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Seismic Structure Study of Buzurgan Oil field, Southern Iraq

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Abstract

The Buzurgan oil field is one of the most important oil fields border in southern Iraq.

Adjacent to the Fauqi and Abu Ghirab oil fields common with Iran. The 3D seismic data showed the structural and stratigraphic of the Buzurgan oil field, where the results showed that the structure is an anticline fold with two structural domes separated by a saddle, the northern culmination is shallower and less deformation. Thirty-one faults were detected and most of them at the south part of the field which are small while the north faults are larger.

Keywords*:* Buzurgan oilfield, structure study, 3D seismic, faults.

دراسة زلزالية تركيبية لحقل البزركان النفطي، جنوبي العراق

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الخلاصة

حقل البزركان النفطي واحد من اهم الحقول النفطية الحدودية في جنوب العراق، موازٍ لحقلي الفكة و ابوغرب المشتركة مع إيران. الدراسة أظهرت استخدام البيانات الزلزالية ثلاثية الابعاد في تحديد الوضع التركيبي والطباقي لحقل البزركان النفطي، حيث أظهرت الدراسة ان التركيب عبارة عن طية محدبة ذات ذروتين تفصلهما منخفض، الذروة الشمالية اضحل واقل تشوها. وتم تحديد احدى وثلاثين فالقا معظمها في الجزء الجنوبي حيث تكون صغيرة بينما الشمالية منها تكون أكبر.

Introduction

Buzorgan oil field is one of the most important field in southern of Iraq. Mishrif Formation (Cenomanian-early Turonian) is the main production reservoir. The first exploration well BU-1 was drilled in June 1969 with total depth of 4298 m. Buzurgan Oilfield was discovered after the drilling of BU-1 well which proved the availability of commercial oil in Mishrif Formation, Buzurgan Oilfield was brought into production in 1976. The 2D seismic survey was carry out for more information of the structure boundaries from 1974 to 1977. Three-dimensional survey carried out at 2013 [1].

The aim of study is to determine the structure description of Buzurgan oilfield by using three-dimensional seismic data. The workflow start by identify the main horizons then gridding this horizons, subsequently determination of faults and their patterns, finally create the structure framework of the field.

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Location and geological setting of study area

Buzurgan oil field is located in Missan province southeast of Iraq 175km north to Basra city close to Iraq-Iran bolder (Figure-1). The trend of Buzurgan structure is NW-SE parallel to Zagros Mountain series with 40km length and 7km width, the total area of the anticline is 394 km^2 [1].

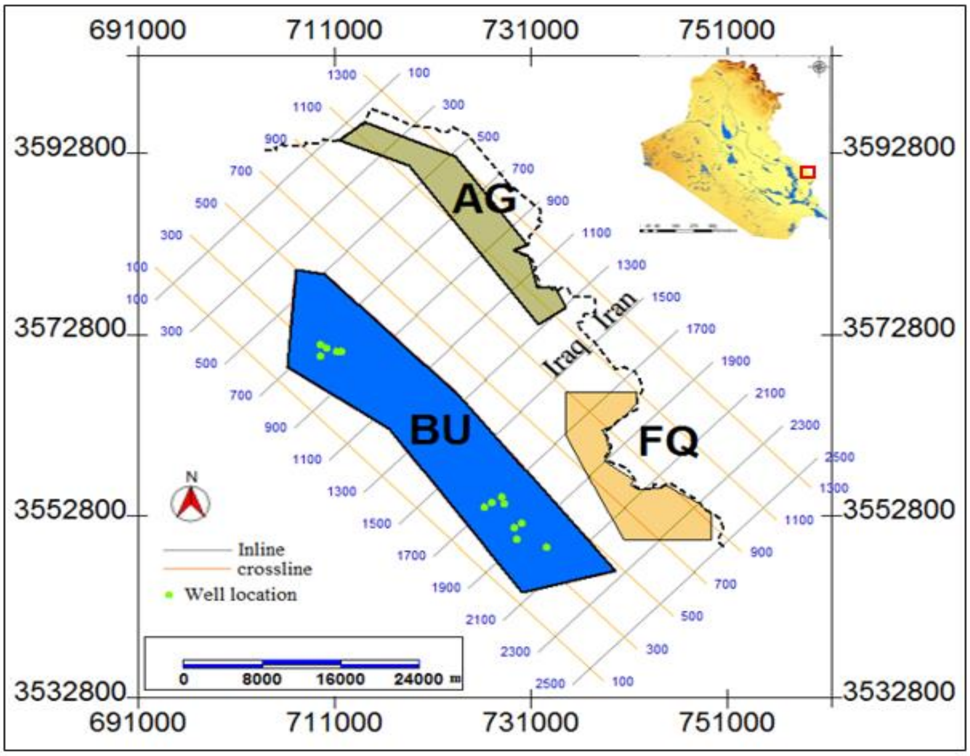

Figure 1-Base map of 3D seismic survey of Missan oilfields shown the study area (BU).

The framework of Iraq generally divided into two tectonic plate (Figure-2), Eurasian plate that represent very small part of Iraq called Shalair Terrane and Arabian plate which represents most area of Iraq. Main tectonic zones of Arabian plate are Inner Platform and Outer Platform that separated by Ana graben fault at western part and Abu Jir–Euphrates faults zone at southeast part. Inner Platform divided into Mesopotamia Fore deep and Zagros fold-thrust belt, which also subdivided into Suture zone, imbricate zone, High folded zone, and low folded zone [2].

Buzurgan structure is situates in the foreland basin of Zagros mountain within Mesopotamia zone formed during the Himalayan orogeny. This orogeny that results from the movement of Arabian plate toward Eurasian plate caused horizontal compression; thus produced compressional structures [3].

The boundary of Mesopotamia from the NE is bounded by Makhul-Hemrin fault which have an extension on the surface representative by Badra-Amara fault and from the SW is bounded by Euphrates fault [4] (Figure-3).

