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The Impact of Drilling Operation Parameters on the Lost Circulation Problems for Oil and Gas Wells Based on Field Data

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ABSTRACT

Lost circulation, the loss of drilling fluid into holes or fractures throughout the geological formations being drilled, is the most expensive problem encountered in drilling operations for oil and gas wells. It is known that when there is a loss of circulation during the drilling process, the operation activities are delayed or stopped for curing or treatment, resulting in extra time known as non-productive time (NPT). The NPT issues during the drilling operations are the most important priorities for planning any drilling program. Therefore, the lost circulation is one of the main problems which can control the NPT. To mitigate the lost circulation problems, an integrated investigation is necessarily needed for the main parameters which enhance/downgrade the rate of lost circulation.

Drilling through the Dammam and Hartha formation is typically accompanied with substantial nonproductive time due to severe and often entire drilling fluid losses. The majority of the curing this problem require time for preparation, placement or setting. In this research, a field study was carried out to investigate the effect of 6 drilling parameters on the rate of the lost circulation. The investigated parameters are the rate of penetration, weight on bit, stand pipe pressure, mud weight, flow rate, and the equivalent circulation density. Furthermore, the effect of lithology type on the lost circulation rate was clearly determined and correlated. In addition, a graphical representation of bit depth vs the real drilling time/date was constructed to compare the lossy wells vs non-lossy wells named frithogram. This study was based on field data for 350 wells drilled in Rumaila Oilfield, southern Iraq. The results of this study showed that if these six operating parameters are standard and controlled, the significance of lost circulation problems could be reduced. However, the main factors which are responsible for the lost circulation problems are lithology types, facies and/or diagenesis process, which mainly distinguish the carbonate formations.

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تأثير معلمات حفر الابار على مشكلة فقدان طين الحفر

الوقت الغير منتج في تكويني الدمام والهارثة / حقل الرميلة جنوبي العراق

ميساء نوري شهاب السعد, أ. م. د. فهد منصور صقر, أ. د. محمد هليل حافظ

الملخص

اختراق سوائل الحفر الى داخل التكاوين الجيولوجية او التكسرات يمثل مشكلة مكلفة تؤخذ بالحسبان عند وضع خطة لحفر البئر. فعندما تحدث مشكلة فقدان طين الحفر قد تتأخر عملية الحفر او تتوقف لأغراض الصيانة والعلاج وينتج عنها ما يسمى الوقت غير المنتج وهو من الاهمية حيث يشكل من اهم اولويات خطة الحفر. ولأجل احاطة هذا الموضوع كان من الواجب اجراء دراسة معمقة لاختباراهم المعاملات المستخدمة في عمليات حفر الابار النفطية والغازية والتي تساهم في علاج المشكلة. اجريت دراسة متخصصة لعشرة سنين تمتد من 2010-2020 لاختبار 6 معاملات لتكويني الدمام والكارثة الكابونانية في حقل الرميلة جنوبي العراق. المعاملات التي تم دراستها هي معدل اوسرعة الاختراق لبريمة الحفر، وزن البريمة ، ضغط انابيب الحفر وكثافة طين الحفر ، كثافة طين الحفر ، كمية الجريان وكثافة الدوران. هذا وقد تم الاستعانة بمخطط بياني يمثل الاس السيني والصادي منه بيانات الحفر الزمنية والعمق على التوالي. هذه الدراسة استندت على بيانات 350 بئر تم حفرها خلال فترة العشر سنوات حيث اظهرت النتائج ان هذه المعاملات اذا ماتم استخدامها ضمن القيم القياسية فأنها غير مسؤولة بشكل كامل عن حدوث مشكلة فقدان طين الحفر وربما كانت الصخارية والعمليات الجيولوجية التحويرية المميزة للصخور الكاربوناتية تمثل سببا "رئيسيا" لهذه المشكلة

Introduction

Lost circulation and wellbore stability problems play a major role of increasing nonproductive time (NPT)during drilling process. Wells drilled in the Rumaila Oilfield are highly responsive to (NPT) problems, especially during the drilling process throughout Dammam and Hartha formations. NPT defines as the time spent of any activities out of the well drilling operation plan. It can occur while drilling, running casing/liner, completing or cementing the well. Although the drilling fluid lost is expensive, the lost circulation also generates results which are not only even more costly, but can lead to overall failure of the drilling operation.

In the oil industry, the estimated cost for drilling fluids in 2018 was over $12 billion as indicated by the drilling mud global market [1]. Mostly, the powerful and continuation of NPT problems are relevance to the type of formation lithology and the lost circulation fluid. Generally, there are three distinct formation types correlated to NPT problems which are highly permeable, natural and induced fractures, and cavernous/vugular formations. Such rock types are usually found in limestone and dolomite [2]. Losses can be happening for many reasons such like natural fissures and fractures, cavernous and vugular formations, hole in the casing or riser, induced fractures, excessive mud weight, excessive equivalent circulation density (ECD), poor filtration control, excessive pump rate/fluid viscosity, and others [3]. Lost circulation materials (LCM) are frequently used to prevent or treat seepage or partial losses. If it is severe losses, often caused by larger fracture sizes and/ or large vuggy facies, special treatments are being applied (cement plug). Curing severe losses with specific treatments requires more time since some treatments can't be used when downhole instruments are present [3].

Lost circulation can be classified into three classes. Firstly, there is a seepage loss. This type of lost circulation happens when the lost mud rate is between (0-2) m3/hr. It could be caused by a number of reasons which results from the drilling operation such as fast-drilling rates, displacement of drilled solids with fluids, equivalent circulating density, overbalanced drilling fluid pressure as compared to the formation pressure and/or the nature of the formation lithology being drilled. Secondly, there is partial loss, a situation whereby a fluid is lost into the formation and yet part of it can be recovered back to the surface. The rate of lost circulation is between (2-15) m3/hr. In such condition, the cost of the fluid becomes more critical in terms of choosing whether to drill ahead or take curing action. Based on the rate of the mud loss and the physical characteristics of the thief zone, a more containment treatment procedure may be tried. Lastly, there is total loss up to 15 m3/hr happens in units of gravels, natural horizontal fractures, partially opened induced vertical fractures, and vuggy formation. Predominatingly, this type has to use plugs if the standard.

This research deals with the Dammam reservoir in Rumaila Oilfield. Dammam Formation is a water-bearing interval that is significant for waste water disposal and as a source for future water-flooding projects. Dammam reservoir is made up of interbedded limestone and dolostone with thickness from 200 to 230 meters. It is Eocene in age, spanning the Lutetian to Priabonian stages, (34 to 48 million years old) and was deposited during a period of gradually degradation of sea level [4]. In south of Iraq, the formation consists of grey green

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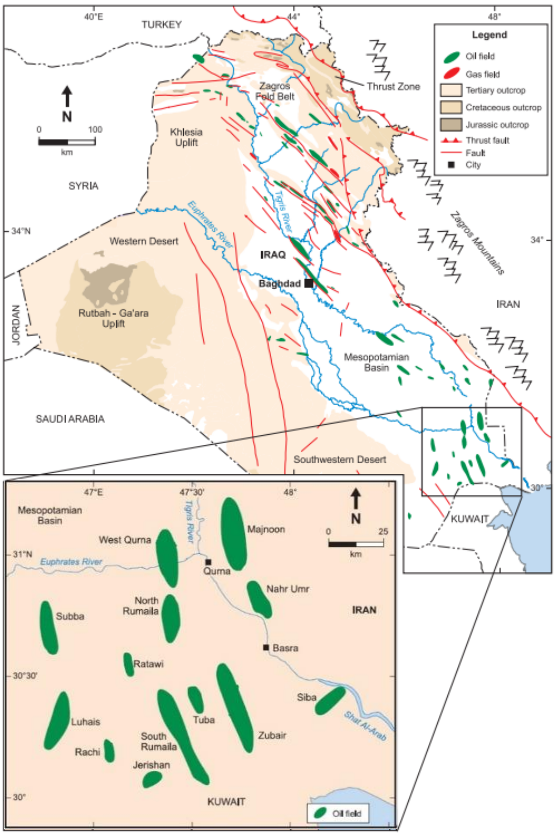
waxy shale layer which often occurs near the base depth at 530-550 m [5]. Unconformably overlying the Dammam Formation is the clastic Ghar Formation [6]. The Hartha Formation also generates a lot of drilling problems as an overburden horizon in the Rumaila Oilfield creates much NPT associated with drilling mud losses because dolomite which is almost forms the lithology. The Hartha Formation represents the neritic limestone sediments formed in transgressive cycle between the Upper Campanian and Maastrichtian [7].

There are numerous exceptional treatments which have been proposed to treat the severe or total losses events, including but not limited to cement [8, 9, 10, 11], chemically activated cross-linked pills [12, 13], cross-linked cement [14], deformable viscous cohesive systems [15, 16, 17], nano-composite gel [18], and gunk squeezes [19, 20]. The loss typically begins with a gradual decrease in pit level, and if no treatment action is taken, the loss may exceed the rig pumping capacity.

