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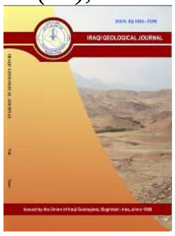

Structural Study of Judaida Subsurface Structure, North of Iraq

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Abstract

This research focuses on the structural study of three folded horizons of Fat'ha, Jeribe, and the Euphrates in Judaida structure, Northern Iraq. Depth contour maps for three horizons using the time and velocity data called from seismic surveys. Seismic interpretation suggests that Judaida structure is a positively inverted structure. It is an anticline on the level of Tertiary and the top and an extensional structure on the level of pre-Tertiary sequence. Judaida structure is an asymmetrical longitudinal anticline; its Northeastern limb is steeper than its Southwestern limb. The axis of the anticline and the major normal faults are both trending toward the Northwest. The normal fault picked influencing only the pre-Late Cretaceous sequence where is the folding affected the whole sequence; of the extension forces, it affected the region during that period. Late Pliocene compressions resulted in folding and reverse faulting of the whole sequence and inversion of movement along the pre-existing normal faults. The resulted faults are called inverted faults.

Keywords: 2D seismic reflection data; Structural interpretations; Judaida structure area

1. Introduction

This study deals with interpretation of 2D seismic data with well information to evaluate the structural geology of the Judaida subsurface structure. The structural maps showed that the Judaida structure is an asymmetrical longitudinal fold, characterized by structural trend and facies changes that are parallel to Zagros, Taurus belts (NW – SE) (Jassim and Goff, 2006). The study area is located within unstable shelf, at Low Folded Zone (LFZ), within Hamrin belt between the Mesopotamia Fore deep from the SW, and the High Folded Zone (HFZ) from the NE. The fold generally flattens toward the Mesopotamian basin, where a relatively narrow anticline is separated by a wide syncline (Aqrawi et al., 2010). Economically, The Jeribe Formation is a main reservoir in the region, according to the results of Jd-1 well testing. The geometry of folds gives an indicator about the degree and orientation of strain, which in turn provides critical information about the deformation history of a region (Van Der Pluijm and Marshak, 2004). This study is considered one of many studies that employed the interpretation of 2D seismic data with wells data to evaluate the subsurface structural geology in different countries (Ahmad, 2018). In Iraq (Almayahi, 2004), (Al-Ridha and Al-Khafaji, 2019) and (Abdullah et al., 2021). In Egypt (Zahra, 2016), In Pakistan (Khan, 2019).

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2. Location of the Study Area

The location of the study area of interest is within the administrative borders of Kirkuk district, northern Iraq. Its located 60 Km southwestern Kirkuk Field and 35 Km southwestern Jambor Field. The Judaida structure is bordering from the south by Hamrin Field; the Daquq River passes over the study area (Fig.1).

Fig.1. Location map of the study area (modified after United Nations, 2014)

3. Tectonic of Study Area

Tectonically, the study area is situated in the northern part of the Arabian Plate within LFZ. The tectonic map of Iraq shows that the study area lies between two fault systems (Jassim and Goff, 2006), (Fig. 2).

- Longitudinal Fault System: The area lies between two ranges of longitudinal fault systems
  Kirkuk Fault
  Hamrin- Makhol Fault
- Transversal Fault system: The area lies between two ranges of transversal fault system
  Anah-Qalat Dizeh Fault.
  Amij-Samarra Fault.

4. Materials and Methods

4. 1. Structural Interpretation of the Data

The presence of faults in the area can be recognized according to the principle of faulting on reflection sections by discontinuities in reflection falling along with essentially linear pattern misclosures in tying reflection around loops (Dobrin, 1976). The study area affected by the main normal fault extends from the early Triassic to late Cretaceous; these faults result from extension forces that affected the area during the Cretaceous age. The fault axis direction to the Northwest-Southeast. The interpreted seismic section (Fig. 3) is divided the section into three zones:

- Zone (A) (pre-Late Campanian-Maestrichtian age).
- Zone (B) (Late-Campanian-Mestrichtian age).
- zone(C) (post Maestrichtian age).

