AREA COVERAGE BY GEOCHEMICAL STUDIES OF THE TARGET HORIZON AND DIFFERENCES IN COMPOSITION DUE TO RESERVES

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ABSTRACT

This article shows the geochemical studies of associated produced reservoir water of the Bobrikovian horizon by the area of research at one of the deposits of the Republic of Tatarstan. The horizon is characterized by terrigenous rocks, which in turn is underlain by a massive carbonate reservoir. Quite a lot of producing wells work for it, and also, in view of reserves development, a system for maintaining reservoir pressure has been introduced. Based on the composition of the produced water, maps of the distribution of geochemical parameters over the area are constructed. 3 zones according to the concentration of elements were identified. In the region with maximum oil saturation, the water composition is characteristic of the waters of the Bobrikovian horizon. And in the region with the most depleted reserves and greater water cut, water is most likely to flow from the underlying Tournaisian carbonate strata, which is reflected in a change in composition. Also, tracer studies were conducted to establish flows in the deposits. The work shows an integrated approach to the study of real flows in deposits, based on the composition of produced formation water, and can be used to understand the processes occurring in the reservoir and refine hydrodynamic models, since it is a direct method of study.

Keywords: geochemical composition, terrigenous reservoir, tracer test, water cut.

INTRODUCTION

Recently, during the development of oil fields, the number of wells that shutdown for geological reasons, intensification of development and, as a consequence, watering, an increase in the amount of produced water.

The source of water inflow into the well is not always clear, and in the presence of watered layers, which lie both above and below the target production interval, the possible number of ways of water inflow increases during the development of the oil interval. Therefore, the study of the complex composition of formation waters remains relevant, since this system is multicomponent. With an aerial study of the composition of the produced water of one horizon, it becomes possible to build maps of the distribution of elements over the area and monitor their change. One of these guiding properties of water is its isotopic composition [1].

The paleohydrogeological conditions for the formation of the initial composition of waters undoubtedly affect its composition. However, the assessment of the degree of metamorphization of waters according to the classical metamorphization coefficients (Na / Cl, (Cl-Na) / Mg) in most cases does not work: the correlation coefficients between them, the depth of aquifers and reservoir temperature are close to zero [2]. It should be noted that some components in water may not be related to the conditions of its formation, but are “introduced” due to industrial pollution, the most common are heavy metals and they are also the most stable (Fe, Cu, Cr, Mn, Cd, Pb, Zn) [3].

It is also necessary to take into account the effect of injection - fresh water injected at fields to maintain reservoir pressure and significantly affects the change in salinity and density of the produced reservoir water. The oil field under study contains high-viscosity oils concentrated in the sediments of the Bobrikovian horizon. The reservoirs of the Tournaisian stage, which lie below, in the sections of wells that have opened the part of the top of the Tournaisian structure that are not affected by the channel, are also oil-saturated. In connection with the development of the channel, a hydrodynamic connection between the carbonate Tournaisian and terrigenous Bobrikovian reservoirs and a single OWC of the deposit is assumed. A reservoir pressure maintenance system has been introduced at the field with water injection into 3 wells (Fig. 1).

