

Crushing Hard Formation Coring Technique in Chad

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Abstract

To solve Chad crushing hard formation drill-ability poor, fractured, broken formations, large drilling time, low core recovery and coring tool tight trip issues, Based on the B-2 well encountered during coring of each typical problem analysis and research, initiative to change the coring bit, coring tools, optimized drilling coring parameters, and apply the comparative method to develop countermeasures, theory and practice, effective solved to the broken hard formations coring problems encountered improve the formation crushing hard core recovery, but also improve the ROP, as crushing hard formations coring foundation.

Keywords

Crushing Hard Formation, Coring Technology, Coring Bit, Tight Trip, Core Recovery.

1. Introduction

B basin in southern Chad, from the capital N'Djamena 300 km. B Basin oil and gas exploration began in 1974, but until 2003 drilled M-1 well discovered a valuable industrial oil flow.

B-2 program is an exploratory well Basin B, B-1 well located in the northwest, B-7 well east. B-2 exploration well in the area of the upper part of the formation of the P block, by a number of syn-rift extensional fault overlays and uplift from the Late Cretaceous complex fault block. Buried fractured bedrock projections favorable for hydrocarbon migration. Therefore, the object of the B-2 well is to collect sufficient data to evaluate the P stratigraphic oil and gas horizons buried hills.

2. Coring Tool

B-2 well layer coring bits Basement reservoir fracture development, the formation lithology and fracture to cave development acidic granite, hard and broken lithology, drill-ability poor, low ROP, coring is difficult. To this end, the choice DFC1312 type PDC coring bits and smooth wall of a conventional hard formation glass steel coring tool.

2.1 Coring Bit

Basement of fractures and broken reservoir lithology hard and broken, poor drill-ability, usually use high abrasive diamond set coring bit and diamond impregnated coring bit (see Figure 1), but this drill penetration rate is low, hard core at the bottom of recurring long time grinding, big impact on the core recovery [1]. In order to improve core recovery and ROP, finally decided to use high cutting efficiency DFC1312 type PDC coring bits, including DFC1312 type PDC coring bits and DFC1312 scalloped type PDC coring bits (see Figure 2).

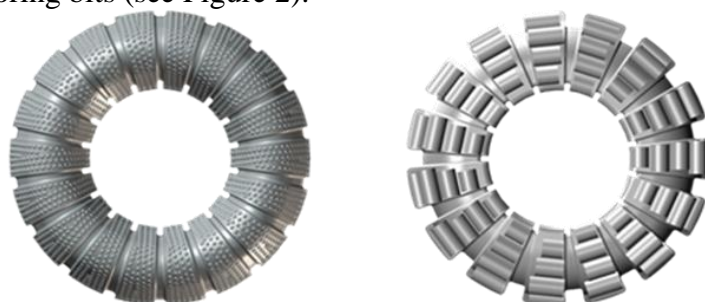


Fig. 1 Diamond set coring bit and diamond impregnated coring bit



Fig. 2 DFC1312 type PDC coring bits and DFC1312 scalloped type PDC coring bits

2.2 QXT 172-101 Type Coring Tool.

2.2.1 QXT 172-101 Type Structure Coring Tool

This tool consists of safety connectors, suspension assembly, glass, steel inner cylinder, the outer tube, the outer cylinder centralizer, cutting and coring drill centering mechanism and other components [2]. The structure shown in Figure 3.



1.Core Catcher 2.3.4. Inner Barrel Shoe Assembly 5. Fiberglass inner tube 6. Inner Tube top sub 7.Rotary Assembly 8.Coring Bit 9. Lower Stabilizer 10.Coring Outerbarral 11. Top Stabilizer 12. Friction Ring 13.Safty Sub

Fig. 3 QXT 172-101 Type Structure Coring Tool

2.2.2 QXT 172-101 Type Coring Tool Features

- (1) A smooth surface in the inner cylinder, the small resistance into the core tube. Conventional coring tools are used for ordinary seamless steel inner cylinder, such pipe wall roughness is generally 0.19mm, the old pipe is 0.5 ~ 1.0mm, rough walls, large resistance core into the tube, likely to cause blocking HEART core recovery rate. Glass fiber tube made of steel inner tube, pipe friction resistance of only 25%, the small resistance into the core tube, easy to block the core barrel blockage.
- (2) Non-slip buckle design. Fiberglass thread on the inner lumen of the tube design with anti-slip buckle lateral force to prevent lateral forces generated by the reduced diameter slider.
- (3) To facilitate the core put out of the inner tube, the core of high quality, easy to transport. Since the inner tube using a glass pipe, directly cut the core and inner tube, without beating the inner tube, effectively ensuring the integrity of the core, improve the quality of the core.
- (4) Within the core pipeline components using flat header, smooth, completeness shoulder to ensure that small core resistance into the tube, low resistance is not easy core card, will help improve the monocular coring footage and core recovery.

