THE GEOCHEMICAL COMPOSITION OF OIL AS A WAY OF CHECKING THE QUALITY OF HYDRAULIC FRACTURING

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ABSTRACT

The article describes the results of laboratory measurements of the micro-component composition of the produced oil and the mathematical processing of the obtained values in one of the fields of the Republic of Tatarstan. Vereiskian and Bashkirian horizons were studied, which are quite widespread in the Republic and surrounding areas. The studied horizons lay one above the other in close proximity to each other. The Bashkirian deposits are a massive reservoir, while the Vereiskian deposits have the form of a layer-uplifted deposit. When hydraulic fracturing is carried out on Vereiskian reservoirs, penetration of hydraulic fractures into underlying Bashkirian fractures is possible. Hydraulic fracturing can significantly increase the flow rate of wells developing the Vereiskian horizon, and is a common operation in existing geological conditions. To understand the situation in the well after hydraulic fracturing, it is proposed to study the composition of oil from the reservoirs between which overflows are possible. For this, oil samples are taken from wells operating at target horizons, called reference samples. The characteristic features of each of them are established. Then, oil samples are examined in the wells in which the hydraulic fracturing was performed. In this work, flows between the Vereiskian and Bashkirian strata were established and the share of the contribution of each of these strata to the production of wells was calculated using the developed algorithms based on the methods of mathematical statistics. Additionally, technological difficulties associated with causes of various natures were identified at the reference wells. An individual approach to each such well was made, the history of its work and the well intervention were studied. Separate recommendations are given for wells. Thus, the prospect of using the composition of the produced oil to determine the quality of the hydraulic fracturing work has been considered.

Keywords: carbonate reservoir, geochemical composition, hydraulic fracturing.

INTRODUCTION

Significant oil reserves of the Republic of Tatarstan are concentrated in oil deposits composed of carbonate reservoirs. Vereiskian and Bashkirian horizons are the most common. This type of oil field are often developed using hydraulic fracturing technology for Vereiskian reservoirs, which are characterized by low permeability (Fig.1).

In hydraulic fracturing, fracturing fluid is pumped under high pressure into the reservoir. As a result, natural or artificial cracking occurs. By pumping a sand-liquid mixture or an acid solution, hydraulic fractures are wedged, ensuring their high throughput is maintained after the end of the process and pressure reduction.

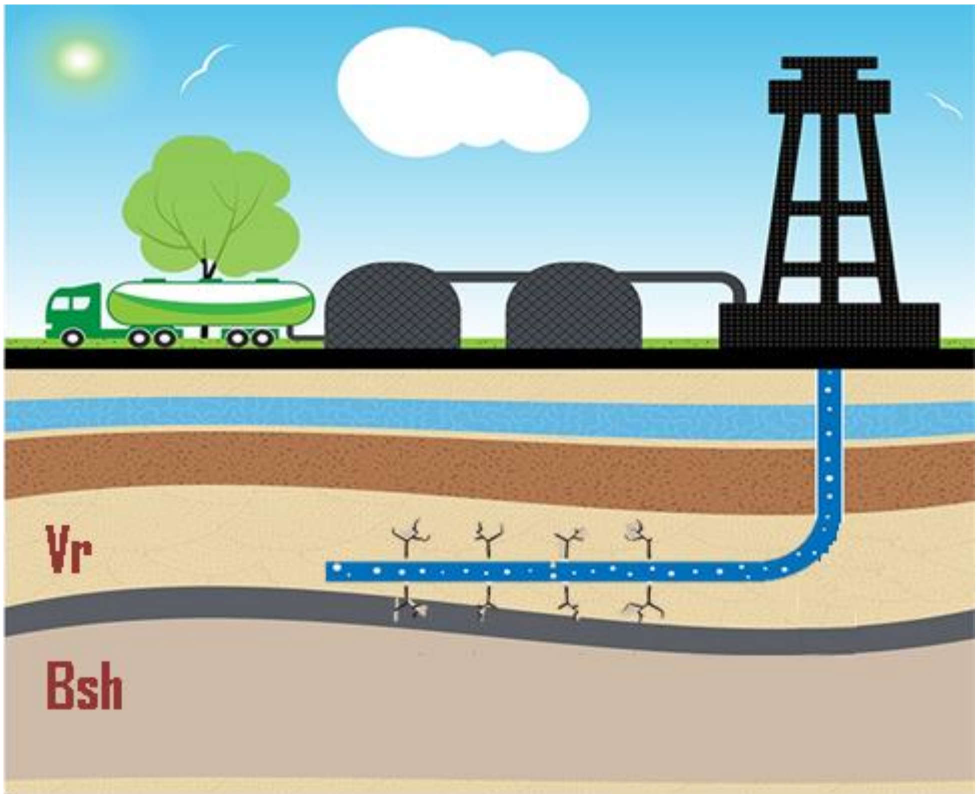

Figure 1 –Hydraulic fracturing on the Vereiskian horizon

The main factors on which the success of hydraulic fracturing depends on are: the correct object selection, the use of optimal hydraulic fracturing technology for these conditions, and the proper selection of wells for processing [1].

