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Integrated Geophysical Approaches for Assessing Lost Circulation While Drilling in the Shiranish Formation, Saddle Area of the Rumaila Oilfield, Southern Iraq

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ABSTACT: Loss of circulation while oil well drilling is a major problem and is regarded as the most challenging difficulty during drilling and well construction. A significant circulation loss can result in drilling risks such as sticking, blowout and well collapse. This research focused on Shiranish Formation downhole mud losses while drilling and stuck pipe in the saddle area of the Rumaila super giant oilfield, in southern Iraq. Over 1100 wells were drilled in the Rumaila oilfield and only a few wells within the saddle area experienced downhole formation losses/problems and stuck pipes. Seismic data, petrophysical data and drilling reports were used to investigate Shiranish Formation loss and stuck pipe issues. The seismic interpretation revealed small-scale faults and fractures within the examined area, most likely influenced by the strike-slip deep-seated Al-Hammar fault.

Correlation within three wells was performed to understand the effect of these faults within the Shiranish Formation, which demonstrated that the Shiranish Formation top is roughly 40 m different from the neighboring wells within 1.5 km and other formation tops are not affected within these faults. Identifying the location of faults and fractures will aid in avoiding drilling in these particular areas and choosing locations where there are no faults, or at the very least in mitigating and assisting the risk of drilling in such areas, such as controlling the rate of Penetration (ROP) while drilling and preparing extra mud and lost circulation materials (LCM).

Keywords: seismic section, Shiranish Fm., Lost circulation, Fracture Zone, Iraq

1. Introduction

The Rumaila oil field is the most important field in southern Iraq was founded in 1953 and is presently operated by the Rumaila Operating Organization (ROO). Located between 47 14'46" – 47 26'14" E and 31 12'41" - 30 05'5.7" N. (Fig.1). The major oil reservoirs of the Rumaila oilfield are the clastic Zubair Formation and the carbonate Mishrif Formation. The Shiranish Formation resides within an expansive sedimentary basin encompassing vast regions of Iraq and the southwestern expanse of Iran [1]. This basin's sedimentary formations exhibit remarkable similarities between Iraq and southwestern Iran, albeit with minor variations and nomenclatural distinctions. The Shiranish Formation, spanning a considerable geographical breadth, extends prominently across Iraq and neighboring territories. Its extensive exposure in highland regions further accentuates its geological significance within these areas [2].

It was deposited in the middle-late Cretaceous. It is roughly 100 m thick, although thickness varies around the field, ranging from 60m at the north and south Rumaila domes to 150 m towards the saddle area between the two domes. The lithology is a rather uniform light grey marly limestone across the field.

Marine planktonic foraminifera have been found in core, indicating a completely marine depositional environment [3].
Drilling into the Shiranish formation is relatively risk-free. There have been a few partial downhole losses. There have also been reports of tight holes and stuck tools most of it were happened while drilling in the saddle area of Rumaila field, however only a few wells out of the total number of wells (more than 1100 wells) drilled have encountered this.

Prior research on this aspect is notably scarce, with only a handful of studies especially for Dammam Formation, such as [4, 5, 6, 7, 8]. Because the rocks of the Dammam Formation have the ability to melt [9]. This study represents the inaugural examination of the Shiranish Formation incorporating seismic sections, marking a pioneering endeavor in its comprehensive analysis.

The primary aim of this research is to comprehensively analyze and address the challenges related to loss circulation encountered during oil well drilling, particularly focusing on the Shiranish Formation within the saddle area of the Rumaila super giant oilfield in southern Iraq. The occurrence of significant downhole mud losses and stuck pipe incidents poses critical risks during drilling operations, including potential threats such as sticking, blowouts, and well collapse.

Down hole losses or Lost circulation events have historically been a substantial source of non-productive drilling time (NPT), which drives up well construction costs. Lost circulation events might be characterized as partial losses when loss rates are less than 50 bbl/h, moderate losses when loss rates are between 50 to150 bbl/h, and severe losses when loss rates exceed 150 bbl/h. Millions of dollars are spent each year by the industry to counteract lost circulation and its negative consequences, such as stuck pipe, kicks, NPTs, and so on [3].

Lost circulation can be induced by formation features like as caves, high permeable rocks, fractures, faults, vugs, and so on. When fractured zones are present, the effect is magnified, and the effect is considerably more dramatic when these fractures are linked to a network of natural fissures [10]. The study aims on analyzing the reason of lost circulation in Shiranish formation in the saddle area from various sources of data such as: drilling reports, petrophysical data (logs) and seismic sections.

