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Vagif SEIDOV, Prof.
ORCID ID: 0000-0002-3076-4621
e-mail: vagif1439@gmail.com
Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Maleyka AGHAYEVA, Lecturer
ORCID ID: 0000-0002-3399-449X
e-mail: meleykeagayeva12@gmail.com
Azerbaijan State Oil and Industry University, Baku, Azerbaijan

DETERMINATION OF THE OPTIMAL METHOD OF INFLUENCE TO INCREASE THE EFFICIENCY OF RESERVOIR EXPLORATION

(Представлено членом редакційної колегії д-ром геол. наук, проф. О.М. Карпенком)

Background. *Even though the layers that make up oil and gas fields have different geological properties and, as well as different exploitation regimes applied in drilled wells, in most cases it is not possible to extract the expected volume of oil. To increase production, it is necessary to apply various physical effects to the layers. If the influence method is effective, it is possible to extract a certain amount of additional hydrocarbon from the layer. For this reason, selecting an effective influence method is considered to be one of the most important issues in the oil industry.*

Many factors influence the decrease in oil production at the field, one of which is the presence of high-molecular components. These components form pseudocrystalline plug in the pores of the rock and clog them.

The article substantiates the effectiveness of using ultrasonic waves to clean rock pores from pseudocrystalline plug formed by high-molecular components (asphaltenes, resins). It determines the limiting values of ultrasonic vibration frequencies.

There was selection, justification, and determination of limiting values characterizing an effective method of action for cleaning rock pores from pseudocrystalline plugs formed by high-molecular components during the development of oil and gas fields.

The dependence of the influence of ultrasonic waves on the composition and density of fluids found in the pores of the rock, on the density of the rock, as well as on the liquid column settled in the well is established.

Methods. *It is recommended that ultrasonic waves be used to destroy pseudocrystalline plugs in the pores of the rock formed by high-molecular components found in heavy oil during the development of oil and gas fields.*

Results: *as a result of the studies, it became known that for 1 m near the well, seismic waves with a frequency of 287 Hz should be used. For 10 m – 28.7 Hz; 100 m – 2.87 Hz; 200 m – 1.44 Hz; 300 m – 0.98 Hz; 400 m – 0.71 Hz; 500 m – 0.53 Hz. For an acoustic wave: from 0.33 to 525 Hz.*

Conclusions. *Selection of rational methods of influencing the formations, an acceptable method of influencing the formation when the flow rate of wells in the development of fields decreases or completely stops and to justify the effectiveness of the choice.*

Keywords: *development, layers, pores, influence methods, ultrasonic waves, etc.*

Background

The seismic wave influence technology (SWIT) results from many years of research and experiments to develop methods for efficient monitoring and control of geodynamic processes and to solve the problem of protecting the environment from negative environmental changes caused by large-scale industrial operations. The technology can be applied to virtually all geological structures and oil deposits in a wide range of depths, capacities, formation pressures, and water cut parameters. SWIT does not require additional injection of water or other chemical reagents during its application. Prevention of oil deposit destruction and their rehabilitation, increased field life, increased oil percentage in the produced fluid, increased formation pressure, and reduced environmental pollution make it possible to achieve and maintain for a long period the following economically and environmentally important results: - increased oil production by 15–35 %; - decreased current water cut in the produced fluid by 5–12 % for low- and medium-flow wells and up to 20 % for high-flow wells; - increasing the current oil recovery factor to 45 %; - increasing the final oil recovery factor to 70–80 % or more (Kerimov, & Kerimov, 2015).

The problems associated with the difficulties of oil movement in formations, and the nature of pseudocrystalline plug formation are considered, and ways of preventing their formation by wave action are shown. To overcome these difficulties, it is proposed to influence the formations with elastic waves, and a physical justification is given for elastic waves, which play a significant role in increasing oil recovery from formations. Analysis of the elastic effect on oil production showed that this method of action is relatively simple and effective compared to other methods of increasing oil recovery (Seidov, 2003).

Many methods of wave and thermal wave (vibration, shock, pulse, thermoacoustic) action on an oil formation or its bottomhole zone are known. The main goal of the technology is to develop low-permeability isolated zones of a productive formation into development by influencing them with elastic waves that fade in highly permeable sections of the formation but spread over a significant distance and with sufficient intensity to excite low-permeability sections of the formation. By using such methods, it is possible to achieve a noticeable intensification of filtration processes in formations and increase their oil recovery in a wide range of amplitude-frequency characteristics of the impact modes. In this case, the positive effect of wave action is detected both in the directly treated well and, in individual cases, under appropriate treatment modes, in wells located hundreds or more meters from the source of pressure pulses (Ruzin, & Morozyuk, 2014).