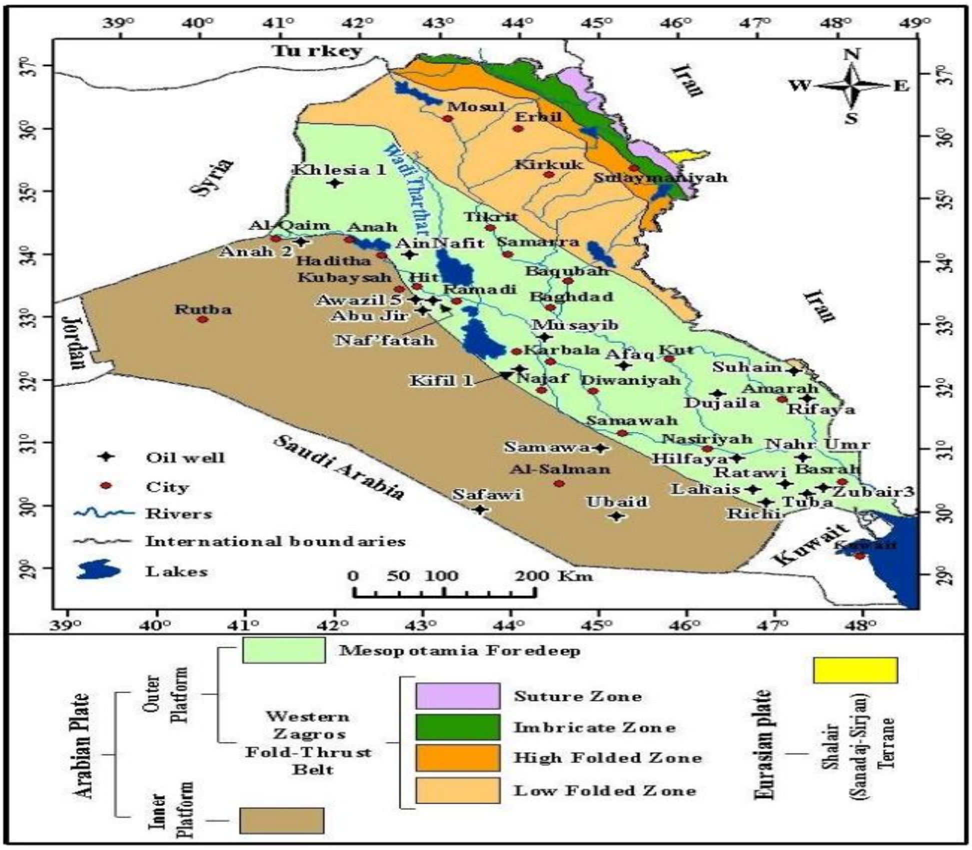

Figure 2-Tectonic division of Iraq [2].

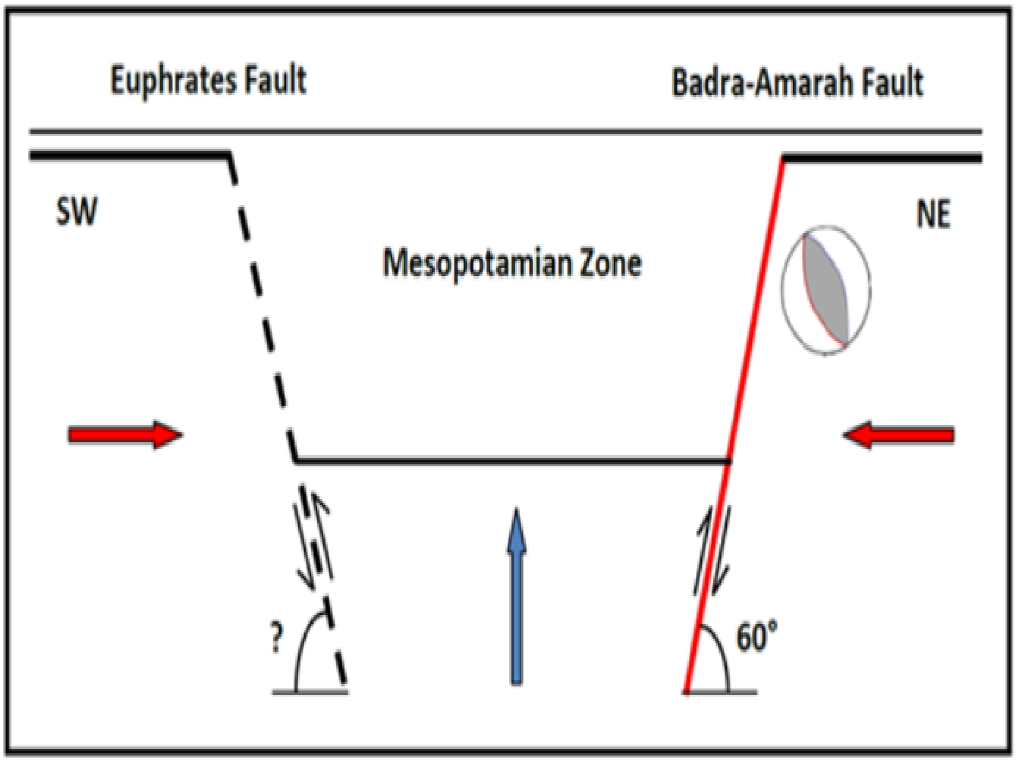

Figure 3-Simple model of Mesopotamia Zone without scale [4]

Stratigraphy

The stratigraphic column that penetrated in Buzurgan oil field consists of two sequences (Cretaceous and Tertiary). Tertiary time are represented by the formations from younger to older:

Upper Fars (Injana) , Lower Fars (Fatha), Asmari, Jaddala, Aliji, Shiranish, and Hartha, While, Cretaceous are represented by the following formations: Saadi, Tanuma, Khasib, Mishrif, Rumaila, Ahmadi, Maudud, Nahr Umr, and Shuaiba. (Figure-4). The lithological description and geological age of each formation according to [3]:

- Upper Miocene series

Upper Fars (Injana) Formation: dominated by sandstone and shale, locally anhydrite, with thickness of over 2000m.

- Middle Miocene series

Lower Fars (Fatha) Formation: dominated by anhydrite and salt, with thickness of about 800m, it is regional cap rock.

- Oligocene to Early Miocene series

Asmari Formation: consisted of limestone and dolomite with sandstone in some areas, of which the gross thickness is approximate380m, and it was divide into 4 members that were named as A, B, C and D members.

- Paleogene to Eocene

Jaddala Formation: Chalky limestone and marl soft inclusions of chert, with thickness of about 160m.
Aliji Formation: Marl intercalation of limestone, with thickness of about 40m.
Shiranish Formation: Marl and Chalky limestone, with thickness of about 30m.
Hartha Formation: Whitish limestone sometimes argillaceous with thickness of about 70m.

- Upper Cretaceous

Saadi Formation: Whitish limestone and glauconitic marl, with thickness about of 100m.
Tanuma Formation: Marl and Chalky limestone, with thickness of about 20m.
Khasib Formation: White Limestone and sometimes marl, with thickness of about 80m.
Mishrif Formation: Reservoir lithology is mainly limestone with 340m gross thickness, and it is divided into 3 members as MA, MB and MC mainly based on the sequence by means of analysis and correlation with 3D seismic data and well logs as well as cores.
Rumaila Formation: Grey beige limestone, with thickness of about 60m.
Ahmadi Formation: Limestone with shale and marl, thickness is nearly150m
Mauddud Formation: Limestone with chalky aspect packstone and some layers of bioclastic recrystallized packstone with thickness of about 170m.
Nahr Umr Formation: Fine Sandstone or sand more or less shaly, about 200m;
Shuaiba Formation: Micro detrital, recrystallized limestone, with thickness of more than 200m.
The early Cretaceous has not yet been excavated.

Data inventory

Different data types were used in this study represented by 3D seismic data volume well logging data, and geological information of the study area.

The seismic represent by post stack data (SEG format), which done by using geodetic datum WGS84 200m above sea level. The study area (BU oil field) limited by inline (400-2300) and crossline (140-580) (Figure-1). Logs (sonic and density) are used with check shot to create synthetic seismogram, which used to tie with the geological information like formations tops that obtain from final well reports.