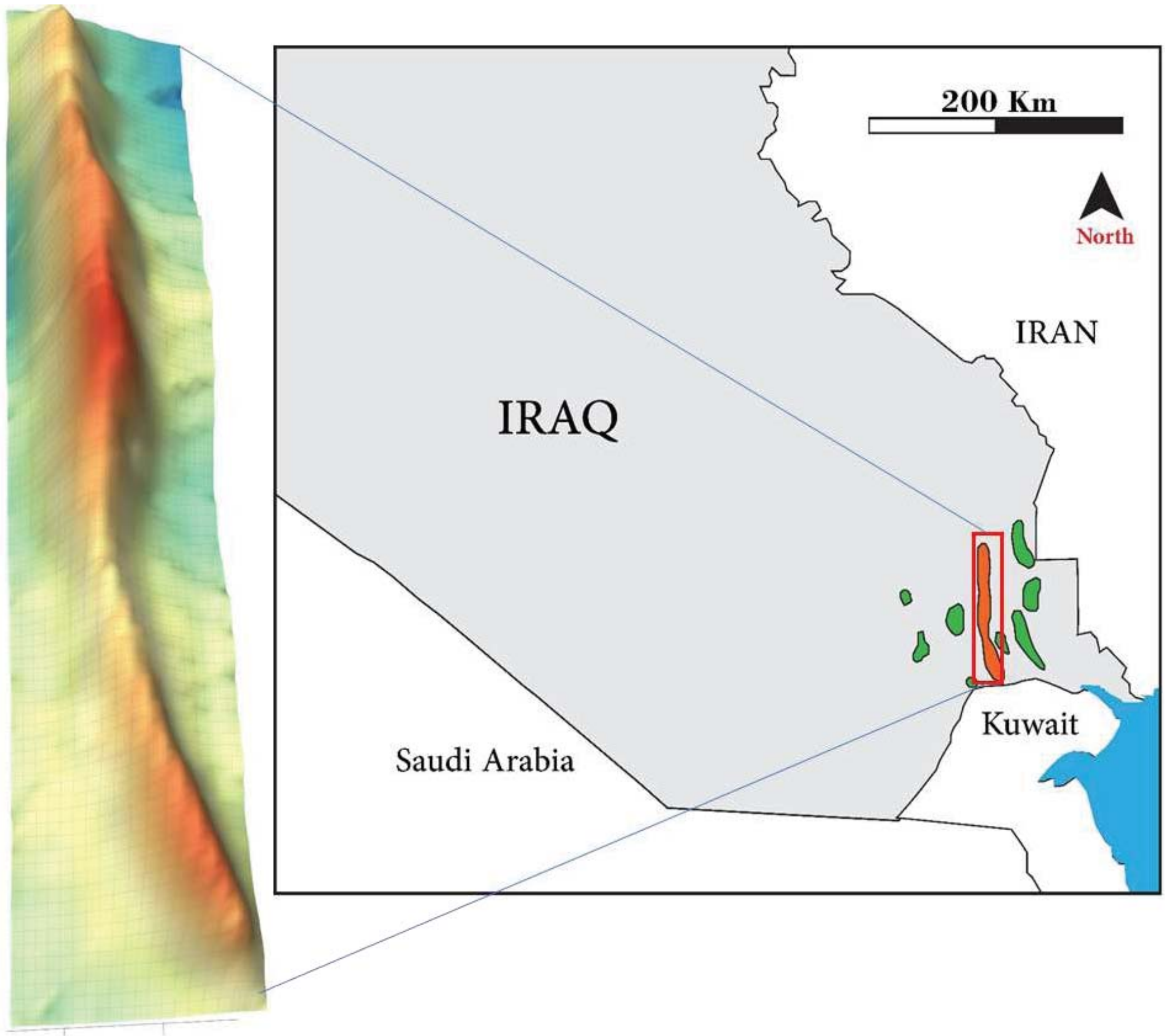

Fig. 1 The location of the studied oil field within Mesopotamia foredeep.

2. Geology of the study area

Stratigraphically, the initial characterization of the Shiranish Formation dates back to Henson's seminal description in 1940, originating from its type section located in the Shiranish-Islam area, situated to the northeast of Zakho in northern Iraq. Owen and Nasr's findings in 1958 delineated the lower contact boundary, noting local unconformable surface with the Hartha Formation. Conversely, the upper boundary interfaces with the Tayarat Formation in a conformable contact, as established by subsequent research [2][11] (Fig.4).