3. Core Construction and Causes

3.1 First Six Times Coring Briefings and Causes.

3.1.1 First Six Times Coring Date Statistics

Table 1 B-2 well first 6 times coring data statistics

NO.	Interval (m)	Footage (m)	Core Length (m)	Recovery (%)	ROP (m/h)
1	534.00-538.25	4.25	3.60	84.71	2.55
2	538.25-542.80	4.55	4.30	94.51	1.95
3	542.80-546.20	3.40	2.80	82.35	2.37

4	546.20-551.36	5.16	4.80	93.02	3.13
5	551.36-555.75	4.39	3.55	80.87	3.06
6	555.75-563.50	7.75	7.50	96.77	3.18
Total		29.50	26.55	90.00	2.71

The B-2 well first six times coring footage accumulated 29.50 m, core length 26.55m, average core recovery: 90.00%.

3.1.2 First Six Times Coring The reasons for the loss of core analysis

B-2 wells buried weathering crust formation rock characteristics are: fracture is good, rock crushing serious, the core into a pillar of the poor. According to the B-2 well coring actual situation, causes the core losses are mainly the following points:

(1) Buried seriously weathering crust, weathering lithology very loose and easily lead to core block (see Fig 4). When coring to this interval, since the portion of the formation weathered, lithology loose, even into loose sand-like, into the column of the poor, from the formation drill core the weight of the core strength has been insufficient to support the feed tube, resulting the core difficulties in core barrel and crushing each other to wear, easy to plug the core pieces and the inner core barrel gap, and continue to accumulate in the core of the claw, coring block occurs (see Fig 5) [3].

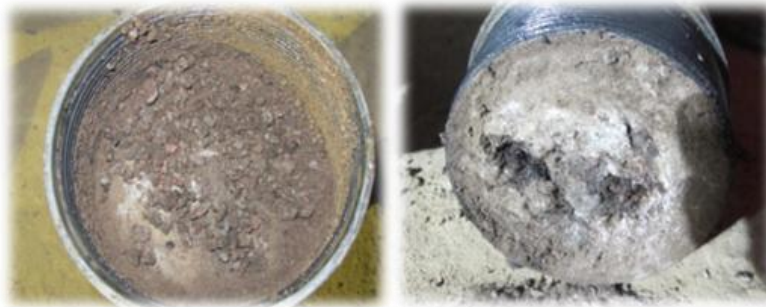


Fig. 4 First times coring and Fifth times coring block

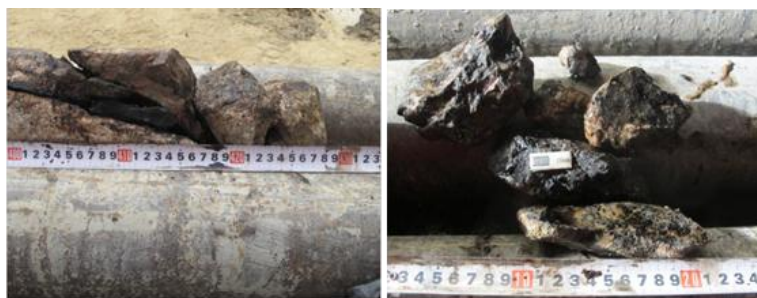


Fig. 5 Third times core and fourth times core

(2) Formation fracture is good, hard and broken lithology and core pillar of the poor

Formation fracture well, the rock column poor and easily broken, irregular pieces of hard, at the bottom of hard and broken core is very unstable, difficult to enter the core inner tube, and some fragments easily coring drill card large accumulation between the ferrule holder and core catcher, causing core block, broken hard core also very easy to fall from the core self-locking jaws at the time of tripping [4].