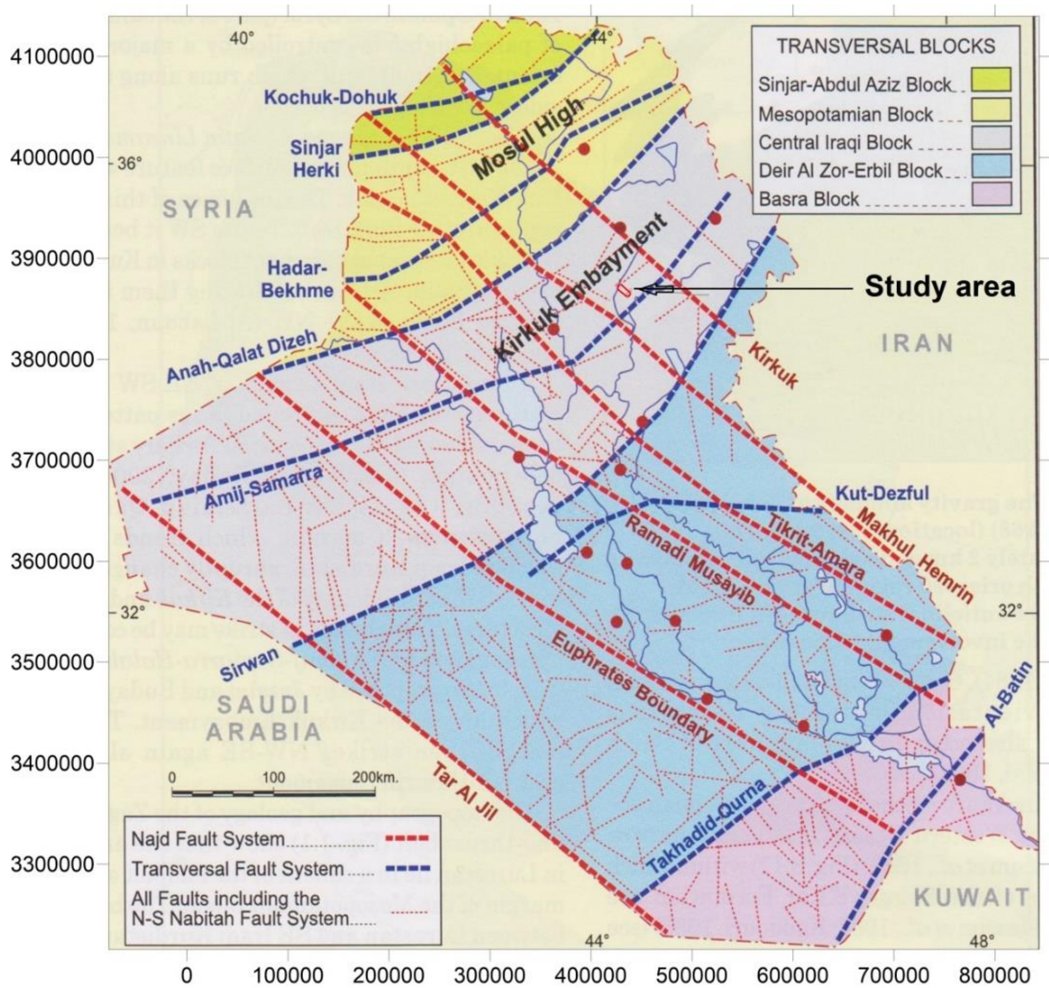

Fig. 2. Tectonic map of Iraq showing the regional fault system in the study area. (Jassim and Goff, 2006)

Its Shows zone A and zone C maintain approximately the same thicknesses; this is reflected by the approximate parallelism between the detailed reflectors within each zone. Zone C is folded, whereas zone A is folded and faulted. The same faulting is also influenced zone; B Shiranish Zone, inducing pronounced thickness variation across the major faults. The zone B is faulted and folded and suffered from fault-controlled eastward thickening. According to, this zone is considered as a synrift sequence and zone A is considered as a pre-rift sequence, whereas the upper zone C is considered as post-rift sequence. Marouf and Al Kubaisi, (2005) discussed in details similar cases from the surrounding foot Hills Subzone of Zagros simply folded belt in Northern Iraq.

The same figure shows that the Judaida structure was developed as a rift structure during the Late Campanian-Maestrichtian period. The normal faults displaced the pre-rift (Pre-late Campanian) sequence. The continuous movements along during the pre-Campanian-Mestrichtian period interval induced the thickness variations in the syn-rift Shiranish sequence. The relative tectonic quiescence in the post Maestrichtian time resulted into continuous relatively constant thickness deposition of Tertiary post-rift sequence. Later Pliocene (syn- Bakhtiary) compressions resulted into folding and reverse faulting of all sequence and inversion of movement along some of the pre-existing normal faults. The resulted faults are called inverted faults, and they are presented by two opposite (arrows) directions of displacements.

