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Wellbore Instability in Oil Well Drilling: A Review

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Abstract:-Wellbore instability is one of the key problems that engineers encounter during drilling. Often, field instances of instability are a result of a combination of both chemical and mechanical factors, the former resulting from the failure of the rock around the hole due to high stresses, low rock strength, or inappropriate drilling practice and the latter arising from damaging interactions between the rock, generally shale, and the drilling fluid. The increasing demand for wellbore stability analyses during the planning stage of a field arise from economic considerations and the increasing use of deviated, extended reach and horizontal wells, all of which are highly susceptible to the problem. This paper presents a review of the causes, symptoms, prevention, associated consequences, types and respective problems and the principle behind the problem of wellbore instability in oil well drilling.

Keywords:-Borehole Instability, Drilling Problems, Hole cave-in, Instability Symptoms, Wellbore Instability

I. INTRODUCTION

Drilling operation in the oil and gas industry is a challenging task. The drilling stem and the drill bit must be tough enough to bore holes into different layers of strata in the formation and withstand high temperature, pressure, shock and abrasion from the formation. The drilling mud must meet all the criteria necessary for the drilling operation to be successful. Some layers in the formation like shale, fractured and abnormally high pressured formations are problematic and require a great deal of technicality[1].

Wellbore instability is a natural function of the unequal mechanical stress and physio-chemical interactions, and pressures created when support in material and surfaces are exposed in the drilling process of the well [2]. Wellbore instability (WI) is recognised when the hole diameter is markedly different from the bit size and the hole does not maintain its structural integrity. Succinctly put, an overguageor undergauge hole implies wellbore instability [3]. For oil and gas wells to be successfully completed, it is imperative toformulate mud of an adequate mud weight to maintain hole stability, avoid formation fluid influx into the wellbore and minimise mud loss to the formation [4].

Unexpected or unknown behaviour of rock is often the cause of drilling problems, resulting in an expensive loss of time, sometimes in a loss of part or all of the borehole. Borehole stability is a continuing problem which results in substantial yearly expenditures by the petroleum industry [5],[6]. As a result, a major concern of the drilling engineers is keeping the borehole wall from caving in. Detailed attention is paid to drilling fluid programs, casing programs, and operating procedures in drilling a well to minimize these costlyproblems [7].

Wellbore instability has become an increasing concern for horizontal and extended reach wells, especially with the move towards completely open hole lateral section, and in some cases, open hole build-up section through shale cap rocks. More recent drilling innovations such as underbalanced drilling techniques, high pressure jet drilling, re-entry horizontal wells and multiple laterals from a single vertical or horizontal well often give rise to challenging wellbore stability question [8], [9], [10].

In many cases, the selection of an optimal strategy to prevent or mitigate the risk of wellbore collapse might compromise one or more of the other elements in the overall well design, e.g., drilling rate of penetration, the risk of differential sticking, hole cleaning ability, or formation damage. For drilling situations, it is therefore desirable to apply integrated predictive methods that can, for instance, help to optimize the mud density, chemistry, rheology, the selection of filter cake building additives, and possibly temperature. Sensitivity studies can also help assess if there is any additional risk due to the selected well trajectory and inclination. Wellbore stability predictive models may also be used to design appropriate completions for inflow problems where hole collapse and associated sand production are concerned. For example, in highly permeable and weakly cemented sandstones, such predictive tools can be used to decide whether a slotted or perforated liner completion would be preferred over leaving a horizontal well completely open hole [11].

Four wells drilled in Gulf of Suez and Mediterranean Sea, offshore Egypt, wereanalyzed for wellbore instability, to improve drilling performance in future wells [12]. A suite of logs, including DSI sonic, GR, and density were used as input to IMPACT-ELAN of Geoframe to predict rock strength, petrophysical properties, and safe mud weight windows. The weak shales in the overburden were failing due to inadequate wall support inspite of using oil based mud (OBM). The simulation predicted higher mud weight for adequate wall support. Use of predicted higher mud weights during drilling improved the hole condition and related instabilities. Therefore, OBM used often to drill shaly sections should be checked for correct mud weight.

