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Институт органического катализа и электрохимии им. Д. В. Сокольского,
каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz
Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

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R.N. Nasirov[1], G.K. Baimukhasheva[1], S.P. Solodovnikov[2]

[1]Atyrau State University named after Kh. Dosmukhamedov;
[2]A.N.Nesmeyanov Institute of Organoelement Compounds
of Russian Academy of Sciences (INEOS RAS), Russia, Moscow
rnasirov.48@mail.ru gaini.baimukasheva@mail.ru

SEPARATE DETERMINATION OF THE AMOUNT OF OIL EXTRACTED BY ONE WELL FROM TWO LAYERS

Abstract. The authors of this article proposed a different sampling technique for determining reservoir productivity. Relative shares of two in common developed layers in the general output of one production well are determined by vanadium content in oil of several neighboring wells working at each of productive layers separately. Results of experiments on mixture of oil of different layers of the Kalamkas field showed that concentration of vanadium changes in proportion to a volume ratio of oil that confirms competency of such offer.

Proposed method was approved in Martyshi and Southeast Kamyshitov multi-layer deposits. The flow rate of the studied reservoirs according to EPR spectroscopy data is in good agreement with the field data.

Unconditional advantages of the EPR method are its productivity providing a possibility of receiving the express – information, higher precision and reliability in comparison with the listed methods and no need to stop production wells when sampling oil for a research.

Key words: electronic paramagnetic resonance, photocolorimetric method, vanadium paramagnetism, relative flow rate, multilayer deposit.

To solve the problems of development of oil fields of Western Kazakhstan, R. N. Nasirov and others [1] used data from the study of vanadium paramagnetism. It is found that in the Kalamkas field in the context of productive layers there is a clear distinction between two independent deposits by paramagnetic features and vanadium distribution (in the upper – 200g/t, in the lower -140g/t). This gave rise to the authors argue that the vanadium content is a reliable correlation feature that can be used in monitoring the development of oil reservoirs.

In the geological and field analysis of oil field development it is necessary to have information about the operating modes of productive horizons. Basically, the control over the development of deposits is carried out by geophysical and hydrodynamic methods. However, for the most complete study of oil fields, it is desirable to use other, non-traditional methods of research.

In recent years, one of the promising areas of control over the development of the field was the study of changes in the physical, in particular optical and paramagnetic properties of oils.

I. F. Glumov and A. F. Gilmanshin [2] used the photocolorimetric method of separate determination of oil inflow into the well from two layers operated jointly. The relative debits were calculated according to the formulas:

$$q_1 = \frac{(K^{II} - K^*)}{(K^{II} - K^I)}; \quad (1)$$

$$q_{II} = 1 - q_1, \quad (2)$$

where K^I, K^{II}, K^* - light absorption coefficients of oil, respectively, of the first, second layers and produced oil.

The main disadvantage of this method is the inability to directly determine the optical properties of oils with a significant content of colored substances (asphaltenes and resins). The method of electronic paramagnetic resonance (EPR) is devoid of this disadvantage and can be used for separate determination of reservoir productivity. Paramagnetism of oils is mainly due to the presence of various complex compounds V^{4+} and free radicals (FR) in them.

V. M. Arbuzov with co-authors [3] proposed to replace the optical density with the concentration of tetravalent vanadium or FR in formula (1) and then to determine the productivity of both layers. In one specially drilled well, first samples are taken from the upper layer, then from the lower and, finally, a mixture of oils from both layers is taken.

The authors of this article propose a different method of sampling to determine the productivity of layers. The relative share of the two jointly developed seams in the overall production rate of one producing well is based on the content of vanadium in the oil for a few nearby wells operating at each of the productive strata separately. The results of experiments on the mixing of oils from different layers of the Kalamkass field showed that the concentration of vanadium varies in proportion to the volume ratio of oils, i.e. confirmed the validity of such a proposal [4].

In the present work, using the EPR method, a new technique was introduced to the fields of Martyshi and Southeast Kamyshitov.

The above-salt oil and gas deposits in the Ural-Volga region are characterized by a complex geological structure, due to the influence of salt tectogenesis, as a result of which they are divided by numerous discharges into individual wings, blocks, fields. Oil and gas resources are dispersed in these blocks and fields.