3.2 Seventh times coring tool twice tight trip cause analysis and take measures.

3.2.1 Tight trip cause analysis

After sixth times coring (depth 563.50m), instead of the well underbalanced drilling, coring see display as evidences of oil and gas. When the depth of 802.00m, for the seventh times coring, but put out of well full-cone bit diameter only 213.8mm, and the body worn seriously, coring drill diameter

of 215.9mm, evident not down the hole possibility, really serious tight trip (depth of 802m, tight trip point 610m), tripping out wiper trip. Than continue to coring, but the result just like last time (depth of 802m, tight trip point 690m), can only suggest reaming, but for other reasons decided to change coring depth of 1000 meters.

After careful analysis and research, the reasons for the twice tight trip following three points:

(1) Pull out comprehensive drilling bit diameter size less than coring bit

Pull out comprehensive cone drilling bit wear serious, size is 213.8mm (original size 215.9mm), significantly less than the coring bit size 215.9mm. Thus, the underground portion of the wellbore will be significantly smaller than the size of coring bit, tight trip great possibility. To make coring smooth, coring engineer recommended use the new cone bit wiper trip well, but in order to save time, the Party decided use the coring tool a try. In the absence of the well through the drill forced, for the first time tight trip inevitable.

(2) The wall surface is not smooth, irregular wellbore

Formation is too hard, so hard bedrock large segment used the cone drilling bit resulting in the wall surface is not smooth, the borehole is also very irregular, resulting in more rigid coring tool tight trip serious.

(3) The bottom hole assembly and cone bit poor rigidity, coring tool rigidity

After wiper trip, the second run in hole continues to tight trip, because assembly no centralizer, only less rigid cone bit, cone bit in the face of a diameter greater resistance inherent plasticity, again plus only three cone bit slap tight trip point is relatively easy by an irregular wall, so well performed wiper trip the role is not obvious. To make sure more rigid the coring tool to go down smoothly, we must ream.

3.2.2 Take Measures

In the case of the Party do not want to ream, so that the coring tool to trip in smoothly, coring engineer finally has taken the following measures:

(1) Get rid of the coring tool under centralizers (not first centralizer)

In order to effectively reduce the coring tool rigidity, get rid of the coring tool under centralizer, reducing the coring tool in the wellbore anchor to reduce the possibility of tight trip.

(2) Switching to unconventional size coring bit (diameter 214.7mm)

In the case without reaming, apply unconventional small size coring bit is the best and final measures coring tool to trip in hole smoothly. In the application of unconventional coring bit and get rid of the under centralizer, and the micro-reaming trip up and down together with the time, coring tools run in hole smoothly [5].

3.3 Seventh times coring tool twice tight trip cause analysis and take measures.

3.3.1 Coring Cause Analysis

Seventh times coring cycle cleaning bottom in the end, pitching steel ball and began coring drilling, but from the coring began the ROP is very low, but stable drilling without the slightest limp-hop phenomenon, drilling 6 hours, footage 0.28m, Since the ROP is too low, pull out.



Fig. 6 Seventh taking core and pull out coring bit

By taking the core(see Fig 6), the drilling ROP and drilling-related parameters were analyzed, there are ROP low for three reasons:

(1) Formation of hard and dense, high abrasiveness

Taking the core is very hard and dense, smooth surface without cracks, into a massive structure, the main ingredient in positive feldspar and quartz-based, Mohs hardness of between 6-7 (Mohs hardness of stainless steel is 5.5), highly abrasive.

(2) Diamond set coring bits match this formation is poor, high threshold WOB

Diamond set coring bits and formation match is poor, unable to eat into the formation, formation drill-ability poor[6], strong abrasive, high threshold WOB. Formation drill-ability coefficient test drilling by the drill data and statistics based on drilling rate equation can be obtained:

$$K_R = \frac{V_{pc}}{C_H C_p (W - M) n^\lambda}$$

Can be obtained by the formula, in other parameters constant, the threshold WOB larger formation drill-ability coefficient KR is greater [7].

Threshold WOB M refers ab line intercept in drill finale that is WOB drill began to eat into the formation when its size value depends on the nature of the rock, there is a strong regional, with the drill bit and formation the correlation matching.

From the drilling situation, this formation threshold WOB M larger.

(3) Diamond set coring bit own characteristics due

Diamond set coring bit does not have cutting teeth, only have small abrasive particles, mainly by mutual grinding between the abrasive particles and the formation of the realization to drilling, the low ROP is the table diamond set coring bit a big feature.