Saidin et al discussed wellbore instability encountered when drilling through the Terengganu shale (K-shale), Bekok field, Malaysia [13]. Due to the time dependency of the observed instability cases, K-shale was thought of as reactive and unstable due to shale– fluid interaction. An Invert emulsion OBM was used to drill the wells. This, however, resulted in severe formation damage without any improvement in stability. Rock characterization and laboratory measurements of rock mechanical properties indicated that K-shales had predominantly non-reactive weak clay. This information helped in improving the design of mud weight window leading to successful completion of a new well. To minimize differential sticking due to high mud weights, invert emulsion SBM was used.

Santarelli et al [14] presented wellbore instability problems occurring in a developed field in Italy. The problems were back analyzed with respect to the mud types, mud weights, azimuths, and stress regime. More drilling problems like reaming and stuck pipe occurred at a particular azimuth. This proved the existence of anisotropic distribution of horizontal stresses, which was not known because of absence of any in-situ stress related data. The non-inhibitive water based mud gave better results compared to other mud system. In the light of new data, drilling practices which were planned during the appraisal drilling phase were continued with necessary modifications.

Severe instability was encountered while drilling horizontal drains in Hamlah-Gulailah Formation, ABK field, offshore Abu Dhabi, though vertical wells were drilled without encountering any significant problem. To analyze the instability problem, a comprehensive rock mechanical study was carried out to characterize rock strength and in-situ horizontal stresses. The study suggested that the horizontal stresses were anisotropic in nature with strike–slip–thrust stress regime. The rocks were weak and fissured. The rock mechanical simulation predicted higher mud weights than those actually used in the field [15].

In general, wellbore instability is caused by a combination of different reasons or presence of more than one mechanism. Wells drilled in complex geological areas encounter many layers of rock having different properties. Some layers could be weak, while others brittle, fractured, chemically reactive or rubble. There is no simple solution for wellbore instability in such cases. A collapsing weak layer needs high mud weight for stability, but increasing the mud weight could excite instability in fractured layers by mud invasion. Therefore, such cases require careful rock characterization and mud weight optimization. In the past, fields were developed using vertical wells which did not exhibit any drilling trouble. The trend nowadays is to drill horizontal wells to enhance productivity. The experience of drilling vertical wells is carried forward without appropriate modifications to drill the horizontal wells resulting in wellbore instabilities. The consequences of such ill-judgements are presented below.

II. CAUSES OF WELLBORE INSTABILITY

Wellbore instability manifests itself in different ways like hole pack off, excessive reaming, overpull, torque and drag, sometimes leading to stuck pipe that may require plugging and side tracking. This requires additional time to drill a hole, driving up the cost of reservoir development significantly. In case of offshore fields, loss of hole is more critical due to a limited number of holes that can be drilled from a platform. Wellbore instability is usually caused by a combinationof factors which may be broadly classified as being eithercontrollable or uncontrollable (natural) in origin. These factors are shown in table I[11], [16], [17], [18].

Table I: Causes of Wellbore Instability

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 Interaction
Unconsolidated Formations	Drill String Vibrations
Naturally Over-Pressured Shale Collapse	Erosion
Induced Over-Pressured Shale Collapse	Temperature

A. Uncontrollable factors

*1. **Naturally fractured or faulted formations:*** A natural fracture system in the rock can often be found near faults. Rock near faults can be broken into large or small pieces. If they are loose, they can fall into the wellbore and jam the string in the hole [19]. Even if the pieces are bonded together, impacts from the BHA due to drill string vibrations can cause the formation to fall into the wellbore. This type of sticking is particularly unusual in that stuck pipe can occur while drilling. Fig. 1 shows possible problems that result drilling a naturally fractured or faulted system.

