Nafta-Gaz 2023, no. 4, pp. 257–260, DOI: 10.18668/NG.2023.04.04

Analysis of cavern and narrows of drilling wells in Azerbaijan fields

Analiza kawern i zwężeń w otworach wiertniczych na złożach węglowodorów w Azerbejdżanie

Rafiq S. Ibrahimov[1], Shirin O. Bahshaliyeva[1], Leyla Efendiyeva1, Zaur R. Ibrahimov[2]

[1] *Azerbaijan State Oil and Industry University*
[2] *Baker Hughes, Azerbaijan*

ABSTRACT: An analysis of numerous well data from the Karabagly and Kursangi monocline regions in Azerbaijan showed that the main reasons of natural curvature are structural and geological conditions of wells. In contrast to a number of fields where wells are naturally bent in only one direction under the combination of geological, technical and technological factors, there are three other directions in the areas of the Karabagly and Kursangi monocline. It is suggested that according to the proposed technology, drilling intervals are minimized by an assembly with a crooked sub, and the technical and economic parameters of drilling are improved. With an increase in the content of alkaline reagents in the drilling fluid, despite a significant decrease in the absolute value of fluid loss, the likelihood of complications increases. One of the main requirements for maintaining the integrity and stability of the wellbore is the prevention of filtration. This condition imposes a certain limitation on the amount of fluid loss in drilling fluids. In drilling practice, it is necessary to strive not only to minimize the fluid loss of flushing fluids, but also to the qualitative and quantitative evaluate various additives that slow down their physical and chemical impact on the rocks forming the walls of the well.

Key words: well deviation, drilling, technical and economic parameters of drilling, mathematical statistics.

STRESZCZENIE: Analiza licznych danych otworowych z rejonu monokliny Karabagly i Kursangi w Azerbejdżanie wykazała, że głównymi przyczynami naturalnej krzywizny są warunki strukturalne i geologiczne otworów. W przeciwieństwie do wielu złóż węglowodorów, na których odwierty są naturalnie wygięte tylko w jednym kierunku pod wpływem kombinacji czynników geologicznych, technicznych i technologicznych, na obszarach monokliny Karabagly i Kursangi występują jeszcze trzy inne kierunki. Zgodnie z proponowaną technologią należy zminimalizować interwały wierceń poprzez montaż w zestawie przewodu wiertniczego zakrzywionego łącznika, co pozwala na poprawę wskaźników techniczno-ekonomicznych wiercenia. Wraz ze wzrostem zawartości odczynników alkalicznych w płuczce, pomimo znacznego spadku wartości bezwzględnej utraty płynów, wzrasta prawdopodobieństwo komplikacji wiertniczych. Jednym z głównych warunków zachowania integralności i stabilności odwiertu jest zapobieganie filtracji płuczki. Warunek ten nakłada pewne ograniczenia na wielkość utraty płynu w płuczkach wiertniczych. W praktyce wiertniczej należy dążyć nie tylko do minimalizacji ubytków filtratu z płuczki, ale także do jakościowej i ilościowej syntezy różnych dodatków spowalniających fizyczne i chemiczne oddziaływanie na skały budujące ścianę odwiertu.

Słowa kluczowe: odchylenie odwiertu, wiercenie, techniczno-ekonomiczne wskaźniki wiercenia, statystyka matematyczna.

Introduction

Let us consider what explains the process of narrowing of the wells and cavern forming during drilling. It should be noted that the filtration of the drilling fluid partially unloads the formation and reduces the resistance of permeable rocks on the walls of the wells. In addition, there is a physical and chemical interaction between liquids and surfactants with various materials coming into direct contact. However, the mechanism of the physicochemical effect of the drilling fluid on the various rocks that make up the walls of the wells remains unclear (Ilnitskaya, 1973; Movsumov, 1976).

Objective

For the above reasons, prevention or reduction of narrowing of wells is of great practical importance.

Corresponding author: R. Ibrahimov, e-mail: *rafiq.ibrahimov@yahoo.com*

Article contributed to the Editor: 17.11.2022. Approved for publication: 30.03.2023.

