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LOWERING COST AND IMPROVING THE PRODUCTION EFFICIENCY OF SIDETRACK WELLS IN MATURE FIELDS

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Abstract

Mature fields abound around the world and bear enormous amount of un-swept hydrocarbon reserves which operators are increasingly making efforts to access and produce by use of the sidetracking technology; a more economically viable option than drilling new wells in these fields. Sidetracking technology and the equipment for sidetracking have developed over the years and new equipment options are still being developed by companies with the intent to reduce or eliminate nonproductive rig time. Reaching total depth speedily and successfully in addition to preserving reservoir productivity decreeses the cost of the operation, maximizes oil recovery from sidetrack wells and improves the economic viability of sidetracking in mature fields. Field results prove that anchored whipstock systems are more reliable and more cost effective than cement plugs as initiators of wellbore deviation, that the choice of kick off point affects the success of the sidetrack operation and that the choice of drilling fluid systems affects the amount of oil recoverable from the target reservoir. Therefore, choosing an anchored whipstock over cement plug in combination with the proper choice of kick off point, milling equipment and fluid, in cased hole sidetracking, and a drilling fluid that neither decreases reservoir permeability nor interacts with the formation fluid negatively, lowers operational costs and makes sidetracking in mature fields more efficient and more economically viable. In the United States of America's shale plays anchored whipstocks saved operators 2.5 days of rig time per sidetrack on the average in comparison to cement plugs and a corresponding 82,250 USD. In deep offshore wells, saving two days of rig time can lead to over 875,000 USD in cost savings.

Keywords: *mature field; sidetracking; anchored whipstock; cement plug; kick off point KOP; reservoir productivity; formation damage.*

1. Introduction

There are many reasons for sidetracking: the casing is damaged or collapsed, junk may be lost in the hole, the production zone may have been damaged in the original well, or to tap into another less-depleted drainage area [1]. The process today is increasingly being employed, for the purpose of enhanced and sometimes accelerated recovery form mature oil fields [2]. Sidetracking on such fields has become an integral part of field development and production plans of many operators. They sidetrack purposely from a central wellbore to drill deviated wells, horizontal wells and multilateral wells to reach untapped reserves, increase well contact with the producing formation and control water cut in the produced reservoir fluid. In unconventional reservoirs, operators sidetrack to drill horizontally for maximal wellbore exposure. For expensive offshore developments, sidetracking is used for slot recovery on drilling templates [3].

In the oil and gas industry, mature fields include such fields as are in their third stage of production, have produced over fifty percent of their known reserve and or those in which production has reached its peak and began to decline. On such fields, reaching untapped reserves at a low cost is the primary reason for sidetracking. Achieving this involves reducing well construction cost and ensuring maximum preservation of the filtration properties of the target reservoir.

Enhancing efficiency and effectiveness of the operation starts from a proper choice of the kick of point, well design and the deviation and milling instruments in addition to a proper choice of drilling fluid system for the sidetracking operation.

Drilling sidetracks in mature fields presents the following challenges identified by Chukwuemeka *et al* [2]. These challenges include:

1. Geological and stratigraphic uncertainties arising from changes due to earlier drilling and production activities in the field
2. Abrasive metallic particles from the window milling process, that present additional demands on the hole cleaning programme
3. Limited choice of well diameter
4. Wellbore stability issues [2].

A proper choice of drilling fluid and adequate control of its parameters in large parts helps overcome or reduce the effect of these challenges on the sidetrack construction process and helps ensure optimal hydrocarbon production after well completion.

On these fields, earlier wells serve the purpose of a pilot hole. Logging activities are performed to determine the location of the untapped reservoir, the state of the current producing reservoir and the integrity of the well before designing and kicking off the sidetrack. This type of sidetracking is gaining importance in the industry as companies drill multilaterals under difficult conditions offshore to maximize the amount of reservoirs reachable from a single platform. The kick of point determines whether or not a casing milling operation will be required before drilling the sidetrack, the number of casings that will be milled, affects the choice of well deviation initiation equipment and dictates the number of casing or stringers that will be necessary for the sidetrack's completion.