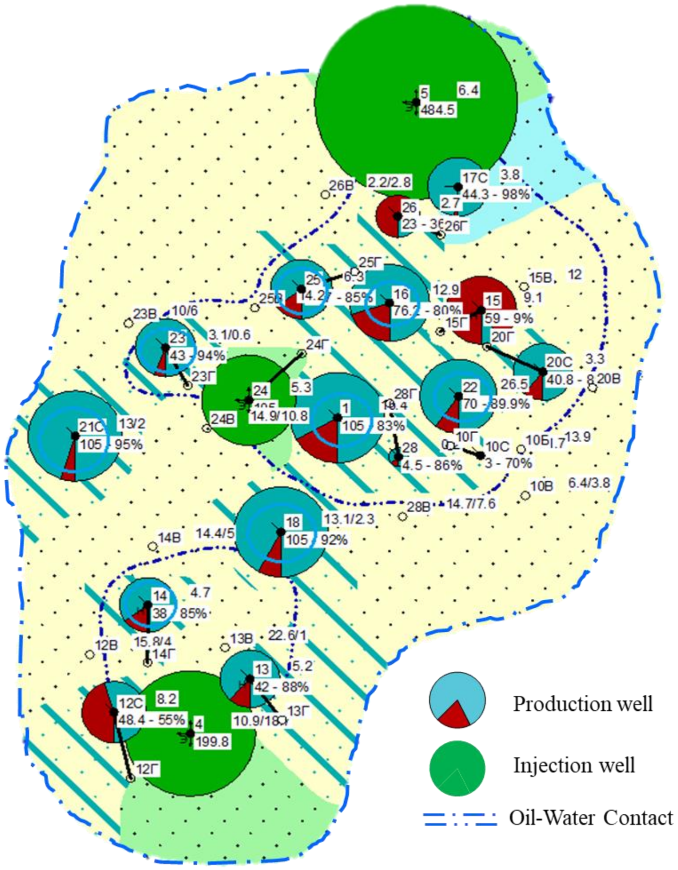

Figure 1 – Development map

Production wells operate with high water cut, it was necessary to find out the source of their flow. The following reasons are possible: 1) leakage of the cement ring behind the production casing, 2) inflow of bottom water through the flooding cone when creating an excessive drawdown on the formation, 3) breakthrough of injected water through highly permeable layers.

However, the third reason is probably not the main one, since the tracer studies carried out earlier showed an insignificant contribution to the watering of production wells from injection well № 24 (Fig. 2). The identified filtration systems account for about 0.46% of all water injected by the injection well.

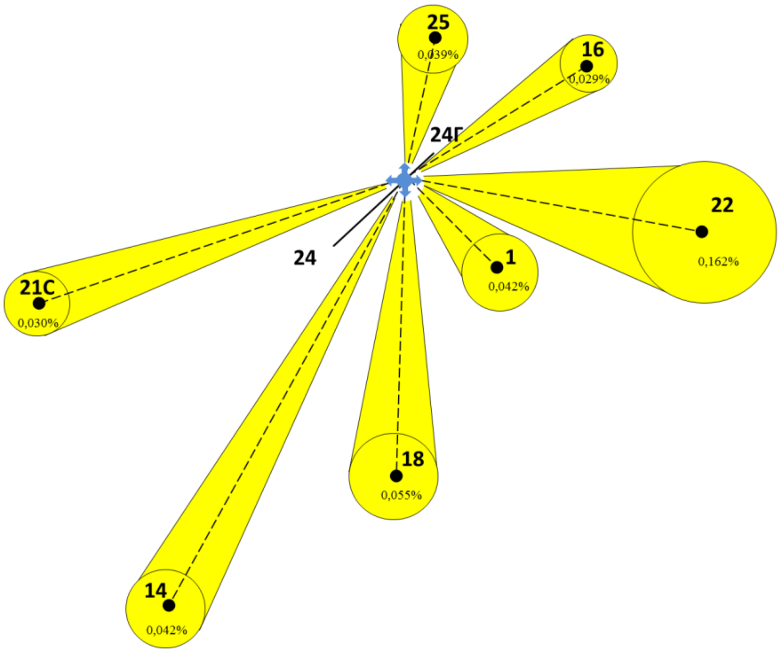

Figure 2 – Distribution map of the contribution of the identified system of channels with LFR to the well water cut

METHODOLOGY

On the basis of micro-component, macro-component and isotopic studies of the produced fluid, it is possible to determine its source in the well production [4,5]. This is achieved due to the fact that at the level of chemical components, water has its own characteristic features.

Within the framework of this work, wells operating on the Bobrikovian horizon are studied. The characteristic features of this water are recognized. Among the reference wells, there are those in which strong differences in composition from the majority in the area are noted. In such wells, there is a suspicion of crossflow behind the casing.

