

Spatial Variability of Chemical Composition of Eurasian Oils

Yuri M. Polichtchouk*, Irina G. Yashchenko

The Institute of Petroleum Chemistry, Russian Academy of Sciences, Siberian Branch
3, Academicheskoy Ave., 634021 Tomsk, Russia

Abstract

The study of relationships governing the variability of chemical composition of the Eurasian oils has been carried out on the basis of the statistical processing of the data on contents of total sulfur, resins, paraffin wax and asphaltenes in oils. These indices are considered as the principal chemicals of oils chemical composition. The data processed for Eurasian continent was chosen from database on petroleum chemistry, which is create by Institute of Petroleum Chemistry of Siberian Branch of Russian Academy of Sciences and nowadays includes more than 9,000 entries of oil physical-chemical data on all main world oil-bearing basins. Latitudinal and longitudinal dependencies of the above indices of oils chemical composition were studied by methods of statistical and cluster analyses and means of geographical information system (GIS) ArcView 3.1. The results of these studies are represented on the computer maps. It is shown that properties of oils are statistically inhomogeneous in Eurasia depending on geographic position. In average, contents of total sulfur, resins and asphaltenes in crude oil increase in direction from east to west. But the analysis doesn't reveal longitudinal dependence of paraffin content, only a latitudinal dependence. In average, paraffin wax content in oils increases in direction from north to south. From the analysis of the results of geozoning of oil-bearing territories using the whole complex of indices, the zones of oils that are homogenous by their properties was revealed. The results obtained may be used to solve the problems of a rational use of hydrocarbon resources, in particular:

- a) siting the oil-refining and petrochemical enterprises,
- b) developing the regional nets of a rational transporting of hydrocarbons and petroleum products.

Introduction

In accordance with the experts' evaluation, the natural gas, crude oil and coal will be the principal energetic resources in the first half of the 21st century. It is expected [1] that the oil part of the world energy balance will be about 30% to the end of the first decade of the 21st century. The maximum level of oil production may be reached between 2010 and 2020 and the world oil needs will further increase. It is known that oil resources are distributed on the world territory very irregular [2,3]. Now geographical regularities of oil resource distribution in the world are enough studied. But regional variability of physical and chemical properties of crude oils hasn't been studied enough. There are some problems decision of which needs information about regional regulatory of petroleum properties. One of the important problems is to determine the rational ways of oil trans-

portation to countries of Southern Asia, which will be the most dynamically developing region of the world in the nearest decades. So the main purpose of this paper is to investigate the spatial variability of petroleum properties for oil-bearing basins of Eurasia.

Oil hydrocarbons are formed in the process of complex and continuous catagenetic transformations of the buried organic matter of the sediments [2]. The interaction of oil hydrocarbons with the matter of oil-bearing rocks and their migration causes the changes in the chemical composition of the oil that lead to a significant non-uniformity of the territorial distribution of physicochemical oil properties within oil fields and oil-gas bearing basins. It is known that oil is characterized by a large number of physicochemical indices. That is why the database on the petroleum chemistry [4,5] includes more than 50 oil parameters.

Figure 1 represents averaged chemical composition of Eurasian oils. As it is shown in Fig.1, the sum of averaged contents of IBP 350°C fraction, total sul-

*corresponding author. E-mail: yuri@ipc.tsc.ru

fur, paraffins, resins and asphaltenes is above 70% of total mass of crude oil. Therefore besides oil fraction the main oil components are sulfur, paraffin wax, resin and asphaltene in average. These chemicals have significant influence on commercial properties of crude oil as well. Really high sulfur content in oil causes both an intensive corrosion of the equipment during oil processing and catalyst poisoning that significantly increases the expenses for refining high-sulfur oils. An increased paraffin content results in its deposition in the technological equipment and in the pipelines that causes the growth of the price of petroleum products due to de-waxing required. An increased content of asphaltenes and resins in oils provokes the formation of stable water-oil emulsions. Under the conditions of vacuum distillation and thermal cracking the oil resins are subjected to coking causing the coke depositions in the heat-exchange equipment and on the catalyst during the catalytic cracking and reforming. To remove resins and asphaltenes from the lube fractions the processes of deasphalting and after purification are required that increases expenses at the production of petroleum products.

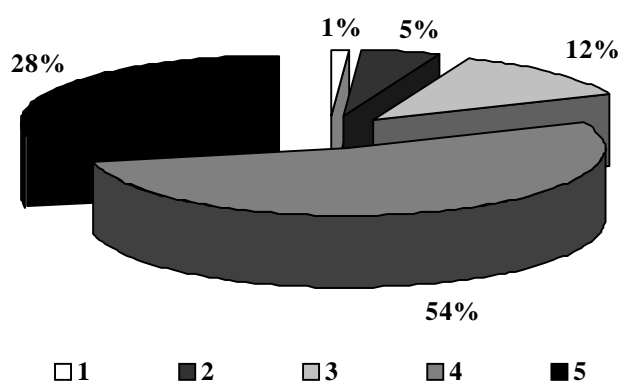


Fig. 1. Averaged contents of fraction, sulfur, paraffin, resins and asphaltenes in oils of Eurasia (in mass percents). Symbols: 1 – sulfur content; 2 – paraffin content; 3 – resin and asphaltene content, 4 – content of IBP 350°C, 5 – other chemicals.