Materials and methods

The physicochemical reasons for the violation of the cylindricity of the well as a result of cavities and narrowings have not been established. Only the separate issues of adsorption and corrosion fatigue of the strength of materials under the influence of an adsorption-active medium have been studied (Malevanisky, 1976).

As can be seen from Table 1, the sizes of caverns and narrowings increase with an increase in the fluid loss of the drilling fluid and its activity in relation to the rocks being drilled (Seid-Rza, 1963; Lapinskaya, 1981).

Table 1 shows that the dimensions of cavities and narrowings are significantly affected by the density of the drilling fluid. The experience gathered in the Karabagly and Kursangi areas in Azerbaijan shows that the lower density of the drilling fluid corresponds to larger caverns and narrowing of the well. This point once again quite convincingly confirms the role of the stress state.

Based on analysis and laboratory experiments, it has been established that if the clay layer is stratifiedand minerals dissolve well in the drilling fluid filtrate, then the formation of large caverns is observed in combination with intense screes and collapses. In particular, Figures 1a and b respectively show two sections of caliper logs taken from well 303, Kotur-Tepe and well 14, Kursyanga, with the expansion of the well. The sampled core material from these intervals was clay disintegrating in the mud filtrate.

In the formation of caverns in such rocks, significant pressure drops play an important role, contributing to the penetration of fluid deep into the formation. At the same time, it should be noted that, in contrast to the Darcy law, in low-permeability rocks, filtration begins only when a certain pressure is reached, which depends on the physicochemical properties of the rocks and the viscosity of the filtered fluid (Seid-Rza, 1963; Himatudinov, 1982).

In addition, in well conditions, when opening hydrophilic rocks, is favored by the pressure of the proppant fluid – capillary pressure, which can be huge for some clayey rocks. The pressure of the proppant leads to stress relief in the formation and inflow of filtrate from the drilling fluid.

The acceleration of the process of physical and chemical interaction of the drilling fluid with the rocks of the walls of the trunk is especially facilitated by tripping operations, as a result of which the forming crusts are constantly destroyed, preventing the penetration of the filtrate into the formation (Rzhevsky and Novik, 1978; Abramson et al., 1984).

As noted, an increase in the diameter of the well also occurs in the oil-bearing part of the well section, despite the extreme permeability of the formation.

This is due to the high reservoir pressure and excess surface tension between oil and oil-bearing rock tension between the rock and the density of the drilling fluid. The latter excludes the possibility of mud filtration into the reservoir, but does not eliminate the intense erosion of the well walls due to the friability of the oil-bearing rock (Sulakshin, 1973; Golubintsev, 1968).

Table 1. Formation of caverns and narrowing of the well
Tabela 1. Powstawanie kawern i zwężeń w otworach

Area	Well number	Ø of the bit [mm]	Constrictions		Extensions		Physical and lithological characteristics of rocks	Drilling fluid parameters	
			interval	max. meaning.	interval	max. meaning.		$\gamma \cdot 10^{-4}$	$B \cdot 10^2$, $m^3 \cdot 30$ min
Karabaglı	2	445	1063–1883	90	–	–	limestone	1.26–1.28	10–16
	2	445	1470–1540	80	–	–	sandstone	1.26–1.28	10–16
	2	445	–	–	1557–1568	100	clay	1.26–1.28	10–16
	12	394	1660–1670	50	–	–	sand	1.26–1.30	10–16
	12	394	–	–	1683–1752	100	clay	–	10–16
	18	394	–	–	196–242	125	clay	1.15	25–30
	18	394	1470–1538	50	–	–	shell rock	1.24	25–30
	18	394	–	–	760–775	100	clay	1.20	20–35
	18	394	–	–	1539–1543	180	–	1.26	20–28
	18	394	–	–	1830–1840	150	siltstone	–	8–10
	14	269	2290–2710	50	–	–	sand	1.38	8–10
	14	269	2740–3292	100	–	–	–	1.40	8–10
Kursangi	7	214	–	–	3220–3235	60	sandstone	1.86	4–5
	13	214	–	–	2600–2710	85	clay	1.40–1.50	5–7
	13	214	–	–	2740–2880	100	sandstone clay	1.40–1.60	6–7
	15	214	–	–	2600–2670	125	–	1.40–1.54	7–8
	15	214	2680–2705	25	–	–	–	1.56	7–9
	15	214	–	–	2710–2920	160	–	1.55	7–9
						–		1.45	7–9