This study performed different scenarios to investigate the drilling parameters which control the rate of lost circulation in oil well drilling operations based on field data for 350 wells. The investigated scenarios tried to correlate the lost circulation rate with 6 drilling operating parameters as well as the lithology type in the Rumaila Oilfield, mainly in Dammam and Hartha formations.

2. Study Area

Rumaila Oilfield is supergiant Oilfield in Iraq which is ranked as the 18th largest Oilfield in the world with an estimated oil reserve of about 17 billion barrels covering an area of 1,800 km2 as showing in Fig. 1 [21]. The field was discovered in 1953 and brought in production since 1972. It is located at 50 km west of Basra City, southern Iraq, 41km northwest of Jabal Sanam structure near the Iraq – Kuwait border. Rumaila Oilfield is surrounded by Zubair Oilfield about 25km to the east, 50 km north of Luhais Oilfield and it is very closely from the north of West Qurna Oilfield because they have the same geological structure [22, 23, 24]. In April 2019, the daily oil production rate from Rumaila Field reached 1.5 million barrels per day, nearly one-third of Iraq's total oil supply, due to the upgraded facilities and water injections projects [25].



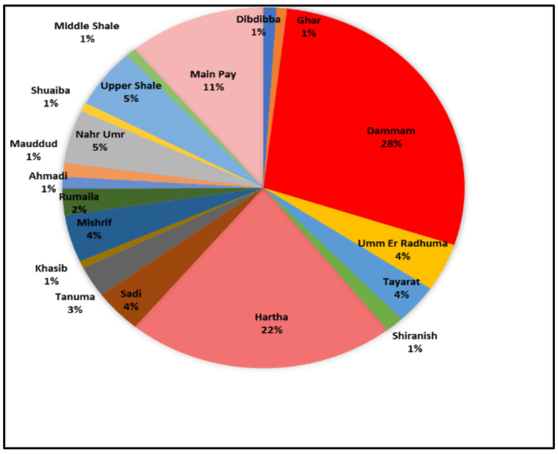


Fig.1: Location map of the studied Rumaila Oilfield (Abeed et al., 2016)

3. Research Methodology

3.1 Data gathering and screening

To accomplish the requirements of the study, the following steps are adapted. Firstly, collecting the field data which are concerning the study area from different sources such as final geological well reports, well logs, technical reports, internal reports, previous studies, thesis, and published articles. All the collected data were from the archive of Basra Oil Company (BOC). Secondly, the daily drilling reports were carefully reviewed and analyzed. Most of the wellbore instability and lost circulation data have been evaluated based on the daily drilling reports from the wells in Rumaila Oilfield. These reports usually contain: 1) the drilling operation progress, 2), the drilling parameter being used, and 3) the associated time for any activity during the drilling process. Thirdly, the final well reports were reviewed where they are described as powerful tools in quantitative and qualitative analysis for the major drilling problems. All data correlating the NPT and production time were obtained from such reports which can be summarized reports to improve the future well

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performances. In addition, the bits' evaluation reports for each bit being run, have been involved in the final well report. Fourthly, the mud logging reports were analyzed. Mud logging reports were used to predict the formation lithology of the interval of interest. Fifthly, the daily mud reports were reviewed. Such reports were employed to estimate the mud characteristics such as mud weight, viscosity, yield point, and solid percent. Additionally, these daily mud reports describe the daily losses as well as the cutting size.

3.2 Selecting wells and drilling parameters

We carefully chose the wells to be considered in this study based on:

a-The availability of data for the selected wells.

b- Select the wells which were nearby each other, and which encountered different performance results such as lossy vs successful wells.

c-The distribution of wells across the field.

3.3 Frithogram

It is a graphical representation of bit depth vs the real drilling time/date. The purpose of this graph is to correlate between lossy and non-lossy wells. These graphs show events leading up to losses. The collected wells are close, so the distance among them is short; however, they were encountered different problems throughout the Dammam and Hartha formations. The main reason behind using closely located wells is to minimize the effect of the geological lithology variation across the field. According to that, we could assume that the selected wells had the same failure criteria prior to drilling operations because they were drilled in the same area of the formation. We used frithogram to spot the differences between each well type. Then, designing the best practices and parameters for drilling successful wells and avoiding NPT could be possible.

3.4 The parameters investigated in the database of this study

a.The measurements of rate of penetration (ROP) were investigated at the top of Dammam and Hartha formations before losses were experienced. We covered the ROP on a separate graph beside the frithogram. Rapid drilling, may add an additional stress to the weak zones and we expected that high ROP could contribute to the breakdown of Dammam and Hartha formations leading to losses or stuck pipes. In addition, we anticipate the high or low ROP could lead to identify losses areas or tight hole respectively.

b.The measurements of standpipe pressure (SPP) in psi were reviewed at the top of Dammam and Hartha formations right before the losses were occurred. We covered the SPP on a separate graph beside the frithogram. We expected that the high SPP adds an additional stress to the weak zone so that the high SPP could correlate with the lost circulation zones.

c.The measurements of weight on bit (WOB) in tons were gathered at the top of Dammam and Hartha formations before lost circulation problems were experienced. We covered the WOB data on a separate graph beside the frithogram. We anticipated that the high WOB could add an additional stress to the weak zones so that the high WOB would be matching with losses.

d.The reported measurements of mud weight (MW) were reviewed and covered in a separated graph beside the frithogram. Theoretically, the high mud weight could add an additional stress on thief zones and the hydrostatic pressure will be increased; therefore, it should be designed between the pore pressure and the fracture gradient in order to prevent any problems. The mud engineers can take decisions to change the mud weight during the drilling process according to the well conditions. We expected the high mud weight would be matching with the lost circulation trend.

e.The measured data of the equivalent circulating density (ECD) in sg were reviewed and gathered. ECD can be defined as the effective density of the fluid at downhole conditions. It is safe to maintain the ECD below the fracture propagation (extension) pressure which is lower than the formation breakdown pressure.

f.The reported data for the drilling flow rate (Flow) were gathered and reviewed. The flow rate data can be used as an indication for the types of fractures whether they are natural or induced. The induced fractures happen during the drilling process. Excessive flow rates with the same fluid properties could result in high ECD pressures.

4. Results and Discussion

4.1 NPT Database Refinement

The first step performed to understand the lost circulation should be done by refining the NPT database. The refinement process was performed throughout the following steps. Firstly, the data of the wells drilled prior to the Rumaila Oilfield organization (ROO) establishment, which we were not sure of their accuracy, were removed from the database. Secondly, for the duplicate well entries, the wells which were experienced multiple losses, we plotted only the most severe loss on the map. Thirdly, we sorted the losses types to find out more details about the lost circulation variation across the field. From the aforementioned steps, we refined the NPT database into three end member color units with different lost circulation rates as shown in Table 1.

Subsurface nonproductive time in the Rumaila Oilfield is variance according to the lithological types; however, it is so intensified in Dammam and Hartha formations. There are 350 wells which have been drilled from 2010 to 2020 by ROO. During

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these 10 years of drilling operation, over 62315.9 hours of NPT have been accumulated. Dammam and Hartha formations have the greater amount of NPT (16524.3, 12617.1 hours respectively). Dammam Formation has 28% whereas Hartha Formation comprises 22% of the total NPT in the Rumaila Oilfield as shown in Fig.2. During these 10 years, there are 135 wells encountered complete losses in Dammam Formation and 54 wells in Hartha Formation as shown in Fig.3 and Fig.4.

The NPT caused by different problems such as mud losses, both partial losses and complete losses, stuck pipes, and bit failure during both drilling and casing setting as shown in Table 2. The NPT event number in Rumaila Oilfield was (2297) which is more than event number in South Rumaila Oilfield (1880). Both complete and partial losses have the vast majority of NPT events types, particularly in Dammam and Hartha formations as shown in Fig. 5 and Fig. 6.

Table 1: Member colors for different types of lost circulations with their definitions

Color on map	Loss classification	Definition
Red	Complete losses	NPT loss rate with >45m^3/h
	Severe losses	NPT with a loss rate of between 15-45 m^3/h
Yellow	Partial losses	NPT with a loss rate of between 2-15 m^3/h
Green	Seepage losses	NPT with a loss rate of between 0-2 m^3/h
	No loss	ROO wells with no loss report

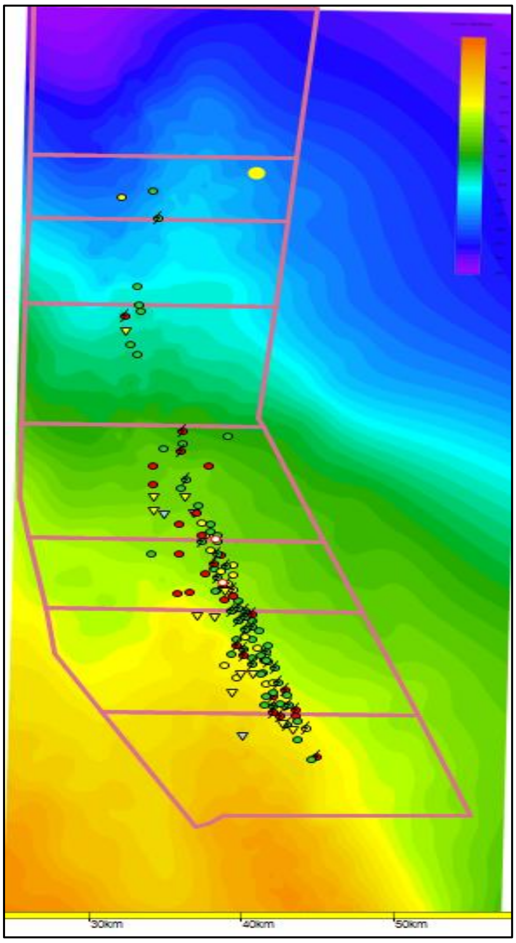

Fig.3: Top Dammam structural map shows 141 wells encountered complete losses in Dammam Formation

