IDENTIFICATION OF OIL DEPOSIT REFORMATION AND DEEP FEEDING ON EXTRACTED OIL COMPOSITION

Dr. Yury Turov[1]
Dr. Marina Guznyaeva[2]
[1,2] Surgut State University, Russia

ABSTRACT

During the operation of multilayer oil fields, there is a likelihood of the occurrence of interstratal oil flows due to the occurrence of secondary technogenic channels of migration along vertical or lateral fill-spill chains. This is due to numerous perforations of fluid-tight and fluid-insulating layers, intensive oil withdrawal, the use of intensive oil recovery technologies (hydraulic fracturing, reservoir pressure maintenance systems and the other physicochemical effects in the reservoir). Thus, the original geological structure of the oil deposit may change during its operation. Besides, for some oil deposits in the later stages of their exploitation, the oil inflows from deeper geological structures can be detected. In this paper, the detection capability of oil deposit reformation and deep feeding on extracted oil composition is shown. The geochemical composition indices are calculated based on the GC/MS analysis of the isomeric composition of paraffins and some classes of aromatic hydrocarbons in oil samples recovered from different wells. The possibility of identifying the source of oil by their values is shown. When comparing the distributions of the values of geochemical indices in different samples of oil from one field, it was found that some of the wells extract oil from one horizon, while the composition of the extracted oil from other wells is of a mixed nature. The composition of oil from one well with a long service life is significantly differ from all others and cannot be explained as the result of mixing oil from two productive horizons. The composition of this oil is highly likely influenced by deep feeding or other technogenic factors.

Keywords: *petroleum, hydrocarbon composition, geochemical indexes, interstratal flows, replenishment of stocks, crude oil mixtures*

INTRODUCTION

The initial geological structure of the deposits may change significantly in the process of exploitation of oil and gas fields, especially in the late stages of development due to numerous perforations of fluid-insulating (fluid-resistant) geological structures, as well as a result of the use of various technologies for intensifying hydrocarbon recovery.

In addition, the hypothesis of the geodynamic formation of oil and its fields which is gaining popularity suggests a high likelihood of deep recharge of already exploited fields due to ascending flows of hydrocarbon fluids [1].

These phenomena demonstrate themselves in changing the composition of the recoverable oil with an increase in the operating time of individual wells and the field as a whole.

It is well known that many in-reservoir mixing processes, biodegradation or mixing with indigenous organic matter can be detected by changing the isomeric composition of different classes of substances of recoverable oil [2], [3], [4], [5]. Multivariance of in-situ processes is a consequence of the thermodynamic nonequilibrium of the oil system [6] and in each case and in every time period requires a detailed study. Therefore, at present, there are attempts to 4D modeling of natural oil systems and oil-bearing Basin Province [7].

Detailed (thorough) geochemical support of oil and gas production processes, based on monitoring the composition of the recovered fluid can be a tool to optimize the regime of oil recovery from each well to achieve (increase) the accumulated (total) amount of extracted oil.

The aim of this work is to verify the possibility of identifying the source of the oil sample by analyzing the isomeric and homological composition taking into account the total error of the analysis results to observe changes in the composition of the recovered oil due to oil deposit reformation and deep feeding.

MATERIAL AND METHODS

We studied the hydrocarbon composition variations in oil samples and their change over time in the consistency of recovered oil during well exploitation on the territory of the Khanty-Mansiysk Autonomous Okrug (Western Siberia).

In the geological assessment of field reserves and their contouring the belonging of the oil fluid to a specific productive horizon based on the composition of the recovered oil were specified.

The isomeric composition of paraffins and several classes of aromatic hydrocarbons in oil samples obtained from seven different wells from one of the Khanty-Mansiysk Autonomous Okrug-Yugra oil fields (Western Siberia) was studied by gas chromatography / mass spectrometry (GC/MS) methods.

The complexity of the composition of crude oil necessitates its preliminary fractionation into simpler components with a quantitative assessment of the contents of the obtained fractions. In this case, seven initial crude oil samples were divided into four fractions: saturated substances, aromatic, resins and asphaltenes (**SARA** analyzes: – **S**aturates, **A**romatics, **R**esins, **A**sphaltenes) [8], [9].

