Difficulties and Countermeasures of Drilling Technology for Deep Shale Gas Horizontal Wells in Sichuan and Chongqing

Yongxing Sun

College of Tourism and Geographical Science, Leshan Normal University, Leshan, 610400, China

daisysm@163.com

Abstract. Aiming at the problems of deep burial, high temperature, high pressure, many strata series encountered during drilling, and poor comprehensive economic benefits of shale gas reservoirs in Sichuan and Chongqing, the engineering geological characteristics and drilling technical difficulties of deep shale gas in Sichuan and Chongqing are analyzed through the comparison and systematic summary of deep shale gas drilling technologies at home and abroad. According to the drilling practice of deep shale gas, not only the optimization of well bore structure and drilling speed increasing technology, It also conducts detailed research and analysis from aspects such as the optimization of speed increasing tools, and puts forward suggestions and countermeasures for the follow-up large-scale development of deep shale gas resources in Sichuan and Chongqing, which provides a certain reference for solving the drilling technical problems of deep shale gas horizontal wells in Sichuan and Chongqing areas.

Keywords: Deep Shale Gas, Horizontal Wells, well structure, Fast Drilling Technology.

1 Introduction

The standard of Geology and Mineral Resources Industry of the People's Republic of China (DZ/T 0254-2014) provides the standard of deep and ultra-deep shale gas, that is, shale gas buried at a depth of 3500 ~ 4500m is deep shale gas, and when the vertical depth exceeds 4500m, it is ultra-deep shale gas [1]. Huge deep shale gas resources are important substitute resources for fossil energy, and Sichuan Basin is the region with the richest shale gas resources in China [2-7]. Therefore, the efficient development of deep shale gas in Sichuan Basin is of great significance for ensuring national energy security. The Zus202-H1 well deployed in Rongchang, Dazu, Huangguashan and other structures has a depth of 3,925m and a test daily output of 456,700 cubic meters. Huang202 well is buried 4,018m deep and has a daily output of 223,700 cubic meters, demonstrating the exploration potential of deep shale gas in western Chong

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qing. In the deep shale gas Wells in southern Sichuan [8,9], the daily test output of Lu 203 well reached 137.9×104m3, which set a new record for the highest daily output of shale gas in China and confirmed that deep shale gas in southern Sichuan has a good exploration prospect [10]. Deep shale gas in Sichuan and Chongqing area is about to enter the stage of platform development, but some Wells have low ROP, long cycle and poor economic benefits.

2 Technical difficulties in drilling deep shale gas Wells

The deep shale outlying layer in the Sichuan-Chongqing area has changed from the Jialingjiang Formation to the Jurassic Shaximiao Formation. Due to the addition of sea-land interlocking sedimentary strata, the regional geological conditions have become more complicated and the differences are great. The target layer Longmaxi Formation is a high-pressure area with a pressure coefficient of more than 1.8.

2.1 Poor drillability of rock and serious bit wear

Old formation, poor rock drillability and slow drilling rate are the main characteristics of deep shale in Sichuan and Chongqing area. The fine sandstone of Xujiahe Formation in western Chongqing area has high quartz content and coal seam. The average drilling rate of Xujiahe Formation is about 3m/h. The formation of Longtan Formation is heavy in mud, strong in plasticity and difficult for drill bit to penetrate, and the average mechanical penetration rate is lower than 2m/h. The Permian Maokou to Qixia strata in Changning area contain pyritic and chert nodres, and the strata in Hanjiadian to Shiniulan strata are highly heterogeneous, with mixed soft and hard layers and high mud content [11-13]. In Changning block, wear is still serious even if imported PDC bits are used, and the mechanical drilling rate of Hanjiadian and Shiniulan well sections is much lower than the average mechanical drilling rate of the whole well, which restricts the speed increase of the whole well.

