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Reservoir Characterization and 3D Geological Modeling of Jeribe Formation in Mansuriya Gas Field

A Thesis Submitted to the Council of College of Science, University of Diyala in Partial Fulfillment of the Requirements for the Master Degree in Geology\Earth Science

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Abstract

Al-Mansuriya gas field is regarded as one of Iraq's most important gas fields because of its good economic gas reserves, The major gas reserves of the Mansuriya field are situated in Jeribe Formation, The age of the formation is the period of formation deposition dates back to the lower middle Miocene. The present study aims to determine the petrophysical characteristics and build a 3D geological model of the Jeribe Formation in the Mansouriya gas Field for the open wells MN_1, MN_2, MN_3, MN_4. The available logs are digitized using the Neuralog Software Package 3.03. Matrix definition (MID) and Density-Neutron cross plots indicate that the lithology of the Jeribe Formation consists of a large proportion of dolomite and limestone and a little anhydrite also in the direction of the gas evident in the Jeribe formation. The Gamma-ray log showed that the volume of the shale is very small in the Jeribe Formation, and the formation may be clean of shale content, and the reason for this small reading is the presence of some radioactive materials in the formation rocks. In general, the porosity in the four wells is medium to high, rangings from 15 to 23% and reaching 26 in well MN-4,Water saturation is medium in the four wells from 20 to 50% and increases towards well MN-4. The Jeribe Formation was divided into seven reservoir units, which are J1, J2, J3, J4, J5, J6, and J7 depending on the final results of CPI computer processing interpretation using the (Techlog program).

The 3D geological model (structure, lithology, and petrophysics models) is built for the Jeribe formation using Petrel software and depending on interpretation of well logs. The 3D grid of the Jeribe Formation model that was built consists of (10494848) cells and each cell has dimensions I =272 * J = 371 * K =104. Structural contour maps of Jeribe units show that Mansouriya structure is composed of asymmetrical anticline fold of 30x6.5 km with axis trending in NW-SE direction. The horizontal porosity between the four wells ranges from 15 to 22%, which is a good porosity value. As for the water saturation, it is medium in most parts of the structure, except for well MN-4, where the saturation reaches 90%. After establishing zones for Jeribe Formation, which is divided into 7 zones. Layers are built for each zone of Jeribe Formation depending on petrophysical properties and well data.

Through the readings of the well logs and petrophysical characteristics, can conclude that units J1 and J6 represent non-reservoir units because they consist of layers of anhydrite with very low porosity can be considered a cap rock for the reservoir units and the units J2, J3, J4, J5 are the main reservoir units for Jeribe

المستخلص

يعتبر حقل غاز المنصورية من أهم حقول الغاز في العراق بسبب احتياطياته الاقتصادية الجيدة من الغاز ، وتقع احتياطيات الغاز الرئيسية لحقل المنصورية في تكوين الجريبي ، وتعود فترة ترسيب التكوين إلى أسفل الميوسين الأوسط. تهدف الدراسة الحالية إلى تحديد الخصائص البتروفيزيائية وبناء نموذج جيولوجي ثلاثي الأبعاد لتكوين الجريبي في حقل غاز المنصورية للآبار MN_1 و MN_2 و MN_3 و MN_4. يتم رقمنة السجلات المتاحة باستخدام Neuralog Software . تم تقسيم تكوين Jeribe إلى سبع وحدات مكمنية ، وهي J1 و J2 و J3 و J4 و J5 و J6 و J7 اعتمادًا على النتائج النهائية لتفسير معالجة الكمبيوتر CPI باستخدام برنامج الفيزياء التفاعلية (Techlog). يشير تعريف المصفوفة (MID) والمخططات المتقاطعة للكثافة والنيوترون إلى أن صخارية تكوين جيريبي تتكون من نسبة كبيرة من الدولوميت والحجر الجيري وقليل من الأنهايدرات. أظهر سجل أشعة كاما أن حجم shale صغير جدًا في تكوين جيريبي ، وقد يكون التكوين نظيفًا من محتوى shale ، وسبب هذه القراءة الصغيرة هو وجود بعض من المواد المشعة في صخور التكوين. تم تصميم النموذج الجيولوجي ثلاثي الأبعاد (الموديل التركيبي و موديل الليثولوجي و الموديل البتروفيزيائي) لتشكيل Jeribe باستخدام برنامج Petrel واعتمادًا على تفسير سجلات الآبار. تتكون الشبكة ثلاثية الأبعاد لنموذج Jeribe الذي تم إنشاؤه من (10494848) خلية ولكل خلية أبعاد I = 272 * J = 371 * K = 104. توضح الخرائط الكنتورية التركيبية لوحدات الجريبي أن هيكل المنصورية يتكون من طية منحنية غير متناظرة بطول 6.5*30 كم مع محور يتجه في اتجاه شمال غرب وجنوب شرق. بعد عمل آفاق لتكوين Jeribe ، والذي تم تقسيمه إلى 7 مناطق ، تم بناء طبقات لكل منطقة من مناطق التكوين اعتمادًا على الخصائص البتروفيزيائية وبيانات الآبار.

