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Geomechanics Analysis of Well Drilling Instability: A Review

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ABSTRACT

Wellbore instability is a significant problem faced during drilling operations and causes loss of circulation, caving, stuck pipe, and well kick or blowout. These problems take extra time to treat and increase the Nonproductive Time (NPT). This paper aims to review the factors that influence the stability of wellbores and know the methods that have been reached to reduce them. Based on a current survey, the factors that affect the stability of the wellbore are far-field stress, rock mechanical properties, natural fractures, pore pressure, wellbore trajectory, drilling fluid chemicals, mobile formations, naturally over-pressured shale collapse, mud weight, temperature, and time. Also, the most suitable ways to reduce wellbore instability are selecting the appropriate drilling mud and maintenance, reducing the Equivalent Circulating Density (ECD) by using suitable hydraulics, selecting hole-trajectory, and compatibility of drilling fluid with the formation being drilled. Moreover, factors such as (minimizing time spent open hole, using offset-well data, and monitoring trend changes (torque, circulating pressure, drag) must be considered. As a result of this paper, wellbore instability problems can be controlled by careful study of reservoirs to find the solutions to some issues or reduce them.

Keywords: Geomechanical Model, Wellbore Instability, Wellbore Failure

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تحليل جيوميكانيكا الأرض لعدم استقرار حفر الآبار

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الخلاصة

يعد عدم استقرار جوف البئر مشكلة رئيسية أثناء عملية الحفر تسبب فقدان دورة سائل الحفر، والتكهف، واستعصاء الانابيب ، ورفسة الآبار أو انفجارها. تستغرق هذه المشاكل وقتًا إضافيًا للعلاج وزيادة الوقت غير المنتج (NPT). الغرض من هذه الورقة هو مراجعة العوامل التي أثرت على استقرار جوف البئر ومعرفة الأساليب التي تم التوصل إليها للحد من ذلك. بناءً على الدراسة الحالية فإن العوامل التي أثرت على استقرار الآبار هي الإجهاد في المجال البعيد، والخصائص الميكانيكية الصخرية، والشقوق الطبيعية، وضغط المسام، ومسار الآبار، والمواد الكيميائية المكونة لسائل الحفر، والتكوينات المتحركة، وانهيار الصخر الذي يعاني من ضغوط زائدة بشكل طبيعي، ووزن الطين، ودرجة الحرارة، والوقت. أيضًا أكثر الطرق ملاءمة لتقليل عدم استقرار الآبار هي اختيار طين الحفر المناسب وصيانته، وتقليل الكثافة الدورانية المكافئة (ECD) باستخدام المواد الهيدروليكية المناسبة، واختيار مسار البئر، وتوافق سائل الحفر مع التكوين الذي يتم حفره. علاوة على ذلك، يجب النظر في عوامل مثل (تقليل الوقت الذي يقضيه البئر مستخدما، واستعمال بيانات البئر، ورصد التغيرات في الاتجاه (عزم الدوران، والضغط المتداول، والسحب). كنتائج لهذه الورقة، يتم التحكم في مشاكل عدم استقرار الآبار من خلال الدراسة الدقيقة للمكامن لإيجاد حلول لبعض المشاكل أو الحد منها.

الكلمات الرئيسية: نموذج جيوميكانيكي ، عدم استقرار حفرة البئر، انهيار جوف البئر.

1. INTRODUCTION

Despite modern advancements and using new technologies in the petroleum and gas industry, wellbore instability is still one of the most challenging drilling and completion operations for wells, leading to increased budgets. Therefore, wellbore stability is an important stage for planning wells and has been studied extensively **(Bell, 2003).** Field stresses, pore pressure, and mechanical properties of rock influence wellbore instability. The formation before the drilling operation is in balance. As soon as drilling begins, the cutting is removed, which causes a redistribution of stresses around the wellbore and presents a stress concentration, leading to the wellbore's failure. To avoid that, an appropriate mud pressure (internal wellbore pressure) must be chosen **(Mohammed, 2017)**. When mud weight is less than the compressive strength of the rocks, many problems, such as wellbore collapse (enlargement), are caused. Also, fracturing is acquired when mud weight exceeds the formation fracture pressure, leading to lost circulation. These problems increase drilling costs and cause increasing in Non-Productive Time (NPT).