The geological, physical and physical-chemical properties of productive formations and fluids were analyzed. The objects were grouped and the centers of the grouping were determined, adjacent objects were selected for further research. The geological features of various groups of objects were analyzed, allowing for planning measures to improve the development system to increase oil recovery. An optimal set of technologies for increasing oil recovery and reducing water cut in formations was recommended, differentiated by the selected groups of fields. It was proposed to apply the recommendations to objects of each of the selected groups (Mukhametshin, Andreev, Dubinsky et al., 2016).

The large differences in water flooding efficiency of the models in different blocks of Beibu Gulf Oil Field, China, are taken as an example of water flow problems leading to low recovery factors. The cores of the W3IV formation in Well W and the L3III formation in Well B were taken for study. By combining dynamic nuclear magnetic resonance, constant rate mercury injection, and microplate visual model, the flow characteristics and factors affecting the water flow at the pore scale of these reservoirs were analyzed. The radii of the pores and throats were small, but the pore throat ratio was large and its distribution range was wide. For example, the pore volume of Well B samples was mainly controlled by the smaller throats. Under such conditions, the dominant flow path of the injected water is easily formed, and this adversely affects the volumetric sweep efficiency of water flooding. The mechanism of this is explained. This leads to the oil recovery in the medium and small pores reaching about 40 %, while it is less than 5 % in the large pores. As a result, the average oil displacement efficiency of well B was only 44.7 %, which was 22.3 % lower than that of well W. (Shen, Lei, Guo et al., 2017).

To increase oil production, it is necessary to influence the formation by methods with different physical characteristics. For this purpose, the application of the method of influence by ultrasonic waves was considered. The graphical dependence of Shvedov-Bingami (Fig. 1) is known, the dependence of the shear rate on the shear stress for the rheological model of the body. When creating shear stress in the medium, there is no inflow; as the medium behaves like a liquid with viscosity (1) (Seidov, 2003)

$$\eta = \frac{d\tau}{d\gamma}, \quad (1)$$

where, $d\tau$ is differential value of the shear rate, and $d\gamma$ is differential value of the shear stress.

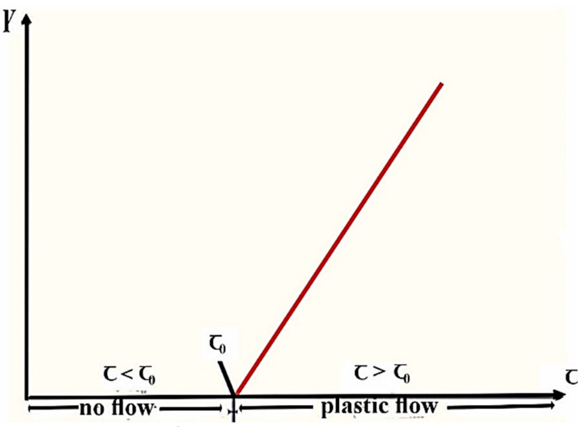

Fig. 1. Shvedov – Bingham dependence.
γ – is the shear rate; τ – shear stress

Such media are called rigid elastic and at $\tau > \tau_0$ there is a plastic inflow. The value is called the ultimate shear stress and cannot create a fluid inflow. This model describes the pattern of hydrocarbon movement in the pore space of rocks.

During reservoir operation, in the bottomhole zone of the reservoir, in most cases, pseudocrystalline plug formed by high-molecular components clog the pores of the rocks. As a result, permeability in this zone decreases sharply, and the well flow rate drops to zero (Fig. 2) (Seidov, 2012).

It is known that the flow rate depends on the permeability of rocks lying within the near-wellbore layer with a thickness of 1.0 m. It is this layer that determines the productivity of the well and its hydrodynamic drainage/flow. In a radius of 1 m of the near-wellbore zone of the formation, the created pressure from different sources increases by several megapascals. In this case, the pressure gradient can be determined by the following formula (2):

$$qradP = A_0/L, \quad (2)$$

where, L is the wavelength; A_0 is the amplitude of the acoustic pressure.

