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To cite this article: M. S. Shipaeva *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **282** 012042

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Analysis of the results of tracer tests for the monitoring of the development of super-viscous oil deposit

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Abstract. The article describes the results of implementation tracer studies at one of the super-viscous oil deposits in the Republic of Tatarstan. Accurate information on the flow of liquid in oil deposits is absent, this is an obstacle to the successful development of such deposits. The information obtained as a result of tracer studies is an addition to the general history of field development and is used to reduce uncertainties in the construction of geological and hydrodynamic models of deposits. The main tasks were the determination of the hydrodynamic connection between the wells along channels with low filtration resistance, the determination of the filtration rates of the condensate in the reservoir and the heterogeneity of the reservoir in the inter-well space of the investigated section of the oilfield. In order to determine the quality of the hydrodynamic connection within the bituminous deposit, the geological structure, as well as the direction of the filtration streams, a solution of the chemical eosin indicator was pumped into one of the steam injection wells, followed by registration in the samples of the surrounding production wells. To detect fluorescent indicators in the wells, unique equipment was used that significantly reduces the previous sample processing and detection time.

1. Introduction

One of the informative and inexpensive ways for investigation of the filtration properties of reservoirs is the well to well tracer test. The results of this method reflect the characteristics of the reservoir in the entire interwell space. The technology of the indicator method is simple and based on the injection of a tracer agent into the injection well, followed by the selection of the products of the production wells surrounding it. These samples are measured in the laboratory for the presence of an indicator. The concentration and arrival time of the indicator are interpreted, and the results are used to create a picture of fluid movement through the formation, as well as to clarify the geological structure of the site [1].

By the time of the first registration of the indicator from exploration wells, zones of high dynamic permeability are determined. The concentration and quantity of the indicator extracted to the surface determine the conductivity of the filtration paths. The indicator method allows to establish control over the distribution of flows in directions, to identify areas of absence of hydrodynamic connectivity between wells.

Eosin Y was chosen as an indicator, because it is supposed to use markers in the development of extra-viscous oil deposits using steam and gravity drainage technology, that is, at pressures up to 10 MPa and temperatures up to 200 ° C. During laboratory studies, it was found that exposure to high pressure and high temperature led to a significant increase in fluorescence intensity. This effect is explained by an increase in the solubility of eosin Y at high temperatures. This feature of the selected indicator will be very useful in the real conditions of the production of SVO in the Republic of Tatarstan, because will positively affect the sensitivity of the method.



The object of research was the SVO deposit, associate with the Ufa bituminous complex, to the sand pack of the Sheshminsky horizon of the Permian system (Fig.1).

This territory is well studied, the productive horizon contains lithological heterogeneities represented by dense consolidated sandstones and lenses of water saturated sands above the oil-water contact. The deposit is characterized by irregular OWC over the entire area, in contrast to traditional deposits [2].

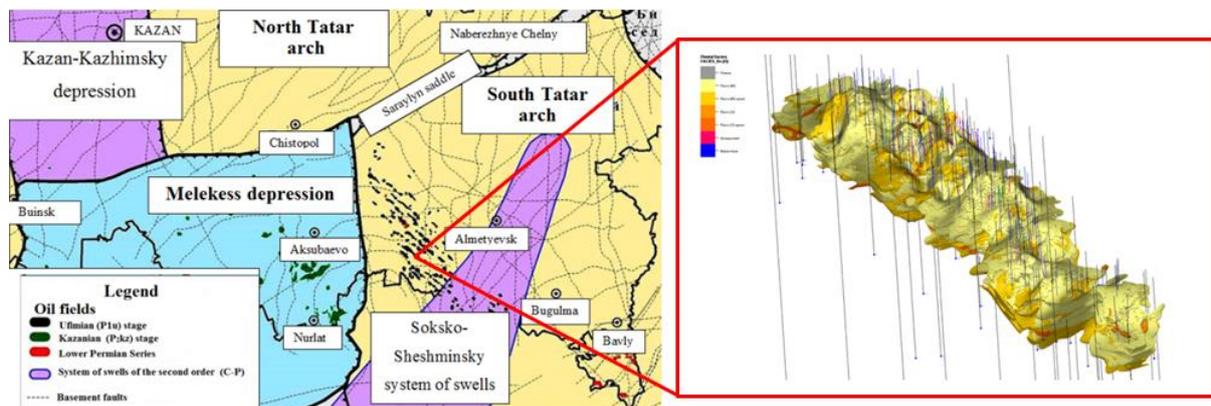


Figure 1. Fields of super-viscous oils and natural bitumens of the Republic of Tatarstan, object of research

2. Methodology

The methodology includes both field and laboratory work.