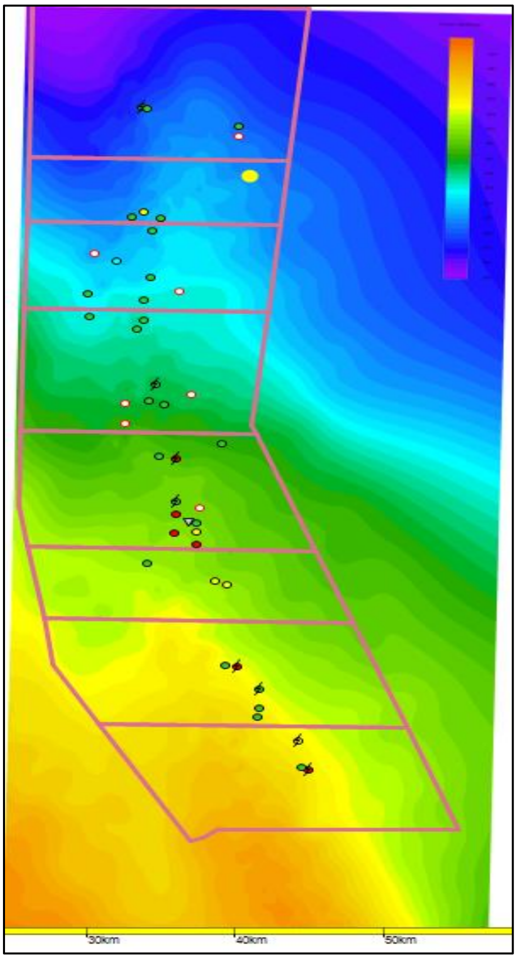

Fig.4: Top Dammam structural map shows 54 wells encountered complete losses in Hartha Formation

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Table 2. NPT hours and events number from 2010-2020Formation

formations	NPT hour	Invisible NPT hour	NPT Event Type			
			Complete	partial	Tight hole	other
Dibdibba	538.5	66.8	1	62	48	-
Lower Fars	107.2	65.3	-	7	86	-
Ghar	455.8	38	-		9	-
Dammam	13162.1	3362.3	204	560	83	-
Rus	190.8	35.5	-	-	42	Bit failure6
Umm Er Radhuma	2416.8	220.8	-	16	163	Stuck24
Tayarat	1885.3	640	-	10	187	Kick25
Shiranish	917.3	60.5	-	-	-	-
Hartha	10662.3	1954.8	84	229	141	-
Sadi	1984.3	353.3	-	-	95	Stuck6
Tanuma	1257	823.5	-	-	62	Stuck10
Khasib	311.5	67.3	-	2	46	-
Mishrif	1785.5	692.8	-	24	177	Stuck7
Rumaila	1275	108.8	-	-	65	Stuck6
Ahmadi	2061.5	416	-	-	124	-
Mauddud	600.5	119.5	-	-	97	Stuck6
Nahr Umr	2379.5	401.8	-	-	243	Stuck12
Shuaiba	422.8	63.8	-	3	69	Stuck7

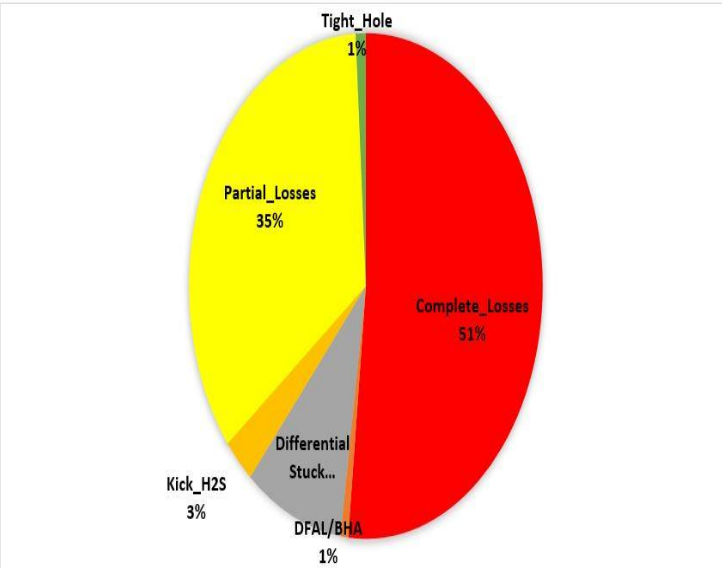

Fig.5: Distribution of NPT in

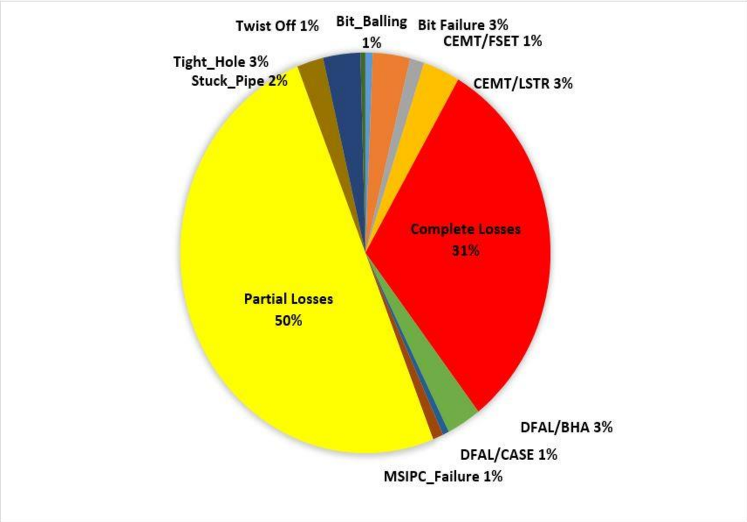

Fig.6: Distribution of NPT in Hartha Formation from 2010-2020

4. well R-586 and well R-592

The data of well R-586 and well R-592 in Rumaila Oilfield were gathered and integrated to understand the main reasons behind the lost circulation problems and how to correlate such problems with drilling parameters as well as the lithology type. Well R-586 experienced 607 h of NPT with different types of losses in Dammam and Hartha formations although the total NPT is 622 h in variant zones throughout the trajectory of the well. Well R-592 was considered as non-lossy well according to the geological and operation reports. The parameters used as well as the events types throughout the drilling operations for both wells were summarized in Table 3- 8.

Frithogram for well R-586 is presented in Fig. 7. (a,b) The bit depth is presented in x-axis while the drilling time is presented in y-axis. Both Dammam and Hartha formations show different types losses at several depths. In the depths of 1848-1863 m, it is extremely evident of total losses which have 447 h of NPT in only 15 m of Hartha Formation thickness. It was treated by 16 cement plugs and 44 m3/h of LCM materials. The parameters were used in the drilling operation in Dammam and Hartha formations are shown in Table 3. Although the entire drilling operation for Well R-586 has 622.8 h of NPT, Dammam and Hartha formations alone consumed 607 h. Table 4 shows different activities which caused these problems and the event types contributing to the NPT. The drilling operational parameters which were used during the important points during the drilling process such as the thief zones (before and after 5 m depth of reaching to the thief zones) are shown in Table 5.

Fig. 8 of R586 and R-592 reveal that ROP values are dropping in both Dammam and Hartha formations. Nevertheless, there is a huge thief zone in well R-586 while there is no any in well R-592. This means that the change in the ROP parameter does not have a significant impact on the lost circulation rate (connected to different facies). This indicates that there is a weak relationship between rate of penetration and facies. Fig. 9 shows the influence of the SPP parameter on the performance of drilling operations in Dammam and Hartha formations for wells R-586 and R-

592 respectively. The values of SPP parameter decrease in both Dammam and Hartha formations for both wells. There is no evident connection between the SPP and the lost circulation rate. The effects of WOB on the rate of lost circulation are shown in Fig. 10 for well R-586 and for well R-592. Both wells show a decrease in WOB value in Dammam Formation. In Hartha Formation, there is a reduction in the WOB value in R-586 while there is no reduction in the WOB value for well R-592; however, there are no losses. Hence, we can conclude that there is no a significant connection between the WOB and the lost circulation rate. Mud weight parameters of well R-586 and R-592 are shown in Fig. 11. In Dammam Formation of well R-586, the depth of thief zone is at 663-800 m while MW parameter ranges between 1.04-1.12. The value of 1.07 is present in depth of 720-750 m within the thief zone and this may be one of the reasons for inducing losses in this case. The value of mud weight in well R-592 is stable at 1.06 in depth of (665.5-755) m whose contains partial losses zones whereas the value of 1.08 and 1.09 in depths of 725-755 and 755-792 respectively without losses. Accordingly, the mud weight is not the main reason for the lost circulation as compared to the type of facies. Fig. 12 presents that drilling flow rate was decreased in both Dammam and Hartha formations to prevent losses although there is an increase in the drilling flow rate in non-lossy wells of Hartha Formation. There are normal ECD values in both formations for all successful and failed wells as shown in Fig. 13. All details of drilling operating parameters for non-lossy well R-592 are presented in Table 6- 8.

