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A Statistical Survey for Drilling Problems at North Rumaila Field, Southern Iraq. A Review enhanced with Well Logs Analyses

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Abstract

This study was accomplished to review the drilling problems in the North Rumaila Field, Southern Iraq. A statistical analysis for each formation reflecting the effect of drilling problems with overall analysis for the selected part of the field. The recorded mud logs will be used to confirm the results. The results show that losses should be expected at the base of the Dammam Formation and Hartha, Mishrif, and Zubair Formations. A significant washout in the Tanuma Formation occurred. The injector(s) should remain shut in until the Mishrif Formation case is off to prevent the potential for flow. The variability of Mishrif reservoir architecture and rock types might lead to irregular sweep and water breakthrough if higher permeability layers are present. Sloughing formations represent Tanuma, Nahr Umr, and Upper Shale. Generally, the potential for stuck pipes will be evident in the Mishrif, Nahr Umr, and Zubair Formations. Bit damage occurs through drilling entire anhydrite layers in L. Fars and Rus Formations. The high-effect problem (36.41%) was the loss of mud circulation, while slide drilling (0.54%) represented the lesser effect. Dammam is the most formation that faced drilling problems according to the percentage of all wells drilled (56.4% for each caving and mud loss), while no significant problems occurred in Dibdibba, Khasib, Rumaila, Ahmedi, Mauddud, and Shuaiba Formations. In general, the Middle South part of the field shows fewer drilling problems than the edge of the Field with South Rumaila Field, especially in the productive Formations (Mishrif, Mauddud, and Zubair).

Keywords: *Statistical Analysis; Drilling Problems; North Rumaila Field; Mud log; Mud Loose*

1. Introduction

Drilling and completion of the wells represent over 40% of all assets in the oil and gas industry. Decreasing losses in drilling time to eliminate difficulties facing drilling and their results is one of the prospects for increasing the effective drilling time (Kiran et al., 2024). The main complications include drill string sticking due to talus and unstable rock collapses, wellbore narrowing from crumbling rocks, absorption of drilling mud, and occurrences of gas-oil-water and brine showings (Al-Dujaili et al., 2025). All drill cuttings must be removed from the well during drilling in a process known as hole cleaning (Nazari et al., 2010). Residual material often remains in the well, causing issues such as pipe sticking, premature bit wear, slow drilling, formation damage (fracturing), excessive torque and drag, and difficulties in logging and cementing (Borozdin et al., 2020; Orun et al., 2023).

Drilling fluid loss is a familiar concern in the oil and gas industry (Zhuang et al., 2024). Loss of mud completely or partially within a formation during the drilling operation or the recovery mud from the well does not match the mud injected into the well, is known as drilling fluid loss or retrieval loss (Salih and Hussein, 2022). Circulation loss normally occurs in highly permeable, depleted reservoirs, natural cracks,cavernous and fracture formations, as shown in Figure 1 (Miranda et al., 2017). Many techniques are utilized to control the loss of circulation (Kang et al., 2023). The first method to address lost circulation is by reducing the density of the drilling mud (Caughron et al., 2022). The second method involves adding lost circulation materials (LCM) to plug and seal off loss zones (Toreifi et al., 2014). Several factors can influence the loss of drilling fluid, including the petrophysical properties (such as porosity and permeability), the characteristics of the drilling mud itself (like mud weight, equivalent circulating density, yield point, and plastic viscosity), as well as the drilling parameters (such as rate of penetration, weight on bit, revolutions per minute, strokes per minute, standpipe pressure, and total flow area). Factors like pore pressure gradient and fracture pressure can also play a significant role (Yang et al., 2023). An analysis revealed that 54% of stuck pipe incidents occurred during tripping and back-reaming operations (Yarim et al., 2007). Growth in the risk stuck pipe was marked due to a current expansion in drilling activities, drilling in depleted and higher-risk reservoirs (Muqeem et al., 2012). Several studies suggest the statistical method to be utilized for predicting stuck pipes (Shadizadeh et al., 2010; Salminen et al., 2017; Elahifar and Hosseini, 2022]. The formations of southern

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Iraqi oilfields were studied clearly, and a full description approach was achieved for the upper Faris to Mishrif formations (Simmons et al., 2025). The power and stringency of the problem were defined in each formation by offering the causes of the problem/s in the wells or what might ensue (Saleh et al., 2018).

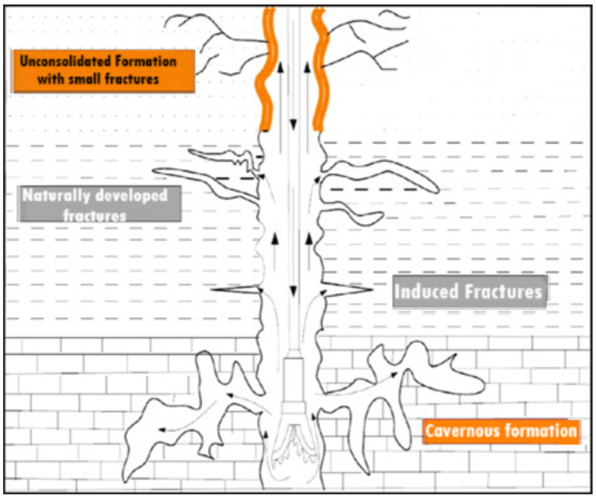

Figure 1. Various types of lost circulation of drilling fluid (Miranda et al., 2017)

