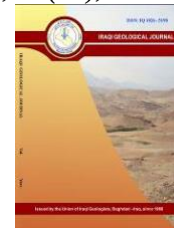




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Delineation of Subsurface Structural Geology in Buzrgan Oil Field Using 2D Seismic Interpretation

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Abstract

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This study focuses on the structural picture interpretation of Buzrgan oil field in the Maysan province of southern Iraq. Using 2D seismic data, Synthetic traces are created by selecting reflectors on the seismic section using the Petrel software and the well (BU-1) data currently available. The reflectors represented Paleocene to middle Miocene, which are L-Fars-Kirkuk-Jaddala-Aaliji. A thrust fault that solely impacts the L-Fars formation is dividing the research region into two blocks that are each affected by the examined reflectors. The fault system extends from northwest to southeast. The structural interpretation of depth maps reveals that some anticline folds were localized roughly surrounding well locations were marked on all maps.

Keywords: 2D Seismic Interpretation; Low folded zone; Buzrgan oil field; Southern Iraq, Seismic attributes

1. Introduction

One of the most crucial components of an effective oil and gas exploration program is the accurate interpretation of geophysical data, particularly the Seismic reflection data (Herron, 2011). High event continuity and good lateral resolution of event terminations at faults make structural interpretation easier. Data conditioning refers to removing unwanted and unneeded information while improving the representation and replacing the original. Hocker and fehmers, (2002). The Zagros Fold-Thrust Belt includes the Thrust, Imbricated, High Folded, Low Folded Zones, the Mesopotamia Foredeep, and the Inner Platform, are the three main tectonic divisions of Iraq's structural position from northeast to southwest. Buday and Jassim, (1987), Numan, (1997), Jassim and Göff, (2006). Fouad, (2015) (Fig.1). Several anticlines running NW-SE represent the boundary between the Mesopotamia Foredeep and the Low Folded Zone. Leturmy and Robin, (2010). Studies suggest that the seismic reflection technique gives most precise depiction of the stratigraphy and structure, a strong description of the subsurface geology, and strong indications of oil deposits. Aldarraji and Almayahi, (2019), Jaafar and Nasser, (2019), Mohammed et al. (2022), Al-Dulaimy and Al-Banna, (2022). The seismic data available from OEC. This project attempts to reveal new features of the Buzrgan oil field in the southeast part of Iraq using Schlumberger Petrel visualization program to see the 2D arrangement of the deeper structure after reprocessing a grid of previous seismic reflection data. The main goal was to locate any structures in this portion of the basin that extended deeper than the overlaying strata and examine them in Petrel to

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determine their likely origin. To extract deeper Two-way trip times, extended vibrations correlation was used to the original seismic reflection field data. The geologic formations' structural characterization was completed in Petrel.

2. The Study Area Location and Tectonic Setting

The location of the study area in the southeast of Iraq within the Maysan Governorate, as shown in Fig.1. In the Mesopotamia zone, which was created during the Himalayan orogeny, the Buzurgan structure lies in the foreland basin of Zagros Mountain. Horizontal compression was created by this orogeny, which is the result of the Arabian plate moving toward the Eurasian plate, producing compressional structures. (CNOOC, 2015). The Long anticlines with Neogene cores and extensive synclines carrying thick Miocene-Quaternary molasses are features of the Low Folded Zone. In the Low Folded Zone, tertiary successions are primarily well exposed inside the anticlinal and synclinal structures. The Makhul-Hemrin fault, which has an extension on the surface represented by the Tikrit-Amara fault, and the Euphrates fault form the NE and SW boundaries of Mesopotamia, respectively. Jassim and Goff, (2006). Fig. 2 shows the surface structure of the formations in a 3D view.

