Interpretation of 2D Seismic Data of Shurau and Sheikh Alas Formations in Ismail Area, Northern Iraq

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Abstract
The 2D seismic reflection data were used to study the structure of Shurau and Sheikh Alas formations (Oligocene) in the Ismail area, northern Iraq. The horizons of Shurau and Sheikh Alas reflectors were identified based on seismic data and well logs through a synthetic seismogram construction. The Two-Way Time, velocity and depth maps of two coinciding formations were obtained. A Great coincidence was noticed between two identical maps of the two formations. The Main closure (syncline) trending NE-SE was detected at the southwestern part of the study area, the syncline is associated with many anticlines in the same trend. The northern part of Bai Hassan structure was appeared at the southeast part of the study area, while some northeastern part of Qara chauq structure was detected in the southwestern part of the study area. The structure features of the two formations mostly trending NW-SE with some local variations may be due to transversal faults.

Keywords: 2D Seismic; Shurau Formation; Sheikh Alas Formation; Ismail Area; Northern Iraq

1. Introduction

In the late 1800s, geophysicists began to track hydrocarbon buildup patterns (Savit, 1988). Geological features in oil and gas resources can be studied via seismic analysis. Using this method, it is possible to estimate the Earth's seismic section, velocity, and time frame (Milsom, 2003). Seismic interpretation oversees the process of obtaining geological data from seismic data. There are three basic processes to conducting a seismic survey: data collection, data processing, and data interpretation. There are several steps involved in creating a seismic segment that is suitable for the interpretation phase of this process (Alsadi, 2015). Numerous oilfields in Iraq have undergone extensive seismic surveys to learn more about their subsurface geology. For the most accurate picture of the stratigraphy and structure, researchers say that the seismic reflection approach provides an outstanding depiction of the subsurface geology and provides good evidence of oil deposit (Roy, 2008; Ali and Kadhim, 2020; Shehab and Ali, 2021; Abdullah et al., 2021; Faisal and Ali, 2021). By using data from the Oil Exploration Company (OEC), to study the Ismail area, which is located in south Arbil, northern Iraq. The goal of this study is to investigate the area's Ismail structural images and identify the geometric boundaries for its structures.
2. Location and Tectonic Setting of the Study Area

At a distance of 55 km from Kirkuk, the study area is located in northern Iraq within the confines of Arbil (Fig. 1). The Bai Hassan Field is located to the northwest of this area at a distance of 1 kilometer. It is located in the Butmah-Chemchem subzone and the Deir Alzor – Arbil block of the unstable shelf (Foothill Zone) of the low folded zone. With the exception of the Kirkuk structure, the predominant features of the subzone are lengthy anticlines that are rarely connected with longitudinal faults. The subzone is notable for its wide and deep synclines. (Jassim and Goff, 2006). Gravel and sand deposits from the Pleistocene era dominate the majority of the region's surface, while mountain chains with dominating rocks from the Bai Hassan and Muqdadiya formations from the Pliocene epoch cover the rest of the territory (Jassim and Goff, 2006).

Fig. 1. The location map for the study area based on the tectonic map (Al-Kadhimi et al., 1996)

3. Materials and Methods

3.1. Acquisition and Data Processing

The study is an interpretation study (mainly structural interpretation) for a 2D survey with previous achievement by oil exploration company and foreign companies obtained in the Ismail area. In this study, Two-dimensional seismic achieved for surveys within the study area, the aim of this study deals with the processing of the 27 line with a total length of 227 km and covered a total area of 405 Km² selected from 2D seismic survey (BH Bai Hassan, BHI Bai Hassan - Ismail, KC Qara Chauq, KK Khormala – Kirkuk) over a long period of time and by a variety of seismic research teams (national and foreign). The processing of 2D seismic sections involved digitizing and re-archiving the sliced picture in digital form, as well as maintaining the continuity of reflectors between the two formations within the Kirkuk Group utilizing digital and paper seismic data. In this investigation, we're looking at two different types of structures (EOC, 2019a).
3.1.1. Sheikh Alas Formation

This Formation represents the oldest Oligocene reefs and forereefs. At Sheikh Alas hamlet, 50 kilometers south-southeast of Mosul. (Bellen et al., 1959) described the formation by an outcrop in the north dome of the Qara Chauq. This formation consist of porous rubbly dolomitic and recrystallized limestone structure. In the Kirkuk area, the thickness rises to 50 m (Jassim and Goff, 2006).

3.1.2. Shurau Formation

The well K-109 in the Kirkuk structure contains the Oligocene subsequence which was first described by (Bellen et al., 1959). Coralline limestone measures 18 meters thick in the bottom portion, and grey dense limestones are found further up. The contact between the Sheikh Alas Layer and the overlying formation is conformable. There is an unconformity at the upper contact of the Baba Formation (Jassim and Goff, 2006).