من خلال قراءات سجلات الآبار ونتائج حدود القطع والخصائص البتروفيزيائية ، يمكننا أن نستنتج أن الوحدتين J1 و J6 تمثلان وحدات غير مكمنية لأنها تتكون من طبقات من الأنهيدريت ذات مسامية منخفضة جدًا يمكن اعتبارها صخرة الغطاء. و الوحدات المكمنية J2، J3، J4، J5 هي وحدات الخزان الرئيسية لتكوين الجريبي وفقًا لنتائج مؤشر تفسير الكمبيوتر ونتائج الخصائص (المسامية الفعالة العالية ، تشبع الماء المنخفض) ويظهر نوعان من الصخور (الدولومات والحجر الجيري) ، مما يجعلها خزانات ذات جودة عالية. أظهر البئر mn-4 نتائج مختلفة عن بقية الآبار ، ولا يمكن اعتبار أي من وحداته مكمن بسبب حجم التشبع المائي الكبير فيه.

Chapter One
Introduction

Introduction

1-1 preface

Al-Mansuriya gas field is regarded as one of Iraq's most important gas fields because of its good economic gas reserves. The major gas reserves of the Mansuriya field situated in the Zagros Fold Belt are located in the Jeribe and the Lower Fars Formations transition Zone (TPAO,1998).

The structure of the Mansuriya field is located, according to the structural divisions prepared by the Iraqi-Soviet team in 1971, within the central faults area of the Mesopotamia zone, the northeastern unit of the Stable Shelf. The Mesopotamian Basin had relatively uniform deposition of the Early Miocene (Burdigalian) Jeribe Formation. This area had a total thickness of 63 meters. (Al-Juboury *et al*, 2007).Jeribe Formation has a semi-uniform thickness ranging from 60 to 65.5 meters in the Mansuriya gas field and contains four wells shown in (Table -1).

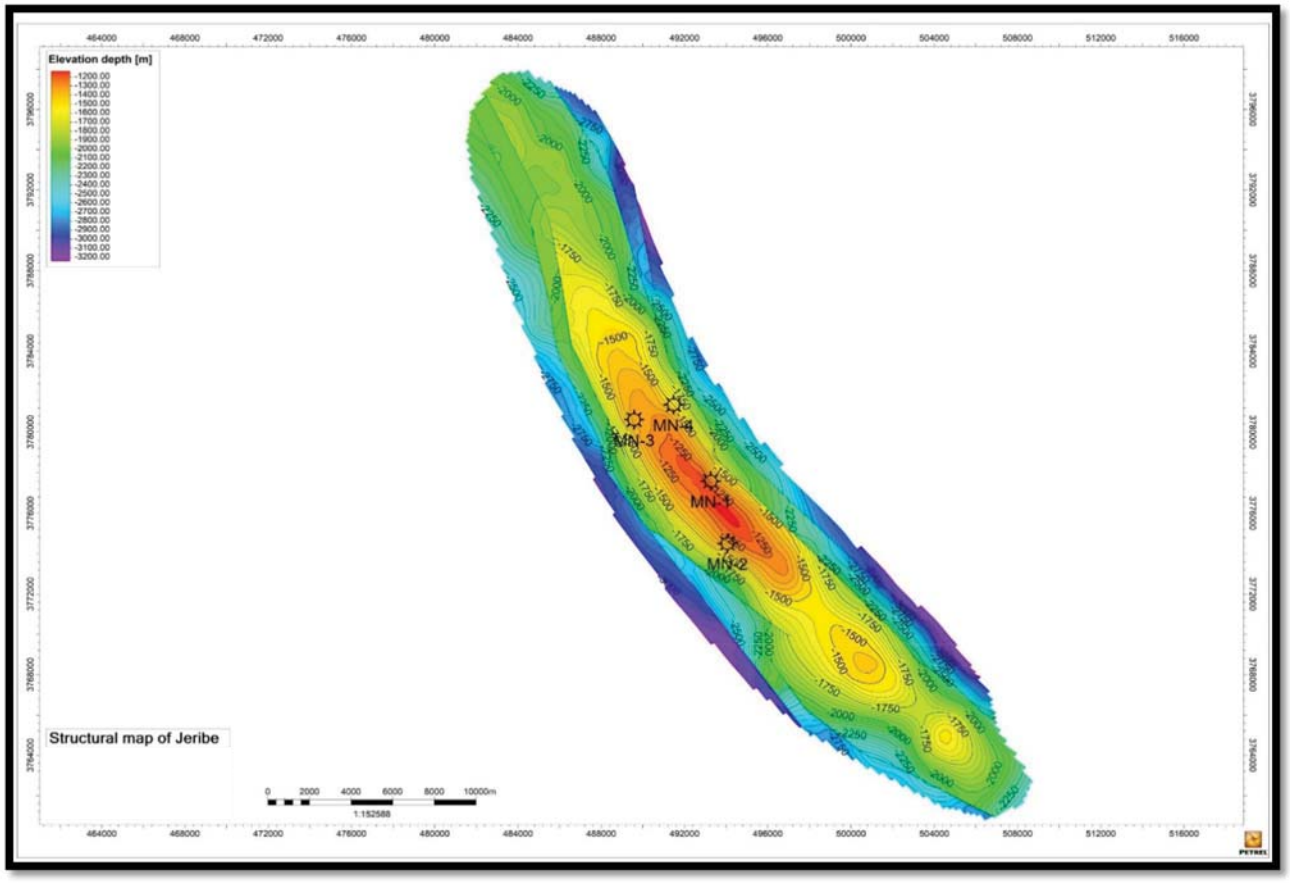
The purpose of the current study is to identify the reservoir units and estimate their petrophysical characteristics through the analysis of well logs, in addition to building a 3D geological model to interpret the distribution of reservoir properties for the formation in AL- Mansuriya gas field.

