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## Characterization of Structural Geology of Faihaa Oilfield, Southern Iraq

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### **Abstract**

Faihaa Oilfield is a new exploration Iraqi Oilfield located in southern Iraq and within Mesopotamian Plain, including the Block 9 exploration area, along the Iraqi-Iranian border. The study area included Faihaa Oilfield (in Iraq) and Yadavaran Oilfield (in Iran). They belong to one anticline (Dome) structure separated by the Iraqi-Iranian border, without a geological boundary between the fields. The current study aims to achieve structural geology analysis to the study area (Faihaa/Yadavaran structure). The structural analysis included geometric and genetic analyses of the study area. According to geometric and genetic analyses results, the Faihaa/Yadavaran structure is classified as an anticline, gentle, upright, non-plunge, and asymmetrical. According to thickness variation, there are two types of formations' folds are recognized, Thickened and Supratenuous fold generated by two folding mechanisms bending and buckle mechanisms. Bending form Supratenuous fold, perhaps due to the vertical uplift of salt structure and/or basement faults, while buckle produces Thickened fold because of the parallel tectonic movement causes collision between Arabian Plate and Eurasian Plate. Consequently, a special strain pattern was formed and the reservoir quality in the crest of Mishrif and Yamama Formations was the best. The fold axis of the Faihaa/Yadavaran structure has a Boomerang shape, whereas it is almost straight from south to the center of the structure, then tends to the NW with different deviations over the study area formations. This direction may be due to the anticlockwise rotation of the Arabian Plate motion. The results of geometric and genetic analyses revealed that may be Faihaa/Yadavaran structure is one structural trap formed by tectonic activities; Hormuz salt structures, reactivated Basement faults, and Collision between Arabian and Eurasian Plates. The intensity of the tectonic activities of the study area maybe be less than surrounding Oilfields, therefore, the Faihaa Oilfield formation's depth was deeper than adjacent Oilfields.

**Keywords:** Faihaa Oilfield, Yadavaran Oilfield, Structural Geology study, southern Iraq, Mesopotamian Plain.

## دراسة الجيولوجيا التركيبية لحقل فيحاء النفطي، جنوبي العراق

### الخلاصة:

يعتبر حقل فيحاء النفطي احد الحقول النفطية الأستكشافية الجديدة والذي يقع جنوبي العراق ضمن السهل الرسوبي (سهل وادي الرافدين)، الذي يشمل الرقعة الأستكشافية (9)، وعلى طول الحدود العراقية – الأيرانية. تضمنت منطقة الدراسة حقل فيحاء النفطي (في العراق) وحقل يادفران النفطي (في إيران). ينتمي الحقلان الى تركيب تحديبي (قبة) واحد، يفصل بينهما الحدود العراقية - الأيرانية وبدون أي فواصل جيولوجية. تهدف الدراسة الحالية الى انجاز تحليل تركيبتي لمنطقة الدراسة (تركيب فيحاء / يادفران). تضمن التحليل التركيبية كل من التحليل الهندسي والتحليل المنشأ لمنطقة الدراسة. صُنفت منطقة الدراسة حسب نتائج التحليلين الى تركيب تحديبي، لطيف، قائم، غير غاطس، وغير متناظر. تم تميز نوعين من الطيات لتكاوين منطقة الدراسة وذلك بالأعتماد على اختلاف السماكة بين الهامة (القمة) والأجنحة وهما طية السماكة وطية المترققة والتي تكونت بفعل ميكانيكي الطي وهما الثني والأحناء. شكلت ميكانيكة الثني الطيات المترققة بفعل القوة العمودية التي ربما نتجت من تأثير التراكيب الملحية و/أو فوالق صخور القاعدة، بينما ميكانيكة الأحناء كونت طيات السماكة وربما تكون نتيجة الحركة التكتونية التي ادت الى حدوث تصادم جانبي للصفحة العربية واليوراسية. وتكون كنتيجة لهذه الميكانيكيات نمط تشوهي خاص والذي بدوره جعل الخصائص الممكنية في منطقة الهامة (القمة) افضل من الجناحين لتكويني المشرف واليمامة. يمتلك محور طية لمنطقة الدراسة شكل منحني (بوميرانج او العصى المرتدة)، بحيث تقريبا هو مستقيم من الجنوب الى المركز التركيب وبعدها ينحني باتجاه شمال – غرب مع درجات مختلفة للأحناء لكل تكوين. قد يكون هذا الاتجاه نتيجة لدوران الطبقة العربي باتجاه عكس عقارب الساعة. كشفت نتائج التحليلين الهندسي والمنشأ بأن منطقة الدراسة هي عبارة عن طية تركيبية ربما تكونت نتيجة النشاط التكتوني لتراكيب املاح هرمز وإعادة تنشيط فوالق القاعدة، و التصادم بين الطبقتين العربي واليوراسي. ربما تكون شدة الأنشطة التكتونية على منطقة الدراسة اقل منها على الحقول النفطية المجاورة في العراق، وذلك ما نلاحظه من كون أعماق التكاوين اكثر من الحقول المجاورة.

