in creating of faults in basement rocks. These faults have represented by longitudinal faults and transverse faults. Later, these faults influenced on sedimentary cover and then on main waterways in Iraq. Tigris and Euphrates Rivers have flow toward the northwest-southeast with direction of the longitudinal faults, while transverse faults were affected directly on tributaries of the Tigris River, which have same direction in northeast – southwest [18].

IV. DESCRIPTION OF CROSS SECTIONS:

In order to show and describe the tectonic setting of the area, five cross-sections are drawn and traverse the studied area (Fig.4), the horizontal scale of these sections is 1cm= 16.66km. and vertical scale is 1cm= 1km. These sections are:

Fig.4: Locations of the cross-sections of study area.

1- cross-section 1:

The section was taking in the southern Iraq (Fig.5), it extends toward the W-E. This section is connecting between many oil wells, which drilled to various depths. These wells are Ubaid1, Luhais12, Ratawi3, Rumaila172, and Nahr Umr1.

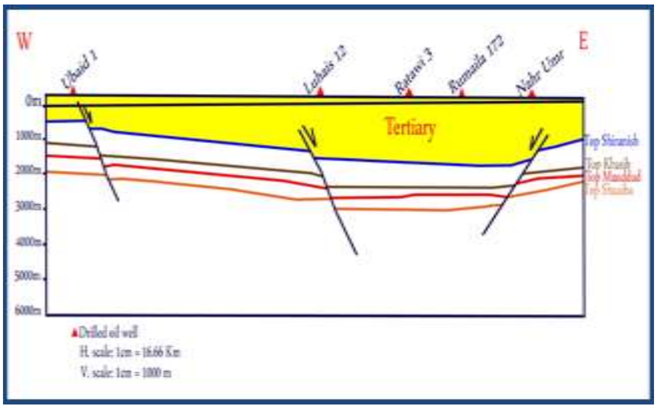

Fig.5: W-E structural cross-section 1(see profile location in Fig.4).

The section includes many formations which belonging to Mesozoic such as Shiranish Formation belongs to Upper Cretaceous (Camp.-Maast.), Khassib Formation belongs to Upper Cretaceous (Turonian), Mauddud Formation belongs to Lower Cretaceous (Albian) and Shuaiba Formation belongs to Lower Cretaceous (Aptian). The depth of the basin increases from west to east; it shows the presence of normal faults in the region which could indicate the presence of tension forces. There is an impression to show broad folds in this section. These forces led to make a graben in the east of the section. The main reason of these forces belong to the separation of the Iranian and Turkish plates from the Arabian plate in Cretaceous and formation of The Neo-Tethys Ocean during opening phase. Mauddud and Shuaiba Formations represent the subsurface reflectors.

2- cross-section 2:

The section was taken in the southern Iraq (Fig.6), it extends toward the W-E. The section is connecting between many oil wells, which drilled to various depths. These wells are Ghalaisan1, Samawa1, Nasiriya1, Halfaya1, and Huwaiza1. The section includes many formations which belonging to Mesozoic such as Tayarat Formation belongs to Upper Cretaceous (Campanian-Maastrichtian), Shiranish Formation belongs to Upper Cretaceous (Camp.-Maast.), Mauddud Formation belongs to Lower Cretaceous (Albian), Shuaiba Formation belongs to Lower Cretaceous (Aptian), Ratawi Formation belongs to Lower Cretaceous and Gotnia Formation belongs to Upper Jurassic. The presence of normal faults mentioned in Samawa1, Nasiriya1, and Halfaya1 indicates the presence of the tension forces and affected on the sediments thickness, and led to

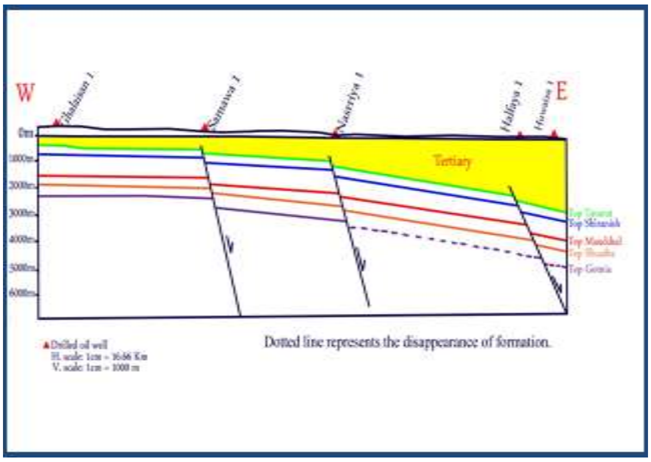

Fig.6: W-E structural cross-section 2 (see profile location in Fig.4).

increase in the depth of the basin eastward. Mauddud, Shuaiba, and Gotnia Formations represent the subsurface reflectors.

3- cross-section 3:

The section was taken in the southern Iraq (Fig.7), it extends toward the W-E. The section is connecting between many oil wells, which drilled to various depths. These wells are Samawa1, Garraf1, Rafidain1, Dujaila1, Buzurgan1, and Abu Ghirab3. The section includes many formations which belonging to Mesozoic such as Tayarat Formation belongs to Upper Cretaceous (Campanian-Maastrichtian), Shiranish Formation belongs to Upper Cretaceous (Camp.-Maast.), Mishrif Formation belongs to Upper Cretaceous (Cenomanian-Turonian), Mauddud Formation belongs to Lower Cretaceous (Albian), Shuaiba Formation belongs to Lower Cretaceous (Aptian), Ratawi Formation belongs to Lower Cretaceous and Gotnia Formation belongs to Upper Jurassic. Normal faults between Dujaila1 and Buzurgan1 oil wells led to form a step fault. The same phenomenon noted as above in section 2, where the normal faults induced deepening in the basin eastward. Mauddud, Shuaiba, and Gotnia Formations represent the subsurface reflectors.