Table (1-1): Geographical coordinates and thicknesses of the Mansouriya field wells (Final well report from NOC, 1981).

Wells	Latitude	Longtude	Thickness	Top	Bottum
MN-1	34°8'29.849"N	44°55'27.48"E	65.5	1349.5	1415
MN-2	34°6'51.077"N	44°55'58.552"E	60	1400	1460
MN-3	34°10'7.663"N	44°53'0.639"E	61.5	1420	1481.5
MN-4	34°10'23.193"N	44°54'19.166"E	60	1637	1697

1-2 Location of the study area

The field to be studied is located in Diyala Governorate, northeast of Baqubah city, about 50 km away from it, and about 102 km away from Baghdad towards the northeast and southwest of the Hamrin Lake, as shown in. The general topography of the field area is slightly hilly and partly covered with water. The field occurs in Block 45. The field covers an area of about 150 km^2 and was discovered in October 1979. The Mansuriya structure is an asymmetric anticlinal extending in a northwest-southeast direction, about 5-6 km wide and 25 km long. (OEC,2007 Figure (1-1) a contor map of the Mansouriya structure and Figure (1-2) Location of the study area.



Figure(1-1) showing a contor map of the Mansouriya structure.

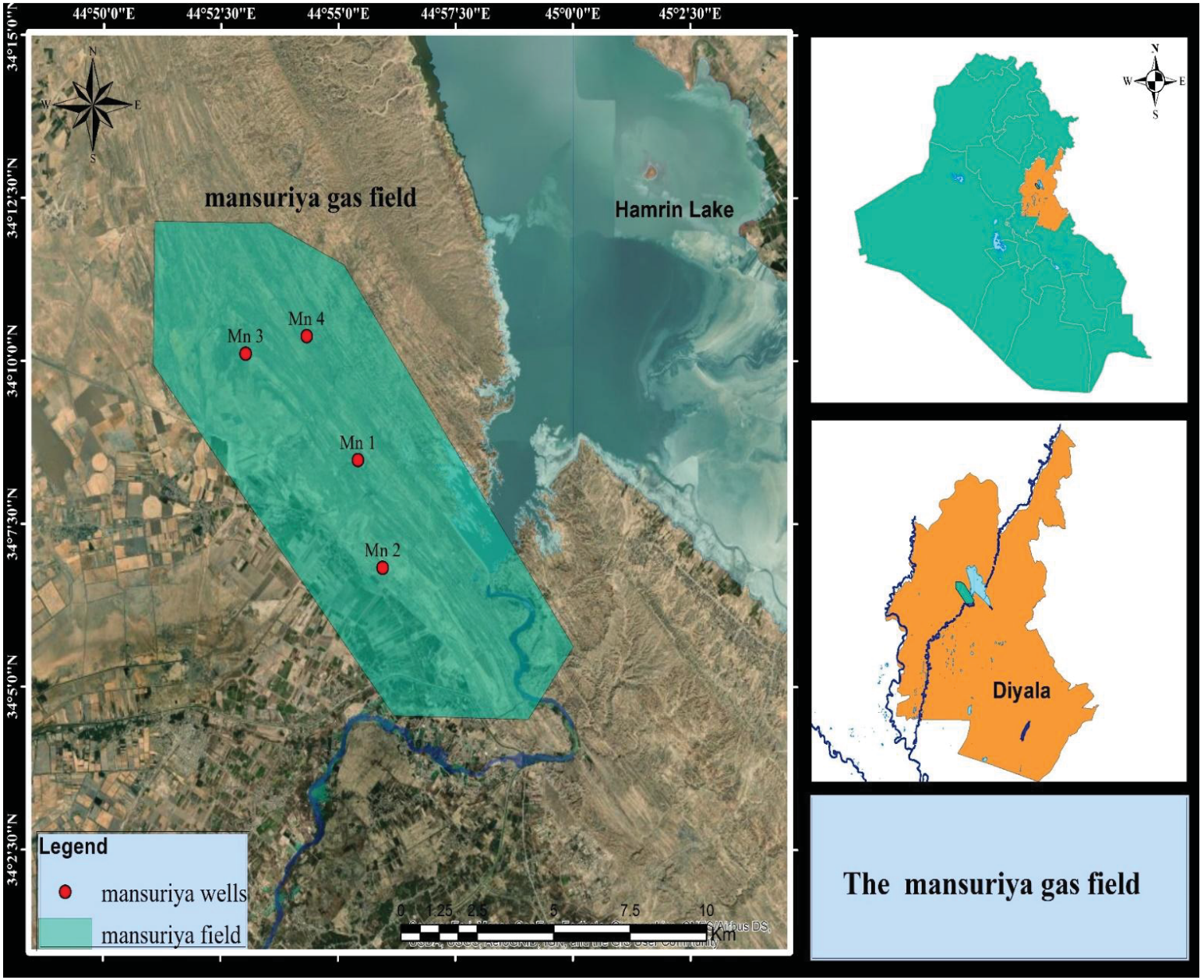


Figure (1-2): Location of the study area

1-3 Aims of the study

The objectives of this study are:

1- Well log measuring and interpretation of the petrophysical properties and evaluation of the petrophysical properties for each reservoir unit to recognition the vertical and horizontal distributions in the Jeribe reservoir using available logs data.

2- Creation Three-dimensional geological model to explain the distribution of petrophysical properties of the reservoir units of the Jeribe Formation in the Mansuriya gas field.

1-4 Geologic setting

1-4-1 Stratigraphy

The following is a brief description of the formations that were penetrated in the Mansuriya wells, MN-1 which are the deepest wells that were penetrated and shown in the field compared to the rest of the wells, Table (1-2) and Fig (1-3). Showing these formations:

1- Anjana Formation (Upper Fars): The facies of this formation consist of a succession of sandstone, Celtic, and mudstone, Anjana formation was deposited during the Upper Miocene period (Bellen *et al*,1959).
