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High-Performance Water-Based Drilling Fluid Engineered to Target Deeper Horizontal Section in Onshore Middle East Field

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Abstract

Drilling more challenging reservoirs with long lateral section to improve well production, has become a common practice, especially in the Middle East where fit for purpose HPWBFs are preferred to ensure the success of those projects.

An operator in Middle East planned to drill a long horizontal gas reservoir section with anticipated operational challenges such as narrow fluid density window of 8.8-9.2 ppg, high tendency of formation losses, excessive torque and drag, possible differential sticking, wellbore instability across unstable shales and downhole temperature above 250° F.

This complex environment required the formulation and lab verification of an engineered HPWBF designed to ensure the success of the project in a safe manner within the scheduled timeframe.

The HPWBF was customized to overcome the drilling of a horizontal section in an area characterized by inconsistent formation pressures with relatively high reactivity, stressed interbedded shale and sandstone sections exacerbated by potential formation losses.

Paramount work was done in designing the bridging and sealing package for this well, including a blend of different metamorphic calcium carbonate in conjunction with a nano-scale polymeric agent that improved filter cake quality, strengthen the wellbore and reduce pore pressure transmission.

Reactive clays were controlled through the use of KCl in conjunction with an amine-based shale inhibitor while the very low-fluid-loss targets were ensured thanks to the utilization of a customized blend of chemically modified polymers.

A tailored thermal polymer extender was added to preserve the polymers effectiveness when mud was exposed to BHST during trips.

Torque was minimized through use of sized graphite based solid lubricant combined with engineered styrene spherical beads.

The gas reservoir lateral section was successfully drilled ahead the planned days with the deployment of an engineered HPWBF establishing the record of longest horizontal section ever drilled in the area.

The HPWBF provided the required shale inhibition, lubricity, minimization of fluid invasion toward formation with optimum bridging, thermal stability, and outstanding wellbore stabilization while drilling as well as when performing logging operations for data acquisition prior to run and cement the liner.

Furthermore, a customized LCM strategy comprising of marble materials with different size and concentration helped to minimize formation losses.

All fluids were planned to be built on location, requiring exceptional logistical management and pre-well planning.

Introduction

In Middle East, a legacy operator planned to drill a challenging horizontal reservoir section through reactive and unstable stressed interbedded shale and sandstone formations.

Large amount of cavings, hole enlargements, improper hole cleaning, pack-off, prolonged reaming, overpull, torque and drag, induced losses caused excessive ECD, difficulties in running casing, stuck pipe events followed by drilling costly sidetracks (Van Oort, 2003) (Mohiuddin et al. 2006) (Van Oort et al., 2017) are the main common operational problems related to wellbore instability that operator tried to alleviate on this specific well with a selection of an appropriate drilling fluid.

This project presented additional problems like potential risk of losses through a formation with a permeability from 200 to 600 mD that required a narrow fluid density range of 8.8-9.2 ppg, excessive torque and drag while building trajectory and drill the horizontal hole high temperature environment above 250° F.

After a detailed analysis of available data and lessons learned from offset wells, the fluids team conducted a thorough lab study to provide a fit for purpose and cost-effective fluid solution to target the fluid's benchmarks established by operator.

Due to the limitation to utilize appropriate Mud Weight above the established range that would represent first barrier against the wellbore instability, the goal was to minimize fluid's invasion thus limit the pore pressure transmission (Stowe et al., 2001) through addition of customized bridging and sealing materials.

After extensive lab testing, decision was to deploy an engineered HPWBF designed with selected package of engineered chemicals to provide hole stabilization and shale inhibition, proper filtration and bridging properties, lubricity, and thermal stability of polymers.

A dedicated LCM decision tree strategy was also implemented to face potential downhole losses.

This paper will present an overview of offset experience in same area that have been carefully evaluated for the pre-well planning. Fluid's design and final lab test results will also be discussed. A brief evaluation of the operator's well design will be also addressed. Drilling results and fluid's performance of each section where the HPWBF was utilized will be then discussed and concluding statements conveyed.

Offset Experience

On offset wells in a field in Middle East, a legacy operator faced several challenges while building the angle and then drilling the horizontal reservoir sections such as hole instability, severe formation losses and excessive torque and drag.

Offset Well#01- This well was scheduled to be drilled horizontally to a final measured depth of 17,265 ft. While drilling the lateral section, to improve hole cleaning, a sweeping program was put in place. 10 bbl of low viscosity pill at 9.1 ppg was pumped ahead 20 bbl of high viscosity/high density pill at 10.7 ppg every 100 feet. This allowed to increase cuttings volume at shakers from 5 to 10% v/v and reduce torque value of approximately 500 kilopound. Due to severe downhole losses experienced at 14,075 ft in the lateral interval, after several attempts to mitigate losses without success, operator decide to suspend drilling activity at this depth.

Offset Well#02- On this well, after drilling few feet of lateral section, uncontrolled downhole losses occurred. Operator decided to abandon the project due to the impossibility to properly cure losses.