Wellbore failure classifies into two types, mechanical failure, which may result from (low rock strength, high stresses, and unstable drilling operation) and cause many problems such as collapse and fracture gradients, and chemical failure may be results from (the interface between the drilling fluid and rock).In many cases, the failure occurs by combining the two types because of many problems resulting from the well bore instability. The scientist promoted finding a way to control the wellbore instability, so their orientation was toward building a geomechanical model **(Mohammed, 2017**).

Geomechanics is a numerical method in rock engineering that is implemented for covering all parts of rock mechanics, so the geomechanical model plays an important role in all aspects of well life, particularly in drilling planning for new planned wells by understanding wellbore failures and predicts the stability of new wells paths. Wellbore instability is controlled by pore pressure, far-field stress, and property strength of rock. Therefore, the building geomechanical model combines many parameters, including far-field stresses, pore pressure, and mechanical rock properties. The output of the geomechanical model includes a mud weight window by using failure criteria and the wellbore trajectory that can be optimized to mitigate the shear and tensile failure of the wellbore **(Hussein et al., 2021).**

Several common failure criteria, such as Mohr-Coulomb, Mogi-Coulomb, modified Lade, Hoek-Brown, and Weakness Plane Models, were utilized for anticipating the prospective rock failure around the wellbore. Mohr-Coulomb failure criterion is classified as 2D criteria, a widely used criterion for finding out wellbore breakout and the basic assumption to build a linear increase between the minimum and maximum stresses and ignore intermediate stresses, which may give the rock more strength. Therefore researchers found the Mohr-coulomb criterion as a deficient and conservative assessment of appropriate mud pressure **(Vernik and Zoback, 1992)**. Mogi -coulomb and modified Lade are classified as 3D criteria that account for the influence of intermediate stress, estimated when True Triaxial is performed. Hoek-Brown describes the failure in transversely isotropic rocks and analyzes the failure in rocks exhibiting anisotropy due to discontinuities. The weakness plane model is one feature that expresses rocks' distinctive nature in the presence of inherited anisotropy. This anisotropy results from schistocyte and foliation in the cases of metamorphic rocks, lamination, and bedding planes in sedimentary rocks.

(Plumb, 1994) studied the impact of the composition and texture of clastic rocks on the failure of the rocks, which have porosities varied from 0% to 40% and volume fraction of clay minerals in the range of 0% to 72%. The study demonstrated that Young's modulus provided the best relative indicator of unconfined compressive strength. **(Thiercelin and Plumb, 1994)** presented an evaluation of two fundamentally different stress models: elastic and failure models. Their study demonstrated that the proposed failure model appears in the shales more accurately than the elastic models. **(Ewy, 1999)** extended the Lade criterion to be qualified to consider the impacts of intermediate main stress on the strength properties of rock. At that point, the study decided that the critical mud weight which the modified Lade criterion predicted was a lower amount than of conventional mud weight that had been predicted by the Mohr-Coulomb criterion.

(Barton and Zoback, 2002) presented new techniques of borehole image log analysis, which discriminate natural fractures from induced failures in boreholes using image logs. They discussed a case study of the relationships between natural fracture systems in the original place stress state and permeability in the low-permeability fractured reservoir. **(Bell, 2003)** summarized the techniques utilized to determine the orientations of the far-field stress and magnitudes. Density logs are the method that determines the magnitude of vertical stress, samples of rock, as well as determine minimum horizontal stress magnitude via massive hydraulic fractures, mini-frac test, micro-frac, and the tests of Leak off and to magnitude of maximum horizontal stress determination by failure simulations, inversion technique, and equations, also image log and multi-arms diameters are the methods applied to detect the orientation of mini-horizontal stress. **(Al-Ajmi and Zimmerman, 2006)** specified that the most stable failure criterion for brittle rock is the Mohr-coulomb. This failure considered the maximum and minimum stresses but ignored the intermediate stress. Also, they developed a model of the Mogi-coulomb to calculate the critical mud drilling window easily. **(Rahimi, 2014)** looked at the impact of utilizing various rock failure criteria for analyzing the wellbore's stability. The author evaluated and examined the 13 most typical rock failure factors. Three lithologies' rock failure criteria have been assessed. Statistical analysis was conducted to ascertain the differences and similarities among failure criteria. Three separate offshore wells were evaluated as field cases for failure criteria. According to the outcomes of field instances. Modified Lade, Mogi-Coulomb, and Modified Wiebols-Cook criteria mostly predicted the lowest mud weight near the field mud weight that was effectively employed to drill the borehole.