In the present, to kick off the sidetrack, a cement plug or whipstock is commonly used to start bit deviation along the desired trajectory [2]. There are also varied options of milling instruments available to the driller. The choice of one or the other instrument or a combination of instruments is accompanied by some advantages and disadvantages that affect the efficiency of the sidetracking operation and its total cost.

This work presents a study of various detouring and milling instruments available for sidetracking, their advantages and disadvantages and examines how a proper combination of these instruments with the right choice of kick off point and drilling fluid affects the efficiency of sidetracking and the productivity of the sidetrack well.

2. Wellbore detouring equipment options

The choice of wellbore detouring or deviation instrument is influenced by the choice of kick off point; giving rise, in some cases, to sidetracking from the cased section of a hole and in other instances, sidetracking from the open section of the wellbore. Openhole sidetracking is most commonly applied in three scenarios: to drill a horizontal lateral from a main wellbore; to drill a lateral in a multilateral well; or to manage unplanned events, such as a collapsed borehole or lost BHA [4]. Advances in cased hole sidetracking and peripheral equipment, coupled with more complex wellbore geometries, have impacted open hole sidetracking applications to the point where risk is minimal, installation is easy, and it is often times more economical and faster to set a whipstock than setting a cement plug [5]. The available options of instruments for kicking off the sidetrack include: cement plug, various types of whipstock and bent house downhole motors that are used especially in openholes when bypassing a fish.

2.1. Cement plug

In the drilling industry, cement plug is used during several operations. These include: well abandonment, squeeze cementing and sidetracking operations. The use of cement plug for openhole sidetracking involves setting a cement plug that extends, in some cases to about 50 meters above and below the desired kick off point, after which, the sidetrack is kicked off by use of a bottom hole directional assembly. Traditionally, most openhole sidetracks are kicked off from a cement plug [6].

However, the success rate of using cement plugs for sidetrack operations is an issue for concern. Data from field experience indicates roughly 2.4 attempts per sidetrack on the average with each attempt requiring about 24 hours for proper cement curing. With cement plugs, the success of sidetracking is dependent, in large parts, on the strength and integrity of the cement plug relative to those of the formation present at the kick of point. In instances where the developed cement plug strength is of lower value than that of the formation, the bit usually drills into the cement plug which, in this case, is the path of least resistance.

Birch [7] identifies the following as the reasons for failure of sidetrack cement plugs:

1. Plug slippage
2. Drilling out too soon without waiting for compressive strength development
3. Inaccurate well data
4. Insufficient slurry volume
5. Slurry design
6. Losses while reversing
7. Poor mud removal (not using a proper spacer [7].

In wells of mature fields, the presence of residual completion fluid or oil film may prevent cement from bonding properly with the wall of the wellbore and insufficient waiting time on cement for adequate curing prevents the development of compressive strength needed to support wellbore deviation especially in hard formations.

Common instances where cement plugs may not be a good option for initiating a sidetrack in mature fields include: highly deviated wellbore, in smaller diameter open hole sections, deep open hole sections, high temperature and/or high pressure intervals, or where there are depth constraints above the kickoff point. At deeper depths with higher temperature and pressures, cement plugs rarely strengthen more than the surrounding formation [8]. The disadvantage of using cement plugs for sidetracking lies in the extra costs arising from additional rig time, usually about 24 hours, spent on waiting for cement curing, time spent and resources spent on dressing the cement to kick of point and the extra costs of repeating plug placement and dressing when plug failures occur.

2.1.1. Improving cement plugs compressive strength for efficient sidetracking

Earlier studies on cement plug failures focused attention on the effect of hole geometry and size, and drilling fluid contamination of cement slurry as causes of plug failures during sidetracking with attempts made to improve placement of cement formulations as a way of improving performance [9-12]. However, even with proper cement placement and use of sufficient spacers to avoid cement contamination by drilling fluid, completion fluid and or oil film, failure of sidetrack cement plugs still occur especially in hard formations and high temperature and high pressure situations. Effectively improving cement pug performance as a sidetracking tool involves improving its compressive strength to levels where the rate of penetration of the adjacent formation is greater than that of the cement plug or the difference between rate of penetration of the cement plug and that of the formation at kick off point is minimized.