Hydraulic fracturing for each well should be considered as an independent investment project. This will make it possible to more reliably evaluate the economic efficiency of the measure, compare the results of hydraulic fracturing with alternative options for increasing oil recovery, select the best option in each case [2].

While injecting the fracturing fluid, the pressure necessary for fracturing the rock is created to form new and open existing cracks [3]. The prediction of pore pressure is very important for the formation of optimal cracks, because new cracks can touch adjacent layers, thus causing inter-layer flows [9]. To determine this, the properties of the fluids of different reservoirs can be used.

In order to determine the source of water in production wells and possible leakage in the column for subsequent surgical intervention in the operation of the wells, the isotopic composition of the produced water can be researched [4].

It is also possible to study the isotopic composition of the oil produced. The isotopic composition of oils of different ages should differ [5]. Kinetic isotopic fractionation is one control on the $\delta^{13}C$ value of n-alkanes in the maturation process. In this case, the source of organic matter is the controlling factor in the isotopic composition of oils [6].

The joint integration of tracer surveying and monitoring of isotopes makes it possible to increase the information content of the processes occurring in the formation and gives a more complete understanding of the distribution of flow paths. However, instead of injecting tracer fluid, some components in the oil can be “natural” tracers and characterize a particular horizon. If we find out the oil characteristics of each horizon, we can assume that adjacent layers are affected, and what proportion of the total well production comes from them. Similar studies were done for produced water and it was shown that the fluids of different reservoirs differ in isotopic composition, which can be used to defects in the column of the producing well and flows between the layers of produced water in vertical wells.

The relationship of the microelement (ME) composition of oils of various ages with the physical and chemical properties of oils, as well as with the structures of their hydrocarbon fractions, was studied in detail by T.A. Botneva [7]. According to the nature of the distribution of ME, oils of different age groups are clearly distinguished, five geochemical types of oils are identified, and elements such as S, Ni, V are used.

The study of biomarkers in oil was also considered at the Marcheline deposit of Western Venezuela, where the authors divide them into two groups: 1) elements Cd, Cu, Mo, Zn, 2) V, Ni as indicators of secondary oil migration during the formation of the field [8].

It was also successfully shown that geochemical characteristics which are biomarkers of oil, changes in the composition of hydrocarbons and trace elements are shown depending on the horizon and depth of oil occurrence [10]. The following trace elements have been identified: Mn As Ba Co Cu Li Mo Pb Ti V.

METHODOLOGY

First step: reference wells, operating separately on the Vereiskian and Bashkirian horizons (Fig. 2, well №1 and №2), are investigated. Their properties and differences in the composition of the horizons are determined.

Second step: selection. The methodology for studying the geochemical features of the produced fluid allows us to simultaneously identify possible damages of the column in the reference wells. They can be: packer leaks (Fig.2, well № 3), dib hole (Fig.2, well № 4), and cross flows behind the casing from other layers. Such wells are not further considered in the analysis and separate recommendations are given for them.

Third step: after sampling the reference wells, wells with hydraulic fracturing (Fig.2, well №5) are examined and the characteristics of its composition are determined.

Fourth step: the data obtained is processed using mathematical statistics methods to determine if oil mixing is occurring. Then there is a calculation of the distribution of products by formations.