2- Fatha (Lower Fars): This formation forms the regional top seal for almost all the Cenozoic reservoirs in Arabia (Goff *et al*, 1995). Facies of calcified or dolomitic limestone with the shale. The transitional layers constitute the bottom part of the formation and the most important in terms of the reservoir, as it was divided into several units depending on the appearance of the limestone. The age of formation dates back to the Middle Miocene (Goff *et al*, 1995).
3- Jeribe Formation: The carbonate formation was first mentioned by (Damesin, 1936 in Bellen *et al*,1959). The Mesopotamian Basin of Jeribe Formation was formed very consistently during the Early Miocene (Burdigalian) period, Figure (1-4) according to (Aqrawi *et al,* 2010). The total thickness in Jeribe

field is 65 metres (Al-Juboury *et al*, 2007). In the Mansuriya gas field, the upper contact is unconformable with the Fatha Formation and Dhiban Formation is conformable with the lower contact of Jeribe (Bellen *et al*,1959), The facies of this formation consist of calcified rocks containing a very small percentage of clay. The percentage of dolomite increases towards the top of the formation, The formation was affected by several transformational processes, including mainly dolomite, hydrodynamic, and silicic, which are limited, where it was noted the presence of anhydrite crystals as well as silica as a cementitious substance that fills some voids. The composition was divided into two main units, depending on the severity of the dolomitization. The period of formation deposition dates back to the Lower Middle Miocene (OEC,2007).

4- Dhiban Formation: This formation consists of a periodic alternation of calcified calcareous limestone or dolomite with anhydrite and brine. The age of formation dates back to the lower Miocene- the lower Middle Miocene (Bellen *et al*,1959).

5- Euphrates Formation: The deep pelagic facies of this formation are considered the last deep facies in the stratigraphic column of Iraq, which arose in the permanent basin area in the eastern part of Iraq.

6- Basal Anhydrite: The Anhydrite represents the first total desiccation of the basin system. It is rarely more than 4-5 m thick in Iraq (OEC,2007).