2.2 Risk of wall collapse, well loss and wellbore instability

The shale of Longmaxi Formation is prone to crushing collapse and has strong sensitivity to fluid, which is aggravated by erosion and immersion of drilling fluid [14-17]. The equivalent circulating density (ECD) reached 2.25sg after the horizontal interval growth, which was close to the formation model loss zone and increased the risk of loss. At the same time, due to the increase in ECD, the wellbore breathing effect was increased, increasing the chance of wellbore instability resulting in block loss. The strata near the fault and fold are squeezed, and the internal stress is large. After the stress concentration zone/fracture zone is drilled through the hole, the stress concentration is released, resulting in the formation collapse and block falling, causing drilling sticking. The characteristics of borehole caving are dark bands arranged vertically and symmetrically.

2.3 Severe pressure support and slow drilling speed

Cluster well group is one of the main ways to improve the development effect of shale gas reservoirs, and the "double-line" wellhead is the most commonly used mode, generally deploying 6 to 8 Wells [11,13]. Due to the large inclination of shale reservoir, nearly half of the horizontal Wells are drilled in the updip direction, with the maximum inclination Angle exceeding 100°. During horizontal section drilling, the friction resistance is large, the drilling tool is prone to buckling, and the failure risk is high [18-20]. The long horizontal section in Changning area leads to large friction resistance along the drilling tool, especially the upward tilt of the horizontal section in the second half. The gravity component of the drilling tool along the borehole direction is opposite to the direction of the bit weight applied. When the bit weight is less than 80kN, the drilling tool at the lower part of the deviation section and near the target point is seriously helical buckling, resulting in the bit weight being spent on the wall of the buckling section. The effective weight on bit is difficult to transfer to the bit, and the drill tool bends and periodically releases, resulting in bit runout, which seriously reduces the rock breaking efficiency of the bit.

2.4 Large dips, thin reservoirs and complex wellbore trajectories

In Changning area, there are great differences in the vertical, transverse and vertical ratio of reservoirs, and great changes in formation dip, and the overall formation track shows a large "W-shape", and it is difficult to identify small faults in seismic data [21-22]. There is a large local difference between real drilling and seismic data. In the 4500~5300m interval, the formation is predicted to be slowly steepened (3.4° ~ 6.1°) before drilling, while the dip Angle of real drilling is changed between -1.6° ~ 8.1°, and the horizontal formation is crumbled in a wave shape. In the Zu block, the real drilling hole trajectory also showed a wavy shape, and the deviation in the 4560-5400m interval increased from 81.44° to 95.86°, and the deviation in the 5400-5700m interval decreased from 95.86° to 83.90°.

2.5 High temperature and high pressure lead to poor matching of oil-based drilling fluid and high failure rate of downhole tools

Under high temperature and high density conditions, conventional oil-based drilling fluid is prone to emulsification, poor stability, barite settlement and maintenance difficulties, etc. Meanwhile, with the extension of horizontal section length, oil-based drilling fluid is repeatedly used and drilled for a long time, and inferior solid phase continues to intrude into the drilling fluid, resulting in excessive viscosity and shear force of oil-based drilling fluid and deterioration of rheology. The density of oil-based drilling fluid used in drilling completion is greater than 2.0g/cm3, the solid phase mass fraction is higher (greater than 30%), the viscosity shear is increased, and the rheological property is not easy to control.

Due to the formation high temperature and high pressure, the use of high-density drilling fluid has resulted in an increase in the failure rate of measuring instruments such as rotary steerable or near-bit [8]. The measured temperature of well Yang 101H1-2 reached 155°C, and the instrument failed 5 times. Filter 202 instrument no signal drilling 6 times, screw degumming drilling 9 times, due to high temperature caused damage; Filter 203 replacement screw drilling 10 times, near the drill repeatedly damaged; Lu 204 drilled 4 times due to instrument signal problems; Due to the high content of chloride and sulfur ions in oil-based mud at high temperature, the rotary steering tools, screws and near-bit antenna joints of Lu 202 and Lu 203 Wells were corroded to a certain extent.

3 Comparison of deep shale gas drilling technology at home and abroad

3.1 Well structure

The most representative of deep shale gas abroad is the Haynesville shale gas block in the United States [23]. The buried depth of the gas reservoir is 3600 ~ 4500m, the highest temperature exceeds 180°C, and the formation pressure coefficient is 1.6 ~ 2.07. The three-hole well structure is mainly adopted: First, use Φ342.9mm drill bit to drill to a depth of 600m, and run Φ273.1mm casing; The second section uses a Φ250.8mm bit to drill the Bossier formation to the top hole depth of about 3150 ~ 4050m, and runs the Φ193.7mm casing; The three-way drill bit is Φ165.1mm, the drilling depth is about 4950 ~ 5550m, and the φ127 mm casing is run.