### **1. Introduction**

Most previous studies focused on petroleum and petrophysical properties of the Yamama Formation of Faihaa Oilfield, for example [1], [2]. Therefore, the current study based on the structural geology analysis integrated with available petrophysical analysis results to determine the structural picture of the study area in the Faihaa Oilfield. The study area lies in south Iraq, within the Block 9 exploration area, along the Iraqi-Iranian border [1]. According to [3] Faihaa Oilfield occupied the western–central part of the studied oilfield, while Yadavaran Oilfield (in Iran) the eastern-central part, and it separated by the official Iraqi-Iranian border and its main reservoirs were Yamama and Mishrif Formations (Cretaceous Period). Therefore, the current study will achieve structural analysis for both fields (Faihaa and Yadavaran) as one subsurface anticline structure and the structural analysis results will be for both fields. The structural analysis included geometrical and genetic analyses. The geometrical analysis is interested in the geometric properties, and genetic analysis employed the results of the geometric analysis with geophysics interpretations to determine the causes, type, and origin of the study area. The

current study will utilize the available petrophysical properties of the study area's reservoirs to find if there is a connection between the petrophysical properties and the structural picture of the study area.

## **2. Geologic Setting**

Geologically, Iraq located within the NE margin of the Arabian plate, close to the suture zone of the Arabian -Eurasian plates collision [4]. According to the tectonic divisions of Iraq, the study area is located in Mesopotamian Plain (or zone) [5]–[8]. The Mesopotamian Plain is part of Mesopotamia Foredeep, which represents intern the terrestrial remnant of the Zagros Foreland Basin and it forms the central and the southern parts of Iraq. It contains several subsurface structures including faults, folds, and diapiric structures that are covered by Quaternary sediments, see Figure (1) [6]. The Mesopotamian Plain has been considered an unstable part of the Arabian Plate and the reasons for instability are basement faults, salt structures, and Alpine Orogenic Movements [9], [10] and these reasons form anticline subsurface structures in southern Iraq [9], [11]. The study area is located in Zubair Subzone, which is bounded by basement faults which are the Takhaded-Qurna Transversal fault from the north and Basra-Zubair fault from the south [12] as shown in Figure (2A). The study area is surrounded by other Oilfields (from north-west Azdagan and Majnoon Oilfields, from south-west Nahr Umr Oilfield, and south from Sindibad Oilfield), as shown in Figure (2B). The negative gravity of the Zubair Subzone structures may be due to the presence of deep-seated Infracambrian Hormuz salt rocks [11]–[14] while positive residuals attributed to basement uplift [13]. The study area included 17 geological formations within the Cretaceous, Paleogene, and Neogene, as shown in Table (1).

## **3. Materials and Methods:**

The current study used a geological model drilling data (Static Model 2019) of the Faihaa Oilfield to construct depth, thickness, dip contour maps (with scale 1:200,000), and a rose diagram of stress distribution via Petrel v2018.2 software. Depending on the available and reliable data the current study mapped the depth, thickness, and dip, contour maps for 17 geological formations as shown in the appendix. Stereonet software (v.11 ) was used for stereographic projection to determine the structural geological attitudes (interlimb angle, hinge line, and axial surface). The dip and dip direction (clockwise) are calculated from the depth

contour maps and thickness variation from drilling data of available formation data. The available image log interpretation of well Faihaa-1 (FH-1) was used to determine the stress distribution of Yamama and Mishrif Formations. The available porosity data from Faihaa static model utilized to constructed porosity contour maps for Mishrif and Yamama reservoirs to find if there is a relation between the structural picture and porosity of the study area.