Drilling Fluid Design and Lab Test Results

After an accurate assessment of potential drilling challenges, reviewing of lessons learned and results achieved on offset wells in same area and other fields in Middle East that faced similar issues (Al-Ajmi et al. 2018) (Al-Khaldy et al. 2019), the projects engineers established the following benchmarks for the design of an appropriate HPWBF suitable for the success of this project:

- Formulate an inhibitive drilling fluid using minimum concentration of acid-soluble solids to achieve the required MW range.
- Optimize the bridging materials package for plugging microfractures and bridging the formation with a permeability in the range of 200-600 mD.
- Optimize fluid loss control and maintain a superior filter cake while drilling.
- Enhanced rheology allowing excellent cuttings transport efficiency with minimal difference between ESD and ECD to minimize induced losses.
- Use polymers with temperature stability exceeding 250°F.
- Strengthen formation with proper bridging and suitable sealing material technology when drilling through unstable formations.
- Provide superior lubricity to minimize torque and drag in long horizontal section (Maliardi A. et al. 2015).
- Build the required fluids volumes on location.
- Easy Mud Logistics and dedicated LCM management plan in case of Formation Losses.
- Balance Fluid performance with minimum cost impact

The fluid laboratory evaluated several fluid formulations with the goal to meet the above needs and provide a cost-effective solution. As result of this work, an engineered HPWBF was developed and optimized to be used at the field. The fluid was formulated with a selection of fit-for purpose additives:

- Sodium chloride was selected as weighting agent to minimize solid content when required.
- Potassium chloride was chosen as primarily shale inhibitor to control reactive clays.
- Amine-based product was deployed as secondary shale inhibitor (Bussaglia et al. 2017).
- Blend of modified starches were used to ensure superior fluid loss control and filter cake quality with thermal stability above 250° F.
- Polysaccharide viscosifier was chosen to maintain rheological properties for optimum hole cleaning.
- Blend of sized metamorphic calcium carbonates were selected for bridging purposes, control potential losses across natural microfractures and optimize filter cake quality. The bridging blend was selected and optimized by means the use of proprietary software to confirm the suitable bridging properties using 20-micron ceramic disk. Figure 1 shows the curve from bridging software used to optimize the blend of marble materials. The Blue line is the calculated target for ideal bridging while the red one is the optimized blend of bridging agents utilized in the fluid formulation.

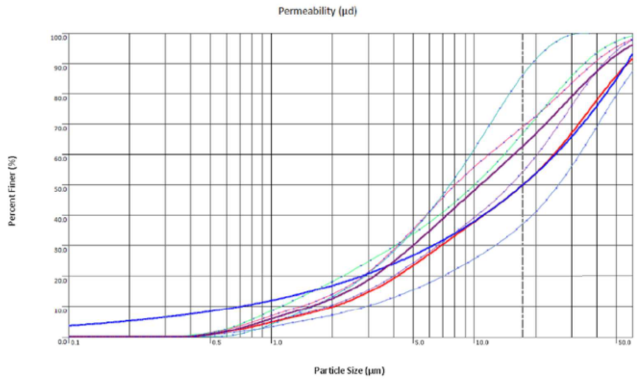

Figure 1: Outcome from bridging package design-Blue Line Target, Red Line Optimal blend

- Based on previous excellent results in different Middle East field (Al-Ajmi at al. 2018) (Al-Khaldy at al. 2019), a nano-scale latex agent was selected to be used through the horizontal section as WSM for plugging interbedded shales and sealing low permeability sandstone to reduce pore pressure transmission and strengthen the borehole. PSD is shown on Figure 2.
- Styrene plastic spherical beads (Figure 3) combined with sized graphite were selected as solid lubricants to be used in the lateral section to minimize torque and drag while drilling and tripping. Figure 4 and Figure 5 show respectively the particle size distribution of plastic beads and graphite material.