2. Geological setting

North Rumaila is a supergiant oilfield situated 50 km to the west of Basrah city in the south of Iraq (Salih et al., 2016). It has piled up in multiple Clastic and Carbonate reservoirs. North Rumaila field was explored in 1953 and represents 33% of Iraq's total oil production (Figure 2) (Almalikee and Al-Najm, 2019). Rumaila structure represents a mild tilting longitudinal anticline that extends approximately longitudinally 83 km and 12 km wide. The North Rumaila structure is approximately 11 to 42 km in width and slopes southwards to form a saddle that separates it from the southern part (Handhal et al., 2022; Al-Dujaili, 2023). Two faults have been found, the northeast to southwest, Takadid-Qurna and Al-Batin. Faults are reactivated Precambrian transverse faults that define the Zubair fault block within the Mesopotamian basin (Al-Dujaili, 2024a). The stratigraphic column from the Rumaila field represents sedimentary rocks, ranging in age from Late Jurassic to recent (Chafeet and Handhal, 2024). It mainly comprises clastic, carbonate, and evaporitic rock cycles (Shehab et al., 2023). This stratigraphic column's most prominent hydrocarbon system is the Early Cretaceous to Miocene (Al-Dujaili, 2024b). In this petroleum system, the Sulaiy and Yamama formations represent source rocks; the Tanuma, Shranish, and Rus formations form the sealing rocks; and the Yamama, Zubair, Nahr Umr, and Mishrif formations represent the reservoir rocks (Figure 3). (Al-Ameri et al., 2011; Al-Dujaili et al., 2023; Lazim et al., 2024). The drilling issues in the Rumaila oilfield have been addressed in various studies where key drilling parameters were identified to mitigate mud losses in the Dammam Formation of the South Rumaila Field (Al-Mimar et al., 2018; Khashman et al., 2025), and the requirements solutions for their previous study were suggested (Al-Hameedi et al., 2017), and machine learning was used to predict lost circulation in the Rumaila Field (Al-Hameedi et al., 2018). The Hartha and Mishrif formations behave similarly to the Dammam formations, causing the loss of cement and drilling mud circulation (Al-Dujaili et al., 2024).

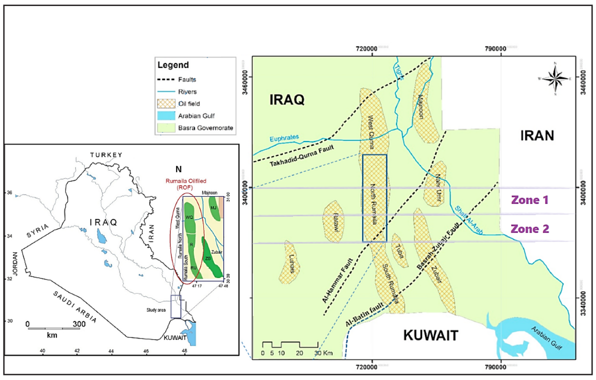

Figure 2. Location of North Rumaila oilfield

3. Data and methods

3.1 Data and Methods

The data were obtained from 80 drilled wells in the North Rumaila oilfield, southern Iraq, between latitude lines (3360000 to 3400000 N).

The wells, drilled between 1977 and 2014, were divided into two categories:

1. Zone 1: includes the wells drilled in the field (41 wells) between latitude lines (3370000 to 3385000 N).
2. Zone 2: includes the wells drilled in the field (39 wells) between latitude lines (3385000 to 3400000 N) (Figure 1).

The data also include mud logs, which were used to determine lithology descriptions in addition to core data and to identify drilling problems with the support of field outlook. (Figure 4).

The wells under study were drilled across 19 formations in the North Rumaila field with different reservoir targets. Geomechanical analyses were made for all formations. The statistical methods were utilized to survey all drilling problems in many categories:

1. Identifying drilling problems for each formation and calculating the percentage of each problem relative to the total number of identified drilling problems in the selected formations.
2. Determining the percentage of drilling problems concerning the total number of wells for the southern part of the field (Zone 1) and the northern part (Zone 2).
3. Calculating the percentage of each drilling issue relative to the total.
4. Evaluating the likelihood of various drilling problems occurring in the North Rumaila field based on all formations drilled and the projected formations.
5. Assessing the likelihood of drilling issues in the North Rumaila field by considering the drilling processes of all formations and comparing this to the possibility in formations where they have occurred.