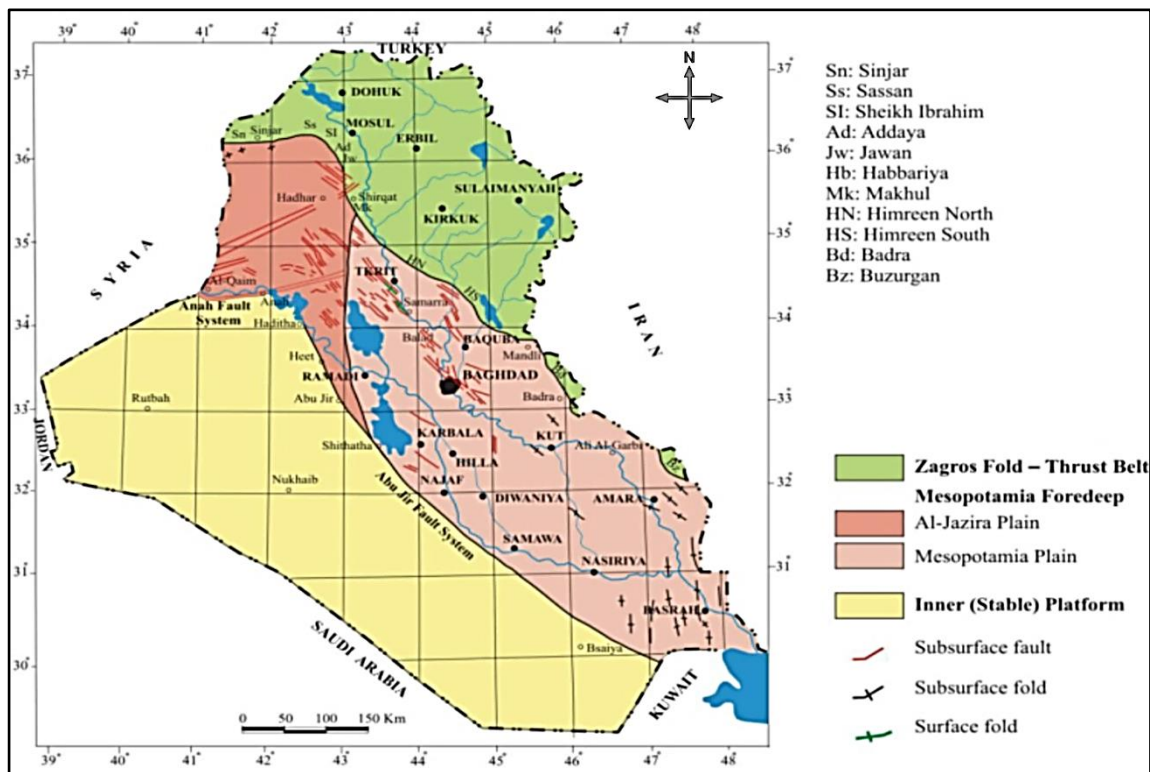


Fig. (1): Geological division of Iraq included the Mesopotamian Plain [6].

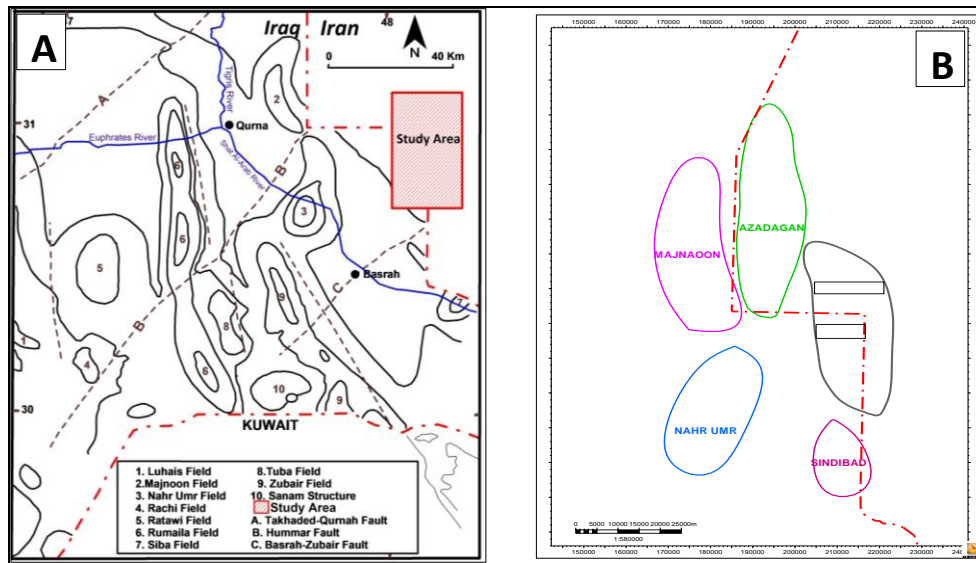
Table (1) Geological Column of Faihaa Oilfield, form Faihaa-1 (FH-1).

Geological Age				Formation	Tops (subsea)	
Era	Sub-era, Period Sub-Period	Epoch and/or Stage				
CENOZOIC	NEOGENE	Early-Middle Miocene	Langhian	Lower Fars	963	
			Burdigalian Aquitanian	Ghar	1377	
	PALEOGENE	Middle-Late Eocene	Priabonian Bartonian	Pabdeh/Jaddala	1593	
			Lutetian	Dammam	1676	
	Early Eocene/ Palaeocene	Ypresian Thanetian Danian	Umm Er Radhuma	1901		
MESOZOIC	CRETACEOUS	Upper Cretaceous	Maastrichtian - Late Campanian	Shiranish	2115	
				Hartha	2330	
		Middle Cretaceous	Early Campanian - Middle Turonian		Sadi	2605
					Tanuma	2684
			Early Turonian - Latest Albian		Mishrif	2699
					Ahmadi	3321
			Late Albian - Latest Aptian		Mauddud	3172
					Nahr Umr	3359
		Lower Cretaceous	Late Aptian - Late Valanginian		Shuaiba	3534
					Zubair	3715
	Early Valanginian - Berriasian		Ratawi	3909		
			Yamama	4011		

#### 4. Structural Geology Analysis:

##### 4.1. Geometric Analysis:

The main role of geometric analysis is to determine the physical properties and classify the fold to use it in genetic analysis with available geophysical interpretations of the study area and surrounding structures to find the forming causes of the study area. Depth and dip contour maps of the Study area formations were used to obtain the Stereographic Projection results as shown in Table (2) to employ it in a fold classification.



**Fig. (2): (A); The location of the study area concerning the surrounding major structures at the depth (4000m), southern Iraq with some of the basement faults in the Mesopotamian zone, after [15]. (B); the location of the Study area concerning the closed surrounding major structures in Iraq and Iran.**

There are several classifications of the folds and each one uses specific geometric parameters of the fold. The current study will use the main geometric description principles of a fold to determine the structural picture of the study area (Faihaa/Yadavaran Structure). [16] summarized the fold classifications to (a) Fold facing, (b) Fold orientation (an attitude of axial Plane, plunge of the hinge line (fold Axis), and symmetry of fold), and (c) Fold-shape in profile plane (interlimb angle and variation in thickness). Table (3) outlined the results of these classifications of the study area.