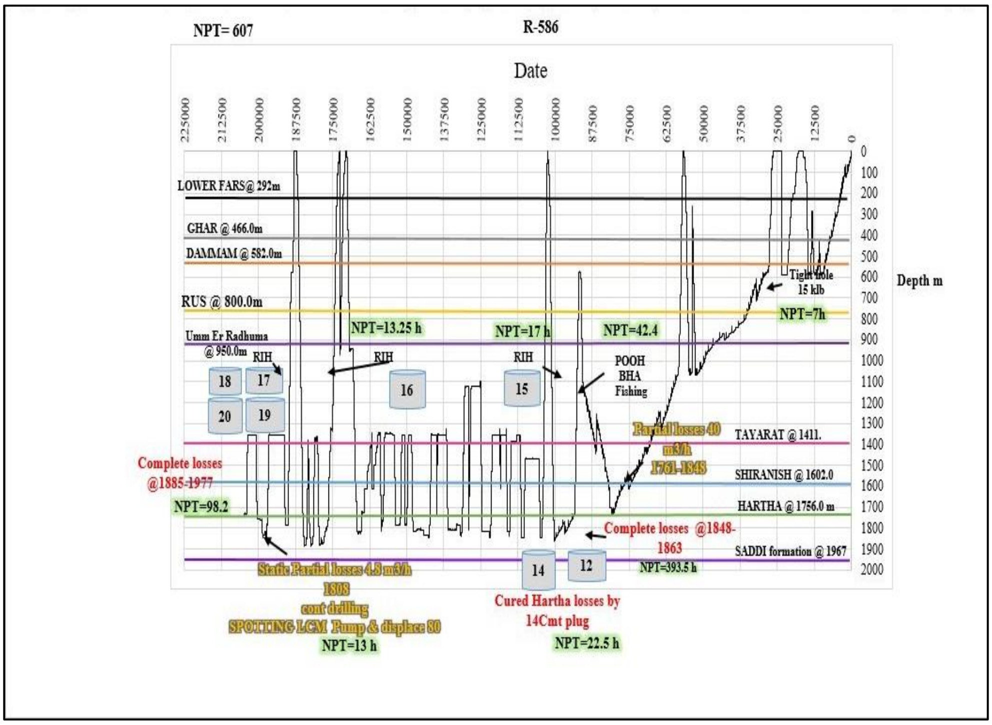

Fig.7. a: Frithogram for
well R-586

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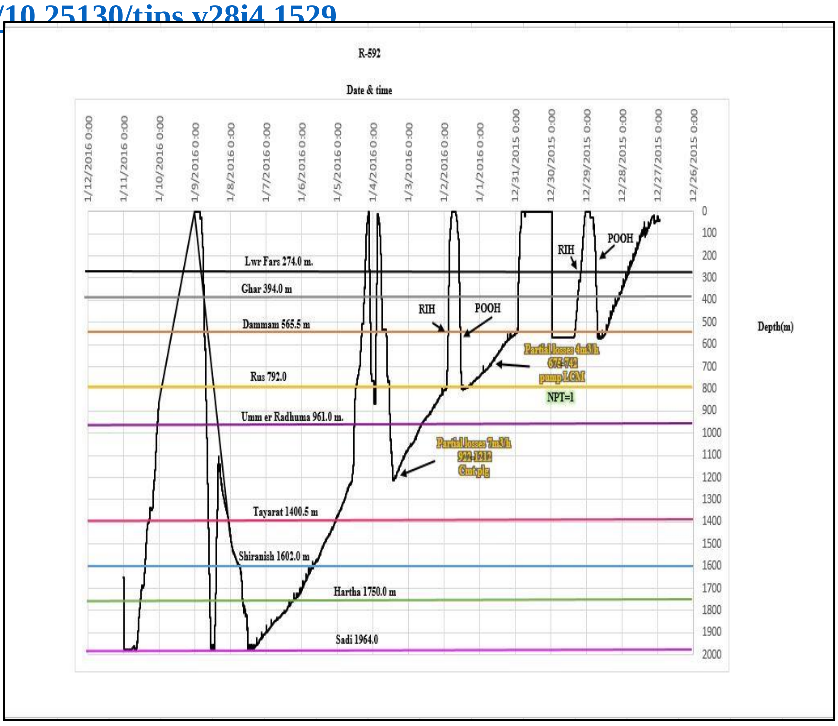
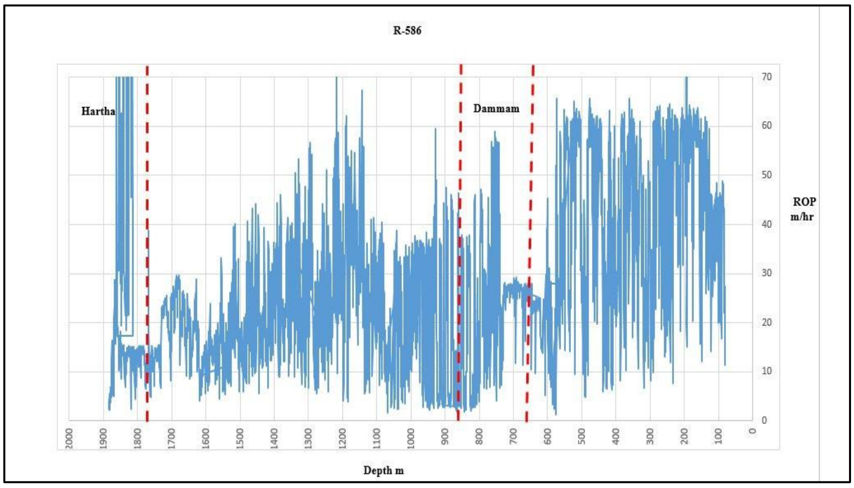


Fig.7.b: Frithogram for well R-592



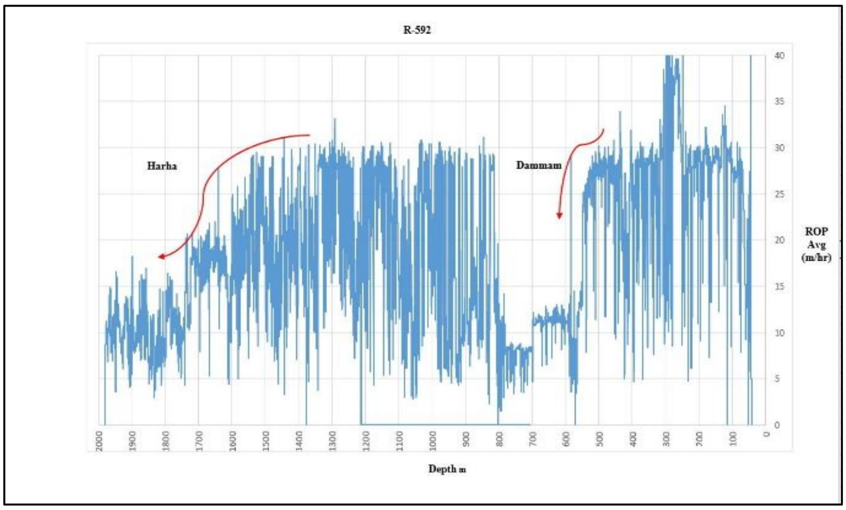


Fig. 8. ROP for well R-586 and well R-592

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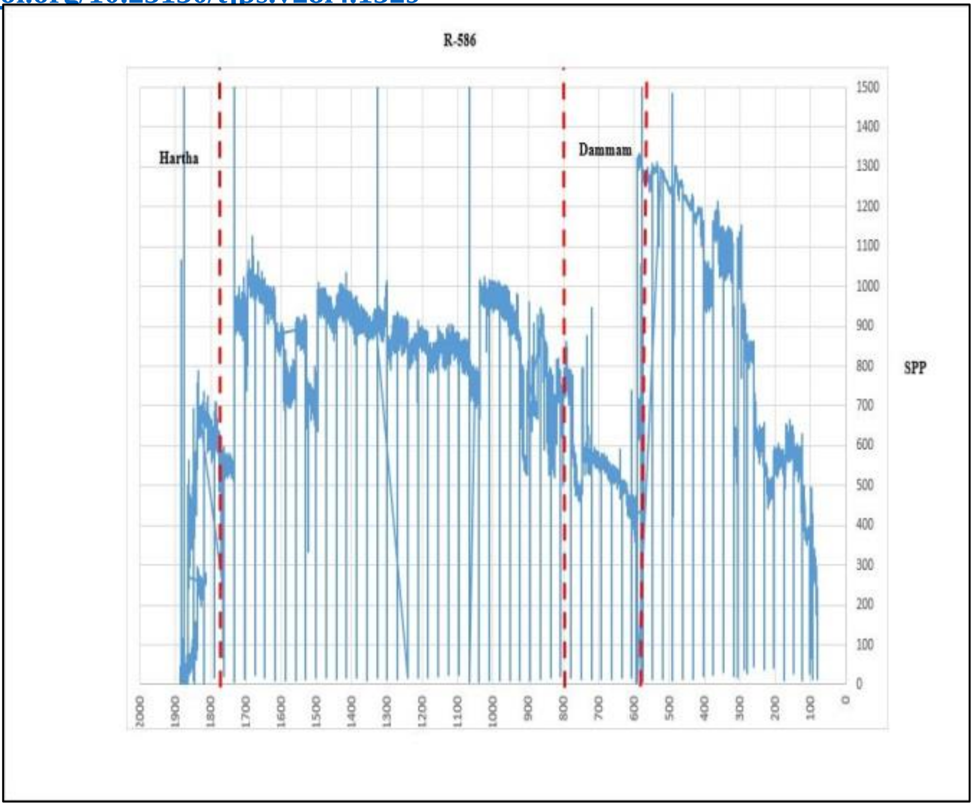


