CSCanada
Advances in Petroleum Exploration and Development
Vol. 20, No. 1, 2020, pp. 72-82
DOI:10.3968/12170

ISSN 1925-542X [Print]
ISSN 1925-5438 [Online]
www.cscanada.net
www.cscanada.org

Diffcult Point & Solution of Zhengan Shale Gas High Effective Horizontal Well Drilling

YU Jiliang[a],*

[a] Guizhou Shale Gas Exploration and Development Caompany, China.
*Corresponding author.

Received 2 September 2020; accepted 21 November 2020
Published online 26 December 2020

Abstract
This article aims to provide technical support for the high-efficiency and high-quality horizontal drilling construction in Zhengan shale gas field. Based the analysis of the formation characteristics and drilling conditions in the Zhengan area, the technical issues of horizontal drilling improving in this area are explained, and based on speed-up and efficiency-increasing technologies such as the resigned high-efficiency PDC bit, high-torque&long-life motor, drilling parameter optimization, friction&torque monitoring, friction-reducing and torsion-reducing tools, near-bit geology steering technology, rotary steerable drilling technology and loss control and anti-collapse mud etc., solutions for the issues have been proposed. Through the application of related technologies, it is expected that improvements for the ROP of horizontal wells in the area and the drilling cycle will be made.

Key words: Shale gas horizontal well; Resigned high-efficiency PDC bit; High-torque& long-life motor; Drilling parameter optimization; Loss control& anti-collapse mud

Yu, J. L. (2020). Diffcult Point & Solution of Zhengan Shale Gas High Effective Horizontal Well Drilling. *Advances in Petroleum Exploration and Development*, *20*(1), 72-82. Available from: http://www.cscanada.net/index.php/aped/article/view/12170
DOI: http://dx.doi.org/10.3968/12170

1. GENERAL SITUATION OF ZHENG'AN SHALE GASGEOLOGY

1.1 General Situation of Geology
Zheng'an Field is located in Zheng'an County, Zunyi City, Guizhou Province, bordering Chongqing Nanchuan District in the north, Daozhen County and Wuchuan County in the northeast, Fenggang County and Meitan County in the southeast, Suiyang County in the south, and Tongzi County in the northwest. The acreage is 2595 sq.km. (Figure 1). Limestone is widely distributed in the area, and karst landforms such as karst caves, karst depressions, torrents, and blind valleys are developed.

Figure 1
Location of Zhengan field

Based on regional geological data and offset well drilling condition, combined with seismic, offset well drilling& logging data, the formation drilled from top to bottom are: Triassic Jialingjiang Formation, Yelang Formation, Permian Heshan Formation, Maokou Formation, Qixia Formation, Liangshan Formation, Silurian Hanjiadian Formation, Shiniulan Formation, Xintan Formation, Longmaxi Formation, and Ordovician Wufeng Formation, Linxiang Formation, and Baota Formation. Among them, the Wufeng Formation to Longmaxi Formation is the main target zone, with a thickness of 17-24m. The lithology is shown in Figure 2