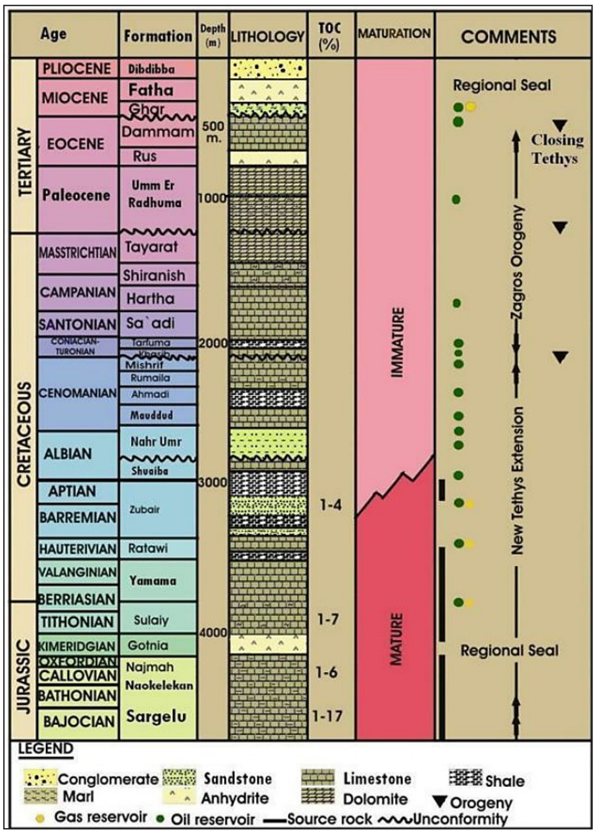

Figure 3. Stratigraphic column of North Rumaila oilfield [28]

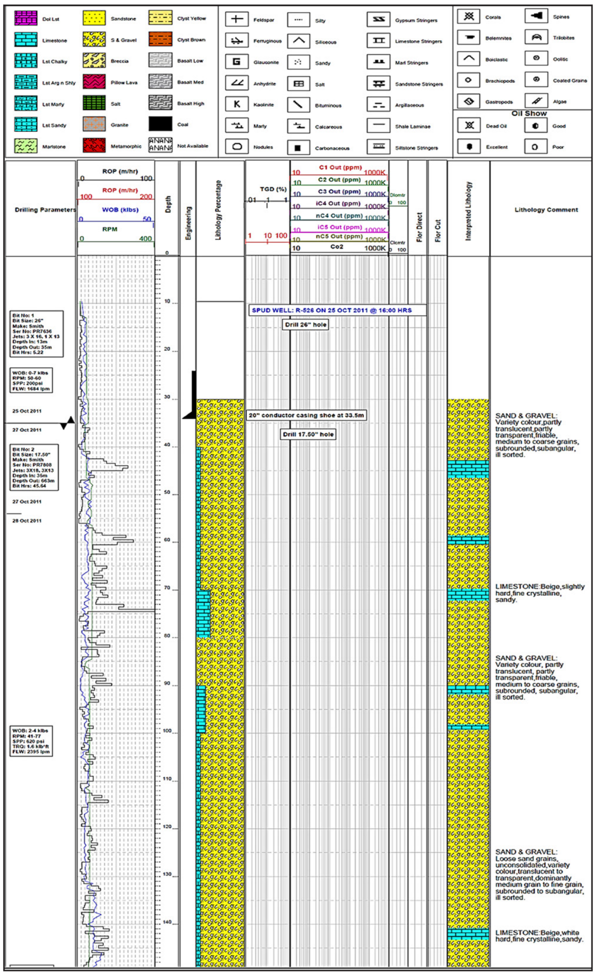

Figure 4. Mud log from Well R-XX6

4. Results

4.1 Mud Weight Window

Figure 5 shows the results of geomechanical analyses conducted on the formations from Dibdiba to Zubair. Initial studies do not indicate any significant pressure ramps or regions of overpressure within the horizons likely to be encountered, except an implied minor pressure ramp in the Shiranish. The appropriate pressure/depth summary should be examined and incorporated into the detailed well planning.

4.2 Percentage of each drilling problem to the total problems in the specified formation

The percentage of each drilling problem in the selected formations (from the Dibdibba to Hartha Formations) was summarized in Figure 6.

The percentage of each drilling problem in the selected formations (from the Sadi to Zubair Formations) was summarized in Figure 7.

4.3 Percentage of each drilling problem to the total number of wells for Zones 1 and 2

The percentage of drilling problems related to the total number of wells for the Southern part of the field (Zone 1) and Northern part (Zone 2) was summarized in Figures 8 and 9.

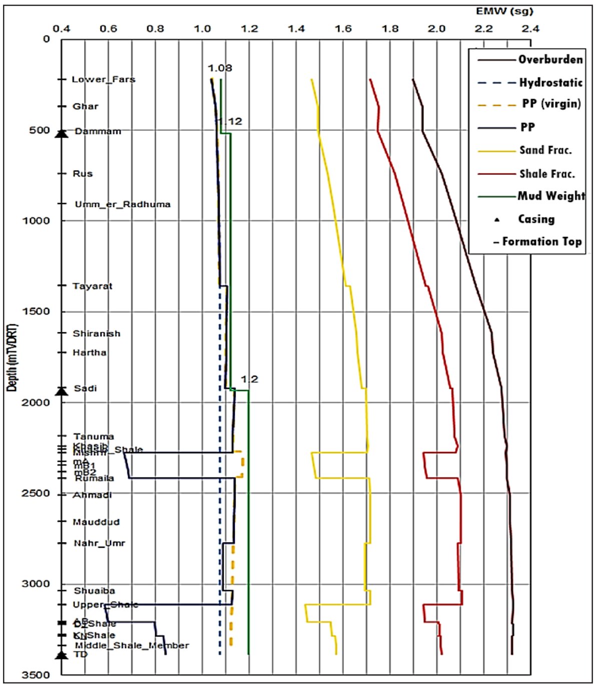

Figure 5. Geomechanical analyses for Rumaila field

Figure 6. Percentage of drilling problems in Dibdibba, L. Fars, Rus, Ghar, Dammam, Um E Radhuma, Tayarat, Shiranish and Hartha Formations