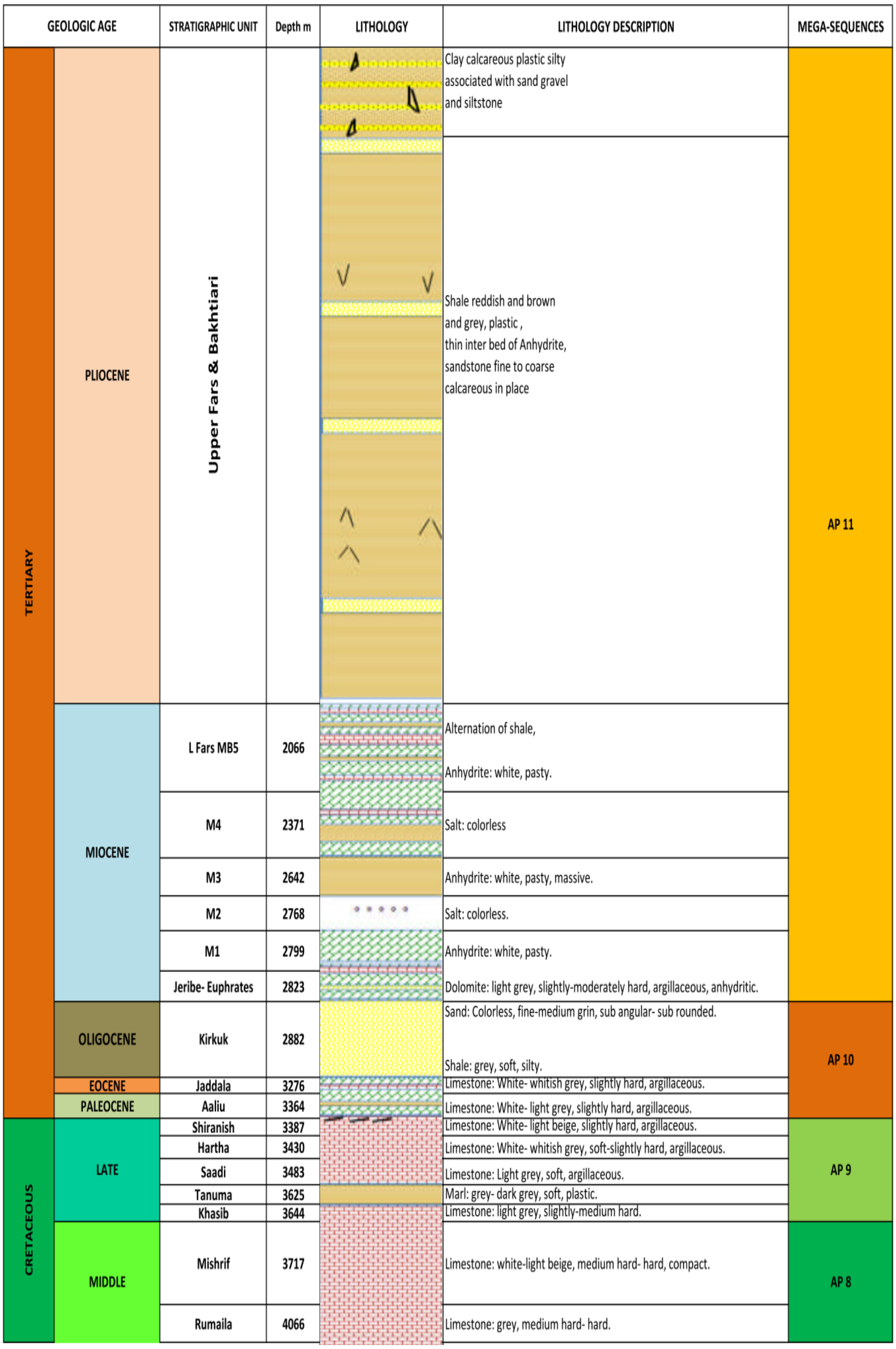

Figure 4-Buzurgan Stratigraphy column [5].

Preparing data for seismic interpretation

The seismic interpretation represents by concluding the subsurface geological setting from seismic data. The interpretation can be divided into three parts: first, the structure which interpreted directly by creating a structural maps from observed 3D configuration of arrival time; second, stratigraphic interpretation according to related of reflectors pattern; third, lithological interpretation in this part, seismic data are used to predict the change in lithology, fluid, porosity, fractures intensity. Before starting the interpretation steps, it is recommended to check the available geological information for the area (e.g., stratigraphy column from the drilled wells). Then, correlate (puzzle piece wise) the local geological information with the reginal structural and stratigraphically framework. It is important for the interpreter to collect the available data and understand what he need from this data, what the regional tectonic, structure, and deposition trend, and what pattern of seismic locking for. Also, collect the well data, vertical seismic profiling (VSP) or check shot, and cores.

The first step in interpretation process creates a Synthetic Seismogram(s) to tie the well information with the seismic data.

Compute time-depth chart and wavelet

Check shot used to create T-D chart of BUCN-51 (Figure-5).

Ricker wavelet zero phase used for this study (Figure-6) with maximum amplitude at zero time. Ricker wavelet is easy to realize, useful for resolving power, and appropriate to pick reflection peak or trough [6].

