Analysis of the causes of flooding of long-term deposits under conditions of high geological heterogeneity

Ruslan Gilyazetdinov[1*], *Rif* Vafin[1], *Lyubov* Kuleshova[1], and *Vyacheslav V* Mukhametshin[2]

[1]Institute of Oil and Gas FSBEI of HE "Ufa State Petroleum Technological University", (Branch in the City of Oktyabrsky), 54a, Devonskaya Street, Oktyabrsky, Republic of Bashkortostan, 452607, Russia
[2]Ufa State Petroleum Technological University, 1, Kosmonavtov Street, Ufa, Republic of Bashkortostan, 450064, Russia

Abstract. In this work, the object of research was the long-term deposits of liquid hydrocarbons located within the boundaries of fields with high geological heterogeneity, the proportion of which is actively increasing every year due to the selection of a significant part of the "light" oil reserves. Based on the generalization of the results of direct and indirect research on the topic of the work, the key causes of well flooding were identified and their primary sources were identified, which made it possible to successfully describe the mechanisms of formation of the transition zone of the oil-water system, depending on the stage of development. The conclusion is made about the importance of applying relevant and reliable scientific and methodological approaches in interpreting the results of geophysical research to solve various problems of oil field development.

1 Introduction

The regular flooding of wells is the result of depletion of reserves in the zone of the productive formation, with which a hydrodynamic connection has been established, due to prolonged drainage and extraction of useful hydrocarbons to the daytime surface. This is a typical reason for well flooding for deposits in the Russian Federation, when the well has worked for a sufficient number of years and, based on the results of field and geophysical studies, together with economic calculations, the lack of prospects has been determined for its further operation due to low profitability [1-5].

Based on the experience of the development and operation of deposits in the Russian Federation, together with the study of the mechanisms of well flooding under various conditions, a premature increase in the share of extracted water in products occurs due to the following common reasons [6-9]:

- Violation of the integrity of the space between the casing and the formation.
- Formation and movement of plantar water.

* Corresponding author: vv@of.ugntu.ru

- The movement of the agent used in the reservoir pressure maintenance system to implement the oil displacement process through highly permeable channels obtained during prolonged selective exposure to the object area [10-12].
- Development of deposits of useful hydrocarbons, the geological features of which consist in the presence of alternating zones with a pronounced volume of water and oil, which are in direct contact and mutual influence with each other.

2 Methods and materials

The group of reasons for premature watering of wells should also include the circulation of liquid behind the casing, caused by violations of the technical condition of the well due to regular wear and external influences, geological factors or incorrect operations during major and routine well repairs [14-16]. Column circulation includes a large list of manifestations of this complication, which can be represented by the classification implemented in Table 1.

Table 1. Classifier of types of column circulations by primary source and type of problem.

Causes of column circulation in production and injection wells	**Primary sources (or) varieties of the problem**
The presence of vertical permeability in the borehole part of the well	Geological
Leaky connection between casing strings and cement filler	1. Deformation of pipe coatings due to the properties of metals (technological); 2. The presence of clay solution residues in the area of casing pipes (geological and technological);
Formation of channels of various lengths and character in cement support	Resistance of tampon materials to the effects of various processes occurring during operation
Incomplete replacement of clay mortar with cement composition	1. The eccentric arrangement of the casing strings as a result of geological and technological factors; 2. The presence of areas clogged with drilling mud residues;
Leaky interaction of the cement cup and the walls of wells	Destruction of clay formations of various shapes as a result of its extrusion, dehydration due to the contractional effect and coagulation under the action of electrolyte
Wear of cement stone during various major and routine repairs (perforation, hydraulic fracturing, acid treatment)	Technological

In addition to the above-mentioned reasons for the ingress of third-party waters into the borehole space and the products of their operation, many researchers identify the following factors of premature flooding for a certain group of deposits:

- Variability of the relative phase permeability of oil-saturated horizons in the conditions of zones between which the well-reservoir hydrodynamic connection is implemented.
- Instability of temperature and dynamic parameters of the near-well zone during prolonged development of the productive horizon.
- Cracking of reservoir rocks and other rocks composing the productive thickness of the object due to a decrease in reservoir pressure due to intensive drainage of the deposit and selection of reserves.

According to the results of practical research, the precise determination of the causes and source of well flooding is an important task in planning and implementing operations to eliminate water inflow. In certain cases, it seems impossible to identify the mechanism of

the additional volume of liquid entering the well products, which is not foreseen by the operation technology.

