Research Article

Geochemical Criteria of Productivity of Jurassic Sediments

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ABSTRACT.

This paper results in increased efficiency of logging when prospecting for potentially productivetargets. To solve this problem, a profound system of geochemical core studies has been formed: bitumoid extraction defining its substance composition as well as thermal desorptionand analysis of deeply sorbed hydrocarbons. The obtained data made it possible to study the quantitative and qualitative characteristics of core fluid and to develop geochemical criteria of its mobility. Chromatograms of deeply sorbed gases permitted to define criteria of productivity of sediments under study. The studies showed that the integrated geochemical approach can significantly increase the diagnostics efficiency of perspective deposits.

Keywords: Deeply sorbed hydrocarbons, Oil, Gas, Geochemical criteria, Thermal desorption, Bitumoid, Polycyclic naphthenes, Chromatography.

INTRODUCTION

One of the urgent issues of modern oil and gas prospecting is the reliability of diagnosing the productivity of formations during prospecting drilling [1]. Frequent misses of producing intervals during well tests are primarily caused by the drilling technology and insufficient information capacity of the conventional logging system. Therefore, it is required to searchfor additional criteria of oil and gas bearing capacity during logging and core studies. In this connection, the use of geochemical methods to identify productive intervals of the section is highly reasonable, since geochemical methods are direct, e.g., operate directly with the substance contained in the rock unlike other mediated methodologies.

MATERIALS AND METHODS

The object of the study in this paper is core samples of Jurassic formations of one of the fields of the Nadym-Pur-Tazovsky region, wells Nos. 1 and 2. The rocks are represented by fine and medium-grained sandstone, aleurolite, some of which have a characteristic smell of hydrocarbons.

The research system included: extraction and weight analysis of bitumoid, separation of deeply sorbed gases by thermal desorption. The composition of bitumoid and emitted gas was determined by the gas chromatography method.

RESULTS

In order to determine the amount of oil hydrocarbons in the core, an extraction weight analysis was carried out for 5 samples of wells Nos. 1 and 2. Extraction was carried out with the Soxhlet unit using chloroform. The content of bitumoid in the presented samples varies from 1.9081 to 9.5413 g per 1 kg of rocks.

The bitumoid solution in hexane, i.e. itsdeasphalted part, was subject to chromatography analysis. The analysis yielded

chromatograms that showed that all bitumoid samples mainly consist of oil-row hydrocarbons – normal and branched alkanes and they have a so-callednaphthenehump – an increase of the

basic line by means of non-divided polycyclic naphthenes.

The interpretation of bitumoid chromatograms showed a number of their significant differences from typical oil chromatograms (Figs. 1-3).
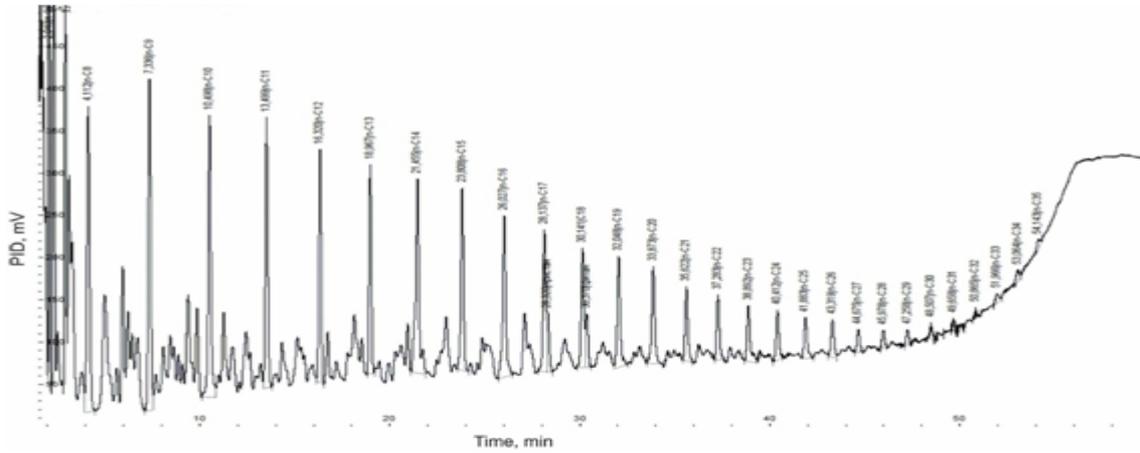