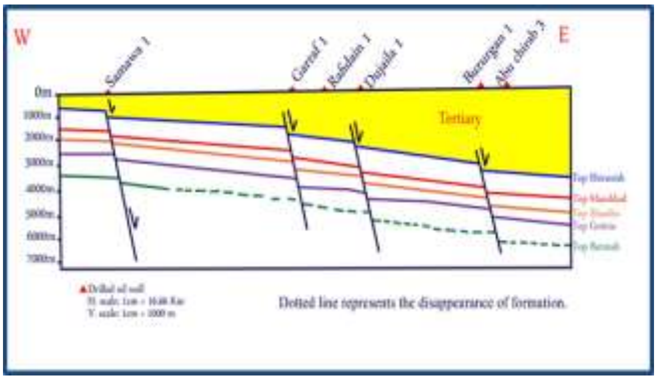

Fig.7: W-E structural cross-section 3 (see profile location in Fig.4).

4- cross-section 4:

The section was taken in southern Iraq (Fig. 8), it extends toward the NW-SE. The section is connecting between many oil wells, which drilled to various depths. These wells are Merjan1, Kifl1, Afaq1, Rafidain1, Dujaila2, Amara1, and Halfaya1.

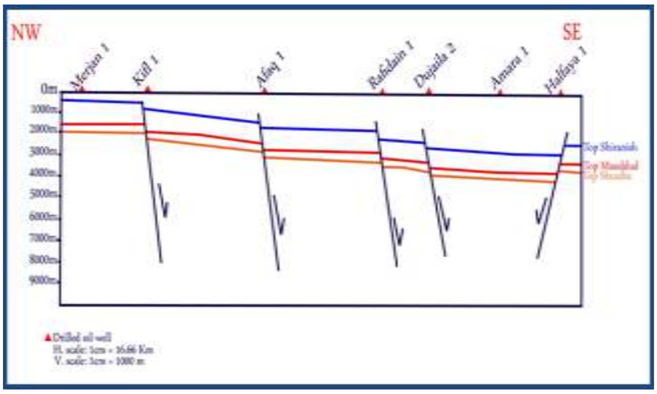

Fig.8: NW-SE structural cross-section 4 (see profile location in Fig.4).

The section includes many formations which belong to Mesozoic such as Shiranish Formation belongs to Upper Cretaceous (Camp.-Maast.), Mauddud Formation belongs to Lower Cretaceous (Albian) and Shuaiba Formation belongs to Lower Cretaceous (Aptian). The basin is deepening toward the Kifl1 oil well and that could refer to the effect of tensile forces in the region. Shiranish Formation below down due to a number of normal faults found in the section, producing graben which was observed between Dujaila2 and Halfaya1. The normal faults in this section are characterized by high angle of fault plain. Mauddud and Shuaiba Formations can be considered as subsurface reflectors.

5- cross-section 5:

The section was taken in northern of Iraq (Fig. 9), it extends toward the SW-NE. The section is connecting between many oil wells, which drilled to various depths. These wells are K 7/2, Melh Tharthar1, Samarra1, and Injana5.

The section includes many formations which belonging to Mesozoic such as Shiranish Formation belongs to Upper Cretaceous (Camp.-Maast.) and Mauddud Formation belongs to Lower Cretaceous (Albian). There are many normal faults could result from tension forces which caused a high depression increased toward ENE. Mauddud Formation can be considered as a subsurface reflector.

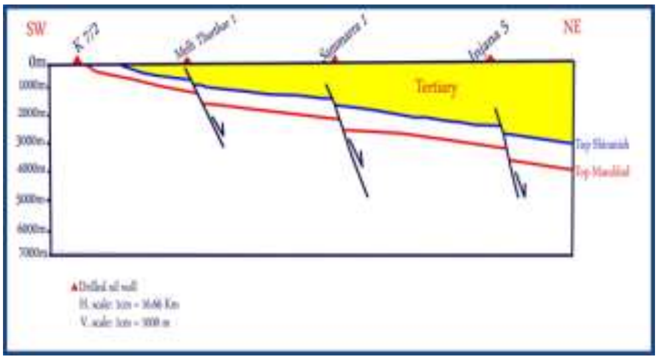

Fig.9: SW-NE structural cross-section 5 (see profile location in Fig.4).

The five sections note that the eastern region of the southern part of the Mesopotamian plain was subjected to strong tension forces that led to the manifestation of many normal faults. These faults show grabens and in some area the fault planes are of high angle.

V. CONCLUSION:

The cross-sections in the south of Iraq contain folds and faults while the cross-sections in the north of Iraq have only the faults and this could belong to the presence of salt layers. The tension forces in the Cretaceous are responsible for the normal faults and grabens before and after the deposition at that period. It could summarize that the region was subjected to tension forces during the Mesozoic followed by compression forces during the Cenozoic. These alternative forces led to the emergence of some surface and subsurface morphological features causing by; basement rocks (uplift), the salt structure and tectonic movements.

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