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Geological and Mathematical Analogy of Reservoir and Polymer Structures

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Abstract:
The problem of the article is associated with the study of the conditions development of the formation volumetric deformation as a complex function depending on the geomechanical properties of the rocks. The connection of the differential entropy and reservoir strength characteristics during the study of the rock heterogeneity has been revealed. The geological - mathematical analogy of the rocks' volumetric deformation process and the polymer-gel screen structure destruction process are established. The aim of the study is to obtain analytical expressions to estimate the differential entropy of the geomechanical characteristics of the productive formation, as well as the expressions to study the probability of the polymer-gel screen volumetric deformation in the conditions of polymer flooding under uncertainty. Probabilistic and statistical methods of the field-geological information processing have been chosen as geological-mathematical base of the study. The regularities of the differential entropy change in the transition from a number of the "loose" rocks to the coherent rocks are established. The geological and mathematical analogy study of the productive formation volumetric deformation and the changes of the polymer-gel structure of the flow-deviation screen under the conditions of polymer flooding are proposed. The obtained approximation regularities are recommended to be used for in-depth study of structural and textural features of the sedimentary rocks, containing clay component, as well as to predict the "life time" of the polymer-gel screen in the situation of polymer flooding.

Keywords:*Rehbinder effect; volumetric deformation; Hooke's law; differential entropy; fibrils; heterogeneity of the rocks; flow-deviation technologies.*

I INTRODUCTION

Geomechanical properties of the rocks have a significant impact on geological and technological processes during various hydrocarbons deposits'exploitation even at the stage of drilling-in.

At the initial formation exposing, geological and technological systems of redistribution of the

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acting stresses arise, changing the crystal structure of the minerals and, ultimately, leading to a partial or complete destruction of the interlayers, layers and thicknesses in the borehole zone and beyond [20,21].

The nature of the formation stress state can be represented as a complex function, one of the arguments of which will be the production depth of the reservoir, and the limit of this function will be the occurrence of zonal disintegration.

In its turn, zonal disintegration can also be represented as a complex function of the geomechanical properties of the rocks. Having conducted a tectonophysical analysis of the reservoir properties of the formation, it is possible to identify its production zones with changing (increased) porosity and permeability properties or reservoir properties (RP), depending on the degree of their self-destruction. In this case, the volumetric deformation of the layers will be traced mainly in clay reservoirs (dilation process), where the process of the pores' closure will depend on the fluidity of clay cement (elastic-plastic and viscoplastic deformation models).

The above physical and chemical phenomena significantly affect the level of the well productivity, not only at the stage of formation exposing by various methods of drilling, but also in the further planning process to test the well and influx encroachment stimulation in general.

If we imagine the rock matrix as a large set of individual blocks (elementary volumes), then each such geological fragment of the formation will be in a complex stress individual state, the deformation of which can develop in different ways. The studied formation, located at some depth H will be influenced by the weight of the overlying rocks, which indicates its clamped state. Therefore, the main characteristic that determines the effective stress on the formation will be the vertical (lithostatic) pressure.

The question arises: what analytical expressions describing the deformation processes in the formation and what kind of geomechanical environment should be chosen for?

The equilibrium equations in the framework of the elasticity theory, corresponding to the generalized Hooke's law, will be valid for the elastic medium.

But, the elastic environment is the idealization! The real geological environment is always represented by the anisotropic or orthotropic components, not by an isotropic one. It also can be represented by the transversally isotropic or general complex geological system, which includes all of the abovementioned types.

II MATERIALS AND METHODS

The works in the sphere of rocks' characteristics by Khanin A. A., Yagafarov K. A., Katanov, Y. E. and other native and foreign scientists were used to prepare the study.

III LITERATURE REVIEW

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Hydrocarbon reservoirs with varying degrees of pore cementation, fractured-porous and cavernous space are subjected to the deformation, like any solid body, when exposed to comprehensive stresses, liquids and temperatures.

The deposits of Western Siberia are characterized by the overwhelming predominance of sedimentary rocks, the degree of heterogeneity of which in the study of elastic properties will be significant even at the micro level.

Consequently, the concept of an elastic medium will not make any sense for rocks of sedimentary origin, emphasizing the inapplicability of Hooke's law for real heterogeneous geological environments, the essence of which is a linear pattern between the effective stress on the formation and the deformation processes. This law can be considered as a valid tool only in the case of infinitely small increments of the stresses for the ideal elastic media, rejecting most of the postulates that are usual in classical mechanics and transferred to the real geological environment.

The variability of physical strength characteristics of the rocks, such as compressibility, is not taken into account in the process of modeling that leads to significant errors in the calculations. In this case, the algorithms of the classical basis of the elasticity theory are transferred directly to the study of the rock structure, without taking into account the heterogeneous nature of their formation and further transformation, which can be observed as a non-random or random characteristic.

In addition, from the position of structural features, the productive formation is a fractured-porous, porous or cavernous geological system, which contains hydrocarbons and formation water in its pore space, micro-cavities, cracks and caverns (vugs). When the structure of the reservoir pore-void space is deforming, and, consequently, there is a predominance of physical and chemical factors of structural impact, causing the overlap of pore channels and partial (or complete) blockage of microchannels in the geological environment, there is a deterioration of the main petrophysical characteristics, such as permeability in the borehole zone, which leads to an unregulated redistribution of filtration flows and water cut acceleration in the drainage area.

For such structural transformations, the main geomechanical parameters such as Young's modulus (longitudinal deformation), Poisson's ratio and shear modulus are unsteady, therefore, during stressing (with an increase in lithostatic pressure, with an increase in the depth of deposition), relaxation and creep phenomena will occur in the formation. The relaxation is determined by the reduction of stresses at constant strain, while creep is characterized by the growth of strain at constant stress. In the conditions of an anisotropic medium for the formation stress-strain state system, both of these phenomena can be manifested, mutually replacing each other depending on the external forces level [1,3,6,17].