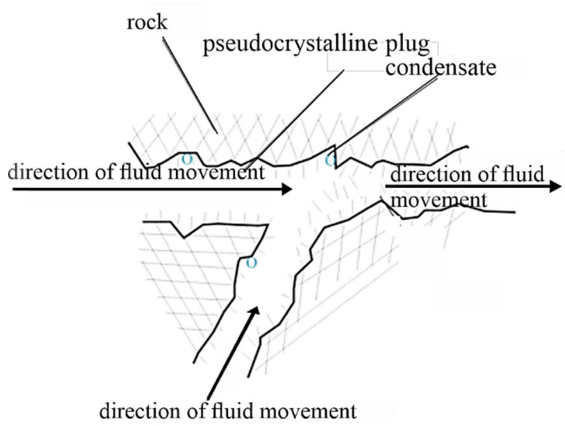

Fig. 2. Scheme of creating plugs in porous rocks

When the formations are affected by emitted wave sources (located in the well), stress of different intensities is created at various points near the wells: near the source; in the rocks located near the wellbore; 1 m from the wellbore. Therefore, it was concluded that when influencing the strata with waves, the radius of their propagation can be increased by several hundred meters by selecting the necessary frequency values. The ultrasonic waves used in the impact correspond to the frequency ranges of acoustic and seismic waves, therefore the analysis of their implementation is studied separately.

Methods

Impact of wave impact. The following effects were revealed during the acoustic wave impact on the formation: vortex motion of the wave in the formation pores; "heating" of the liquid filling the rock pores under the influence of the waves; turbulent motion of the liquid in the rock pores; decrease in oil viscosity. The study showed that all of the above mentioned phenomena cannot co-occur; in this case, it is necessary to create an intense acoustic field, because, without this, it is impossible to increase the impact field. Indeed, during intense impact, resonance occurs in the waves propagating in the rock pores, which ensures its deeper penetration. At the same time, as noted above, the liquid in the pores begins to heat up, after which the shape of the liquid flow becomes turbulent, as a result of which the stress value before the impact is high. After the start of movement in the pores, the temperature field created by the wave energy creates conditions for reducing the viscosity of oil. The analysis showed that the mechanism of acoustic impact is somewhat different, which is associated with the nonlinear rheological form of hydrocarbon behavior. Studying the stress field and its velocity in a nonlinear medium is much more difficult than in a linear medium. To determine the acoustic impact on the formation, we will consider a cylindrical pore of rocks of radius with a rigid-plastic medium placed in it. The flow is not achieved under the condition (Seidov, 2012):

$$\frac{\gamma}{2} grandP < \tau_0. \quad (3)$$

The reason is that the pressure gradient is directed along the pore axis. Taking into account some conditions and transforming inequality (3), we obtain the following inequality (4) *(Seidov, 2012)*

$$\omega^2 A_0 \succ \left(\frac{\rho_1+\rho}{\rho_0}\right) g, \qquad (4)$$

where, ρ_1 is the density of the liquid.

Acoustic impact can be carried out by both transverse and longitudinal waves. At this time, the density of acoustic energy must satisfy the equality (Seidov, 2012):

$$W = \frac{1}{2}\rho\omega^2 A_0^2. \qquad (5)$$

Using the formula (5), the value of the density of acoustic energy was calculated for different values of quantities ρ, ω, A_0 (Table 1).

Looking at the calculated values, it can be seen that the density of acoustic energy changes in a very large range. During the impact on the formation, the wave amplitude and the density of acoustic energy must be proportional to the square of the frequency. Therefore, according to the volume of the formation, it is necessary to increase the frequency so that it does not exceed the attenuation of the wave in numerical value.