Rumaila oilfield located in the Mesopotamian plain, which is a part of the Mesopotamia Foredeep basin, the Mesopotamian plain has flat terrain and relatively gentle slope towards the Arabian Gulf [12]. According to [13], the tendency of subsurface folds is N-S in the extreme southern region of the Mesopotamia Plain, known as the Zubair Subzone. Almost all of the Mesopotamia Plain's subsurface anticlines are gentle folds with interlimb angles of 170° and limb dips of 5°. Long anticlines like the Rumaila and Zubair are non-cylindrical folds with two or three domes. The Zubair Subzone is the most productive petroleum region in Iraq [14]. The Shiranish Formation was laid down during the pre-collision phase, a period preceding the collision between tectonic plates. This collision occurred as the oceanic crust of Neo-Tethys subducted beneath the Iranian and Turkish plates. The regions where this subduction occurred were active margins, while the Arabian plate remained a passive margin during this geological activity [15] [16].

Many Subsurface basement faults were identified from the gravity survey within the area trending NE-SW, the major faults are Takhadid Qurna, Hammar and Basra Zubair faults [17] (Fig.2). The major source rock and reservoir in southern Iraq, including the Rumaila field, are Mesozoic deposits. The source rocks are represented by the Sulaiy Formation, whereas the reservoir rocks are represented by the Yamamma, Zubair, Nahr Umr, Mishrif, and Fatha formations. The main producing zone in the Rumaila oilfield is the Zubair Formation. It was deposited 300 m to 450 m thick in the Early to Middle Cretaceous (Barremian) [12, 17, 18, 19].

3.Data and Methodology

Three wells of lost circulation within Shiranish Formation situated in the saddle area were selected in this study. All data available such as petrophysical logs, formation tops data and seismic section were gathered for these three wells. Shiranish formation top were obtained from the geological reports, downhole problems within Shiranish formation collected within the selected wells. Well correlation created to visualize and interpret the differences between the wells. All wells were closed to each other within less than 1 km as illustrated in figures (4 and 5).

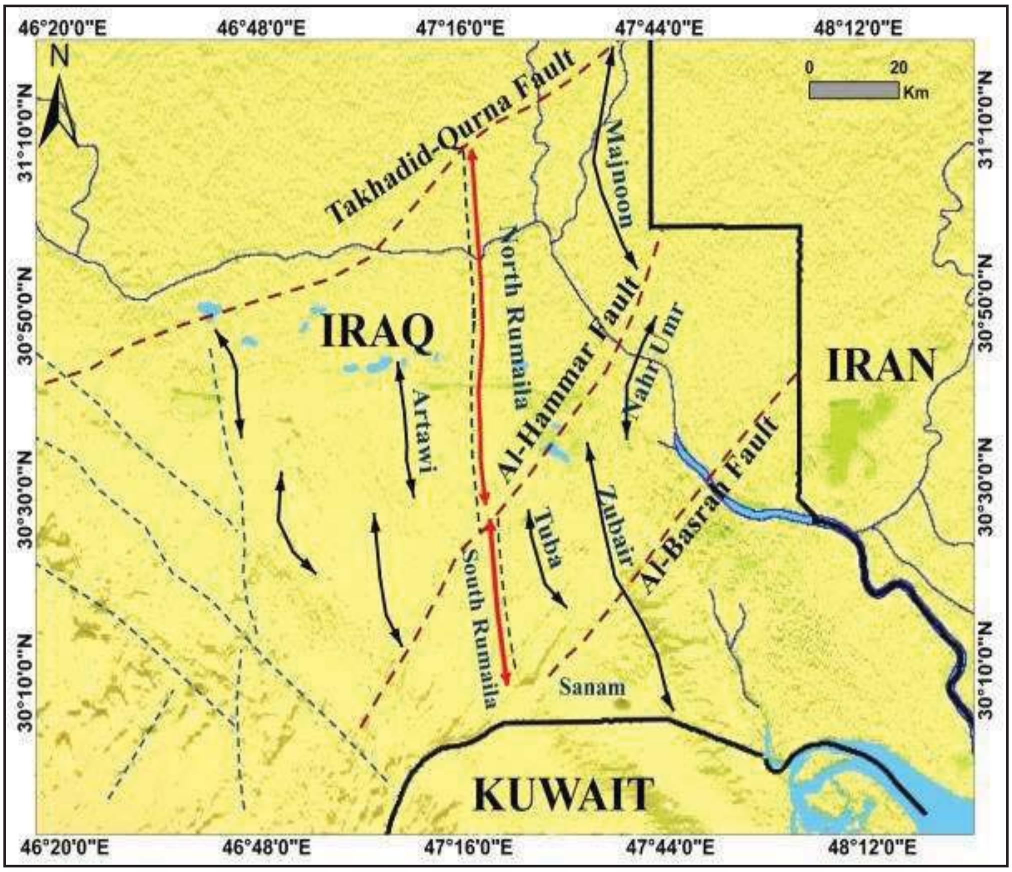

Fig.2 Rumaila oil field trends with the main transverse faults [20].