A 2008 research by Al-Yami *et all.* [13] in addition to known good cement plug placement operations such as avoiding cement contamination and allowing proper curing time, identified the following as methods of improving cement plug performance:

1. The use of manganese oxides additives at temperatures not exceeding 250°F which improves performance by about 400% over conventional neat cements
2. Use of a special formulation called SACP in this study resulted in their research. The combinations when mixed with cement and cured at 290°F resulted in a strong cement core that required 28.5 minutes to drill 2-inches through it under experimental conditions. The use of this formulation is temperature dependent proving effective in temperature ranges above 250°F.
3. Increasing the density of cement [13].

2.2. Whipstock options for sidetracking

The time consuming nature of using traditional cement plugs for sidetracking operations, which significantly affects its cost and the often unreliability of cement plugs in certain formations, and such conditions, necessitate the use of an alternate deviation equipment that reduces operational cost and improves reliability. An innovative technical alternative to the cement plug is the whipstock. They exist in various designs tailored for defined conditions. There are openhole whipstock and cased hole whipstock options. They are either retrievable or non-retrievable. While some whipstock systems are anchored mechanically others are anchored hydraulically and by use of packers that are either retrievable or non-retrievable.

2.2.1. Openhole whipstock

In sidetracking wells of mature fields from kick off points that are in uncased sections of the wellbore the openhole whipstock can be used to initiate hole deviation. In addition to its ability to provide an accurate kickoff depth control and the direction of the sidetrack, openhole whipstocks eliminates the nonproductive rig time needed for cement curing and allows for wellbore departures from any point in a well of any profile regardless of the nature of formation present.

Openhole whipstock options are available from various service companies including Schlumberger, Weatherford, Baker Huges, Bittekhnika, DDI Group of companies amongst others. The available options include but not limited to the following:

1. TrackMaster OH openhole whipstock system developed by Schlumberger, which permits the operator to lock an anchor in place and establish a reliable KOP at the precise depth and orientation needed often, in just one trip [6]. This system is used when there is no need for a cement plug beneath the kick off point for zonal isolation.
2. TrackMaster OH-C openhole whipstock and cementing system, another Schlumberger product that lets the driller set a whipstock and a cement plug beneath it in a single trip. With the anchor holding the whipstock in place, the operator can sidetrack the well without waiting for the cement to cure [6]. This system is developed for situations where zonal isolation of the wellbore interval below kick of point is required.
3. Whipstock KLEN-HA systems developed by DDI group of companies that come with either a hydraulic or packer anchoring system [14].
4. The Baker Hughes openhole whipstock (OHWS) system with Pip Whip™ (production inflatable packer) whipstock anchor [15]. The anchor is retrievable, inflatable and hydraulically activated making the system a good choice in irregular openhole interval.
5. Weatherford's openhole whipstock system inflatable type anchor (IPP®). A single-trip, screw-in whipstock that can be run with multiple anchoring options [16].

2.2.2. Cased hole whipstock

To sidetrack a cased well, from a kick off point within the cased interval, a window has to be cut through one or more of the well's casings after setting the cased hole whipstock system in place [2,6]. This system has been applied by drillers for decades with increasing modifications as more service companies enter the industry and attempt to meet the challenging situations the industry faces. The standard cased hole whipstock assembly configuration includes three mills. A lead mill, which starts the window milling process, a follow mill, that elongates the window and a dress mill which further brushes the window for easy passage of subsequent assemblies. A bimill option is sometimes used, in which case, the dress mill is eliminated.