Anisotropy of the mechanical properties of the rocks is manifested in the study of the elastic modulus at uniaxial or all-round compression of the formation sample, directed perpendicular to the stratification (predominance of orthotropy) and along the stratification (transversally isotropic geological environment). For example, for mono-, oligo - and polymictic sandstones with porosity of about 22-25 % with all-round compression, the longitudinal deformation modulus can increase up to 15-17 %, which corresponds to a sharp change in elastic properties at pressures of 60-110 MPa and continues to the pressures of about 200 MPa. Such substantial change ranges of the effective pressure are formed during the heterogeneities' system growth in the geological environment.

Thermodynamics may be a fundamental scientific discipline n the studying process of the heterogeneous nature of geological environments,

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where the rocks are represented as highly heterogeneous geological complexes, the degree of heterogeneity of which can be investigated in the systems of "disorder - order" and "order-disorder".

Changing of the rock tensile strength (compression, shear) in the transition from the micro-level (slides), by-passing the meso-level (core samples), to the macro-level (formation) leads to uncertainty of the physical and mechanical properties of the geological environment.

The semantic content of the uncertainty concept will include a set of aspects of qualitative and quantitative nature, such as the lack of an unambiguous method of measurement, the adequacy of which is not fully clear; ambiguity of the geological body (geological individual, geological unit) properties; fuzzy interpretation of the measurement results and calculation in the cases where the problems of fuzziness and ambiguity have not been solved a priori. Consequently, there is an interrelated set of systemic manifestations of the rocks' strength parameters in the form of a set of all kinds of "heterogeneity-uncertainty" cases.

The measure of "disorder" in thermodynamics is entropy [11], the mathematical relationship of which with the probability of different "order-disorder" systems' states was presented by Ludwig Boltzmann [5], but Max Planck showed this relationship in the form of a formula analytically:

$S = k \cdot \ln(\Omega)$, (1)

where constant $\mathrm{k} = 1{,}38 \cdot 10^{-25}\mathrm{J/K}$ is the value of the Boltzmann constant, and Ω is the weight of various statistical states, that is, the number of various ways of grouping (microstates), with a help of which a single macroscopic state is formed.

It should be noted the "evolution" of the entropy concept. Initially, as it was mentioned above, the term refers purely to thermodynamics. Further, Claude Shannon (1949) introduced the concept of information entropy as a measure of uncertainty in the processing and further use of heterogeneous data (information theory and statistical physics). The next stage of the development was formed by A. N. Kolmogorov (1954), who introduced the concept of differential entropy as a measure of chaotic motion in a phase space of random dimension.

In the context of geology and geomechanics, it is often necessary to differentiate the source data to minimize the spread of discrete values on the plane during visualization. The essence of this differentiation is the difference between the subsequent and current values of the processed data to find the value of their displacements relative to each other. During this transformation, the original series will be reduced by one observation.

It is with respect to these displacements of discrete data series from each other the term of differential entropy for geological systems is linked.

The authors of this research paper propose to use differential entropy as a measure of qualitative description of the rocks' heterogeneity.

To determine the differential entropy, on the example of rock compressive strength, it is necessary to find the probabilities $p_1(A_1), p_2(A_2), \dots, p_n(A_n)$of the events $A_1, A_2, \dots, A_n$describing the different states of this strength characteristic of the reservoirs as a random variable [7].

The following formula was proposed to determine the entropy of H for statistical mechanics, describing thermodynamic systems [8,13]:

$$H\big(p_1(A_1), p_2(A_2), \dots, p_n(A_n)\big) = -\sum_{k=1}^{n} p_k \cdot lgpk, \qquad (2)$$

where$\sum_{i=1}^{n} p_i(A_i) = 1$-acomplete system of all kinds of events.

Since the events are independent of each other, then denoting the P_i - probability of the $i-th$ factor of occurrence and development of deformation defect (point, linear) on the principle of the "weakest link", for the normal law of distribution of the reservoirs' strength parameters, we obtain the following:

$$P_i = \frac{1}{\sigma_i \cdot \sqrt{2\pi}} \cdot \int_0^{x_i} e^{\left(-\frac{(x-\mu)^2}{2\sigma_i^2}\right)} dx,$$
(3)

where $\mu, \sigma$are the characteristics of the probability distribution represented by physically specific values that are associated with the choice of the measurement scale, while $\sigma_i > 0$is the scale factor (standard deviation, displacement), μ - is the shift coefficient (mean value, expectation, median, distribution mode), x_i- is the intercept of the investigated factor for the $i-th$ step.

The choice of normal distribution is characterized by the central limit theorem of the probability theory, the main essence of which is as follows: if the studied discrete values do not have an effect significantly different from the influence of other data in the total population, their distribution within a single measurement system is considered to be close to normal. In addition, the limit of any kind of distribution, with an increase in the number of observations, is the normal distribution law (Gauss law). We divide the curvilinear figure described by formula (1) into two sections and transfer this scheme to the problem of rock deformation (Fig1).

To the left of the vertical, the interval $(0;\mu)$ will be determined by the reversible deformation of the reservoir, when there is a redistribution of nodes in the crystallattice of the minerals their structure preservation; point $x=\mu$ will determine the tensile strength of the reservoir (compression, shear) when the structure of the crystal lattice of the mineral begins to collapse during the entire interval $(\mu;2\mu)$, which corresponds to the irreversible deformation. In this case, each selected interval is equally probable.