Deep shale gas Wells in China mainly adopt four-open well structure: a Φ660.4mm drill bit is used to drill to 50m and a Φ508mm casing is lowered; A Φ406.4mm drill bit was used to drill the Φ339.7mm casing into the top of Ziliujing Formation or Xujiahe Formation. In the third section, Φ311.2mm drill bit is used to drill into the top of Shiniulan Formation or Longmaxi Formation and insert Φ244.5mm casing; The quad used a Φ215.9mm bit to drill the Φ139.7mm casing to the full drilling depth.

3.2 Drilling speed increase technology

The Haynesville shale gas block adopts the underbalanced/managed pressure drilling technology [23-24] to improve the underground complex processing capacity. When overflow occurs, local pressure is generally released through controlled pressure circulation exhaust . Shell used an automatic pressure control system to reduce the horizontal equivalent circulation density from 1.92 ~ 1.97g/cm3 in the previous drilling period to 1.71g/cm3, and the ROP increased from 3 ~ 6m/h to 15 ~ 24m/h.

Shaximiao Formation and Ziliu well (Φ406.4mm borehole) in Sichuan and Chongqing area tested the speed increase technology of air and foam drilling, conventional screw drilling and vertical drilling. The use of vertical drilling tools not only obtained a higher mechanical drilling rate, but also achieved one trip. Conventional screw and vertical drilling tools were tested in Xujiahe Formation (Φ311.2mm hole). Compared with conventional screw, three Wells including Yongye 1-2HF used vertical drilling tools. Compared with conventional screw, vertical drilling tools had no obvious advantage in ROP and were mainly used for anti-skew and straighting [25], which is shown in table 1.

Table 1. Comparison of technical indexes of different drilling processes in Yongchuan Block

Number	Drilling mode	Ride number	well section	footage(m)
Y1-2HF	Vertical drilling	3	789	3.22
Y 1-3HF	Vertical drilling	4	758.3	3.49
Y 1-4HF	Vertical drilling	3	769.91	2.95
Y 5-1HF	Conventional screw	1	490.51	3.47

3.3 Borehole trajectory control

In the aspect of trajectory control of deep shale gas Wells, foreign technologies and practices are relatively mature, and high build slope rotary steering system (15°/30m) is generally adopted in the inclined section. A geosteering instrument with rotary steering integrated near the bit is used in the horizontal section. In the Haynesville area of the United States, high build slope rotary steerable system [23] is mostly used, and the inclined section and horizontal section are basically completed in one trip [4].

At present, 90% of the deviation section and 80% of the horizontal section of the medium-shallow shale gas Changning block in China are drilled with motors and rotary steerable tools, and the ROP has been greatly improved. The skew section with motor (average speed about 7m/h) is more than 30% higher than that without motor (average speed about 5.5m/h); The horizontal segment with motor (average speed of about 9.0m/h) is more than 12% higher than that without motor (average speed of about 8.0m/h).

3.4 Oil-based drilling fluid

For deep shale gas Wells, oil-based drilling fluids with a temperature resistance of 180°C and a density of 1.8-2.1g /cm3 have been developed abroad, with an oil-water ratio of 85/15 to 80/20 and a demulsibility voltage of no less than 600V. They have good temperature resistance, suspension stability and rheological properties, which are conducive to maintaining wellbore stability and cleanliness.

The domestic developed oil-based drilling fluid has a density of 2.2g/cm3 and a temperature resistance of more than 150°C, which still lags behind that of foreign countries in terms of comprehensive performance [8]. As the length of horizontal Wells continues to extend, the temperature increases, and inferior solid phase invasion becomes more serious, rheological properties of drilling fluids are difficult to control, and rock-carrying efficiency decreases (the dynamic plastic ratio is 0.1-0.15). The need to repeatedly replace diluted drilling fluid leads to increased maintenance and treatment costs, increased waste drilling fluid volume, and increased safety and environmental pressure.