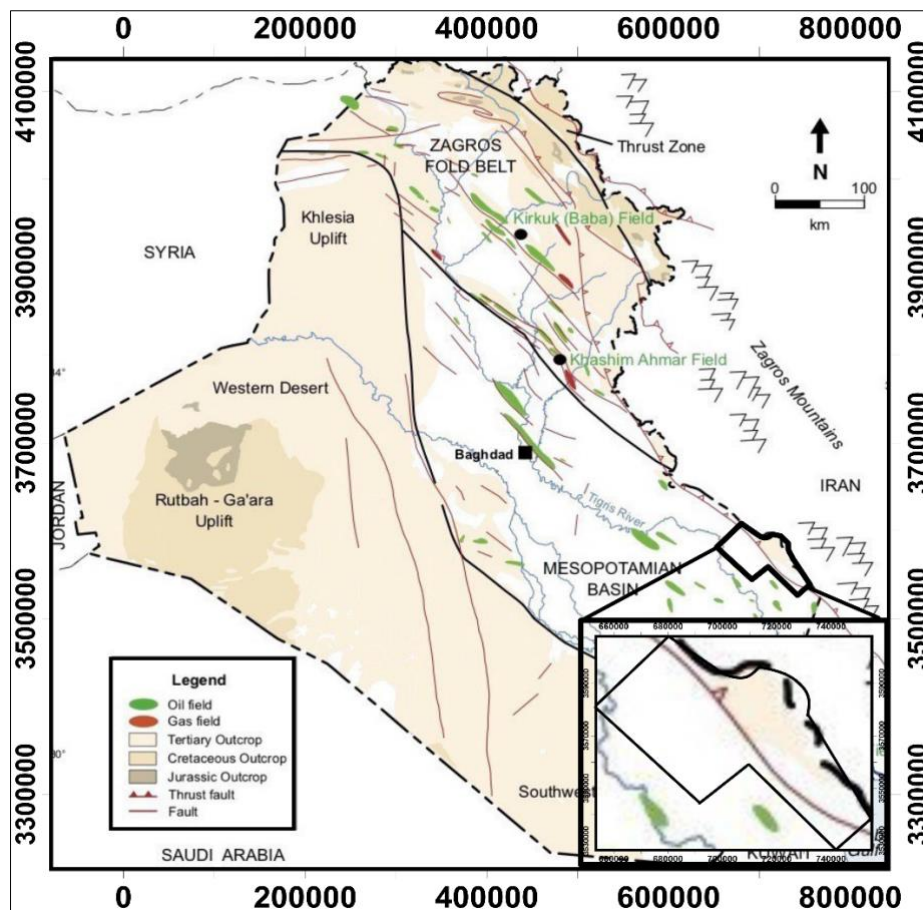


Fig.1 The location map of the study area

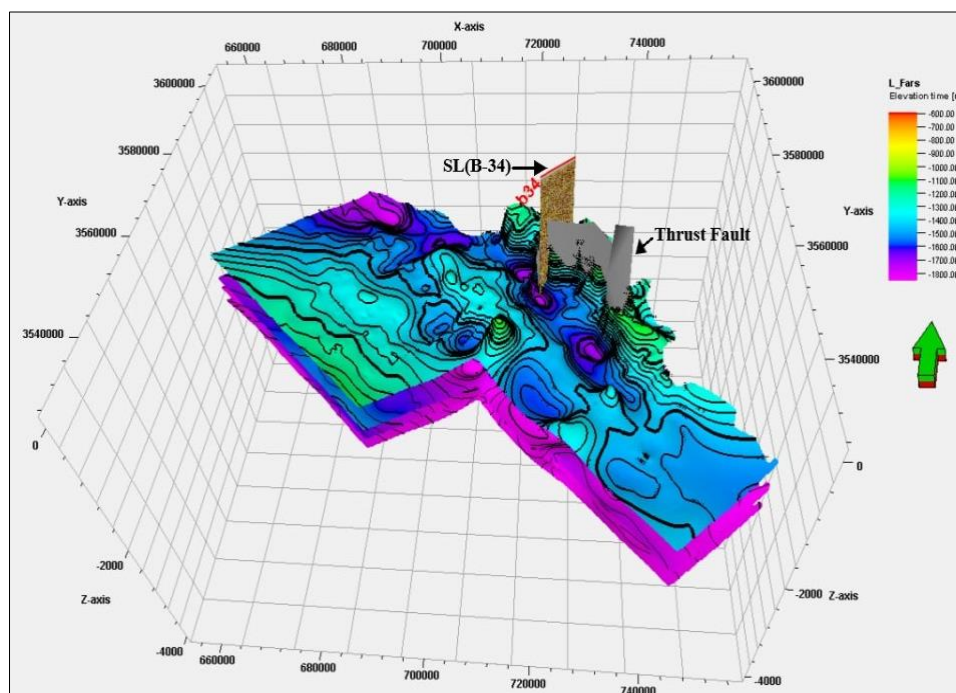


Fig.2 3D map of the study area within L-Fars Formation

3. Materials and Methods

3.1. Data Acquisition and Processing

This research relied on collecting information and results of previous research and studies from Iraq. Petrel program was used to interpret seismic sections, capture reflectors, and extract two-way time, velocity and depth maps of Tertiary formations. The project 2D surveys were carried out by different seismic crew (foreign and national) with different field parameters and for varying periods of time. The French contractor (C.G.G) carried out a 2D survey of the Buzurgan area (Bu) in the period (1977-1978) with a coverage of 12%, the (seismic crew-8) carried out a survey of the West Buzurgan area (WB) in the period (1978-1980) with a coverage of 30%. Interpretation Department, OEC, (1990).

3.2. Base Map Construction

A view map showing wells, seismic lines, and other things with a geographic reference like latitude and longitude or the Universal Transverse Mercator is essentially what is meant by the term "base map" (UTM). The interactive workstation for interpretation loads processed seismic data in SEG-Y format. This procedure is known as construction of a project to accomplish an interactive interpretation process workstation. After that, the study area base map is created, (Fig. 3).

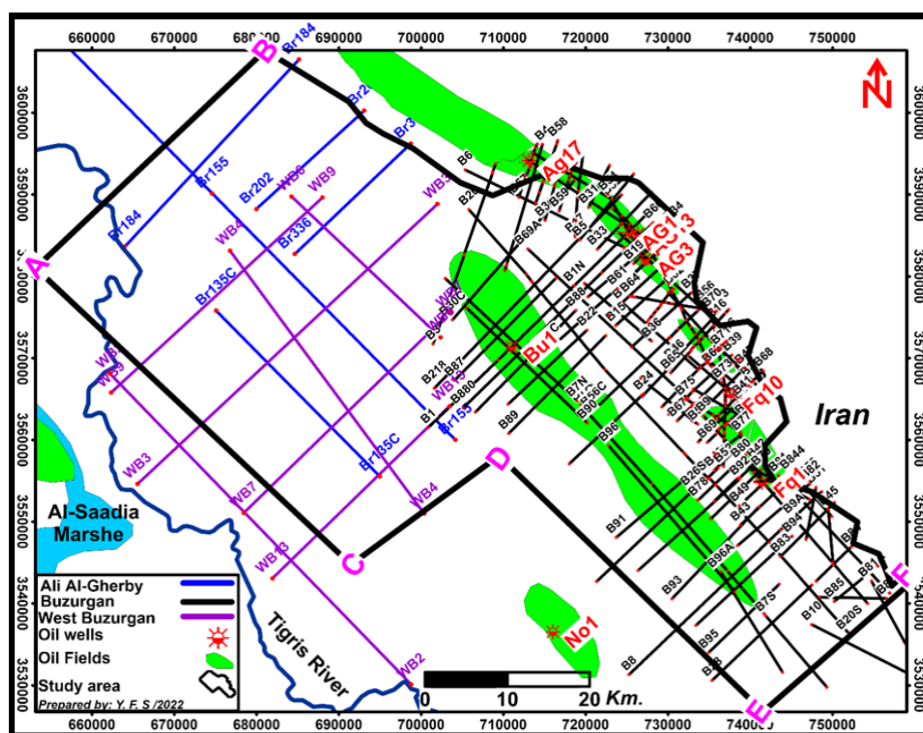


Fig.3.The study area's base map

4. Results and data Interpretation

Seismic interpretation is the last and most important step in any seismic exploration project. This method transforms seismic data into equivalent geological data. (Alsadi, 2015). There were various stages to the interpretation process, as following.

4.1. Horizon Picking

Geology defines a horizon as a layer surface where there is a lithological transition within the context of a sedimentary succession, or as a defining layer with a fossil content or a distinctive lithology within a sequence. (Rey and Galeotti, 2008). The horizon, as seen from the viewpoint of geophysicists, is an interface that could be represented by a seismic event (reflection), the horizon being produced by contact between two rock bodies with different properties that produce different seismic velocity. (for example, fluid content, porosity, density, or all of those (Schlumberger. 2013) (Fig. 5).