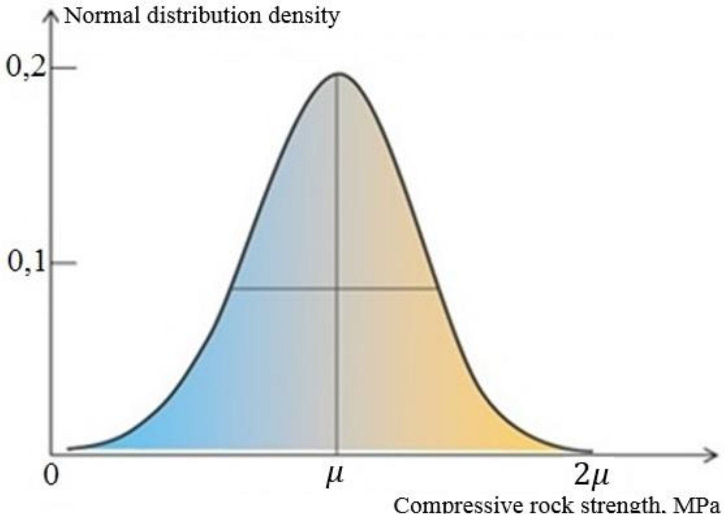

Fig.1.The density curve of the normal distribution of the rock compressive strength (tension, shear), formed by symmetrical sections that correspond to the intervals of permissible values $(0;\mu)$ and $(\mu;2\mu)$

Since each interval of permissible rock compressive strength values (tension, shear) is equally probable, the index$i$ for the heterogeneity parameter σ can be omitted and, as a result, we obtain the following:

$$p_1 = \frac{1}{\sigma \cdot \sqrt{2\pi}} \cdot \int_0^{\mu} e^{\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]} dx, \quad (4)$$

$$p_2 = \frac{1}{\sigma \cdot \sqrt{2\pi}} \cdot \int_{\mu}^{2\mu} e^{\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]} dx,$$
(5)

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For the formulae (4) and (5), the value of x will be determined by the current effective stress on the formation, butμ - by the tensile strength of a particular lithological type of the reservoir;σ- is a dispersion (sampling or general totality), qualitatively characterizing the level of the reservoirs' heterogeneity.

It is necessary to mention the factor of physical and chemical impact on the formation during the hydrocarbon deposits exploitation; the effect of adsorption reduction of the rock strength when it is exposed to active substances. This effect is called the Rehbinder effect, which can be both external and internal.

The external effect of Rehbinder is caused by the substances' adsorption on the outer surface of the deformed geological body, and the internal effect of Rehbinder occurs when the reservoir fluid adsorption on the surface of the defects of the geological structure within the rock happens, as a result, gradual transformation from a stable to an unstable state occurs, leading to an adsorption decrease of the strength (in certain zones) and the process of rock dispersion with rapid leaching of the cementing material between the grains of the rock (intraformational suffusion) as a result of the reservoir fluid influence.

Factoring out$\frac{1}{\sigma\cdot\sqrt{2\pi}}$in the formulae (4-5) and, taking into account (2), the differential entropy H can be represented as follows:

$$H = \frac{1}{\sigma\cdot\sqrt{2\pi}}\cdot\left\{lg\int_0^{\mu} e^{\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]}dx + lg\int_{\mu}^{2\mu} e^{\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]}dx\right\}, \quad (6)$$

where the first (left) addend "in brackets" corresponds to the manifestation of the external Rehbinder effect, and the second (right) - to the internal Rehbinder effect.

According to the obtained expression (6), the differential entropy is described by a complex function of the dispersion σ, which expresses the reservoir heterogeneity that emphasizes the analytical relationship between these characteristics, which is as follows: the smaller the differential entropy, the higher the dispersion value and, consequently, the higher the heterogeneity of the rock under study. The reverse nature of interaction remains.

To show the practical use of this formula, let us consider the pore reservoir as a geological system consisting of three spatial characteristics: the pore volume; a set of spatial relationships that give the rock the properties of a solid physical body, as well as a skeleton from solid particles of the rock. This structural set of productive formation can be represented as a system of loose, medium and strongly cemented rocks.

Loose rocks have minor or no relationship among individual grains of minerals, which characterizes their maximum disorderliness within a single geological body, where the differential entropy should be maximum in comparison with other rock structures.

If we consider the "loose" rocks from the point of view of the statistical approach [10], they will structurally form a statistical ensemble, that is, a set of a large number of similar physical systems consisting of sets of particles (rock grains) that are in relatively similar macroscopic states. And, as the transition from loose rocks to strongly cemented rocks happens, the emergence of new and strengthening of the existing bonds among minerals will be observed.

According to the P. A. Rebinder classification, with respect to the geological series: "loose" rocks - sandstones - clay minerals (clay), their density and the number of bonds in the formation will increase. In this case, the proportion of clay matter (or carbonate cement, depending on the lithological composition of the rock) in the "loose" rocks will be minimal, and in clay minerals - maximum.

Consequently, the differential entropy in a

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series of loose rocks - sandstone - clay will decrease.

According to the A. A. Khanin classification, the feature ω - relatively average concentration of clay colloids in the examined rock - was introduced for reservoirs of Western Siberia [12,15]; according to this feature the "loose" rocks are defined by the interval of allowed values ω=0-0,17; sandstones: ω=0,17-0,5; clay: ω=0,5-1; for the rock-forming minerals: mixed-layer formation (MLF) - 0.13, hydromica - 0.17, chlorite - 0.33, kaolinite - 0,34.

The authors have established an analogy of the differential entropy change in the process of changing of formation petrophysical characteristics on the example of the permeability field (according to the lithological type) (Fig2).