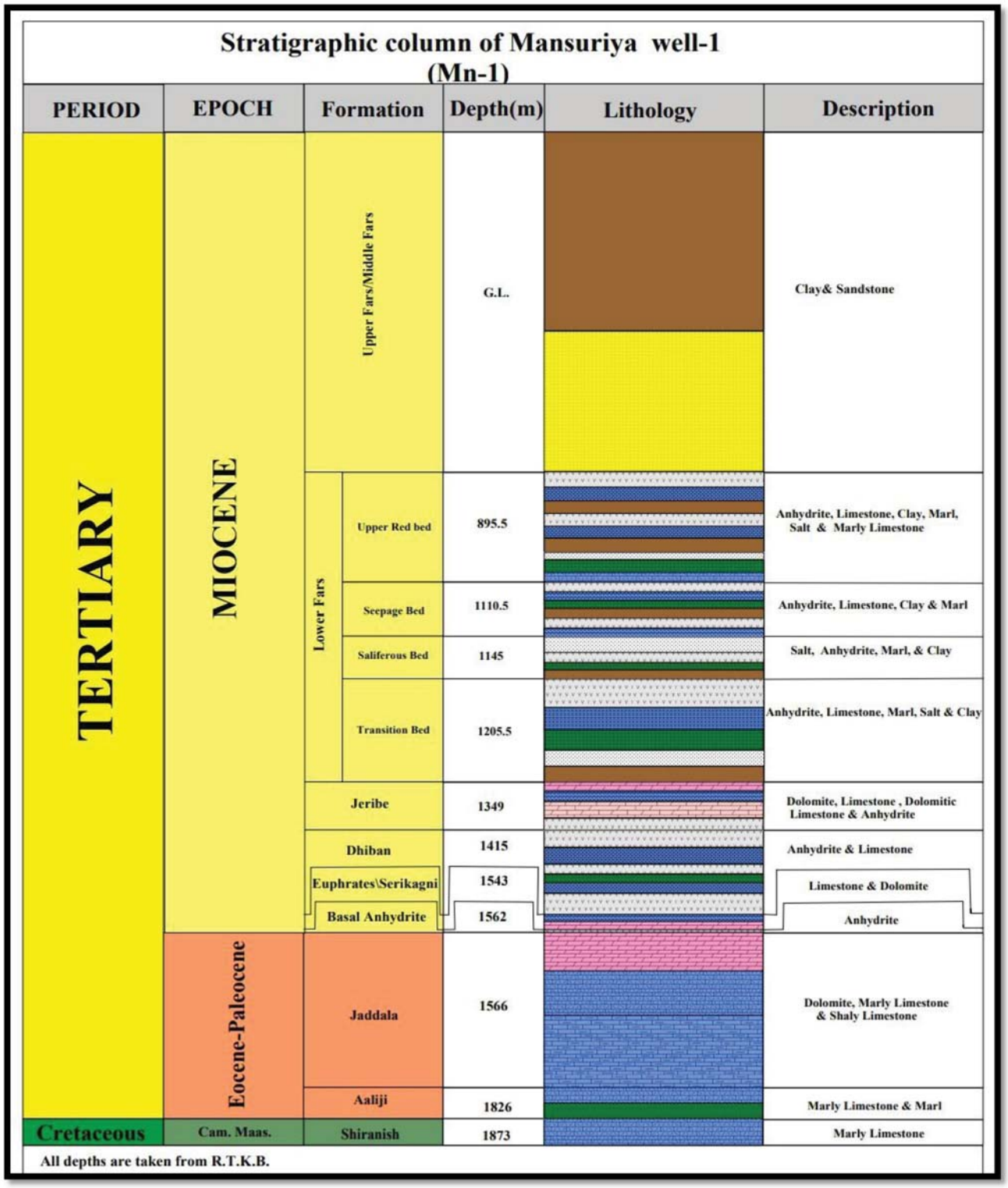
7- Jadalah Formation: The formation consists of agglomerated and partially recrystallized shale limestone with pelagic pasinal facies, the age of the formation is Paleocene.

8- Aliji Formation The formation consists of shale and shale limestone, and the percentage of shale and shale may increase in some parts of the formation, transforming into shale and silt, The clauconite grains appear at the top of the formation. The microfacies of the formation are wake limestone and Bulk limestone, and the grain limestone facies is intermingled with them. The upper and lower contact of the formation are represented by two unconformity surfaces, and their age dates back to the Paleocene

9- Shiranish Formation: This formation consists of mud limestone, in which fossils have increased under depth 901. The entire formation was not penetrated, the age of the formation is Maastrichtian (Henson, 1940).

Table (1-2) shows the tops of the formations in the wells of the Mansuriya field (Final well report from NOC, 1981).

Formation	Mn-1	Mn-2	Mn-3	Mn-4
Injana	surface	surface	surface	surface
Fatha	895.5	886.5	846	1166.5
Jeribe	1349.5	1400	1420	1637
Dhiban	1415	1460	1481,5	1697
Euphrates	1543	1636	1648	1895
Basal anhydrate	1562	1653	1664	1917
Jaddala	1566	1661	1670	1921
Aliji	1826			
Shiranish	1873			
The end depth	1933	1665	1681	2006



Figuer (1-3) Stratigraphic succession of Jeribe Formation in Mansuryia gas field (final geological report from NOC, 1981).