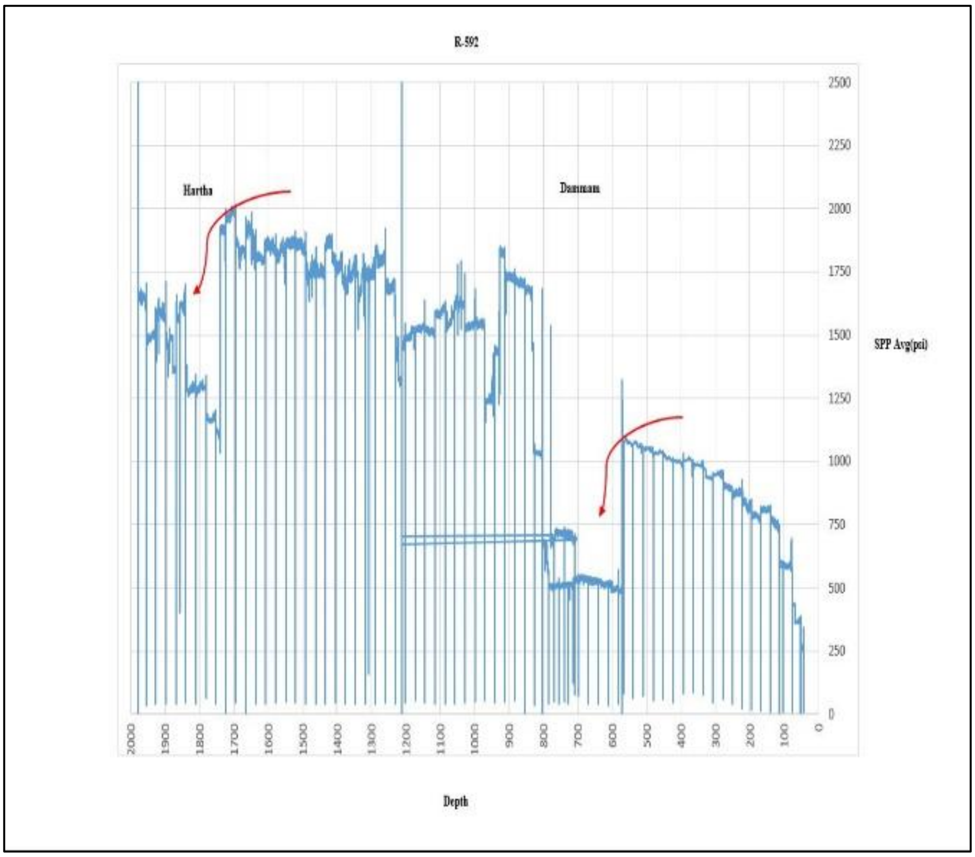
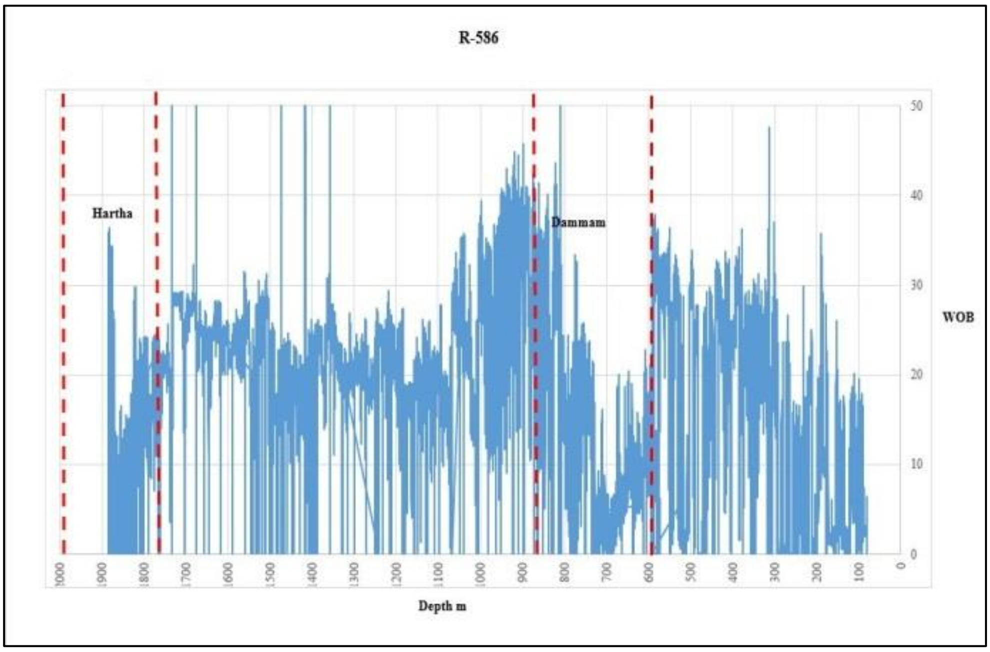