2.1 Field Work

To select wells for the study the specialists were guided primarily by the geology of the deposit and the tasks that were set. The deposit is a reservoir with several domes. It was necessary to find out whether there is a connection between the Eastern and Western domes, whether the water moves through the depression that separates them (Fig. 2). It was also necessary to find out the presence and direction of movement of the and the influence of the location of the pump on the flow of condensate inside the reservoir.

Before the indicator was injected, water samples were taken from wells for baseline survey.

The fluorescent indicator aqueous solution was injected through injection well № 61. This well located in the center of the East dome and is the highest in the entire field and has relatively high production rate. In order to realize a homogeneous distribution of the tracer in the wellbore and in the reservoir, it was decided to inject the indicator into the heel of the well №61 (Fig. 2).

Before the indicator was injected, well №61 was stopped to reduce the temperature in the column. Well downtime lasted 2 days. Well № 60 was stopped before the indicator was injected to ensure equidistribution of the indicator solution in the perforation interval of the production well №60. Well did not work for 1 day.

The aqueous solution contained 15 kg of the eosin indicator dissolved in 5 m³ of warm fresh water. The final concentration of eosin in water was 3 g/l. Surveys were conducted for 10 days. The established monitoring fund is 24 wells.

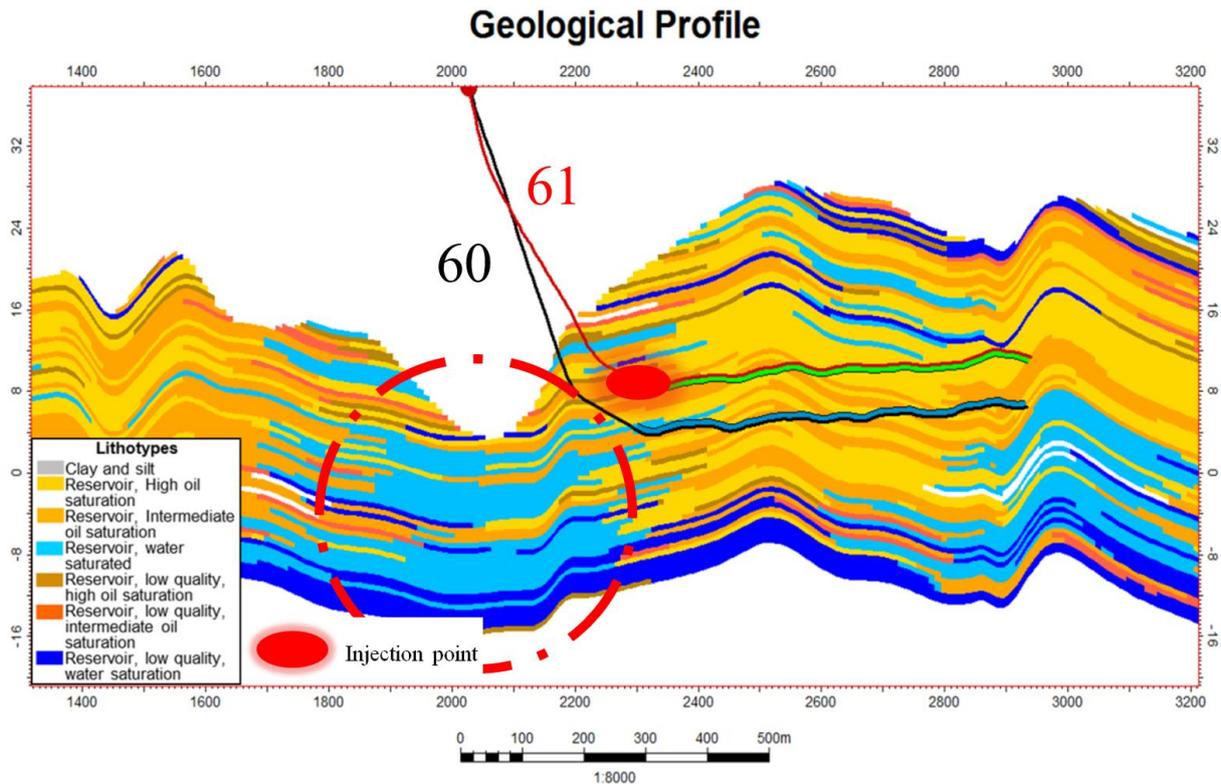


Figure 2. Geological profile of the Eastern and Western domes

2.2 Lab work

Experimental hydrodynamic studies of a technical fluid using hydrodynamic markers (in particular, fluorescent indicators) indicate the presence of a special highly sensitive optical system for their detection by fluorescence spectra in real conditions of oil production. For the study, an automated mobile field laser spectrofluorimeter was used (Fig. 3). The MPLS-2 was developed as part of a joint project of Kazan Federal University and Kazan E. K. Zavoisky Physical-Technical Institute of the RAS.