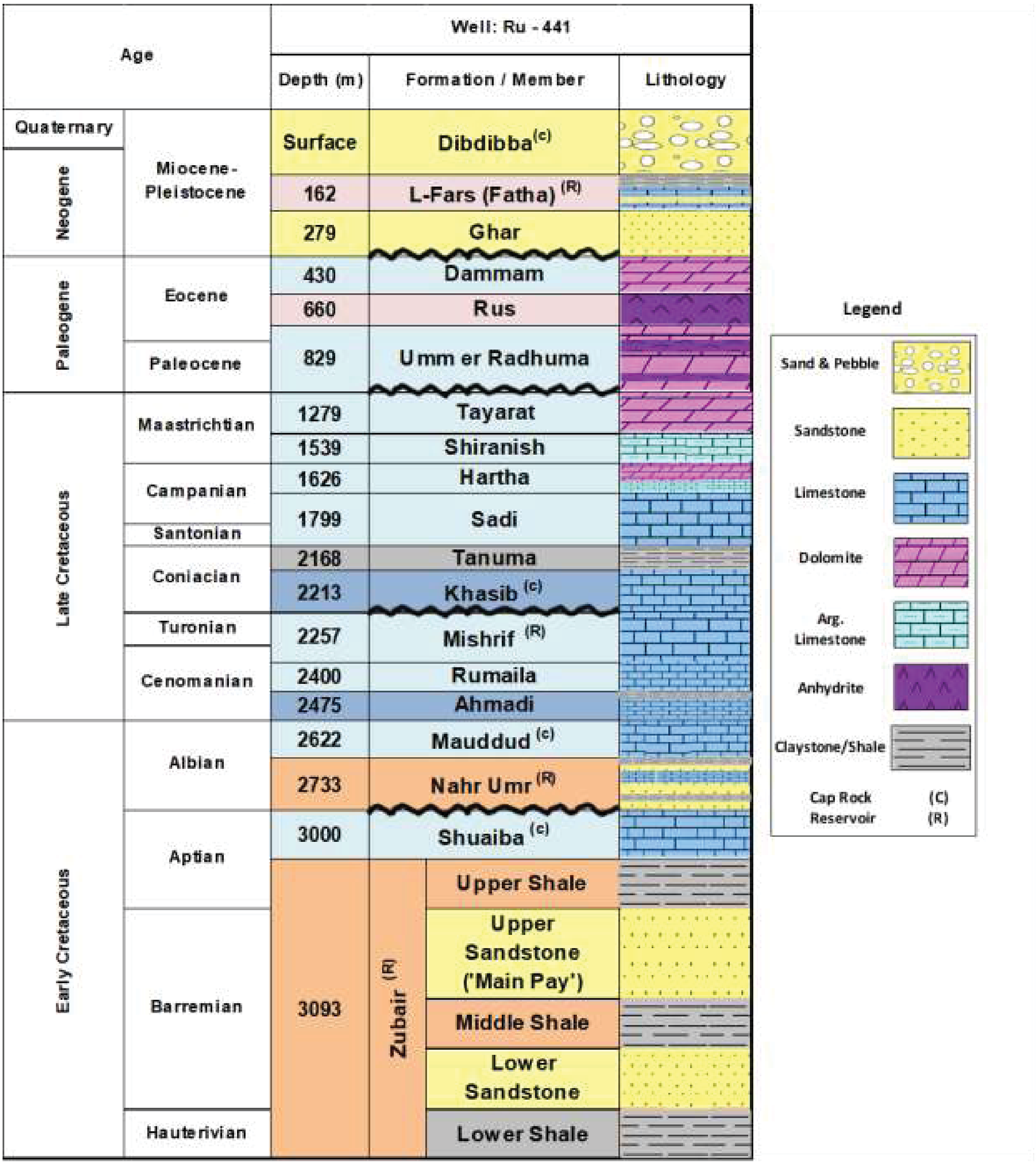

Fig. 3 Stratigraphic column for Ru-441, illustrated all the formations in the region with the type of contact.