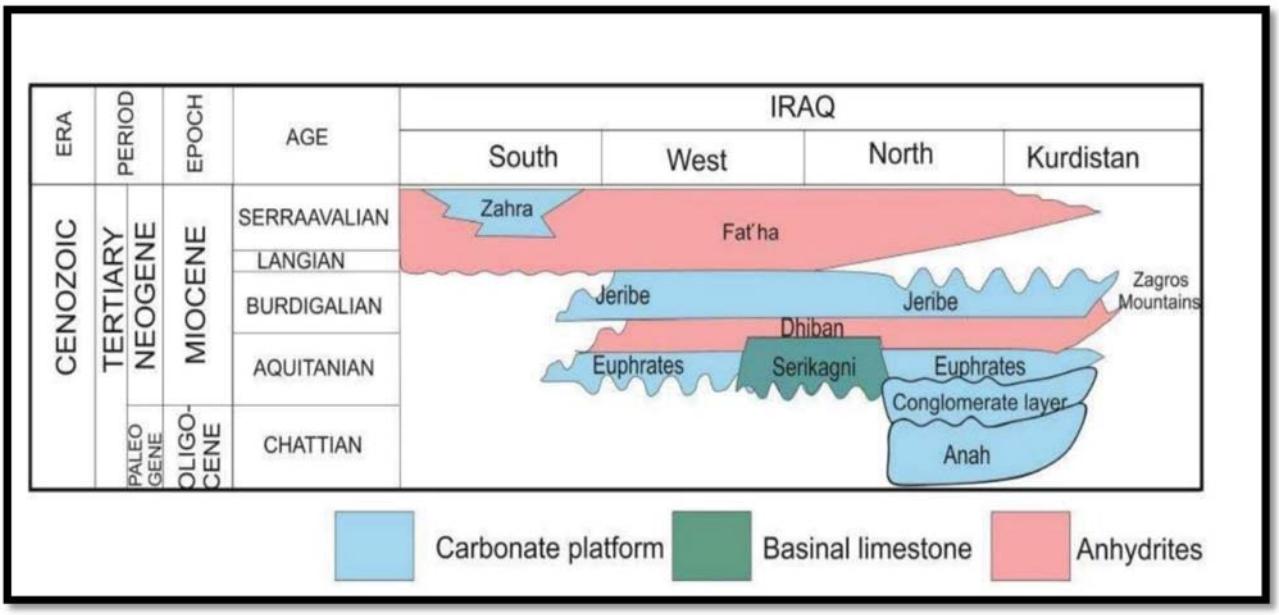


Figure (1- 4): showing the Chronostratigraphic of Jeribe Formation (after Petroleum Geo-service, 2000).

1-4-2 Trap Type (Fold)

The field structure is an elongated NW-SE trending compressional asymmetric anticline, about 20 km long and 4-5 km wide with an overturned or reverse fault trending NE-SW along the western flank, and a structural closure of about 70 square km at the top of the Formation (TPOC 2012).

1-4-3 Seal/ Cap Rock

The Middle Miocene Lower Fars Formation (Fatha. F) anhydrite covers Jeribe carbonate reservoir, forming a seal for the area (Al-Ameri, 2010).

1-4-4 Source rocks

The source rocks of the hydrocarbon charged Al-Mansuriya Gas Field are the Shiranish, Kometan, and Balambo Formations, Only the Shiranish Formation, as described above, is identified in the Al-Mansuriya Gas Field, and the nearby area of the field is thought to include a thick section composed of the Kometan, Shiranish, and Balambo Formations with abundant organic materials. (Peter *et al*, 2001)

1-5 Tectonic and structural setting

The Structure of Al-Mansuriya Field is located according to the structural divisions prepared by (Fouad, 2012) within the central faults area of the low folded zone is the northeastern unit of the outer platform, Figure (1-5). The field is a longitudinal surface structure, where it is characterized by having two asymmetrical limb, its northeastern and less inclined limb protrudes on the surface.The Mansuriya structure results from the influence of compressive forces as a result of the Orogeny movement (alpine movement for the formation of mountains), which reached its crest in the Miocene / Pliocene era, when the Zagros Mountains were formed. This region is characterised by special movement activity, as it has been exposed throughout its geological history to the influences of different forces. (TPOC, 2014)

The structure of the central fault's region is also characterized by being complex, particularly in the higher part of it (at the level of the formation of Injana) by the influence of thrust faults and the inelastic deformation of salts, (Beydoun,1992).