Figure 3. Mobile field laser spectrofluorimeter

First of all, it is necessary to investigate test solutions of eosin with a known concentration prepared in natural water wells, with the aim of calibrating the device MPLS-2. Samples were cleaned with a paper filter, as they contained oil contamination.

Results and discussion

As a result of the study, a map has been created showing the location of the horizontal wells, percentage extraction of indicator and arrival time (Fig. 4). All calculations were carried out at the location of the pump inside the producing horizontal well due to the predominant flow into this area. The tracer is confidently fixed in all investigation wells. The tracer enters in the wells mainly on the 1st and 2nd day.

The wells located near the injection well №61, failed to investigate due to the absence of water in the produced fluid. This may be due to the stop of the steam injection well №61 to reduce the temperature in the column by 2 days. Hence we can conclude about the existence of impact of the development of the steam chamber №61 for the extraction of nearby wells №58 and №47

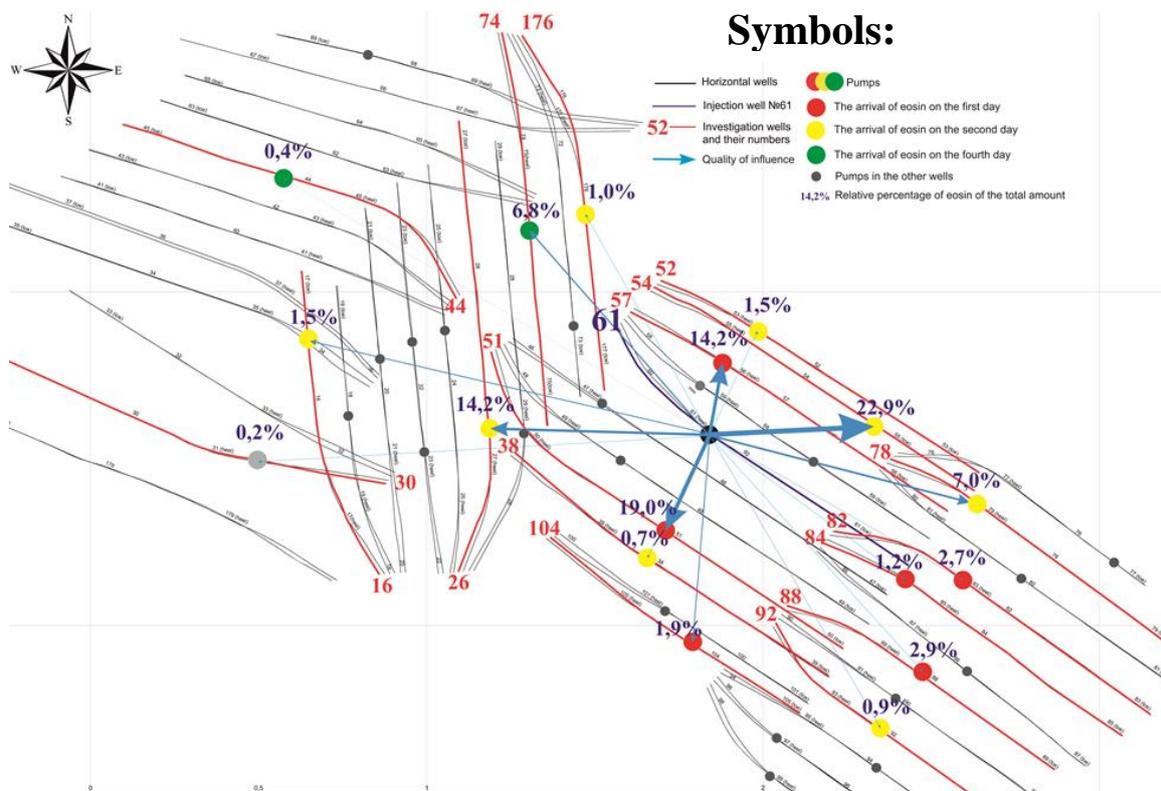


Figure 4. The map of the location of the investigation wells and the amount of extracted tracer

A map of filtration channel productivity was also created (Fig. 5). Analyzing this map, it can be seen that 4 wells of the site have the most productive filtration channels and extract the main volume of the tracer agent.