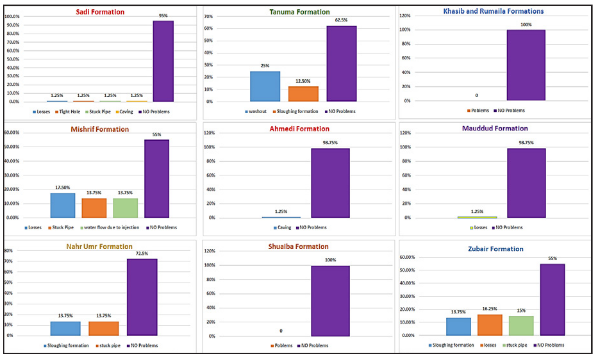

Figure 7. Percentage of drilling problems in Sadi, Tanuma, Khasib, Mishrif, Rumaila, Ahmedi, Mauddud, Nahr Umr, Shuaiba, and Zubair Formations

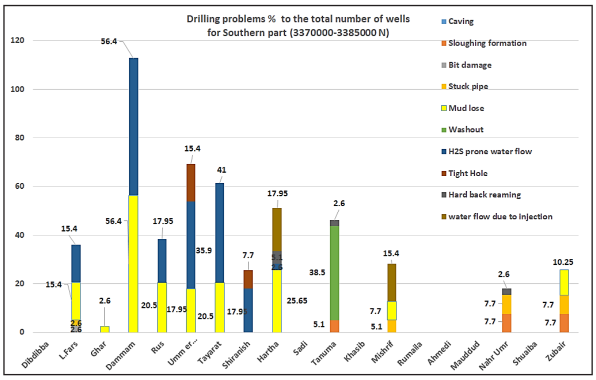

Figure 8. Drilling problems percentage to the total number of wells for zone 2

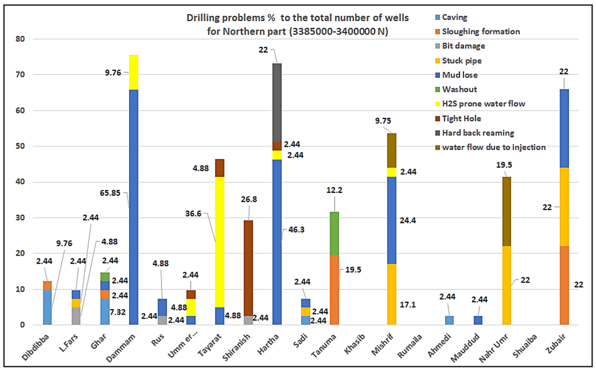

Figure 8. Drilling problems percentage to the total number of wells for zone 1

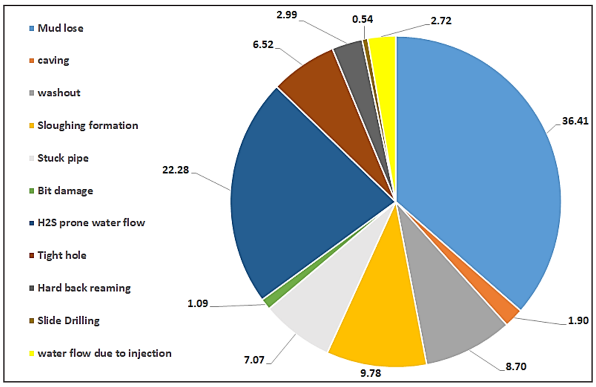

Figure 10. Percentage of each drilling problem according to the total problems that occurred

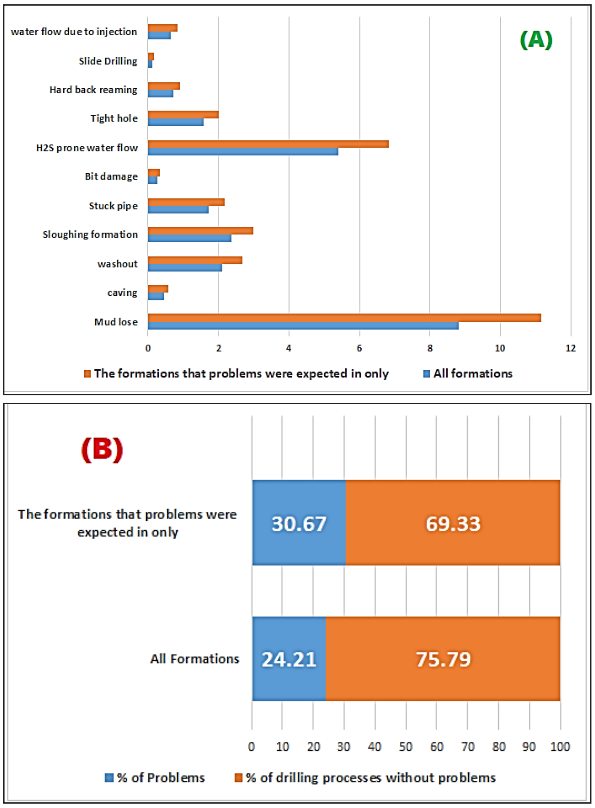

Figure 11. A- % of each problem to (All formations and formations that the problems are expected in)

B- % of all to (All formations problems and to formations that the problems are expected in)

4.4 Percentage of each drilling problem to the total number of problems

The Possibility percentage for the drilling problem in the North Rumaila field according to all formations drilled was summarized in Figure 10.