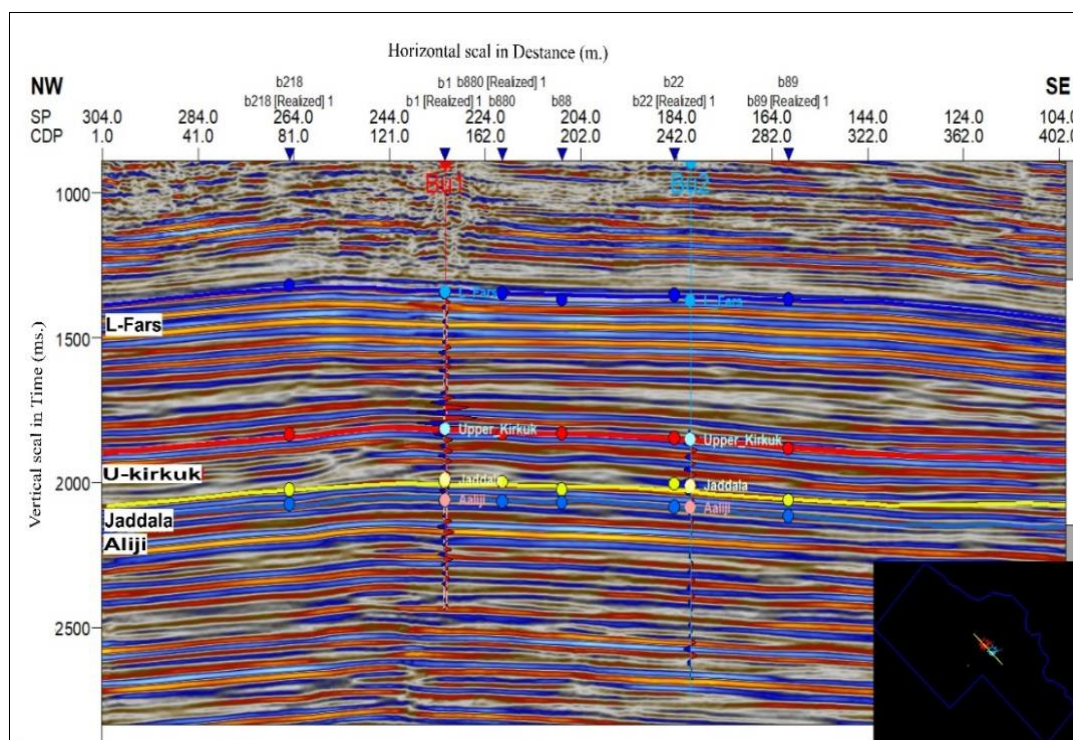


Fig.5. A seismic line BU-1 showing the reflectors of formations with their continuity

4.2. Fault Analysis

After picking reflectors the faults were picked in the study area. Examination the seismic sections that showed the effect of the faults. During the picked process the minor and major fault were identified. Fig.7 shows effect fault (4) which is considered (major fault) The interpretation process of the seismic sections showed presence of thrust fault, the type of this fault determines depending on studying number of seismic sections of a number of seismic lines (b-34) (b-37) as following:

- hanging wall rock units displaced upwards by a relative displacement at the fault plane, and the foot wall rock units displaced downwards by a relative displacement at the fault plane.
- The angle of this fault calculated by using conventional geological engineering methods, it ranges between (37° – 40°), so it is considered as thrust fault.

The study area is tectonically and structurally complex, and the reason is compressional forces stresses on the rock units of these structures due to the collisions the Arabian plate and the Eurasian plate. This fault considered one of the extensions or influences resulting from the main fault (Makhoul-Hamrin), which was activated during the Pliocene age. It is believed that it is the boundary between Mesopotamian and Kirkuk blocks. Component known (late tertiary folding).

Fault geometry details as shown in Fig. 6:

- Fault direction (NW-SE) It is the direction of most structures in Iraq.
- The angle of inclination of the fault (approximately of 38° in the direction of the southwest) and is written as (38° to SW). and strike line (N 52° W).
- It is classified geometrically from parallel faults as well as sharp faults (thrust fault) according to the angle.
- Relative displacement is difficult to measure because of the difficulty in identifying two points on either side of the fault.

- The length of the fault is estimated according to the depth map approximately 38 km within the boundaries of the study area, and its depth does not exceed approximately (2800m). It was determined depending on the seismic sections extracted from the 2D seismic data.

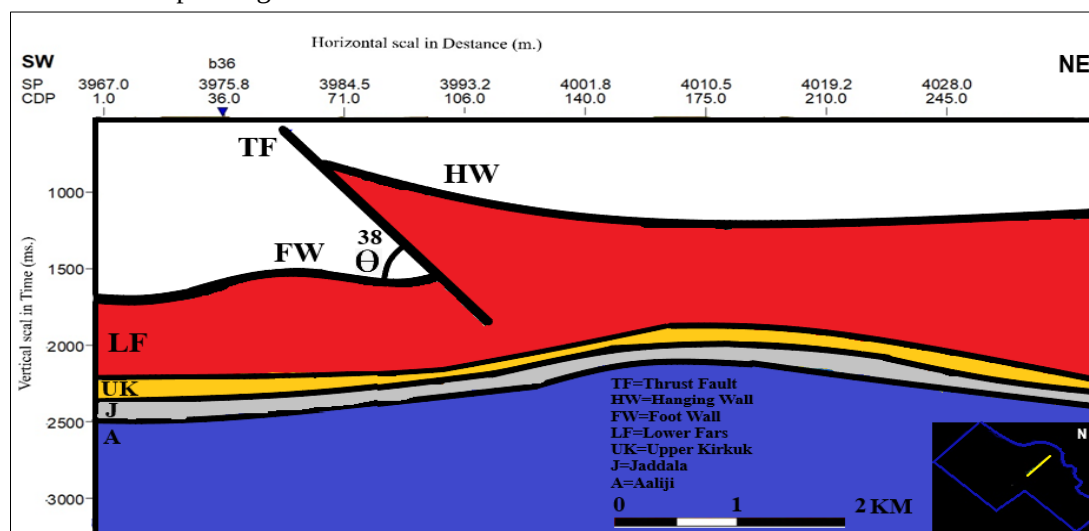


Fig.6. Transverse seismic section NE-SW trend shows fault system

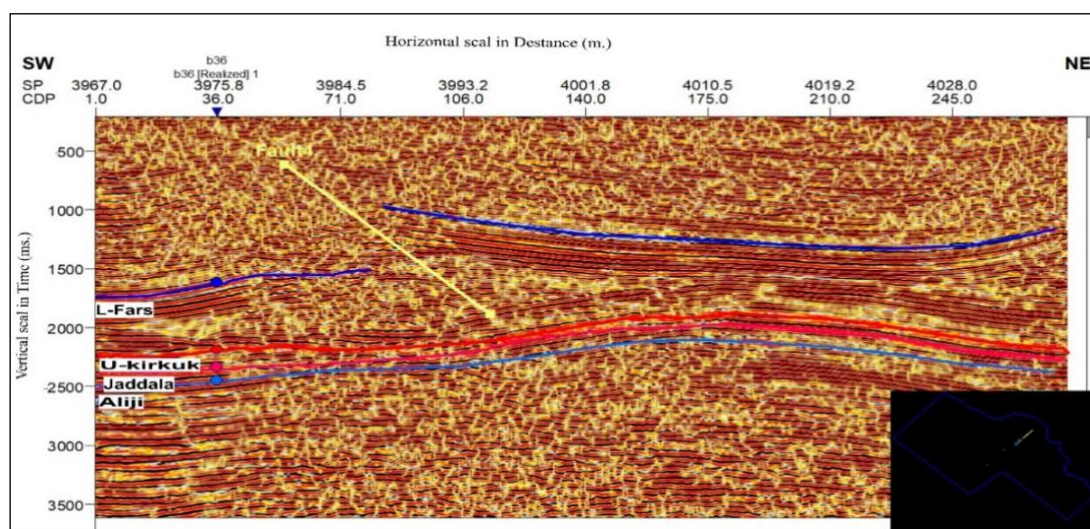


Fig.7. The seismic line B-34 displaying the selected reflectors continuity and fault delineation

4.3. Seismic Attributes

Seismic attributes are the elements of seismic data derived from the seismic data through measurement, computation, and other techniques. Early in the 1970s, seismic attributes were introduced as a component of seismic interpretation. Since then, numerous new properties have been computed and deduced. The majority of these features are of economic interest, and many interpreters and users still do not fully comprehend how to use them. Reviewing the most popular seismic features and their application as interpretation tools and reservoir characterization is the primary goal of this study. (Subrahmanyam and Rao, 2008)

4.3.1. Instantaneous Frequency attributes section

This attribute can be helpful for cross-correlation across faults and for measuring the cyclicity of geological intervals by. It is frequently employed to compute seismic attenuation. High frequency

components typically decrease due to the presence of oil and gas reservoirs. Measurement of the cyclicity of geological intervals and cross-correlation across faults are both facilitated by it. Additionally, it may spot any gas-water or gas-oil contacts. In the presence of noise, instantaneous frequency is frequently unpredictable and challenging to discern. Fig. 8 demonstrates how the frequency at the reflector varies laterally. While the yellow reflects the high frequency and weakly suggests the presence of hydrocarbon accumulation, the red-to-black color represents the low-frequency area and indicates hydrocarbon accumulation.