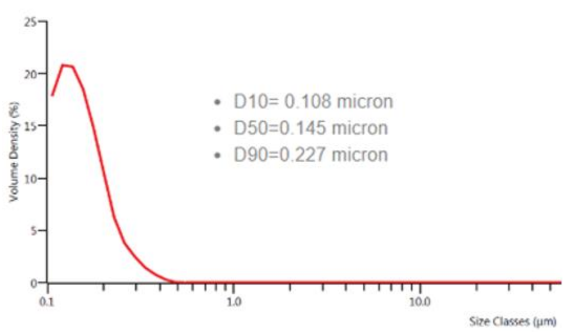

Figure 2: PSD of Latex polymer

Figure 3: Styrene plastic spherical beads lubricant

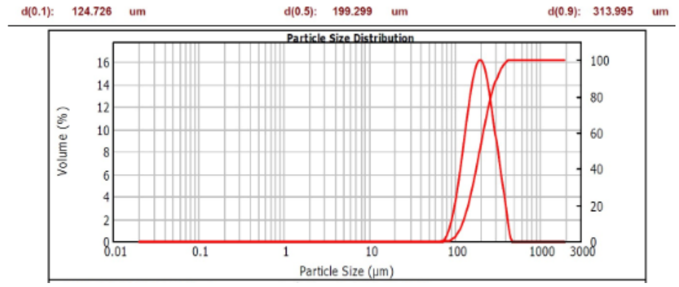

Figure 4: PSD of styrene plastic spherical beads lubricant

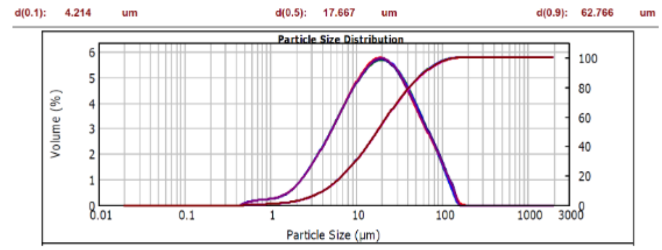

Figure 5: PSD of Graphite material

- An amine-based agent was selected as thermal polymers extender to improve, together with ammonium bisulfite oxygen scavenger, fluid stability after prolonged period of static ageing inside the hole.

Table 1 presents the customized HPWBF recipe for the horizontal reservoir section while Table 2 shows its properties after hot rolling at 250° F for 16 hrs.

Table 1: HPWBF Composition for horizontal reservoir section

Product	Function	ppb
Sodium Carbonate	Alkalinity	0.5
Caustic Soda	Alkalinity	0.15
Ammonium bisulfite	Oxygen scavenger	0.1
Potassium Chloride	Shale Inhibitor	12.0
Amine based product	Shale Inhibitor	3.5
Polysaccharide Polymer	Viscosifier	1.0
Modified Starch 1	Fluid loss control	2.0
Modified Starch 2	Fluid loss control	4.0
Marble material 2 µm	Bridging	5.0
Marble material 10 µm	Bridging	5.0
Calcium carbonate M	LCM	15.0
Calcium carbonate F	Weighting agent	25.0
Latex Polymer	WSM	3.5
Sized Graphite	Sealing/solid Lubricant	4.0

Table 2: HPWBF properties after hot rolling at 250° F for 16 hrs

Properties	Unit	BHR	AHR
MW	ppg	9.2	9.2
Plastic Viscosity @ 120 °F	cP	16	11
Yield Point @ 120 °F	lb/100ft²	37	32
3 rpm @ 120 °F	lb/100ft²	14	11
6 rpm @ 120 °F	lb/100ft²	16	14
Gel strength (10 sec.) @ 120 °F	lb/100ft²	12	10
Gel strength (10 min.) @ 120 °F	lb/100ft²	12	11
API Filtrate	ml	5.0	4.8
HTHP Filtrate @ 225° F	ml	12.8	13.0
PPT (1500 PSI/250° F/20 µm)	ml	-	13.2
PSD (D_{50})	µm	-	58.16

Figure 6 shows the filter cake generated after PPT test performed at 1500 PSI/250° F using 20 µm ceramic disk as filter media.

Figure 6: Filter cake generated on 20 µm ceramic disk after PPT

Well Design

Table 3 shows the well sketch design with mud type selection, max deviation angle and anticipated MW for each hole section. The plan was to drill the 8 3/8" vertical pilot hole across the reservoir section to 13,478 ft true vertical depth for formation evaluation and then, after P@A operation, drill the 8 3/8" sidetrack followed by lateral 6 1/8" sidetrack section to well TD. Figure 7 shows the deviation program for the sidetrack drilling.

Table 3: Well and fluid design for vertical well and sidetrack

MD (ft)	CSG	Hole size	Mud Type	Max Angle (°)	MW (ppg)
1,650	24"	34"	FW+PHB sweeps+PAD	0	8.3-11
3,259	18 5/8"	22"	NaCl-KCl-PO	0	9.8-10.0
7,416	13 3/8"	16"	NaCl-PO	0	9.8
9,210	11 ¾" lnr	12 ¼"x14 ¾"	NaCl-KCl-PO	0	13.5-18
11,605	9 5/8"	10 5/8"x12 ¼"	**HPWBF**	0	8.7-8.9
13,478	Pilot Hole	8 3/8" and P&A	**HPWBF**	0	9.2
11,923	7" Tie-back	8 3/8" ST	**HPWBF**	56.4	8.7
15,738	4 ½"	6 1/8" ST	**HPWBF**	86	9.2

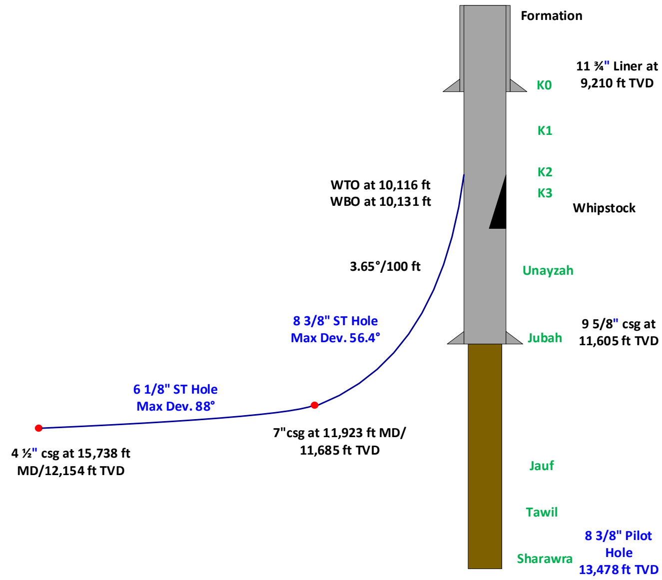

Figure 7: Deviation program for the sidetrack drilling

Drilling Results

The actual well profile and fluid utilized for each section is shown on Table 4. The well was safely and successfully drilled to TD allowing to the acquisition of logs data for reservoir evaluation. The 4 ½" liner was then run and cemented in accordance with the drilling program.