(Haider et al., 2017; Mohammed, 2017) discovered that all of the problems related to the wellbore instability primarily resulted from the shear failure around the wellbore because of low rock strength and high stresses, as well as inappropriate drilling practice in terms of heterogeneity of Nahr Umr Formation. They suggested a geo-mechanical analysis regarding issues of wellbore instability in the Nahr Umr Formation in southern Iraq using various laboratory and field data. **(Alkamil et al., 2017)** presented a one-dimension geomechanical earth model for Mishrif formation in the E-oilfield in south Iraq. Their results concluded that the better well design should be sideways with minimum horizontal stress direction with more than 400 dispositions. Also, the mud weight should be adequate to prevent differential sticking and collapse failure.

(Shaban and Hadi, 2020) extracted an analysis of geo-mechanical to avoid considerable drilling dangers in Zubair Oilfield with the help of (1DMEM) model that was regulated by applying a hydraulic fracturing test (Mini-frac) test of repeated formation and (triaxial test). Three failure criteria, including Mogi-Coulomb, Mohr-Coulomb, and Modified lade, were coupled with their model. They found that the Mogi-Coulomb criterion and a predicated azimuth of 140^{o} that are parallel to minimal horizontal stress for the horizontal. The mud weight that is used to drill wells at 12 to 12.6 ppg, as well as a predicated azimuth of less than 30 degrees for vertical and slightly deviated wells, and the mud weight that is utilized to drill wells at 11.6 ppg, provided the best forecasting stability analyses. (**Darvishpour et al., 2019)** attempted a safe mud weight window (SMWW) in certain sandstone layers using the FLAC3D program and a finite volume model that has been created utilizing geomechanical drilled strata characteristics and the onset of the plastic condition. They looked into the impact of pore pressure, significant stresses near the wellbore, and rock strength factors on the SMWW. Their sensitivity analyses showed that the decrease in the internal friction angle and the cohesion level causes the SMWW to narrow noticeably.

(Abbas et al., 2020; Flori et al., 2020) applied quantitative risk assessment for determining optimum mud weight window design. They used adaptation probabilistic techniques for describing the performing a wellbore stability analysis to capture uncertainty in input variables. A Monte-Carlo simulator was used to determine the safe mud weight window as a probability distribution and a once-at-time method (OAT) to conduct a sensitivity analysis and identify the most important input parameters. The outcomes of this study led that for a better drilling program, the well design tool can be used before drilling to predict the appropriate mud weight window.

(Dawood, 2020) submitted an investigation of wellbore stability in horizontal wells drilled in an interbedded sandstone reservoir regarding the Zubair field. The real data of eleven wells and Triaxial and Brazilian tests of four wells had been used to determine the mud window for a horizontal well from the geo-mechanical model built by Schlumberger's Techlog software and for the reason that the unreliability of some results of log-derived parameters they used Monte Carlo method to establish probabilistic analysis and make them more realistic study. **(Dakhiel and Hadi, 2021)** suggested building an adequate drilling plan to avoid instability problems for further well drilling. To create the 3DMEM, they first establish the 1DMEM using field data (logs, drilling, geological reports, and offset well tests). According to the findings, drilling deviated and horizontal wells should be done at an azimuth 140° to the north to achieve the lowest possible horizontal stress. With no anticipated problems with wellbore instability, the suggested mud weight ranges along the 12.25" and 8.5" sections of highly deviated and horizontal wells have been in the range of (1.46 gm/cm^3 to 1.58 gm/cm^3).

(Abdulaziz et al., 2021) provided calibrated 3-D mechanical earth model (3 DMEM) for X-field in southern Iraq. They employed pressure measurements, mud logs, drilling reports, well reports, mechanical core tests, and well logs. To create a 3DMEM mechanical earth model, Mohr-Coulomb and Mogi-Coulomb failure criteria for one-dimensional mechanical earth models (1DMEM) were interpolated. The findings demonstrated that 3DMEM specified relative heterogeneity in the characteristics of the rocks and the field stresses between the northern and southern parts of the field under study. Additionally, shale intervals indicated greater susceptibility to failure than other intervals, and the optimal orientation for the directional wells is 140° clockwise from North. More stable than high-angle directional Wells are vertical and slightly inclined Wells (less than 40°). **(Allawi and Al-Jawad, 2021)** work was used to analyze wellbore stability and build geo-mechanical modeling to establish wellbore instability management regarding the Zubair shale formations in southern Iraq. The results proved that modified Lade and Mogi-Coulomb failure criteria best suited Zubair formation.