The thickness variation of a fold considers a very significant parameter to classify the fold of the study area. There are four types of folds based on their thickness variation. These are *S-Fold (Supratenuous Fold)*, when the thickness of hinge is less than limbs, *T-Fold (Thickened Fold)*, when the thickness of hinge is more than limb, *P-Fold (Parallel Fold)* when the thickness is same from hinge to limb, *F-Fold (Flow Fold)* when thickness variation has no certain distribution as previous types [17]. The thickness difference between hinge zone (or crest) and limbs of study area formations fluctuated from thinning crest to thickening crest, as shown in Table (3), and this led to configuring the folding mechanisms responsible for the form of the study area. According to [16], [18], [19] these folding mechanisms are bending, (thinning

hinge zone versus thickening limbs) and buckling (thickening hinge zone versus thinning limbs), as illustrated in Figure (3).

Bending happens when the layer acts to a force across it while buckling the force will be parallel to layers [19]. Arching and thinning of the layers originated by extensional tectonic are common features associated with folding form by bending mechanism, unlike buckle mechanism where the thickening and shorting of the layers [18]. The relationship between fold mechanism and tectonic events of the study area will be explained in the genetic analysis to clarify its implications to form situated case from fold within the studied area, and its influence on reservoir properties.

**Table (2) Stereographic Projection results of the study area.**

Formation	Dip/Dip Direction of Limbs (°)				Interlimb Angle (°)	Plunge/ Direction of Hing Line (Fold Axis) (°)		Axial Plane(°)	
	Center – South Part		North part			North Part	Center – South part	North Part	Center – South part
	NW	SE	NW	SE					
Lower Fars	2.5/357	2.5/173	2.5/300	2.5/120	175	0.5/120		90/120	
Ghar	2/357	2/173	2/300	2/120	176				
Pabdeh/Jaddala	2.5/357	2.5/173	2.5/315	2.5/135	175	0.5/135	0.5/173	90/135	90/173
Dammam	5/357	5/173	5/315	5/135	170				
Umm Er Radhuma	5.5/357	4.5/173	5.5/315	4.5/135	170				
Shiranish	3.5/357	2.5/173	3.5/315	2.5/135	174				
Hartha	2.5/357	2.5/173	2.5/315	2.5/135	175				
Sadi	2.5/357	3/173	2.5/315	3/135	174.5				
Tanuma	2.5/357	2.5/173	2.5/315	2.5/135	175				
Mishrif	2.5/357	2.5/173	2.5/315	2.5/135	175				
Ahmadi	3/357	3/173	3/315	3/135	174				
Mauddud	3/357	3.5/173	3/315	3.5/135	173.5				
Nahr Umr	3.5/357	3.5/173	3.5/315	3.5/135	173	0.5/150		90/135	
Shuaiba	3.5/357	4/173	3.5/315	4/135	172.5				
Zubair	3.5/357	4/173	3.5/330	4/150	173				
Ratawi	3.5/357	4/173	3.5/330	4/150	172.5				
Yamama	4/357	4/173	4/330	4/150	172				

Table (3) Geometric Analysis Results of Study Area.

Formation	Fold-shape in Profile Plane		Fold Facing	Fold Orientation		
	Thickness variation	Interlimb Angle		Axial surface	Plunge	Symmetry
Lower Fars	S-Fold (Supratenuous Fold)	Gentle	Anticline	Upright Fold	Non-Plunge	Asymmetrical
Ghar						
Pabdeh/Jaddala						
Dammam						
Umm Er Radhuma	T-Fold (Thickened Fold)					
Shiranish						
Hartha						
Sadi	S-Fold (Supratenuous Fold)					
Tanuma						
Mishrif						
Ahmadi						
Mauddud						
Nahr Umr						
Shuaiba						
Zubair						
Ratawi						
Yamama		T-Fold (Thickened Fold)				

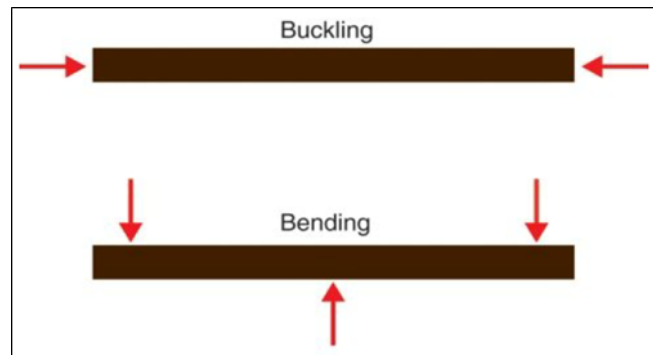
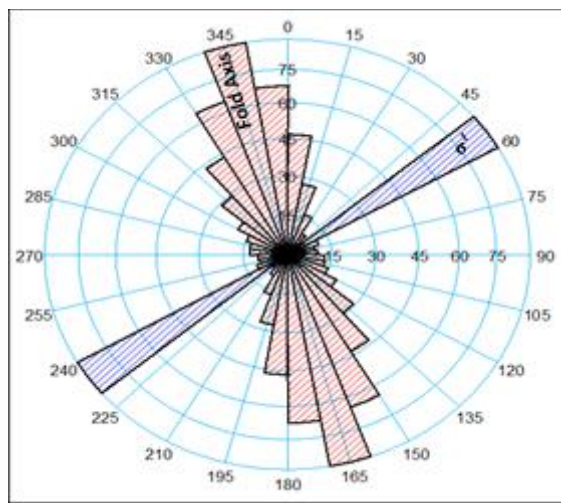


Fig. (3): The relationship between fold mechanism and applied force direction, after [19].