In this work, the elemental composition of water was studied by mass spectra, and the isotopic composition of water: oxygen and hydrogen. It should be noted that the isotopic composition of water is a unique characteristic describing the nature of water molecules. The content of heavy isotopes of hydrogen and oxygen in natural waters was determined by an international standard introduced by the International Atomic Energy Agency (IAEA): the Vienna Standard Mean Ocean Water (VSMOW) standard, which determines the isotopic composition of the deep water of the World Ocean.

RESULTS

As a result of laboratory studies, results were obtained for 12 wells.

Isotopic composition of water (oxygen and hydrogen)

Oxygen is the most common chemical element in the earth's crust. It has three stable isotopes: 16O = 99.63%, 17O = 0.0375% and 18O = 0.1995%. Hydrogen has two stable isotopes 1H and 2H (deuterium), the abundance of which is 99.9852% and 0.0148%, respectively.

The isotopic composition of oxygen and hydrogen in the sample is expressed as δ18O and δD, which characterize the difference in ratios in the sample and the SMOW standard (standard mid ocean water). These values are measured in ppm.

A positive value of δ18O and δD indicates the enrichment of the sample in 18O and D relative to the SMOW standard, and a negative value indicates depletion.

Water with a more negative composition is light water, with a less negative composition (closer to zero) - heavy, it contains more deuterium.

As a result of processing the obtained data, a diagram of the water isotopy distribution of the wells under consideration was made (Fig. 3).

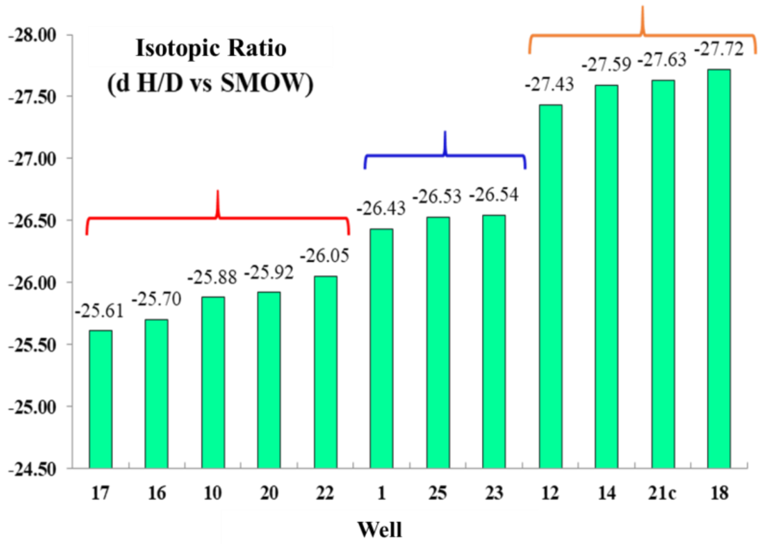

Figure 3 – δD (VSMOW), ‰

Wells № 10, 16, 17, 20, 22 are characterized by heavier water (with less negative composition), the values are close to Tournaisian strata in the region (average -25.5).

For the Bobrikovian reservoirs, the regional average is -27.5, which is shown by wells No. 12, 14, 18, 21c. With a general comparison, including the joint oxygen isotopy, this group of wells differs from most of the wells studied at the site. What may be associated with the terrigenous channel in the carbonate reservoir C1turne (Fig. 4).

The channel zone within the field was built on the basis of seismic data from 2012. According to seismic data, the channel zone includes the following wells: 10, 12, 13, 14, 21, 28. Wells that did not penetrate the Tournaisian sediments were drilled in varying degrees of proximity to the incision zone and theoretically can be channel.