3.2. Base Map Construction

A total of 27 seismic lines were employed and fed into the Petrel software as 2D time-domain data in the SEG-Y format using the seismic interpretation window. The interactive workstation's interpretation procedure is accomplished through the usage of this method. After that, create the basic map of the study area (OEC, 2019b) (Fig. 2).

![Fig. 2. The base map of the study area including the considered seismic line of Is-1 well.](image)

3.3. Synthetic Seismogram generation

The acoustic impedance is computed by multiplying the calibrated sonic log by the predicted density log, and the reflection coefficient is then derived. A synthetic seismogram is created by convolution of the reflection coefficient with the deterministic wavelet. By using the information of well Ismail-1(Isl-1) represented by good logs (sonic log & density log), and seismic data to create the synthetic for well Ismail-1, and create the best (Wavelet) from seismic data in well location by correlating significant reflections on the seismic section with marker beds or other correlation points on the excellent log, synthetic seismogram is in good agreement with the seismic section (Fig. 3).
4. Results

4.1. Seismic Data Interpretation

The final and most critical step in any seismic exploration endeavor is the seismic interpretation. Seismic data is converted into equivalent geological information via this technique (Alsadi, 2015).

4.1.1. Horizon picking

Picking is the act of identifying the reflection of a seismic segment. Is it possible to identify the same wiggles in each trace, or which wiggles come from the same rock layer (Abd Al-Ridha and Yousif, 2019). Horizon choosing is the most critical step in seismic interpretation. The Shurau and Sheikh Alas Formations chosen reflectors have good to intermediate continuity and quality. In addition to the number of faults that were picked from the seismic section (Fig.4).
4.1.2. Two Way Time (TWT) maps

Two-way-time maps were created using Petrel 2018 software, with a contour interval of 50 ms (Figs. 5 and 6). The two maps have a strong correlation in terms of greater and lower values, as well as the position of structural closure. Figs. 5 and 6 show the TWT map of the Top Shurau Formation and the TWT map of the Top Sheikh Alas Formation respectively, the TWT value ranges from -200 to -1200 ms. Furthermore, the TWT maps of the Top Shurau and Top sheikh Alas show that the larger value of time is toward the W-direction and decreases in the E and NE directions of the area and structural closure (syncline) away from Ismail-1 well with a distance of two kilometers southwest of the well, with a closure value of 50 ms and its axis NW-SE, with a dimension of approximately (10*3) km. These maps also show the northern part of Bai Hassan structure at the southeastern part of the study area, while at the northeastern side of the Qara Chauq structure was appeared (Fig. 5) (Al-mufti and Qanbar, 2019).

![TWT map of Top Shurau Formation](image)

Fig.5. TWT map of Top Shurau Formation

4.1.3. Velocity maps

Check-shot surveys of many wells surrounding study area can be used to calculate the average velocity, which is the most precise method for converting time to depth as showing in Figs.7 and 8 for the Shurau Formation and the Sheikh Alas Formation respectively, average velocity maps were obtained using a velocity model. The velocity maps of the two formations are similar in terms of high and low values and their distribution in the study area. Using a 50 m/s contour interval, we measured the velocity of the top Shurau at 2600-3050 m/sec and the velocity of the top Sheikh Alas at 2620-3220 m/sec. For the two formations, the highest values of velocity were concentrated in the south and southeast regions, while the lower values were concentrated in the center, north, and north-east of the study region.
Fig. 6. TWT map of Top Sheikh Alas Formation

Fig. 7. The Velocity map of Top Shurau Formation
4.1.4. Depth maps

The depth maps values were obtained from the velocity and one-way time using the equation 1 below.

\[
\text{Depth} = \frac{\text{Average velocity} \times \text{TWT}}{2}
\]

There is also evidence of the main closure (syncline) on the TWT map (Figs. 9 and 10), as well as the presence of anticline folds visible on the depth maps, with structures such as the Bai Hassan Field, the Dawood Dome, and the fixed Qara Chauq structure effect all located east and southwest respectively. These fixed structures are all part of the Bai Hassan Field. It was apparent from both depth maps of the two formations that high-depth zones are located in the southeast, whereas shallow depths can be found in the south and east of the research area.

![Fig.8. The Velocity map of Top Sheikh Alas Formation](image)

![Fig.9. The Depth map of Top Shurau Formation in Ismail Area](image)
5. Conclusions

The 2D seismic reflection interpretation of the two coincide formations (Shurau and Sheikh Alas) were interpreted. Finally, two depth maps of the Shurau and Sheikh Alas were obtained. Both maps indicate presence of many structures mostly trending NW-SE such as main closure (syncline) and many anticlines located at the eastern side of the main closure in the study area. The northern part of the Bai Hassan structure appears at the southeast part of the study area, while northeastern part of Qara Chauq structure appears at the west side of the study area.

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