4 Integrated supporting drilling speed increase technology

4.1 Well structure

The development of deep shale gas in Sichuan and Chongqing is based on four-way conventional well structure, and the upper casing depth is mainly optimized in the west Chongqing area. A Φ508mm casing depth optimized from 150 ~ 300m to 50m; The two-opening Φ339.7mm casing is optimized from the bottom to the bottom of Jiasan Member to the top of Xujiahe Formation, and the casing depth is reduced by about 750m. Three open Φ244.5mm casing to the top of Shiniulan Formation or Longmaxi Formation (missing Shiniulan Formation); Casing completion Φ139.7mm. Using the above well structure, the drilling cycle of well Zu-203 is shortened by 71 days compared with that of well Zu-201, and the average ROP is increased by 15%.

4.2 Special layer PDC bit optimization

First, for Xujiahe, Longtan, Maokou and other formations of deep shale gas in southern Sichuan, it is necessary to optimize and develop special layer personalized PDC bits to improve the penetration rate and mechanical drilling rate of a single bit. The second is to promote the application of mature drill series according to field experience and successful practices. In the deviated well section, the matrix PDC bit should be selected to increase the anti-wear ability. In horizontal well section, it is recommended to use steel PDC bit, which can not only improve the bottom hole flow field, but also improve the bottom hole cleaning efficiency, so as to increase the ROP.

4.3 Well trajectory optimization and control measures

The research shows that using the "straight-augment-steady-augmentation, twist-augment-flat" type borehole trajectory can better bring the comprehensive speed increase effect of rotary steerable drilling technology into play.

(1)Straight well section + increasing slope section + stable slope section

The deviation measurement should be performed once every 30m ~ 50m drilling in the straight well section, and the deviation measurement interval between the increasing inclination section and the stable inclination section should not be greater than 30m. The deviation measurement should be encrypted under necessary working conditions such as collision prevention and obstacle winding. The multi-point inclinometer must be used to measure the trajectory data of the corresponding well segment before drilling to reach the middle completion depth and the depth of the deviation point. After drilling to the depth of the deviation point, the bottom of the well is rinsed with a large flow rate, and the drilling fluid properties are adjusted according to the requirements of directional drilling.

(2) Increased skew twist azimuth section + increased skew section

Rotary steerable drilling technology can realize trajectory control when the drill string is rotating. After the rotary steerable system is put into the well, the lowering speed should be controlled reasonably. When encountering resistance, the drilling tool should be lifted up, rotated in different directions and then lowered. During the drilling of directional deviation section, MWD should be used to monitor the track, and the measurement interval should not exceed 30m. The directional parameters and drilling measures are adjusted reasonably according to the deviation situation to ensure the smooth trajectory of the well. According to the actual situation, the field technicians add LWD geological steering drilling in time to ensure that the target formation is accurately drilled. If the downhole situation is complex, the need to go through the well and check the hole, in principle, the previous drill structure, such as the actual situation must change the drill structure, the rigidity of the drill tool must be less than the rigidity of the drill tool.

(3) Horizontal section

The Longmaxi Formation tracks the reservoir according to the measured data of LWD geological guidance, strengthens the monitoring of borehole trajectory, predicts the borehole trajectory in time, and accurately controls the borehole trajectory. In the drilling of the highly inclined well section and horizontal section, to prevent sand settling stuck, it is necessary to adhere to the use of large displacement sand carrying. Once it is found that the friction torque increases and there is a cuttings bed, short trip and segmented circulation should be carried out in time to reduce the cuttings bed and ensure safe drilling.

4.4 PDC+ screw anti-skew play fast technology

Compared with the conventional screw speed increase, the ROP of Shaximiao Ziliujing Formation in southern Sichuan has been improved after using the vertical drilling system. The use of vertical drilling tools in Xujiahe formation can effectively solve the engineering problem of formation inclined, but the high cost of vertical drilling is not conducive to the low-cost economic development of shale gas. Therefore, PDC+ screw is widely used in the early stage of the upper straight well section of the west Chongqing block.