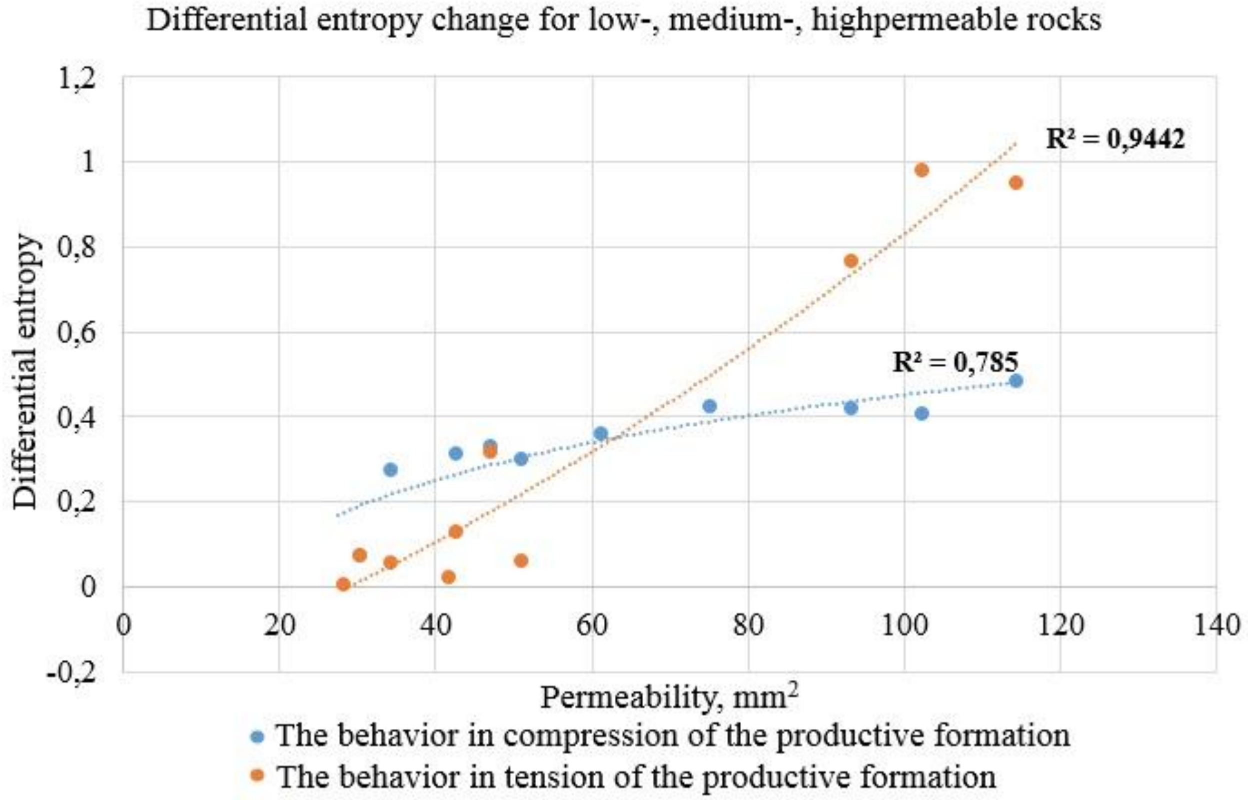

Fig.2. Differential entropy as a complex function depending on the permeability field change, according to the lithological types of the rock formation

In the transition from low - to medium - and high-permeable rocks, the differential entropy increases, due to a decrease in the clay component between the grains of the rock-forming minerals; that fact increases the probability of uncontrolled changes in the structure of the rock, due to the constantly changing thermodynamic characteristics.

In the scientific work [Katanov Yu. E. Geological and mathematical modeling of reservoir deformation in the development of oil reserves. Candidate thesis in Geological and Mineralogical Sciences. Tyumen, 2018. - 124 p.] the analytical expressions were obtained to study the probabilities of the volume deformations development (dilatancy process) and the reservoirs' destruction (disintegration process) taking into account the Rehbinder effect.

We transfer these algorithms to the study of the volumetric deformation process and polymer structure destruction, thereby establishing a new geological and mathematical analogy.

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It should be noted that the Rehbinder effect is rather universal in the process of deformation (destruction) of the rock structures and the polymers’ structure transformation.
To understand the nature of the polymers’ structure, it is necessary to introduce a number of explanations.

Polymer films contain a set of macromolecules that are held together by hydrogen bonds or Van der Waals’ forces, which are weaker than covalent bonds within the macromolecules. That’s why, a single macromolecule, even as an independent node in the totality (collective), retains the relative individual qualities and isolation within a single structure.

The structural feature of any polymers is the chain structure of their macromolecules, due to which their flexibility is provided by deformation of the valence angles and possible turns of the links under the action of external (system) mechanical stress.

If the intracrystalline and intercrystalline features of the minerals are taken into account to estimate the deformation of the formation, this analogy is realized in polymers by intermolecular bonds. The emergence, development and further transformation of the new surface for any adsorption-active liquid will be observed in the process of volumetric deformation of the polymer, and not only in the destruction of its structure, which is accompanied by the reorientation of macromolecules.

Polymer flooding is implemented in the porous, fractured-porous and other hollow-porous reservoirs, which is also accompanied by a comprehensive stress on the formation, the structure of which is subjected to volumetric deformation, and fibrillar-porous structure is formed in the polymer, which consists of filamentous macromolecules (fibrils), separated by pores’ analogues (micro-voids).

Fibrils are randomly distributed in the polymer space (analogy with the random distribution of vacancies (point defects in the rock) in the reservoir), therefore, such kind of a structure contains many micro-voids, constant (increasing) physical and mechanical impact on which will lead to the formation of irreversible deformation of the polymer structure.

