УДК 622.69; https://doi.org/10.37878/2708-0080/2024-2.05
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IMPROVING THE TECHNOLOGY OF DRILLING AND WELL WORKOVER IN CONDITIONS OF UNSTABLE ROCKS

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The exploration and extraction of hydrocarbons in regions characterized by unstable rock formations pose significant challenges to the oil and gas industry as increasing operational costs, safety hazards and environmental risks. This study focuses on advancing the technology of drilling and repairing wells in conditions where geological instability complicates traditional drilling processes, for example hole closure, collapse, fracturing etc. Moreover, it discusses all aspects of wellbore instability in drilling, from causes and symptoms to prevention and its impact.

The importance of ongoing research and development initiatives to advance drilling fluid technology suitable for unstable geological situations is also emphasized in the paper. In order to reduce the risk of borehole instability and maximize drilling efficiency, it investigates the formulation of high-performance drilling fluids with improved lubricity, filtration control, and shale inhibitory qualities. A frequent issue is lost circulation. Drilling fluid leaks into the nearby rock formations from the borehole cause this to happen. Numerous issues, like as decreased drilling efficiency, formation damage, and potentially environmental contamination, can result from lost circulation.

The development of new technologies such as advancing drilling fluids, improving real-time monitoring are essential for improving the efficiency and safety of drilling and workover of wells in unstable rock formations.

KEY WORDS: *Drilling, unstable formation, borehole instability conditions, drilling mud*

СОВЕРШЕНСТВОВАНИЕ ТЕХНОЛОГИИ БУРЕНИЯ И РЕМОНТА СКВАЖИН В УСЛОВИЯХ НЕУСТОЙЧИВЫХ ГОРНЫХ ПОРОД

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Разведка и добыча углеводородов в регионах, характеризующихся нестабильными горными породами, создают серьезные проблемы для нефтегазовой отрасли, поскольку увеличиваются эксплуатационные расходы, угрозы безопасности и экологические риски.

В данном исследовании основное внимание уделяется совершенствованию технологии бурения и ремонта скважин в условиях, когда геологическая нестабильность осложняет традиционные процессы бурения, например, смыкание ствола скважины, обрушение, трещиноватость и т.д. Кроме того, в нем рассматриваются все аспекты нестабильности ствола скважины при бурении, от причин и симптомы, профилактика и ее влияние.

В статье также подчеркивается важность текущих инициатив в области исследований и разработок для продвижения технологии буровых растворов, подходящих для нестабильных геологических ситуаций. Чтобы снизить риск нестабильности скважины и максимизировать эффективность бурения, компания исследует составы высокоэффективных буровых растворов с улучшенными смазывающими свойствами, контролем фильтрации и ингибирующими глинистые свойства. Частая проблема – потеря циркуляции. Причиной этого является утечка бурового раствора в близлежащие горные породы из скважины. Потеря циркуляции может привести к многочисленным проблемам, таким как снижение эффективности бурения, повреждение пласта и потенциальное загрязнение окружающей среды.

Разработка новых технологий, таких как продвижение буровых растворов, улучшение мониторинга в реальном времени, необходимы для повышения эффективности и безопасности бурения и ремонта скважин в нестабильных горных породах.

КЛЮЧЕВЫЕ СЛОВА: *бурение, нестабильный пласт, условия неустойчивости ствола скважины, буровой раствор.*

ТҰРАҚСЫЗ ТАУ ЖЫНЫСТАРЫ ЖАҒДАЙЫНДАҒЫ ҰҢҒЫМДАЛАРДЫ БҰРҒЫЛАУ ЖӘНЕ ЖӨНДЕУ ТЕХНОЛОГИЯСЫН ЖЕТІЛДІРУ

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Тұрақсыз тау жыныстарының түзілімдерімен сипатталатын аймақтарда көмірсутектерді барлау және өндіру операциялық шығындардың өсуіне, қауіпсіздік қауіптеріне және экологиялық тәуекелдерге байланысты мұнай және газ өнеркәсібіне елеулі қиындықтар туғызады. Бұл зерттеу геологиялық тұрақсыздық дәстүрлі бұрғылау процестерін қиындататын жағдайларда бұрғылау және өңдеу технологиясын жақсартуға бағытталған, мысалы, ұңғыманың жабылуы, опырылуы, жарылуы және т.б.

Бұған қоса, ол бұрғылау кезінде ұңғыма оқпанының тұрақсыздығының барлық аспектілерін, себептері мен белгілерін, алдын алу және оның әсерін қамтиды.