The fold axis of the study area has a Boomerang shape. It's almost straight from south to the center of the structure, then tends to the NW with different deviations over the study area formations. The image log and Sonic Scanner interpretations of Faihaa-1 well (FH-1) show the direction of maximum stress ( $\sigma^1$ ) direction is NE-SW, while minimum stress ( $\sigma^3$ ) direction is NW-SE of Mishrif Formation [20]. The  $\sigma^1$  and fold axis directions are plotted as the rose diagram for Mishrif Formation and this exposed that the  $\sigma^1$  is not perpendicular to the fold axis (as supposed to be), as shown in Figure (4).

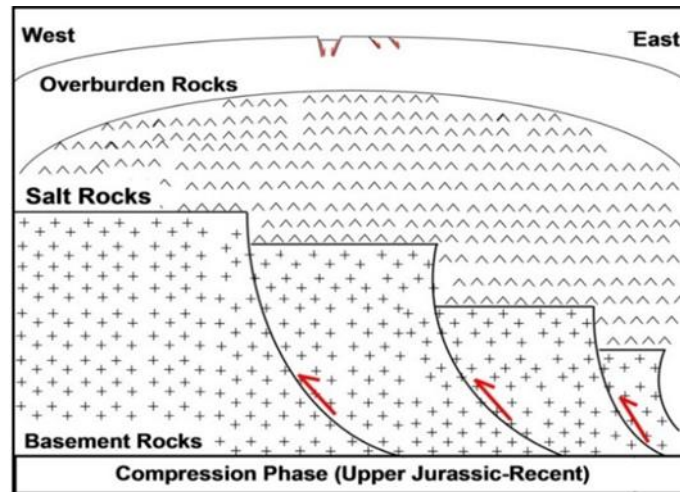


**Fig. (4): Rose diagram of Fold axis (red dashed) and  $\sigma^1$  (blue dashed) of Mishrif Formation plotted based on image log and Sonic Scanner interpretations and it shows that  $\sigma^1$  is not perpendicular on the fold axis.**

#### 4.2. Genetic Analysis:

The geometric analysis results referred to that the study area may be affected by tectonic activities. Three combined main forces worked together to form subsurface anticline structures in southern Iraq, these are tectonic Movements (collision between Arabian and Eurasian Plates), reactivated basement faults, and Hormuz salt structures [7], [9], [11], [13], [14] as shown in the tectonic model in Figure (5). Negative and positive gravity indicated in geophysical survey interpretations in southern Iraq. Negative gravity could be a result of deep-seated salt beds of Infra-Cambrian salt beds, while the positive residual referred to basement uplift [11], [13], [14]. [15] Summarize the tectonic history of the Mesopotamian plain (included study area) into two phases; the Opening phase (Permian-Jurassic) and Closed phase (Upper Jurassic 'L. Tithonian' – Recent), which is the interesting phase for the current study. The closing phase involved compressional stress and reactivated for listric basement fault. The interesting geological

periods for the current study are the Cretaceous period, Paleogene (Paleocene and Eocene epochs), and Neogene (Miocene). The current study summarizes the tectonic events and history according to [21] and compares it with the results of the geometric analysis to find the causes behind of the actual structural picture of the study area, as shown in Table (4).



**Fig. (5): Tectonic model for Oilfields in southern Iraq for Cretaceous Period, after [22].**

The geometric analysis results of study area formations are similar, except the thickness variation parameter and based on the difference of thickness between the crest and limbs for each formation show the majority of two folding mechanisms; bend (S- Fold) and buckle (T- Fold). The bending mechanism acts due to vertical force, which may be related to the salt activity of deep-seated Hormuz salt as referred to by gravity negative anomalies associated with Zubair subzone and surrounding Oilfields to Faihaa\Yadavaran structure. The buckle mechanism acts because of parallel force, which is probably related to the collision between Arabian Plate and Eurasian Plate (specifically the Iranian Plate).

**Table (4) The tectonic events and history comparison with results of geometric analysis of study area.**

Geological Time		Tectonic Events	Formations	Folding Mechanism
NEOGENE	Early-Middle Miocene	Reactivation of normal faults due to compressional stress during the Palaeocene. The inversion transmitted southward through the Eocene. Burdigalian (Miocene Period) stage included intense uplift of entire Zagros Margin. Deposition of Lower Fars Formation suggests a dominant tectonic effect on deposition and it represents the final convergence stage between continents in the middle Miocene.	Lower Fars	Bending Mechanism
			Ghar	
			Pabdeh/Jaddala	
PALEOGENE	Middle-Late Eocene	Initially, the pattern of Paleogene facies of Iraq reflects the effects of regional end cretaceous inversion.	Dammam	Buckle Mechanism
	Early Eocene/ Palaeocene		Umm Er Radhuma	
Cretaceous	Maastrichtian –Late Campanian	It characterized by alteration in plate motion direction from north to the northeast with anticlockwise rotation with N15°E, tilted fault blocks and horst developed, the orientation of major extensional fault was perpendicular or oblique to the axis of regional compression, and obduction of ophiolites onto Arabian plate began and then ceased at the end of the early Maastrichtian with the return to the motion direction toward the north, thus the closing of southern Neo-Tethys finalized.	Shiranish	Buckle Mechanism
			Hartha	
	Early Campanian late Turonian	It is considered the most important period in terms of tectonic activity because it included the growth of large-scale subsurface anticline structures in the Basra area with N-S trending and inversion for basement fault.	Sadi	Bending Mechanism
Tanuma				
Early	Involved subtle structure	Mishrif		