The EPR method was used to estimate the productivity of the jointly operated I and II layers of the VII middle Jurassic horizon in the North-West wing of the Southeast Kamyshitov field. Well 7 receives oil from these formations. The content of vanadium in the oils of I and II layers is given in table.1. Its average concentration in these layers is 24.7% and 13.3%, respectively. According to the formulas (1) and (2) it is possible to determine the productivity of these layers: as a percentage of the well flow rate 7, it is 11 and 89, respectively. As can be seen from table 1, the productivity of the second layer is much higher compared to the productivity of the I layer, which, in our opinion, is due to their different permeability (table. 2) calculated from well testing data.

Table 1 - Determination of the relative flow rate of two jointly operated oil reservoirs at the Southeast Kamyshitov field

Well number	Horizon age	Oil production rate		Data according to EPR	
		t/day	%	V^{4+} .g/t	Oil production rate, %
The North–West wing					
7	J_2; VII (I+II layers)	29,3	100	23,5	11 (I layer)
					89 (II layer)
19	J_2; VII (I layer)	3,0	100	24,7	-
18	J_2; VII (II layer)	25,0	100	13,6	-
131	J_2; VII (II layer)	23.5	100	13,1	-
South-East wing					
117	J_2; VI	9,2	100	13,2	95(VI)
	J_2;VII				5 (VII)
123	J_2; VI	7,1	100	10,0	-
110	J_2;VII	3,3	100	71,1	-
16	J_2; VII	3,2	100	68,3	-

Table - Permeability of oil-saturated reservoirs in the middle Jurassic horizons, mkm^2

Horizon age	Permeability, 10^{-3} mkm
The North–West wing	
J_2; VII (I layer)	0,338
J_2;VII (II layer)	0,505
South-East wing	
J_2; VI	0,217
J_2;VII	0,070

High productivity of the VI horizon in comparison with the VII within the South-Eastern wing can be associated not only with its permeability (table.2), but also with the physical and chemical properties of the oil lying in it. The flow rate of the studied layers according to EPR spectroscopy is in good agreement with the field data.

To clarify the process of development by EPR, paramagnetic features of the oil field Martyshi (between the Ural - Volga) were studied). The main object of the development here consists of I the Neocomian and the Aptian - Neocomian horizons. According to the results of the development in previous years, it was assumed that the I Neocomian horizon either does not participate at all in this process, or takes a small part in it. To find out the share of the Neocomian horizon I in the total flow rate, the EPR method was used to analyze the vanadium content in the oils selected from the wells of joint operation of the I Neocomian and Apt - Neocomian horizons, as well as only the Apt - Neocomian horizon.

The average value of vanadium content from the oil of jointly operated horizons is 6.72 g/t, from the oil of the Apt - Neocomian horizon is 6.78 g/t. Apparently, the proximity of these values means that the Neocomian horizon I is practically not developed. The main reason for this, in our opinion, is a significant difference in the permeability of the layers, despite the fact that the other reservoir properties of the layers and the physico - chemical properties of oils are close. Permeability of the Apt - Neocomian horizon is 0,414 mkm^2, I Neocomian is 0,143 mkm^2.

Thus, based on the data obtained by the EPR method, it is possible to recommend the I Neocomian horizon of the Martyshi field for the development of an independent well grid.

In conclusion, it should be noted that in the practice of operating multi-layer oil fields in individual production wells, several productive deposits are often combined into one development object. Under these conditions, the possibility of determining the share of each deposit in the total well flow rate is a very complex and extremely important problem.

The undoubted advantages of the EPR method are its performance, which provides the possibility of obtaining express information, higher accuracy and reliability compared to the above methods and the absence of the need to stop producing wells when sampling oil for research [5,6].

EXPERIMENTAL PART

EPR spectra were recorded on the E-12 spectrometer of Varian company. We have found EPR signals from vanadium ions in the oils of the studied fields. For the determination of concentrations used the most intense line hyperfine structure (HFS) of complexes of tetravalent vanadium [5,7]. The standard concentrations were the oil from Urichtau field (from well 8) with known vanadium content (27,6 g/t). Samples of oil before the analysis was subjected to purification from associated water and solids by centrifugation (centrifuge T-22) when the rotation frequency of 4000 rpm. The oil samples prepared in this way were sealed in order to avoid evaporation of gasoline fractions into glass ampoules 0.2 cm in diameter and 10-15 cm in length.

Gratitude. The authors express their gratitude to the head of the laboratory of electron paramagnetic resonance (EPR) of Institute of Organoelement compounds from Russian Academy of Sciences - S. P. Solodovnikov for assistance in recording the spectra of oil on the EPR spectrometer.