The study of spatial variability of chemical composition of oil has been carried out on the basis of the statistical processing of the data [4,5] on the above principal oil chemicals. In this case, the data on the values of total sulfur, paraffin wax, resins and asphaltenes contents averaged by the territory of oil-bearing basins of Eurasia were used. Some results of this analysis were given in [6,7]. Below are general regularities of geographic distribution of Eurasian oils

by above mentioned chemical contents.

Variability of Sulfur, Resin and Asphaltene Content

Figure 2 shows the distribution of oil-gas bearing basins by sulfur content in oils on the Eurasian continent. The investigations of the variability of sulfur content were carried out by the data procession using the oils classification [8] given in Table 1. The low-sulfur oils occur preferentially on the East of the Asian continent. Observed is the tendency for increasing sulfur content in oils as from the East to the West by the Eurasian continent: the oils of West-Siberian, Timan-Pechora and Near-Caspian provinces are low-sulfur, the oils of Volga-Urals, Persian Gulf and Northern Sea shelf are sulfur ones. Mediterranean oils have the highest sulfur content.

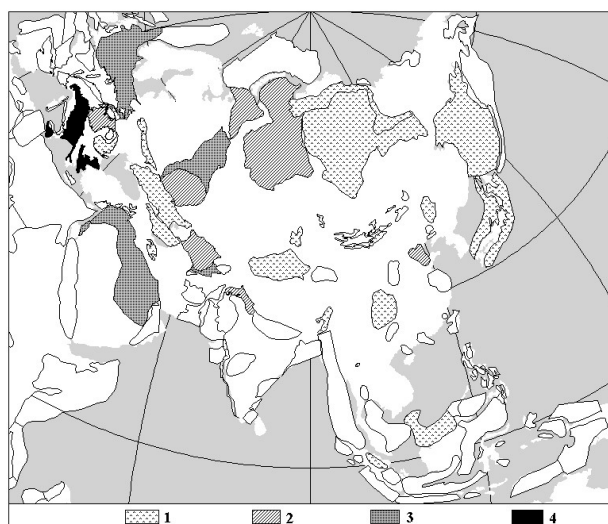


Fig. 2. Spatial variability of the sulfur content in oil. Legend: 1 – low-sulfur oils, 2 – middle-sulfur oils, 3 – sulfur oils, 4 – high-sulfur oils.

Similar regularities are observed [6,7] when studying the spatial variability of total content of asphaltenes and resins (AR content) in Eurasian oils. As it was shown by the results, the oils of South Asia and the oils on almost all the territory of Siberia and Far East are low-resin. Resin oils are located mainly at the Urals, in the European part of Russia, in Kazakhstan and Mongolia. The oils of the Central Europe, Afghanistan and China are very high-resin oils. The oils of the Sicilian basin are very high-resins. Therefore comparing the results of investigations of the spatial oil distribution by sulfur and AR content, one

may conclude the following: sulfur and AR contents of Eurasian oils have a meridional dependence: the averaged values increase in direction from east to west of the continent.

The relationship between sulfur, resin and asphaltene content in oils and longitude given in Fig. 3, where the average values of chemicals content were calculated in longitude intervals width of which was 30°. The vertical bars in Fig. 3 show the confidence intervals calculated with a confidence level of $\beta = 0.95$. As it is shown from Fig. 3, contents of these chemicals in oils increases (in average) from east to west of the Eurasian continent.

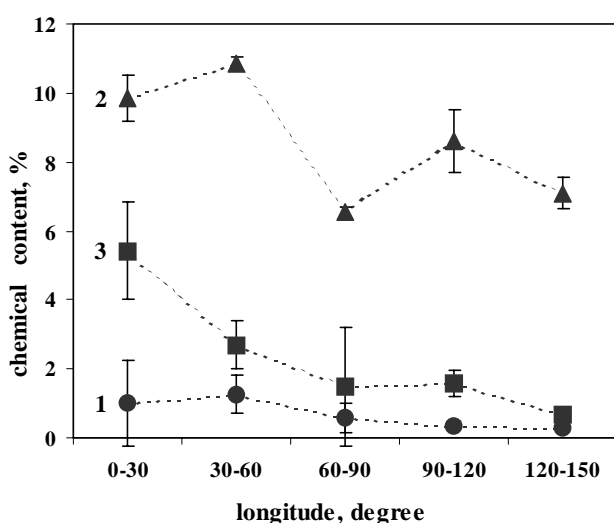


Fig. 3. Relationship between contents of sulfur, asphaltenes and resins and longitude. Symbols: 1 – sulfur content; 2 - asphaltene content; 3 - resin content.