4.5 Underbalanced drilling speed increase technology

PDC+ screw-cutting technology has achieved preliminary results in the west Chongqing block, but the average machine speed is generally lower than 3m/h in the Lower Triassic to Permian strata. Drawing on the experience of Haynesville shale gas [23], under balanced pressure control drilling technology was used to accelerate the speed test of well Zu203, and the drilling rate was 42% higher than that of the adjacent well Zu202-H1. The speed increase test of air drilling was carried out in the Φ406.4mm hole of Zu203H1-2, and the mechanical drilling rate increased by 29% compared with the same period last year, which provides an important technical reference for the speed increase of the upper continental formation in the west Chongqing block.

4.6 Rotary steering + motor dual power system speed up technology

Referring to the successful experience of using rotary steering + motor to increase the speed in the inclined section and horizontal section of medium-shallow shale gas, the use of rotary steering + screw technology in the inclined section of Zu203 well is 64% higher than that of Zu201-H1 without motor, and the use of rotary steering + screw in the horizontal section of Zu203 well and Zu206 well is 80% and 70% higher, respectively, than that of Zu201-H1 without motor. In view of the high failure rate and cost of directional tools in deep shale gas Wells, the "gamma while drilling +MWD+ bending screw" guiding mode is preferred in Wells or well segments with simple geological conditions and gentle inclination. Rotary steerable tools are recommended for formations with complex dips.

4.7 Optimize and test drilling acceleration tools

Some Wells in the early stage of Yuxi block used Φ660.4mm/Φ609.6mm large-size drill bit to open the hole, Φ508mm pipe depth of 150 ~ 300m, during the drilling process of jumping seriously, bit damage, Zu202-H1 well using hydraulic pressure + roller bit drilling, mechanical drilling rate is 34% higher than Zu201-H1 well.

In view of the unsatisfactory application effect of composite bit in hard formation of Xujiahe Formation, PDC+ torsion-impactor drilling test was carried out in Ziliu-Xujiahe section of Zus202-H1 hole with Φ406.4mm in Lu Block, and the ROP reached 5.51m/h. Ziliu Well - Xujiahe section of Ziliu Well Ziliu Well was drilled with "PDC+ screw", and the average ROP was 3.88m/h, which was 30% lower than that of the same period last year, indicating that the speed increase method of "PDC+ torque impact device" had a certain speed increase effect.Compared with "PDC+ torque impactor + screw", the drilling rate of Φ311.2mm hole in Foot 202-H1 has increased by 43%."PDC+ torsional punching + screw" speed increase method provides a new way for Xujiahe and other speed increase bottleneck formation.

5 Conclusions

(1) Complex geological and structural conditions, poor drillability and multiple layers in deep shale gas reservoirs in Sichuan and Chongqing area are the main geological problems faced by deep shale gas drilling.

(2) High temperature, high pressure, difficult hole trajectory control, and high drilling fluid density are still the main technical problems restricting the efficient drilling of deep shale gas, which need to be solved.

(3) It is suggested to carry out a three-pressure formation study to clarify the formation pressure and provide support for the subsequent well structure optimization; Further optimize the drilling speed increase technology by well section, increase the application of "one trip" drilling and other technologies, and form a drilling speed increase technology chart suitable for different regions.