Moreover, conclusions indicated that the formation's problems of the wellbore unreliability were primarily a result of the incorrect weight of the mud (which was 10.6ppg). In the Zubair shale formation, the ideal mud weight window must be used between 11.5 and 14 ppg. Additionally, the azimuth ranges between 115° and 120° northwest-southeast (NE-SW) could be less risky, and the inclination angle must be less than 25°. The optimal stability regarding drilling the Zubair shale formation will be provided by a well azimuth parallel to the lowest horizontal stress (Sh_{min}) in the NE-SW direction.

This work aims to review the most influential factors on wellbore stability and understand the methods that have been reached to reduce it. The fundamental parameters discussed included stress, rock mechanical properties, pore pressure, wellbore trajectory, drilling fluid, pore fluid chemical, mud weight, temperature, and time. Also, this research discussed the basic parameters that must be calculated to build the geomechanical model.

2. ANALYSIS OF WELLBORE INSTABILITY

Wellbore instability results in several causes, such as tensile failure, which leads to lost circulation, or when shear failure has been occurring, leading to spalling and/or hole. Wellbore instability severely causes stuck pipes and circulation loss **(Mclean and Addis,**

1990; Nmegbu and Ohazuruike, 2014). Many factors affect wellbore stability under classified controlling and uncontrolling wellbore stability.

2.1 The Uncontrollable Factors (Natural)

2.1.1 Far-field Principal Stress

There are three types of far-field stress; vertical stress, max-horizontal stress, min-horizontal stress, which are used to determine the in-situ stress around the wellbore, which has a significant role in different stages of drilling wells (construction, design, and process), and there must be a great interested to magnitude and direction of these stress to analyses wellbore instability.

2.1.2 Rock Mechanical Properties

It includes Young modulus, Poisson ratio, tensile strength, cohesive strength, internal friction angle, the Biot's constant, rock porosity, permeability, and bulk densities, which are important parameters to analyze instability and affect borehole behavior. Knowing the prediction of wellbore stability for helping well planners to reduce the risk by selecting a different well path.

2.1.3 Naturally Fractured Or Faulted Formations

Natural fracture is founded in the rocks laying near fault because these rocks are broken into large or small pieces, and these pieces are bounded together, when impacting occurs by BHA due to the vibration of the drill string, the formation may fall into the drill hole and causes mechanical stuck pipes and results wellbore instability.

2.1.4 Pore Pressure

It is one of the important factors in the drilling plane, the petroleum production plane. Supported pressure, which affected the state of stresses around the wellbore, also controlled wellbore stability; therefore must be accurate to production pore pressure.

2.1.5 Naturally Over-Pressured Shale Collapse

It results from geological phenomena such as naturally removed overburden, under-compaction, and uplift, which causes pore pressure greater than the gradient of normal hydrostatic pressure. That happens when using inappropriate mud weight for these formations causes wellbore instability and collapse. These phenomena are based on expected sequences of rapid deposition shale.

2.1.6 Time

Wellbore stability is time-dependent. The propagation of pore pressure in the formation results from Chemical and thermal effects, so time-dependent stress redistribution causes processes to change with time. Then, wellbore stability considers a time-dependent phenomenon.

2.2 Controllable Factors

2.2.1 Well-Bore Trajectory

The azimuth and inclination angle of a wellbore is the two important parameters in calculating in-situ stresses around a wellbore because normal and shear stresses acting on the rock in the near-wellbore region consider as a function of inclination and azimuth, also when selected appropriate wellbore trajectory during well planning, leads to avoiding or reducing borehole failure during drilling operation **(Ewy, 1999)**.

2.2.2 Drilling Fluid And Pore Fluid Chemical

The difference between the drilling fluid and formation fluid in terms of type, concentration, and chemical composition is caused when drilling the formation, which results in the variation in chemical potential that lead to fluid flow in or out of the pores and redistribution of pore pressure. The difference in chemical potential can be ignored for formations that have large permeability, and for formations that have low permeability (such as shales) can generate significant pore pressure propagation from induced fluid flow, therefor the changing of chemicals concentration in the drilling fluid is widely used in the field for preventing shale formations from failure.

2.2.3 Mobile Formations

Overburden forces compress the formation and cause it to creep inside the hole, and when the weight of the mud is insufficient to support the wall of the wellbore then, deformation under pressure was resulted and caused decreasing in the wellbore size, causing problems in operation BHA´s.

2.2.4 Mud Weight

It is the main factor in maintaining wellbore stability and support of the wellbore wall, which requires increasing the mud weight to maintain wellbore stability but should be considered fracturing when the weight of the mud is chosen as the heavy drilling fluid.