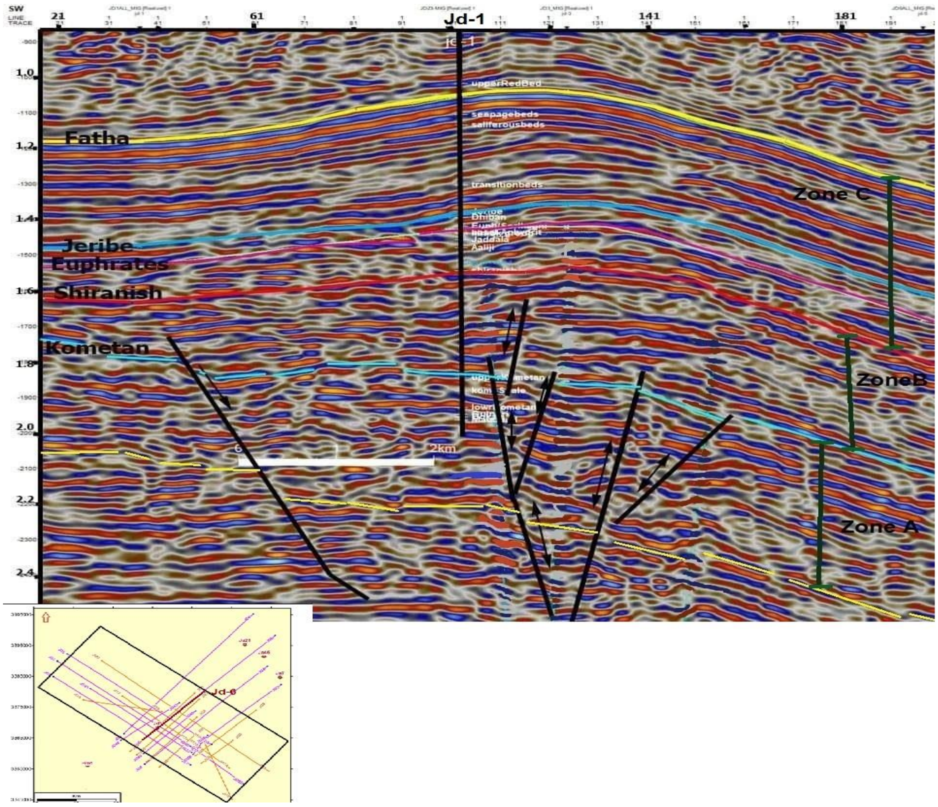

Fig. 3. Seismic sections show inverted faults and the development of Judaida structure during Cretaceous and Tertiary periods in the area

4.2. Classification of Fold

Jahangir, (2007), classify the folds by using the certain geometric parameters (Fig.4).

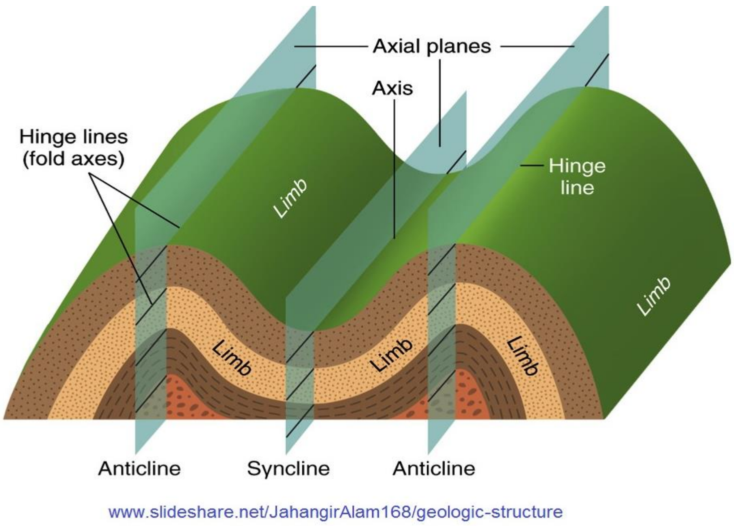

Fig.4. The geometric parameters of a fold (Jahangir A. 2017)

For the purpose of carrying out this classification of the geometric analysis is needed to make three structural contour maps (Fatha Formation, Jeribe Formation, and Euphrates Formation), (Figs. 5, 6, and 7) and correlation cross section. According to two cross sections, dip section (A - A¯), strike section (B - B¯) was constructed (Figs.8 and 9).