Since micro voids (pores) are filled with formation fluid, the heterogeneous structure of the polymer will remain after the removal of the effective stress (reversible deformation). But the fibrillar-porous structure of the polymer occurs only in some of its zones (a direct analogy with the zones of adsorption decrease of the reservoirs’ strength) and as the volume deformation develops, the structure of the remaining volume of the polymer will change (a direct analogy with the stress concentrators in the reservoir, as the places of vacancies concentration and disturbance in the process of their "movement" during the transition from micro-to macro-investigation).

Although it is believed that the polymer-gel screen is impermeable, but since it contains micro-voids, it should be considered as low permeable and in the process of interaction with the formation fluid, the level of void space in its structure will only increase.

Since the temperature of the formation can also change during the wells’ operation, the most exposed areas of the polymer-gel screen will form the so-called lamellas. A lamella is a crystalline form of a polymer that is characterized by a folded conformation (defined by a spatial configuration) of macromolecules. The appearance of such crystallized ordered complexes, which in their structure resemble the shape of the tape, is due to the appearance of excess energy on the surfaces of the phases in the process of the polymers’ crystallization [8].

Since the structure of the polymer acquires a crystalline feature, similar to the structure of the reservoir, the volume deformation and disintegration of such areas of the polymer-gel screen can be studied by the same methods that

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are applied to the rocks.

Let us consider the basic essence of the polymer flooding implementation (diverter technology), the meaning of which is to reduce the permeability in the borehole and wipe-out zones, as well as in the area of rock decompression.

Geological and technological efficiency of the diverter technologies, for example, viscoelastic gels (VEG) and cross-linked polymer-disperse systems (CLPDS) can be studied by comparing the values of the permeability field after and before treatment [2,3]:

$$\gamma = \frac{K_2}{K_1}, \quad (7)$$

whereK_1- is the permeability value of the investigated area of the formation before treatment (VEG, CLPDS), K_2 - is the permeability value of the investigated area of the formation after treatment (VEG, CLPDS).

The increasing technology of the hydrocarbons selection from the productive formation when used (VEG, CLPDS) will be aimed at the increasing of the current and final coefficient of fluid return by increasing the reservoir coverage by polymer flooding, which is carried out selectively, that is, in the form of sequential injection of slowly crosslinking solutions of different concentrations that can penetrate deep into the formation [14].

It should create conditions for redistribution of filtration flows with the identified factors of initial and residual resistances (Fig3), which leads to:

-relative containment of pumped water breakthrough into production wells;

- involvement of new non-operating areas of the formation and individual geological zones with reduced permeability into development;

-the water content reducing or stabilizing of the drained zone with the injection wells that are connected hydrodynamically;

- hydrocarbon production increase.

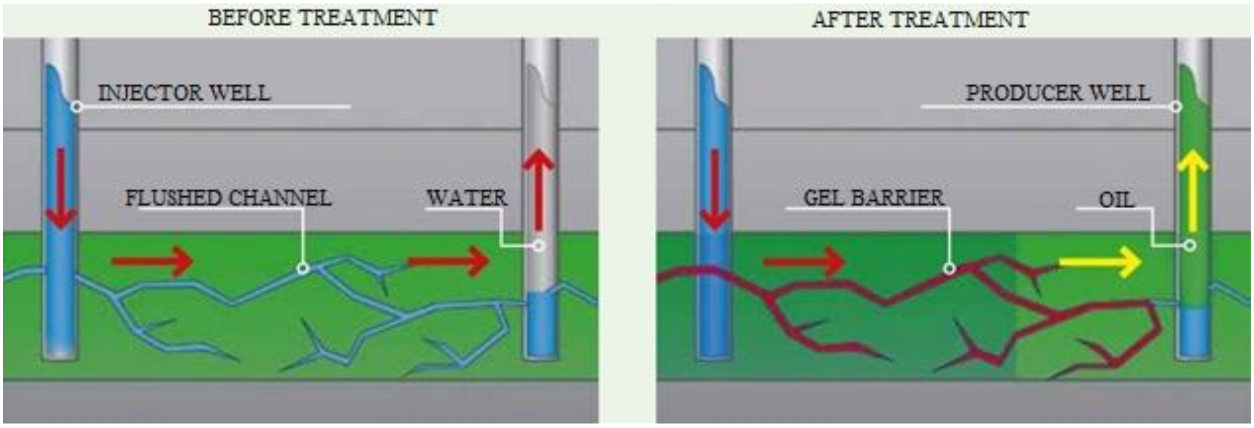

Fig.3. Selective injection of polymer solutions;injection of the compositions [8]

The basis of the polymer solution can consist of different compositions, but most often, it is represented by a composition of polyacrylamide (PAA), solvent (often water) and crosslinker. At the same time, if an aqueous solution is injected into the well, which hydrophobically associates the polymer, it will begin to form a physical gel over the entire volume of the well.

But the gel can block the filtration flows not only of the water prevailing in the formation, but also the hydrocarbons. To minimize this phenomenon, it is necessary to use an individual inhibitor of gel formation, which is not dissolved in the fluid, but is soluble in water, thereby redistributing it in the direction of the optimal filtration flow (Fig. 3).

It should be noted that there are varieties of diverter technologies that block wipeout and borehole zones completely and there are those technologies that change only the wettability of the rock and change the relative phase permeability.

We transfer the proposed algorithm for the volumetric polymer-gel screen deformation studying into an interactive mode and investigate the final result.

Hydrodynamic models of oil saturation and permeability change ofthe productive formation YuV_1^1, Las-Eganoil field, the base of which are thepolymicticsandstones have been built with the step of 1 quarter, during the basic period of investigation (1 year) , using hydrodynamic simulator TNavigator [9,18,19] (Figs. 5-6).