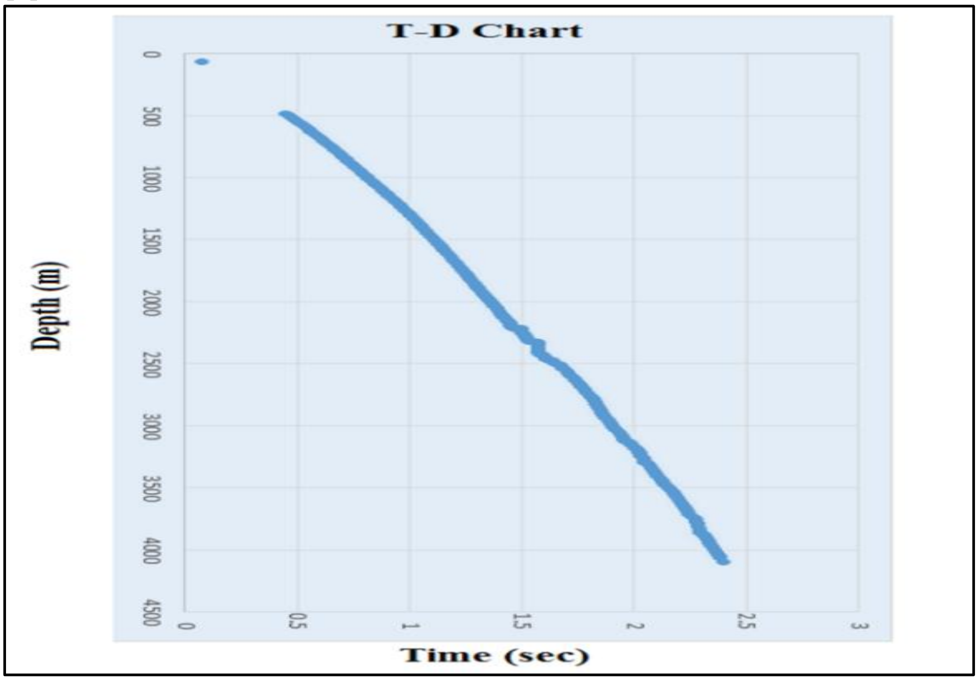

Figure 5-Time-Depth chart of BUCN-51

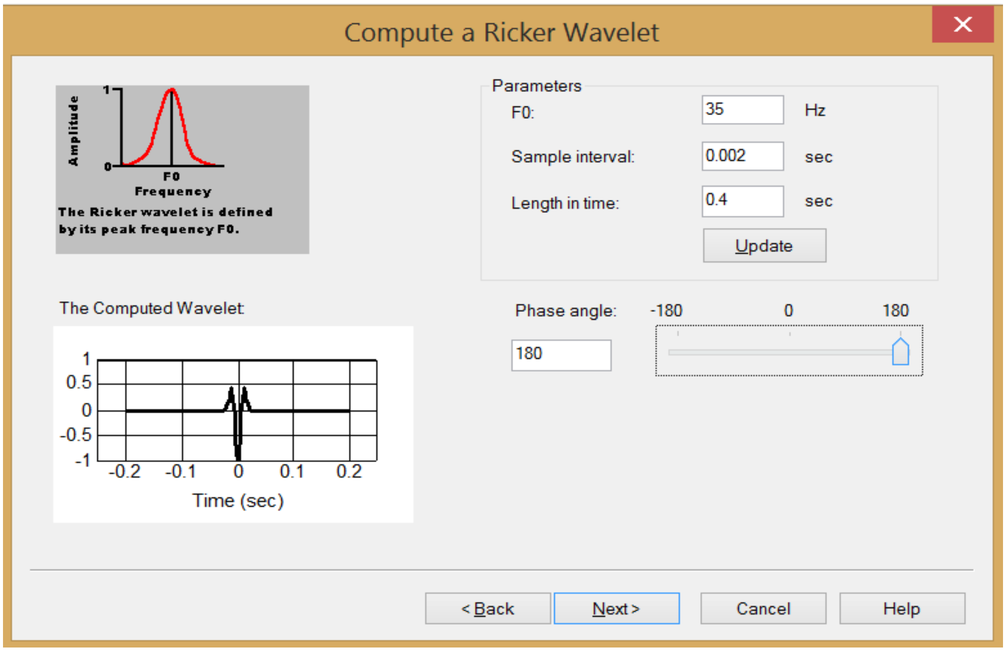

Figure 6-wavelet generate by using theoretical Ricker method.

Create synthetic seismogram

To create synthetic seismograms, the wavelet is convolved by reflection coefficient [7]. Fourteen synthetic seismograms created for this study to be used in reflector identification (shared the synthetic to nearest well and make editing then shared again to next nearest well). The synthetic seismogram of well BUCN-51 shown at Figure-7

The correlation coefficient (r) of the synthetic is 0.828 which reflects a very good match of synthetic trace with seismic trace (where: r=1 exactly match, 0= no match).

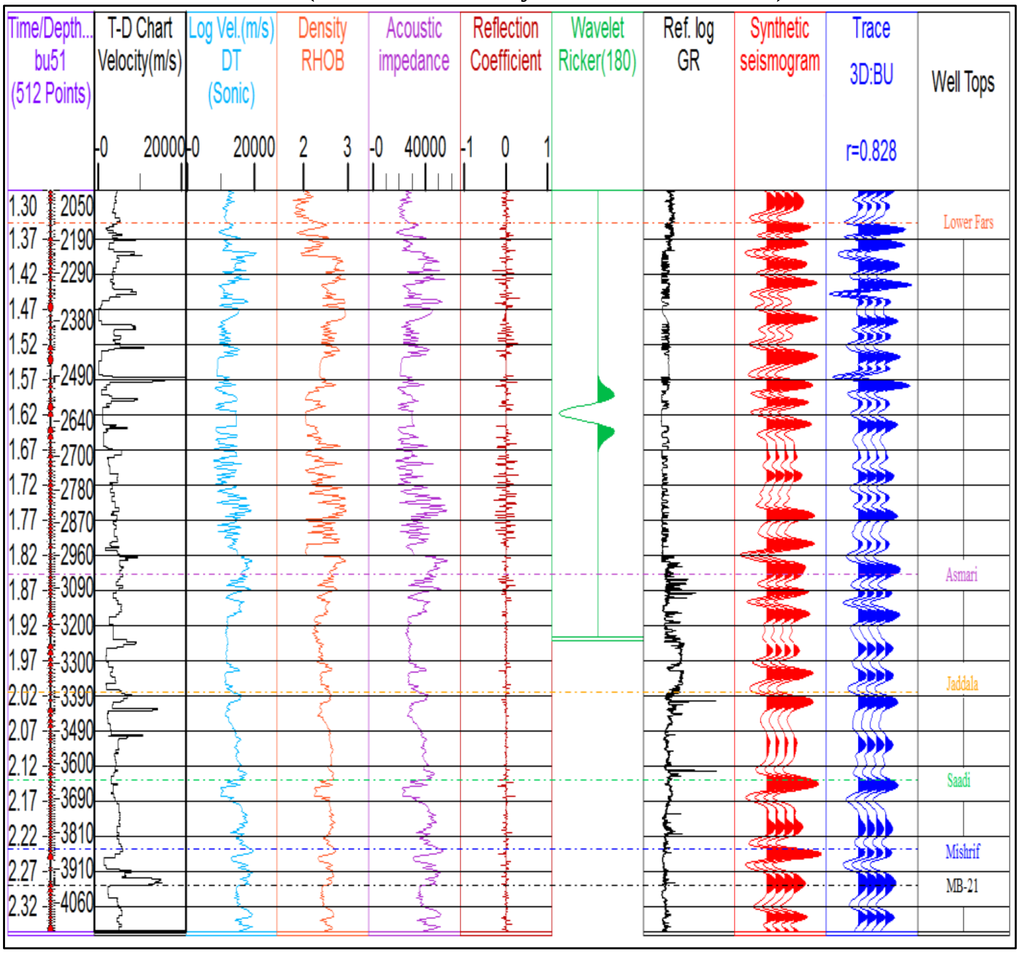

Figure 7-synthetic seismogram of BUCN-51

Horizon Identification

Geologically, a horizon refers to a layer surface where there is a change in the lithology within a sedimentary sequence, or a distinctive layer with a fossil content or a characteristic lithology within a sequence [8].

From the point of view of geophysicists, the horizon is an interface that may be represented by a seismic event (reflection), the horizon produced from contact between two rock bodies of different characteristics (e.g.,fluid content, porosity, density, or all of those) which produce different seismic velocity [9].

Depending on the synthetic seismograms and well information, reflectors from the Jurassic to Tertiary age were identified.

The reflectors represent the tops of the formations. Picking the largest amplitude of the reflectors that done by picking horizons every five skips for inline and crosslines, which mean 380 and 88 horizons picked for inline and crossline respectively of each horizon (Figure-8). Then create the grids for the horizons to distribute the horizons overall region of the study area.