Fig. 9. SPP of well R-586 and well R-592



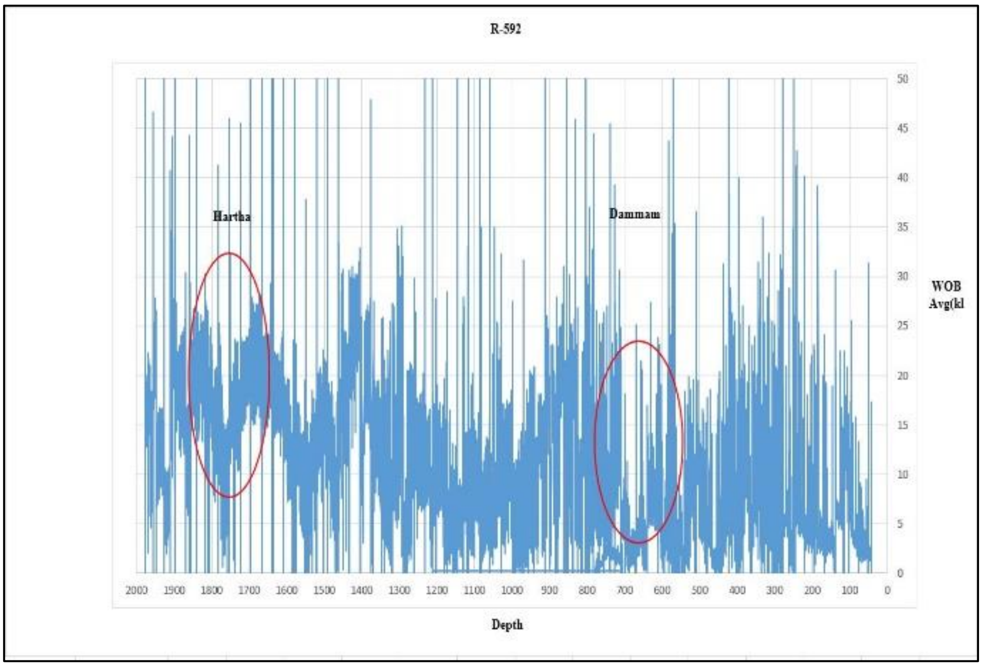


Fig. 10.WOB of well R-586 and R-592

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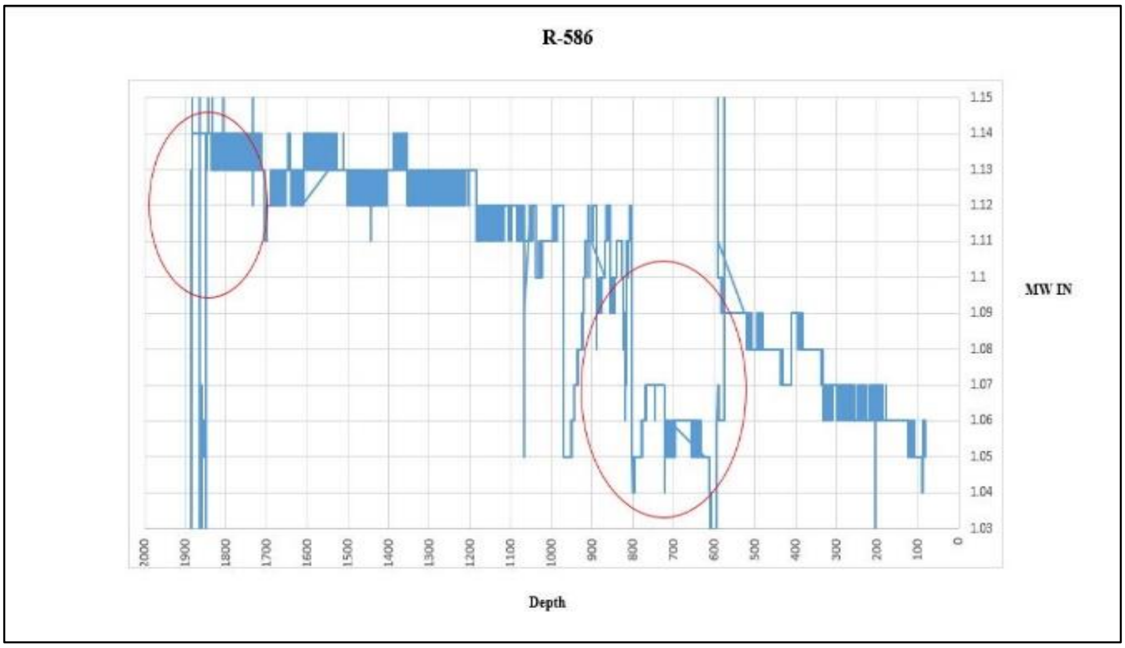


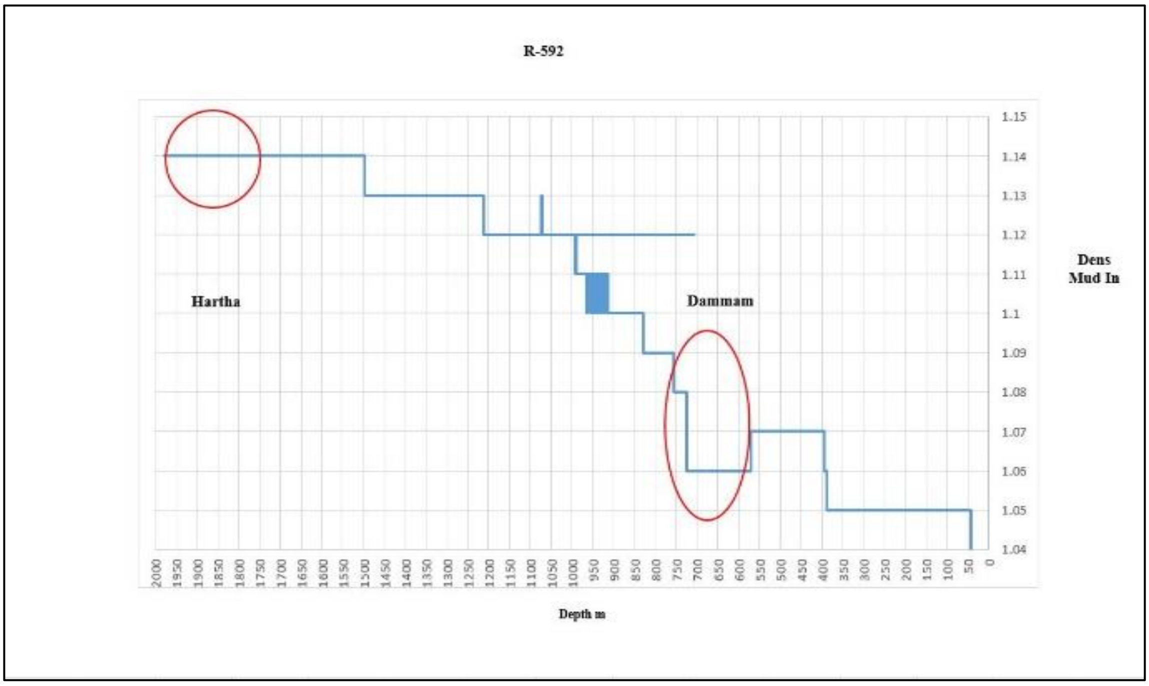
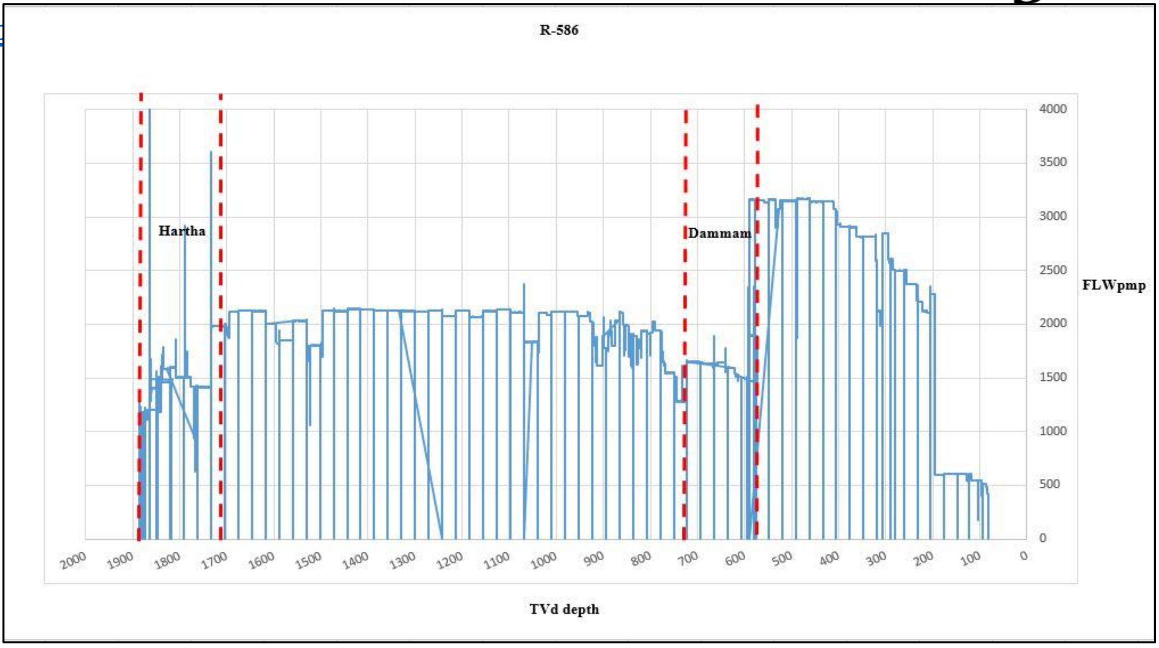