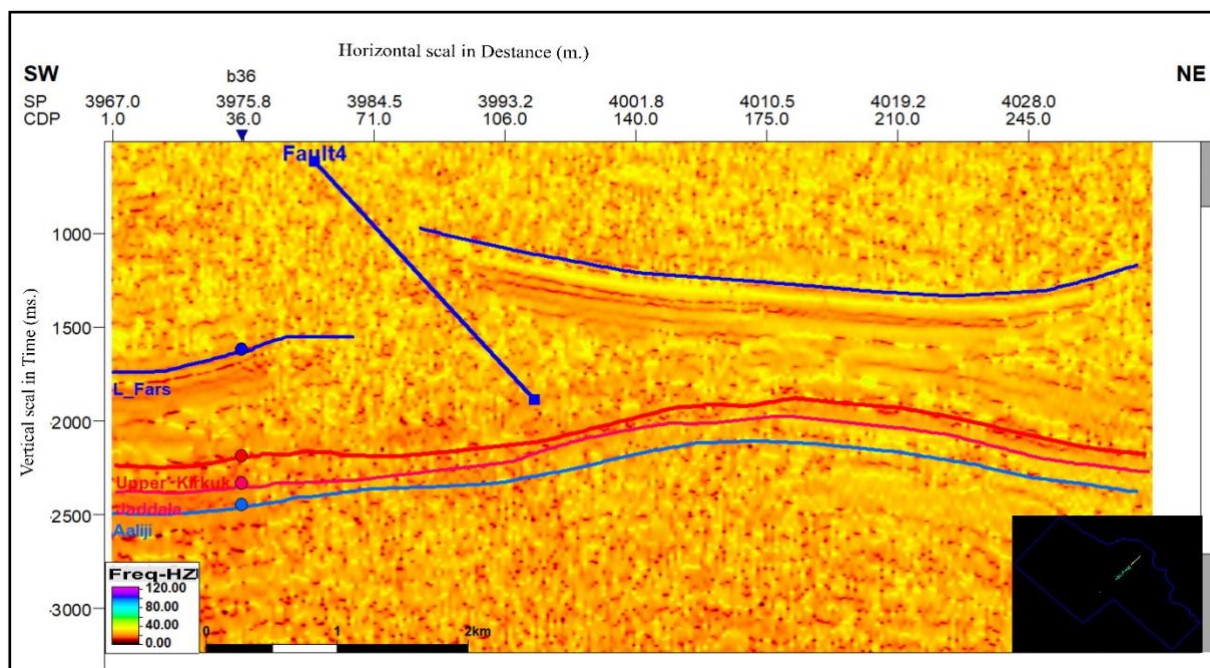


Fig. 8. Seismic instantaneous frequency attribute of Buzurgan survey(b-34)

4.3.2. Instantaneous phase

A strong indicator of continuity, faults, pinch-outs, bed interfaces, sequence borders, and areas with on-lap patterns is instantaneous phase. Due to the attribute's amplitude invariant nature, the Cosine of instantaneous phase is typically utilized. It is frequently used to identify tiny faults and dipping events as well as to determine the continuation of weak occurrences. Although the feature tends to increase noise, it also tends to amplify weak intra-reservoir occurrences. The fault feature in the seismic section in the Buzurgan Survey (b-34) (Fig. 9)

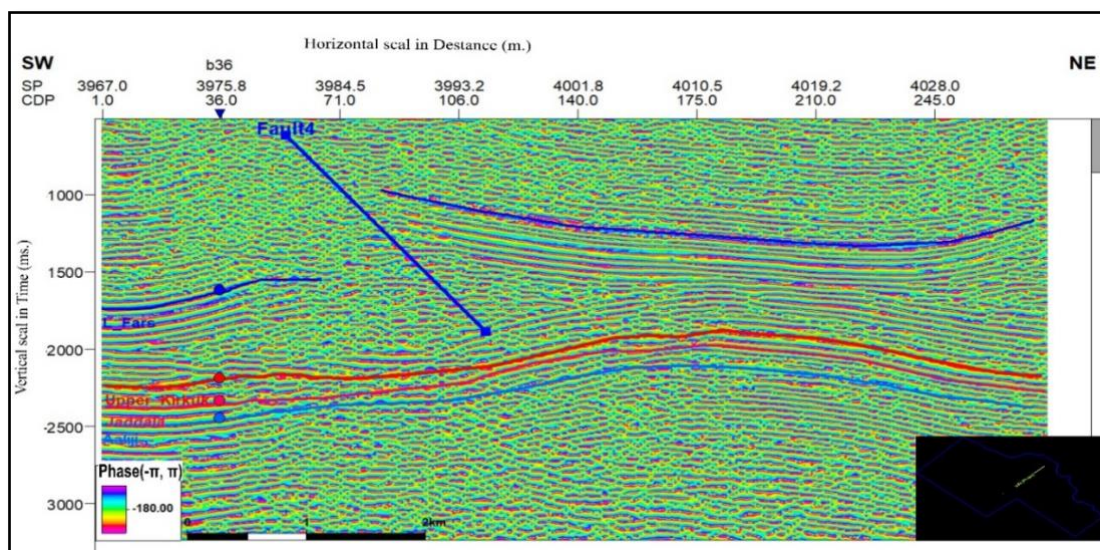


Fig.9. Seismic instantaneous phase attribute of Buzurgan survey(b-34)

4.4. (TWT) Maps

4.4.1. L-fars (TWT) map

The time map of the lower Fars (Fatha) reflector showed the thrust fault system in the far eastern side of the study area and how the structures of Abu Gharb and Fauqi were affected by it, where the reversed thrust fault separated the two surnames of Fauqi and Abu Gharb, and this appears at the level of 1100 milliseconds. The level of 1350 milliseconds in the Abu Gharb structure area is on the east side of the study area, while the west side remains compositionally higher than the eastern side and less affected by the area of the fault.