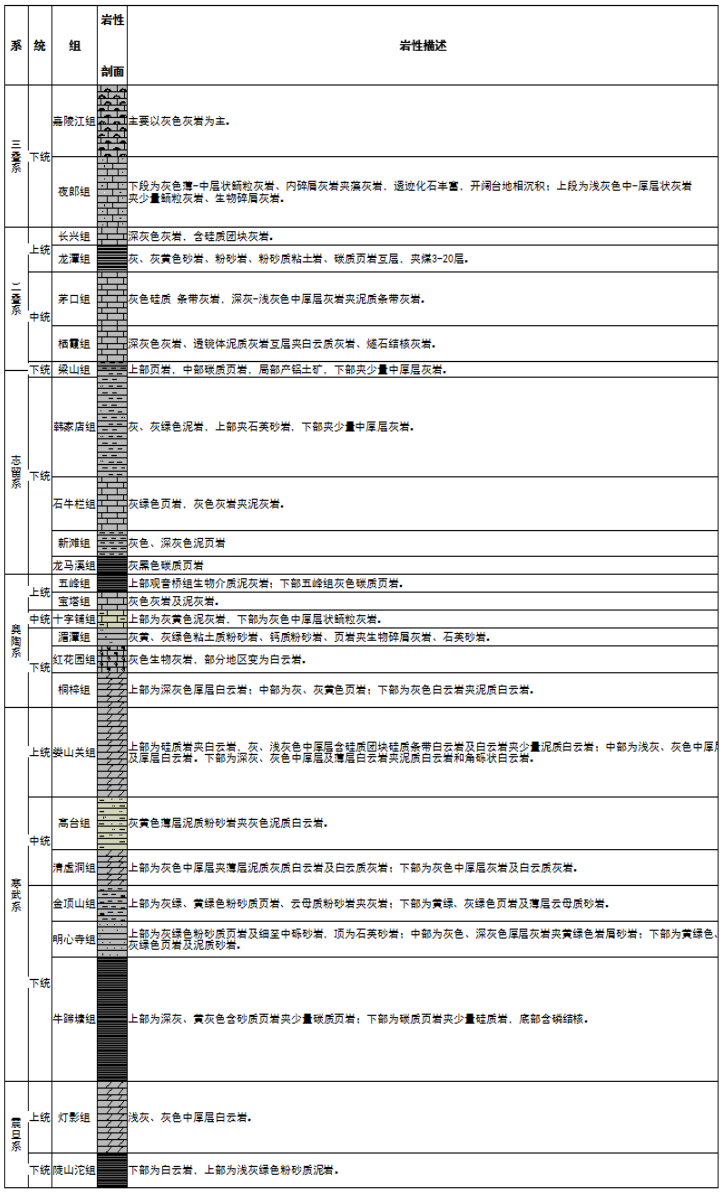

Figure 2
Formation Condition of Zhengan field

Jialingjiang Formation: The lithology is a combination of micrite limestone mainly intercalated with dolomite and breccia, and the lower formation lithology is dominated by micrite limestone intercalated with sandy limestone and dolomite. The limestone has good stratification and clearbedding. The the middle and upper parts at bottom of the formation top are mainly composed of a set of dolomite, lime dolomite and breccia with upper and lower boundaries.It also have a set of thick micrite limestone in the middle, which iswith little of argillaceous micrite limestone and breccia limestone.

Yelang Formation: The lithology is mainly composed of micrite limestone and calcareous mudstone intercalated with silty mudstone; while the lithological of underlying Heshan Formation is weathered soil, which is dark gray or yellow, containing siliceous rock fragments.

Heshan Formation: The lithology is dominated by flint bands or nodule micrite limestone, micrite bioclastic limestone, and bioclastic micrite limestone, with sprite bioclastic limestone, siliceous stone, a small amount of claystone and thin coal seams or coal lines.

Maokou Formation: The lithology is gray, light gray thick layer and massive micrite limestone, micrite bioclastic limestone, mud-sprite (recrystallized) algae sandy bioclastic limestone, dolomitic limestone, flint nodules and flint banded limestone, with a small amount of thin to middle marl (or calcareous claystone) between layers. The bedding in the formation is not developed with suture structure.

Qixia Formation: The lithology is dominated by dark gray micrite limestone and bioclastic micrite limestone, containing flint masses, and partially marl and calcareous mudstone bands.

Liangshan Formation: The lithology is a set of mudstone, aluminous mudstone and carbonaceous mudstone. Parallel unconformity contact with the underlying strata.

Hanjiadian Formation: The lithology is mainly a set of gray-green, yellow-green (with a small amount of purple-red) mudstone(shale), silty-mudstone(shale), argillaceous siltstone or silty mudstone, middle and upper part with a small amount of micrite bioclastic limestone.

Upper Shiniulan Formation: The lithology is mainly a set of bioclastic limestone intercalated with argillaceous limestone and calcareous mud (shale) rock.

The lower part of the Shiniulan Formation: The lithology is mainly composed of a set of frequent interbeds of lime mudstone and argillaceous limestone. Integrate contact with the underlying formation.

Xintan Formation: The lithology is a set of interbedded gray, gray-green mudstone and calcareous mudstone, with a small amount of lenticular argillaceous limestone and calcareous sandstone in the upper part.

Longmaxi Formation: The lithology is gray-black mudstone and black carbonaceous shale.

2. ANALYSIS OF DIFFICULTIES IN DRILLING ZHENG'AN SHALE GAS HORIZONTAL WELLS

2.1 Low ROP, Less ft per Trip, Frequently Trip.

According to the statistics of the drilling operation of 16 wells in two rounds, the average drilling period of the first round of wells was 126.93 days, the average ROP was only 5.26m/h, the average single well used 15 bits, and the average single bit footage was 322m; The average drilling period of the second round of wells is 52.92 days, the average ROP is 7.51m/h, the average single well uses 11 bits, and the average single bit footage is 451m.

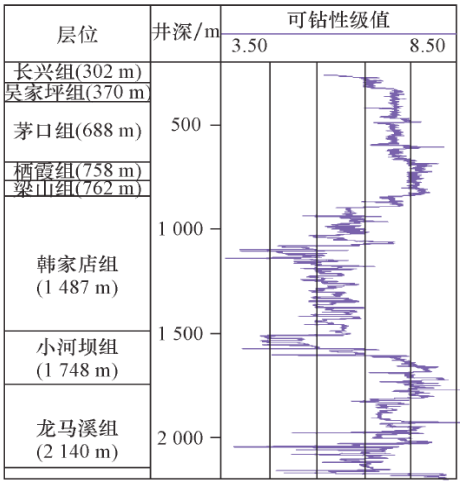

Figure 3
The Comparison of Drillability in Pengshui Block

Taking the drillability of the adjacent Pengshui block as a reference, the drillability of this area is between 4.5-7.5. Although the construction indicators of the second round of wells in Zheng'an field have been significantly improved, there is still a lot of room for drilling speed increase, and also there is still a strong need for speed increase. Compared with the Longye field whichis a straight-line distance of 100km from the Zheng'an field, the drilling cycle of the same well type and depth is within 20-30 days. For example, the Longye 1-3HF well has a TD of 4693m and a drilling cycle of 25.52 days, the average ROP is 15.62m/h, and the highest single-day ft in the horizontal section is 473m. The Longye 1-2HF well has a TD of 4592m, a drilling cycle of 22.22 days, and an average ROP of 17.58m/h.