Fig.11. MW of well R-586 and well R-592



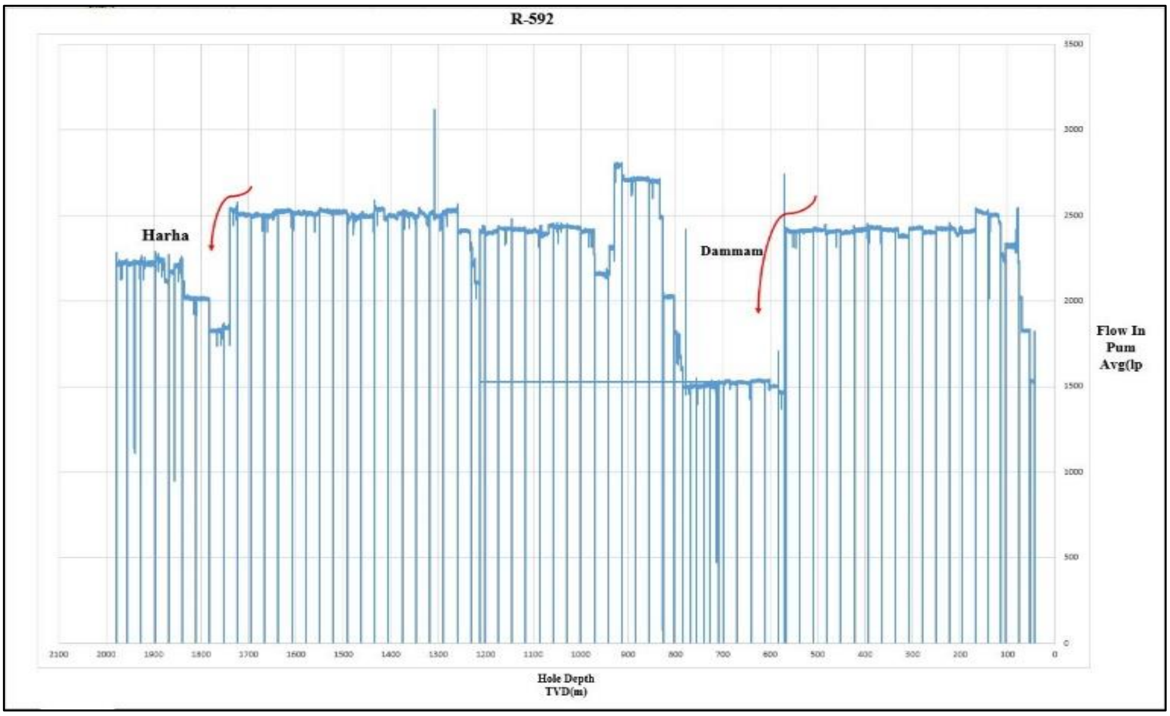


Fig.12. flowrate of well R-586 and well R-592

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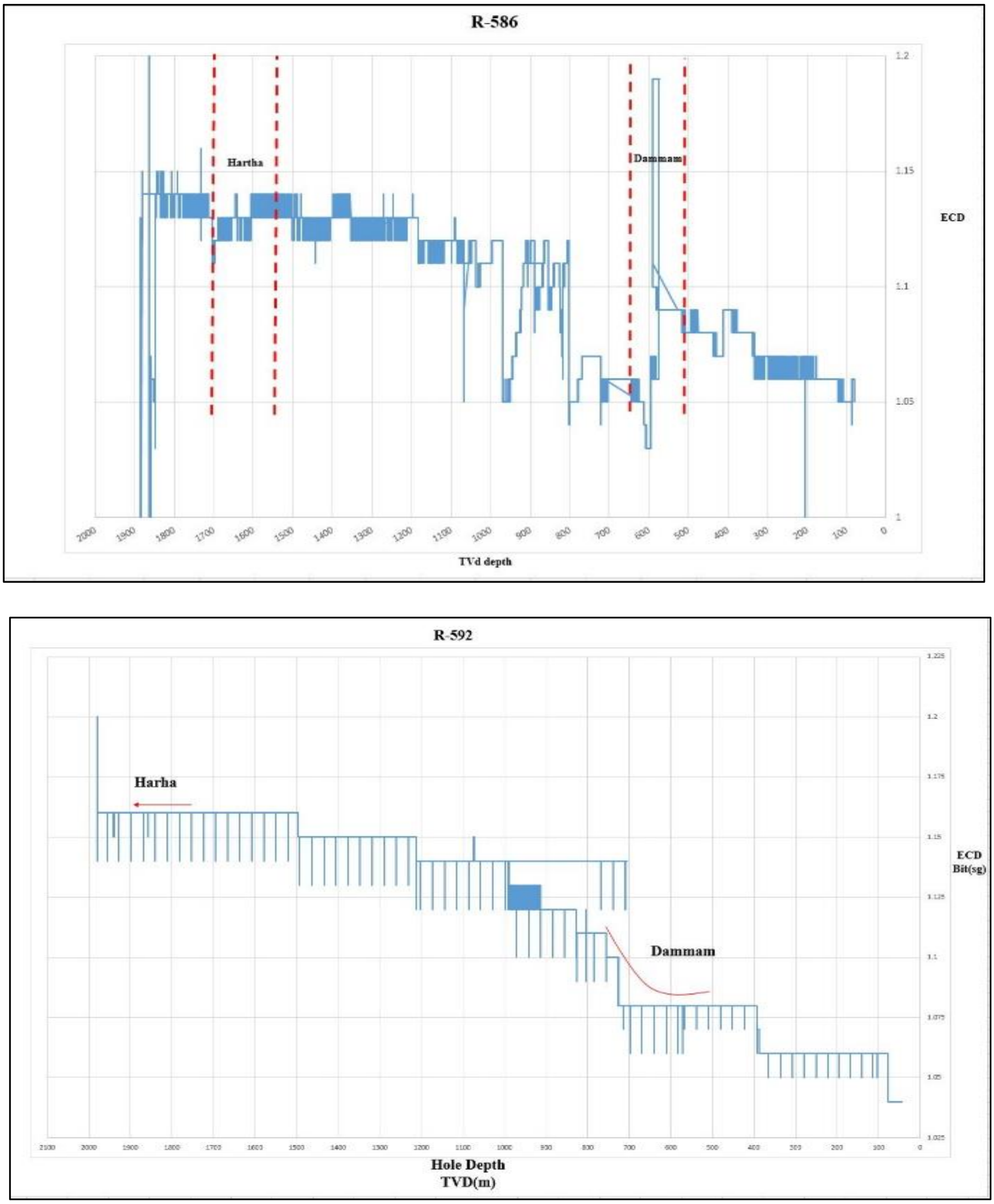

Fig.13. ECD of well R-586 and well R-592

https://doi.org/10.25130/tjps.v28i4.1529

Table 3: Operational drilling parameters for Dammam and Hartha formations of well R-586 in Rumaila Oilfield

Formation depth	Parameters						Note
	Mw	Rop (m/d)	Wob (ton)	Spp (psi)	Flow (Ipm)	ECD (sg)	
Dammam (582-800)$_m$	1.03-1.07	1.2-58.95	0-33.4	2-947	0-2029	1.03-1.07	Mw in depth (720-770)m =1.07
Hartha (1756-1967)$_m$	0.9-1.33	2.17-303.85	0-36.4	0-2982	0-19550	0-1.33	

Table 4. Types of events during the drilling process for Dammam and Hartha formations of well R-586 in Rumaila Oilfield

well	Formation	Nu	Depth event	NPT Type	Rating m^3/h	NPT hour	Activity	Response	Lithology from Mud log
R-586	Dammam	1D	663-800	Partial losses	11	0.5	Drilling	Pump hi vis mud	DOLOMITE: Yellowish grey, pale yellowish brown, moderately hard to hard, sub-blocky, micro crystalline to crypto-crystalline, occasionally sucrose, vuggy porosity, no shows
		2D	765-824	Tight hole	15 kb	6	RIH	M/U TDS & Washed down the tight interval	
		3D	800-864	Seepage losses	2	0.5	Drilling	continue drilling	
	Hartha	1H	1808	Partial losses	4.8	13	Circulation	SPOTTING LCM_ Pump & displace 80 bbls of LCM on bottom	DOLOMITE: Pale yellowish brown, dark yellowish brown, hard to very hard, sub blocky to blocky, micro to fine crystalline, occasionally, sucrose, no visible porosity, no shows LIMESTONE: Mudstone, yellowish grey, soft to firm, amorphous to sub blocky, micro-crystalline, no visible porosity, no shows
		2H	1809	BHA	-	42.45	POOH dropped last 2 stands in the hole	Fishing	
		3H	1761-1848	Partial losses	40	-	Drilling	continue drilling	DOLOMITE: Pale yellowish brown, dark yellowish brown, hard to very hard, sub blocky to blocky, micro to fine crystalline, occasionally, sucrose, no visible porosity, no shows LIMESTONE: Mudstone, yellowish grey, soft to firm, amorphous to sub blocky, micro-crystalline, no visible porosity, no shows
		4H	1848-1857	Complete losses	-	17	RIH	Cmt plug #15	
		5H	1848-1857	Complete losses	-	13.25	RIH	Cmt plug #16	
		6H	1848-1863	Complete losses	-	393.5	Drilling	POOH, pump LCM then Cmt plug #12	
		7H	1848-1863	Complete losses	-	22.5	Drilling	Curing losses POOH, pump LCM then Cnt plug #14	
		8H	1843-1920	Complete losses		98.25	Drilling	Spotting $13m^3$ LCM & cmt blug 17 18 19 20 no success	

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Table 5. The operational drilling parameters for the important points in Well R-586 in Rumaila Oilfield

N	Depth event	Parameter						
		Rop	Wob	Mw	Spp	Flow	ECD	
1D	Before 5_m	24.46-27.94	3.4-8.9	1.06	506-553	1627-1645	1.06	
	663-800	3.93-58.95	0-33.4	1.04-1.07	14-947	0-2029	1.04-1.07	
	After 5_m	3.93-29.07	13.2-24.4	1.04-1.12	699-726	1912-1914	1.04-1.12	
4,5,6,7H	Before 5_m	13.24-15.75	0-15.1	1.13-1.15	368-584	1194-1507	1.13	
	1848-1863	8.58-61.31	0-16.5	1.03-1.14	12-693	0-19577	0.88-1.33	
	after 5_m	15.64-28.68	0-13.6	1.14	25-78	1113-1203	1.14	

Table 6: Types of events for Dammam formation of well R-592 in Rumaila Oilfield

well	Formation	N	Depth event	NPT Type	Rating m^3/h	NPT hour	Activity	Response	Lithology from Mud log
R-586	Dammam	1	675-742	Partial losses	4	0.5	Drilling	Pump LCM material	DOLOMITE: Yellowish grey, hard to very hard, blocky to sub-blocky, micro-crystalline to fine crystalline, sucrose, poor to good visible porosity, vuggy porosity, no oil shows.

Table 7. Operational drilling parameters for Dammam and Hartha formations in Well R-592 in Rumaila Oilfield

Formation depth	Parameters						Note
Dammam (565.5-792) m	Mw	Rop (m/d)	Wob (ton)	Spp (psi)	Avg Flow (Ipm)	Avg ECD (sg)	
	1.06-1.09	0-29.5	1.2-63.7	0-1322	1.07	0-2742	Mw in depth (725-792)=1.08-1.09
Hartha (1750-1964)m	1.14	2.95-18.2	0-32	36-1712	2010	1.159	There are many negative value in various depth

7. Conclusions

This study was conducted to understand the reasons behind the lost circulation problems in Rumaila Oilfield. The results of this research were built on an integrated screening analysis for field data gathered from 350 wells. The following conclusions can be drawn from this study:

1.There is no direct link between ROP and the lost circulation rate. It is clear from the details of the study presented in this research that the ROP parameter is not responsible for the lost circulation rate because of their weak relationship.