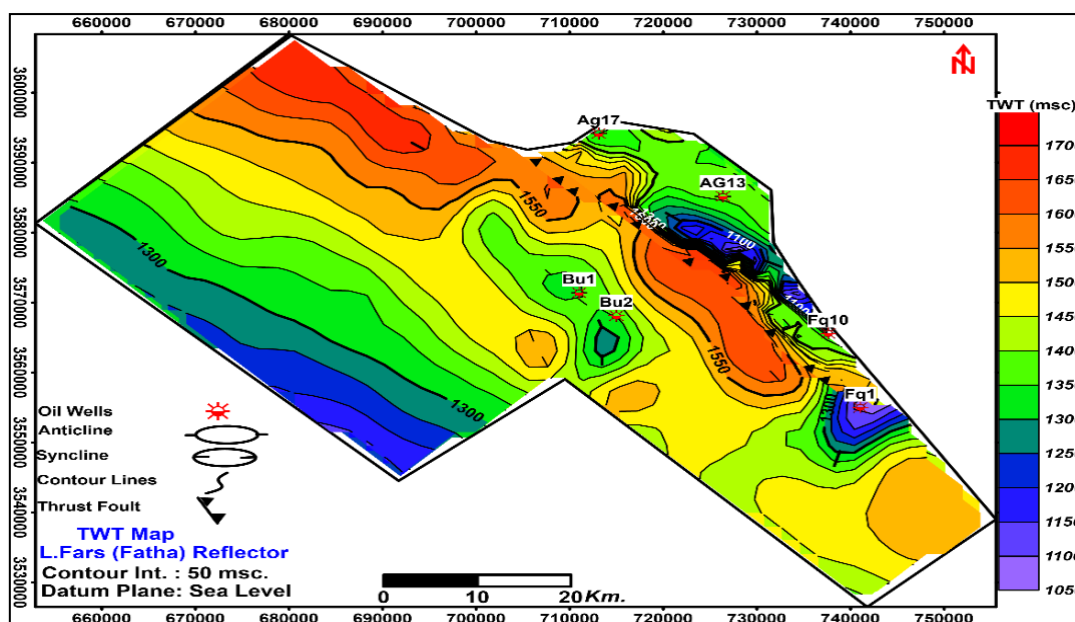


Fig.10. TWT map of Top L-fars Fn

4.4.2. U-Kirkuk (TWT) map

The TWT map of the Upper Kirkuk reflector shows the general slope from the west towards the east and shows the structures of Buzrgan with a contour value of (1900 ms.), which appears as a plunging fold on the time map (Fig 11). The structure of Abu Gharb appears with a period of (1900 ms.) and is located to the east of the thrust fault area towards the Iraqi-Iranian border. The structure of the Fauqi appears with a contour value of (1700 ms.) southeast of the project and neighboring the Iraqi-Iranian border

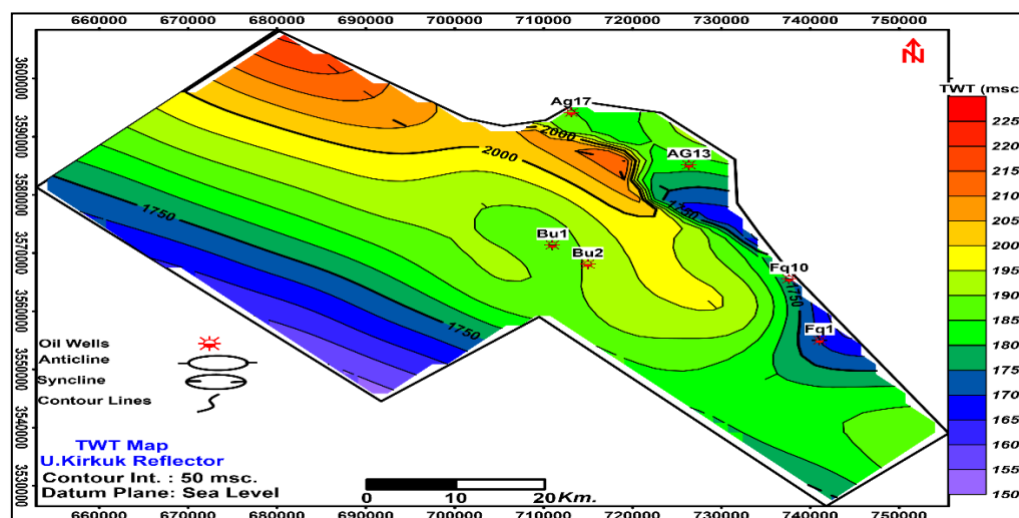


Fig.11. TWT map of Top U-Kirkuk Fn

4.4.3. Jaddala TWT map

The TWT map of the Jaddala reflector shows the general slope from the west towards the east and shows the structures of Buzrgan with a contour value of (2000 ms.), which appears as an anticline on the time map (Fig. 12). The structure of Abu Gharb appears with a period of (2200 ms.) and is located to the east of the thrust fault area towards the Iraqi-Iranian border. The structure of the Fauqi appears with a contour value of (1950 ms.) southeast of the project and neighboring the Iraqi-Iranian border

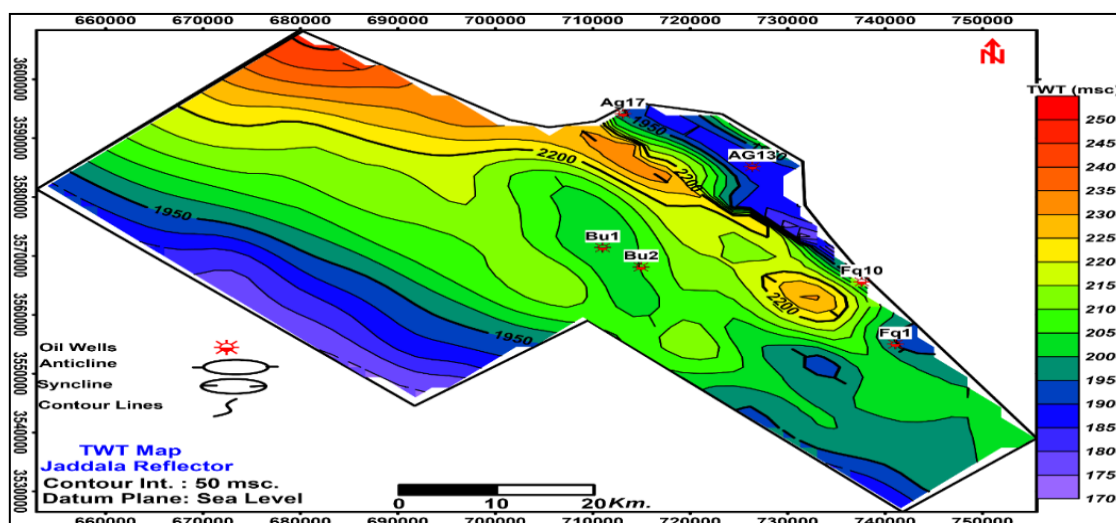


Fig.12. TWT map of Top Jaddala Fn

4.4.4. Aliji TWT map

The TWT map of the Aalijii reflector shows the general slope from the west towards the east and shows the structures of Buzrgan with a contour value of (2100 ms.), which appears as an anticline on the time map, (Fig. 13). The structure of Abu Gharb appears with a period of (2050 ms.) and is located to the east of the thrust fault area towards the Iraqi-Iranian border. The structure of the Fauqi appears with a contour value of (2300 ms.) southeast of the project and neighboring the Iraqi-Iranian border