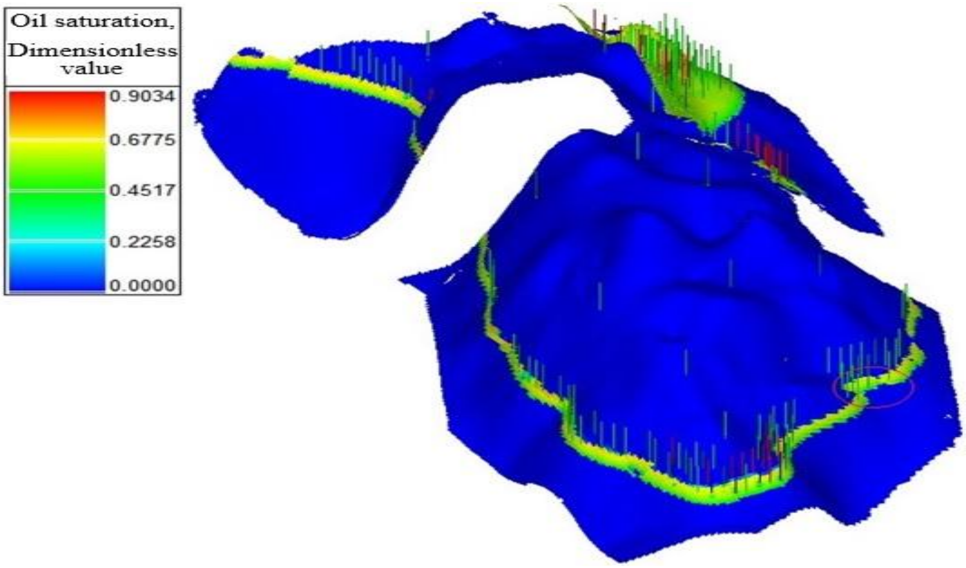

Fig. 4. Oil Saturation of the investigated area of the productive formation YuV_1^1 of Las-Egan oil field

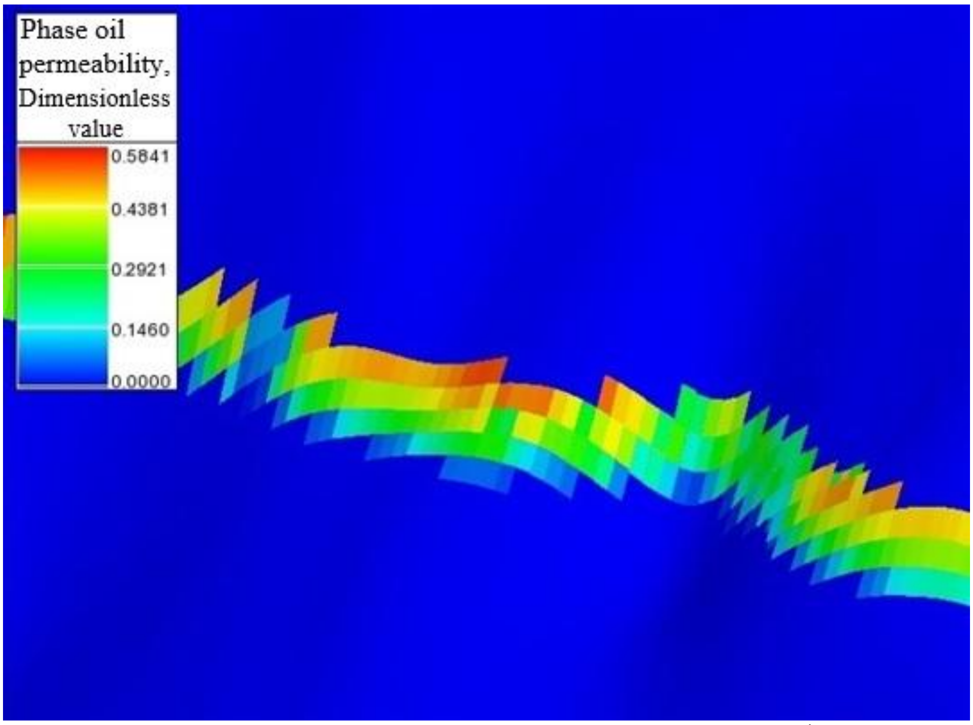

Fig. 5. Permeability field of the investigated area of productive formation YuV_1^1 Las-Egan oil field (the area is highlighted by the circle on Fig. 4) for the study period of 1 quarter

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After conducting the similar studies for the remaining three cases, we have obtained the following changes in the permeability fields (Fig. 6).