Сондай-ақ мақалада тұрақсыз геологиялық жағдайларға қолайлы бұрғылау сұйықтығы технологиясын ілгерілету бойынша жүргізіліп жатқан ғылыми-зерттеу және тәжірибелік-конструкторлық бастамалардың маңыздылығы атап өтілген. Ұңғыманың тұрақсыздығы қаупін азайту және бұрғылау тиімділігін арттыру үшін ол жақсартылған майлау, сүзу бақылауы және тақтатастарды тежеу қасиеттері бар жоғары өнімді бұрғылау ерітінділерінің формуласын зерттейді. Жиі кездесетін мәселе - қан айналымының жоғалуы. Бұрғылау сұйықтығының ұңғымадан жақын жердегі тау жыныстарына ағып кетуі мұның орын алуына әкеледі. Бұрғылау тиімділігінің төмендеуі, қабаттың зақымдалуы және қоршаған ортаның ықтимал ластануы сияқты көптеген мәселелер айналымның жоғалуынан туындауы мүмкін.

Бұрғылау сұйықтығын ынталандыру және нақты уақыттағы мониторингті жақсарту сияқты жаңа технологияларды дамыту тұрақсыз тау жыныстары түзілімдерінде бұрғылау мен өңдеудің тиімділігі мен қауіпсіздігін арттыру үшін қажет.

ТҮЙІН СӨЗДЕР: *бұрғылау, тұрақсыз қабат, ұңғыманың тұрақсыздығы жағдайлары, бұрғылау ерітіндісі.*

Introduction. Drilling and well workover in unstable rock formations is a complex and often precarious endeavor. The unpredictable nature of these environments can lead to a multitude of challenges, including borehole collapse, lost circulation, and stuck tools. These challenges can not only hinder the success of drilling and workover operations but can also pose significant safety risks to personnel and the environment.

In recent years, there has been a growing emphasis on developing and implementing new technologies to improve the efficiency and safety of drilling and wells workover in unstable rocks as lost circulation, stuck tools, collapse, fracturing [1,2]. The goal of this review article is to give a thorough summary of the state of the art in this topic right now. We will discuss the various challenges associated with drilling and repairing wells in unstable formations, as well as the latest technologies and techniques that are being used to address these challenges.

Unstable rock formations can be found in a variety of geological settings, including shale formations, salt caverns, and permafrost regions. These formations are often characterized by weak and unconsolidated rocks, as well as the presence of faults, fractures, and other geological features that can further compromise stability.

The challenges of drilling and wells workover in unstable formations are manifold. One of the most common problems is borehole collapse (geological and technical). When the rock surrounding the borehole is unable to support its own weight, it can cave in, blocking the wellbore and making it impossible to continue drilling or workover operations.

Another common challenge is lost circulation. This occurs when drilling fluids leak out of the borehole into the surrounding rock formations. Lost circulation can lead to several problems, including reduced drilling efficiency, formation damage, and even environmental contamination.

Stuck tools are another major challenge associated with drilling in unstable formations. When tools become stuck in the borehole, it can be extremely difficult and expensive to retrieve them. In some cases, it may even be necessary to abandon the well altogether.

Methods and materials. Predicting unstable formations involves a combination of geological analysis, wellbore data interpretation, and predictive modeling techniques. Geologists examine rock samples and core data to assess lithological properties, structural features, and depositional environments. Additionally, geophysical surveys, such as seismic imaging and logging, provide insights into subsurface geology and potential hazards. Advanced computational models, including finite element analysis and geomechanical simulations, enable engineers to predict formation stability and anticipate potential challenges during drilling operations. Moreover, we have to detect problems during drilling operations, it requires continuous monitoring and analysis of drilling parameters, wellbore conditions, and equipment performance. Anomalies such as sudden changes in drilling rate, excessive torque or drag, unexpected pressure fluctuations, and abnormal gas or fluid influxes may indicate potential drilling problems.

Causes of formation instability:

Numerous factors, such as hole pack off, excessive reaming, overpull, torque, and drag, can indicate wellbore instability. In certain cases, this can result in trapped tubing that may need side tracking and plugging. Because of this, drilling a hole takes longer, which raises the price of reservoir development considerably. Hole loss is especially significant in offshore areas since fewer holes can be drilled from a platform. Typically, a series of events that can be loosely categorized as either controllable or uncontrollable (natural) in origin generate wellbore instability [3].