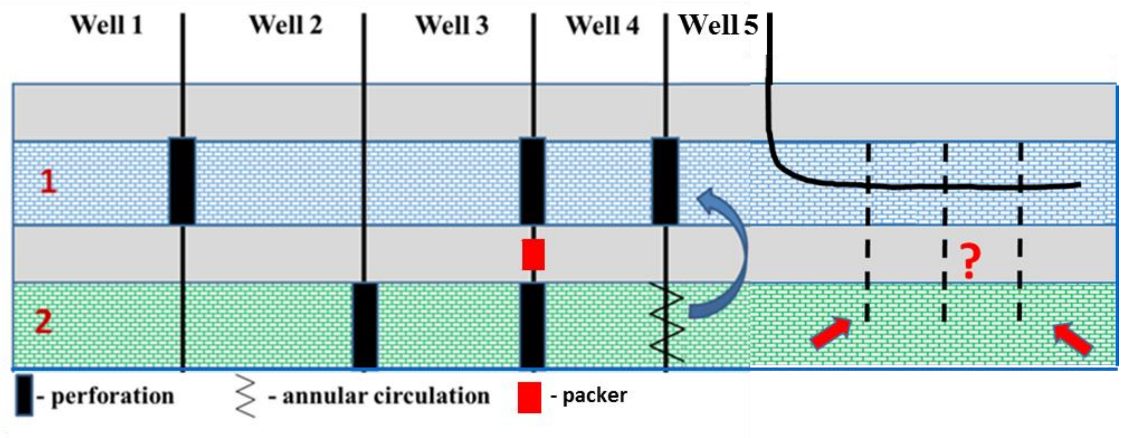

Figure 2 – Type of wells

RESULTS

9 reference wells were investigated: 5 for Vereiskian and 4 for Bashkirian horizon; 4 wells with hydraulic fracturing on Vereiskian horizon.

As a result of the study of reference wells on the Vereiskian and Bashkirian formations, markers M and M1 (table 1) were identified, it is natural markers found in oil in the form of groups of elements (Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, V, Ni).

Table 1 Marker Values

Well #	Horizon	$\delta^{13}C$	Marker M	Marker M1
1	Vereiskian	-29.67	287.97	19.73
2	Vereiskian	-29.73	97.36	9.31
3	Vereiskian	-29.85	47.86	4.45
4	Vereiskian	-29.79	94.72	7.60
5	Vereiskian	-29.98	1010.64	74.29
6	Bashkirian	-29.98	3609.46	179.61
7	Bashkirian	-30.02	2853.07	144.22
8	Bashkirian	-29.95	32585.95	1522.71
9	Bashkirian	-30.01	166.57	13.63
10	Hydraulic fracturing	-29.67	159	12
11	Hydraulic fracturing	-29.86	36203	1811
12	Hydraulic fracturing	-29.74	1214	96
13	Hydraulic fracturing	-29.72	6323	398

The obtained data is processed by constructing a cloud of values, where the X-axis is the marker value, and the Y-axis is the well number (from 1 to 13) (Fig.3,4). Strong differences were found in the composition of the produced fluid for some wells (wells №5, 8, 9). This indicates possible damages of the wellbore integrity.

So, for example, well.№ 9, the only one of the investigated wells is equipped with a packer, producing oil from both the Vereiskian and Bashkirian formations, and when examining the Vereiskian production, its composition is more similar to the Bashkirian one (according to the M marker, the value is 1011, which is not normal for the

Vereiskian and according to the M1 marker 74, which is also closer to the Bashkirian strata). A packer permeability test should be performed on this well.

The presence of a «dib hole» is noted in well № 5. This is a «non-working» interval of the wellbore located in its lower part from the lower holes of the lower perforation to the current bottom of the well, the readings of the M and M1 markers indicate the possible leakage of this interval, and fluid production from the lower Bashkirian formations (Fig.2, well №. 4 ; table 1).

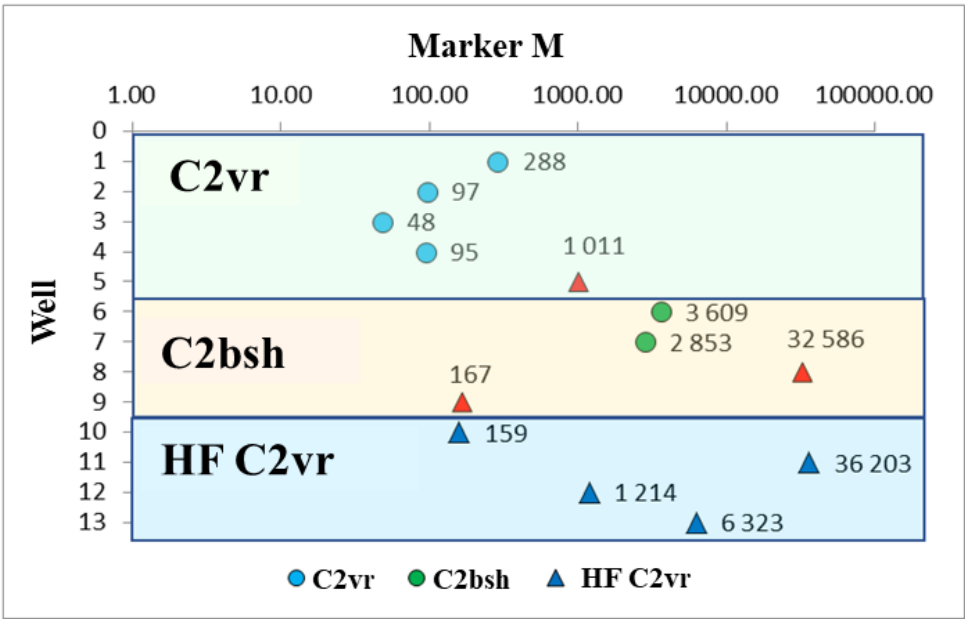

Figure 3 – Marker M (Alkalis metals)

