ANALYSIS OF GEOCHEMICAL TRENDS FOR THE BAZHENOV OIL SHALE FORMATION BASED ON PYROLYSIS DATA

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The productivity of oil shales depends on genesis and content of organic carbon, maturity and presence of intervals with better collector properties. These characteristics are usually evaluated from pyrolysis data for different intervals of unconventional plays. The integration of pyrolysis data from different regions and intervals of one unconventional play provides an opportunity to evaluate potential productivity for the whole formation. The objectives of this study are to integrate a large amount of pyrolysis data on the Bazhenov formation, to generalize geochemical trends and to analyze the process of oil generation and migration in order to obtain additional information for the evaluation of productive intervals of this unconventional reservoir.

The Bazhenov formation is one of the largest oil shale formations which covers more than one million square kilometers in the Western Siberia, Russia. In such regions as Salym, Krasnolenonsky, Nazym the productivity of the formation has commercial value, but in many other regions, there are no or very few wells with commercial production. According to the results of pyrolysis, total organic carbon (TOC) varies from few percents up to 25% with the average value ~ 9%. Maturation varies from immature up to the end of the oil window. Other characteristics of organic matter including pyrolysis indexes (hydrogen index HI, production index PI, etc.), chemical composition (aliphatic to aromatic ratio), isotope composition (carbon, hydrogen, nitrogen, and sulfur), kerogen porosity and other parameters considerably vary depending on maturation (Spasennykh *et al*., 2019).

The study is based on results of pyrolysis on more than 3000 samples from 30 wells located in central and peripheral regions of the Western Siberia. Rock-Eval analysis (Espitalie, 1993) has been performed in the Skoltech laboratory by "HAWK Resource Workstation" (Wildcat technology). The geochemical study included pyrolysis of core samples before and after extraction in the Soxhlet apparatus. The results of pyrolytic studies were analyzed by two- and three-dimensional diagrams which show the correlation of standard pyrolysis parameters and indexes S0 (gas yield), S1 (oil yield), S2 (hydrocarbons generated from kerogen by thermal cracking at 300-650^{o}C), GOC and NGOC (pyrolyzable and residual organic carbon) and others. The maturity of the organic matter of the Bazhenov formation was determined using pyrolysis indexes Tmax, HI, PI and the parameter $GOC/TOC_{after\ extraction}$.

Modified van Krevelen plot with colored GOC/TOC scale (fig. 1a) shows decrease of hydrogen index (from 715 to 100 mg HC/g TOC) and GOC/TOC ratio (from 70 to 15%) with increase of Tmax (from 430 to 455°C), which corresponds to the thermal conversion of type II kerogen. Only very few (less 2%) points on the diagram with HI above 715 could be considered as type I kerogen.

Cross-plot S2 vs TOC (fig. 1b) with colored GOC/TOC scale shows change of slope for trends combining the points of the same maturation and decrease of TOC maximum values with the increase of maturation, which provides an opportunity to compare and describe quantitively the process of kerogen thermal transformation for different regions of Bazhenov formation.

Graph of S0+S1 vs S2 with colored GOC/TOC scale shows the redistribution of hydrocarbons between solid and mobile (liquid and gas) phases depending on maturity. All the points on the diagram are located in the sector between two trends of different slopes, corresponding to different conditions of maturation and migration. Points corresponding to intervals with better

collector properties (zones of accumulation) are located in the area closer to the line with a higher slope, points corresponding to the intervals of oil generation (source rocks) are located closer to the line with a lower slope. (fig. 1c).
Productivity index (PI) vs Tmax plot (fig. 1d) shows that the maximum content of mobile hydrocarbons is reached at a Tmax value of 445 ± 2 ºC, which corresponds to the middle-late stage of the oil window, where GOC/TOCex varies in the range from 20% up to 40%.