2.2 The High Friction & Torque in The Later Stage of The Build-up Section, and The Low Sliding Drilling Efficiency, Lowering The Overall ROP

The horizontal wells in the Anchang field are mostly three-dimensional horizontal well with long horizontal section. The directional section is long and the azimuth torsion is large. The sliding efficiency of conventional motor is low.[1] In the later stage of the building-up section, the rotary steering tool needs to be used for trajectory control construction, which greatly increases the cost of drilling in the field.[2]

2.3 With Thin Reservoirs, Large Angles, and The Drill-through Rate ofHigh-quality Reservoirsis Difficult to Guarantee

The thickness of the shale gas reservoir in the Anchang field is thin, and the formation occurrence changes greatly. The box of horizontal section is only about 5m, and the well trajectory is easy to derail the box. The high-quality shale is difficult to drill, and the rate of reservoir drilling-through in some wells need to be further improved.

2.4 The Pressure System is Complicated and The Contradiction between Kick and Loss is Prominent

There is karst geomorphology developed in the upper formationof Zheng'an field. Pores, caves and fractures developed in the Jialingjiang Formation, and the risk of loss is high. There is a big difference of pressure coefficient between the local abnormal high pressure in the Shiniulan Formation and normal pressure in the Longmaxi Formation (see Table 2-2). The contradiction between kick and loss is prominent. Longmaxi Formation cracks, micro-fractures, and faults are well developed, and loss occurs frequently.[5]

According to statistics, there are 16 shale gas wells in Anchang, 10 wells with oil-based drilling fluid have loss, 31 times of losses happened, a total of 2270.26m3 of oil-based drilling fluid lost. 3 wells found loss among totally 8 wells in Zone 1, and 3 wells found loss in Zone 2(totally 3 wells), 1 well found loss in Zone 3(totally1 well), 2 wells found loss in Zone 4(totally 3 wells), 1 well found loss in Zone 5(1 well), 5 times losseswas found in the Shiniulan Formation, 6 times losses was found in the Xintan Formation, and 25 losses was found in the Longmaxi Formation. There are 9 times of no-return loss was found, 5 times of loss speed beyond 20m3/h, 4 times of loss speedbetween 10m3/h-20m3/h, and 13 times of loss speedless than 10m3/h. Totally 6 times cement plugging, 27 timespressure-bearing plugging, while 16 timesdrilling + density reduction plugging, and 6 timesreturned to normal without plugging. There were 13 times losses during drilling, 15 times losses occurred in circulation, and 3 times losses due to uneven drilling fluid density + hold-up pump. [6]

2.5 Frequently SidewallInstability and High Proportion for Complex Aging

In the Wufeng-Longmaxi formation, the degree of cementation of the formations is poor, and the horizontal section is severely dropped during drilling, and it is often accompanied by loss, which can easily lead to stuck.

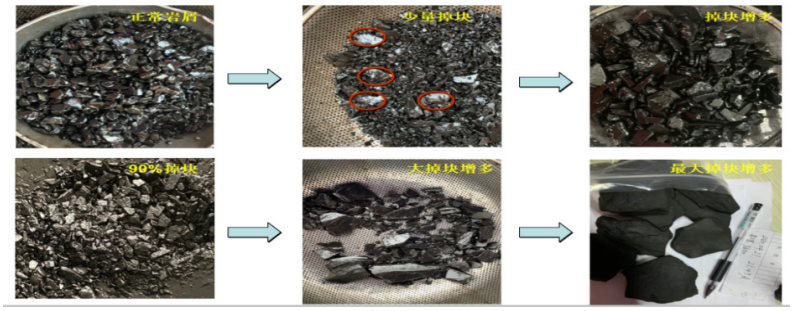

Figure 4
Dropping condition in Longmaxi formation

3. DRILLING ROP SPEED-UP TECHNOLOGY

3.1 Resigned High-effective PDC Bit Optimization

Drilling bit improving plan in the Anchang block: At present, 19mm highly aggressive composite cutter is rarely used to drill from the Jialingjiang Formation to the Heshan Formation in the Zhengan block. From the actual situation, the formation of this section is not very abrasive.We can consider using a 5 blade with 19mm composite cutter to increase the ROP. The vertical guide hole from Heshan Formation-Longmaxi Formation considers using 5 blade with 16mm cutter PDC or 4 bladewith 16mm high wear-resistant profiled composite cutterPDC to increase the ROP in this section. The overall drillability of the 215.9mm section formation is pretty good. So it focuses on improving the lateral cutting ability and aggressiveness of the PDC bit. The short gauge-protection, short parabolic and shallow inner cone is designed on the PDC bit.