2.2.5 Temperature

This factor became one of the factors that must be considered. The difference between the temperature of the fluid and the composition can be encountered when the degree of heating or cooling is about 60 ~ 70 ℃. Also, pore fluid and chemical potential of drilling fluid can affect by the temperature resulting from the movement of fluid near-wellbore region.

3. PROBLEMS RESULT FROM WELLBORE INSTABILITY

3.1 Hole Enlargement or Borehole Collapse

Borehole enlargement, or borehole collapse, occurs when the pressure of drilling fluid is lower than the formation press, and the collapse happens when the rock's compressive strength is larger than the stress applied by drilling mud. These types of failures are classified as breakout failures. The symptoms are sand production results, poor cementing influx of formation fluid, bad effective hole cleaning, which needs increased hydraulic requirements, and difficulties in performing and responding to well log tools. When the collapse happened, the pieces of rock collapsed, fell into the hall, and settled on the drill string, which caused the inability to withdraw the drill string, which caused a stuck pipe and instability of the well **(Mohammed, 2017).**

3.2 Hole Closure or Narrowing

Hole closure or narrowing results of the creep under the influence of the overburden (plastic flow of the rock) usually occurs in shale, sandstone, and salt sections. The symptoms are; increasing torque, drag, difficult casing landing, possible pipe sticking, and preventing hole closer requirement to repeat reaming operations.

3.3 Fracture

Fracturing results when the pressure of mud weight exceeds the pressure of formation fracture. The symptoms of that: are lost circulation and well control problems (kick and blowout), which appear when drilling fluid invasion the formation and leads to diminishing the influence of the applied drilling fluid pressure.

4. GEOMECHANICAL ANALYSIS OF WELLBORE INSTABILITY

In the oil and gas industry, geomechanics plays a substantial role, and it has become an important and integral part of every field development plan, starting from exploration operation pore pressure prediction, fluid flow evaluation, and hydrocarbon column height, even after field abandonment. This great role because of the geomechanics studying the impact of rock interaction, stresses and distribution of it, pressure and temperature stresses, and the effect of that in the well stability and drilling progress, therefore Earth Mechanical Modeling (MEM) must be built, and applied through the lifetime of the reservoir to resolve the geomechanical problems. An important parameter must be determined to build a geomechanical model.

4.1 Magnitude and Orientation of Far-Field Stresses

It includes two principal stresses; vertical and horizontal (maximum and minimum). Vertical stresses are overburden stress, defined as the pressure applied to the rock at a given depth that results from the weight of the rock and the fluids containing it **(Aadnoy and Looyeh, 2019).** The vertical stress (σ_v) can be determined if the average density of formation is available by using the equation:

$$\sigma_v = \rho_a * g * Z \tag{1}$$

where:
Z represents the depth (m),
g represents the acceleration due to gravity (m/s^2),
ρ_a represents the average bulk density (kg/m^3).

The overburden stress could be obtained from the integral densities at depth if the formation has a different density.

$$\sigma_v = \rho_w * g * Z_w + g \int_{zw}^{z} \rho_b * Zdz \qquad (2)$$

where:
$\rho_b(z)$ represents the bulk rock density along depth and can be obtained from the density log,
ρ_w represents the density of seawater;
Z_w represents water depth for onshore drilling $Z_w = 0$.
Horizontal stresses result from vertical stress on a specific point which causes sequences of the rocks vertically, and due to the effect of this stress, rocks tend to move horizontally. There are two methods to calculate horizontal stress magnitude: direct and indirect. The direct method includes the Leak-off test (LOT), hydraulic fracturing test, and measurement of pressure while drilling (MWD). These methods determine minimum horizontal stresses $\boldsymbol{\sigma_h}$ and maximum stresses $\boldsymbol{\sigma_H}$ **(Zoback et al., 2003).** There were no direct methods to calculate it, but it can be utilized by theoretical and empirical relations to evaluate $\sigma_{H\,max}$ based on $\sigma_{h\,min}$ and σ_v values **(Kosset, 2014).** In the direct method, the physical method estimates the min- horizontal stress value, depending on pore pressure, vertical stress, and poisson ratio. The determination of max-horizontal stress is based on min- horizontal stress, pore pressure, and reopening of the fracture pressure. The horizontal stress orientation is an important parameter for building a geomechanical model. Estimating horizontal stress direction helps to appoint an optimized wellbore trajectory during the drilling operation and in the production operation helps to locate the optimum orientation of perforation and avoid sand production. Hence, many logging tools, such as Formation Micro Imager (FMI) and Caliper logs, can be used to estimate the horizontal direction.