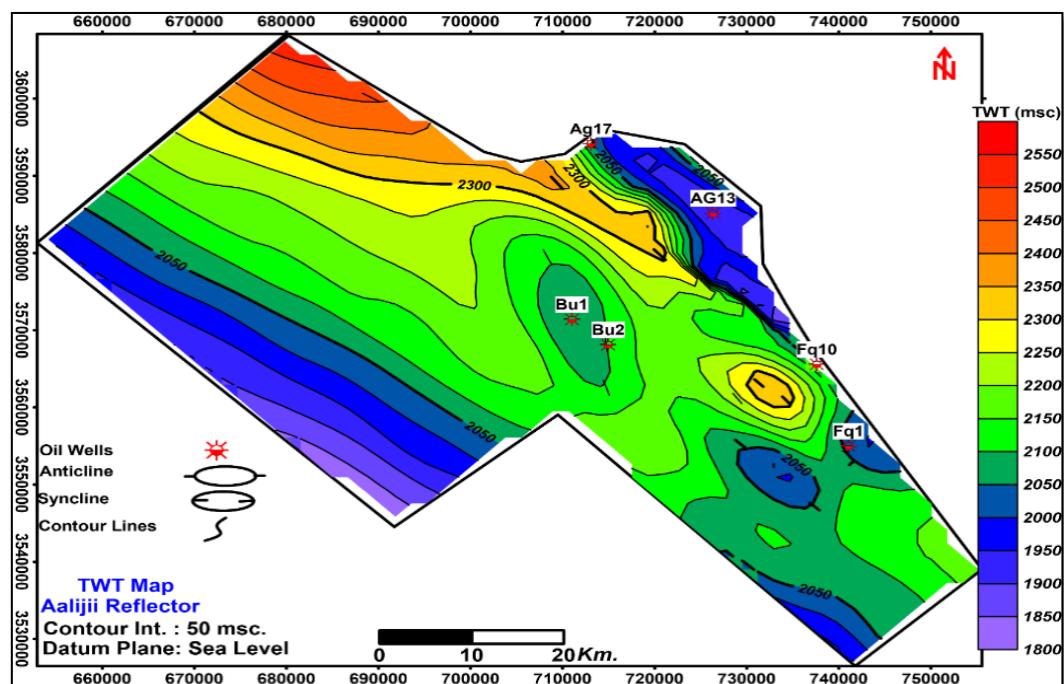


Fig.13. TWT map of Top Aliji Fn

4.5. Velocity Maps

The average velocity should be used to convert time to depth because it is more precise. By using the Check-shot survey for many wells in the study area, we can determine the average velocity from (Time/Depth scale in Check-shot) and contouring the velocity values of wells to draw the velocity map (McQuilline et al. 1984).

- **L-Fars Velocity Maps**
the average velocity increase in N and NE regions, while the lower value concentrated in SW of the study area.
The magnitude of velocity ranges from (2760-3120) m/s (fig 14)
- **U-Kirkuk Velocity Map**
the average velocity increase in N and NE regions, while the lower value concentrated in SW of the study area.
The magnitude of velocity ranges from (2690-3320) m/s (fig 15)
- **Jaddala Velocity Map**
the average velocity increase in N regions, while the lower value concentrated in SW of the study area.
The magnitude of velocity ranges from (3040-3500) m/s (fig 16).

- Aaliji Velocity Map
the average velocity increase in N regions, while the lower value concentrated in SW of the study area.

The magnitude of velocity ranges from (3100-3540) m/s (fig 17).