1-6 Paleogeography and Equivalents of Jeribe Formation

The Jeribe Formation was deposited in the Middle Miocene cycle (Jassim and Goff, 2006). The middle Miocene cycle is found in Tertiary Period rock strata in northern Iraq is an important cycle that contains a reservoir basin that was filled with sediments. Most of the shelf transformed throughout this cycle into a shallow marine basin, where deposits accumulated (Bellen *et al*, 2005). The collision between the Tethys Sea was completely sealed off as a result of the collision of the Arabian plate with the Iranian and Anatolian plates, creating numerous stages of transgression and regression (Numan, 1997). The Jeribe Formation was deposited as a result of these events (Buday, 1980) and (Jassim and Goff,2006). Southern Iraq does not record the Jeribe Formation (Bellen *et al,* 2005). However, This formation is pervasive at the surface and in the northern oil fields in Iraq. In this region, it is comparable to the limestone formations of Kovand in northern Iraq in terms of age and the Gar Formation in southern Iraq. Regionally, the Kalhur Formation is comparable to Jeribe Formation (Buday, 1980) and a part of the upper

Asmari Formations in Iran (James and Wynd, 1965), while in Turkey, the formation is (by age and facies) comparable to the Firat Formation and the Lice Formation, (figure 1- 6). The Jeribe Formation is also comparable in age to the Dam Formation in Saudi Arabia and the Gar Formation in Kuwait, (Beydoun 1997). The Jeribe Formation's lithology is generally homogenous and consists of gypsum, chert nodules, dolomite, and dolomitic limestone.

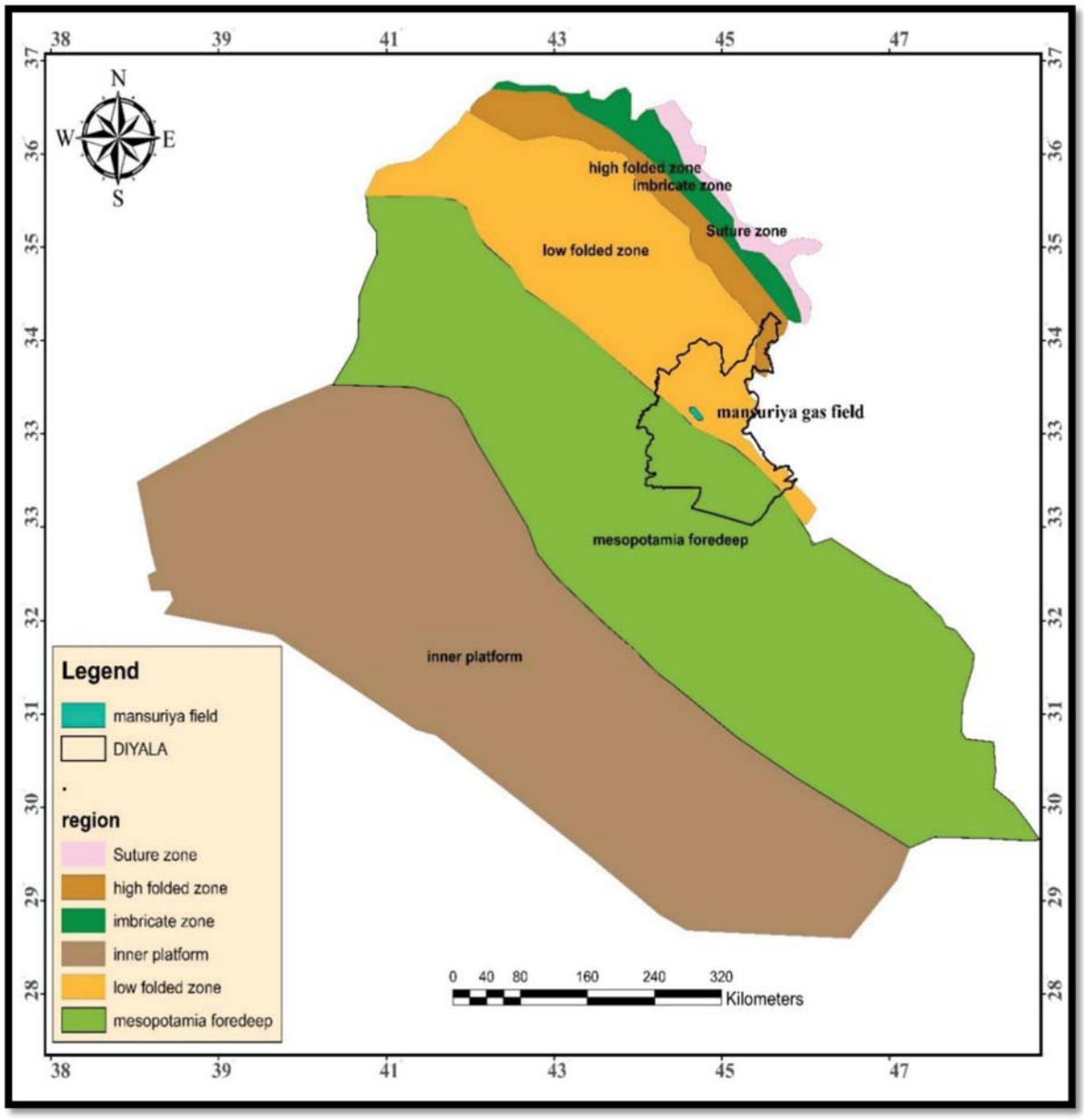


Figure (1-5): Tectonic divisions of Iraq with the location of the field. (after Fouad, 2012 b)

Fig :(1-6). The palaeogeographic and equivalent setting of the Jeribe Formation (modified from Goff *et al*., 1995).