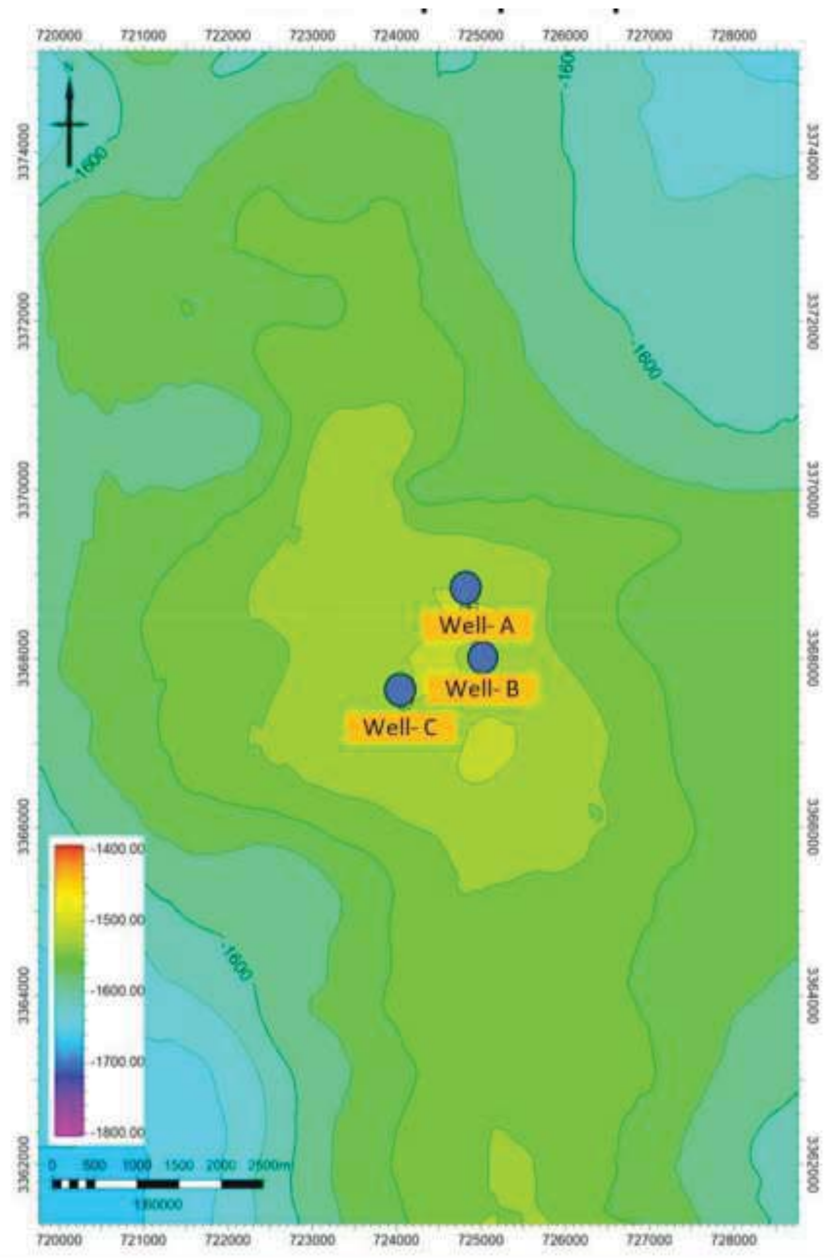

Fig. 4. Isopach map for the top of Shiranish Formation with the studied wells.

Two seismic sections were obtained for this study within the saddle area as shown below in figures (6 and 7). The seismic sections have been taken as part of 3D seismic performed in 2012 to Rumaila oilfield as part of the development of this oilfield, so this part to the saddle area, which is affected by a local minor fault. Wells and seismic sections imported to the Petrel (2019) software and formation tops were identified all together with the seismic sections.

4. Result:

The concept of lost circulation, also known as lost returns, refers to the partial or complete escape of circulating fluid from the wellbore into the surrounding formation. This phenomenon involves the actual loss of entire fluid volume rather than just filtrate. It can stem from natural occurrences or be induced, causing varying magnitudes of losses, from a few barrels per hour to several hundred barrels within minutes. Lost circulation stands as a significant expense in drilling operations, impacting both rig efficiency and safety. Uncontrolled instances of lost circulation pose serious pressure control risks and can potentially lead to the loss of the well itself [21].