4.5 Percentage of the drilling problems according to all drilling processes

The Possible percentage for the drilling problem in the North Rumaila field according to all formations drilled and the formations in which the problems are expected was summarized in Figure 11-A.

4.6 Percentage of the drilling problems according to all drilling processes

The possible percentage for the drilling problems in the North Rumaila field according to all drilling processes in all formations is also the same. Still, the formations in which the problems are expected are only shown in Figure 11-B.

4.7 Analysis of the Drilling Problems

Analysis of drilling problems was based on Table 1, which classified the problem due to its effect on the drilling process into eight groups.

The results of this analysis are shown in Figure 12.

Table 1. Classification of drilling problems due to the percentage of iteration in each formation

Legend	% of Problems	Analysis
	Zero	Excellent
	1-10%	Very Good
	11-20%	Good
	21-30%	Acceptable
	31-40%	Medium
	41-50%	Noteworthy
	51-60%	High
	over 60%	Severe

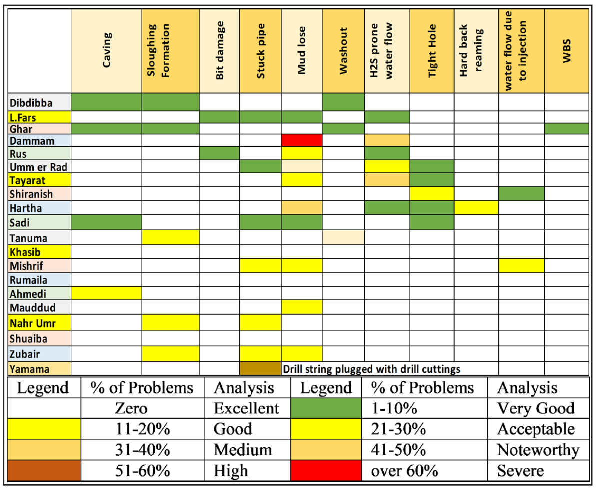

Figure 12. Analysis of the drilling problems problem for each formation due to its effect on the drilling process

5. Discussion

The most common hazard is the potential for severe losses in the Dammam formation. Current understanding suggests that no losses can be expected whilst drilling the first 50-100m of the formation in North Rumaila Field. The probability of incurring significant or even total losses increases from the depth onwards. This increase has led to Non-Productive Time (NPT). Also, it is called (dead time)—over 10 days from the total time for the well. Another potential hazard is water ingress while drilling across the formation. This water flow could occur because the field has water disposed in Dammam. Surge and swab in Dammam, Rus, or UER Formations must be avoided. They might fracture formation and cause excessive losses. H2S exists in the vuggy porosity of the Dammam Formation (Figure 13).

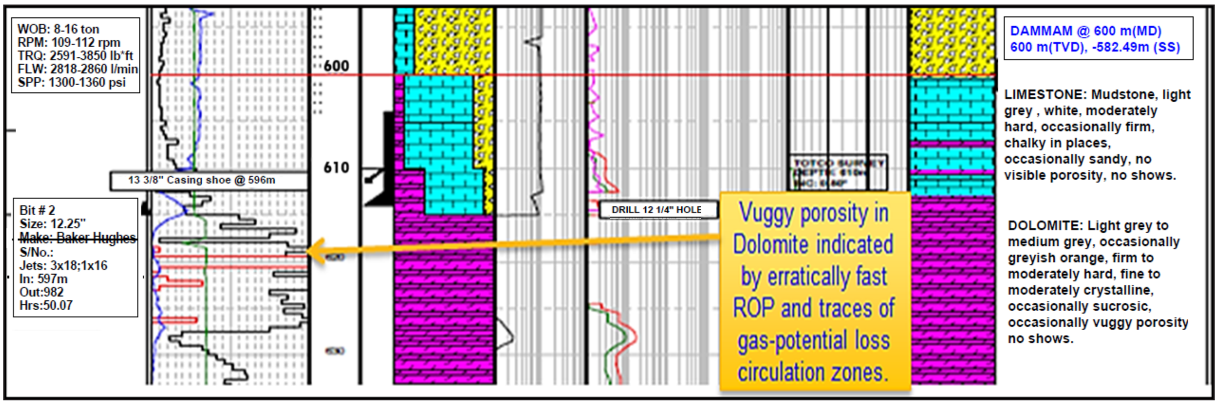

Figure 13. Master log of Dammam Formation in Well RN-X31

Several historical wells were experienced, and loss events, more commonly called sulfurous water gains, were found while drilling through Tayarat Formation. This has been seen in wells with static mud weights of up to 1.18 sg. Increasing the mud weight up to 1.19 sg should kill any ingress.