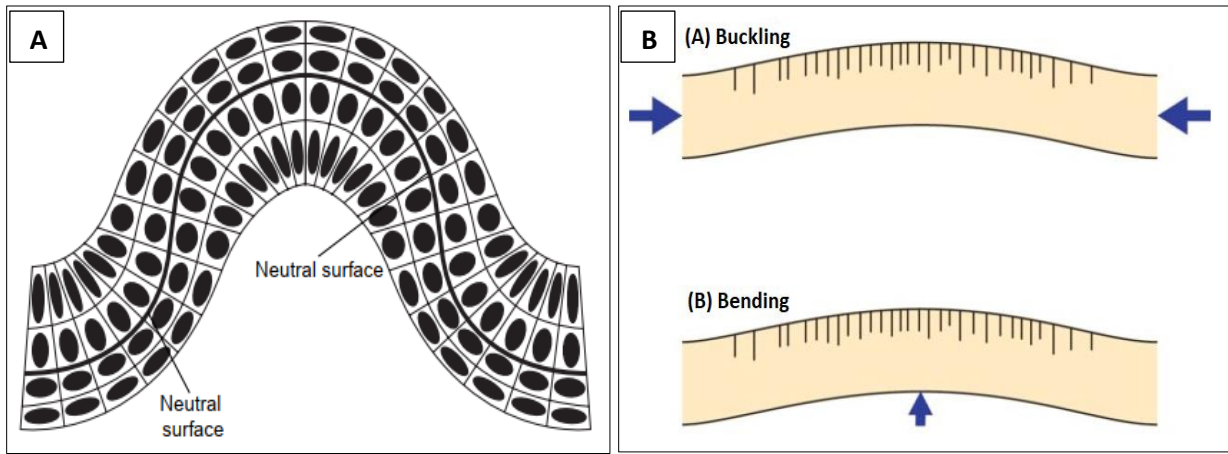
	Turonian – Early Cretaceous	growth controlled by the movement of basement faults till late Albian. Interaction between tectonic processes on the NE plate margin and successive plate-interior epeirogenic phases resulted in stratigraphic breaks of varying amplitude and effect.	Ahmadi	
			Mauddud	
			Nahr Umr	
			Shuaiba	
			Zubair	
			Ratawi	
	Early Cretaceous	Transmission (inheriting) geological setting from Upper Jurassic to Early Cretaceous.	Yamama	Buckle Mechanism

There is no interpretation for gravity and magnetic geophysical data of the study area, but depending on the results of adjacent Oilfields and structures within the Zubair subzone (like Nahr Umr and Zubair Oilfields) the salt structures of Hormuz salt and basement faults has been indicated [11], [13], [14]. These geophysical results are linked with the oilfields’ structural pictures and folding mechanisms (bending and buckle) [23]–[25]. Therefore, the bending mechanism could be attributed to the influence of salt structure-activity of Hormuz salt and/or reactivated basement faults as vertical force, while buckling mechanism to the collision between Arabian Plate and Eurasian Plate as a parallel force. The depth of study area formations is deeper than adjacent oilfields formations, this may be due to the intensity of tectonic activities affected on the study area is less than other oilfields within Zubair Sub Zone. This could be confirmed by the occurrence of normal faults on the Nahr Umr field [22], while there is no fault on the study area and simplicity of its structural picture as confirmed by 3D seismic interpretation [26]. The fold axis of the study area trends to NW-SE and this direction may be attributed to counterclockwise rotation of the Arabian plate and this direction is similar to surrounding fold axes of Oilfields of southern Iraq, such as Nahr Umr Filed [22], Zubair Oilfield [23]–[25] West Qurna Oilfield [27]. The fold axis of the study area has almost 3° from center to south, and for north part approximately ≈ 30° for Lower Cretaceous, ≈ 45° from Lower Cretaceous to Miocene, and ≈ 60° for early and middle Miocene. This difference may be primarily related to the direction of counterclockwise rotation of the Arabian Plate through the tectonic history, in addition to the intensity of tectonic activities. Generally, the values of dip, thickness, and depth show homogeneity between Faihaa and Yadavaran Oilfields. This maybe