The composition of saturated and aromatic fractions isolated by column adsorption chromatography in accordance with [8] was studied by full spectra GC/MS and mass-fragmentography.

Quantitative geochemical parameters (indices) were calculated from the relative isomer concentrations of saturated and aromatic substances.

RESULT AND DISCUSSIONS

More than 300 individual substances were identified in the studied samples. The total error of the results of the analysis of the isomeric composition and calculated geochemical indices was evaluated. The reproducibility of the results was 5% for the relative content of isomers and 3% for the calculated geochemical indices.

The data (information) on the isomeric composition of the studied samples were processed by the methods of cluster and factor analysis. Using techniques similar to those described in [10], [11], [12], the principal component method was able to distinguish three main groups of samples by hydrocarbon composition: 1 - oil samples from wells I and II; 2 - oil from well III; 3 - oil from well VII.

Oil from the first two wells has an almost identical composition. The composition of oil samples from wells IV, V and VI is a mixture of the first and second groups in different ratios. For the wells of the first and second groups, repeated sampling and analyzes were carried out (4 times within six months), which showed the absence of significant changes in the composition of the recovered oil for the indicated observation period. Differences in the values of geochemical indices calculated from the isomeric composition for these samples did not exceed 3% rel.

Fig. 1 is a graphical illustration of the obtained composition characteristics for the first three (I. II, III) and seventh (VII) wells. According to preliminary information received from the geological service of the oil company first three wells operating on two different productive horizons. As follows from Fig. 1 the composition characteristics of the saturated part of the oil from the wells I and II are very similar. Their diagrams in individual sections almost completely overlap; the differences in the values of geochemical indices do not exceed 3%.

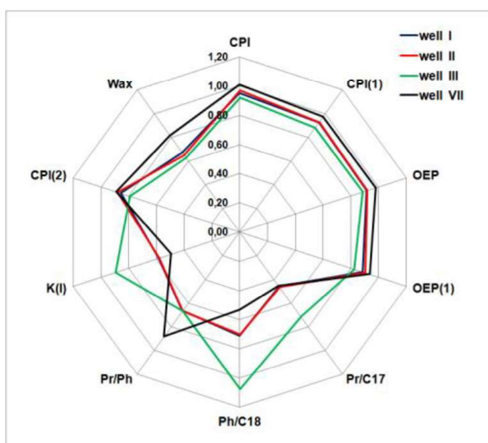

Fig. 1. Values of geochemical parameters calculated by the isomeric composition of paraffins in oil samples from different wells

CPI – carbon preference index = ((C25+C27+C29+C31+C33)/(C24+C26+C28+C30+C32)+ +(C25+C27+C29+C31+C33)/(C26+C28+C30+C32+C34))/2;

CPI(1) – carbon preference index (1) = 2(C23+C25+C27+C29)/(C22+ 2(C24+C26+C28)+C30);

CPI(2) – carbon preference index (2) = 2(C27)/(C26 +C28); K(I) = (Pr+Phy)/(C17+C18);

OEP – odd over even predominance = (C21+6C23+C25)/4(C22+C24); OEP(1) – odd over even predominance (1) = (C25+6C27+C29)/4(C26+C28)

A different picture is observed for the third well (III) - the values of the parameters OEP(1), CPI(2), K(I), Pr/C17 and Phy/C18 differ significantly from the values of these characteristics calculated for oil samples from the first two wells. Differences exceed 30% for the most differentiating composition characteristics.

The maximum differences are observed for the isoprenoid coefficient K (I) (34.7%) and the ratios between the contents of pristan and heptadecane n-C17 (Pr/C17; 35.1%), as well as phytane and octadecane n-C18 (Phy/C18; 34.3%).

Composition of oil from wells VII and the values of geochemical indices calculated for it differ significantly from all others. It should be noted that this well has the longest exploitation time compared to other wells studied in this work.