This mechanism can occur in tectonically active zones, in prognosed fractured limestone, and as the formation is drilled. Drill string vibrations have to be minimized to help stabilize these formations [16]. Hole collapse problems may become quite severe if weak bedding planes intersect a wellbore at unfavourable angles. Such fractures in shales may provide a pathway for mud or fluid invasion that can lead to time-depended strength degradation, softening and ultimately to hole collapse. The relationship between hole size and the fracture spacing will be important in such formations.

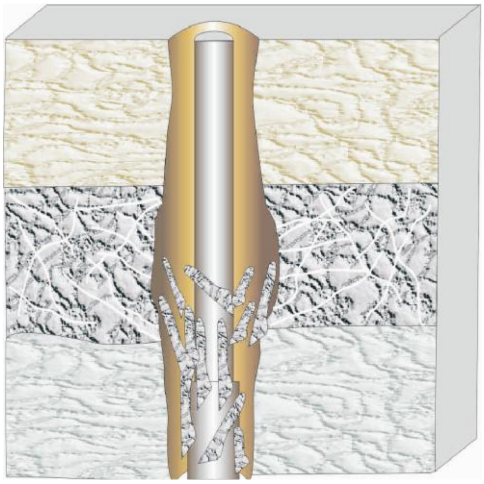

Fig. 1: Drilling through naturally fractured or faulted formations [7]

2. Tectonically Stressed Formations: Wellbore instability is caused when highly stressed formations are drilled and if exists a significant difference between the near wellbore stress and the restraining pressure provided by the drilling fluid density. Tectonic stresses build up in areas where rock is being compressed or stretched due movement of the earth´s crust. The rock in these areas is being buckled by the pressure of the moving tectonic plates. When a hole is drilled in an area of high tectonic stresses the rock around the wellbore will collapse into the wellbore and produce splintery cavings similar to those produced by over-pressured shale (Fig. 2). In the tectonic stress case the hydrostatic pressure required to stabilize the wellbore may be much higher than the fracture pressure of the other exposed formations [16]. This mechanism usually occurs in or near mountainous regions. Planning to case off these formations as quickly as possible and maintaining adequate drilling fluid weight can help to stabilize these formations

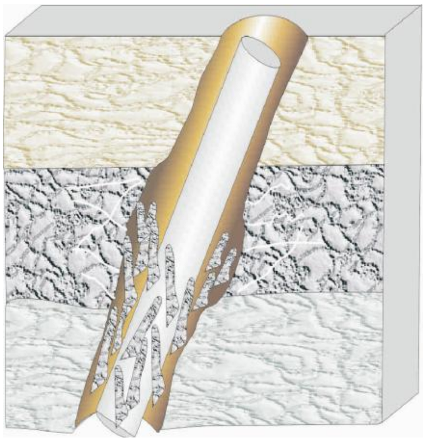

Fig. 2: Drilling through tectonically stressed formations [7]

3. High in-situ stresses: Anomalously height in-situ stresses, such as may be found in the vicinity of salt domes, near faults, or in the inner limbs of a folds may give rise to wellbore instability. Stress concentrations may also occur in particularly stiff rocks such as quartzose sandstones or conglomerates. Only a few case histories have been described in the literature for drilling problems caused by local stress concentrations, mainly because of the difficulty in measuring or estimating such in situ stresses.

4. Mobile formations: The mobile formation squeezes into the wellbore because it is being compressed by the overburden forces. Mobile formations behave in a plastic manner, deforming under pressure. The deformation results in a decrease in the wellbore size, causing problems of running BHA´s, logging tools and casing (Fig. 3). A deformation occurs because the mud weight is not sufficient to prevent the formation squeezing into the wellbore [16]. This mechanism normally occurs while drilling salt. An appropriate drilling fluid and maintaining sufficient drilling fluid weight are required to help stabilize these formations.