Shale at the top of the Tayarat Formation then became massive hard, crystalline dolomite was noted with tight porosity and very low gas values throughout this formation (Figure 14).

Drilling in the Shiranish carbonate formation expects the unexpected; pits trend and mud losses must be watched closely. The formation consists of Marly Limestone, poorly visible porosity, uniform ROP, low background gas (Figure 15).

Mud Loss has occurred in the Hartha Formation (Figure 16).

Tanuma Formation is a massive fissile Shale with sloughing and water flows. Note that gas peaks just above Tanuma top, as well as increasing background gas, indicate porosity and path for fluid flow (Figure 17).

Mishrif limestone zones show several layers of differing porosity. Gas leaks and oil show throughout the formation, indicating good porosity development.

Potential for flow in the Mishrif Formation due to active injection operations. The adjacent injector(s) should be shut in while the Mishrif Formation is being drilled to prevent flow into the Mishrif Formation (Figure 18).

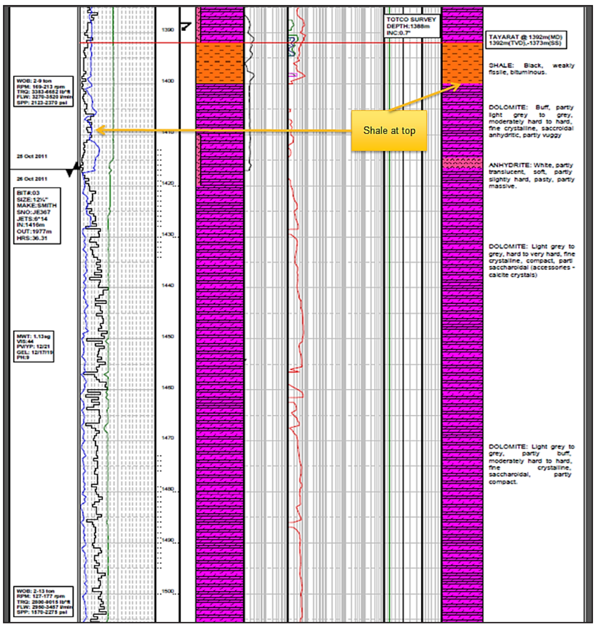

Figure 14. Master log of Tayarat Formation in Well RN-X26

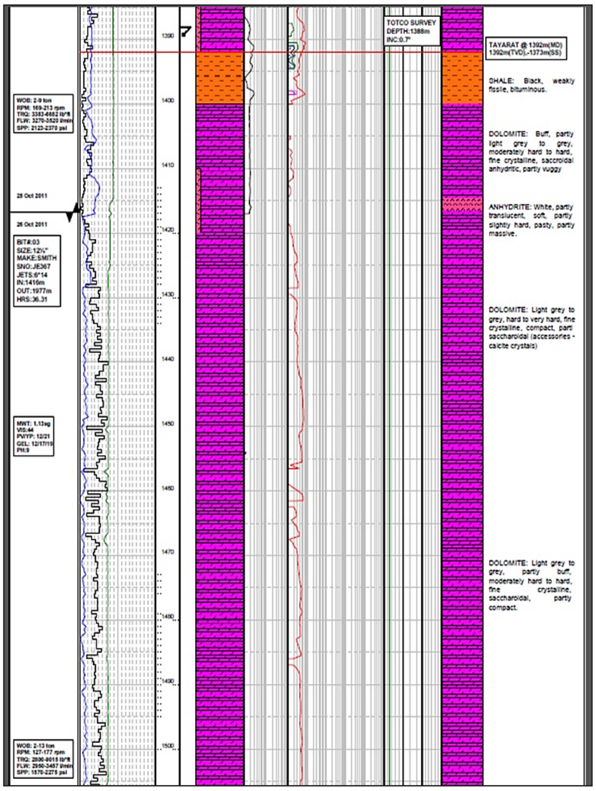

Figure 15. Master log of Tayarat Formation in Well RN-X31

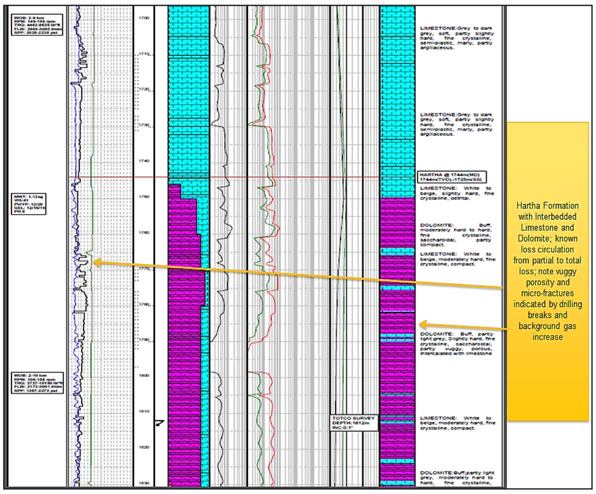

Figure 16. Lost circulation from partial to total in Hartha Formation (Well RN-X41)