In similar manner to the openhole whipstock option, cased hole options are available from various service companies and in varying configurations. The following are some available options:

1. Schlumberger's TrackMaster CH cased hole whipstock system
2. The EATON whipstock
3. Baker Hughes' WindowMaster and PathMaster whipstock systems
4. QuickCut™ and MultiCatch™ developed by Weatherford

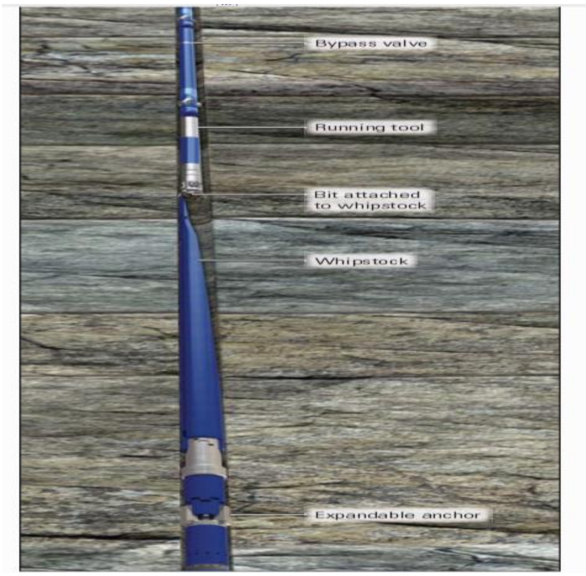

Fig.1.Sidetracking with TrackMaster OH system [6]

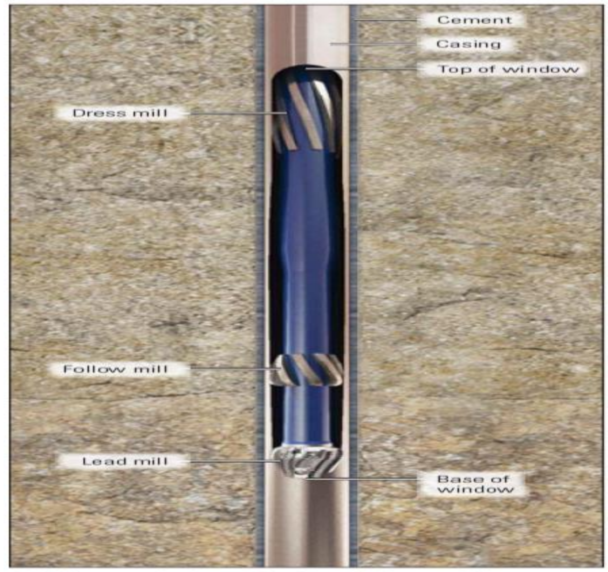

Fig.2. Milling a window with the TrackMaster CH whipstock system [6]

Fig.3. Options for securing the cased hole whipstock [6]

To ensure proper setting of this system, a casing scraping operation is necessary to clean up the casing of any debris. This process is performed in the presence of a fluid whose properties are mostly dictated by the need for isolation of the zone below the whipstock assembly of the lack of it. In addition to this, an orientation tool is required with both openhole and cased hole to ensure proper orientation of the whipstock face. In cased holes a gyro is recommended to avoid errors arising from magnetic influence of the iron casing. In openhole applications, measurement while drilling tools are the usual choice of orientation tool.

The four options for securing a cased hole whipstock are represented in Figure 3. They include: (A) The hydraulically actuated expandable anchor which provides flexibility for a range of casing sizes and is used when borehole isolation with a packing element is not required. (B) The retrievable anchor that is hydraulically set. (C) The retrievable anchor with packer assembly which is a hydrau-lically set system and can be used when borehole isolation with a packing element is required. (D) The permanent packer anchor which is used when an isolation barrier is required; as its name suggests, this packer is not retrievable.

2.3. Milling options

In addition to choosing the right wellbore deviation tool, the choice of milling equipment plays an important role in the efficiency of sidetracking in cased holes. A successful casing milling operation requires selecting an appropriate milling fluid and techniques in combination with the right milling tools. Choice of milling tools in large parts depends on the nature of the casing material. The selected milling fluids should be capable of moving milled metal shavings to the surface and the technique adopted for the milling operation suitable for the conditions of the well. A wrong choice of one or a combination of the above will usually result in an additional trip or elongated window milling operation that increases cost.