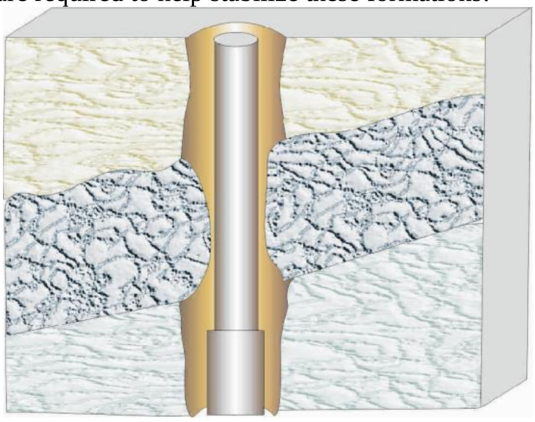

Fig. 3: Drilling through mobile formations [7]

5. Unconsolidated formations: An unconsolidated formation falls into the wellbore because it is loosely packed with little or no bonding between particles, pebbles or boulders. The collapse of formations is caused by removing the supporting rock as the well is drilled (Fig. 4). It happens in a wellbore when little or no filter cake is present. The un-bonded formation (sand, gravel, etc.) cannot be supported by hydrostatic overbalance as the fluid simply flows into the formations. Sand or gravel then falls into the hole and packs off the drill string. The effect can be a gradual increase in drag over a number of meters, or can be sudden [16]. This mechanism is normally associated with shallow formation. An adequate filter cake is required to help stabilize these formations.

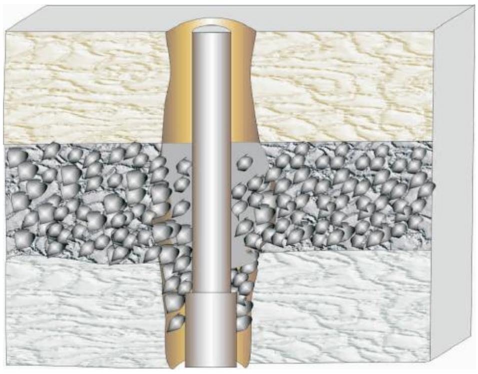

Fig. 4: Drilling through unconsolidated formations [7]

6. Naturally Over-Pressured Shale Collapse: Naturally over-pressured shale is the one with a natural pore pressure greater than the normal hydrostatic pressure gradient. Naturally over-pressured shales are most commonly caused by geological phenomena such as under-compaction, naturally removed overburden and uplift (Fig. 5). Using insufficient mud weight in these formations will cause the hole to become unstable and collapse [10], [16]. This mechanism normally occurs in prognosed rapid depositional shale sequences. The short time hole exposure and an adequate drilling fluid weight can help to stabilize these formations.

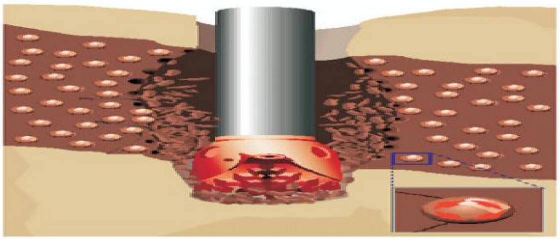

Fig. 5:Drilling through a naturally over-pressured shale [7]

7. Induced Over-Pressured Shale Collapse: Induced over-pressured shale collapse occurs when the shale assumes the hydrostatic pressure of the wellbore fluids after a number of days' exposures to that pressure. When this is followed by no increase or a reduction in hydrostatic pressure in the wellbore, the shale, which now has a higher internal pressure than the wellbore, collapse in a similar manner to naturally over-pressured shale (Fig. 6) [16]. This mechanism normally occurs in water based drilling fluids, after a reduction in drilling fluid weight or after a long exposure time during which the drilling fluid was unchanged.