Table 1 - **Reasons for instability in wellbore**

Uncontrollable (Natural) factors	Controllable Factors
Naturally Fractured or Faulted Formations	Bottom Hole Pressure (Mud Density)
Tectonically Stressed Formations	Well inclination and Azimuth
High In-situ stresses	Transient Pore Pressures
Mobile Formations	Physico/chemical Rock – Fluid properties
Unconsolidated formations	Drill String Vibrations
Naturally Over-Pressured Shale Collapse`	Erosion
Induced Over-Pressured Shale Collapse	Temperature

Principles of formation instability. At a given depth, the in-situ rock stresses (effective overburden stress) and the effective horizontal confining stresses are in balance prior to drilling. Nevertheless, during the drilling operation, the balance between the in-situ stresses and the rock strength is disturbed. Furthermore, the introduction of foreign fluids triggers a process of interaction between the fluids in the borehole and the formation. A possible hole-instability issue arises as a result [4]. Several borehole-stability simulation models have been developed because of extensive research; however, they are all flawed by the unpredictability of the input data required to do the analysis.

Formation instability prevention. Wellbore stability management requires the application of wellbore stability analysis results to create and implement the optimal drilling and completion strategy. The best practices include selecting a drilling fluid that is compatible with the formation and has adequate hydrostatic and lubricating properties, as well as minimizing fluid invasion, filtrate loss, or particle accumulation. Furthermore, every facet of drilling activities, including hole cleaning, bit selection, drilling speed, bit weight, and circulation rate, needs to be modified to align with the wellbore stability objectives and geomechanical conditions. The use of appropriate cementing, perforating, gravel packing, fracturing, or acidizing procedures are some examples of completion techniques that should be used to maintain or improve the wellbore stability and formation integrity. Moreover, the possible influence of injection or production on wellbore stability needs to be considered.

Because the rock can never be brought back to its original state, it is impractical to completely prevent borehole instability [5]. Nonetheless, by following appropriate field procedures, the drilling engineer can lessen the issues caused by borehole instabilities.

These practices include:

•Appropriate selection and upkeep of mud-weights

•Controlling the equivalent circulation density (ECD) with appropriate hydraulics

• Proper hole-trajectory selection

Use of borehole fluid compatible with the formation being drilled Additional field practices that should be followed are:

•Cutting down on time spent in an open pit

•Making use of offset-well data (learning curve)

•Tracking variations in trends (drag, fill-in when tripping, torque, and circulating pressure)

•Working together and sharing data.

Technological Innovations. Despite the challenges, there have been significant advancements in the technology of drilling and repairing wells in unstable formations. Some of the most promising new technologies include:

1. **Advanced drilling fluids.** New drilling fluids are being developed that are specifically designed to improve borehole stability and prevent lost circulation. These fluids can be tailored to the specific properties of the rock formation and can help to mitigate the risks associated with drilling in unstable environments.

2. **Casing and liner technologies.** New casing and liner technologies are being developed to provide additional support for the borehole and prevent collapse. These technologies include expandable liners, slotted liners, and pre-packed liners.

3. **Real-time monitoring and data acquisition.** Real-time monitoring systems are being used to track drilling progress and identify potential problems early on. This data can be used to adjust the drilling program and to avoid costly mistakes.

4. **Robotics and automation.** Robotic and automated technologies are being used to perform tasks that are too dangerous or difficult for humans to do. This can help to improve safety and efficiency in drilling and repair operations in unstable formations [6].

The development of new technologies is essential for improving the efficiency and safety of drilling and wells workover in unstable rock formations.

Discussion. While new technologies offer opportunities to address complex challenges in drilling, it is important to assess their downsides and risks in order to make informed decisions about their use. The development and implementation of new drilling technologies often comes with significant expenses for research, development, testing, and training. This can lead to substantial initial investments and increased operational costs for companies. New technologies often require specialized knowledge and skills for their use. This may mean that personnel need additional training or the hiring of specialists, which can result in additional costs and time delays. Some new technologies may be limited in their effectiveness in certain geological conditions or types of wells. For example, technologies developed for use in sandstone formations may be less effective in carbonate or shale formations.

Conclusion. In conclusion, the oil and gas sector has made great strides thanks to technological advancements in wellbore rehabilitation and drilling within unstable geological formations. By enabling operators to overcome obstacles that were previously insurmountable, these advances have improved productivity, security, and environmental sustainability. It is imperative to acknowledge that there is always more work to be done in this subject in order to achieve perfection. As technology advances and new problems arise, teamwork, creativity, and a dedication to ongoing development will always be crucial. By adhering to these guidelines, the sector may more skillfully negotiate the intricacies of unstable formations and guarantee the ethical extraction of energy resources for future generations.

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