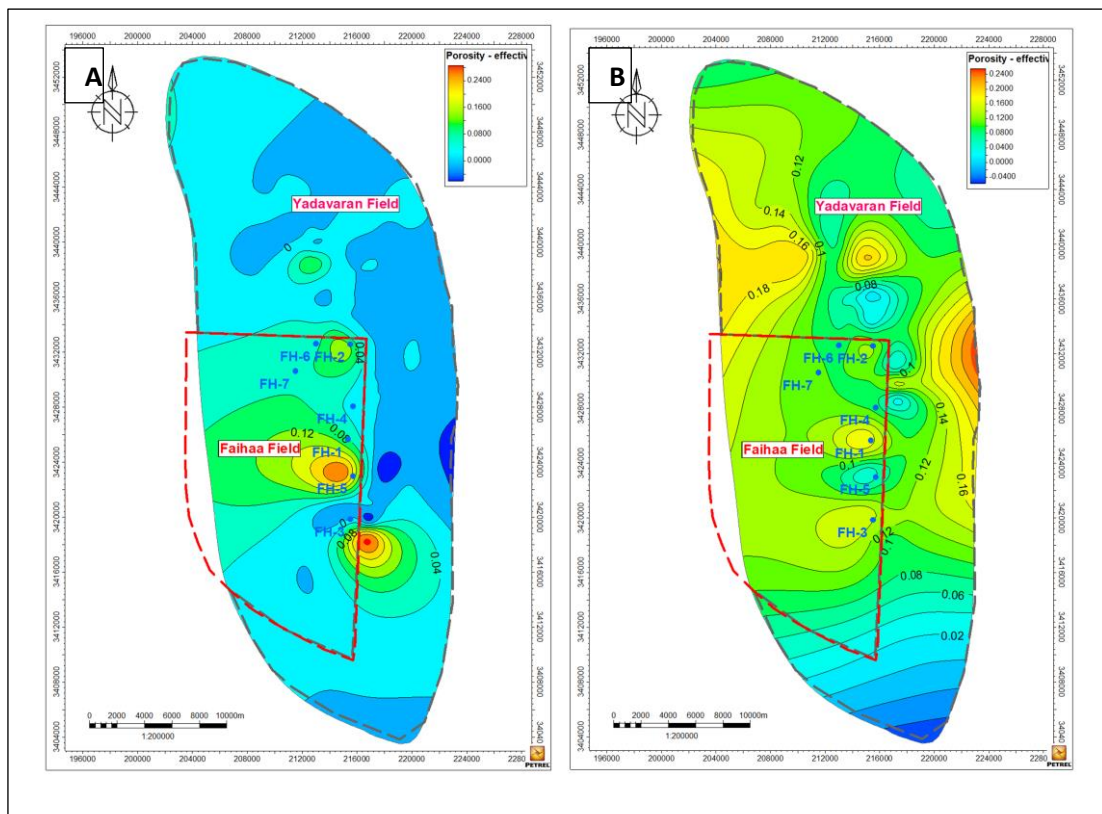
confirm that they are one field or structure, belonging to the same subsurface anticline formed with the same structural events and history.

## **5. Results and Discussion:**

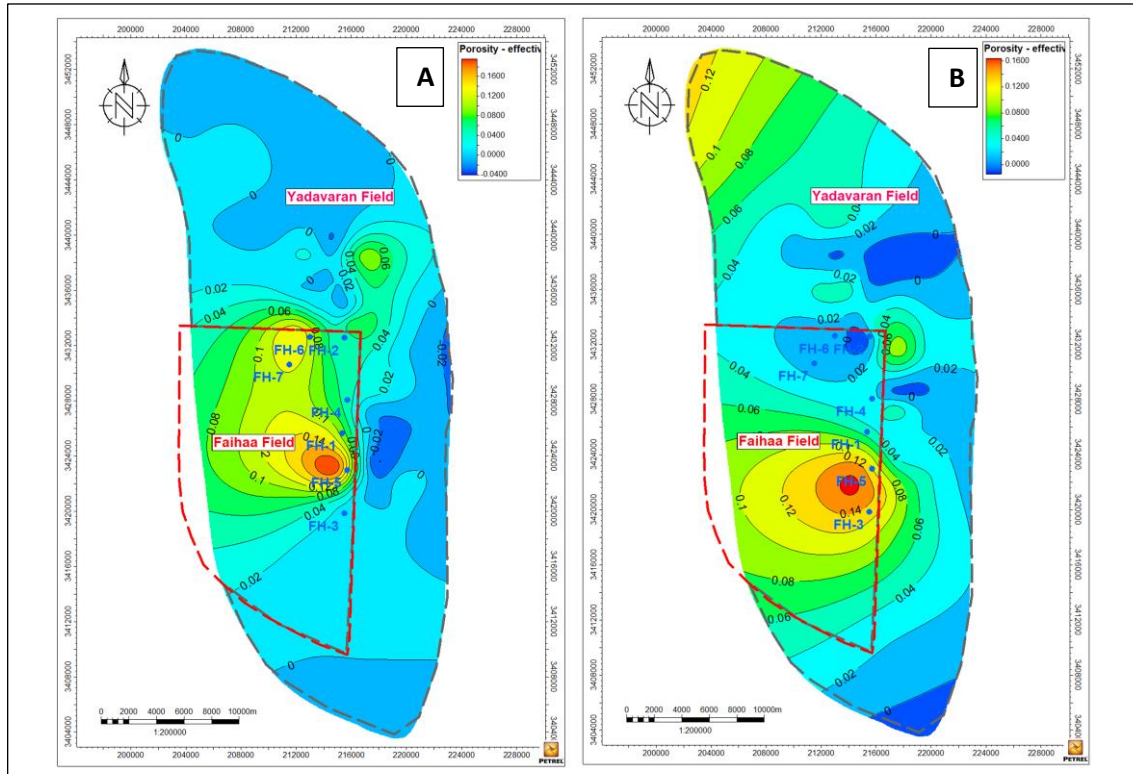
Integration between geometric and genetic analysis results referred to that the study area may be controlled by tectonic activities. These results confirmed that the study area formed by same geological conditions of surrounding oilfields [22]–[25], [27], but with less intensity. The tectonic history of the study area passed through geological periods; Cretaceous, Paleogene, and Neogene Periods, and these have significant events, as shown in (Table 3). Each one could be triggered a particular folding mechanism with direct influence on the structural picture of the study area. These activities varied between the vertical force, which could be related to the salt structure of Hormuz salt and/or reactivated basement faults and parallel force may be due to compressional force of the collision between the Arabian plate and Eurasian Plate, and these are common geological causes responsible about the structural picture of southern Iraq oil fields [9], [11], [13], [14]. These forces are probably represented by two mechanisms, bending (vertical force) and buckling mechanism (horizontal force of compressional stress). Based on [18], [28], [29] these mechanisms have considerable strain patterns on folds layers. Whereas the outer arc has an extension feature while those in the inner arc are compressed, with no strain neutral surface separating regions of extension from regions of contraction as shown in Figure (6A). The outer arc of the fold regularly forms extensional fractures like faults, joints, and veins [28], as shown in Figure (6B). These fractures play important role in oil migration, and the extensional fracture dies out down to the neutral surface with maybe separate to systems of pressure, one belongs to extension part and the other to compressed part [30]. As consequence, the reservoir properties in terms of porosity, permeability, and oil saturation of Mishrif and Yammama Formations show good quality in the crest area better than flank area as mapped in Figure (7 A&B) and Figure (8 A&B). This may be related to the influence of the folding mechanism. The homogeneity of depth, thickness, and dip of study area formation may be indicated that the Faihaa and Yadavaran structure belong to an anticline structure separated by Iraq and Iranian borders but there is no geological boundary between the fields.



