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PROCESS OF OIL-GENERATION FROM THE TRACE ELEMENT CONCENTRATION

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Introduction

Petroleum generation is regarded as a complex process controlled by the combined effects of different deep and near-surface factors. This suggestion was confirmed below by the results of the examination of the trace element composition in crude oils and its correlation with the organic matter composition, with main and minor elements composition in different rock types, and with the mean chemical content of the upper and lower continental crust.
Most of trace elements in oils are suggested to be inherited from living organisms, as it is indicated by a connection between the distribution of trace elements in oils and the average chemical composition of biological materials. However, some other trace elements in oils indicate the contribution of the deep source. Really, some elements indicate lower crustal contamination, and a positive Eu anomaly indicates a contribution of the lower crustal fluid (Taylor and McLennan, 1988). However, these conclusions have mostly qualitative character and do not allow to compare the relative contributions to the trace element content of hydrocarbons from the lower and upper crust and from living matter. Our study is aimed to obtain quantitative comparison of these different contributions
Trace elements in hydrocarbons are known to defive from biological matter, aqueous fluids and country rocks. The genetic characteristics of different oils are estimated from a few indicators such as the V/Ni ratio, Eu anomaly, etc. But these characteristics depend from the variation in the concentration of individual elements that depend from many factors. The use of concentrations of all available trace elements instead of individual elements can present more robust characterization of oil samples. Such estimations were obtained from coeffecients of correlation between trace element concentration in different rock types, in different caustobioliths, in the upper and lower continental crust, in living matter, and in oils.

Method and results

The correlation coefficients between different geochemical reservoirs are calculated using a logarithmic scale, this fairly routine method appears to be effective for comparison of very different values of trace element concentrations. To our knowledge, this simple mathematical approach has not been used before for the calculation of koefficients of correlation between chemical compositions of main and trace elements in different rock types and in oil. The calculation became possible because of an essential increase of amount of analytical data characterizing the trace metal composition in different caustobioliths and different types of rocks. This progress has been made becouse of the use of inductively coupled plasma mass spectrometry method (ICP— MS), which enabled more accurate and precise analysis of a wider range of trace metals in specimens.
The used method confirms quantitatively the qualitative conclusions obtained previously. It was shown (Rodkin et al., 2016) that the trace element compositions of clays, coals, and oil shales show a better correlation with the upper crust than with the lower crust. At the same time, the trace elements in oils show weaker correlation with the composition of living matter

and the upper crust, and stronger correlation with the lower crust composition (see Table).
The obtained results indicate a significant contribution from the lower continental crust to the trace element composition of oils. Our results confirm also that oils are homogeneous on a basin scale and can be very essentially heterogeneous in trace elements composition in different petroleum basins.
To promote data accumulation, it is proposed to restrict oil analyses to 7 characteristic elements (Cs, Rb, K, U, V, Cr, and Ni) instead of analyzing the entire set of elements. As can be seen from the Table, the analysis of concentrations of these characteristic elements only can provide comparable data on the relative upper and lower crustal contributions to the trace element composition of oils with a simultaneous 5-fold and more decrease in the amount of analytical measurements.

Table.

*Correlation coefficients between trace element compositions of clays, coals, shales, and oil with the upper and lower continental crust and living matter**

	Clay	Coal	Oil shale	Black shale	Oil
Number of used elements	33/6**	33/6	31/6	33/6	28/5
Upper crust	0.98/0.93	0.92/0.89	0.94/0.97	0.87/0.90	0.56/0.46
Lower crust	0.94/0.90	0.89/0.89	0.90/0.86	0.87/0.91	0.70/0.98
Living matter	0.85	0.81	0.81	0.78	0.56/0.63

* - more detailed tables are available in (Rodkin et al, 2016)
** - the number of all used elements, and of the characteristic elements only. In the cases when calculation with the characteristic elements were not performed the coefficients of coppelation for all elements are presented only.

Conclusion

The results obtained confirm the effectiveness of a simple technique employed for estimating the correlation between trace element compositions of different geochemical reservoirs: oils, coals, oil and black shales, living matter, and continental crust and provide additional support for the polygenetic model of hydrocarbon generation. The results obtained agree with the scheme of the oil generation from dispersed organic matter with the crucial contribution of upward fluid flow as it was suggested in the scheme of source of oil generation as a non-equilibrium flow reactor (Rodkin, 2004). The most corresponding to such scheme are the areas of deep thrusts zones (subduction zones in particular), where upward fluid flows are represented with low-mineralized waters mobilized during dehydration of rocks in the deep thrust zone.

References

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