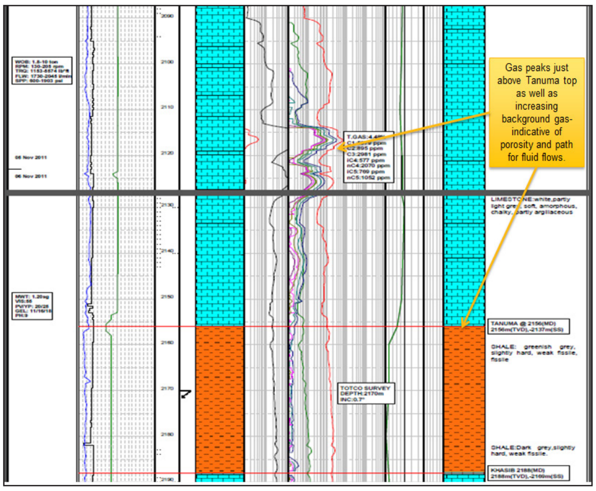

Figure 17. Tanuma Formation (Well RN-X31)

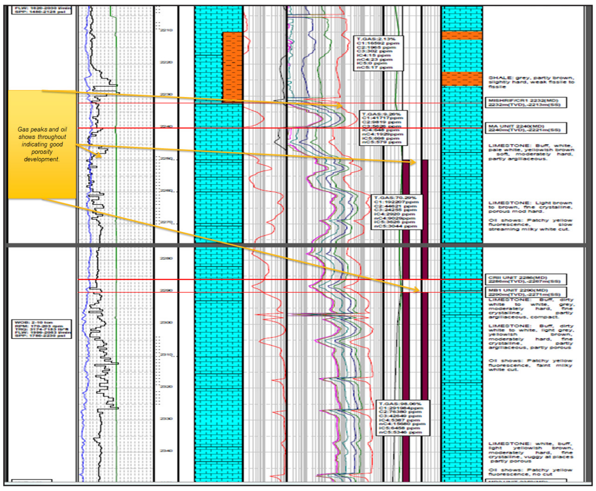

Figure 18. Mishrif Formation (Well RN-X40)

According to Figure 19 and Table 2, the percentage of drilling problems that face the drilling operations in the Rumaila Field will increase at Zone (1) by about 66% for the sandstone Formations and 46% for dolomite and dolomitic limestone Formations. In comparison, it will decrease for the anhydrate Formations to 8.5%. In Zone (2), the percentage will increase for dolomite and anhydrate Formations to 63.6% and 35.9%, respectively, while it decreases to 6.85%, 16%, and 26.65% for limestone, shale, and sandstone formations.

Table 2. Problems percentages according to the type of Formations in the Zones 1 and 2

Formation Lithology	% of problems	
	zone 1	zone 2
Sand/ Gravel Intercalation	26.80%	2.60%
Anhydrite (L. Fars and Rus)	8.5%	35.90%
Dolomite and Dolomitic Limestone	46.80%	63.60%
Limestone (Mishrif, Mauddud, and Shuaiba)	26%	6.85%
Shale (Tanuma, Ahmedi, and Nahr Umr)	19.00%	16.00%
Sandstone (Zubair)	65.85%	26.65%

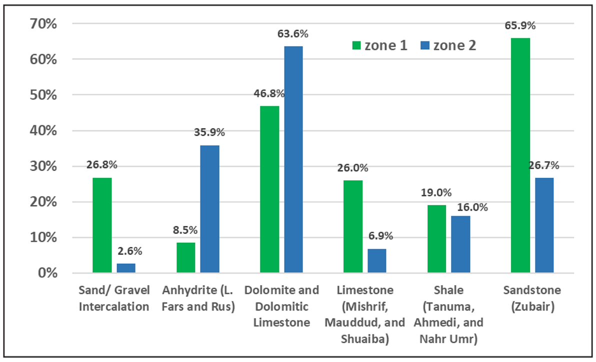

Figure 19. Problems percentages according to the Formations in the Zones 1 and 2

6. Validation of results

The stability validation was carried out with WellCheck™. In this case, it was found that the case where σV =σHmax is similar to the strictly strike-slip case (σHmax=1.05*σV), so there is sufficient confidence in the results, providing the chosen stresses are appropriate. The figure contains the estimated trends of the magnitudes of the pore pressure (Pp) in blue, the least stress (σHmin) for the shaly materials in brown, and the minimum mud weight for drilling a breakout-free hole in red. Also included are the casing points as designed and the various formations likely to be penetrated (Figure 20).

The pale green shade defines the mud-weight windows for drilling breakout-free holes at any depth. The darker green shade defines the available mud weight window for drilling a hole section based on a single minimum mud weight per section. The simulation suggests that the minimum mud weights for drilling the three well sections are 1.06SG, 1.07SG, and 1.26SG, respectively, with corresponding upper mud weight limits of 1.75SG, 1.79SG, and 2.06SG, respectively. However, in the past, we have restricted the mud weight for drilling the lowest section to 1.24SG because of potential damage to the reservoir. Although the mud weight of 1.24SG has not been sufficient to allow breakout-free drilling in the Tanuma, it has adequately facilitated running casing. Therefore, we recommend maintaining an initial mud weight of 1.24SG for the 8-1/2" section with the proviso that mud weight can be raised in steps of 0.02SG immediately 10%-plus cavings have been detected or observed during the operation. When mud weight is raised by 0.02SG (e.g., from 1.24 to 1.26SG), the adjustment must be allowed to work through the fluid system before further step increases of 0.02SG can be applied, as necessary.