The development of diamond speed mills in the 1970's proved successful for casing exits for kick off points adjacent to hard and abrasive formations and is still utilized today in some areas for casing exits. Mills dressed with inserts of Polycrystalline Diamonds PCD have exceeded the performance of diamond speed mills [17-18]. The KLEIN mill system is made of AISI 1045 steel with Tungsten carbide for fast cutting of all steel grades of casing [14].

It is generally recommended that its yield point to plastic viscosity ratio of the milling fluid be maintained at values less than one at certain range of pump rate determined based on well geometry. Table 1 below shows the percentage of metal shavings recovery during a milling operation by Addax petroleum in three of its wells in Nigeria during a sidetracking operation to restore production from these wells.

Table 1. Summary of expected metal recovery versus actual recovery [19].

	Well A	Well B	Well C
Casing size, inches	9 $^5/_8$	7	9 $^5/_8$
Mud weight, ppg	11	11	10
Plastic viscosity, cP	52	47	42
Yield point	24	20	17
YP:PV ration	0.46	0.43	0.40
Expected metal recovery, lbs	113	157	246
Actual metal recovery, lbs	85	121	216
Percentage recovery, %	75	77	88

2.3.1. Optimizing whipstock deployment and application

The advantages of whipstock assembly for well deviation over cement plugs can further be increased by sticking to the following guidelines:

1. Casing tally report of the parent well should, where available, be used to locate the casing collar when choosing whipstock anchoring point. This saves the operator the additional cost associated with running a dedicated casing collar locator.
2. When using non retrievable whipstocks, casing scraper operation should be performed in seawater, this ensures that any leftover debris in the wellbore sinks to the space below kick of point instead of remaining suspended in the wellbore and ensures that the whipstock assembly deployment process is not hindered.
3. The use of seawater for whipstock assembly deployment reduces cost as no costly synthetic oil based mud is left in the original wellbore below the whipstock, especially when the whipstock assembly deployed is no retrievable.
4. Where formation conditions permit, the dedicated rat hole extension trip can be eliminated by using the milling assembly to extend the rat hole for up to 30 meters. This saves rig time and corresponding cost.
5. Whipstock deployment could be done with reliable measurement while drilling MWD equipment. This saves the operator money in upwards of 50,000 USD in charges associated with for a back-up gyro tool.

3. Cost comparison between the cement plug and anchored whipstock systems

Sidetracking from the openhole whipstock, eliminates all uncertainties and limitations related to the cement plug and the following benefits are gained [20]:

- Possibility to sidetrack at high temperature and pressure
- Elimination of a separate trip for setting the cement plug
- No need to wait for the cement to be cured
- No loss of material to replace a failed cement plug

Figures 4 and 5 below compare the time spent on sidetracking operations from using cement plugs to time spent using anchored whipstocks. Figure 5 shows that using an anchored whipstock in shale plays around the United States of America saved approximately 60 hours (about 2.5 days) of rig time in comparison to cement plugs. In doing this, using the anchorchered whipstock saved operators the corresponding cost of running the rig for an additional 2.5 days. On these shale plays this led to 82,250 USD in savings per well on the average. In deep ofshore wells, where daily cost of rig operations can be in excess of 350,000 USD per day, saving 2.5 days of rig time will save companies approximately 875,000 USD per well.

Figure 4 highlights waiting on cement as the main cause of extended rig time when cement plugs are used for sidetracking operations. However, in additon to waiting on cement, dressing cement plugs is a slow time consuming process that is eliminated when anchored whipstocks are deployed. Where whipstock deployment and milling is done as suggested in 1.3.1 above, additional savings can be made.