Table 4: Actual Well profile and Fluid design

MD (ft)	CSG	Hole size	Mud Type	Max Angle (°)	MW (ppg)
1,642	24"	34"	FW+PHB sweeps+PAD	0	8.3-11
3,127	18 5/8"	22"	NaCl-KCl-PO	0	9.8-10.0
7,427	13 3/8"	16"	NaCl-PO	0	9.8-9.9
9,201	11 ¾" lnr	12 ¼" x 14 6/8"	NaCl-KCl-PO	0	13.5-13.8
11,511	9 5/8"	10 5/8"x 12 ¼"	**HPWBF**	0	8.7-8.9
13,674	Pilot Hole	8 3/8" and P&A	**HPWBF**	0	9.2-10.4
11,873	7" Tie-back	8 3/8" ST	**HPWBF**	47	8.7-8.8
17,540	4 ½"	6 1/8" ST	**HPWBF**	88	8.8-9.2

Figure 8 shows the actual deviation profile for the sidetrack drilling.

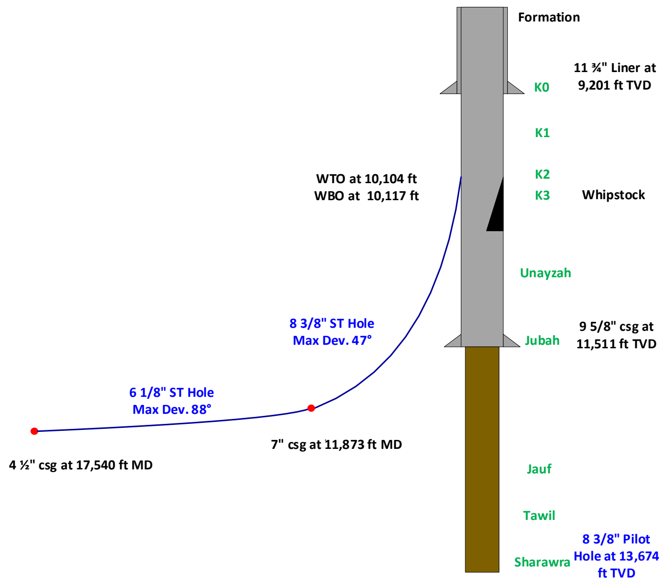

Figure 8: Actual deviation profile for the sidetrack drilling

A brief description of operations of each hole section where the HPWBF fluid was deployed is outlined below.

10 5/8" x 12 ¼" Vertical Hole from 9,201 ft to 11,513 ft

The 10 5/8" Vertical Hole enlarged to 12 ¼" was drilled with the use of 8.7-8.9 ppg HPWBF to section TD at 11,513 ft. At the depth of 9,675 ft and 11,010 ft faced seepage losses with a loss rate ranging from 8 bph up to 17 bph promptly cured after spotting 45 ppb Carbonatic LCM pills in accordance with the engineered LCM strategy plan. Observed background gas at different depths during drilling, while circulating bottom ups and pipe connections from 0.8% to a max peak of 22.3%. Figure 9 shows the actual well profile after completed the 10 5/8" x 12 ¼" Vertical Hole.

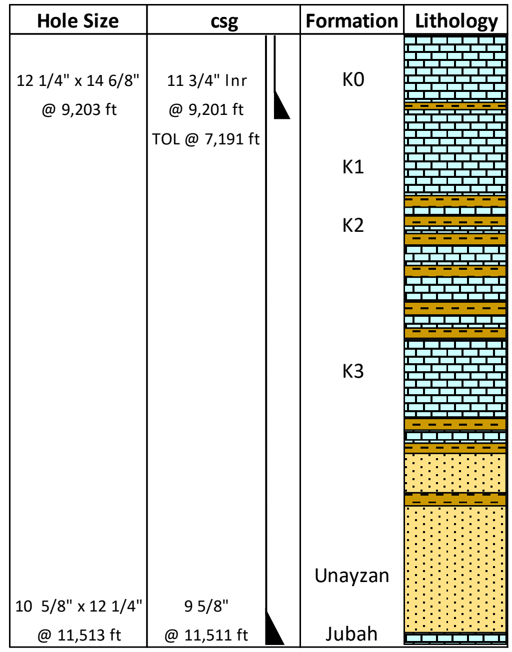

Figure 9: Final Well Profile after completed the 10 5/8" x 12 ¼" Vertical Hole

8 3/8" Vertical Pilot Hole from 11,511 ft to 13,674 ft & P&A

The operator drilled the vertical 8 3/8" vertical pilot hole to 13,674 ft in order to evaluate the reservoir using the HPWBF with initial MW of 9.2 ppg. At the depth of 12,717 ft, the mud weight was raised up to 9,5 ppg and then to 10.5 ppg after reaching section TD prior to logging operations.