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References

1. Geology and Mineral Industry Standard of the People's Republic of China. DZ/T 0254-2014 Technical Specification for calculation and evaluation of shale gas resources [S]. Beijing: Standards Press of China.
2. Juntao Yan, Yongqiang Fu, Chengfeng Guo, Jeremy A Greenwood, Lingjun Wang, Hansou Xianyu, Nour Hariri. Implementation of HPHT RSS for Performance Improvement in Deep Shale Gas Drilling[C]. Paper presented at the Abu Dhabi International Petroleum Exhibition & Conference, November 15–18, 2021, Paper Number: SPE-207662-MS, https://doi.org/10.2118/207662-MS.
3. LiWei Jiang, Chunduan Zhao, Jun Peng, Lipeng Wang, Chenglin Liu, Qingshan Li, Yongjie Huang, Bowen Cao, Hong Tian. Application of Geo-Engineering Integrated Technologies for Ultradeep Longmaxi Shale Gas Life Cycle Management, Sichuan Basin[C]. Paper presented at the SPE Argentina Exploration and Production of Unconventional Resources Symposium, March 20–22, 2023, Paper Number: SPE-212407-MS. https://doi.org/10.2118/212407-MS.
4. Zang Yanbin. Key technologies of deep shale gas drilling in southeast Sichuan [J]. Petroleum Drilling Techniques,2018,46(03):7-12.
5. Ran Wei, Bian Xiaobing, Zhang Xudong, Xiao Bo, Cao Nai, Zuo Luo, Du Jinlong, Su Yuan. Three-Dimensional High Efficiency Fracturing Technology for Preventing Casing Deformation in W Deep Shale Gas[C]. Paper presented at the 57th U.S. Rock Mechanics/Geomechanics Symposium, June 25–28, 2023, Paper Number: ARMA-2023-0091, https://doi.org/10.56952/ARMA-2023-0091.
6. L. Yuan, S. L. Hu, L. Y. Mu, D. L. Wang, X. T. Yang, Y. Song, J. C. Wang. Study on Parameters Optimisation of Fracturing Stages & Perforation Clusters in Luzhou Deep Shale Gas Horizontal Wells Based on Integrated Drilling and Logging Data[C]. Paper presented at the Asia Pacific Unconventional Resources Symposium, November 14–15, 2023, Paper Number: SPE-217350-MS, https://doi.org/10.2118/217350-MS.
7. Li Fu; Henglin Yang; Xinqun Ye; Yuan Wang; Gang Chen; Guangjie Yuan; Heng Zhang; Zixin Wang. Research and Application of Underbalanced Drilling Technology for Deep Shale Gas Horizontal Wells in Southern Sichuan[C]. Paper presented at the 57th U.S. Rock Mechanics/Geomechanics Symposium, Atlanta, Georgia, USA, June 2023. Paper Number: ARMA-2023-0383. https://doi.org/10.56952/ARMA-2023-0383.
8. Guodong David Zhan, Bodong Li, Abdulwahab Aljohar, Bing Wang, Huijuan Guo. Research on Long Open Hole Clad Technology Based on High Performance Solid Expandable Tubular in Shale Gas Reservoir[C]. Paper presented at the Middle East Oil, Gas and Geosciences Show, February 19–21, 2023, Paper Number: SPE-213949-MS, https: //doi.org/10.2118/213949-MS.