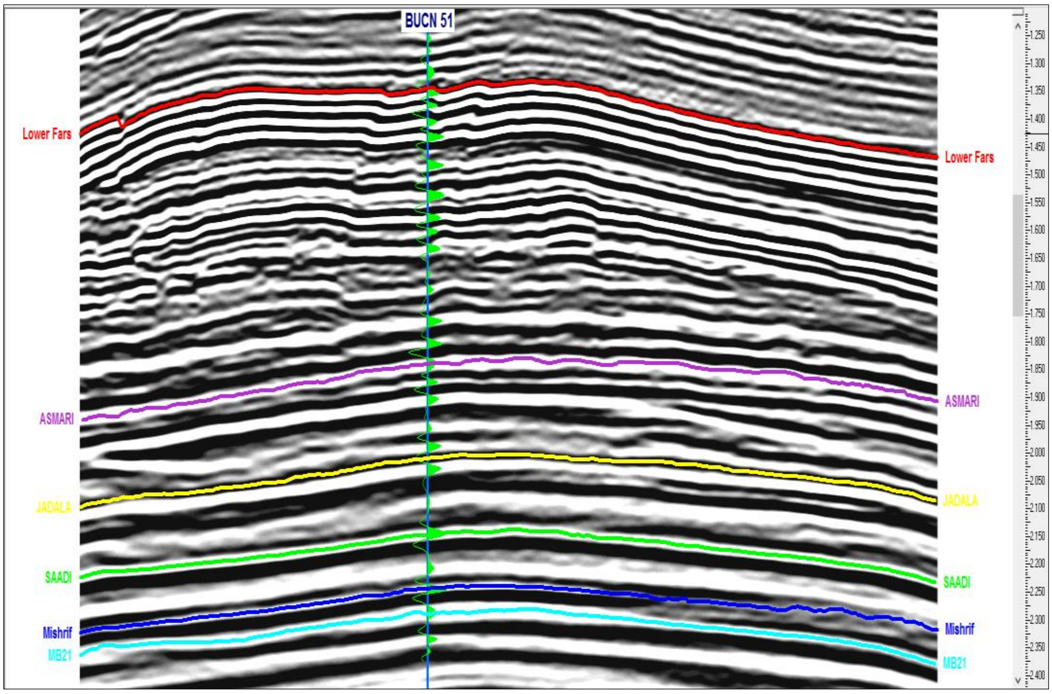

Figure 8-seismic cross section show the picked horizons of the BU field (inline 719).

• Lower Fars: Seismic reflection present trough event (negative polarity) because it represent the top of high acoustic impedance layer (anhydrite) underlined by low acoustic impedance layer (mudstone). Good continuity in seismic section with strong amplitude.
• Asmari: It is strong reflection and good continuity on seismic section with peak event type.
• Jaddala: Seismic reflection represent trough event product from low acoustic impedance layer above high acoustic impedance layer. The reflector has good continuity.
• Saadi: This stat invers Start inverse in the Jaddala reflector, it is a peak reflector product from high acoustic impedance (limestone) overlaid low acoustic impedance layers (sandstone and shale). The reflector has good continuity on seismic section with strong amplitude.
• Mishrif: It is represent a peak seismic signature of medium continuity on seismic section.
• MB-21: It represents the main pay of Mishrif Formation in Buzurgan oil field. It is a peak event, and strong reflector and good continuity on seismic section.

Faults identification

The main principles to determine faults on seismic sections are as following [10] : Discontinuities of reflectors at fault planes, the tying reflections around loops are Mis-closures, displacement of reflection at the vertical sections (or time slice or both), and the sudden termination of reflections events.

Results and discussion

1- Fault interpretation

There are many faults within the boundary of the study area (Fig. 9). The total number of faults are 31, 13 faults of them at the north BU, which are larger and more complex, than the faults at the southern part.

2- Faults Classifications

Depending on the relative movement of the hanging and foot walls of the faults (dip-slip faults classification), they are classified into:
• **Normal faults**: the movement of hanging wall to downward parallel to dip direction. There are 19 faults at study area most of these faults concentrated at the southern part of the field (8, 11, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31).
• **Reverse fault**: the movement of hanging wall to upward parallel to dip direction. There are 12 faults all of them at the north part of the field (1, 2, 3, 4, 5, 6, 7, 9, 10, 12, and 13) except one fault at the south (fault 15).

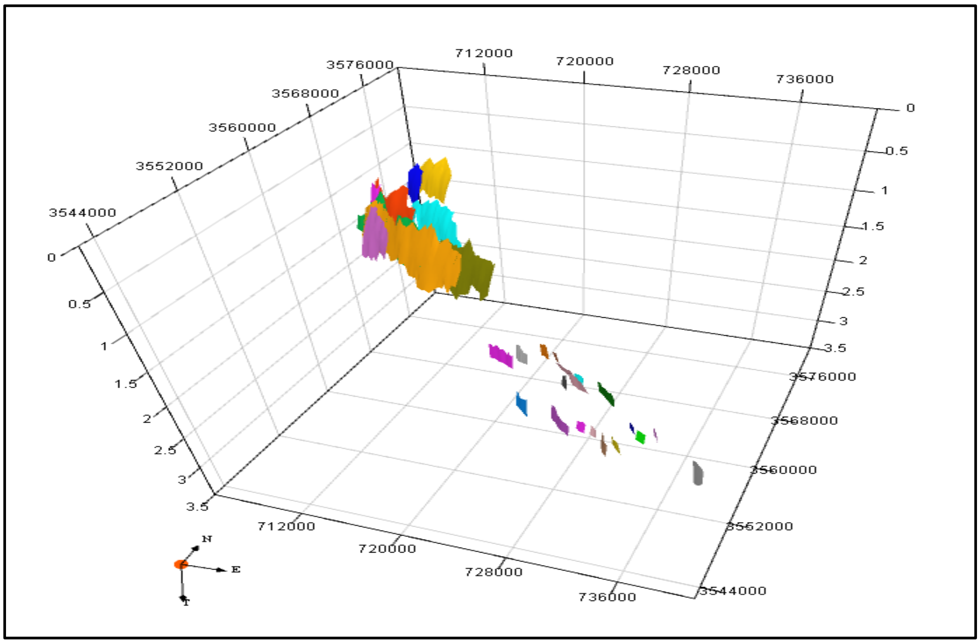

Figure 9-3D display of fault at study area.

3- Patterns result from faults configuration

Two special patterns appear in the study area (Figure-10):

A-Graben: A block down with respect to surrounding, which result from two normal faults dipping toward each other.

B-Horst: A block rise with respect to surrounding, which result from two normal faults dipping away from each other.