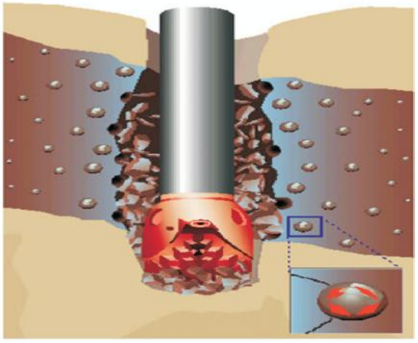

Fig. 6: Drilling through induced over-pressured shale [7]

B. Controllable factors

1. Bottom hole pressure (mud density): Depending upon the application, either the bottom hole pressure, the mud density or the equivalent circulating density (ECD), is usually the most important determinant of whether an open wellbore is stable (Fig. 7 and Fig. 8) [19], [20]. The supporting pressure offered by the static or dynamic fluid pressure during either drilling, stimulating,working over or producing of a well, will determine the stress concentration present in the near wellbore vicinity.Because rock failure is dependent on the effective stressthe consequence for stability is highly dependent on whether and how rapidly fluid pressure penetrate the wellbore wall. That is not to say however, that high mud densities or bottom hole pressures are always optimal for avoiding instability in a given well. In the absence of an efficient filter cake, such as in fractured formations, a rise in a bottom hole pressure may be detrimental to stability and can compromise other criteria, e.g., formation damage, differential sticking risk, mud properties, or hydraulics [18], [21, [22].

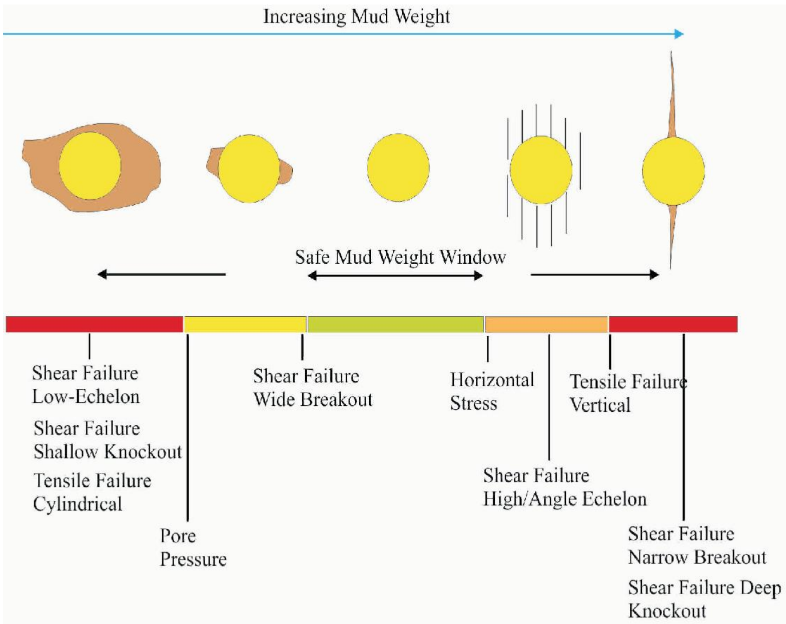

Fig. 7:Effect of mud weight on the stress in wellbore wall [7]

2. Well Inclination and Azimuth: Inclination and azimuthal orientation of a well with respect to the principal in-situ stresses can be an important factor affecting the risk of collapse and/or fracture breakdown occurring (Fig. 8**)**. This is particularly true for estimating the fracture breakdown pressure in tectonically stressed regions where there is strong stress anisotropy [11].

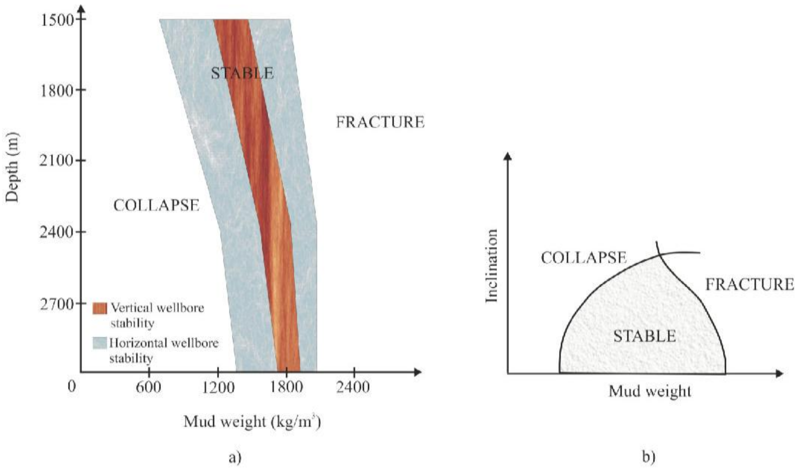

Fig. 8:Effect of the well depth (a) and the hole inclination (b) on wellbore stability [7]