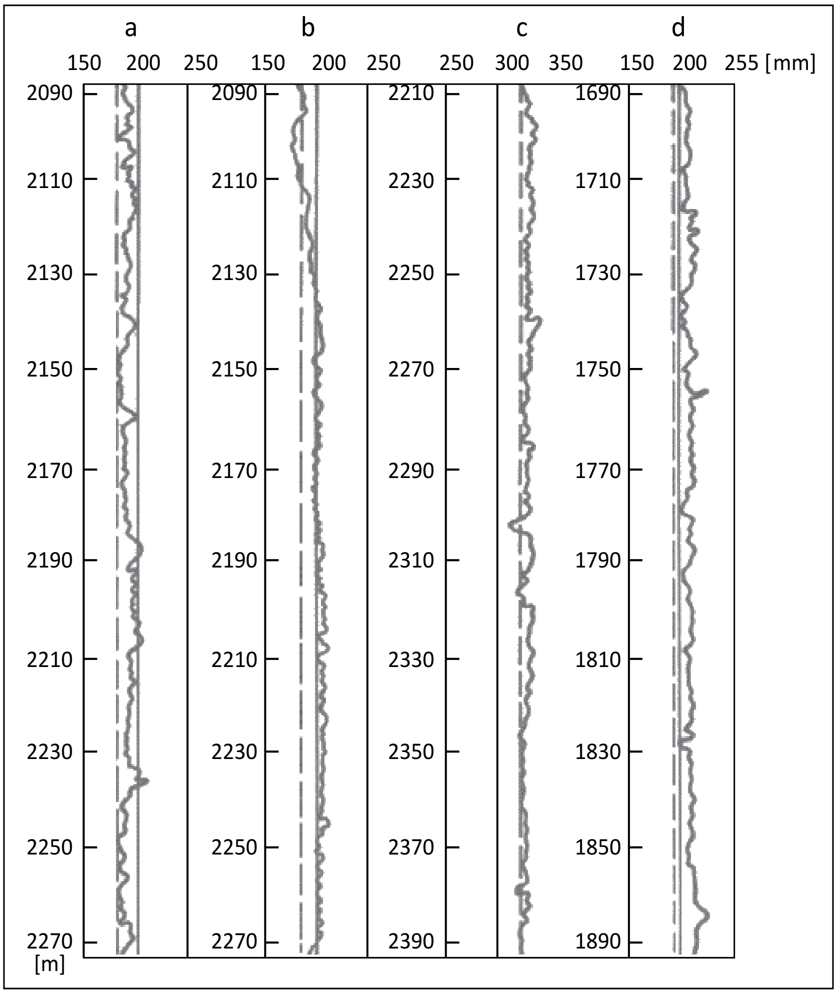


Figure 1. Cavernograms showing erosion fatigue of rocks in wells: a – Karabagly 12, b – Karabagly 26, c – Barsa-Gelmes 3, d – Kursyanga 14

Rysunek 1. Kawernogramy przedstawiające osłabienie erozyjne skał w otworach: a – Karabagly 12, b – Karabagly 26, c – Barsa-Gelmes 3, d – Kursyanga 14

In the remaining low-permeability hydrophobic rocks, adsorption and erosion fatigue of the well walls mainly exists. In this case, the transverse dimensions of the caverns differ little from the nominal diameter of the wells.

In the most permeable rocks (sandstones), as cavernograms show, narrowing of the well is noted (Spivak, 1972).

Results and discussion

The degree of narrowing of the well in permeable rocks depends on the pressure drop in the well, fluid loss, viscosity and fluid circulation rate and its activity in relation to the rock.