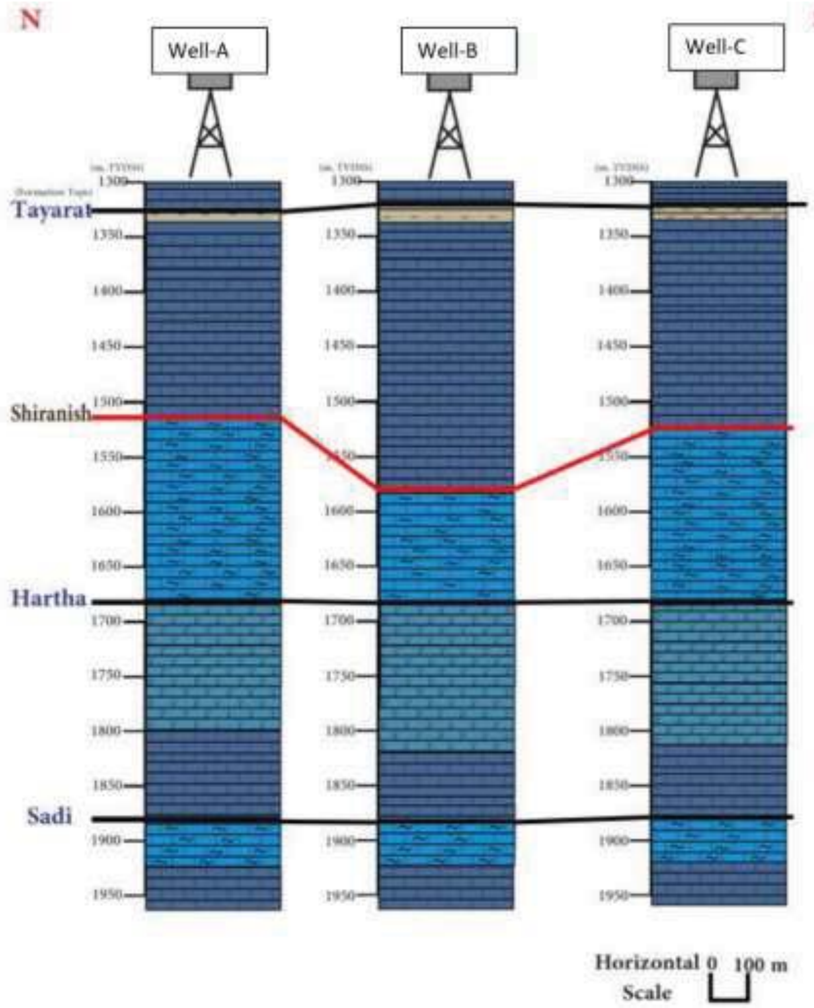

Fig. 5. The correlation of studied wells that showing the deferential in the thickness of Shiranish Formation.

The primary hydrocarbon system within the Mesopotamian Basin spans from the early Cretaceous to the Miocene period and stands as a crucial contributor to petroleum resources. This system comprises key components: the Sulaiy and Yamama Formations as significant petroleum source rocks, along with the Tanuma, Shiranish, and Rus formations serving as seal rocks. Additionally, it includes reservoir rocks such as the Yamama, Zubair, Nahr Umr, and Mishrif formations [22].

The analysis of seismic data, petrophysical data, and drilling reports revealed the presence of small-scale faults and fractures within the Shiranish Formation in the saddle area of the Rumaila oilfield, southern Iraq (Figs. 6 and 7). These faults were found to be influenced by the strike-slip deep-seated Al-Hammar fault. Correlation between three wells demonstrated that the Shiranish Formation top was approximately 40 m different from neighboring wells within a 1.5 km radius, while other formation tops were not affected by these faults. This discrepancy in thickness indicated the presence of a fault in this area, which had a significant impact on the drilling operations.