In this section 3.5% w/v. Potassium Chloride and 1.0 % v/v Amine Based additive were used to control the reactive clays. Before logs, circulation system was conditioned with 1.0 % v/v amine-based agent to extend thermal stability of polymers under static conditions.

Four Cement plugs (top of last cement plug set at 11,174 ft) were set to isolate the open hole. Mud was displaced out of the well with 8.7 ppg Sodium Chloride brine prior to run and set the whipstock at the depth of 10,117 ft (WBO) to begin the sidetrack sections. Figure 10 shows the actual well profile after drilling the pilot hole, P@A operations and set the whipstock for drilling the sidetracks sections.

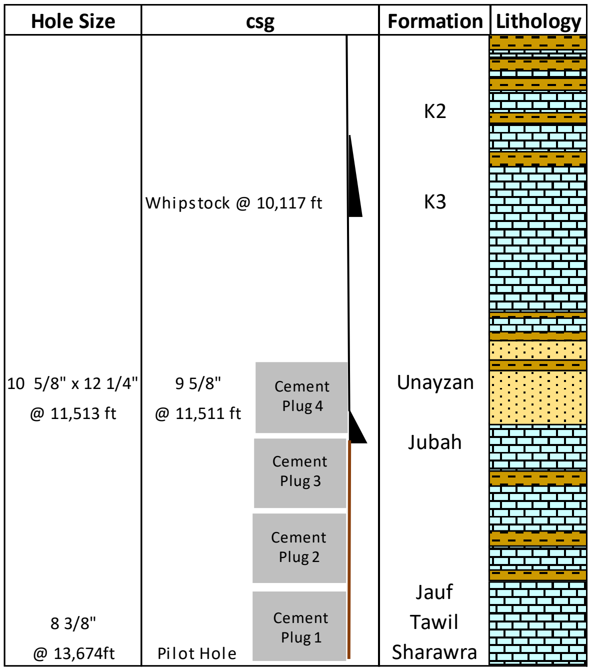

Figure 10: Final Well Profile after drilling the 8 ¾" vertical hole & P&A

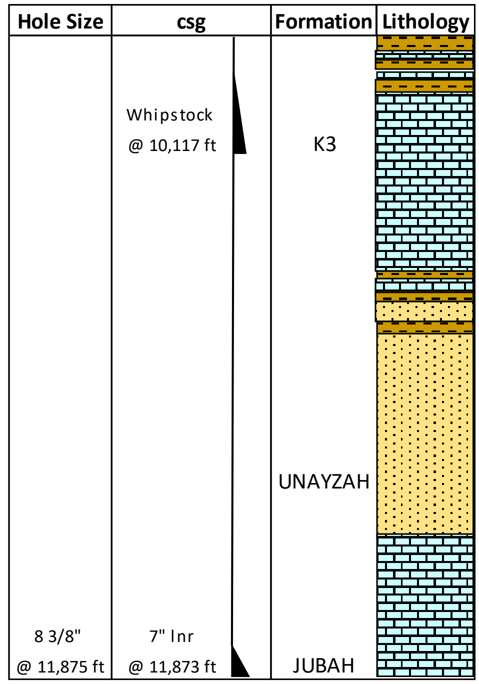

Figure 11: Final Well Profile after completed the 8 3/8" Sidetrack

8 3/8" Sidetrack from 10,117 (WBO) ft to 11,875 ft

After displacing the 8.7 ppg Sodium Chloride brine with 8.7 ppg HPWBF, the casing window was opened and then the new formation drilled. At 10,789 ft, recorded 0.5% background gas and downhole losses with a loss rate of 5-10 bph. Losses were promptly cured spotting 25.0 bbl LCM pill comprising of 45 ppb calcium carbonate materials in accordance with the customized LCM decision tree. Continued drilled to section TD at 11,875 ft building a deviation angle of 47°.

At 11,781 ft, just 92 ft above the section TD, encountered a new loss zone with a loss rate up to 30 bph. Losses were cured spotting 25 bbl LCM pill.

At section TD, recorded 1.6% background gas with an increase up to 13.3% during pipe connection.

During wiper trip to the shoe, tight spots were recorded at 11,311 ft as well as 10,255 ft. Restrictions were registered at 11,784 ft while RIH to the bottom. Recorded 10.6% background gas when restarting circulation at the bottom.

After POOH operations, the 7" lnr was successfully run and cemented.

From fluid prospect, 1.0 % w/v Potassium Chloride and 1.0 % v/v Amine Based additive were used for controlling inhibition while marble materials were added for bridging. During last circulation prior to casing job, the fluid team treated the circulation mud with 1% v/v amine-based polymer extender agent. Figure 11 shows the actual well profile after completed the 8 3/8" Deviated Hole.