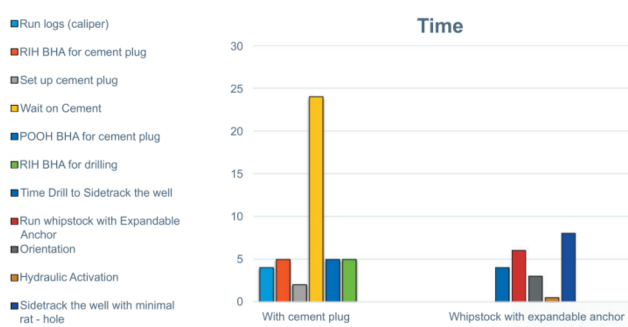

Fig.4. Time comparison between cement plugs and whipstock with expandable anchor [14]

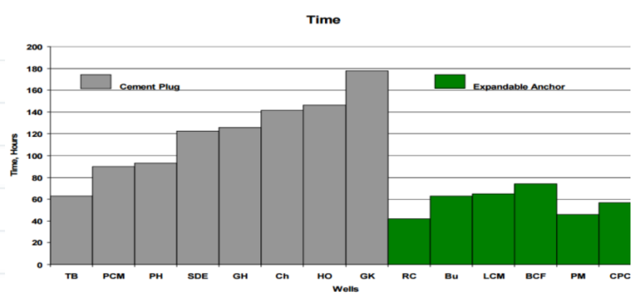

Fig.5. Time comparison between cement plugs and whipstock with expandable anchor in shale plays in the USA [21]

4. Choice of kick of point that reduces cost and increase efficiency.

Sidetrack wells in mature fields are usually deviated wells and in an increasing number of cases, with horizontal endings depending on the situation of the producing reservoir and the nature of the reservoir the operator intends to enter with the help of the sidetrack. The choice of kick of point relative to the target reservoir affects the complexity of the well trajectory, the choice of bottom hole assembly (BHA), the number of casing that will be needed for the wells completion, the ease or difficulty of the milling job and consequently, rig time and cost of the sidetracking operation.

Where possible, the kick off point should be outside known wellbore instability intervals. This is because, sidetrack wells usually show a tendency for high instability around the kick off point where instability is a consequence of both instability in the main well and the sidetrack well [22]. In addition to this, the following factors should be considered when making choice of a kick off point for a successful and cost effective sidetracking:

- ✓ Pore and fracture pressure gradients along the interval between kick off and the target formation should be studied as these affect the number of casing strings that will be needed for the sidetracking. The kick off point should be chosen such that the number of casings is minimized. The importance of this becomes clearer when casing cost, casing landing time and the nonproductive time of waiting on cement are considered.

- ✓ In sidetrack wells with horizontal endings, the distance between kick off point and the horizontal section should be large enough for proper and easy build of angle from deviated to horizontal. 70 meters is usually recommended.
- ✓ Where possible, there should not be any gas bearing reservoir between the chosen kick off point and target formation.
- ✓ In cased hole sidetracking, the kick off point should not be at a tool joint in the casing and preferably, as recommended for openhole sidetracking, should be at an interval composed of rocks with good drillability.
- ✓ In deviated and horizontal parent wells, it is best to come off the low side of the well as this allows gravitational forces to support the process.
- ✓ In wells where all casings extend to the surface, kick off points from the production casing minimizes the number of casings that must be milled in sidetrack operations, reducing rig time and Operational costs
- ✓ Where available equipment permit and completion constraints are not a factor, short radius departures are more cost effective than long radius departure from the existing wellbore.

5. The effect of drilling fluid on productivity of sidetrack wells

The nature, properties and control of these properties of drilling fluid used in any drilling project play very significant roles that affect the ease at which the target total depth is reached and the productivity of the reservoir after well completion. Drilling fluids serves the purpose of cuttings transport, bit cooling, and ensuring wellbore stability amongst others but in side-tracks in mature fields, a production well, a special function of the drilling fluid is protecting the reservoir from all forms of drilling fluid related damage. That is, preserving the natural reservoir properties' values; not interacting with the target producing formation in any way that reduces its permeability, blocks its pores or negatively alters reservoir fluid properties. A reduction in permeability or negative interaction of drilling fluid with reservoir fluids reduces the productivity of the reservoir and hence, the total amount of hydrocarbon recoverable from it.

Butler *et al*. [23] identifies formation damage and completion damage as the two distinct categories of damage the target reservoir may face due to poor choice of drilling fluid. Completion damage is considered the overriding concern, especially in sand control environments given that uniform, natural cleanup of drilling-induced damage is unlikely or impossible in high angle wells. Damage may be caused by solids that migrate and block pores or by drilling fluids that alter the properties of reservoir fluid.