3. Transient wellbore pressures: Transient wellbore pressures, such as swab and surge effects during drilling, may cause wellbore enlargement [20]. Tensile spalling can occur when the wellbore pressure across an interval is rapidly reduced by the swabbing action of the drill string for instance. If the formation has a sufficiently low tensile strength or is pre-fractured, the imbalance between the pore pressures in the rock and the wellbore can literally pull loose rock off the wall. Surge pressures can also cause rapid pore pressures increases in the near-wellbore area sometimes causing an immediate loss in rock strength which may ultimately lead to collapse. Other pore pressure penetration-related phenomena may help to initially stabilize wellbores, e.g. filter cake efficiency in permeable formations, capillary threshold pressures for oil-based muds and transient pore pressure penetration effects [11].

4. Physical/chemical fluid-rock interaction: There are many physical/chemical fluid-rock interaction phenomena which modify the near-wellbore rock strength or stress. These include hydration, osmotic pressures, swelling, rock softening and strength changes, and dispersion. The significance of these effects depend on a complex interaction of many factors including the nature of the formation (mineralogy, stiffness, strength, pore water composition, stress history, temperature), the presence of a filter cake or permeability barrier is present, the properties and chemical composition of the wellbore fluid, and the extent of any damage near the wellbore [11].

5. Drillstring vibrations (during drilling): Drill string vibrations can enlarge holes in some circumstances. Optimal bottom hole assembly (BHA) design with respect to the hole geometry, inclination, and formations to be drilled can sometimes eliminate this potential contribution to wellbore collapse. Some authors claim that hole erosion may be caused due to a too high annular circulating velocity. This may be most significant in a yielded formation, a naturally fractured formation, or an unconsolidated or soft, dispersive sediment. The problem may be difficult to diagnose and fix in an inclined or horizontal well where high circulating rates are often desirable to ensure adequate hole cleaning [11].

6. Drilling fluid temperature: Drilling fluid temperatures, and to some extent, bottomhole producing temperatures can give rise to thermal concentration or expansion stresses which may be detrimental to wellbore stability. The reduced mud temperature causes a reduction in the near-wellbore stress concentration, thus preventing the stresses in the rock from reaching their limiting strength [11].

III. TYPES AND ASSOCIATED PROBLEMS

There are four different types of borehole instabilities [7]:

- Hole closure or narrowing
- Hole enlargement or washouts
- Fracturing
- Collapse

Fig. 1 illustrates the hole-instability problems.

A. Hole closure

Hole closure is a narrowing time-dependent process of borehole instability. It sometimes is referred to as creep under the overburden pressure, and it generally occurs in plastic-flowing shale and salt sections. Problems associated with hole closure are:

- Increase in torque and drag
- Increase in potential pipe sticking
- Increase in the difficulty of casings landing

B. Hole enlargement

Hole enlargements are commonly called washouts because the hole becomes undesirably larger than intended. Hole enlargements are generally caused by:

- Hydraulic erosion
- Mechanical abrasion caused by drillstring
- Inherently sloughing shale

The problems associated with hole enlargement are:

- Increase in cementing difficulty
- Increase in potential hole deviation
- Increase in hydraulic requirements for effective hole cleaning
- Increase in potential problems during logging operations

C. Fracturing

Fracturing occurs when the wellbore drilling-fluid pressure exceeds the formation-fracture pressure. The associated problems are lost circulation and possible kick occurrence.

D. Collapse

Borehole collapse occurs when the drilling-fluid pressure is too low to maintain the structural integrity of the drilled hole. The associated problems are pipe sticking and possible loss of well.