6 1/8" Sidetrack from 11,873 ft to 17,550 ft

After drilling 10 ft of the new formation, the well was displaced with 9.2 ppg HPWBF and the new formation drilled. At the depth of 12,215 ft, recorded seepage losses with a loss rate of 50 bph. Despite an LCM pill made with 45 ppb carbonatic material was spot downhole, loss rate increased to 80-90 bph. Before restoring drilling, the drilling team decided to cut the mud weight to 9.0 ppg but at 12,348 ft total losses occurred. After pumping several LCM pills without success, the team continued drilled with water to 12,929 ft where return to shakers was recorded with a loss rate of 100 bph progressively reduced to 40-50 bph. Continued drilled with mud to 13,176 ft with dynamic losses of 30 bph. The MW was reduced to 8.8 ppg. Started recording background gas up a max of 3.3%. POOH to surface was required to detect possible pipe washout that would have causes a pressure drop. With bit out of the hole, recorded static losses with a rate of 15 bph. The BHA was run to the bottom without any problem. When restarting circulation, recorded a max gas peak of 6.4%. Resumed drilling to 13,291 ft where a second pressure drop was detected. After POOH required to fix the problem, the BHA was run to the bottom and while restarting circulation detected a max gas peak of 4.6%. Continued directional drilling to 14,582 ft with a loss rate of 10-20 bph and background gas of 0.65% up to 3.6% during pipe connections. Performed another trip to surface to check potential blocked nozzles. After RIH to bottom, resumed drilling to well TD at 17,550 ft with loss rate of 15-35 bph and background gas of 3.1% up to a max of 5.2 % during pipe connections. Performed wiper trips every 500 ft with max gas peak of 13%. Circulated the bottom for hole cleaning before POOH prior to logging operations. The 4 ½" lnr was smoothly run to TD and safely cemented. The 7" Tie

Back was then run as per drilling program.

A total of 5,677 ft was drilled in this section with a 4,300 ft horizontal interval.

The HPWBF was implemented in accordance with the fluid plan with addition of nano scale latex sealing agent to strengthen the borehole and seal permeable and fractured formation. Furthermore, styrene plastic spherical beads together with sized graphite were utilized as solid lubricants to minimize torque and drag. Inhibition across interbedded clays was ensured through addition of 2.0-3.5 % w/v Potassium Chloride and 1.0 % v/v amine additive while amine-based agent was used for polymers stabilization.

To ensure proper hole cleaning, tandem pills comprising of 8.8 ppg low vis pill followed by 10.3 ppg high vis/high density were pumped on regular base every 80-100 ft.

Figure 12 shows the actual well profile after completed the 6 1/8” Horizontal Reservoir Hole.

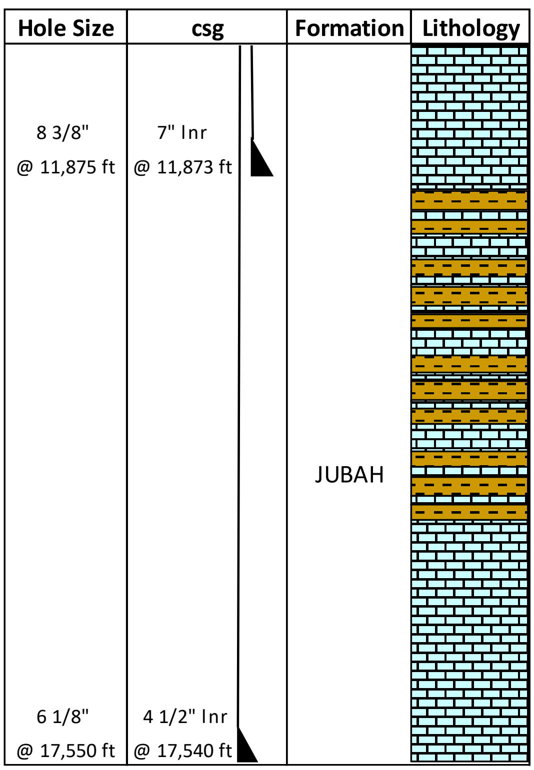

Figure 12: Actual Well Profile after completed the 6 1/8” sidetrack

Completion Interval

The well was finally completed with 8.8 ppg Sodium Chloride completion fluid treated with a package of completion fluids additives comprising of Corrosion Inhibitor, Biocide and Oxygen scavenger. The mud was displaced out of the hole by pumping a spacers train followed by completion fluid as following:

- 30 bbl NaCl Brine
- 60 bbl High-Vis NaCl Brine
- 100 bbl Water
- 60 bbl High-Vis NaCl Brine
- 100 bbl Water
- Completion Fluid

Use of a proprietary wellbore cleanup software allowed the team to optimize the displacement recommendations to minimize the overall number and volumes of spacers required during displacement activities and to run animated, two-dimensional simulations of the displacement from HPWBF to completion Fluid (Figure 13).