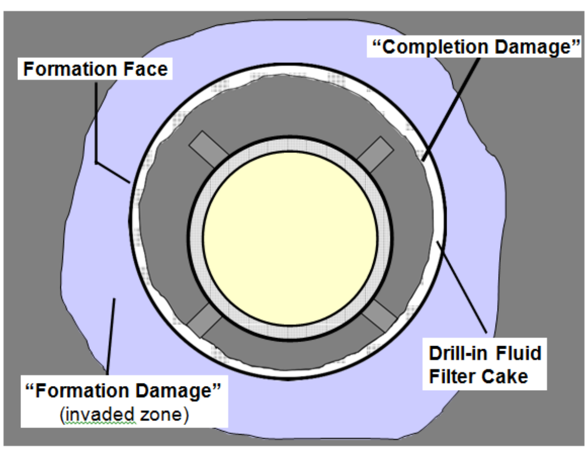

Figure 5. Reservoir damage mechanisms [23]

Formation damage can adversely affect both drilling operations and production, which directly impacts economic viability [23-25]. On wells of mature fields where sidetracks, in many cases, target reservoirs that were earlier considered to be of little economic viability, formation or completion damage can render the choice to sidetrack an economic disaster where recovered hydro-carbon volume does not cover operational costs. Choosing a drilling fluid with the right properties that ensures the preservation of target reservoir's properties and a high rate of penetration while maintaining wellbore stability and control is of great importance in sidetracking for increased recovery from mature fields. The advantages of such drilling fluids manifest in reduced time and cost of drilling and increased oil recovery. In addition to choosing the right drilling fluid, the choice of well profile affects the amount and rate of oil recovery, the amount of water cut associated with the production from the well and the tempo at which water cut increases.

6. Selected oil field cases

Case 1

A company, Surgutneftegas, with operating license in Southern Siberia, drilled a total over 100 sidetracks, including sidetracks with horizontal endings, in wells of its mature fields using diffe-rent types of drilling fluid. Early sidetracking efforts were carried out using water based bento-nite mud. This proved ineffective with instances of nonproductive time as a result of wellbore instability during drilling and poor productivity due to reservoir damage. Studying the drilling report of wells drilled using different fluid systems and the daily production report, showed that wells drilled on biopolymer drilling fluids on the average, reached target depth faster and produced more oil than the other wells. These observations can be explained on the basis of the following special properties of biopolymer drilling fluids:

- ✓ Excellent rheological properties that enables adequate cleaning and transport of cuttings from deviated and horizontal wells.
- ✓ High inhibition property, low fluid loss into formations resulting in low damage. Biopolymer drilling fluid guaranteed permeability restoration of about 86 to 96 percent after drilling on these fields.
- ✓ High lubricity. The coefficient of friction of biopolymer drilling fluids are in the order of 20 to 25 percent less than that of any bentonite mud with lubricity additives.

These special properties of biopolymer drilling fluids combine to overcome the challenges associated with sidetracking in wells of mature fields and preserve formation permeability. In addition to the above, it is further observed that reconstructing wells from vertical to horizontal by sidetracking increased daily production by more than 70 percent in some wells with a few unsuccessful instances due to poor design of the well profile. The company afterwards began active use of biopolymer drilling fluids for most of its sidetracking operations and adopted sidetrack profiles with horizontal endings over traditional sidetracks.

Case 2

A 6 inch sidetrack was kicked off in well H in an oil field in Western Kazakhstan at measured depth MD 4962m using an anchored whipstock system. This point corresponds to the Chernoya-rovski horizon which is predominantly shale. At measured depth 5004m, the string packed off with a KCl/polymer mud system in use. The sidetrack was redesigned and kicked off at MD 4772.7 m with a whipstock system; in an interval corresponding to the Famennian stage domi-nated by dolomite and limestone formation. Drilling was carried out using the same KCl/poly-mer drilling fluid system and the sidetrack was successfully completed with relatively good performance and no severe wellbore instability issues. This field's example demonstrates the importance of right choice of kick off point in the success of sidetracking operations. Tables 2 and 3 below show the operational parameters for these sidetracking attempts [26].