2 of them are developed by the technology of cyclic steam stimulation, these are wells №51 and №57. The technology is carried out by periodically injecting steam into the oil reservoir through the production well, with some holding it in the closed state and subsequent operation. The purpose of this technology is to increase the flow of oil to the wells by reducing the viscosity of the oil, increasing the bottomhole pressure, facilitating filtration conditions [3]. If we developed part of field in this way, a positive depression is created around the well, where condensate is easy to flow than the SAGD method where the steam chamber creates overpressure and repels condensate. Also during the tracer studies well №54 worked only for production, steam injection into the upper pair was suspended for it. This explains the high productivity of the channels in these 3 wells.

Also areas of wells with the same tracer behavior are identified (well №№78, 82, 88, 84). In these wells, there are 2 portions of the arrival of the tracer agent (Fig.6). It is assumed that the first portion is associated with the movement of the tracer through the wellbore of the injection well №61. Leaving the bottomhole tracer was established in the immediate vicinity of the well №61. And the second portion of the indicator came completely on the pore part of the collector later, on the 5th day of the research.



Figure 5. Filtration channel productivity map.

The tracer is fixed in all the studied wells, which indicates the presence of water flows inside the reservoir. But tracer came in different ways. It is also worth noting that the first portion comes in most wells on the 1st and 2nd days. During the study, the operation mode of some wells changed and this is reflected in the behavior of the tracer in the interwell space. In total, 15 g of eosin Y (out of 15 kg) was extracted. Such a small extraction is associated with the injection of the tracer into the reservoir with water that differs significantly in temperature from the reservoir conditions; therefore, main part of tracer is filtered in the underlying aquifer.

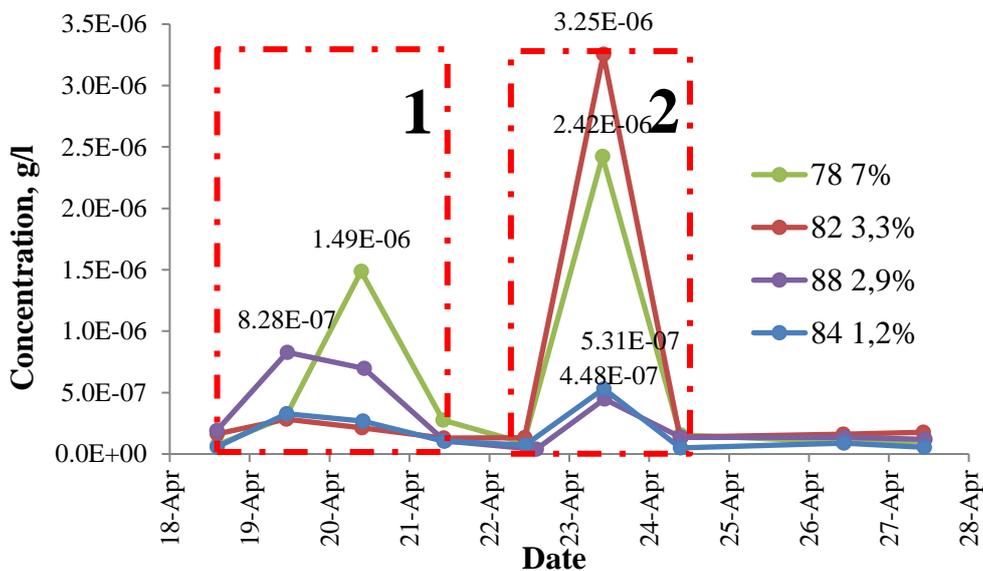


Figure 6. The graph "Tracer concentration - time"

3. Conclusions

The existence of water flows within the bitumen deposit, resulting from the contact of the steam chambers with each other is shown in this work. It was also found that the reservoir is a single hydrodynamic reservoir, the Eastern and Western domes of the investigated area are interconnected (~23% of the tracer left the Eastern dome to the Western). Water with a tracer dissolved in it moves through different aquifers and in different ways.

Acknowledgements

The work was supported by the Ministry of Education and Science of the Russian Federation (project No. 02.G25.31.0170) and by the subsidy allocated to Kazan Federal University as part of the state program for increasing its competitiveness among the world's leading centers of science and education.

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