IV. PRINCIPLES OF BOREHOLE INSTABILITY

Before drilling, the rock strength at some depth is in equilibrium with the in-situ rock stresses (effective overburden stress, effective horizontal confining stresses). While a hole is being drilled, however, the balance between the rock strength and the in-situ stresses is disturbed. In addition, foreign fluids are introduced, and an interaction process begins between the formation and borehole fluids. The result is a potential hole-instability problem [3]. Although a vast amount of research has resulted in many borehole-stability simulation models, all share the same shortcoming of uncertainty in the input data needed to run the analysis. Such data include [3]:

- In-situ stresses
- Pore pressure
- Rock mechanical properties
- Formation and drilling-fluids chemistry

A. Mechanical rock-failure mechanisms

Mechanical borehole failure occurswhen the stresses acting on the rock exceed the compressive or the tensile strength of the rock. Compressive failure is caused by shear stresses as a result of low mud weight, while tensile failure is caused by normal stresses as a result of excessive mud weight [3].

The failure criteria that are used to predict hole-instability problems are the maximum-normal-stress criterion for tensile failure and the maximum strain energy of distortion criterion for compressive failure. In the maximum-normal-stress criterion, failure is said to occur when, under the action of combined stresses, one of the acting principal stresses reaches the failure value of the rock tensile strength. In the maximum of energy of distortion criterion, failure is said to occur when, under the action of combined stresses, the energy of distortion reaches the same energy of failure of the rock under pure tension.

B. Shale instability

Shales make up the majority of drilled formations, and cause most wellbore-instability problems, ranging from washout to complete collapse of the hole. Shales are fine-grained sedimentary rocks composed of clay, silt, and, in some cases, fine sand. Shale types range from clay-rich gumbo (relatively weak) to shaly siltstone (highly cemented), and have in common the characteristics of extremely low permeability and a high proportion of clay minerals. More than 75% of drilled formations worldwide are shale formations. The drilling cost attributed to shale-instability problems is reported to be in excess of one-half billion U.S dollars per year. The cause of shale instability is two-fold: mechanical (stress change vs. shale strength environment) and chemical (shale/fluid interaction—capillary pressure, osmotic pressure, pressure diffusion, borehole-fluid invasion into shale).

1. ***Mechanical-induced shale instability*:** As stated previously, mechanical rock instability can occur because the in-situ stress state of equilibrium has been disturbed after drilling. The mud in use with a certain density may not bring the altered stresses to the original state, therefore, shale may become mechanically unstable.
2. ***Chemical-induced shale instability:*** Chemical-induced shale instability is caused by the drilling-fluid/shale interaction, which alters shale mechanical strength as well as the shale pore pressure in the vicinity of the borehole walls. The mechanisms that contribute to this problem include:
   - Capillary pressure
   - Osmotic pressure
   - Pressure diffusion in the vicinity of the borehole walls
   - Borehole-fluid invasion into the shale when drilling overbalanced

Capillary pressure: During drilling, the mud in the borehole contacts the native pore fluid in the shale through the pore-throat interface. This results in the development of capillary pressure, p_{cap} . To prevent borehole fluids from entering the shale and stabilizing it, an increase in capillary pressure is required, which can be achieved with oil-based or other organic low-polar mud systems.

Osmotic pressure: When the energy level or activity in shale pore fluid, a_s, is different from the activity in drilling mud, a_m , water movement can occur in either direction across a semipermeable membrane as a result of the development of osmotic pressure, p_{os} , or chemical potential, μ_c . To prevent or reduce water movement across this semipermeable membrane that has certain efficiency, E_m, the activities need to be equalized or, at least, their differentials minimized. If a_m is lower than a_s, it is suggested to increase E_m and vice versa. The mud activity can be reduced by adding electrolytes that can be brought about through the use of mud systems such as:

- Seawater
- Saturated-salt/polymer
- KCl/NaCl/polymer
- Lime/gypsum

***Pressure diffusion*:** Pressure diffusion is a phenomenon of pressure change near the borehole walls that occurs over time. This pressure change is caused by the compression of the native pore fluid by the borehole-fluid pressure, p_{wfl}, and the osmotic pressure, p_{os}.