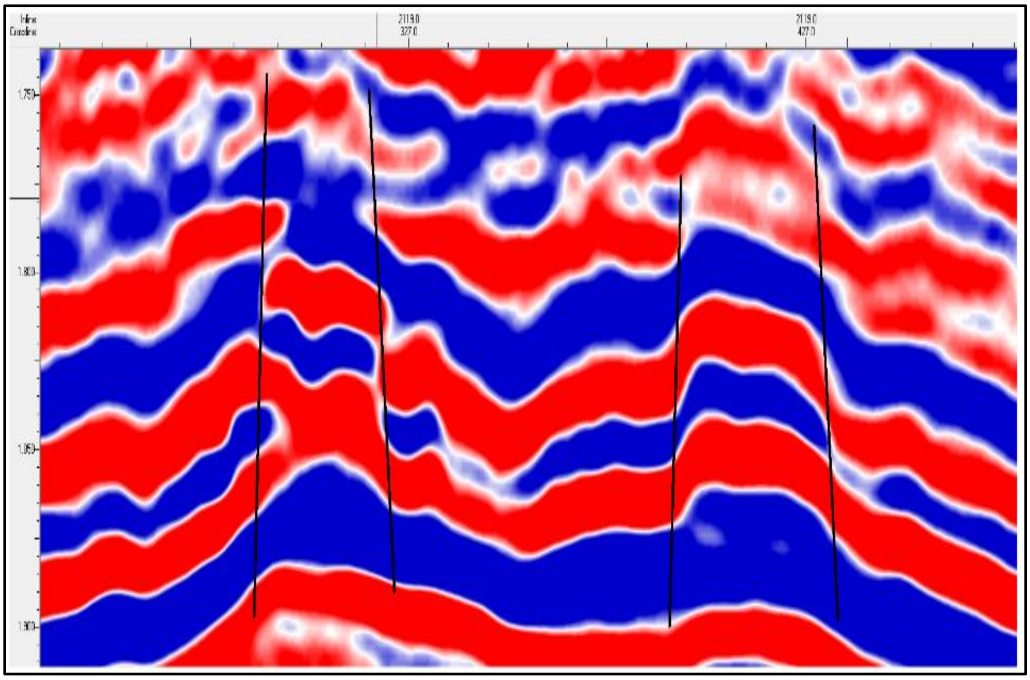

Figure 10-Horsts and grabens result from configuration of normal faults (black lines).

4- Structure interpretation

Geological structure is a description of the rocks in terms of shape form and distribution. The geometry of structures displays some information like stress orientation which supplies the information about the deformation history of the study area [11]. These features result from tectonic and non-tectonic force, which cause deformation to rocks [12].

Time structure map is a useful method to obtain structure framework from the arrival times of reflectors, which represents time back and forth or two-way time (TWT) of seismic wave. The higher values represent the deeper sites (spend more time to travel wave from source to reflector to geophone). The study uses six seismic grids, which were created to construct structural time maps.

A- Top of within Mishrif (MB21 Member).

The time structural map of the main reservoir MB21 articulates the same trend of previous reflectors that is NW-SE. Two domes of the anticline fold with a nose structure raised at the saddle area close to the north dome (Figure-11).

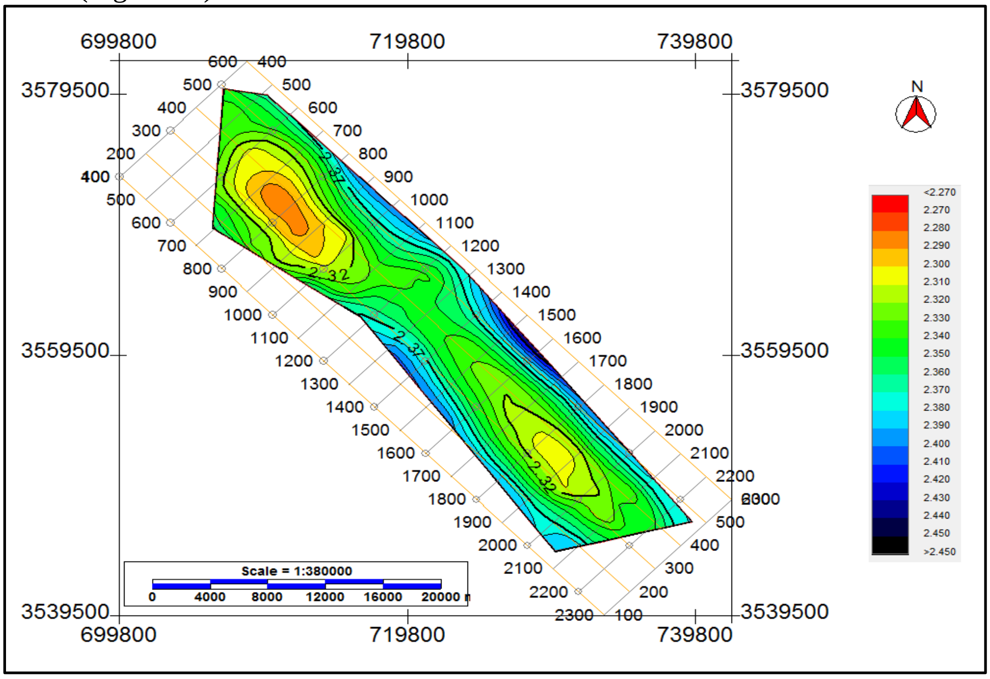

Figure 11-time structural map of Mishrif Formation MB21 Member.

B- Top of Mishrif Formation.

Northwest-Southeast trend of different elevation at the two domes. The shallower sites consist of the crest of north dome. (Figure-12).

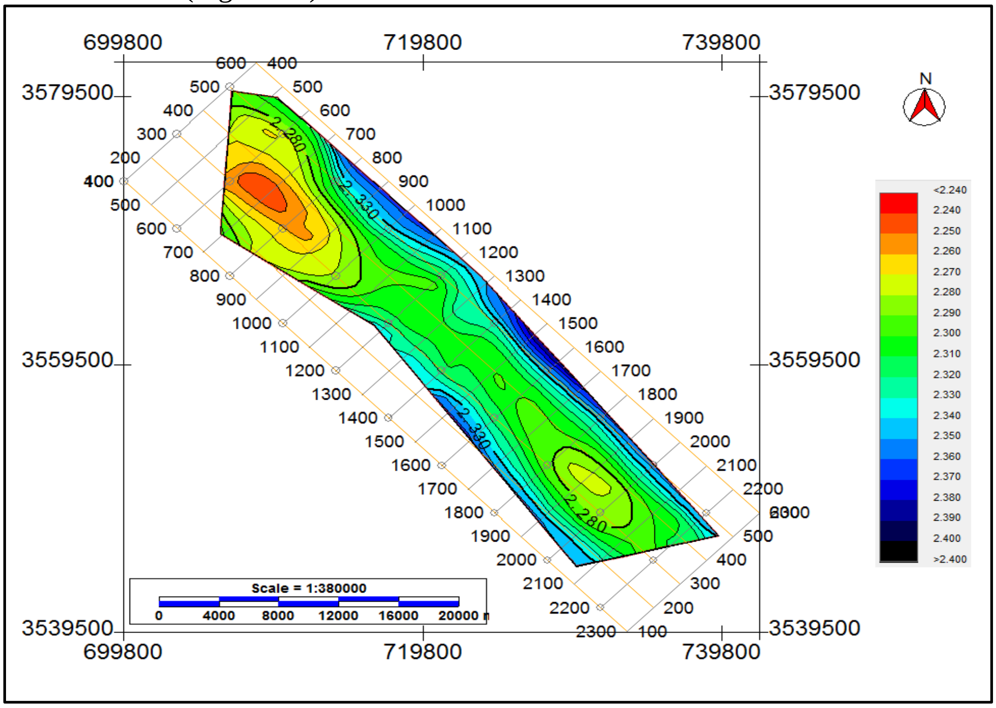

Figure 12-time structural map of Mishrif Formation

C- Top of Saadi Formation

The time structural map of Saadi points out the anticline that is concordant with underlying surfaces trend (NW-SE) The highest values adjacent to the wells (include the well numbers (BU52, BU51, BU12, and BU9) at the northern dome (Figure-13). The nose structure at the saddle starts disappears at Saadi Formation. Two small anticline appear at the southern dome.