3.3.2 Take Measures

Through the application diamond set coring bit, it not suitable this formations, drilling threshold WOB is too high, it cannot eat into the formation, like slipping on a glass steel. In order to improve the ROP, coring engineer through careful analysis and research, finally status and well-oriented in this hill formations designed an unconventional size DFC0806 pinion type PDC coring bit, in order to meet the requirements of the coring well conditions and requirements. And take to reduce speed and increase WOB and other measures to reduce or eliminate the jump in once limp-hopping.



Fig. 7 Eighth run in hole coring bit and pull out coring bit

3.4 Eighth Times coring cause analysis and take measures.

Eighth times coring run in hole smoothly, coring bits used for this well specially manufactured for the status conditions and formation type design DFC0806 small teeth PDC coring bit unconventional size (see Fig 7). In the end the cleaning cycle bottom, pitching steel ball and began drilling. Start drilling 0.1m, severe lost circulation, the drilling fluid has not come out, only temporarily stop the drilling and cycle observation, reduce displacement of pump, about after two hours the return of crude oil, about half an hour there is a return of drilling fluid, core drilling continue. The drilling ROP high, the highest ROP reaches 10m / h, average ROP of 4.34m / h, increase of nearly 15 times higher than in the

first three times coring ROP. The smoothly core drilling, drilling smooth, no limp-hop phenomenon, reaching owner required footage newcomer drilling, cutting and pulling core and pumping no exception [8].

By taking the core, from the coring bit, drilling ROP and related parameters were analyzed, the main reason for this times coring high ROP are the following three points:

(1) Lithology low hardness compared with the previous times, somewhat less abrasive, crack is developed

Remove the core barrel over the previous few low hardness, somewhat less abrasive, crack is developed, but the basic are filled with calcite. Fractures also greatly reduces the formation drill-ability, therefore, the formation is one of the reasons of high ROP.

(2) Application of a new type of DFC0806 small teeth PDC coring bit more suitable for this formation
The new DFC0806 Small teeth PDC coring bit with the formation matching, high ROP, more suitable for this formation.

The new DFC0806 Small teeth PDC coring bit is mainly on the following aspects of the innovation and improvements:

① Optimization of PDC cutter size [9].

Compared DFC0806 Small teeth PDC coring bit and PDC coring bit DFC1312 type, optimized cutting teeth so that the tooth can chip in the face of the development of cracks, corrosion empty hole and wear more strong formation good adaptation layer, to improve the ROP, decrease the possibility of cutting tooth wear, tooth chipping and damage to the coring bit is reduced.

② Redesign PDC coring bit crown shape and arrangement of cutting teeth [2].

DFC0806 Small teeth PDC coring bit similar conical crown, on which the cloth with small teeth, each cutter wing cloth 10 tooth, a total of six wing knife. As two-thirds of its PDC cutter gage teeth embedded in the outer cloth tooth density. Such benefits can be reduced fabric teeth tooth borne by each gage cutting area, due to the larger and more outward cutting teeth line speed, its impact force formations are more inside of the cutting teeth large, so it is the easiest gage teeth damaged, DFC1312 type PDC coring bit each gage basically damaged these tooth.

PDC cutter with more stars to share the outside of the cutting area, thereby increasing the stability and durability of the coring bit. In addition, in accordance with its teeth inclined gage taper tooth arrangement, so that the same area hosts 6-7 cutting teeth (only one before improvements), the contact surface by the vertical and inclined into contact with the contact, so that each tooth We are fully utilized, but also increases the cutting efficiency. This advantage can also make changes to the level of vertical bit cutting. Since the formation of the layer in the horizontal, some vertical drill dense formations by cutting into the formation is difficult to drill, but their development is layered from the side of the cutting easier to break rocks. After experiencing this formation, often drilling process will find a small torque between $3\text{kN} \cdot \text{m}$ - $4\text{kN} \cdot \text{m}$, essentially unchanged, this PDC cutter is unable to eat into the formation caused when the drill is also very SLOW. While the new PDC drill bit when hit this formation, although torque is essentially unchanged, but the former is much larger than the PDC drill bit for about $7\text{kN} \cdot \text{m}$, the drill is relatively much faster [10]. This is because the gauge teeth are oblique angle contacting the formation, formation pressure is applied to the drill can be divided into two parts, the vertical and horizontal component, in the horizontal direction to play a role in the formation of the cutting level, thus improving the efficiency of rock breaking. Its schematic diagram is shown below (see Fig 8).