Borehole fluid invasion into shale: In conventional drilling, a positive differential pressure (the difference between the borehole-fluid pressure and the pore-fluid pressure) is always maintained. As a result, borehole fluid is forced to flow into the formation (fluid-loss phenomenon), which may cause chemical interaction that can lead to shale instabilities. To mitigate this problem, an increase of mud viscosity or, in extreme cases, gilsonite is used to seal off microfractures.

Use of drilling fluid: Drilling overbalanced through a shale formation with a water-based fluid (WBF) allows drilling-fluid pressure to penetrate the formation. Because of the saturation and low permeability of the formation, the penetration of a small volume of mud filtrate into the formation causes a considerable increase in pore-fluid pressure near the wellbore wall. The increase in pore-fluid pressure reduces the effective mud support, which can cause instability. Several polymer WBF systems have made shale-inhibition gains on oil-based fluids (OBFs) and synthetic-based fluids (SBFs) through the use of powerful inhibitors and encapsulators that help prevent shale hydration and dispersion.

V. SYMPTOMS OF WELLBORE INSTABILITY

A list of the symptoms of wellbore instability which are primarily caused by wellbore collapse or convergence during the drilling, completion or production of a well is shown in table 2. They are classified in two groups: direct and indirect causes. Direct symptoms of instability include observations of overgauge or undergauge hole, as readily observed from caliper logs [18]. Caving from the wellbore wall, circulated to surface, and hole fill after tripping confirm that spalling processes are occurring in the wellbore. Large volumes of cuttings and/ or cavings, in excess of the volume of rock which would have been excavated in a gauge hole, similarly attest to hole enlargement. Provided the fracture gradient was not exceeded and vuggy or naturally fractured formations were not encountered, a requirement for a cement volume in excess of the calculated drilled hole volume is also a direct indication that enlargement has occurred [22].

Table 2: Symptoms of Wellbore Stability

Direct symptoms	Indirect symptoms
Oversize hole	High torque and drag (friction)
Undergauge hole	Hanging up of drillstring , casing, or coiled tubing
Excessive volume of cuttings	Increased circulating pressures
Excessive volume of cavings	Stuck pipe
Cavings at surface	Excessive drillstring vibrations
Hole fill after tripping	Drillstring failure
Excess cement volume required	Deviation control problems
	Inability to run logs
	Poor logging response
	Annular gas leakage due to poor cement job
	Keyhole seating
	Excessive doglegs

VI. BOREHOLE-INSTABILITY PREVENTION

Total prevention of borehole instability is unrealistic, mainly because the rock can never be restored to its initial conditions [7]. However, the drilling engineer can mitigate the problems of borehole instabilities by adhering to good field practices. These practices include:

- Proper mud-weight selection and maintenance
- Use of proper hydraulics to control the equivalent circulating density (ECD)
- Proper hole-trajectory selection
- Use of borehole fluid compatible with the formation being drilled

Additional field practices that should be followed are:

- Minimizing time spent in open hole
- Using offset-well data (use of the learning curve)
- Monitoring trend changes (torque, circulating pressure, drag, fill-in during tripping)
- Collaborating and sharing information

VII. CONCLUSION

Key parameters that influence wellbore instability discussed are rock properties, in-situ stresses, pore pressure, wellbore trajectory, drilling fluid and drilling practices.

Wellbore instability problems still exist today due to unknowns (values of rock data) and differences in formations drilled.Total prevention of wellbore instability is unrealistic. Reason is that we caused it and we cannot restore the in-situ rock conditions.Combined analysis (integrated approach) of wellbore stresses, mud chemistry, and excellent drilling practices is the key to minimizing wellbore instability.

Nonetheless, although we cannot control what the drillers do, we can influence them and gain credibility with them by understanding their problems, speaking their language, and letting them understand the consequences of their actions. With adequate planning and supervision the problems can be minimized.

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