2D Seismic Interpretation and Characterization of the Upper Qishn Clastics in Sharyoof Oil Field, Masila Basin, Yemen

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Abstract. The Sharyoof oil field is located off shore in Block 53 in the northeastern part of the Syaun-Masila Basin, in the province of Hadramaut, 550 km from the city of Sana'a, the capital of Yemen. Fifteen 2D seismic lines along with six wells data are used to construct subsurface geological profile, and to identify major structural features in the study area. Synthetic seismograms have been constructed using sonic and density log for all available wells to tie horizons to seismic data and to generate time and depth subsurface maps. This research has been carried out using integrated 2D seismic and petrophysical studies in Sharyoof oilfield. Using the analysis and interpretation of seismic data, the main structural faults were identified, maps of isochrones, structural maps of depth and thickness were constructed, which subsequently will allow us to correctly determine the deep geological structures in Upper Qishn Clastics member and evaluate the oil horizons of the Sharyoof oilfield.

1. Introduction

The Syaun-Masila basin is one of the significant oil-bearing basins in Yemen, which was formed in the Mesozoic period as a result of the formation of Najd fault systems of north-western strike. (Al-Areeq 2014, Brannan 1999, Alaug 2011). The studied Block 53 of the Syaun-Masila basin (Fig. 1) has an area of 482 km² and is located between the Sunah oil field in the southeast (Block 14), the Karir oil field in the west (Block 10) and the Tasuo oil field in the east (Block 32). The Sharyoof oil field is located off shore in Block 53 in the northeastern part of the Syaun-Masila Basin, in the province of Hadramaut, 550 km from the city of Sana'a, the capital of Yemen (As-Saruri 2014, Al-Areeq 2011).

Since 1999, exploration and production work has been ongoing at the Sharyoof oil field. Moreover, the previously conducted 2D seismic surveys in the areas of the basin as a whole and in the Sharyoof oil field turned out to be of poor quality, possibly due to lack of data and / or due to the lack of improved programs that can qualitatively identify the features of the geological structure of the area. Since 2008, studies have been carried out that allow more accurate comprehensive interpretation of seismic and well data. Despite the rather serious study of complex geological structures in rift basins, there is still the problem of obtaining accurate data on oil and gas reservoirs, which negatively affects the efficiency of exploration (King 2003, Senyukov 2016, As-Saruri 2014, Hakimi 2011, Hakimi 2015).
The aim of this work is to study the geological and subsurface structures of the Sharyoof oil field using seismic data and wells data that will characterize its geological structures.

1.1. Geological setting
The Syaun-Masila rift basin is a symmetrical graben made up of mid Jurassic to Palaeocene sediments which overlie Pre-Cambrian igneous and metamorphic rocks (As-Saruri 2012). The structural trends of the basin are defined by NW-SE and ENE-WSW orientated faults. Producible quantities of oil are found in a number of different reservoirs including Precambrian / Archean granitic basement and Lower Cretaceous Saar Formation carbonates, and Qishn Formation clastic deposits (Beydoun 1993, Omran, 2014). The most successful reservoir is the Qishn Formation Sand. (Lashin 2016, Naji 2010, Khamis 2017, Hakimi 2018, Vorobev 2019).

The Qishn formation basically post-rift deposits in the Syaun-Masila rift basin, which start in the period from the upper Jurassic to the lower Cretaceous. Sedimentation age Lower Cretaceous period Barremian-Aptian stage. The Qishn Formation is divided into two groups: Qishn Carbonate and Qishn Clastics. Qishn Clastics has been classified into Upper and lower Qishn Clastics. The Upper Qishn Clastic Member is largely composed of shallow marine sandstones and mudstones in the east and fluvo-deltaic sands, silts and conglomeratic deposits in the west; some intertonguing eastwards with carbonates occurs in the upper part. The Upper Clastics is the main hydrocarbon-bearing reservoir of the Syaun-Masila basin. The Upper Qishn Clastics have been subdivided into 3 units: the S1 (top), S2 (middle) and S3 (base). The S1 sands constitute the main producing reservoir in the Sharyoof Field. The Qishn Carbonate Member is mostly composed of shallow marine and deeper water carbonates and mudstones with local development of shoals consisting of rudists or corals; the sequence often starts with a transgressive shale interval of a few meters thickness preceding full carbonate deposition (Beydoun 1993, Putnam 1997, Leckie 2003, Hakimi 2016).
2. Material and methods

The data were provided accessible by the Data Bank Development Project (DBDP). The 2D seismic data used in this study are covering an area of approximately (482 km²). The data consists of 15 lines, nine of these are oriented in SE-NW and S-N and the other six lines are oriented in the SW-NE and six wells data are used to tie wells to seismic data to construct subsurface geological profile, and to identify major structural features in the study area. The data were processed using Petrel™ (version 2015.5) of Schlumberger Inc.

3. Results and discussion

Horizons and faults were interpreted on the seismic sections as described in figures (2, 3, and 4). The stratigraphic units were identified by tying the borehole data and 2D seismic lines. Synthetic seismograms were used for horizon picking, to match stratigraphy. Eight stratigraphic units have been identified and fully delineated: (Fartaq Formation, Harshiyat Formation, Upper Qishn Carbonate Member, Red Shale “Marker bed”, Upper Qishn Clastics S1 unit, Upper Qishn Clastics S3 unit, Lower Qishn Clastics Member, and Saar Formation).