Variability of Paraffin Content

Figure 4 shows the distribution of oil-gas bearing Eurasian basins by paraffin wax content. The investigations of the variability of paraffin wax content were carried out by the data procession using the oils classification [8] given in Table 1. As it is seen, high-paraffin oils occur mainly in the South Asia: in the southeast of China, in the west of India, in the south of Mongolia and in Russia. Paraffinic oils are located in Romania, Hungary, Iran, China, Indonesia and Central Asia. Low-paraffin oils are concentrated mainly in the north of the Eurasian continent.

One may deduce that Eurasian oils reveal the following regularity governing the paraffin content: the paraffin wax content does not reveal the longitudinal dependence but a latitudinal dependence (Fig. 5). As it may be shown from Fig. 5, paraffin content increases

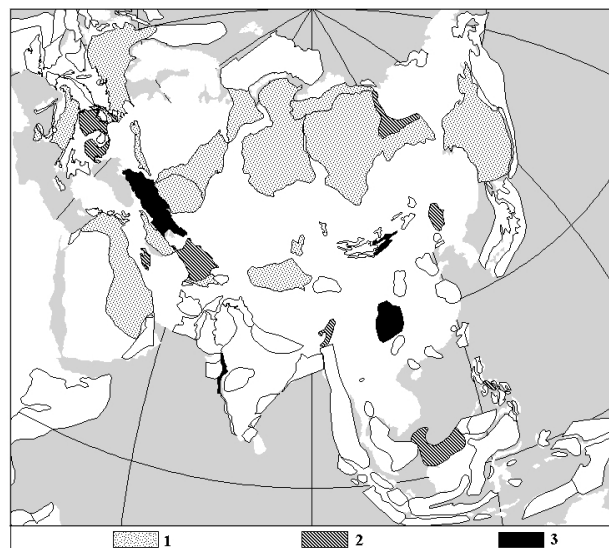


Fig. 4. Spatial variability of the paraffin content in oil. Legend: 1 - low-paraffin oils, 2 - paraffinic oils, 3 - high-paraffin oils.

Table 1

The oil classification by chemical content.

Chemicals	Oil class name	Interval values, %
Sulfur	low-sulfur oils	0±0.5
	middle-sulfur oils	0.5÷1
	sulfur oils	1÷3
	high-sulfur oils	> 3
Paraffin wax	low-paraffin oils	0÷5
	paraffinic oils	5÷10
	high-paraffin oils	> 10

(in average) from north to south of the Eurasian continent. The vertical bars in Fig. 5 show the confidence intervals which were calculated with a confidence level of $\beta = 0.95$.

Conclusion

Regional variations of the indices of the chemical composition of Eurasian oils and the relationships between the contents of total sulfur, resins, paraffins, asphaltenes, fractions in oils and their geographical location have been considered. It is revealed that properties of oils are statistically inhomogeneous in Eurasian territory depending on geographic position of oil-bearing basin. In average, contents of total sulfur, resins and asphaltenes in crude oils increase in

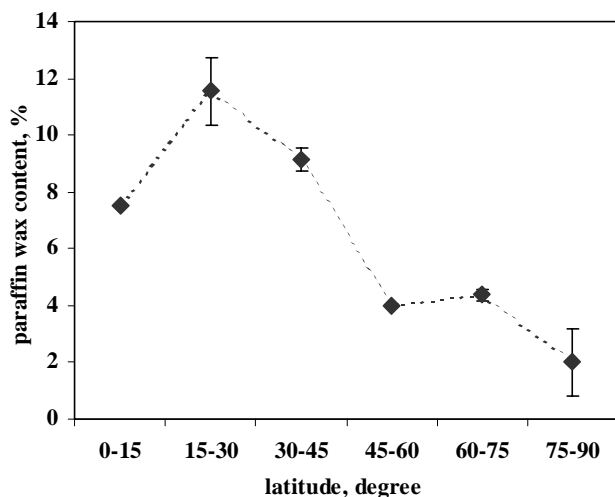


Fig. 5. Paraffin wax contents in Eurasian oils versus latitude.

direction from east to west, but paraffin wax content in oils increases in direction from north to south. Zones of oils that are homogeneous by their properties were revealed on base of analysis of oil-bearing territories geozoning results. The geographical regularities of oil resource distribution in Eurasia obtained may be used to solve the problems of a rational transporting of hydrocarbons and petroleum products and the problem of siting the oil-refining and petrochemical enterprises.

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