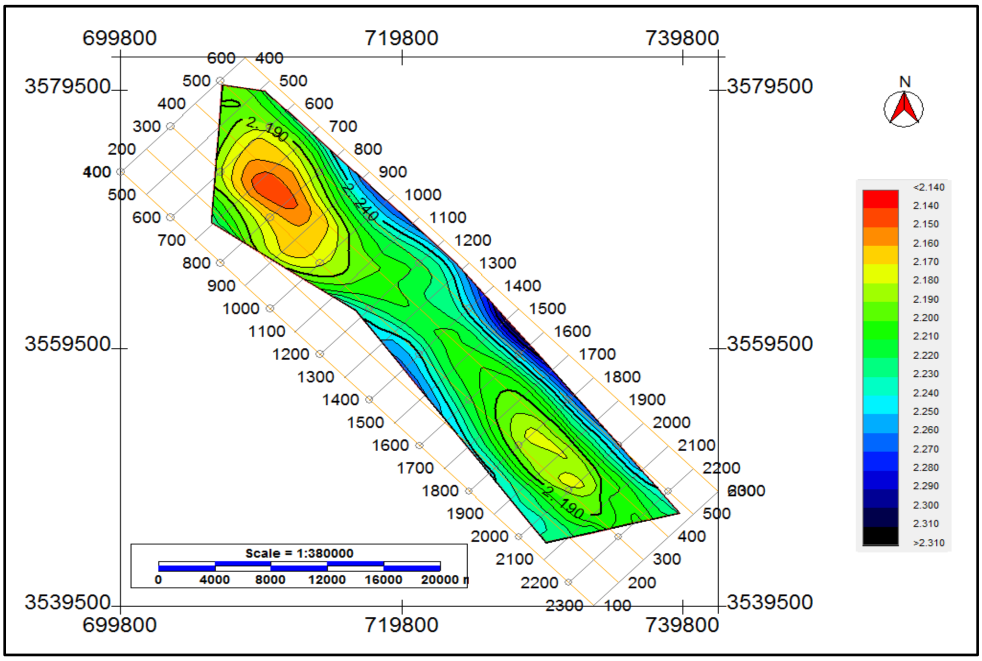

Figure13-time structural map of Saadi Formation

D- Top of Jaddala Formation

The time structural map of the Jaddala also explains the same direction of previous map (the top of Saadi Formation). Two culmination separated by saddle, the saddle becomes more clear and deeper with respect to the dome (compare with saddle at previous maps) (Figure-4). No evidence of faults displacements at this interval time window.

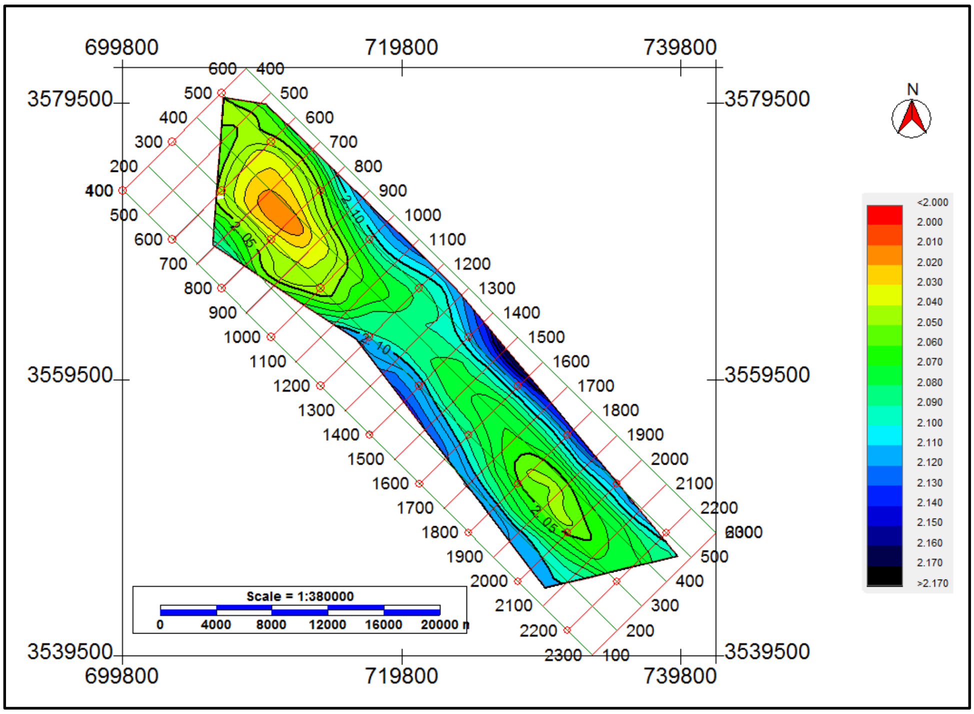

Figure14-time structural map of Jaddala Formation

E- Top of Asmari Formation

The time structuralmap of Asmari shows the same anticline with same trend that is NW-SE (Fig. 15). The highest values concentrated at the northern dome, which reflect the shallowness comparing with the southern dome. A small closure of the contour lines at the saddle area that may express salt intrusion (salt dome). Several faults are noticed at this reflector.

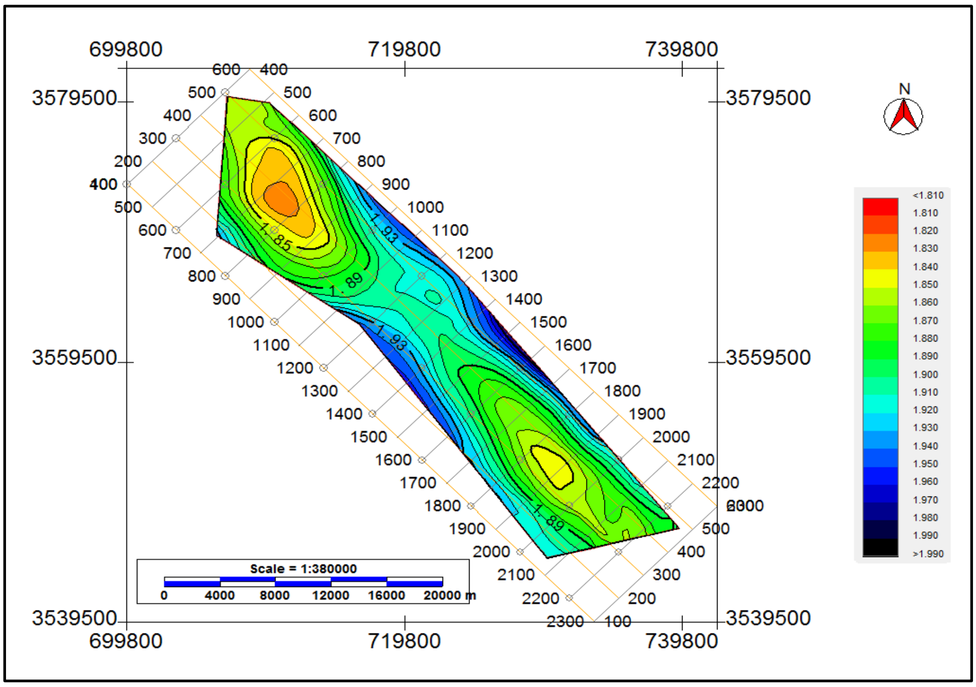

Figure 15-time structural map of Asmari Formation.