3.1. Seismic line 92a29

The 92a29 seismic profile (Figure. 2A) crosses the Sharyoof-02 and Sharyoof-04 wells in the middle part of the study area. The eight stratigraphic units mentioned above have been described and interpreted throughout the section. The tops of these stratigraphic units were identified for the Fartaq Formation at the intersection of wells with an average TWT of 480 ms; and 502.61ms for the Harshiyat Formation, 939.65ms and 987.93 ms, for the tow Qishn Carbonate Members, including Upper Qishn Carbonate Member and Red Shale Marker, respectively; 992.03 ms for Upper Qishn Clastics “reservoir”; 1059.16 ms for Lower Qishn Clastics; and 1074.75 ms for Saar Formation. This seismic section crosses 6 faults, among which four main faults stand out (fault 1, fault 2, fault 4, fault 5). It must be noted that in sum to the disjunctive violation of fault 2 and fault 3, all the others cross the entire Lower Cretaceous department. It should also be noted that all faults extend in the direction of NE strike with different dip azimuths i.e. NW for fault 1, 4 and 6; SE for faults 1, 2 and 5. On the seismic line in the structure of the region we observe a stepwise discharge towards the southeast, High in the central region and Low in the northern direction (fault 1, 2 and fault 3). Thus, a horst is forms between faults 1 and 4, and graben between faults 4 and 5.

![Figure 2. Interpreted 2D seismic section A) Seismic line 92a29 NW-SE showing the faults and horizons and B) Seismic line 116 WN-ES showing the faults and horizons.](image-url)
3.2. Seismic line 116

The Seismic section 0116 (Figure. 2B) is a 2D interpreted seismic section running NW-SE, Sharyoof Oil Field, Syaun-Masila Basin-Yemen. The Seismic section 0116 crosses the Sharyoof-02 well near the middle part of the study area. This seismic section crosses 5 faults, among which four main ones stand out (fault 1, fault 2, fault 4, fault 5). It should be noted that, apart from fault 2 and fault 3, all the others cut through the entire Early Cretaceous structure. It should also be noted that all faults of the north-east strike of NE with different directions of fall (NW for fault 3 and 4, SE for faults 1, 2 and 5).

On the seismic line in the structure of the region we also observe a stepwise discharge towards the southeast, High in the central region and Low in the northern direction (fault 1, 2 and fault 3). Thus, graben is forms between faults 4 and 5, and horst between faults 1 and 4.

3.3. Structural configuration of Upper Qishn Clastics

As a final result of the interpreted seismic data, the structural patterns and faults were depicted to illustrate the tectonic features characterizing the study area. Accordingly, structural and thickness maps were constructed for the main interesting member of Upper Qishn Clastics.

The depth structural contour map constructed on the top of Upper Qishn Clastics member is represented in (Figure 3A) has been color contoured to highlight structure high in red and yellow colors and structure lows in blue and green colors. The Upper Qishn Clastics member occurs in the depth interval of 508-539 m subsea, in the area of wells, determined according to the data of wells (red and yellow colors). When considering changes in the depth of the top Upper Qishn Clastics member, a noticeable gradual increase in the depth towards the southern sector to a maximum value of -750 m (blue and green colors). The middle part of the study area, as seen from depth structural map, is structurally high. The structural contour map on the top of the Upper Qishn Clastics member, shows one main general fault trends NE-SW. These faults, form horsts and grabens. Maximum depth values are found in the graben areas and the minimum depth values are found in the horst areas of the basin. These maps are break down by six faults (F1, F2, F3, F4, F5, and F6), in the NE-SW in direction. horst formed in between (F1, F4), while the graben in between (F4, F5). The Upper Qishn Clastics consists Mainly Sand/ Sandstone with minor streaks of Shale/Claystone and Limestone.

Figure 3. A) Depth structural contour map for the Upper Qishn Clastics member and B) Thickness depth map for the Upper Qishn Clastics member.
The thickness of Upper Qishn Clastics member was obtained from seismic and well logs data and used to construct thickness map to demonstrate the variation in the thickness based on the sequence of structural changes occurred in the interested area. The total thickness of the Upper Qishn Clastics member (Figure 3B). In the central part, determined according to well drilling data is within 79-152 m. It is virtually unchanged throughout the study area. The exception is the south-eastern part of the area, where it reaches 180 m and the blue zone of the study area, where the thickness decreases to 75 m.

4. Conclusions
This research has been carried out using integrated 2D seismic and petrophysical studies in Sharyoof oil field, of the Masila Basin Yemen. 2D seismic data have been processed and interpreted by Petrel™ (version 2015.5) of Schlumberger Inc. The petrophysical prosperities have been evaluated through the analysis of well-logging data using Petrel™ (version 2015.5) of Schlumberger. The results can be concluded in the following items:
- Discontinuous disorders were identified and mapped, the conditions for their development were studied, the block nature of the structure of the Sharyoof oil field was proved.
- Based on the interpretation of two-dimensional seismic data and the distribution of produced wells, it seems that the structure of the studied area is a Horst in the center, the area occupied by most of the drilled wells is limited by group fractures step faults to the southeast and graben to the northwest.
- Eight reflections were revealed at the Sharyoof oil field deposit, which are formed the tops of the Fartaq, Harshiyat, Upper Qishn Carbonate, Red Shale, Upper Qishn Clastics S1, Upper Qishn Clastics S3, Lower Qishn Clastics, and Saar formations.
- Constructed depth structural map shows the complex structure of the studied horizons.

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