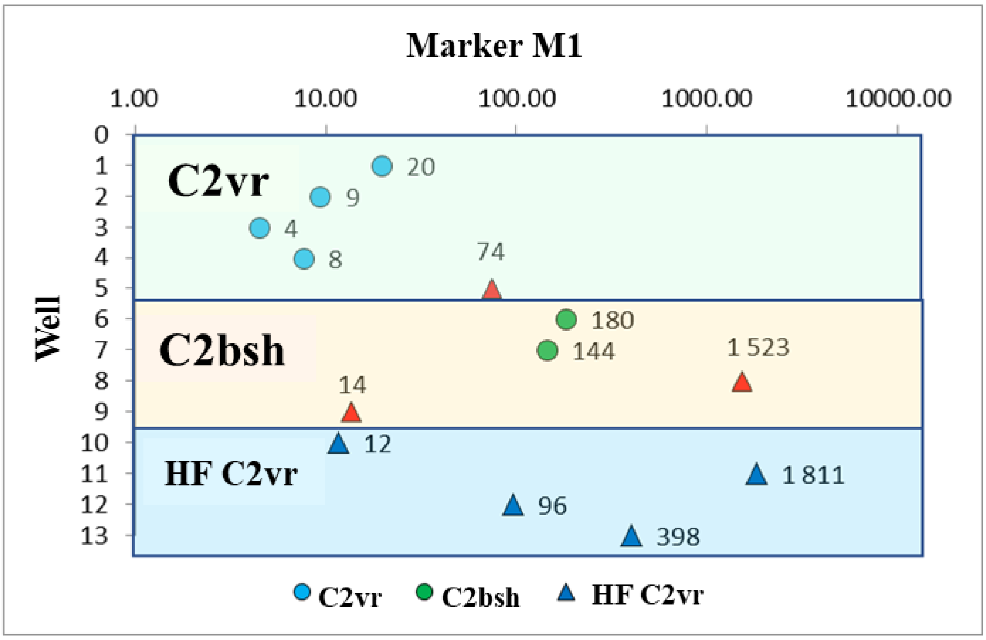

Figure 4 – Marker M1 (Alkaline-earths metals)

After identifying the characteristic features, those values that are considered «outliars» (red triangles) are not taken into account, wells with hydraulic fracturing are distributed to the Vereskian according to these components.

The data are plotted on graphs (blue triangles) and visually it is possible to say to which reservoir the marker value is approximated for the well with hydraulic fracturing.

The initial data are processed by the methods of mathematical statistics. At the same time, mathematical statistics examines all elements and groups of elements identified in oil, choosing the most characteristic for the layers. The model builds a probabilistic relationship between the composition of the fluid and the horizon from which this fluid is taken.

It is assumed that the distribution of each sample of the training sample coincides with the distribution of the test sample X, Y, and each sample is independent in the probabilistic sense from the others. The results of multidimensional processing can be displayed in 2D coordinates (Fig. 5).