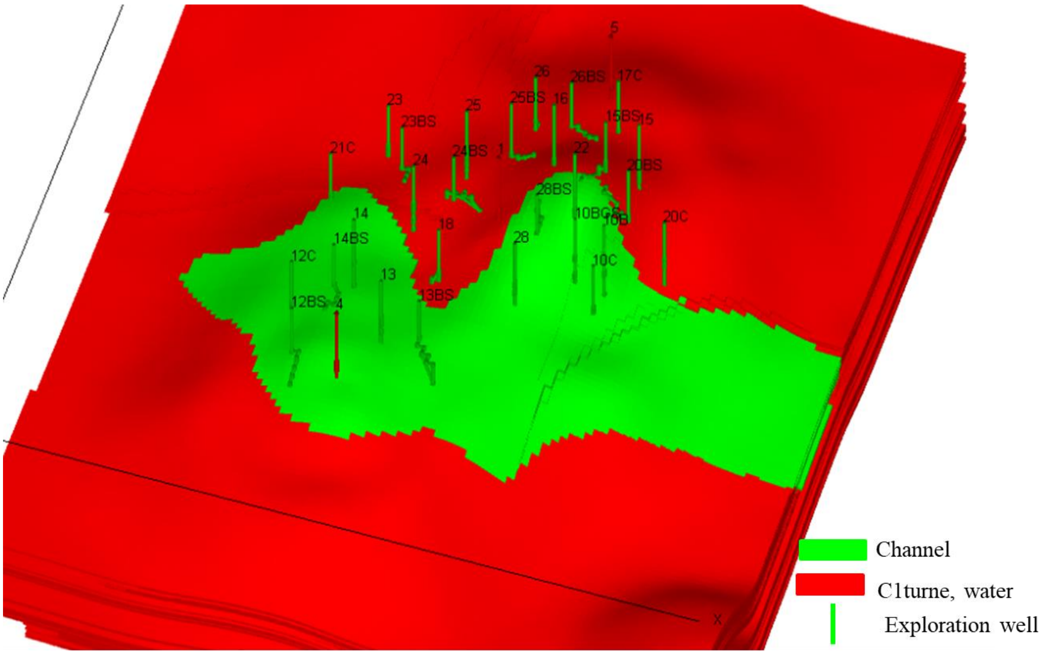

Figure 4 – Chanel location

For further analysis of the results obtained, a map of isotope distribution over the area was created (Fig. 5).