Taking into account the above factors, together with the analysis of modern literary sources devoted to solving the issue of third-party water entering the well, it allowed us to create an integrated approach to understanding the mechanisms of well flooding and identify three key clusters of causes of water inflow not provided for by the operation technology:

- The first cluster contains sources characterized by the features of the geological structure of the object, the extracted fluid and operating conditions.
- The second cluster is represented by sources related to processes occurring in the near-well zone of the formation and affecting the movement of liquid to producing wells and its rise to the surface.
- The third cluster is due to the technical condition of the well, as a result of which leaky spaces between the column and the walls of wells, various corrosion disorders in pipe sections become sources of premature flooding.

3 Results and Discussion

The fight against premature flooding of facilities includes a set of measures aimed at early prevention and subsequent elimination of water flows both during drilling and during well operation. It is worth noting that the period of water entering the well space is not always clearly divided into the following three stages: the primary formation of water inflow, increasing the rate of irrigation, stabilization of high water content in products.

Taking into account the desire of subsurface users to achieve the design indicators of the oil recovery coefficient in many mature fields, there is a tendency to constantly increase or restore the potentials of wells with the help of geological and technical measures. Due to this, the stage of primary formation of water inflow can occur without significant consequences for the well due to the intensity of processes in the bottomhole zone of the formation.

But, after a certain period of time, as field practice shows, the rate of well flooding becomes so intense that it is impossible to accurately identify and identify transition zones. A simplified view of the above-mentioned uncertainty arising during the operation of wells can be represented in the form of Euler circles relative to each stage of field development (Figure 1).

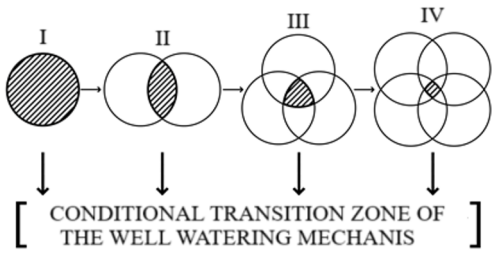

Fig. 1. The scheme of dispersion of the transition zone, characterizing the mechanism of well flooding : I,II,III,IV - stages of field development.

In order to identify the causes of water entering the well space, which is not provided for by the technology of its operation, hydrodynamic and geophysical studies of field development control are carried out. The results of measurements using resistivimeters, moisture meters, flow meters and density meters allow us to study the distribution of fluid

components in the borehole space and establish the nature of the inflow by comparing the interval of its location with the perforation intervals. High-precision thermometry, pulse neutron-neutron logging, are used to register overflows, column circulations and sections in the well that work in conjunction with the main well-formation system. To assess the quality of cementing of production columns, to determine the gap of the CCC and the intensity of overflows, the data of the ACC obtained as a result of measurements at two frequencies at different back pressures in the columns are interpreted.

To clarify the parameters of the borehole-formation system, either a repeated expanded complex of PGR or other theoretical and practical studies that have an impact on the economic component of oil and gas production management are being implemented. In conditions of a limited amount of information, the share of inefficient RIRs implemented at wells increases significantly. Summing up the above research, it can be concluded that the selection of candidate wells for successful repair and insulation work should be based on an assessment of the value of information obtained as a result of using methods of registration and identification of water inflow (PGR) and, if necessary, clarified by various direct and indirect methods.

4 Conclusion

The need for repair and insulation work is justified by the results of the following field and geophysical studies: the method of high-precision thermometry, pulsed neutron-neutron logging, ACC, and the introduction of a special colored substance. The use of hydrodynamic methods in order to identify the inflow of water and, on the basis of which it can be concluded that the well needs repair, provides only secondary information in terms of price.

The breakthrough and tightening of the cone of plantar waters is most difficult to determine both by the results of geophysical and hydrodynamic studies. In these cases, when processing parameters, this type of well operation disturbance is defined as an inflow from the perforation interval. Only by the method of high-precision thermometry can it be revealed that over time, changes in temperature fields and warming of the downhole zones will move lower beyond the boundary of the perforation interval during the rupture of plantar water along the cones.

Based on the above, the determining factor necessary for the successful selection of wells for RIW and further execution of design work in conditions of high geological heterogeneity is the information obtained during the registration and identification of fluid intake, the unforeseen technology of well operation by field-geophysical research methods.

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