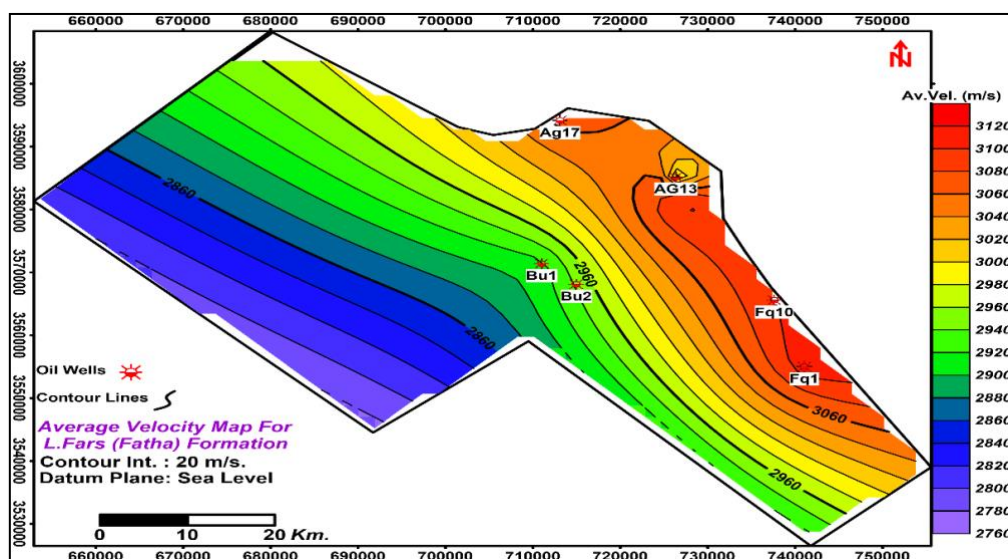


Fig.14. Velocity map of Top L-fars Fn

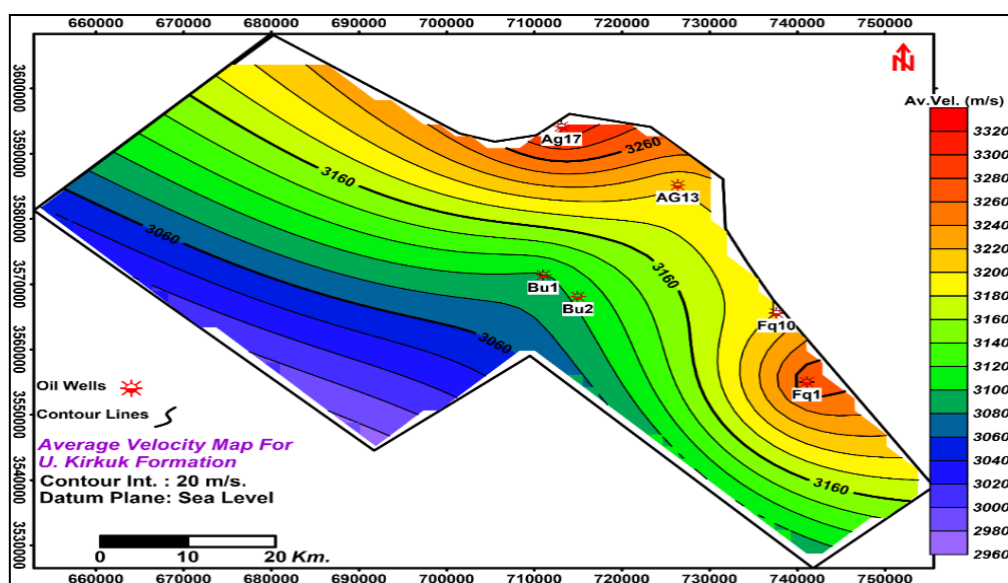


Fig.15. Velocity map of Top U-Kirkuk Fn

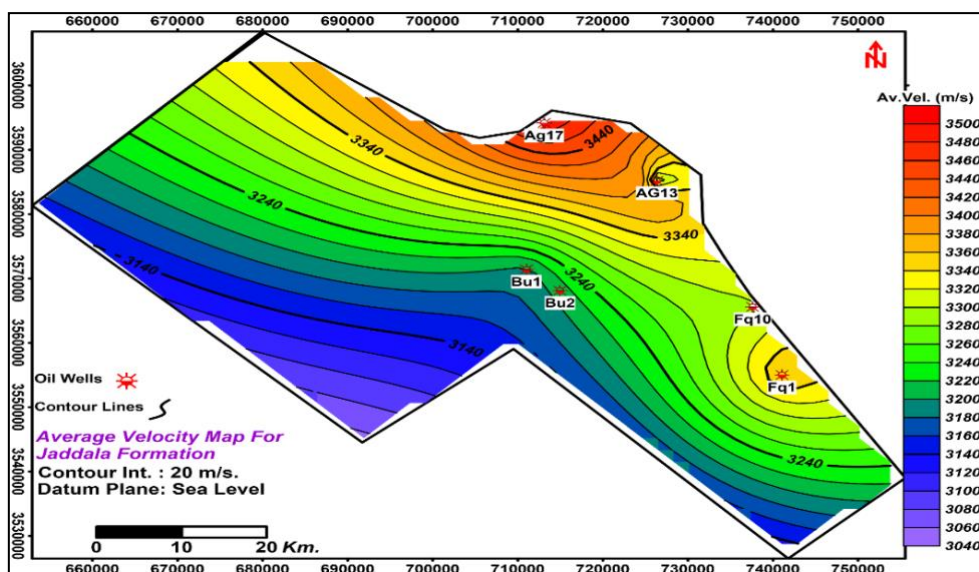


Fig.16. Velocity map of Top Jaddala Fn

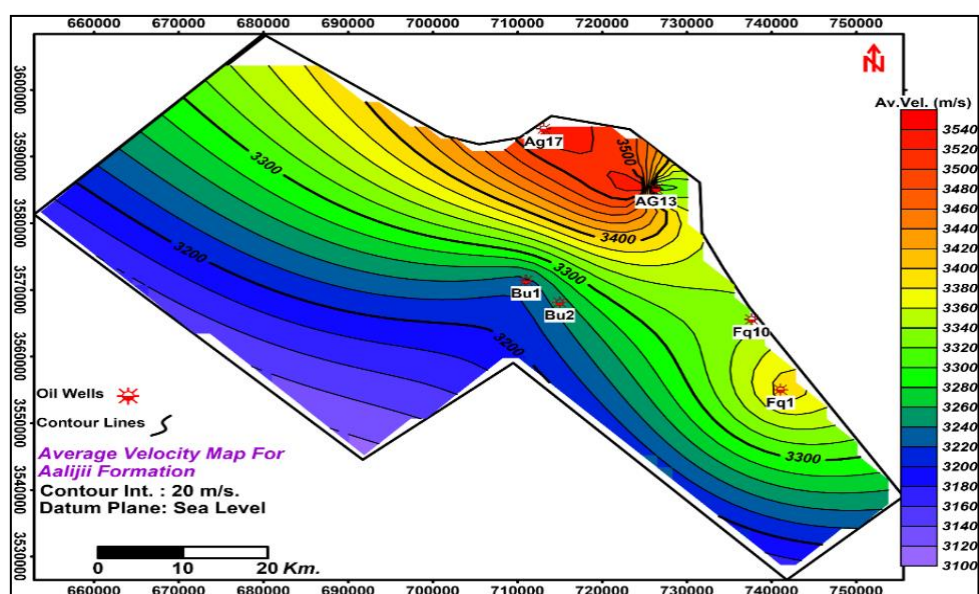


Fig.17. Velocity map of Top Aliji Fn

4.6 Depth Maps

The depth map is a critical step in seismic reflection because it allows the depth and thickness of the depicted subsurface layers to be calculated using reflective data. The depth map values extracted from the reflector time map with its average velocity map:

$$\text{Depth} = (\text{Average velocity} \times \text{TWT} / 2) \text{ at this point}$$

In producing the depth maps, it relied on the velocity file extracted from the wells and applied the relationship of velocity with time. On this basis, four depth maps were prepared to represent the studied formations (L-Fars, Upper Kirkuk, Jaddala, Aalijii) from a unified reference level that is sea level and with a period of contour lines (50 m.).

A depth map gives a structural image of the area that is closer to reality than a time map. The depth maps Figs. 18,19,20&21 show that the northeast part of the study area is structurally complex due to the

presence of a number of anticline folds with a NW-SE direction. The study area according to the tectonic map, it was found that the area falls within two zones, namely: (Kirkuk subzone and Mesopotamian subzone). It is also clear that there is a fault in the direction of northwest-southeast, and it is believed that this fault is the boundary between the (Kirkuk subzone and Mesopotamian subzone) and the type of this fault (thrust fault). The depths increase towards the north and some parts of northeast and southeast parts of the study area, and the depths decrease towards the southwest and specific areas from the northeast around (AG-13) well. We note the presence of a number of structural closures that center around Bu-1, Bu-2, Fq-1, Fq-10 and Ag-13. There is also a structure nose towards the north of the region.