Table 1

Value of acoustic energy density

№	ω (Hz)	ρ (kq/m^3)	A (m)	W (Joule/m^3)
1	0.033	1900	0.0000013	0.0000013
2	0.04	1900	0.0000013	0.000002
3	0.0525	1900	0.0000013	0.000034
4	0.33	1900	0.0000013	0.00013
5	0.4	1900	0.0000013	0.0002
6	0.525	1900	0.0000013	0.00034

№	ω (Hz)	ρ (kq/m^3)	A (m)	W (Joule/m^3)
1	3.3	1900	0.0000013	0.013
2	4	1900	0.0000013	0.02
3	5.25	1900	0.0000013	0.034
4	33	1900	0.0000013	1.3
5	40	1900	0.0000013	2.0
6	52.5	1900	0.0000013	3.4

№	ω (Hz)	ρ (kq/m^3)	A (m)	W (Joule/m^3)
1	330	1900	0.0000013	134
2	400	1900	0.0000013	200
3	525	1900	0.0000013	340
4	1050	1900	0.0000013	1362
5	6600	1900	0.0000013	53196.6
6	8000	1900	0.0000013	7904000

№	ω (Hz)	ρ (kq/m^3)	A (m)	W (Joule/m^3)
1	66000	1900	0.0000013	5379660
2	80000	1900	0.0000013	7904000
3	105000	1900	0.0000013	1315880
4	660000	1900	0.0000013	537966000
5	800000	1900	0.0000013	790400000
6	1050000	1900	0.0000013	131588000

The limiting value of the frequencies of waves used for acoustic impact on rocks of any lithological composition (taking into account its density, pore volume, and fluid composition) are determined in the range 0,33–525 Hs, at which the destruction of plugs in the capillaries of rocks is possible.

Acoustic waves were used in the study. For this purpose, an analysis was carried out and wave sources were selected: vortex sources (Fig. 3) (Seidov, 2012).

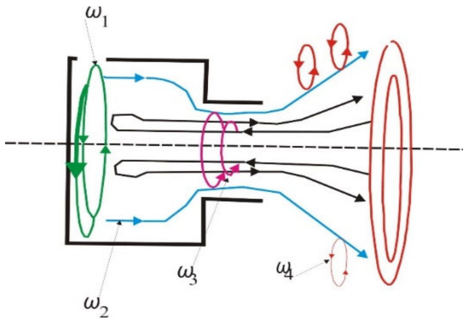

Fig. 3. Schematic structure of the operating principle of a vortex wave source. ω_1 – wave frequency at the input; ω_2 – wave frequency inside the chamber; ω_3 – wave frequency at the output; ω_4 – wave frequency in front of the chamber

In our opinion, hydrodynamic sources can be considered to be the most optimal equipment for creating elastic waves in a high-pressure and temperature environment. The most convenient of these are vortex sources. In our opinion, taking into account the characteristics of oil and gas fields of Azerbaijan, the use of vortex sources in the following structure is more convenient (Fig. 3). The liquid flow from the inlet to the vortex chamber is pumped by a pump, since the outlet of the chamber is perpendicular to the part into which the liquid enters, the liquid entering from the inlet changes direction by hitting the inner part of the chamber located perpendicular to the direction of its movement with great speed, and in this part of the chamber a liquid rotation occurs, the frequency of which is equal to $-\omega_1$. Due to the action of centrifugal force, the pressure along the axis of the chamber decreases, a counter-flow is formed in a certain ratio of its values in the chamber and the head. In the chamber, a precessional movement of the liquid (an attempt to change the direction of the rotation axis of the liquid as a result of the action of the torque) occurs, the frequency of which is also equal to its steady value. As a result, two flows are formed at the outlet, the directions of their rotation coincide, but their rectilinear movements are in opposite directions, which leads to a change in the cross section of the flow, and in this case, the resulting frequency changes.

In addition, the liquid, which is in vortex motion, enters a stationary medium and, as a result, creates a frequency oscillatory motion (expansion). This value, in our opinion, can be expressed by the following formula (6) (Seidov, 2012)

$$\omega_4 = \frac{r^2 \Delta k Q g}{2\pi r_1 c^2 \Delta S} \quad (6)$$

Here, r – is the radius of the hole through which water enters the chamber; r_1– is the radius of the hole through which water exits; Q – is the water flow rate injected into the chamber; c – is the velocity of the liquid exiting the chamber; Δk – is the device coefficient (the difference between the diameters of the outlet and inlet parts); g – is the gravitational field strength; Δs – is the difference between the inlet and outlet fields. Also, the numerical difference between the frequencies obtained is as follows:$\omega_4 > \omega_1 > \omega_2 > \omega_3$. Indeed, if we analyze the entry and exit of the liquid into the chamber, it turns out that it is equal to the value of the smallest frequency. Thus, in other cases, the areas in which the liquid moves are numerically large. However, at the exit of the chamber, this area is numerically the smallest compared to the others, this is done to maximize the numerical value of the liquid velocity (the law of communicating vessels).