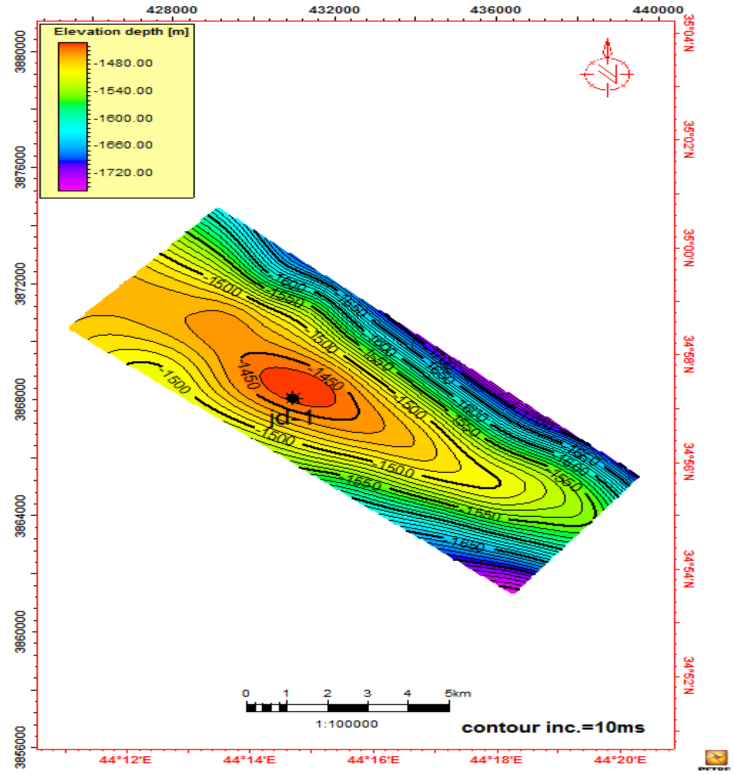

Fig. 5. Depth contour map of the Fatha Formation

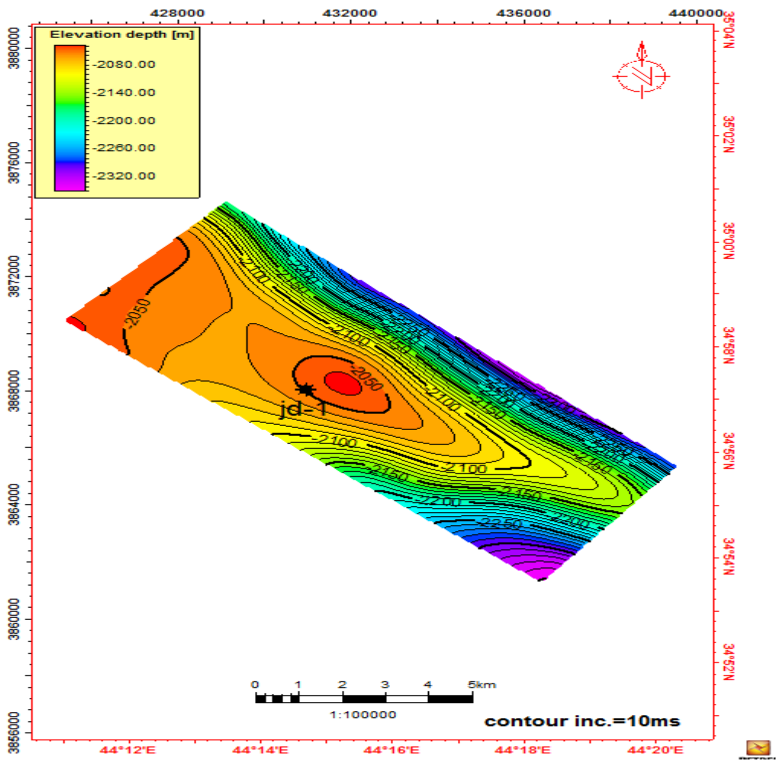

Fig. 6. Depth contour map of the Jeribe Formation.