F- Top Lower Fars Formation

The time structural map shows anticline fold with two main domes that are trend toward NW-SE separated by a saddle (Figure-16). There are several faults at the northern dome break the contour lines. As it is noticed, the left flank is shallower the right flank. Therefore, the southern culmination is deeper than the northern one.

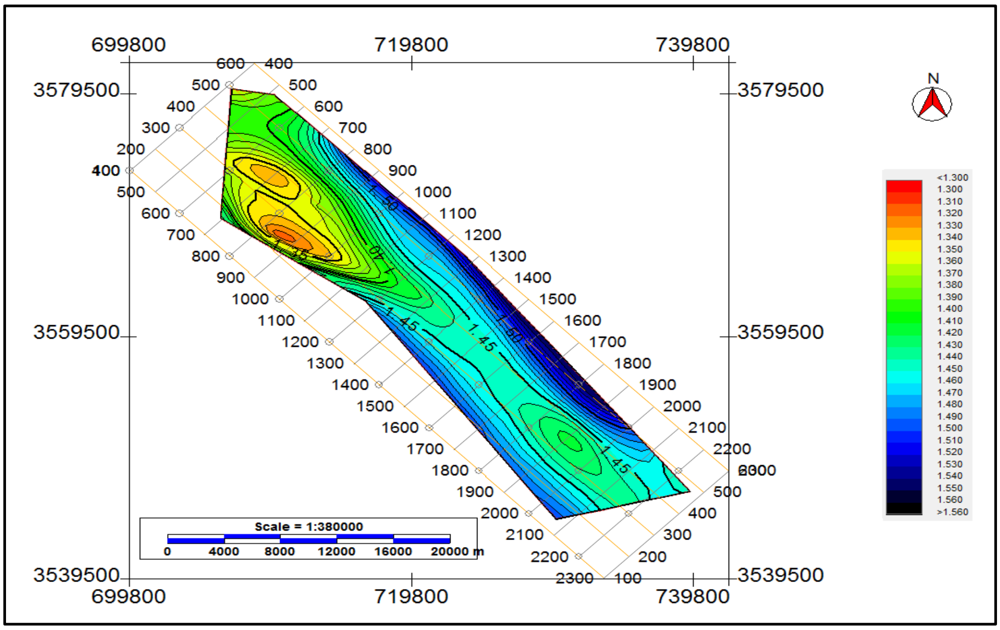

Figure16-time structural map of Lower Fars Formation

Figure-17 shows the thee dimentional display of the time structural maps above which used to classify the structure.

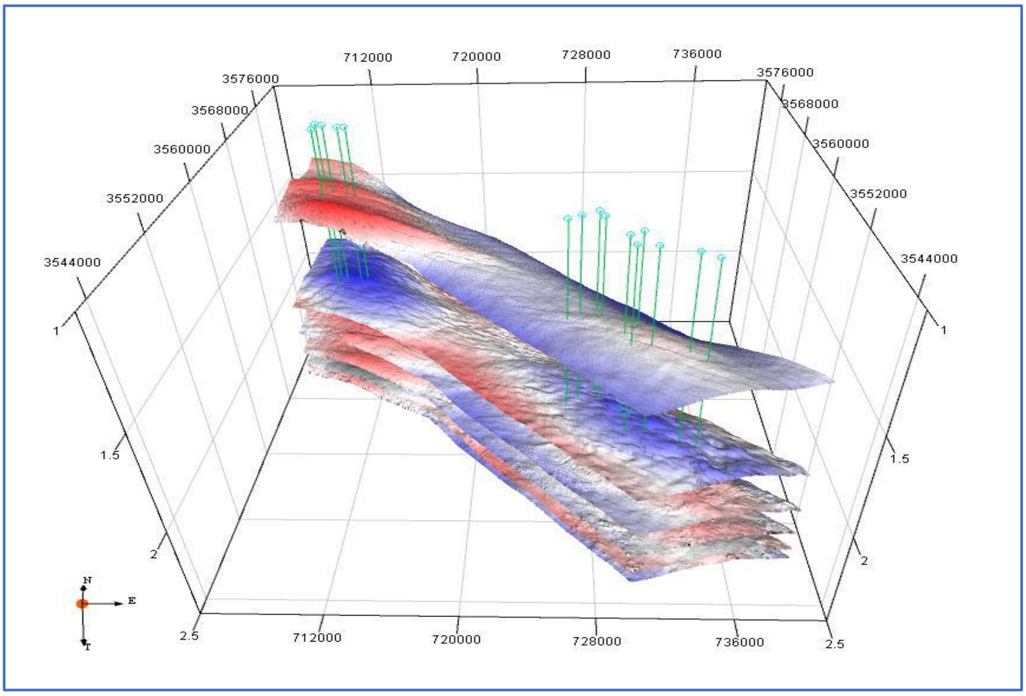

Figure 17 3-D time structural maps (Lower Fars, Asmari, Jaddala, Saadi, Mishrif, and MB21).

5- Geometrical classification of Buzurgan structure

The geometric classification of the folds depends on its geometrical elements. The Buzurgan fold was geometrically classify based on four foundations:

1- Depending on the direction of the curvature of the fold:
- Anticline fold: the curvature direction towards up.

2- Shape of fold in three dimension:
- Non-cylindrical folds, where the hinge line of the fold bend or zigzag.

3- Depending on limbs attitude:
- Asymmetrical fold, the dip angles of fold limbs are not equal.

4- Depending on the hinge line attitude:
- Plunged fold, the hinge line plunge with respect to horizontal level.

Conclusion

The obtained results of structural interpretation of Buzurgan oil field showed the following conclusions:

Thirty-one faults were determined at the field. Thirteen reverse dip-slip faults are in the northern dome and the other faults are normal dip-slip in at the southern part. These fault form horsts and graben structures.

Buzurgan oil field is asymmetrical anticline with two domes separated by a saddle.

The north dome is shallower and has trend deviates about 10 ° close to the north.

Recommendation

It is recommended to conduct detailed structural studies to determine the mini faults and fractures because the area is affected by the lateral tectonic stresses that caused these structural forms and thus affect the process of reservoir management in a certain way.

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