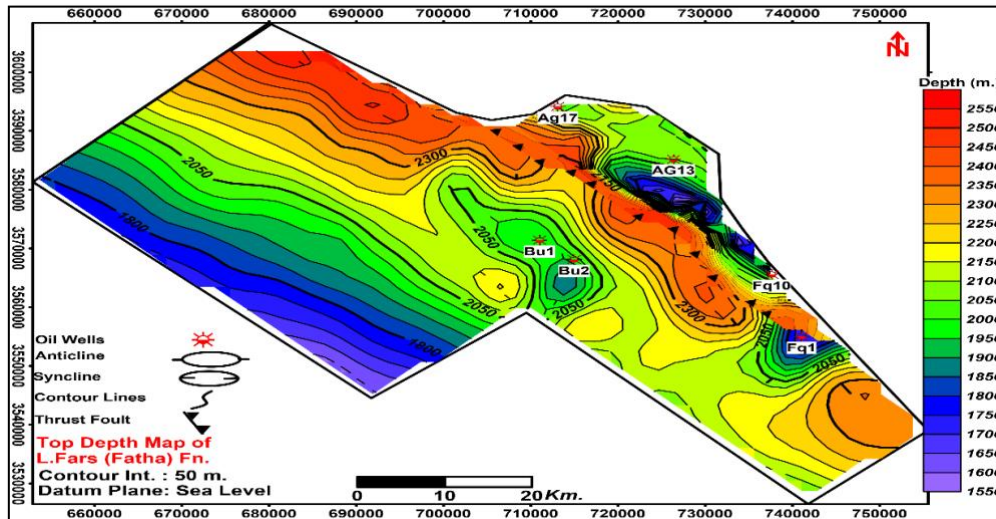


Fig.18. Depth map of Top L-fars fn

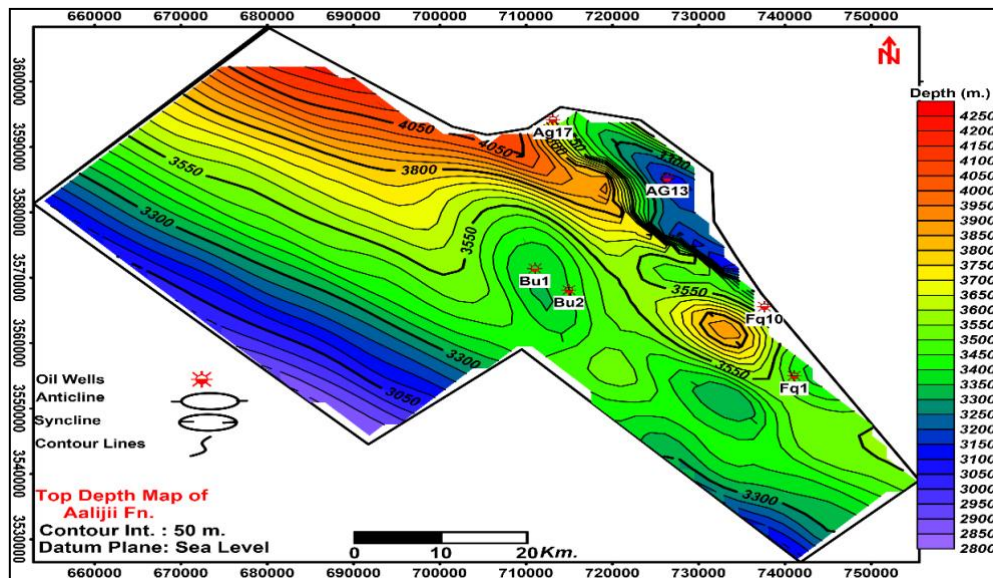


Fig.19. Depth map of Top U-Kirkuk Fn

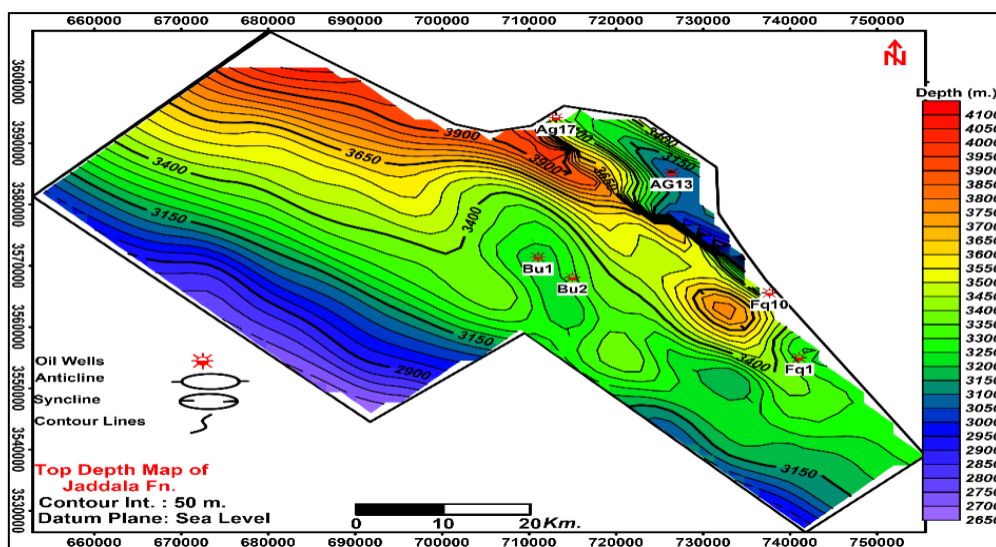


Fig.20. Depth map of Top Jaddala Fn

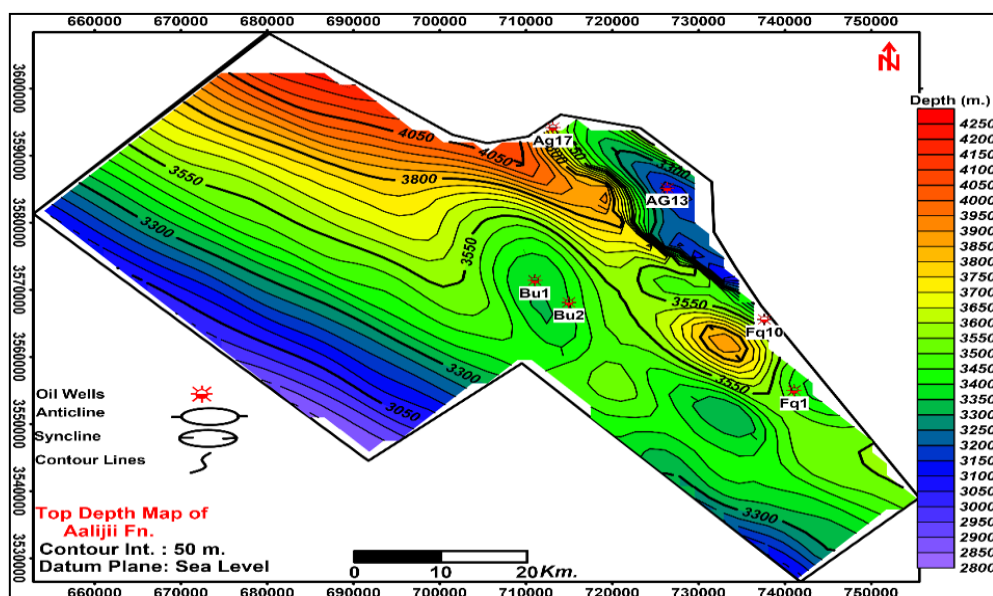


Fig.21. Depth map of Top Aliji Fn

5. Conclusions

Four reflectors, within L-fars, U-Kirkuk, Jaddala and Aaliji for the BU-1 well, synthetic seismograms in the time domain are used to characterize formations. The Four formations 2D seismic reflection interpretation were interpreted, depth maps were obtained of the four formations indicate presence of many closures (synclines and anticlines) as a result of the tectonic complexity of the region, it distributed and trended in NW-SE direction. Through the depth maps, a main fault has been identified in the NW-SE direction, and it is clear the type of this fault is thrust fault. And also, the presence of a structure nose towards the northeast of the study area.

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