Table 2. Key Operational Parameters Used for Drilling the Chernoyarovski Horizon in the 6 inch Sec-tion, Well H

# of spent days	MD m	TVD m	Lithology	Incl. deg	Azi. deg	MW g/cc (ppg)	ECD g/cc (ppg)	Mud type	Comments
2	4980/ 5004	4939/ 4960	LST 0-10%, SLT90-100%	47	185	1.18 (9.85)	1.24 (10.35)	KCL/ Polymer	Severe sloughing, hole cleaning issues, pipe sticking, LIH BHA

Table 3. Key operational parameters used for drilling the Famennian Stage in the sidetracked 6 inch Section, Well H

# of spent days	MD m	TVD m	Lithology	Incl. deg	Azi. deg	MW g/cc (ppg)	ECD g/cc (ppg)	Mud type	Comments
2	4770/ 4814	4739/ 4811	DLT 98%, ARL 2%	14	186	1.18/1.22 (9.85/10.2)	1.27 (10.6)	KCL/ Polymer	No WBI

Case 3

In 1970, BP discovered the Forties field, one of the largest finds in the UK North Sea. After acquiring majority working interest in the Forties field located in about 125m of water east of Aberdeen, Apache in attempt to increase production from the mature field drilled high deviation sidetracks from existing wells ; encountering wellbore instability issues arising from loss of reservoir pressure and anisotropy of the overburden shale.

At the juncture between the original wellbore and the new sidetrack, drillers frequently experienced difficulties. Although many of these sidetracks showed no signs of borehole instability during the initial run to mill the casing window, during subsequent trips with a drilling assembly, the hole packed off at the window as the shale collapsed around the bottom hole assembly BHA. Low casing exit was proposed as a solution to instability issues at the casing window especially for cases where voids in the annulus form a path of least resistance for the mill to follow. As at 2014, 22 low-side windows have been milled at Forties field [6].

Case 4

After unsuccessful attempts to kick off an 8½-in. openhole sidetrack from a cement plug in Keathley Canyon, a 20 year old deep water field containing oil, gas and condensates with layers of complex faults, in the Gulf of Mexico, the TrackMaster OH system was selected to provide a stable platform to initiate the wellbore departure. An openhole whipstock and sidetracking system was deployed, and set with a hydraulic anchor at 31,534 ft, in one run. Using a hydraulically expandable reamer, the anchoring location had been enlarged while drilling, then cemented and re-drilled, as part of the earlier cement plug sidetracking attempt. The Trackmaster OH system provided a clean 8½-in. sidetrack on the first attempt and in the process, set a new world record for the deepest openhole whipstock sidetrack [4].

7. Conclusions

1. Operators are increasingly drilling sidetracks in their mature fields to reach un-swept oil reserves, at costs lower than drilling new wells, to maximize the amount of hydrocarbon bearing formations accessible from a single platform in offshore fields.
2. Wellbore deviation during sidetracking can be achieved with the help of a cement plug, an anchored whipstock or a bent house motor.
3. Using the anchored whipstock is more reliable than cement plug in hard formations, small diameter wells and high temperature and high pressure conditions.
4. The anchored whipstock eliminates time spent on waiting for cement curing and cement plug dressing; saving rig time and associated costs.
5. Numerous field examples confirm the advantages of anchored whipstock systems over traditional cement plugs as wellbore deviation initiator during sidetracking.
6. Choosing the appropriate drilling fluid that minimizes formation and completion damage maximizes oil recovery. The biopolymer drilling fluid systems used by Surgutneft for sidetracking in its mature fields in southern Siberia gave permeability recovery ratios between 86 to 96 percent.
7. A combination of the right choice of kick off point, detouring equipment, milling instrument and drilling fluid system effectively reduces the cost of sidetracking and improves oil recovery in mature fields.

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