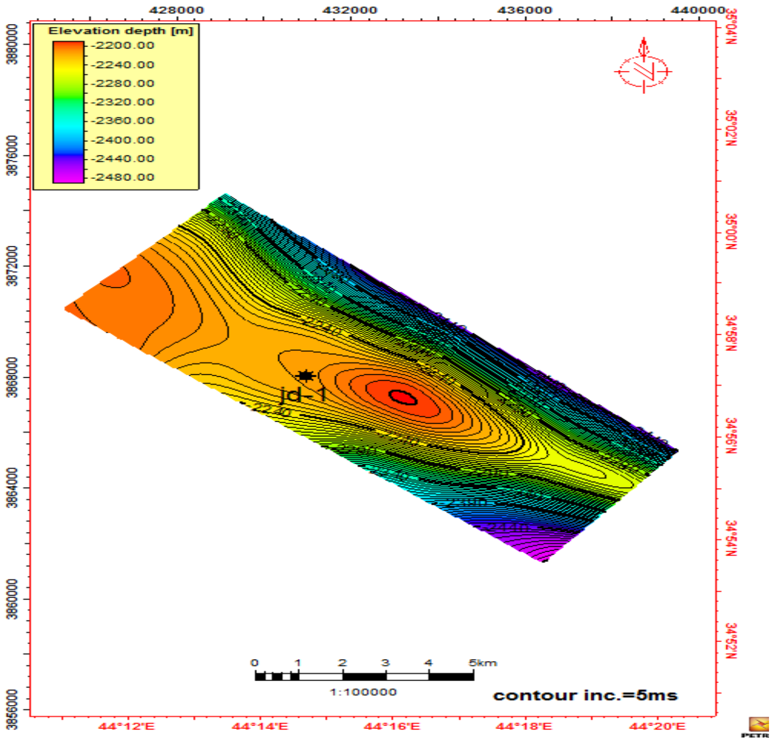

Fig. 7. Depth contour map of Euphrates Formation

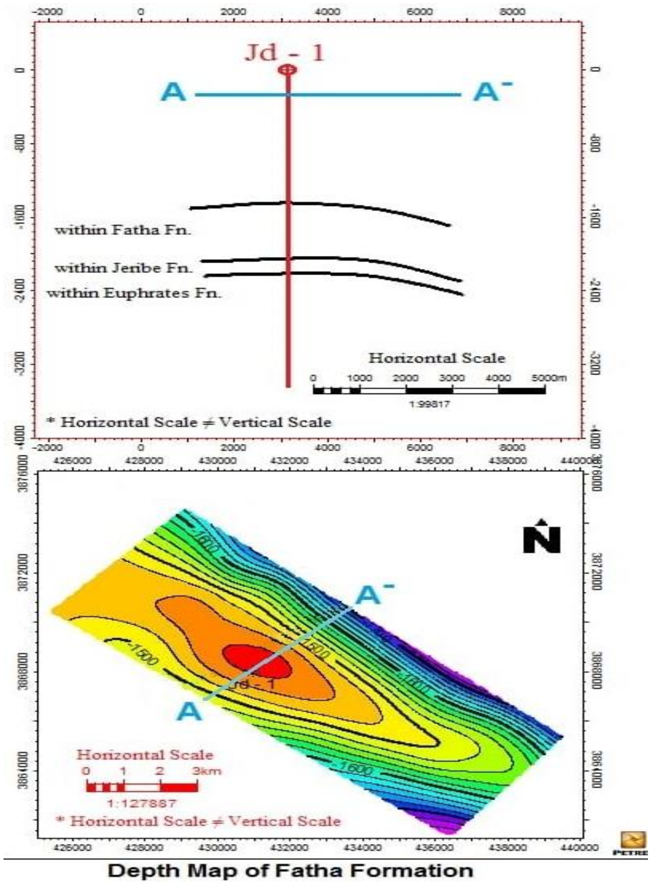

Fig. 8. Correlation Cross Section, Dip sections (A - A¯)