3.1.1 The Bit Optimization in First Section

The size of first section (from Jialingjiangfomation to Yelang formation) is 660.4mm / 444.5mm / 406.4mm, and the lithology is mainly limestone and lime mudstone withlight abrasive, the ideas to increase the ROP mainly focused on aggressiveness of bit andfinishing this section in one trip. The highly-aggressive single-row 19mm composite cutter and large flute of bit is preferred. Specific optimization plan: optimizing the cutter angle; arranging medium or lowdensity of cutters; special-shaped cutter are used to improve rock-breaking efficiency for sandstone & mudstone & other lithology; combined two rock breaking methods: plowing by special-shaped cutter and shearing by round tooth; Large flutes, high-efficiency hydraulic structure (Figure 5).

Figure 5
PK5352S 5 blades 19mm cutter PDC bit

3.1.2 Bit Optimization for Second Section

(1) The 311.2mm section (Jialingjiang-Maokou Formation) is mainly composed of limestone, lime-mudstone and mudstone. The formation is relatively loose and light abrasive. The plan of bit optimization is to increasing the aggressiveness and also taking into high impact resistance of the bit.The first trip of this section was planed to drilling reach the Maokou Formation. The bit is preferred which have large flute andhighly aggressive 19mm composite cutter with conical teeth on the back row. Specific optimization plan: optimizing the angle of cutter, prefer large flutes and high-efficiency hydraulic structure, arranging low-to-mediumdensity tooth on bit; using cone teeth in the back row for sand and mudstone and other formations to improve rock breaking efficiency; combined two rock breaking methods: plowing by special-shaped cutter and shearing by round tooth (Figure 6).

Figure 6
PK5352SZ-311.2mm 5 blades 19mmPDC bit

(2) The lithology of 311.2mm section (Maokou Formation-Hanjiadian) is mainly limestone, mudstone, siltstone, and the formation has poor drillability and strong abrasiveness. The idea of increasing the ROPis taking into account aggressiveness and focus onimproving the anti-abrasive performance of the bit, the goal is directly drill to TD of the second section in second trip. High wear-resistant 16mm special-shaped composite cutteris preferred to improve rock breaking efficiency. Specific optimization plan: All blades use double rows to enhance the durability of the drill; Using imported high-abrasive composite cutters; using high wear-resistant ball teeth at the back row of the bit shoulder to improve wear resistance and impact resistance; Brazed diamond composite cuttersfor gauge protection to enhance durability; Adopts limitedconical teeth to ensure the stability of the drill (Figure 7)

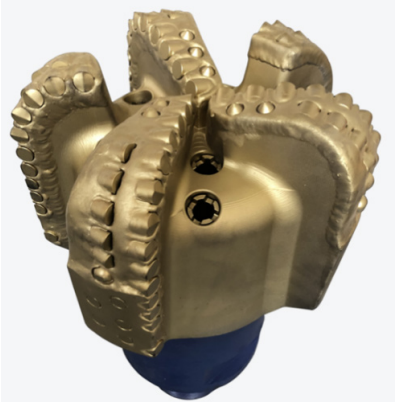

Figure 7
PK5255SJZ-311.2mm 5 blades 16mm cutter PDC bit

3.1.3 Bit Optimization for Third Section

The 215.9mm section (Hanjiadian-Longmaxi/Shiniulan Formation) is dominated by limestone, mudstone, and black carbonaceous shale, with good drillability. In the initial stage of the directional section, a mixed drill bit is used for directional drilling, which has a stable tool face and good aging; in the middle and final stages of the directional section and the horizontal section using highly aggressive design to improve the lateral sheering ability and gauge protecting of the bit while ensuring the stability of the tool face. Optimizing high wear-resistant 16mm composite cutters to improve rock breaking efficiency. Specific optimization plan: Short parabola, shallow inner cone structure; reinforced gauge protection; Imported high anti-abrasive PDC composite cutters, special-shaped cutteralso can be selected; optimizing the angle of cutter one the shoulder of bit to maintain the high aggressiveness; The back row adopts double rows+ conical teeth mixed design (as shown in Figure 8).

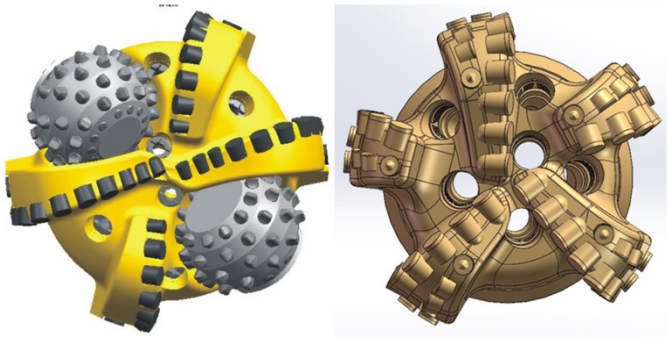

Figure 8
Mixed bit & PK5255SJZ-215.9mm 5 blades 16mm PDC bit

3.2 Drilling Parameter Optimization

Drilling parameter enhancement technology, also called radical parameter drilling technology, is a popular technology in recent years. It has achieved relatively good speed-up effects in the construction of shale gas wells abroad and domestic. The foundation of the drilling parameter enhancement technology lies in the ROP equation. The formula of the typical ROP equation is:

$$ROP=kC_pC_h(WOB-M)\ RPM^{\lambda}\frac{1}{1+C_2h} \qquad (3\text{-}1)$$

In above equation, ROP is the mechanical specific energy; k is the lithology coefficient; Cp is the differential pressure coefficient (kN.m); Ch is the hydraulic energy coefficient, WOB is the weight on bit, M is the rock breaking threshold weight on bit, RPM is the bit speed; λ is the speed coefficient,; C2 isdull grade of bit.[7]

According to the ROP equation, these three parameters such as WOB, ROP, and torque have a greater impact on the mechanical specific energy. Increasing the three parameters is of great significance for increasing the rock-breaking energy and increasing the ROP. The North American shale oil and gas construction has carried out sufficient tests and applications for the enhancement of drilling parameters, mainly using higher WOB, top drive speed and displacement, and achieved good ROP; While in Sichuan and Chongqing fields it has also entered the initial stage of popularization and application of drilling parameter enhancement technology (see Table 3-2-1).

Table 3-1
The condition of Drilling Parameter Enhancement Technology Application in US and CHA' Sichuan Field Shale Gas

Horizontal Drilling	US shale gas	CHA Sichuan shale gas
Section（inch）	8.5/8.75	8.5
TD（m）	3000	3000-3600
BHA	RS+Motor	RS+MWD
Mud Density（g/cm3）	1.4	1.7-2.2
WOB（Ton）	10-18	9
Rotary speed on bit（rpm）	250	100
Displacement（L/s）	36.7	28.3
Pump pressure（Mpa）	30-40	25-30
Torque（kN.m）	30	20-25
ROP（m/h）	＞20	5-10

During the drilling Φ333.4mm section in X well in Pengzhou, the drilling parameters were adjusted and optimized between 1850-1910m. From the actual drilling effect (Figure 9), the average ROP increased from 11.13m/h to 18.58m/h after the drilling parameters were strengthened. There is an increase about 66.87%.[4]

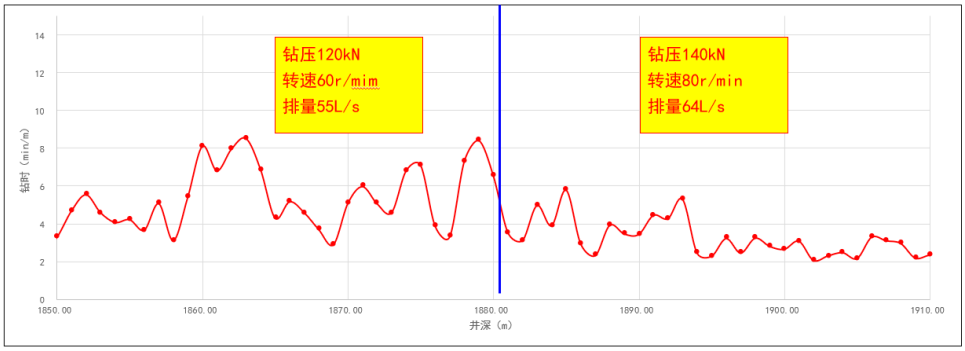

Figure 9
Pengzhou X well Drilling Parameter Enhancement Effect

With the development of drilling technology, the improvement of drilling equipment capabilities, and the improvement of drilling tool performance, combined with the experience of multiple wells in the early stage, comprehensive consideration of process requirements, equipment and downhole safety, the Zheng'an field should be appropriately strengthened for drilling parameters in order toincrease the ROP.These purpose such as shortening the drilling cycle, reducing costs and increasing efficiency will be achieved as follow. The drilling parameter optimization plan of Zheng'an field is shown in Table 3-3.

Table 3-3
Recommendations for Drilling Parameters Enhancement in Drilling Different Sections in Zhengan Block

Section	Parameter items	Organized Parameters	Target Parameters	Target result
311.2mm	Weight on bit	80-120KN	110-150KN	More than 20%
	TD speed	45-60r/min	80-100r/min	
	Displacement	45-50L/s	55-60L/s	
215.9mm	Weight on bit	60-100KN	90-130KN	
	TD speed	45-60r/min	90-100r/min	
	Displacement	28-30L/s	32-35L/s	