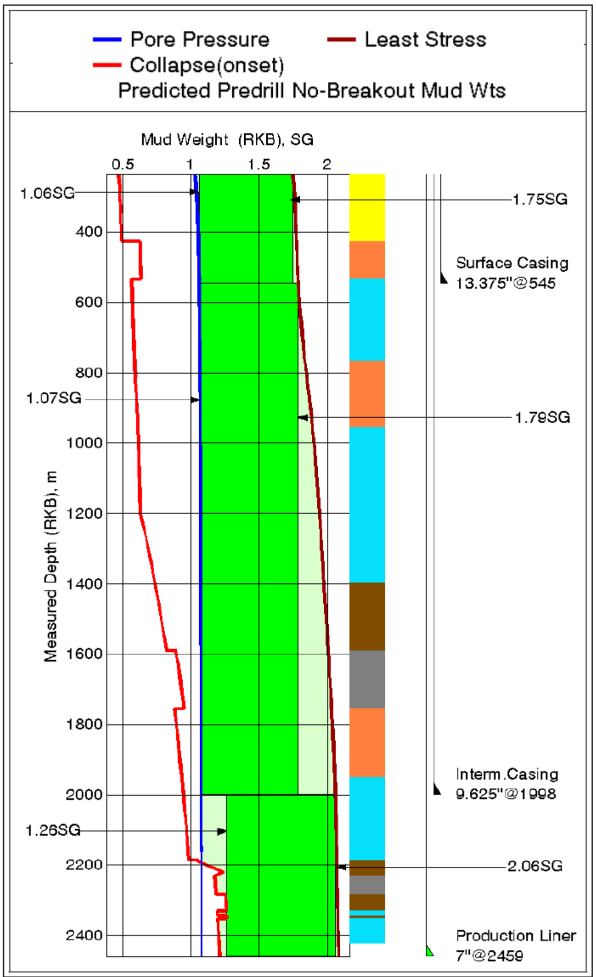

Figure 20. Predrill Mud Weight Validation

The recommended starting mud weights are summarized in Table 3.

Table 3. Recommended Predrill Mud Weights according to drilling problems and validation

Hole Section (inches)	Mud Weight (SG)	Comments
17-1/2	1.06	
12-14	1.07	
8-1/2	1.24	Observe and react to cavings by raising mud weight in steps of 0.02SG (as necessary) in the section.

7. Conclusions

1. Loses should be expected at the base of the Dammam Formation, and lost circulation plans should be ready to execute while drilling this section. In this way, a good casing seat can be achieved before drilling the vuggy/karstic sequence beneath, in which total losses are represented. Water ingress while drilling across the Dammam Formation occurs, so Dammam injectors, which are located within 1.5 km of the wellbore should be shut from 50m above the top of Dammam to the entire formation to be cased off and cemented.
2. Losses occurred in the Hartha Formation. The plans for mitigating lost circulation should be ready to be executed while drilling this section.
3. There was a significant washout in the Tanuma Formation. A program must be adopted to deal with the problem through changes in drilling practices and revisions to the drilling fluid recipe.
4. The injector(s) should remain shut in until the Mishrif formation is cased off to prevent the potential for flow in the Mishrif Formation.
5. The variability of Mishrif reservoir architecture and rock types might lead to irregular sweep and water breakthrough if higher permeability layers are present.
6. Sloughing formations are represented in Tanuma, Nahr Umr, and Upper Shale. Losses occur in Mishrif and Zubair Formations, and potential Stuck Pipes in Mishrif, Nahr Umr, and Zubair Formations.
7. Bit damage through drilling entire anhydrite layers in L. Fars and Rus Formations was the problem with lower effect in the drilling program, so the Tri-cone bit drill must be changed to a PDC bit.
8. In general, Zone 2 shows fewer drilling problems than Zone 1, especially in the productive Formations (Mishrif, Mauddud, and Zubair), which may be due to the differences between Zones 1 and 2 in the sequence of stratigraphy, depositional environment, and the effect of the Al-Hammar Fault on Zone 1.

Nomenclature

ECD	Equivalent Circulating Density
EMW	Equivalent Mud Weight
LCM	Lost Circulation Materials
MW	Mud Weight
NPT	Non Productive Time
NR	North Rumaila oilfield
PDC	polycrystalline diamond compacts
PP	Pore Pressure
PV	Pore Volume
R	North Rumaila oilfield
ROP	Rate of Penetration
RPM	Round per Minute
SPM	Strokes per Minute
SSP	Site Safety Plan
TFA	Total Flow Area
WOB	Weight on Bit
YP	Yield Point

Declaration of Interest

Title of Paper: A Statistical Survey for Drilling Problems at North Rumaila Field, Southern Iraq. A Review enhanced with Well Logs Analyses by the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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