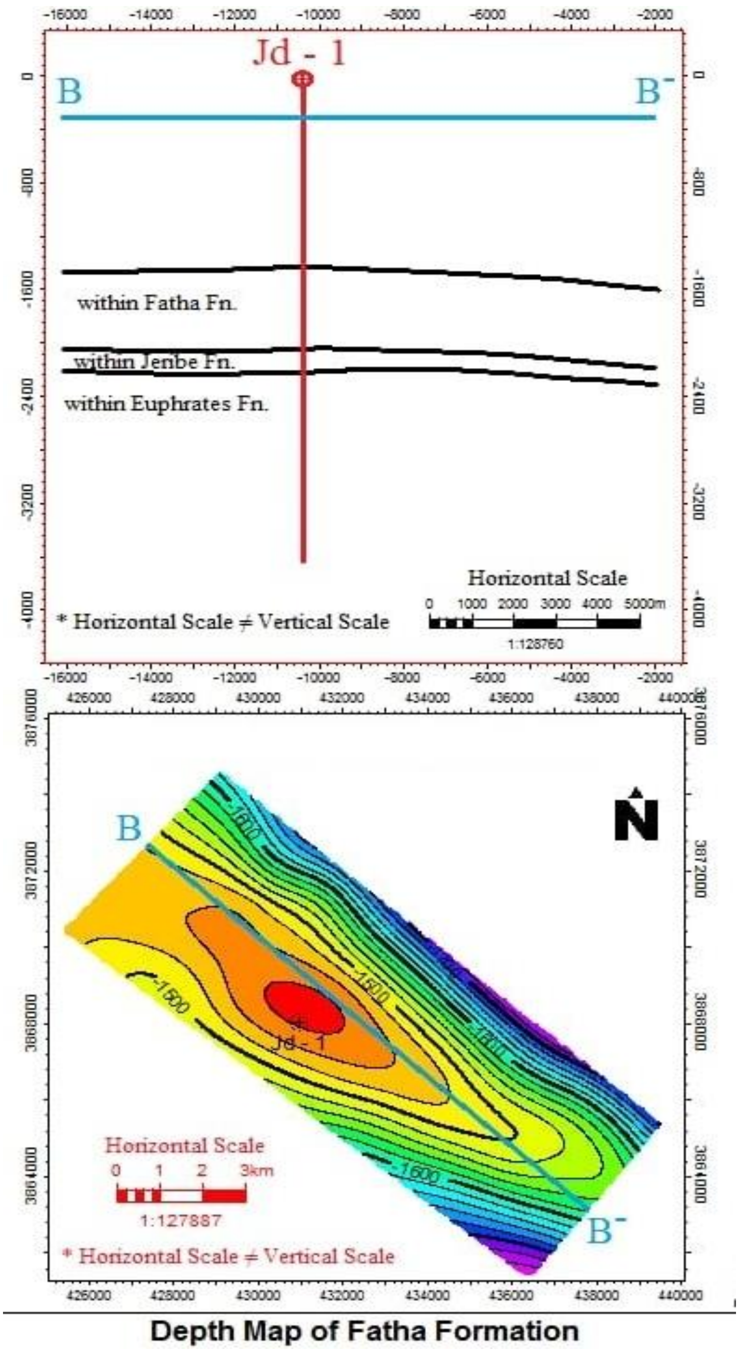

Fig.9. Correlation strike section (B - B‾)

To implement this classification, we need to find dip and dip direction and plunge of the hinge line from the structure contour maps of Judaida structure (Table 1).

Table 1. Dip and dip direction and plunge of the hinge line of the Judaida structure

Formation	Dip direction & dip amount		Plunge of the hinge line	
	NE limb	SW limb	NW plunge	SE plunge
Fatha	35/ 14.43°	215 / 6.9°	3.2°	4.82°
Jeribe	35 / 19.41°	215 / 7.9°	3.2°	3.82°
Euphrates	35 / 19.1°	215 / 7.9°	3.6°	4.12°

4.2.1. Fold facing

Park, (1997) classify the fold depending on facing as shown into 1) Antiform; 2) Synform; and 3) Neutral fold (Fig.10)

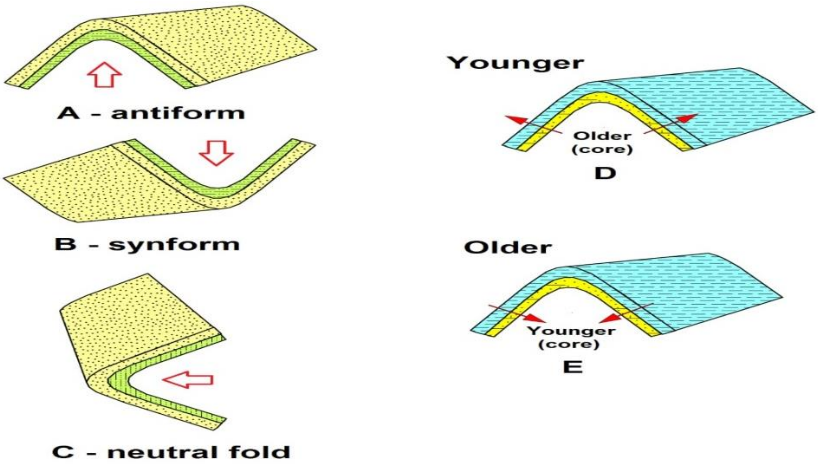

Fig. 10. Classification of folds based on facing of the Park, (1997); According to Park, 1997, the cross section of the Judaida Structure provides an anticline structure (Figs.8, and 9).

4.2.2 Based on fold dimensions

Jaroszewski, (1984) classify the fold based on the ratio between the lengths to width of the folds relative to same layer boundary; it has three types:

- Linear fold L / W > 5
- Brachy fold 5 > L / W > 2
- Domes and basins fold L / W < 2

The axial length and maximum width measured from the contour maps of the Fatha Formation map (Fig. 5) and the Euphrates Formation map (Fig. 7), as shown in Table 2, That indicates Judaida structure belongs to Brachy Fold.

Table 2. The Judaida Structure dimensions

Formation	Contour no.	Length axial (m)	Width axial (m)	Ratio (L / W)
Fatha	1470	5420	2000	2.71
Euphrates	2140	5416	1875	2.9

4.2.3. Fold shape in profile plane

Van Der Pluijm and Marshak, 2004 defined the profile plane of a fold as the plane taken perpendicular to the hinge line. It involves specification of:

- The inter limb angle

Fleuty, 1964 defined the angle made by the limbs of a fold as the fold inter limb angle. The data in Table 1, used in the Georient Software to determine the dip of the axial surface of the fold and to find the interlimb angle (Figs. 11, 12, and 13). And the result in Table 3. Judaida Structure is gentle fold depending on interlimb angle.