3.3 High-Torque & Long-Life Motor Optimization

Bit optimization is not enough to achieve the goal of maximizing single-trip drilling footage and ROP. It requires high-torque and long-life motor to fully achieve the speed-up potential. Motor with equal thickness of wall(see Figure 10)is a new type of motorwhich is successfully developedin recent years. It has advantages such as high pressure for single-stage sealing, low speed, high torque, small radius of curvature, long service life, high temperature resistance and more safe. According to different sizes, the working torque and maximum output torque of motors with equal thickness of

wall are 20-100% higher than normalmotor (see Figure 11), and the average continuous working life can be increased by about 20-50%.[3]

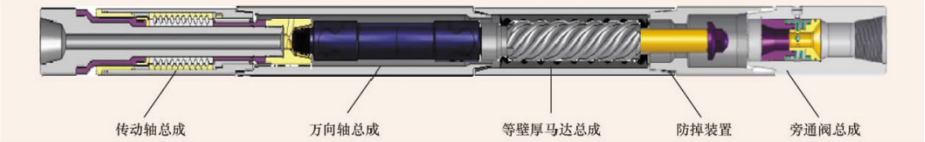

Figure 10
Equal Wall Thickness of Motor

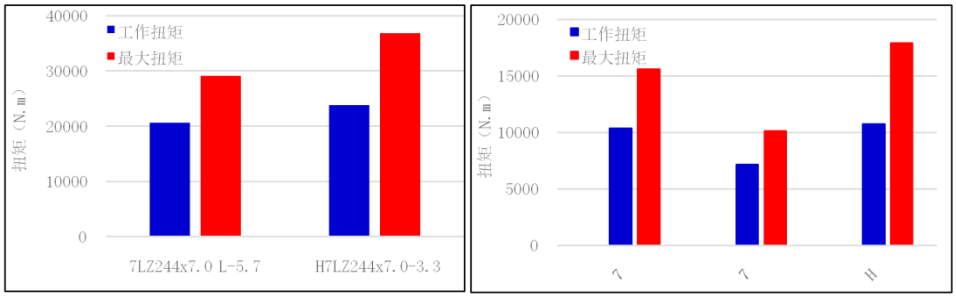

Figure 11
Combined Chart for Different Torque of Different Motor Size

Combining the previous experience in motor selection and the drilling needs in Zhengan field, the recommended motor with equal wall thickness is as follows:

（1）Φ406.4mm/311.2mm section：H7LZ244×7.0-3.3(equal wall thickness);

（2）Φ215.9mm section：7LZ172×7.0V or H7LZ172×7.0-4.6（equal wall thickness).

4. PLUGGING & ANTI-COPPLLOSED DRILLING FLUID

4.1. Plugging Technology

The loss rate is related to the characteristics of the formation loss channel, the loss area on the sidewall, the performance of the drilling fluid, the pressure difference and other factors, and the loss can occur to varying degrees from permeable loss to no-return loss. According to the condition analysis of loss in 10 wells in Zheng'an field, the main characteristics of formation are: Uneven distribution and development of fractures; Micro-fractures are well connected, and the fracture types are medium-fractures and micro-fractures; Proliferation fractures are prone to occur; Repetitive loss is prone to occur; Safe density window is narrow; And there are multiple sets of pressure systems at the same section; The gas value rises while the loss occurring; The vomiting phenomenon occurs after the loss.

The core fabric analysis shows (Figure 12) that the micro-nano pores and fractures of the Longmaxi Formation shale samples from Well Anye 2 are developed, and the pores and fractures have a wide range of sizes which is about 0.01~10μm. It is also have Multi-size features like "cracks (nano) -micro cracks (micrometers)". During the drilling, if the oil-based mud has insufficient plugging performance while drilling. Under the pressure of fluid, the drilling fluid invades the formation along the micro-nano pores and fractures, and the micro-fractures will gradually become extended fractures, causing serious loss of drilling fluid.

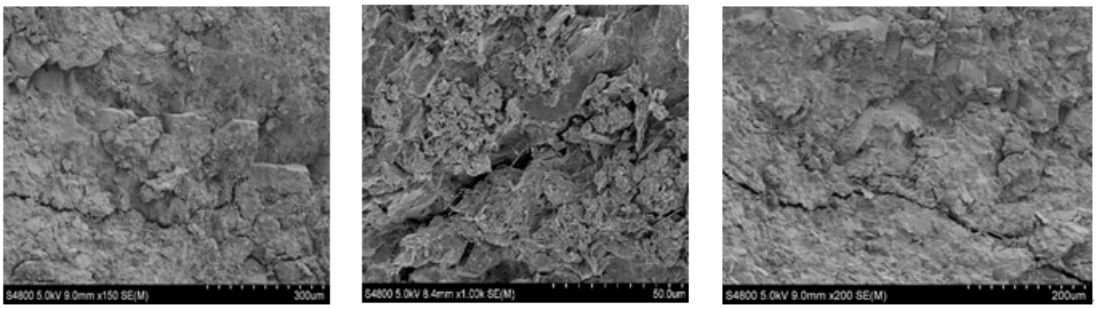

Figure 12
Scanning Electron Microscope Picture

Therefore, the prevention of lost circulation and plugging in Zheng'an Field mainly start from below three aspects:

First way is to reduce or eliminate the positive pressure difference between hole and formation. On the premise of maintaining the stability of the borehole wall and preventing the risk of overflow, minimizing the density of the drilling fluid as low as it can be and reducing the pumping pressure should be good carried out. And segmented circulating should be used to keep the density of the drilling fluid uniform during running in hole. Heavy mud should be used to evenly increased the density of mud during circulating.