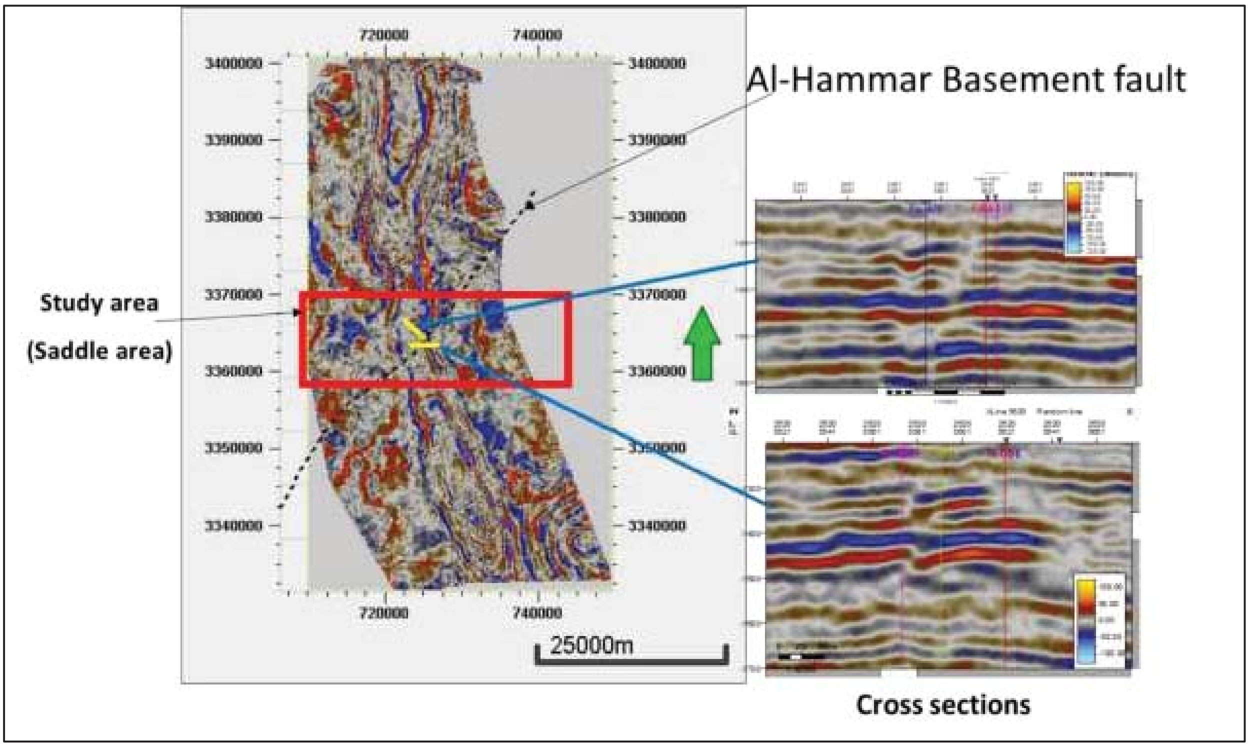

Fig. 6 Seismic section with small scale illustrates the effect of the Al-Hammar fault in the region