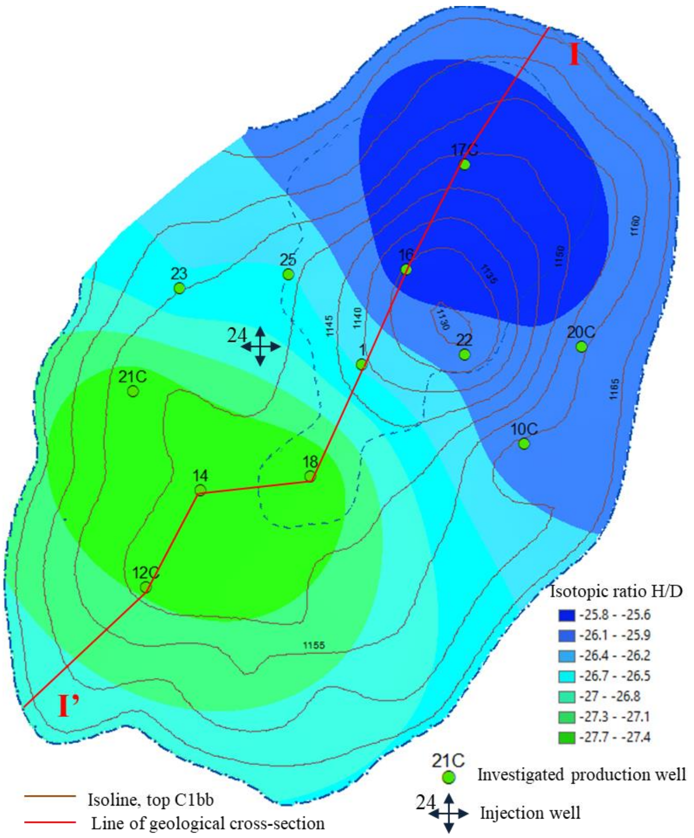

Figure 5 – Map of distribution of hydrogen isotopes over the area

I t can be seen that, according to the isotopic composition, there is a smooth transition, zoning from north-east to south-west. Also on the pressure map and the residual reserves map, the same transition is observed. The beginning of water cut encroachment in well production correlates with a decrease in bottom hole pressure in the well. It can be observed that:

1. **South-West**: most of all oil remained, wells №12, 14, 21, 18 have an isotopic composition characteristic of the Bobrikovian deposits, equal to an average of 27.5 in the region.

2. **Middle zone** with average reserves and average isotope: value -26. Wells № 1, 23, 25 are transitional. This may indicate that these wells are related to the Tournaisian deposits, i.e. the proximity of the Tournaisian water is likely. It can also be assumed that an incision zone may pass nearby, which may lead to flooding of the Bobrikovian deposits.

3. **North-East:** fewer oil reserves remain, the very first wells were put into operation and took their own, perhaps they pulled up the water from the bottom, since the isotopy indicates heavier water, there is also reduced pressure in this zone. This area is characterized by the formation exposing of the Tournaisian strata (Fig. 6), and according to the geological field analysis, water inflow from the Bobrikovian intervals downstream of the Bobrikovian intervals was noted. Thus, wells №10, 16, 17, 20, 22 have an isotopic composition characteristic of the Tournaisian deposits, equal to an average of -25.5 for the region.

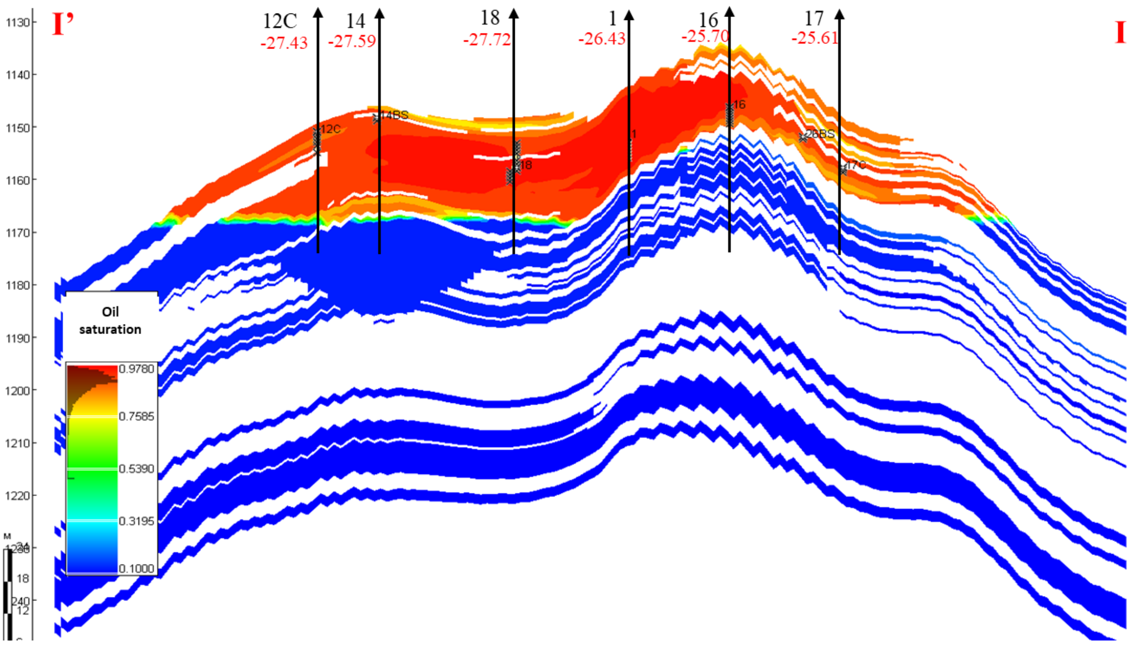

Figure 6 – Geological cross-section

Taking into account the development features, the following conclusions were obtained:

1. A group of wells No. 12BS, 21C is located not far from the OWC contour, presumably the water comes from there.

2. Well No. 12 is located next to injection well No. 4, in which the average daily injection exceeds the production rate by 5 times, which could have affected the water cut. The manganese content in the area as a whole has the same value, and in well 12 it is exceeded (Fig. 7).

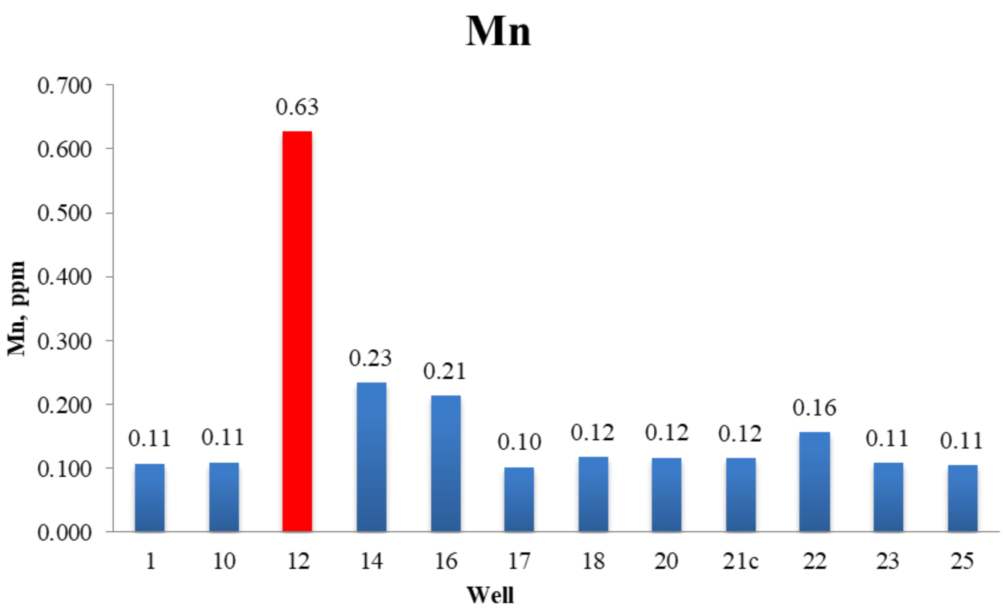

Figure 7 – Mn concentration, ppm

3. For well №18, it is assumed that some measure was taken in the first years of operation to increase production, which contributed to the penetration of bottom waters.

4. About well № 1, a sharp increase in water cut is not observed, presumably there is a natural depletion of reserves and the penetration of underlying waters.

5. Well № 17 is located not far from injection well № 5, which was commissioned earlier than the production well and could have contributed to the flooding of the area.

CONCLUSION

On the basis of constant hydrochemical studies of the produced water, it is possible to predict changes in the geochemical composition over the area of study, in addition, this material serves as the basis for choosing the method of stimulating the formation that is optimal in terms of chemical composition.

In the course of laboratory studies of the composition of the produced water and their subsequent interpretation, water from 12 wells working on the Bobrikovian reservoirs was studied, maps of the distribution of the isotope ratio were built.

According to the areal distribution, 3 zones of the isotopic composition of water were identified. The obtained data are correlated with the map of residual oil reserves and pressure map. This may be due to the pulling up of formation water and the development of reserves.

Joint analysis of field data, development indicators (current and accumulated oil production, water injection, water cut), tracer and geochemical studies allow us to build a substantiated reservoir and hydrodynamic model of fields and find out the sources of water inflow into wells.

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