4.2 Pore Pressure

There are two ways to estimate pore pressure direct and indirect methods. Direct method: - pore pressure can be calculated using resistivity and Sonic logs, and the permeable formation is estimated using techniques such as Drill Stem Test (DST) and other formation Tester. In the direct method: -the main principle to calculate pore pressure is the relationship between porosity with overburden stresses and sonic slowness. These ways are used when the change in the well log values of normal and abnormal intervals, and the principle to determining pore pressure are based on the porosity decreases with the increase of the effective vertical stress, which is the main driver of fluid expulsion during burial and caused dispersing pore fluids,**(Zhang, 2011)**. The normal pore pressure also increases from the fluid density contained in the formation, which increases with depth. Also, pore pressure estimation uses sonic slowness instead of using porosity. Wave slowness is one over the wave velocity, which increases with depth when overburden stresses increase **(Zhang, 2011; Haider et al., 2020).**

4.3 Mechanical Rocks Properties

Mechanical rocks properties contain strength properties and elastic properties. The elastic properties include Young's modulus (resistance of rock sample to uniaxial stress), Poisson's ratio (measuring the rock expands concerning a shorting in axial), the Shear modulus (the number of rock misshapes in response to shear stress), and the Bulk modulus (the hardness under volumetric compression). These properties are estimated by applying many static rock tests or using well logs such as density and sonic log data. Strength properties are the capability of rock to maintain far-field stress medium around the wellbore or perforation cavity, which includes internal friction angle (estimation of rock failure), cohesive strength (defines a reflectance to the degree of adherence between connected molecules), tensile strength (the rock resistance), shear strength (the rock resistance).

4.4 Stresses Around Wellbore

It is dependent upon the pore pressure, in-situ principal stresses, rock behavior, and the borehole mud pressure, which includes hoop (circumferential) stress (σ_θ) (which act around the wellbore), radial stresses (σ_r) (which support for the well wall), axial stress ($o_{z.}$), longitudinal stress which effects on the axis of the wellbore. The convergence of stress trajectories toward the orientation of $S\mathrm{h}_{\mathrm{min}}$ detects a compressive region. However, the divergence of stress trajectories toward the direction of $S\mathrm{H}_{\mathrm{max},}$ a tensile region concentricity of in situ stresses at the wellbore can lead to tensile or compression failure**(Neeamy, 2020).**

4.5 Optimal Determination of Mud Pressure

Optimum mud weight can be obtained by controlling shear failure pressure, formation breakdown pressure, and minimum horizontal stress. Drilling fluid pressure should be greater than shear failure pressure and less than formation breakdown pressure and min-horizontal stress to avoid all problems caused by mud hydraulics, such as unstable wellbore, inadequate lifting capacity, and borehole pack-off.

5. BOREHOLE INSTABILITY PREVENTION

The prevention of the process instability of the wellbore cannot be complete because it isn’t possible to return the rocks to their original position after the distortion process. They are exposed to affect by the problems resulting from the instability of the well, but the drilling engineer can reduce those problems by following some preventive operations. Choosing the optimal for each drilling mud and its maintenance, the equivalent circulating density (ECD) using suitable hydraulics, selection of hole-trajectory, and borehole fluid suitable for drilled formation. It must consider reducing time spent in open holes, utilizing offset-well data, and monitoring the changes in (drag, torque, circulating pressure, and fill-in during tripping) **(Nmegbu and Ohazuruike, 2014).**

6. CONCLUSIONS

The fundamental parameters influencing the discussed wellbore instability were far-field principle stresses, rock mechanical properties, pore pressure, wellbore trajectory, drilling fluid, pore fluid chemical, mud weight, temperature, and time. Also, the basic parameters that must be calculated for building a geomechanical model were the magnitude and orientation of the far field stresses, pore pressure, the rocks' mechanical properties, and the stresses' concentration around the wellbore. There was no radical solution to solve the problems of instability of the wellbore. It might be due to the inaccuracy of the data obtained and the fact that we could not generalize the solutions reached for all types of reservoirs due to the fundamental differences in formation. The prevention of wellbore instability cannot be achieved because the rocks cannot be returned to their original position after the distortion process. However, it cannot control the problems of instability of the well, but it can find solutions to some issues or reduce them through careful study of the reservoir and continuous follow-up of the processes that occur inside the reservoir.

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