The second one is to block the loss channel. There are many different lost circulation materials such as rigid granular (walnut shell, limestone, etc.) + deformed granular (porous mesh plugging agent, rubber particles, etc.) + rigid flake (mica flakes, chaff, etc.) + fibrous (acid melting plugging agent, flax fiber, etc.). The concentration, gradation and amount of bridging and plugging materials selection depends on the degree of loss. The compound ratio is generally granular: flake: fibrous = 2:1:1, and add about 5% of the inert material which is larger than the size of the bridging crack.

The third way is to increase the flow resistance of the drilling fluid in the loss channel. Experiments show that the loss rate has a power function relationship with the consistency coefficient of the drilling fluid. The smaller consistency coefficient, the greater rate.

4.1.1 Drilling Plugging Technology

Non-permeable drilling plugging technology

It can plug heterogeneous permeable formations by using special interface chemical to plug micro-cracks; It also can widen the mud density window; And it is suitable for multiple formation pressure in the same hole; It is positive for environment and reservoir protection.

High-temperature drilling deformation plugging technology by oil-based mud

Plugging while drilling can be combined with multiple particle sizes of material, and itwill be successful by one time, which is effective and long-lasting, suitable for shale fracture loss.And it also can be well compatible with oil-based mudto improve filter cake quality. It can both plug the loss and prevent collapse while enhancing the smoothness and compactness of the mud cake surface, let along the salt resistance and inhibiting for shale hydration and expansion of this tech.

CVB circulating drilling plugging short cross

It can achieve special operations such as drilling while plugging, shorten the drilling cycle, and reduce the risk of well control. It can switch 6 times.

4.1.2 Elastic Mesh Plugging Technology

Elastic mesh plugging technology uses elastic mesh material, which can resist temperature up to 150℃ and rise compressive deformation rate greater than 50%. It also can squeeze into cracks and connect to net. The pressure capacity of this tech is greater than 10MPa.It can quickly form a force structure for plugging the loss. The material has been used in 12 well in North Shanxi, Southwest and other blocks, with a one-time plugging success rate of 83.3%, and it has been applied in Anye 5HF well also. Both pluggings succeed by one-time.

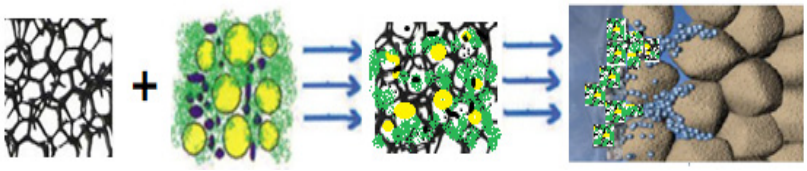

Figure 13
Progress Display for Elastic Mesh Plugging

4.1.3 High-Temperature Drilling Deformation Plugging Technology by Oil-based Mud

In recent years, oil-based mud have been used more widely in drilling. And the drilling fluid plugging technology has also been developed to matching it. At present, oil-based high-temperature deformation plugging technology has the following advantages: l

Continue drilling while Plugging without waitingon cement; l

It can be combined with multiple particle sizes, the plugging will be successful by one-time, which is effective and long-lasting.And it is also suitable for shale fracture loss and can be used in conjunction with other bridge plugging agents and inert materials; l

It have good compatibility with oil-based mud and without any influence to the drilling fluid.Alsoit could further improves the quality of the filter cake; l

It can stop the loss and prevent collapsing and also enhance the smoothness & compactness of the mud cake surface. l

It has salt resistance and inhibitionfor shale hydration and expansion.

4.2 Anti-collapse Technology

There are two ways to solve the problem of hole wall instability in the Zheng'an field: First is choosing a white oil-based drilling fluid system, and control the high temperature and high pressure filtration within 2 mL to minimize the possibility of filtrate entering the formation.Second way is strengthening the plugging ability of oil-based mudand increasing the amount of oxidized bitumen, and optimizingnano formation sealant and sidewall enhancer to plug the micro-cracks in the open hole quickly and reduce the probability of dropping.[8]

4.2.1 Nano Formation Sealant

Nano formation sealantis one kind of synthetic polymer nano formation sealant with a particle size distribution of 50-500 nanometers. It has the characteristics of cohesiveness, amphiphilicity and micro-nano. After nano-polymer particles enter the formation, they can bond the cracks autonomously. They can evenly dispersed in oil and water and easily adsorbed to the two wings of the micro-cracks.Because its particle size is nano-micron spherical and it has good elasticity and shrinkage, even if the particle diameter is larger than the micro-nano cracks, it can effectively enter the shale micro-cracks, or be squeezed into shale micro-nano cracks under pressure.