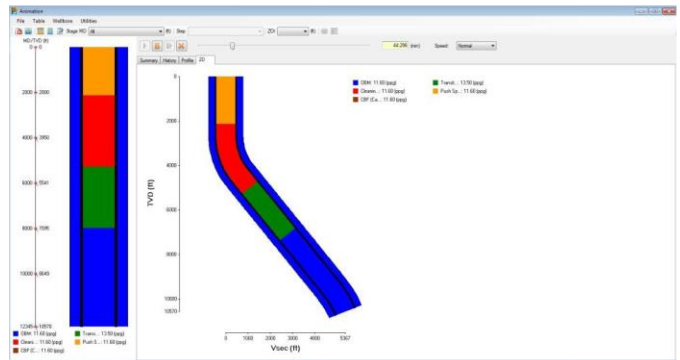

Figure 13: Wellbore Cleanup Displacement Model

Fluid Performances

Tanks to the excellent performance of an engineered HPWBF, the extended reach reservoir gas section in 6 1/8” was successfully drilled without any significant operational issues related to wellbore instability. The drilling team achieved all operational objectives in a safe and faster manner. Additionally, the excellent Fluid’s performances contributed to execute and complete the project 10 days ahead of the plan.

Use of Potassium Chloride and Amine Additive provided the required clay inhibition.

Polysaccharide Viscosifier ensured optimal cuttings transport efficiency while modified polymers contributed to maintain both API and HTHP filtrates in the target ranges.

Marble materials (with cut point D_{50} of 2, 10, 25, 50 µm) helped to bridge the formation as well as minimizing formation losses.

While drilling the horizontal reservoir section in 6 1/8”, addition of nano material additive highly contributed to reduce pore pressure transmission, preventing the occurrence of differential sticking and wellbore instability.

Utilization of polymeric beads in synergy with sized graphite in the lateral reservoir section avoided excessive torque and drag and prevented differential sticking incidents.

Amine-based additive controlled the thermal stability of polymers when fluid was exposed to high bottom hole temperatures above 250° F during tripping out ensuring that proper fluid rheology and filtration properties were always maintained within the planned range.

In addition to overall drilling fluid performance, a customized loss remediation strategy comprising of varying carbonatic products and concentrations helped to minimize formation losses thus keeping the well all time on safe by contributing to reduce mud volumes.

A sweeping plan ensured adequate hole cleaning thus reducing risk of excessive ECD and torque.

Hole cleaning efficiency and hydraulics parameters were daily monitored by running a proprietary software simulator (Figure 14) used to predict fluids behavior downhole and minimize risks for the drilling operation.

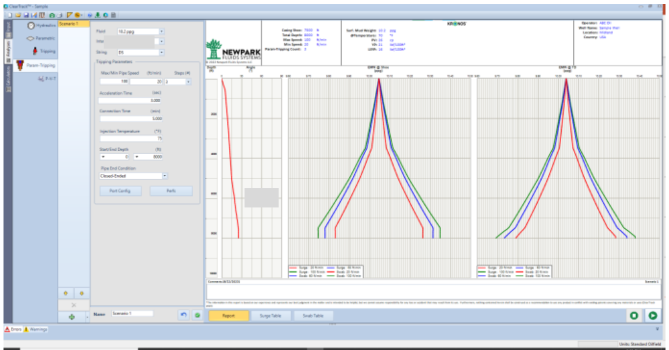

Figure 14: Outcome from Hydraulic Software Simulator

The actual fluid composition in use at the field with average key products concentration is shown on Table 5.

Table 6 presents the fluid properties while drilling the two sidetrack sections respectively in 8 3/8" and 6 1/8".

Table 5: Actual key products concentration of HPWBF

Product	Function	Actual Conc. (ppb)	
		Min	Max
Potassium Chloride	Shale Inhibitor	2,9	18,3
Sodium Chloride	Weighting agent	0	9,9
Polysaccharide Polymer	Viscosifier	1,2	2,1
API Starch	Fluid loss control	0	2,0
Modified Starch 1	Fluid loss control	3,9	5,5
Modified Starch 2	Fluid loss control	0	1,5
Amine based product	Shale Inhibitor	1,5	3,8
Filming amine Agent	Corrosion Inhibitor	0	0,2
Ammonium Bisulfite	Oxygen scavenger	0,02	0,05
Calcium carbonate F	Weighting agent	3,5	51,4
Calcium carbonate M	LCM	3,6	10,9
Marble Package	Bridging	3,4	16,8
*Sized Graphite	Sealing/solid Lubricant	0	3.5
*Latex Polymer	WSM	0	3.5
*Styrene plastic beads	Solid Lubricant	0	3.0
Amine-based additive	Thermal Extender	0	3.5