Limit values of the frequency of acoustic waves impact on rocks of different lithological composition are determined: from 0.33 to 525 Hz (Table 1).

It is preferable to place such sources mainly in injection wells. This is due to the fact that the sources are not repaired for a long time.

Impact of seismic waves. To trace the propagation of seismic waves in the medium, the results of complex studies were considered, and it was found that the attenuation of waves of different frequencies in layers with different physical properties (in a porous medium, filling it with gas, oil, and water) can be different. Separate researchers explained this feature of wave propagation by its non-linearity. Indeed, the study of emitting seismic sources and receivers remote from it at different distances, which register the spectrum of signals, showed that high-frequency waves are absorbed to a large extent. They become the reason for the formation of signals on the spectrum of registered waves, the frequency of which sharply distinguishes them from each other in layers with different petrophysical characteristics. The amplitude of the resulting waves differs by a large amount from the amplitude of the neighboring spectrum of the signal frequency. Scientists called these signals waves of the "dominant" frequency.

Carrying out different transformations, we get a shortened form of the frequency of the "dominant" waves (7) (Seidov, 2012):

$$\omega_{\text{домин}} = \frac{\vartheta_i \beta_i}{K_i}, \quad (7)$$

where, ϑ_i– the propagation velocity of the surface wave in the rocks; $\beta_i = \sqrt{\frac{E_1}{E_2}}$ – this is an immeasurable quantity and is determined by the physical and mechanical properties of the rocks; K_i – the distance of deviation from the wall of the well.

The frequency of waves when acting on the layer is determined for different sizes for carbonate and terrigenous rocks (Table 2).

Table 2

Calculated frequency of seismic waves

Lithological composition	**Porosity (%)**	**ϑ.10², (m/sec)**	**β**	**ω, (Hz)**				
				R_i, (m)				
				0.0005 m	**0.005 m**	**1 m**	**10 m**	**100 m**
Carbonate rocks	6	60	0.001	12000	1200	6	0.6	0.06
			0.01	120000	12000	60	6	0.6
			0.1	1200000	120000	600	60	6
	15	45	0.001	9000	900	4.5	0.45	0.045
			0.01	90000	9000	45	4.5	0.45
			0.1	900000	90000	450	45	4.5
	25	38	0.001	7600	760	3.8	0.38	0.038
			0.01	76000	7600	38	3.8	0.38
			0.1	760000	76000	380	38	3.8
Terrigenous rocks	5	52.5	0.001	10500	1050	5.25	0.525	0.0525
			0.01	105000	10500	52.5	5.25	0.525
			0.1	1050000	105000	525	52.5	5.25
	15	40	0.001	8000	800	4	0.4	0.04
			0.01	80000	8000	40	4	0.4
			0.1	800000	80000	400	40	4
	30	33	0.001	6600	660	3.3	0.33	0.033
			0.01	66000	6600	33	3.3	0.33
			0.1	660000	66000	330	33	3.3

The knowledge of magnitudes when the stratum is affected by seismic waves is studied. Despite the presence of numerous values characterizing such waves, it is impossible to change their values. It is known that for the propagation of waves in the medium over long distances, its reflection from the medium should be equal to the minimum value. i.e. All the energy of the wave must be spent at its farthest distance.

It should be noted that as a result of the diversity of the skeletal structures of the species, the waves propagating in them can reach different distances. As is known, the particles that make up the rock are separated by clay, which once again confirms the connection between the amount of clay in the rock and its wave reflection coefficient. A valid study of the relationship between two parameters (coefficient of clay) and (coefficient of reflection) for each depth was divided into four groups. The reflection coefficient corresponds to the null value. Hence, it follows that clay soil negatively influences the spread of waves. Therefore, in the pure layers of the collectors, the clay "equals to zero", in the propagation of seismic waves, not a skeleton, but a liquid that fills the pores creates an obstacle, which is necessary for the impact of seismic waves on the environment. This peculiarity of liquid bones has a thermal and mechanical effect on the pseudocrystalline plugs formed in the powder rocks, contributing to their destruction. The second task is also to clarify the influence of waves of different frequencies. For this purpose, using velocity values and dimensionless values, reflecting the properties of layers based on formula (7), the required frequencies for wave propagation at distances of 100, 200, 300, 400, and 500 m were calculated. Following the obtained values, it was concluded that it is necessary to reduce the frequency of waves every 100 m to ensure the propagation of waves over long distances. As a result of the conducted research, it became known that during the impact on the well, it is necessary to apply waves with a frequency of 287 Hz. The calculation is carried out for the propagation of waves over long distances. For example, at 10 m – 28.7 Hz.; 100 m – 2.87 Hz.; 200 m – 1.44 Hz.; 300 m – 0.98 Hz.; 400 m – 0.71 Hz.; 500 m – 0.53 Hz.