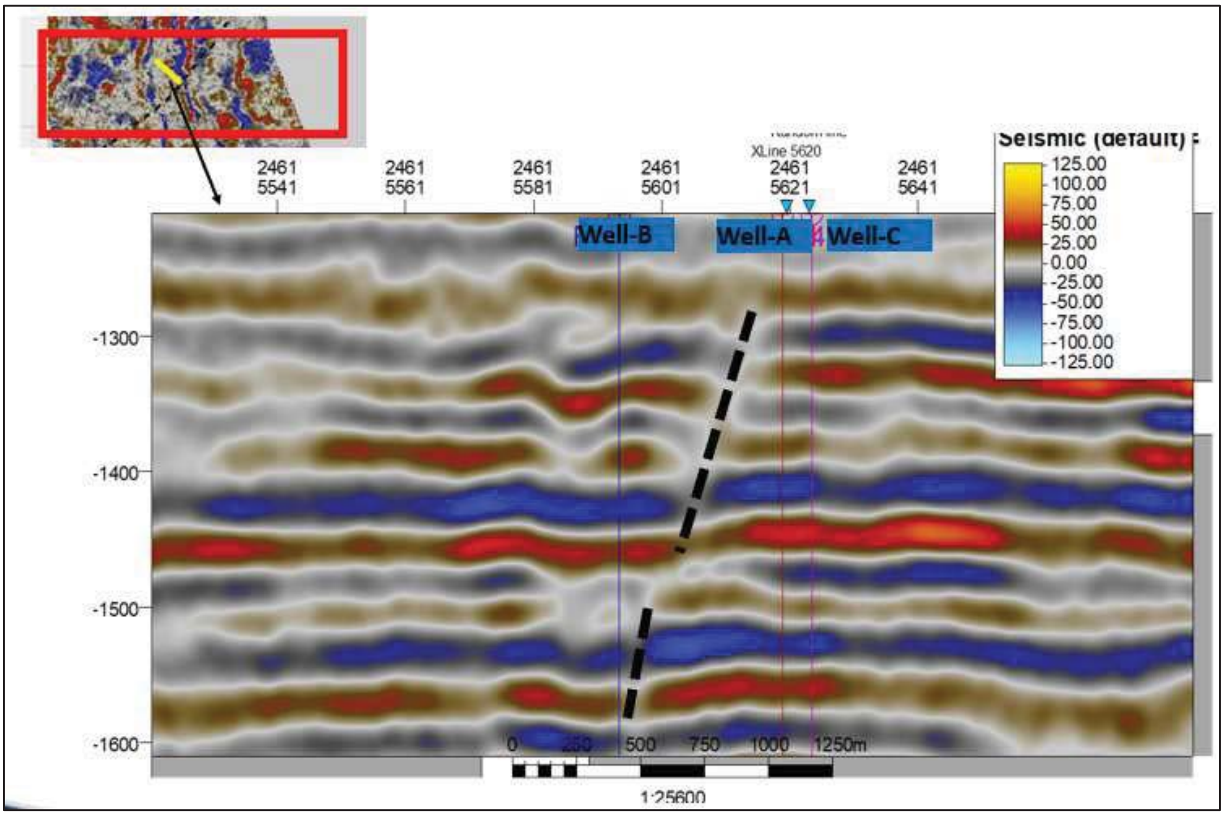

Fig. 7 Seismic section with large scale illustrates the effect of the Al-Hammar fault in the region and the deferential in the thickness of Shiranish Formation.

5. Discussion

The research site lies within the Mesopotamian zone, encompassing the Zubair, Euphrates, and Tigris Subzones as depicted in Figure 2. Situated within the Unstable Outer Platform of the Arabian plate, the Mesopotamia Plain experienced its peak mobility in the Upper Triassic-Middle Jurassic periods, as documented by [13][23]. Addressing drilling mud losses and the challenges linked to lost circulation during drilling constitutes a significant financial burden in the oil and gas drilling sector. Industry reports suggest an annual expenditure exceeding 2 billion USD to manage and alleviate these issues [24]. Ongoing tectonic activity persists due to the collision between the Arabian and Eurasian plates, as noted by [12]. More detailed and in-depth study need to be carried out for the saddle area to cover all the fractures and faults in this zone. Also, drilling crew need to be more careful, prepared, and expect downhole problems, stuck pipe and wireline log tools in any formation while drilling and during run in hole casing in the saddle area zone especially in Shiranish Formation. The results presented in the passage highlight critical aspects of the hydrocarbon system within the Mesopotamian Basin and specific findings related to the Shiranish Formation in the Rumaila oilfield:

1. Hydrocarbon System Components: The study underscores the significance of the hydrocarbon system spanning from the early Cretaceous to the Miocene era within the Mesopotamian Basin. It identifies key constituents of this system, delineating the roles of various formations. The Sulaiy and Yamama Formations are recognized as vital petroleum source rocks, while the Tanuma, Shiranish, and Rus Formations act as seal rocks. Additionally, it highlights reservoir rocks like the Yamama, Zubair, Nahr Umr, and Mishrif formations, outlining their importance in petroleum resource exploitation.
2. Identification of Faults and Fractures: The analysis involving seismic data, petrophysical data, and drilling reports sheds light on the presence of small-scale faults and fractures within the Shiranish Formation, specifically in the saddle area of the Rumaila oilfield in southern Iraq. These geological irregularities are influenced by the deep-seated Al-Hammar fault, characterized as a strike-slip fault. This region has an active and continuous neotectonic activity that may activate local faults [25 and 26].
3. Impact on Drilling Operations: The study's findings reveal that these faults significantly impact drilling operations within the Shiranish Formation. Correlation between wells in the vicinity indicates a substantial discrepancy of approximately 40 meters in the formation's thickness within a 1.5-kilometer radius. This discrepancy strongly suggests the presence of a fault in the area, highlighting its potential to affect drilling activities.

Overall, these results emphasize the complex geological characteristics and their implications for oil drilling operations. Understanding fault presence and their impact on formation thickness is crucial for effectively managing drilling challenges and strategizing for successful oil exploration and extraction within the Rumaila oilfield and similar geological settings.

6. Conclusion:

The study concludes that the fault within the Shiranish Formation in the saddle area of the Rumaila oilfield has led to several drilling challenges and losses. The lithology of the formation, characterized by high argillaceous limestone and its sticky nature, exacerbates the effects of the fault. The fault creates differential pressure among zones, resulting in fluid losses during drilling and sticking of the drill pipe. This differential pressure also affects wellbore logging operations. In normal drilling conditions, the Shiranish Formation is typically drilled without such problems. Therefore, it can be concluded that the fault is responsible for fluid losses and stick pipe issues during drilling operations in the formation.

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