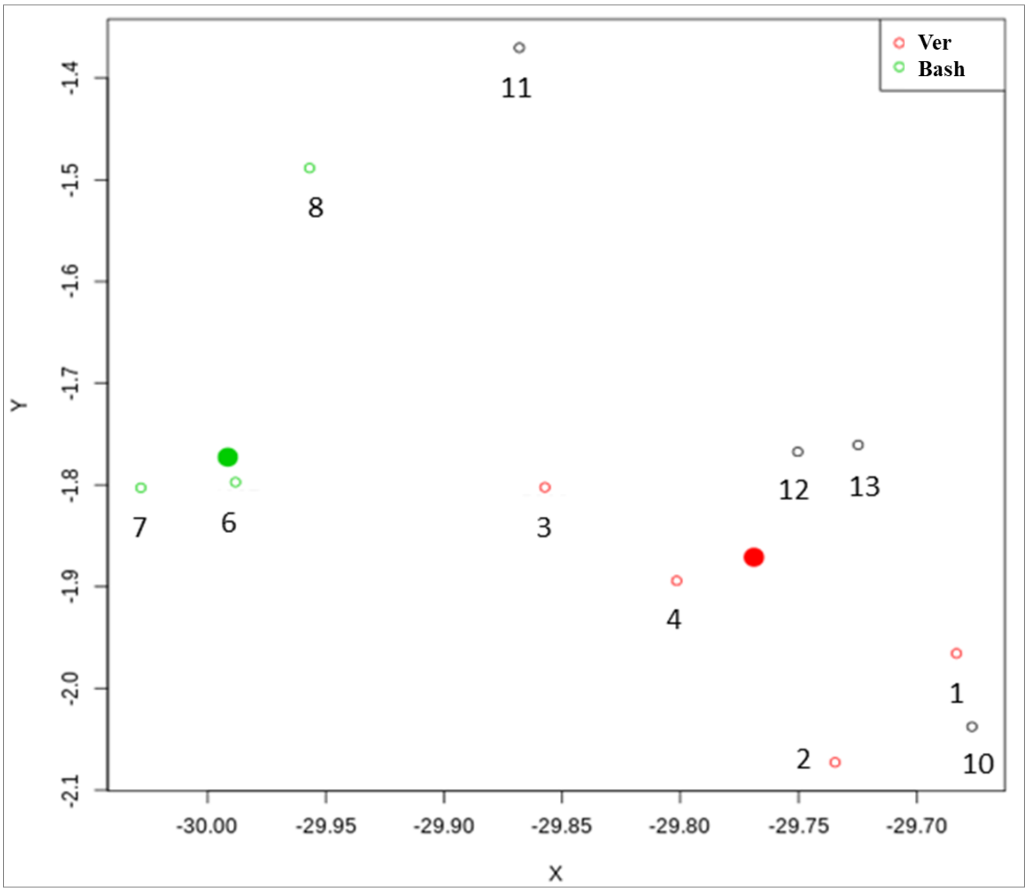

Figure 5 – Algorithm Results

As a result, the proportion of the content of all unique characteristics in the production of wells with hydraulic fracturing on Vereiskian is calculated, from which conclusions can be drawn about the flow of oil from the Bashkirian and its percentage (table 2).

Well № 10 alone receives the majority (85%) of oil from the target fracturing horizon - Vereiskian. The rest of the wells partially or completely (well №11) produce oil from the Bashkirian reservoirs.

Table 2 Algorithm Results

Well #	Horizon	Type of Well	Probability value	Results	Ver	Bsh
10	Ver+Bsh	Hydraulic fracturing	0.71	Верей	0.85	0.15
11	Ver+Bsh	Hydraulic fracturing	0	смесь	0.00	1.00
12	Ver+Bsh	Hydraulic fracturing	0.15	смесь	0.43	0.57
13	Ver+Bsh	Hydraulic fracturing	0	смесь	0.10	0.90
1	Vereiskian	Vertical			1	0
2	Vereiskian	Vertical			1	0
3	Vereiskian	Vertical			1	0
4	Vereiskian	Vertical			1	0
6	Bashkirian	Vertical			0	1
7	Bashkirian	Vertical			0	1
8	Bashkirian	Vertical			0	1

CONCLUSION

As a result of the studies carried out on the reference wells, some differences in the composition of the produced products were found that do not correspond to the normal values for the formation for which they are working. The following recommendations were issued for them:

1. Well №5 check the «dib hole» for leaks.

2. Well №9 check the packer setting quality (products are similar to Vereiskian).

3. Well №8 explore at the cross flows behind casing.

The relative oil production rates in wells with hydraulic fracturing on the Vereiskian have been determined. The following conclusions were drawn from them:

• well. №10 receives mainly oil from the C2ver (85% of the C2ver 15% of the C2bsh);

• well. №12 produces oil almost equally from both layers: 43% of the C2ver and 57% of the C2bsh);

• well № 13 receives oil from the Bashkirian (90% of the C2bsh);

• well №11 with mathematical processing receives 100% of the production from the Bashkirian horizon. Also, its composition is identical with the reference well №8 to the Bashkirian reservoirs, which indicates oil production from a single source, different from all wells in the area.

Thus, it is shown the operational determination of the source of fluid inflow into the well and the quality control of the hydraulic fracturing works, based on geochemical analysis. Geochemical analysis allows one to separate layers of different ages by components in their composition (markers), and on the basis of this division and methods of mathematical statistics, it allows solving various situations that arise in the well. The method does not require well shutdown, it is quite fast, it consists in sampling, laboratory measurements and analysis of the results obtained along with geological and field analysis.

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