Seismic waves were used in the research process. Different sources are used for the excitation of waves. Therefore, it is necessary to consider the selection of the most popular sources of waves. For this purpose, an analysis was conducted and effective sources of waves were selected: electrohydraulic sources with "explosive" wires.

Application. Oil and gas fields of Azerbaijan are considered to be one of the most complex structures in the field of world practice.

This method of impact was not widely used in the oil and gas fields of Azerbaijan. The effect of ultrasonic waves was mainly applied to offshore oil and gas fields. For example, in 4 wells at the Gunashli field, in the 1st well in Duvanny Deniz, in 2 wells in Khara-Zira, in the 1st well in Neft Dashlari, in the 1st well in Pirallahi, etc.

We will consider the sequence of application of this method in the oil and gas sector of Azerbaijan (Fig. 4. Neft Dashlari field).

About 60 % of the liquid flowing out of the well is oil, which is about 0.37 tons/day. The layer is irradiated by a wave source released in front of the filter. During the first month after exposure to waves, the fluid intake increased rapidly, but in recent years, the fluid intake has stabilized with small jumps.

The next example concerns the Gunashli field (Fig. 5). The Gunashli field differs from other fields in its high production capacity. Thus, the daily liquid production in the field's exploitation wells is numerically very large. Therefore, the decrease in the debit is quickly noticeable. The well given in the example produced approximately 90 tons of oil per day during the exploitation period.

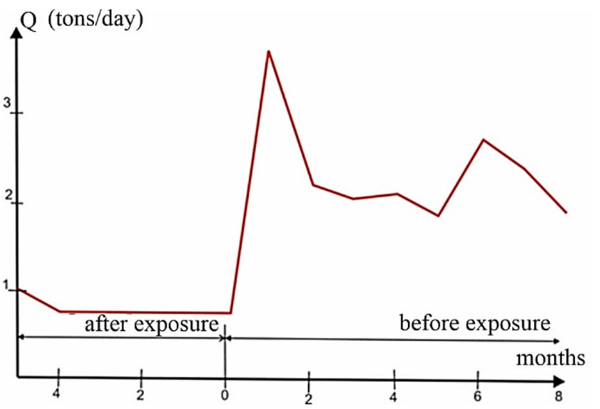

Fig. 4. Dynamics of liquid flow before and after exposure to ultrasonic waves

A two-fold decrease in production was noted in this well. Despite the repair work carried out in the well, it was not possible to restore the previous production. Therefore, two intervals opened in the well were affected by waves. At the initial stage of the impact, the production decreased slightly and the amount of colloidal particles in the liquid increased. After a certain period, the dynamics of liquid production changed in the direction of increase, and this continued, surpassing the previous limit. The duration of the impact in this well exceeded approximately two years.

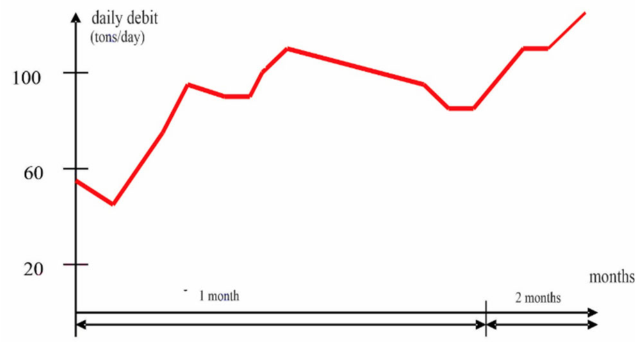

Fig. 5. Dynamics of the produced fluid. Guneshli field, well 143

Discussion and conclusions

Thus, generalizing the results of the research works, with the purpose of effective application of ultrasonic impact on layers of oil and gas deposits of Azerbaijan, the following recommendations can be given: in addition to impact, the oil saturation of layers should be determined; the number of high-molecular components in the extracted liquid is determined; the angle of the layers has to be taken into account; the properties of wave propagation in the medium should be studied (ie, specifying the values affecting it: the strength of the skeleton, the porosity coefficient, the composition of the liquid filling the pores, etc.); it must be determined whether there are violations and ruptures in the tectonic zone exposed to the influence of ultrasonic waves.