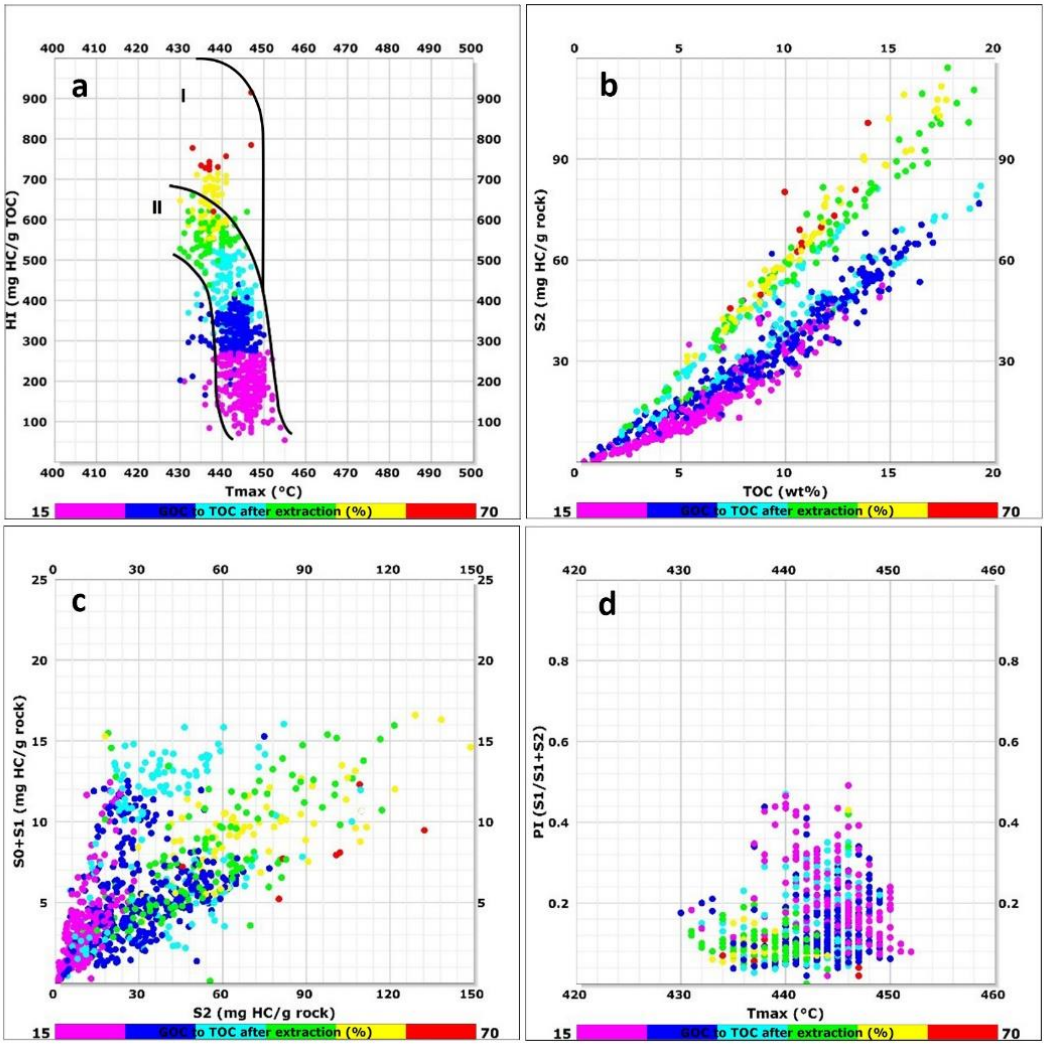

Figure 1. *Pyrolysis parameters distribution with GOC/TOC$_{after\ extraction}$ color scale: a) HI vs Tmax; b) S2 vs TOC; c) S0+S1 vs S2; d) PI vs Tmax.*

Thus, integration of a large amount of pyrolysis data provided an opportunity to identify and analyze geochemical trends, which bring new insight on the processes of hydrocarbon generation, migration and accumulation and allow formulating regional and local criteria of oil productivity for Bazhenov unconventional oil shale formation.

References

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