2.In all investigated wells, SPP trends are relatively similar. The value of the SPP parameter would be mostly decreased within thief zones of Dammam and Hartha formations as compared with other zones. However, there is a weak correlation between the values of SPP and lost circulation rates.

3.Regardless of whether they experienced formation losses or not, all wells show a comparable weight on bit. In most of the wells existed in our dataset, the WOB was approximately 2-5 tones in Dammam Formation whereas 10-15 tones in Hartha Formation although the lost circulation happened in one formation and did not happen in the other. This means there is no a consistent relationship.

4.According to our database, the value of mud weight parameter stabilizes at a range of 1.04- 1.06 and 1.13- 1.04 in Dammam and Hartha formations

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respectively and this applies enough hydrostatic pressure for both formations, in a pressure range between the limit of the minimum mud weight needed to maintain hydraulic safety and the maximum mud weight allowed for mechanical stability of the borehole.

1. The flow rate and the equivalent circulation density seem to be controllable and matching the other drilling parameters.

We can conclude that if the drilling operating parameters are carefully planned and controlled, the facies, lithology, geological heterogeneity and/ or diagenesis process are the main reasons which are causing lost circulation problems. Even in high-risk areas, several wells could be successfully drilled through Hartha and Dammam formations if mud losses were corroborative or alternatively prevented by how the wells are drilled, or how far the drilled wells are from the injection wells. The injected areas, which are close to the disposal of the produced water, are responsible for increasing the formation pressure near the drilled wells and could result in non-lossy wells.

Conflicts of interests

We would like to confirm that there are no known conflicts of interest associated with this publication, and no significant financial support has been provided that could have influenced its outcome.

Nomenclature

ROO: Rumaila Operation Organization
WOB: weight on Bit

MW: Mud weight
ECD: Equivalent Circulating Density

Flow: Flow rate
NPT: Non-productive time

LCM: lost circulation materials
ROP: Rate of Penetration

SPP: Standpipe pressure

References

[1]Al-Hameedi, A.T.T.; Alkinani, H.H.; Dunn-Norman, S.; Flori, R.E.; Hilgedick, S.A.; Amer, A.S.; Alsaba, M.T., 2018. Using Machine Learning to Predict Lost Circulation in the Rumaila Field, Iraq. In Proceedings of the SPE191933-MS presented at SPE Asia Pacific Oil and Gas Conference and Exhibition, Brisbane, Australia, 23–25 October.

[2]Alsaba, M., Nygaard, R., 2014. "Lost Circulation Materials Capability of Sealing Wide Fractures" SPE-170285-MS SPE Deepwater Drilling and Completions Conference held in Galveston, Texas, USA, 10 –11 September 2014.

[3] M-I SWACO. Schlumberger., 2011. "Prevention and Control of Lost Circulation".

[4] Haq, B. U., Hardenbole, J. and Vail, P.R., 1987. Chronology of fluctuation sea levels since the Triassic, Science, V.235, PP. 1156-1167.

[5] Jassim, S.Z., and Göff, J.C., 2006. Geology of Iraq. DOLIN, sro, distributed by Geological Society of London, 341.

[6]Ziegler, P.A., W. Cavazza, A.H.F. Robertson and S. Crasquin-Soleau 2001. (Eds.), Peri-Tethyan rift/wrench basins and passive margins (IGCP 369 results). Mémoires du Muséum National d'Histoire Naturelle, Paris, Peri-Tethys Mémoire 6Raad Z.

[7] Buday, T., 1980. The Regional Geology of lraq. 1: Stratigraphy and Palaeogeography. 1n: Directorate General for Geological Survey and Mineral Investigations, State Organisation for Minerals Library, Baghdad, Iraq, Dar-Al-Kutir publishing House, Baghdad, pp.445.

[8]Messenger, J. U., and McNiel, J. S. 1952. "Lost Circulation Corrective: Time-Setting Clay Cement". Journal of Petroleum Technology, Vol. 4, pp. 59 –64. http://dx.doi.org/10.2118/148-G.

[9]Messenger, J. 1981. Lost Circulation. PennWell Corp., Tulsa.

[10] Morita, N., Black, A. D., and Fuh, G-F. 1990. "Theory of Lost Circulation Pressure". SPE 20409, SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, USA, 23-26 September. http://dx.doi.org/10.2118/20409-MS.

[11] Fidan, E., Babadagli, T., and Kuru, E. 2004. "Use of Cement as Lost-Circulation Material: Best Practices". PETSOC-2004-090, Canadian International Petroleum Conference, Calgary, Alberta, 8-10 June. http://dx.doi.org/10.2118/2004-090.

[12] Bruton, J. R., Ivan, C. D., and Heinz, T. J. 2001. "Lost Circulation Control: Evolving Techniques and Strategies to Reduce Downhole Mud Losses". SPE 67735, SPE/IADC Drilling Conference, Amsterdam, The Netherlands, 27 February-1 March. http://dx.doi.org/10.2118/67735-MS.

[13] Bruton, J. R., Ivan, C. D., and Heinz, T. J. 2001. "Lost Circulation Control: Evolving Techniques and Strategies to Reduce Downhole Mud Losses". SPE 67735, SPE/IADC Drilling Conference, Amsterdam, The Netherlands, 27 February-1 March. http://dx.doi.org/10.2118/67735-MS.

https://doi.org/10.25130/tjps.v28i4.1529
[14] Mata, F., and Veiga, M. 2004. “Crosslinked Cements Solve Lost Circulation Problems”. SPE 90496, SPE Annual Technical Conference and Exhibition, Houston, Texas, USA, 26-29 September. http://dx.doi.org/10.2118/90496-MS.

[15] Wang, H., Sweatman, R. E., Engelman, R. E., Deeg, W. F. J., and Whitfill, D. L. 2005. “The Key to Successfully Applying Today’s Lost Circulation Solutions”. SPE 95895, SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, 9-12 October. http://dx.doi.org/10.2118/95895-MS.

[16] Wang, H., Sweatman, R. E., Engelman, R., Deeg, W. F. J., Whitfill, D. L., Soliman, M. Y., and Towler, B. F. 2008. “Best Practice in Understanding and Managing Lost Circulation Challenges”. SPE Drilling & Completion, Vol. 23, pp. 168 –175. http://dx.doi.org/10.2118/95895-PA.

[17] Whitfill, D. L., and Wang, H. 2005. “Making Economic Decisions to Mitigate Lost Circulation”. SPE 95561, SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, 9-12 October. http://dx.doi.org/10.2118/95561-MS.

[18] Lecolier, E., Herzhaft, B., Rousseau, L., Neau, L., Quillien, B., and Kieffer, J. 2005. “Development of a Nanocomposite Gel for Lost Circulation Treatment”. SPE 94686, SPE European Formation Damage Conference, Sheveningen, The Netherlands, 25-27 May. http://dx.doi.org/10.2118/94686-MS.

[19] Bruton, J. R., Ivan, C. D., and Heinz, T. J. 2001. “Lost Circulation Control: Evolving Techniques and Strategies to Reduce Downhole Mud Losses”. SPE 67735, SPE/IADC Drilling Conference, Amsterdam, The Netherlands, 27 February-1 March. http://dx.doi.org/10.2118/67735-MS.

[20] Collins, N., Whitfill, D., Kharitonov, A., and Miller, M. 2010. “Comprehensive Approach to Severe Loss Circulation Problems in Russia”. SPE 135704, SPE Russian Oil and Gas Conference and Exhibition, Moscow, Russia, 26-28 October. http://dx.doi.org/10.2118/135704-MS.

[21] Qusay Abeed, Ralf Littke, Frank Strozyk and Anna K. Uffmann., 2013. GeoArabia, 2013, v. 18, no. 1, p. 179-200 Gulf PetroLink, Bahrain.

[22] Al-Mimar, H.S., Awadh, S.M., Al-Yaseri, A.A. and Yaseen, Z.M., 2018. Sedimentary units-layering system and depositional model of the carbonate Mishrif reservoir in Rumaila Oilfield, Southern Iraq. Modeling Earth Systems and Environment, 4(4), 1449-1465.

[23] Awadh, S.M., Al-Mimar, H.S. and Al-Yaseri, A.A., 2018. Salinity mapping model and brine chemistry of Mishrif reservoir in Basrah Oilfields, Southern Iraq. Arabian Journal of Geosciences, 11(18), 1-12.

[24] Awadh, S.M., Al-Mimar, H.S. and Yaseen, Z.M., 2021. Effect of Water Flooding on Oil Reservoir Permeability: Saturation Index Prediction Model for Giant Oil Reservoirs, Southern Iraq. Natural Resources Research, 1- 13.

[25] Stacker, 2022. The largest Oilfield in the world. https://stacker.com/stories/3860/largest-oil-fields-world.