(3) Timely optimization core drilling parameters

Coring is a comprehensive technical job, not only should have good coring tools, wellbore quality, but also a reasonable drilling parameters fit. For different formation, different coring tools, core drilling with different parameters, and in accordance with core drilling in a timely manner, can be adjusted accurately. For fractures of the hill formations, in order to improve ROP and the core

recovery, when coring through core drilling engineers real-time drilling, effectively optimized for core drilling parameters, to improve core recovery rate and mechanical drilling speed provide a favorable environment protection.

By this times application DFC0806 type pinion PDC coring bit proves that this coring bit more suitable for the hill formation, so can continue to use this PDC coring bit for the hill formation. However, for different formation to be preferably selected coring bit, without a core bit is a panacea.

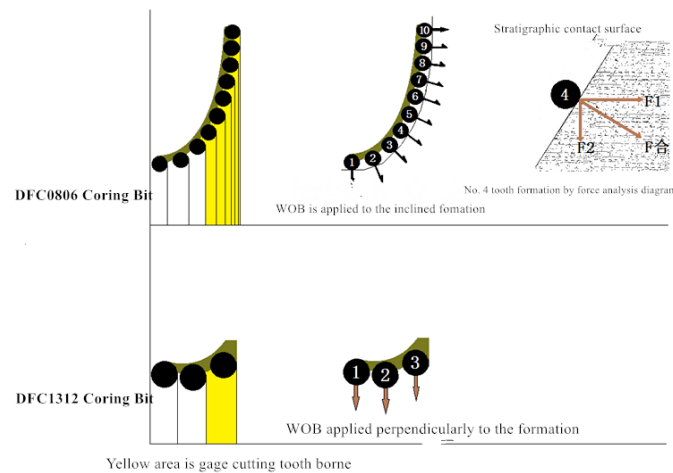


Fig. 8 PDC cutter arrangement comparison chart

4. Conclusion

4.1 Recommendations.

B-2 well encountered many problems in the coring operation, in order to reduce and avoid such problems, it is recommended:

(1) Enhanced rigidity BHA

B-2 well encountered such a large section of bedrock well long open-hole and in situations coring, drilling BHA should be enhanced the overall rigidity [11], centralizers may be added as the BHA so as to prevent the wall irregular or not smooth due to coring tight trip.

(2) If it necessary, before coring drill should wiper trip or reaming

When starting a round drill bit size is significantly smaller than the case of less than or coring bit size, should be carried out under the new drill bit wiper trip or ream wells, under the new drill bit obvious tight trip situation should ream the hole, so as to ensure the coring tool smoothly. In this case, if you do not agree to wiper trip or reaming, coring tools tight trip and not drill in the end will become a necessity, coring tools cannot ream the hole, can only change from drilling bit comprehensive drilling wells or reaming, in order to proceed to the next coring tool. Such a result is not only a waste of a tripping time, but also improve the risk underground.

4.2 Measures.

(1) Optimize BHA depending on well conditions

Before coring, in full knowledge of the wellbore, the well conditions in a timely manner in accordance with different optimization coring BHA, timely adjustment.

(2) Strengthen the two parties to communicate in a timely manner corresponding coring preparations

Coring engineer should be prepared to communicate with the Party, the tool inventory situation and existing problems in a timely manner to contact with the Party, and the Party of combining work plan ready coring tools and fitting statistics, well prepared in advance the coring tool.

(3) Control coring footage

For serious erosion in weathering, lithology loose, to poor pillars interval, core to prevent due to lack of core strength, difficult to support already into inner tube weight core which led into the inner tube difficult to prevent core crushing, abrasion, and in the core portion of the core blocked to prevent the occurrence of core block.

(4) Core drilling process, once the ROP significantly lower and there is a sign of core block, immediately stop coring drilling

ROP decreased probably because of the occurrence of core block, if core block occurs, continue to take the time not only into the core drilling core barrel, and it will increase the mutual friction between the core, the drill will wear out in section. Therefore, when the ROP significantly reduced core drilling be stopped immediately to prevent the core due to the wear and tear caused by blocked.

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