1-7 Previous studies

- **Bellen *et al* (1959)** were the first to provide an adequate description of the Jeribe Carbonate Formation (Early Middle Miocene) in northwestern Iraq, near Sinjar fold in the town of Jadalah. They defined the formation, as seventy meters of dolomitic limestone sequence and crystalline calcareous.

- **INOC (1981)**, Iraq National Oil Company Preliminary sedimentary study of Jeribe Formation in Mansuriya well Mn-1 The primary objective of this research is to determine the nature of the sedimentary basin of the Jeribe Formation (1350-1415) m and to know the type and distribution of primary and secondary pores that arose as a result of post-sedimentation processes.

- **Al-Ayobi (2004)** studied the Jeribe Formation from northwest Iraq. Stratigraphically, he divided the formation into two informal rock units. The lower and upper contacts of the formation are interpreted as unconformities.

- **Al-Ayobi (2005)** studied the microfacies and the deposition pattern of Jeribe Formation (Early Middle Miocene) in northwest Iraq.

- **Moo, Mitsubishi and Inpex (2006)** conducted an integrated technical study for the Mansuriya Field, and the results of this study can be summarized as measuring the porosity and permeability of the formation and measuring the water saturation of the formation, determining the presence of anhydrite layers in the formation, and determining the reservoir units and non-reservoir units in the formation.

- **Al-Hamdani, Al-Khafaji, and Al-Ayobi (2010)** described variations and distribution of facies zones within the Jeribe basin in (The early Middle Miocene), Northwestern Iraq, The facies analysis showed that the facies of Jeribe Formation were deposited in the study area through five sedimentary stages. Each stage embodies a specific environmental scale facies. This

region, starting from the bottom, is: (The reef front, Reef, Back Reef, Tidal flats, lacustrian).

- **EL-Makhr, ABD (2011**) interpreted seismic data from the South Hemreen region of central Iraq to quantify the apparent anticline axis displacement between the Jeribe Formation and Fatha Formation.

- **Salam, Ibraheem, and Ali Gayara (2013)** showed that the Dhiban Formation is difficult to distinguish from the Ja-26 and Hr-41 wells in the Kirkuk region due to their similar facies. As a result, one group favors Euphrates, Dhiban, and Jeribe formations to be comparable in paleoenvironment depositional and facies studies.

- **Kharajiani (2014)** studied the presence of the Early and Middle Miocene rocks (Euphrates, Dhiban, and Jeribe formations) in Ashdagh Mountain, Sangaw area, Sulaimaniyah vicinity, NE Iraq.

- **TPOC (2014)** studied the reservoir modeling and simulation study of the Mansuriya gas field by Turkish petroleum overseas company, in May 2014 (unpublished).

- **Hussein, Collier, Lawrence, Rashid, Glover, Lorinczi, and Baban (2017**) carried out stratigraphic correlation and palaeo-environmental analysis of the hydrocarbon-bearing Early Miocene Euphrates and Jeribe formations in the Zagros Folded-Thrust belt. They defined three environments:
  - Shoal environment .
  - Restricted lagoon environment .
  - Inner and outer ramp belts environment.

Twelve microfacies were identified within these three settings based on the distribution of fauna, primarily benthonic foraminifera, rock textures, and sedimentary structures.

- **AL Atroshe, Yagmurlu, AL-Khatabi (2018)** The Middle Miocene Jeribe Formation in well Khabaz-17 of the Khabaz oil field in the Kirkuk region of northern Iraq is the subject of this current study. According to this, they seemed to be primarily composed of the benthonic foraminifera genera (Borelis Melo curdica, Miliolids, Peneroplis, Nummulites, and Rotalids), where they are distinguished by their excellent preservation, substantial volume, and thick wall.

- **Azeez, Al-Dabaj, Lazim (2020)** Petrel was used to create a 3D geological model for the Mansuriya Gas Field's Jeribe Formation, which was divided into 8 zones.

- **Salam, Al-Kubaisi, and Al-Shari'a (2020)** This study interpreted well logs to determine the petrophysical properties of the Jeribe Formation in the Jaria Pika Gas Field. Total porosity affects the porosity and secondary porosity was calculated from neutron, density, and sonic logs.

- **Mahdi, Al-Kubaisi and Al-Jawad (2022)** This study was concerned with describing the structure of the Khabaz field by analyzing the fault and folding systems of the Azkand and Jeribe formations.

Chapter Two
Methodology