Variations and differences in the isomeric composition of aromatic substances are shown in Fig. 2.

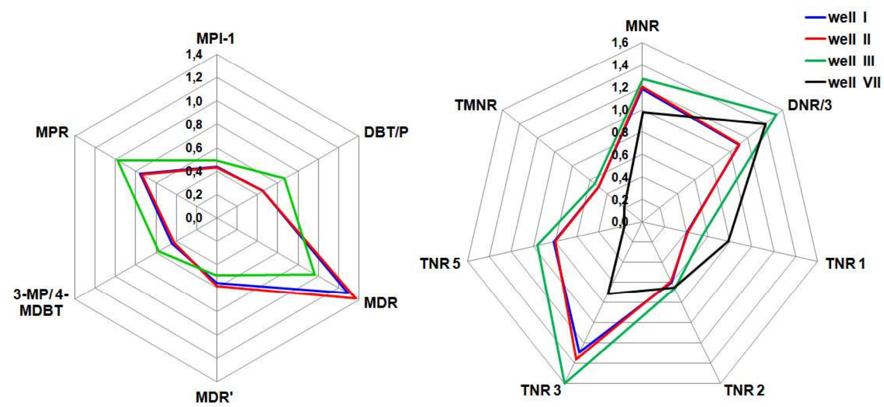

Fig. 2. The values of geochemical parameters calculated by the isomeric composition of bicyclic (right) and tricyclic (left) aromatic substances in oil samples from different wells

MNR = 2-MN/1-MN; DNR = (2,6-DMN+2,7-DMN)/1,5-DMN;
TNR 1= 2,3,6-TMN/(1,4,6-TMN +1,3,5-TMN);
TNR 2=(1,3,7-TMN +2,3,6-TMN)/(1,3,5-TMN +1,4,6-TMN +1,3,6-TMN);
TNR 3=1,3,6- TMN /1,2,5-TMN;

TNR 5=1,3,7- TMN /(1,4,6-TMN +1,3,5-TMN); TMNR=1,3,7-TMN /(1,3,7-TMN +1,2,5-TMN);
MN, DMN and TMN – Methylnaphthalenes, Dimethylnaphthalenes and Trimethylnaphthalenes.
MDR = 4-MDBT/1-MDBT; MDR' = 4-MDBT/(4+1)-MDBT; MPR = 2-MP/1-MP;
MPI-1 = 1.5×(2-MP + 3-MP)/(P + 1-MP + 9-MP);
P, 1-MP, 2-MP, 3-MP, 9-MP, DBT, 1-MDBT и 4-MDBT – Phenanthrene, 1-, 2- and 3-Methylphenanthrenes, Dibenzothiophene, 1- and 4-Methyldibenzothiophenes

From the above results it follows that the sources of oil can reliably differentiate and establish belonging of a sample of extracted oil to a specific reservoir based on a comparison of the relative contents of isomers of various classes of compounds and the geochemical parameters of the composition calculated from them.

In total, the composition of the recoverable oil from seven wells of one two-layer field was investigated and compared in detail. The same two productive horizons were reliably identified as sources of oil for three else wells (IV, V, VI) in accordance with the procedures for comparing the values of geochemical indices.

The oil from IV, V, VI wells and the geochemical indices calculated by their composition suggest that it has a mixed source. The values of geochemical indices are significantly different from those calculated for oil samples from each individual horizon and have intermediate values.

Most likely, the composition of recoverable oil is influenced by the presence of inter-reservoir flows, and oil composition is formed as a result of partial mixing of the oil fluid from both horizons.

The oil of the last (seventh) well is fundamentally different in composition from all previous ones. In Fig. 1 and Fig. 2 (*right*) are given geochemical parameters calculated by the isomeric composition of paraffins and alkylnaphthalenes in oil samples from well VII. This well has the longest lifetime of all investigated. And most likely, the formation of the composition of oil extracted from it is influenced by secondary processes of filling the reservoir, including replenishment from deep horizons cannot be excluded.