CONCLUSIONS

We have proposed a different, simpler sampling technique for determining reservoir productivity. The relative flow rates of the two jointly operated formations are determined by the measurements of wells located near the two layers being operated simultaneously. The proposed method is tested in the multi-layer fields of Martyshi and Southeast Kamyshitov. The flow rate of the studied layers according to EPR spectroscopy data is in good agreement with the field data.

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Р.Н. Насиров[1], Г.К. Баймұқашева[1], С.П. Солодовников[2]

[1]Х.Досмухамедов атындағы Атырау мемлекеттік университеті;
[2] Ресей Ғылым Академиясының А. Н. Несмеянов атындағы элементоорганикалық қосылыстар институты, Россия, Москва

ЕКІ ТҮРЛІ ҚАБАТТАН БІР СКВАЖИНА КӨМЕГІМЕН ӨНДІРІЛЕТІН МҰНАЙДЫҢ ЖЕКЕ ҚАБАТ БОЙЫНША ДЕБИТЫН АНЫҚТАУ

Аннотация. Бұл жұмыс авторлары көп қабатты мұнай кеніштерінен өндірілітен мұнай мөлшерінің, әр қабаттан мұнай дебитын анықтау үшін мұнай үлгісін алудың басқаша әдісін ұсынады. Екі түрлі қабаттан бір скважина көмегімен алынған мұнайдың қоспасындағы ванадий мөлшерін, оның маңында орналасқан жеке қабаттар мен жұмыс жасайтын скважина мұнайындағы ванадий мөлшерімен салыстыру қажет.

Бұл әдіс Мартыши және Оңтүстік Шығыс Камишиті көп қабатты мұнай кеніштерінде сынақтан өтті. Зерттелген қабаттардың ЭПР спектроскопия көмегімен анықталған ванадий мөлшерімен есептелген мәліметтер бұл гаризонттардың өндірістік геологиялық дебиттері мен толық сәйкес келеді. Сонымен қатар тәсілдің іске асуы үшін керекті мұнай үлгілерін алу кезінде мұнай өндірістік ұңғыларды тоқтатудың қажеті жоқ.

Түйін сөздер: электрондық парамагниттік резонанс, фотоколориметрлі әдіс, ванадий парамагнитизмі, салыстырмалы дебит, көпқабатты мұнай кеніші.

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Р.Н. Насиров[1], Г.К. Баймукашева[1], С.П. Солодовников[2]

[1]Атырауский государственный университет им.Х.Досмухамедова
[2] ФГБУН Институт элементоорганических соединений им. А. Н. Несмеянова РАН, Россия, Москва

РАЗДЕЛЬНОЕ ОПРЕДЕЛЕНИЕ КОЛИЧЕСТВА НЕФТИ, ДОБЫВАЕМОЙ ОДНОЙ СКВАЖИНОЙ ИЗ ДВУХ ПЛАСТОВ

Аннотация. Относительные доли двух совместно разрабатываемых пластов в общем дебите одной добывающей скважины определяются по содержанию ванадия в нефти нескольких соседних скважин, работающих на каждом из продуктивных пластов раздельно. Результаты экспериментов по смешению нефтей разных пластов Каламкасского месторождения показали, что концентрация ванадия изменяется пропорционально объемному соотношению нефтей, т.е. подтвердили правомочность такого предложения.

Предлагаемый способ апробирован в многопластовых месторождениях Мартыши и Камышитовое Юго – Восточное. Дебит изученных пластов по данным ЭПР спектроскопии хорошо согласуется с промысловыми данными.

Безусловными преимуществами метода ЭПР являются его производительность, обеспечивающая возможность получения экспресс – информации, более высокая точность и надежность по сравнению с перечисленными методами и отсутствие необходимости остановки добывающих скважин при отборе проб нефти для исследования.

Ключевые слова: электронный парамагнитный резонанс, фотоколориметрический метод, парамагнитизм ванадия, относительный дебит, многопластовое месторождение.

Information about authors:

Nasirov R.N. - Atyrau State University named after Kh. Dosmukhamedov, rnasirov.48@mail.ru, - https://orcid.org/0000-0003-4023-7689;

Baimukhasheva G.K. - Atyrau State University named after Kh. Dosmukhamedov, gaini.baimukasheva@mail.ru, https://orcid.org/0000-0003-4695-9543;

Solodovnikov S.P. - A.N. Nesmeyanov Institute of Organoelement Compounds of Russian Academy of Sciences (INEOS RAS), Russia, Moscow

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