In the dynamic growth of cavities and constrictions, an important role is played by the concentration of surfactants in the solution, which intensify the processes of physical and chemical impact on the rock (Kuliev et al., 1968; Dobrynin and Wendelstein, 1991). Surfactants are known to have the ability to wet the surface, stabilize dispersed systems, form adsorption layers on the phase interface, resulting in a decrease in tension at the interface of the liquid with the rock. Surfactants are especially actively adsorbed on clay rocks. Some reagents used in drilling practice to improve the quality of drilling fluids have surface-active properties that help accelerate the process of physical and chemical stimulation of the formation (Baklanov and Kartosia, 1975; Katsaurov, 1981).

Therefore, it has been established that the tightening, sticking and stability of the well walls during the penetration of shale clays and mudstones with other things being equal, is directly dependent on the concentration of alkaline reagents in the drilling fluid. With an increase in the content of alkaline reagents in the solution, despite a significant decrease in the absolute value of fluid loss, the likelihood of complications increases.

Conclusions

1. One of the main requirements for maintaining the integrity and stability of the well is the prevention of filtration. This condition imposes a certain limitation on the amount of fluid loss in drilling fluids.
2. In drilling practice, it is necessary to strive not only to minimize the fluid loss of drilling fluids, but also to the qualitative and and quantitative evaluate various additives that slow down their physical and chemical impact on the rocks forming the walls of the well.

Literature

Abramson M.G., Baydyuk B.W., Zaretsky V.S., 1984. Reference book on mechanical and abrasive properties of rocks of oil and gas deposits. *Nedra, Moscow*.

Baklanov I.V., Kartosia B.A., 1975. Mechanics of rocks. *Nedra, Moscow*.

Dobrynin V.M., Wendelstein B.Yu., 1991. Petrophysics: Textbook for universities. *Nedra, Moscow*.

Golubintsev O.N., 1968. Mechanical and abrasive properties of rocks and their drillability. *Nedra, Moscow*.

Himatudinov Sh.K., 1982. Physics of oil and gas reservoirs. *Nedra, Moscow*.

Ilnitskaya E.I., 1973. Properties of rocks and methods of their determination. *Nedra, Moscow*.

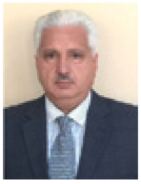
Katsaurov I.I., 1981. Rock mechanics. *Nedra, Moscow*.

Kuliev S.M., Yesman B.I., Gabuzov G.G., 1968. Temperature regime of drilling wells. *Nedra, Moscow*.

Lapinskaya T.A., 1981. Basis of petrography. *Nedra, Moscow*.
Malevanisky V.D., 1976. The discovery of fountains and the fight against them. *Nedra, Moscow*.
Movsumov A.A., 1976. Hydrodynamic foundations of improving the technology of deep wells wiring. *Nedra, Moscow*.
Rzhevsky V.V., Novik G.Ya., 1978. Basics of physical rocks. *Nedra, Moscow*.
Seid-Rza M.K., 1963. Technology of drilling deep wells in complicated conditions. *Azerneshr, Baku*.
Spivak A.I., 1972. Abrasiveness of rocks. *Nedra, Moscow*.
Spivak A.I., Popov A.N., 1994. Destruction of rocks during well drilling. *Nedra, Moscow*.
Sulakshin S.S., 1973. Technology of drilling geological exploration wells. *Nedra, Moscow*.

Shirin Oktay BAHSHALIYEVA, Ph.D. Candidate
Assistant Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and Industry University
16/21 Azadliq Ave, Baku, Azerbaija
E-mail: *bahshaliyeva@mail.ru*

Leyla EFENDIYEVA, M.Sc.
Assistant Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and İndustry University
16/21 Azadliq Ave., Baku, Azerbaijan
E-mail: *orchananalizada@gmail.com*



Rafiq Salman IBRAHIMOV, Ph.D.
Assistant Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and İndustry University
16/21 Azadliq Ave, Baku, Azerbaijan
E-mail: *rafiq.ibrahimov@yahoo.com*

Zaur Rafiq IBRAHIMOV, M.Sc.
Liner Hanger Field Specialist,
Wellbore Construction Product Group, Baker Hughes
Baku, Azerbaija
E-mail: *zaurrafiqoglu@gmail.com*