**Fig. (6): (A) The strain distribution of Buckle and bending mechanisms with the neutral surface [29], and (B) Fractures (faults, joints, and veins) features associated with the extension of outer arc, after [19].**



**Fig. (7): Porosity contour maps of Mishrif Formation; (A) top Mishrif (below the caprock) the better quality in the crest, (B) Lower Mishrif less than crest.**



**Fig. (8): Porosity contour maps of Yamama Formation; (A) top Yamama show the better quality in the crest, (B) Lower Yamama less than crest.**

## 6. Conclusions:

- 1- Faihaa and Yadavaran Oilfields may be considered as one anticline structure (Faihaa/Yadavaran structure) without a geological boundary separate between the fields.
- 2- Faihaa Oilfield is classified as a structural trap.
- 3- Faihaa Oilfield is an anticline, upright, non-plunge, asymmetrical (the length of the western limb is slightly longer than the eastern limb), and gentle fold. While, regarding thickness parameter, there are two types of folds Thickened fold (Yamama, Hartha, Shiranish, and Umm Er Radhuma) and Supratenuous fold (Ratawi, Zubair, Shuaiba, Nahr Umr, Mauddud, Ahmadi, Mishrif, Tanuma, Sadi, Dammam, Pabdeh/Jaddala, Ghar, and Lower Fars).
- 4- The thickness variation between the crest and limb of study area formations is fluctuated between thickening and thinning from crest (hinge area) to limb. This may be attributed to the role of folding mechanisms, *bending folding mechanism* of vertical stress, which may be due to uplift of Hormuz salt and/or basement faults force, while *buckle folding*

*mechanism* may be related to parallel stress of collision between Arabian Plate and Eurasian Plate.

- 5- The bending and buckle folding mechanisms have significant strain patterns: outer arc with extensional feature and inner arc with contraction feature, with no strain surface called neutral surface. This strain pattern maybe has a direct influence on reservoir quality especially the porosity and permeability. Therefore, the reservoir quality in the crest of Mishrif and Yamama Formations was better than the reservoir quality of the limbs.
- 6- The fold axis of the study area has a Boomerang shape. It's almost straight from south to the center of the structure, then tends to the NW with different deviations over the study area formations. This direction may be attributed to counterclockwise rotation of the Arabian plate motion and this direction is similar to surrounding fold axes fields of southern Iraq. This direction from the center to the southern part of study area formations was almost fixed with  $\approx 3^\circ$  and the intensity of the northern part direction continue increasing through the geological history ( $\approx 30^\circ$  for Yamama, Ratawi, Zubair, and  $\approx 45^\circ$  for Shuaiba, Nahr Umr, Mauddud, Ahmadi, Mishrif, Tanuma, Sadi, Hartha, Shiranish, Umm Er Radhuma, Dammam, Pabdeh/Jaddala, and  $\approx 60^\circ$  for Ghar and Lower Fars). This may be attributed to the influence of the tectonic history of the closing of Neo- Tethys and changing of the Arabian Plate and Eurasian Plate.
- 7- The results of geometric and genetic analyses revealed that the Faihaa Oilfield (or Faihaa/Yadavran structure) may be controlled by tectonic activities (tectonic movements of the collision between Arabian Plate and the Eurasian plate, reactivated basement faults, and possibly Hormuz salt) and they worked together to form the Faihaa Oilfield.



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