- Fold attitudes

A. Dip of axial surface

Van Der Pluijm and Marshak, (2004) classify the fold based on dip of the Axial Surface into three types, as shown in Table 4.

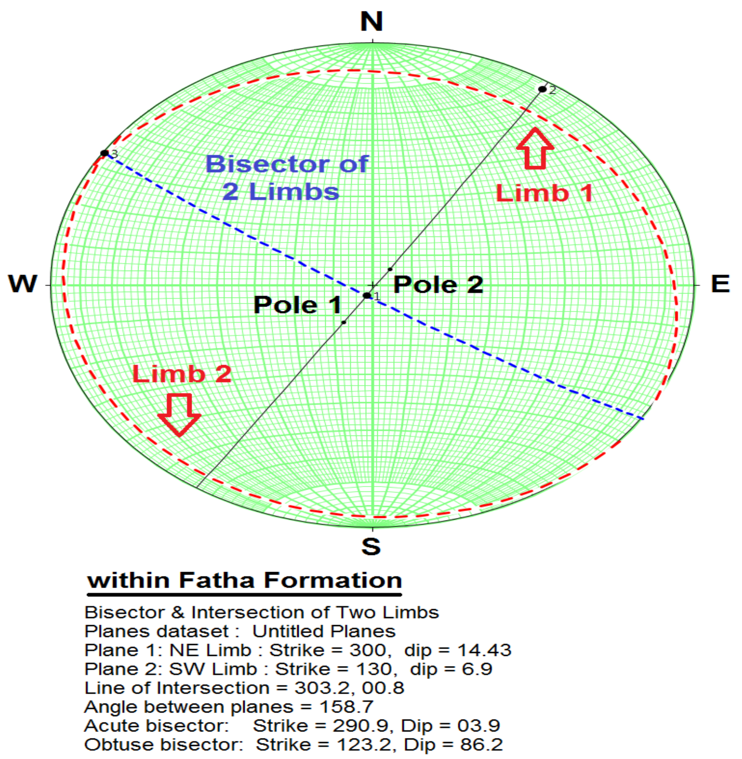

Fig. 11. Stereographic projection of the Judaida Structure within the Fatha Formation

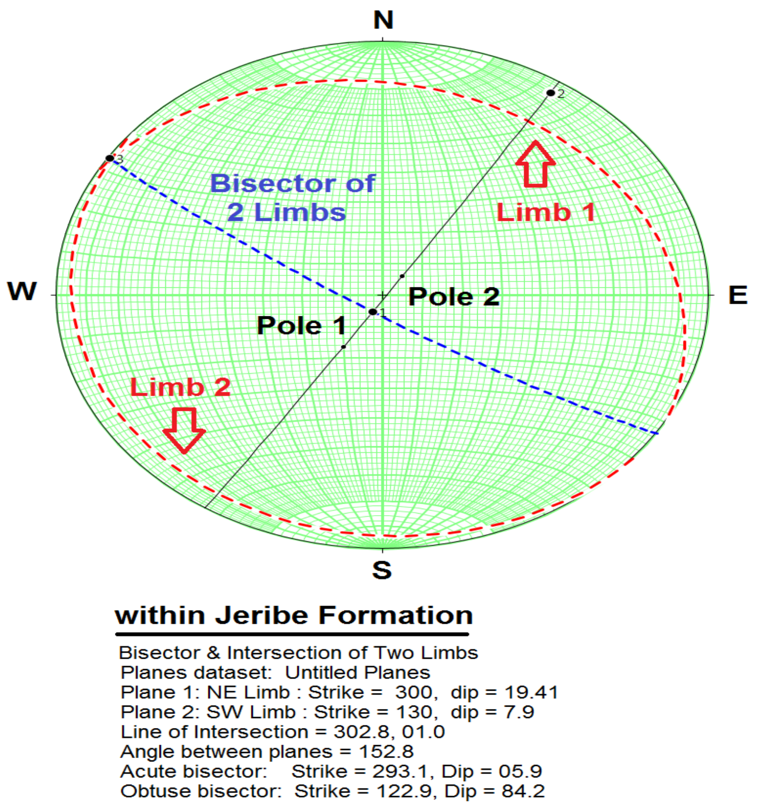

Fig. 12. Stereographic projection of the Judaida Structure within the Jeribe Formation