CONCLUSION

Reliable history reconstruction of the formation and operation of an oil field based on the results of a single sampling of the composition of recoverable oil samples is impossible. Just as it is impossible to assess the quality of a multi-part film epic and the director's talent from a single movie frame or a single episode.

Nevertheless, a detailed analysis and comparison of the composition of oil samples from different wells of the same oil field made it possible to establish the presence of interstratal oil flows, which appeared as a result of technogenic impact on the oil field in the process of hydrocarbon extraction. The detection of a well with a long service life with a dramatically different oil composition from the bulk of the samples suggests the existence of vertical migration of hydrocarbons from deep geological structures at present in notable quantities.

However, other technogenic factors can cause a similar effect. For example, the use of physicochemical enhanced oil recovery methods of a productive reservoir to stimulate oil production. Anyways, the processes of oil deposit reformation during exploitation as a result of technogenic impact on it has been established by isomeric composition and values of geochemical indices. Regardless of the reasons that cause them.

REFERENCES

[1] Muslimov R.Kh., Plotnikova I.N., Replenishment of oil deposits from the position of a new concept of oil and gas formation, Georesursy = Georesources, vol. 21/issue 4, pp 40-48, 2019.

[2] van Aarssen B.G.K., Bastow T.P., Alexander R., Kagi R.I., Distributions of Methylated Naphthalenes in Crude Oils: Indicators of Maturity, Biodegradation and Mixing, Organic Geochemistry, vol. 30, pp 1213-1227, 1999.

[3] Nicolle G., Boibien C., ten Haven H.L., Tegelaar E., Chavagnac P., Geochemistry: a powerful tool for reservoir monitoring, Society of Petroleum Engineers, No. 37804, pp 395-401, 1997.

[4] Peters K.E., Magoon L.B., Bird K.J., Valin Z.C., Keller M.A., North Slope, Alaska: source rock distribution, richness, thermal maturity, and petroleum charge, American Association of Petroleum Geologists Bulletin, vol. 90, pp 261-292, 2006.

[5] Zumberge J.E., Russell J.A., Reid S.A., Charging of Elk Hills reservoirs as determined by oil geochemistry, American Association of Petroleum Geologists Bulletin, vol. 89, pp 1347-1371, 2005.

[6] Turov Yu.P., Guznyaeva M. Yu., Oil system - structure, properties, behavior, Monograph (Study), Surgut State University, Surgut, Russia, 2017, 286 p.

[7] Higley D.K., 4D petroleum system model of the Mississippian System in the Anadarko Basin Province, Oklahoma, Kansas, Texas, and Colorado, U.S.A: The Mountain Geologist, vol. 50, pp 81- 98, 2013.

[8] Sieben V.J., Stickel A.J., Obiosa-Maife C., Rowbotham J., Memon A., Hamed N., Ratulowski J., Mostowfi F., Optical measurement of saturates, aromatics, resins, and asphaltenes in crude oil, Energy Fuels, vol. 31, no. 4, pp 3684-3697, 2017.

[9] Gutiérrez D., Moore R.G., Mehta S.A., Ursenbach M., Bernal A., Phase-behavior modeling of oils in terms of saturates/aromatics/resins/asphaltenes fractions, SPE Reservoir Evaluation & Engineering, vol. 22, no. 03, pp 1-15, 2019.

[10] Peters K.E., Ramos L.S., Zumberge J.E., Valin Z.C., Bird K.J., De-convoluting mixed crude oil in Prudhoe Bay Field, North Slope, Alaska, Organic Geochemistry, vol. 39, pp 623-645, 2008.

[11] Engel M.H., Imbus S.W., Zumberge J.E., Organic geochemical correlation of Oklahoma crude oils using R-and Q-mode factor analysis, Organic geochemistry, vol. 12, pp 157-170, 1988.

[12] Peters K.E., Ramos L.D., Zumberge J.E., Valin Z.C., Scotese C.R., Gautier D.L., Circum-Arctic petroleum systems identified using decision-tree chemometrics, American Association of Petroleum Geologists Bulletin, vol. 91, pp 877-913, 2007.