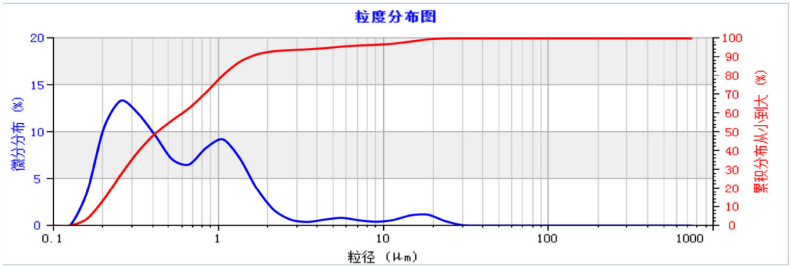

Figure 14
Size Distribution of Nano Formation Sealant

4.2.2 Sidewall Enhancer

It is necessary to optimize high-strength rigid sidewall enhancers. Because the high-strength rigid particles will quickly embed in the pores and micro-fractures around the hole when the bit breaks the rock, causing squeezing along the tangential direction of the sidewall, also expanding the stress around the sidewall, and improving the pressure bearing capacity of the formation (Figure 15).

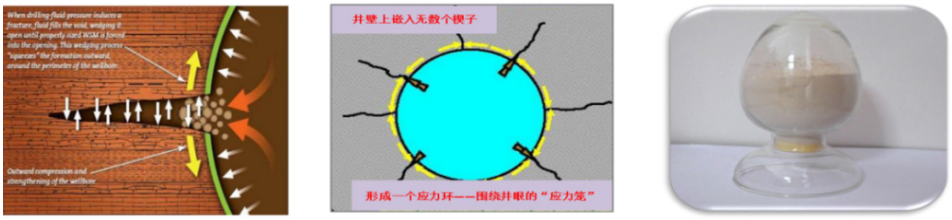

Figure 15
Schematic Diagram for high-strength rigid sidewall enhancer

High-strength rigid sidewall enhancer has the following advantages: l

Good sealing performance, strengthen the sidewall, reduce the occurrence of wall collapse, and prevent further damage to the sidewall by bit; l

Expand the window of the drilling safety density, reduce the probability of lost circulation, and save time; l

Optimize gradation by using reasonable particle size design to control 90% of the particle size within 118um (125 mesh); l

Inert material was selected without polymer which made little influence on rheology and good high temperature stability.

5. RECOMMENDATIONS

(1) The high-quality and high-efficiency horizontal wells drilling in the long horizontal section of Zheng'an field mainly relies on the application of high-efficiency rock breaking tools and techniques, friction and resistance reduction technology, near-bit geosteering technology, rotary steering technology and loss control & anti-collapse drilling fluid

technology. Each technology complements each other to establish a healthy system for speeding up and improving efficiency;

(2) At present, the high-efficiency directional drilling control of Zheng'an shale gas block still relies on foreign rotary steering systems.There is still a lot of room for cost reduction. In the subsequent work, the optimization of BHA and efficient trajectory control technology should be focused to study to further reduce the reliance on high-cost technologies and tools;

(3) The near-bit geosteering technology is gradually developing. It is one of the most effective technologies to ensure the safe landing of horizontal wells and the drilling encounter rate of high-quality reservoirs. The reliability and market scale of domestic near-bit geosteering instruments should be improved.And the cost of horizontal section drilling should be reduced.

(4) The anti-collapse drilling fluid technology can effectively reduce the complex probability caused by the instability of sidewall, but the current application is insufficient.The further optimization and popularization of the technology should be strengthened.

REFERENCES

[1] Tang, H. L., etc. (2016). Method for monitoring friction and torque of extended reach wells. *Natural Gas Industry,* (5).

[2] Xin, S. Y., etc. (2014). Research on continuous pressure pulsation drag reduction and anti-sticking tools for horizontal well drilling. *Petroleum Field Machinery,* (8).

[3] Yang, L. Q., etc. (2012). Development and field test of motor with constant wall thickness. *Petroleum Drilling Technology*, (2).

[4] Xu, H., etc. (2013). Optimum design and construction of horizontal wells in the long horizontal section of Daniudi Gas Field-Taking Well DP31H as an example. *Drilling and Production Technology*, (5).

[5] He, Y. Z., etc. (2020). Geological characteristics and favorable area prediction of Wufeng Formation-Longmaxi Formation shale gasin Zhengan area, northern Guizhou. *Geological Survey of China*, (6).

[6] Chen, Y. H. (2017). *Analysis and research of drilling complexity and countermeasures in Well Anye 1.* China University of Geosciences (Beijing).

[7] Wu, W., etc. (2019). Intensified & comparative & evaluation of drilling parameters in the horizontal section of Changning Shale Gas Wells. *Unconventional Oil and Gas*, (8).

[8] Li, J. S. (2019). Anti-collapse and Anti-leakage Drilling Fluid Technology in Hangjinqi Block. *Drilling Fluids and Completion Fluids*, (5).