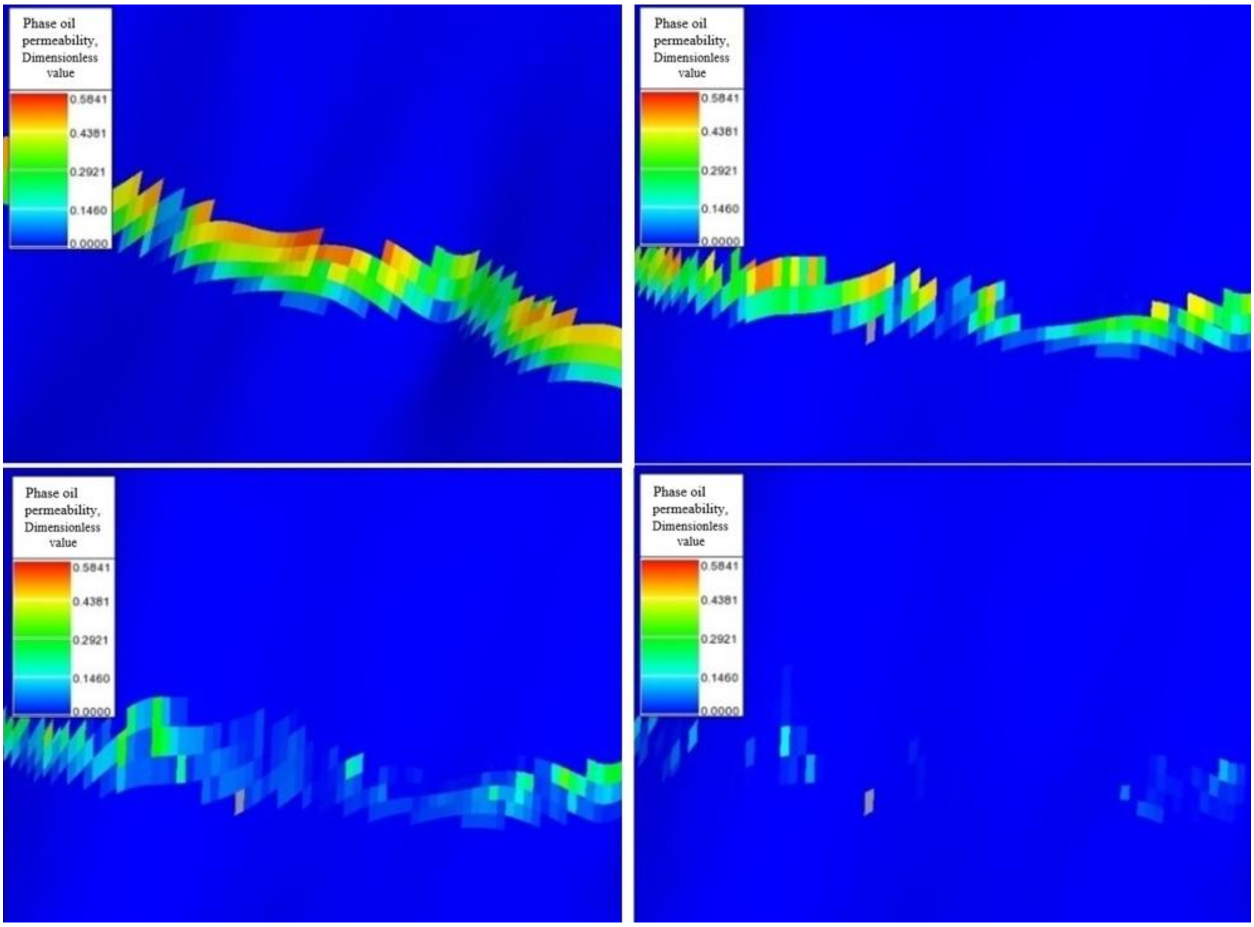

Fig. 6. Change of the permeability fields of the investigated area of the productive formation YuV_1^1 Las-Egan for the 2, 3, 4 quarters

Each of the represented four cases corresponds to the following probabilities of volumetric deformation of the gel (flow-deflecting (diverter)) screen (Fig. 7).

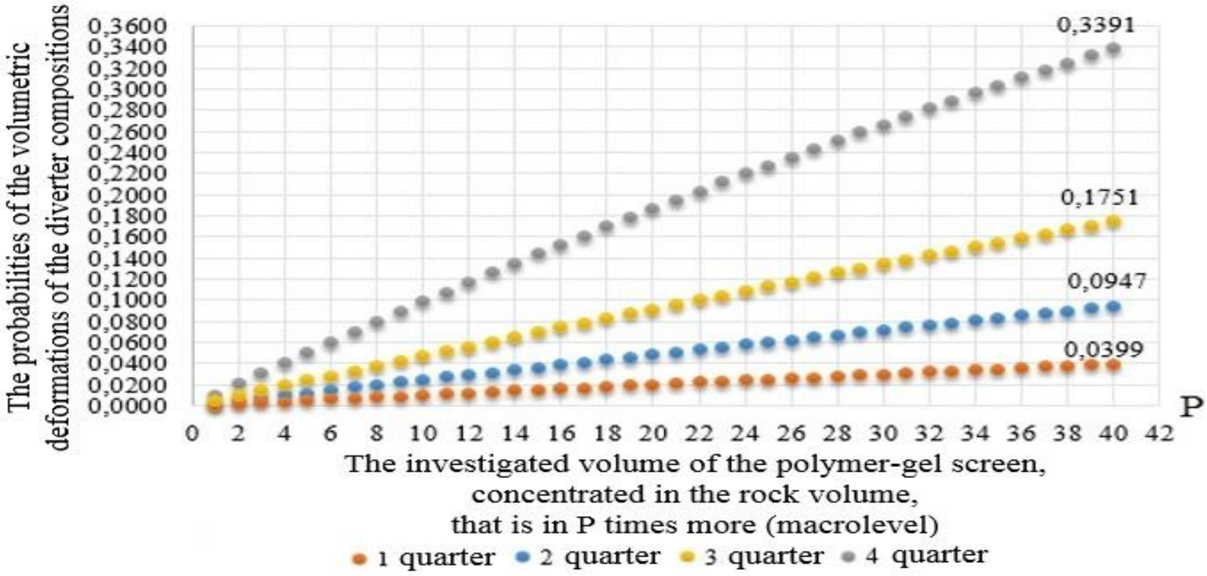

Fig. 7. The Probabilities of volumetric deformation of the polymer gel screen

Comparing the results it is seen that the probability of volumetric deformation of the diverter screen has increased for the period of the 2nd quarter (taking into account the first quarter) by 5.48%, for the 3rd quarter (taking into account the second quarter) - 8.04%, for the 4th quarter (taking into account the 3rd quarter) - 16.4%. At the end of the calculation period (1 year), the volume deformation of the gel screen is 33.91 %.

The general trend of the permeability field change in the well bore and wipeout zones, operating the investigated section of the productive formation YuV_1^1 of Las-Egan oil field is shown in (Fig. 8).