9. Yue Yanhua, Wu Xianzhu, Zhang Qing, Zhao Han, Jiang Wei. Technology integration and large-scale application of shale gas exploration and development engineering in the Sichuan and Chongqing areas [J]. Natural Gas Industry, 2018, 38(2): 74-82.
10. Zhang Shuquan, Xie Xiangfeng, LUO Liangyi, Jing Yang, Tang Meng, Yang Ruifan, ZHONG Guangrong, WANG Jun, Chen Zhengyun. Optimal and rapid drilling technology for deep shale gas horizontal Wells in Sichuan Basin: A case study of Lu 203 well [J]. Natural Gas Industry, 2019,39(7): 88-93.
11. Feng Gui, Shanshan Wang, Sanjeev Bordoloi, See Hong Ong Understanding the Geomechanical Challenges and Risk Mitigation in Sichuan Shale Gas Drilling, China[C]. Paper presented at the International Petroleum Technology Conference, March 26–28, 2019, Paper Number: IPTC-19387-MS, https://doi.org/10.2523/IPTC-19387-MS.
12. Bo Wen, Yuan Wang, Gang Chen, Peiyu Zhang, Kaijie Guo, Li Fu, Ming Feng, Henglin Yang, Chengxu Zhong. Studies on Lost Circulation Risk of Deep Shale Formation Based on Fracture Prediction and Rock Mechanical Properties[C]. Paper presented at the 56th U.S. Rock Mechanics/Geomechanics Symposium, June 26–29, 2022, Paper Number: ARMA-2022-0156, https://doi.org/10.56952/ARMA-2022-0156.
13. Jingfeng Yu, Diao Zhou, Bo Zhang, Haiping Meng, Tong Li, Li Wang, Yong Wang, Fei Wang, Chao Wang, Chengqian Chen, Zhong Hu, Wencheng Lan, Guoyu Liu, Shuai Wang. Horizontal Well Drilling and Geosteering Optimization with Integrated Innovation Technologies: Case Studies from the World Largest Conglomerate Reservoir in West China[C]. Paper presented at the International Petroleum Technology Conference, March 23–April 1, 2021, Paper Number: IPTC-21482-MS, https://doi.org/10.2523/IPTC-21482-MS.
14. Danis Nazipov, Pavel Shpakov.Remote Bed Boundary Detection Tool Data Interpretation Without Special Geosteering Support to Drill Horizontal Wells[C]. Paper presented at the SPE Russian Petroleum Technology Conference, October 12–15, 2021, Paper Number: SPE-206631-MS, https://doi.org/10.2118/206631-MS.
15. Fu Jin, Jia Wanting, Cui Longlian, Yang Guobin, Chen Chen. Research on Drilling Technologies of Ultra-Thick Salt Domes in Middle Asia and Pre-Salt Strata in Middle East: Lessons Learnt from a Pilot Well in Kenkyak Oilfield and an HPHT Well in Halfaya Oilfield[C]. Paper presented at the Offshore Technology Conference Brasil, October 24–26, 2023, Paper Number: OTC-32713-MS, https://doi.org/10.4043/32713-MS.
16. Haitao Wang, Shikun Zhang, Xiaobing Bian, Shuangming Li, Yulin Tu, Xiong Zhang, Zhifa Wang.Development of Fracturing Technology for Deep Shale Gas in South Sichuan, China[C]. Paper presented at the SPE Middle East Oil & Gas Show and Conference, November 28–December 1, 2021, Paper Number: SPE-204804-MS, https:// doi. org/ 10. 2118/204804-MS.
17. Nur'ain Zalia Azmi, Rasheed Rahman, Eliyana Shaibudin, Jason Lew, Danny Chew, Khairul Anuar Alang, Muhammad Afiq Za'ba, SyaifulAzman Mustapa.Boosting Up for Brown Field Oil with Well Placement and Drilling Engineering Synergy[C].Paper presented at the International Petroleum Technology Conference, March 23–April 1, 2021,Paper Number: IPTC-21823-MS,https://doi.org/10.2523/IPTC-21823-MS.
18. Tanaka LAN, Shi Lin, Qiao Lei. Wellbore integrity problems and countermeasures in shale gas horizontal Wells [J]. Natural Gas Industry, 2015, 35(9): 70-76.
19. LI Liuwei, Wang Gaocheng, Lian Zhanghua, Zhang Lei, Mei Jue, and Yu Lou. Deformation mechanism and engineering solution of production casing of shale gas horizontal Wells: A case study of Jinba Block in Zhaotong National Shale Gas Demonstration Zone [J]. Natural Gas Industry, 2017, 37(11): 91-99.
20. LIU Kui, Gao Deli, Wang Banbin, Liu Yongsheng. Effect of local load on casing deformation in shale gas Wells [J]. Natural Gas Industry, 2016, 36(11): 76-82.

21. Song Zheng. Wellbore trajectory control technology of shale gas horizontal well in the east Fuling River and Pingqiao block [J]. Petroleum Drilling Techniques, 2017, 45(6): 14-18.
22. Niu Xinming. Technical difficulties and countermeasures of drilling in Fuling shale gas field [J]. Petroleum Drilling Techniques, 2014, 42(4):1-6.
23. Ursula Hammes, H. Scott Hamlin, and Thomas E. Ewing, Geologic analysis of the Upper Jurassic Haynesville Shale in east Texas and west Louisiana[J]. GEOLOGIC NOTE, AAPG Bulletin, v. 95, no. 10 (October 2011), pp. 1643–1666.
24. Qiao Li, Fan Shenglin, Qi Yu. Optimized drilling technology in Haynesville shale gas block, USA [J]. Drilling & Production Technology,2019,42(04):112-113+116.
25. JU Sheng, SHEN Jianwen, Li Lin, Jiang Yun. Rapid horizontal well drilling technology in Yongchuan shale gas block.2017 National Natural Gas Academic Conference.

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