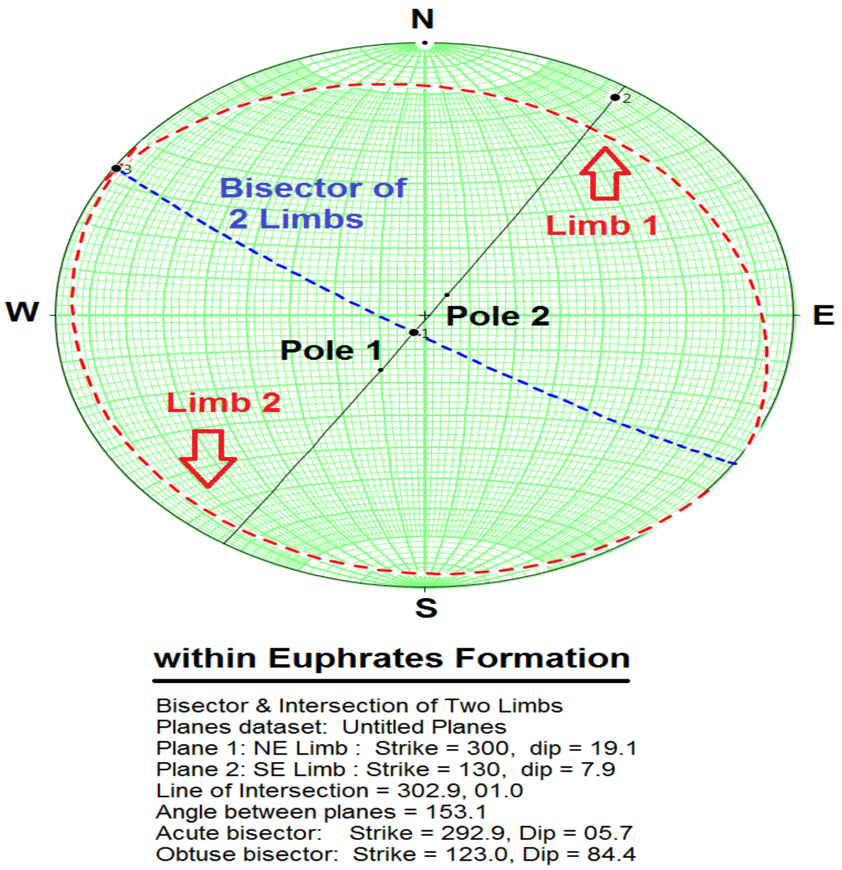

Fig. 13. Stereographic projection of the Judaida Structure within the Euphrates Formation

Table 3. Dip of the axial surface and the interlimb angle of the fold.

Formation	Bearing and dip amount of the axial surface	The interlimb angle
Fatha	123.2 / 86.2°	158.7°
Jeribe	122.9 / 84.2°	152.8°
Euphrates	123.0 / 84.4°	153.1°

Table 4. Classification of the folds based on the dip of axial surface

Type of fold	Dip of axial surface
Recumbent	0° - 10°
Inclined	10° - 70°
Upright	70° - 90°

Judaida anticline is upright based on the displacement axial surface.

B. Plunge of hinge line

Van Der Pluijm and Marshak, (2004) classify the fold based on the plunge of hinge line into five types, as shown in Table 5.

Table 5. Classification of the based on the plunge of hinge line

Type of fold	Plunge of hinge line
Horizontal	0° - 10°
Shallow	10° - 30°
Intermediate	30° - 60°
Steep	60° - 80°
Vertical	80° - 90°

Judaida anticline is horizontal fold depending on the plunge of hinge line.

C. Symmetry of fold

Barnes and Lisle, (2004) used the relationship between length of limbs to explain the symmetry. Asymmetrical folds usually have limbs of unequal length. The Northeastern limb of fold is longer than the Southeastern limb, (fig.8). Then Judaida Structure is asymmetrical Fold.

5. Conclusions

- Three depth contour maps, which represented the top of reflectors (Fat'ha, Jeribe and Euphrates formations respectively were constructed and exploited to illustrate the structural image of the Judaida area. In general, the structure has a general trend in the northwest-southeast direction, all of the depth maps for the three reflectors show a structural closure in the middle of the study area.
- The Judaida Structure is represented an asymmetrical longitudinal anticline, brachy, gentle and upright Fold.
- Normal faults it affected the Jurassic, Early Cretaceous, and part of Late Cretaceous age. Because of late Pliocene compression resulted in folding and reverse faulting of the all sequence and inversion of movement along some of the pre-existing normal faults. The resulted faults are called inverted faults and they are presented by two opposite (arrows) directions of displacements.

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