The limit values of the frequencies of the waves of impact on the rocks of different lithological composition are determined:

a) for acoustic waves – 0.33–525 Hz;

b) for seismic waves - at a distance of 1 meter around the well 287 Hz, 10 meters – 28.7 Hz, 100 meters – 2.87 Hz, 200 meters – 1.44 Hz, 300 meters – 0.98 Hz, 400 meters – 0.71 Hz, 500 meters – 0.53 Hz.

As a result of such an impact, the resulting productivity is 2–8 times higher than in injection wells (2–3 times higher in terrigenous collectors with porosity of 5–8 %, 2–3 times higher in fractured carbonate rocks productivity of wells increases 3–4 times). These figures are slightly different for oil and gas fields in Azerbaijan. Thus, the increase in productivity compared to injection wells is 1.5–2.3 times higher and this is connected with the complex geological structure.

The developed method can be widely used in all fields, considering the deposit geology. In other words, research work in this direction must be adapted to the deposit geology.

Authors' contribution: Vagif Seidov – conceptualization, methodology, writing (original draft), formal analyses; Maleyka A Aghayeva – data validation, writing (review and editing).

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Вагіф Міргамза СЕЇДОВ, проф.
ORCID ID: 0000-0002-3076-4621
e-mail: vagif1439@gmail.com
Азербайджанський державний університет нафти та промисловості, Баку, Азербайджан

Малейка Ага Алі АГАЄВА, викладач
ORCID ID: 0000-0002-3399-449X
e-mail: meleykeagayeva12@gmail.com
Азербайджанський державний університет нафти та промисловості, Баку, Азербайджан

ВИЗНАЧЕННЯ ОПТИМАЛЬНОГО МЕТОДУ ВПЛИВУ ДЛЯ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ РОЗВІДКИ РОДОВИЩ

Вступ. ***Шари, які утворюють нафтові та газові родовища, мають різні геологічні властивості, а також різні режими експлуатації пробурених свердловин. Водночас добути очікуваний обсяг нафти не завжди вдається. Для збільшення видобутку потрібно застосовувати додаткові алгоритми. При знаходжені ефективного методу впливу з пласта можна отримати певну кількість додаткових вуглеводнів. З цієї причини вибір такого методу вважається одним із найважливіших питань у нафтовій промисловості.***

Методи. ***Рекомендовано використовувати ультразвукові хвилі для руйнування псевдокристалічних пробок у порах гірської породи, утворених високомолекулярними компонентами, що містяться у важкій нафті при розробці нафтових та газових родовищ.***

Результати. ***На зниження видобутку нафти у межах родовища впливає наявність високомолекулярних компонентів. Ці компоненти утворюють псевдокристалічні пробки в порах гірської породи та закупорюють їх. У статті обґрунтовано ефективність використання ультразвукових хвиль для очищення пор гірської породи від псевдокристалічних пробок, утворених високомолекулярними компонентами (асфальтенами, смолами). Визначено граничні значення частот ультразвукових коливань. Вибір, обґрунтування та визначення граничних значень є ефективним способом впливу. Встановлено залежність впливу ультразвукових хвиль від складу та щільності флюїдів, що містяться в порах гірської породи, від щільності породи, а також від стовпа рідини, що накопичується у свердловині. В результаті проведених досліджень стало відомо, що на 1 м поблизу свердловини слід використовувати сейсмічні хвилі із частотою 287 Гц. На 10 м–28,7 Гц; 100 м–2,87 Гц; 200 м–1,44 Гц; 300 м–0,98 Гц; 400 м–0,71 Гц; 500 м–0,53 Гц. Для акустичної хвилі: від 0,33 до 525 Гц.***

Висновки. ***Аргументовано вибір раціональних методів впливу на пласти, зокрема таким методом є визначення впливу на пласт при зниженні або повній зупинці дебіту свердловин при розробці родовищ.***

Ключові слова: ***розробка, пласти, пори, методи впливу, ультразвукові хвилі.***

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