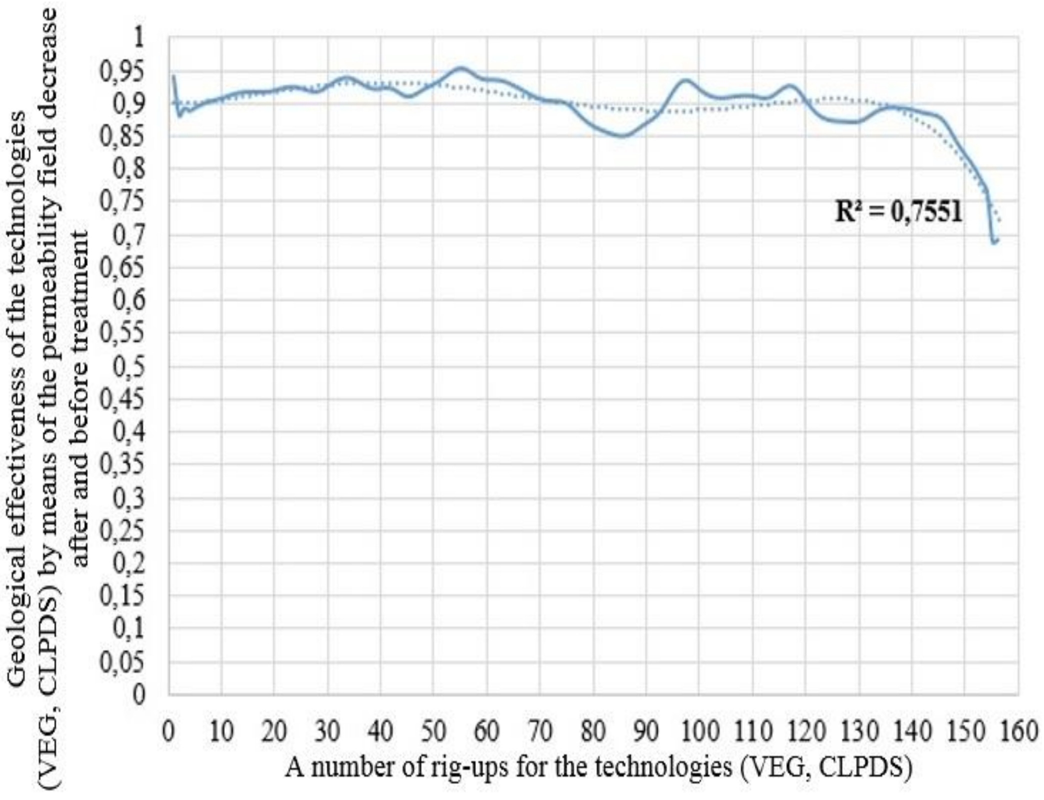

Fig. 8.An average trend of the field permeability decrease in well bore and wipeout zones of the studied productive section of the formation YuV_1^1 through the technologies' application of (VEG, CLPDS)

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Figure 8 illustrates that the use of the technologies (VEG, CLPDS) leads to the permeability decrease, which causes the geological efficiency of flow-deflecting compositions (diverters). 156 borehole-treatments of the investigated boreholes of the productive formation area YuV_1^1 Las-Egan oil field, the permeability decreased (for the period of 1 quarter treatment) on the value: $\gamma^* = 1 - \gamma_{weihgted\ average} = 1 - \frac{\sum_{i=1}^{n} w_i \cdot f(x_i)}{\sum_{i=1}^{n} w_i} = 1 - 0.917 = 0.083 = 8.3\ \%$ - the estimated qualitative assessment of the geological and technological efficiency of the technologies (VEG, CLPDS). For the 2nd quarter, the decrease of the permeability field was 8.5 %, for the third quarter 10 %, for the fourth quarter 14.7 %

Therefore, for the accounting period (1 year = 1 quarter + 2 quarter + 3 quarter + 4 quarter), the total set of geological and technological effect from the implementation of the diverter technologies (VEG, CLPDS) was: 8.3 + 8.5 + 10 + 14.7 = 41.5 %.[22-27]

The permeability decrease of the treated zone of the productive formationYuV_1^1after the technologies (VEG, CLPDS) application is determined by a decrease of the mineral particles' dispersion of the reservoir, which fits to the logic about the transformation of the structure - during the chemical treatment of the rock, the nodes of the minerals' crystal lattice are strengthened and the zones of adsorption strength decrease are eliminated, which causes a decrease in the dispersion of the rock strength properties.

IV RESULTS

A decrease in differential entropy with an increase of the cementing substance concentration of the rock has been found. The analogy of the rock porous medium structure and fibrillar-porous structure of the polymer has been obtained. On the basis of these facts you can explore volumetric deformation and disintegration of the polymer-gel screen and, as a consequence, its effectiveness in the process of exploitation of hydrocarbons deposits.

On the basis of the initial geological data processing, geological and technological efficiency of the technologies implementation (VEG, CLPDS) has constituted 41.5 % of the permeability field reduction in the well bore and wipeout zones of the productive sector of the formation YuV_1^1 from the initial level of this parameter (before treatment (VEG, CLPDS)). The value of the volumetric deformation of the polymer-gel screen, at the end of the calculation period (1 year) is of 33.91 %.

If we expand this study to include other geological and technological characteristics that can significantly affect the process of redistribution of filtration flows in general, the value of the resulting probability of volumetric deformation and, as a result, the disintegration of the polymer-gel screen will increase significantly. Thus, it is possible to predict the "lifetime" of the screen.

V DISCUSSIONS

The results of the research were presented at the seminars of the Applied Geophysics, Geology and Oil and Gas fields' development and operation Department, as well as at scientific conferences of Industrial University of Tyumen.

VI CONCLUSIONS

The presented investigation algorithm of the rock deformation-spatial variability will be useful in the geological and technological polymer flooding efficiency assessingof the productive layers under the conditions of hydrocarbon reserves development.

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