***Note:** Used when drilling the 6 1/8" sidetrack section only

Table 6: Average HPWBF properties

Properties	Unit	8 ¾" ST	6 1/8" ST
MW	ppg	8.7-8.8	8.8-9.2
Plastic Viscosity @ 120 °F	cP	7-9	5-9
Yield Point @ 120 °F	lb/100ft²	20-29	16-22
6 rpm @ 120 °F	lb/100ft²	7-10	8-9
Gel 10 sec. @ 120 °F	lb/100ft²	6-9	6-7
Gel 10 min. @ 120 °F	lb/100ft²	7-10	7-8
API Filtrate	ml	6.5-8.5	5.2-7.8
HTHP Filtrate @ 250° F	ml	17.5-19.8	16.4-25
MBT	ppb	1.25	1.0
pH	-	9.5-10.3	9.5-10
Total Hardness	mg/lt	240-400	160-320
Drill Solids	% v/v	1.0-1.9	1.3-1.8
Chlorides	g/lt	7-16	18-20
KCl	% w/v	1.0	2.0-3.5
Ammine inhibitor	% v/v	1.0	1.0
BHCT	°F	194	256
Max dev. Angle	°	47	88

Logistic, Mud Volumes and Materials consumption

Due to the lack of a full support of LMP present in area, mainly used to mix fluids for shallow wells, the majority of mud volumes for each hole section were built on location requiring exceptional logistics and planning to move all required products and quantity.

Rig pit management was planned in advance and optimized to ensure smooth mud mixing without interrupting drilling operations. Table 7 shows all volumes mixed on location (80%) as well as LMP (20%) and quantity of materials utilized for each hole section.

Table 7: Mud volumes and Material consumption per section

Section	Volume Mixed (bbl)		Material used (Metric Tons)
	Rig Site	LMP	
34"	13.085,0	0	273,8
22"	6.811,0	13.880,0	970,4
16"	4.421,0	850,0	169,2
12 ¼"x14 ¾"	3.493,0	440,0	743,9
10 5/8"x12 ¼"	8.270,0	861,0	184,0
8 3/8" Pilot Hole	3.121,0	0	199,8
P@A	1.296,0	0	77,5
8 ¾"	4.881,0	0	122,3
6 1/8"	15.942,0	0	321,5
Completion	2.000,0	0	38,7
Total	**63.320,0**	**16.031,0**	**3.100,9**

Conclusion

This paper described the successful application of a HPWBF in a long horizontal section in a field historically characterized by wellbore instability, formation losses and severe torque and drag.

Based on established fluid's benchmarks, extensive lab work was performed in order to select suitable products package and then optimize formulation for balancing performances and cost.

Outstanding Fluid's performance coupled with proper drilling practices enabled the operator not only to successfully reach the well TD after drilling a longest lateral section ever drilled in the past in same filed in Middle East but even to complete the project 10 days ahead of the plan resulting in overall project cost saving.

Particularly, throughout the drilling the 6 1/8” horizontal section, superior wellbore stabilization was ensured by means the use of latex polymer WSM. Marble materials provided optimal bridging while minimizing formation losses. Use of plastic spherical beads and sized graphite ensured a smoothly drilling and RIH lnr avoiding excessive torque and drag.

The fluid team implemented a customized lost circulation strategy that significantly reduced the expected formation losses.

Proper hole cleaning was ensured with optimized fluid’s rheology and pumping frequent tandem pills.

Furthermore, in the long lateral section, required trips, logging and RIH lnr were performed without any issues.

Project was completed without reporting any NPT related to borehole instability.

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Nomenclature

API	*American petroleum institute*
% v/v	*Volume/volume percentage*
% w/v	*Weight/volume percentage*
µm	*Micrometer*
AHR	*After Hot Rolling*
bbl	*Volume, Barrel*
BHA	*Bottom hole assembly*
BHCT	*Bottom Hole Circulating Temperature*
BHR	*Before Hot Rolling*
BHST	*Bottom Hole Static Temperature*
bph	*Barrel per hour*
cP	*Viscosity, Centipoise*
CSG	*Casing*
D50	*Diameter, 50%*
ECD	*Equivalent Circulation Density*
ESD	*Equivalent Static Density*
F	*Temperature, Fahrenheit*
ft	*Length, feet*
FW	*Fresh water*
g/lt	*Concentration, Grams per Liter*
HPHT	*High Pressure, High Temperature*
HPWBF	*High Performance Water Base Fluid*
KCl	*Potassium Chloride*
lb/100ft2	*Pound per hundred square feet*
LCM	*Lost Circulation Material*
LMP	*Liquid Mud Plant*
lnr	*Liner*
MBT	*Methylene Blue Test*
mD	*Permeability, Millidarcy*
MD	*Measured Depth*
ml	*milliliter*
MW	*Mud Weigh*
NaCl	*Sodium Chloride*
NPT	*Non-Productive Time*
P@A	*Plug and Abandon*
PAD	*Pump and Dump*
PHB	*Pre-hydrated Bentonite*
PO	*Polymer*
POOH	*Pool out of Hole*
ppb	*Concentration, Pounds per barrel*
ppg	*Density, Pounds per gallon*
PPT	*Pore Plugging Test*
PSD	*Particle Size Distribution*
PSI	*Pressure, Pounds per square inch*
RIH	*Run in Hole*
rpm	*Revolutions per minute*
ST	*Sidetrack*
TD	*Total Depth*
WBO	*Whipstock Bottom*
WSM	*Wellbore Strengthening Material*
WTO	*Whipstock Top*

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