Fig. 1 Typical chromatographic distribution of normal alkanes of Western Siberia Jurassic oil.
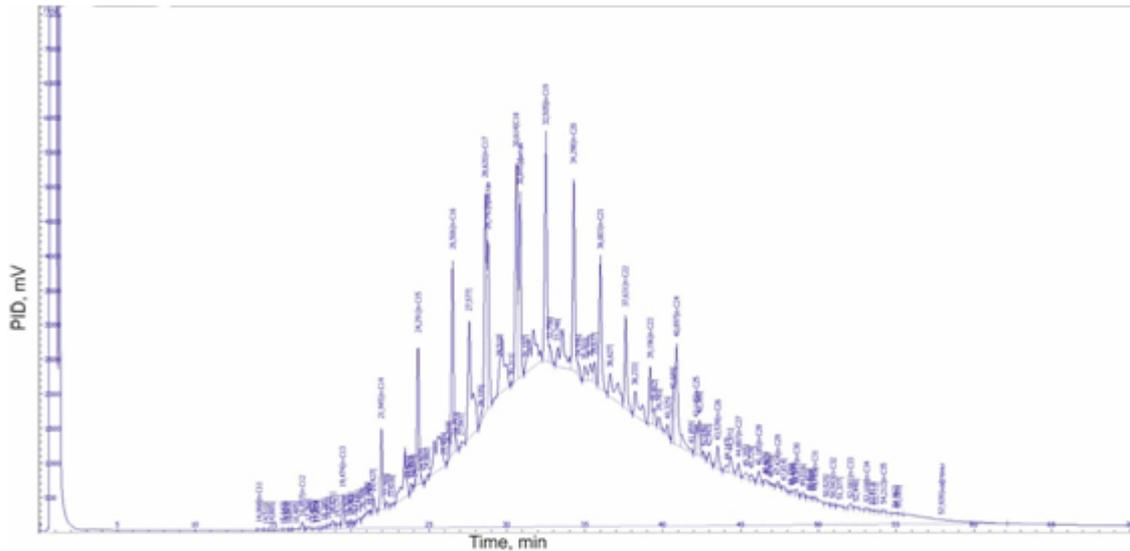

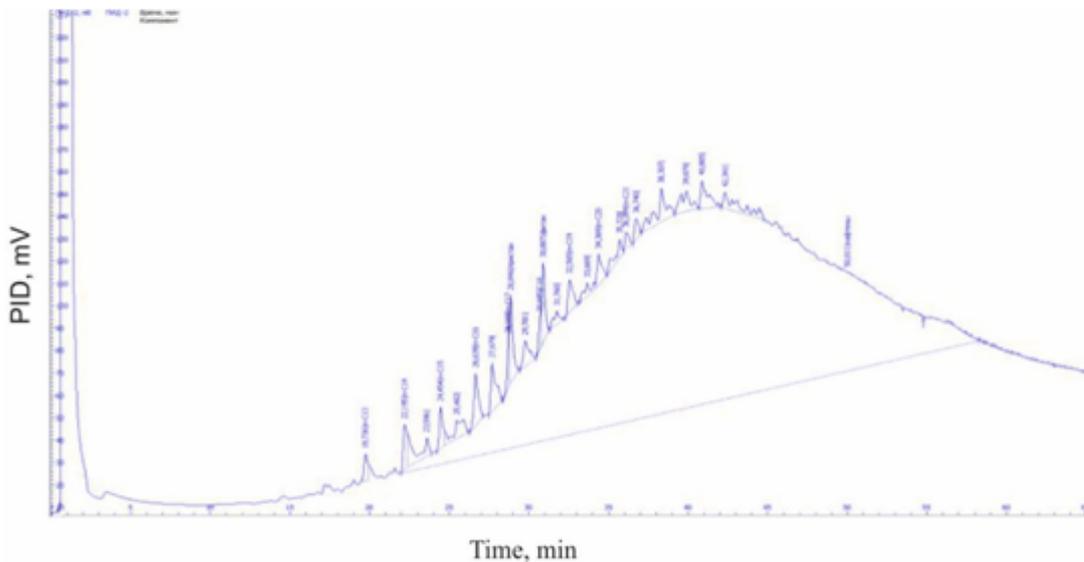**Fig. 2** Chromatogram of sample No. 94 bitumoid in well No. 1.

Fig. 3 Chromatogram of sample No. 204 bitumoid in well No. 2.

All bitumoid samples show a loss of naphtha (to C_{13}), which is caused by evaporation of low-boiling components during core storage. Furthermore, a significant increase in the naphthene components in bitumoid is observed as compared to crude oil.

The chromatogram (Fig. 2) of well 1 sample 94 shows predominant isoprenoids, namely pristane and phytane, above normal alkanes C_{17}, C_{18}, which may indicate either oil bio-degradation or a zone flushed with water. As a result of bio-reduction, the content of normal alkanes falls down relative to branched and polycyclic saturated HCs. Monocyclic aromatics (benzene, toluene, xylene) are resistant to bio-degradation, but are first to be reduced when flushed with water due to higher solubility [2].

A flushed zone can be diagnosed according to no aromatics on the chromatogram. Even if one suggests that they have evaporated with low-boiling oil components, it is impossible to suggest bio-degradation processes 4000 m deep. The primary criterion used to distinguish between thebitumoid component of dispersed organic matter and formation oil is the fluid mobility in the porous space of enclosing rocks.

To determine the mobility of hydrocarbon fluid in the reservoir, patterns were elaborated based on the relationships of the n-alkane sum and naphthene component. The diagram (Fig. 4) shows a clear differentiation of values depending on the HC type: mobile oils will always have the relationships of the n-alkane sum and naphthenes above 0.5, and the range of values for bitumoid (micro-oil) varies 0 to 0.5 (Fig. 4).
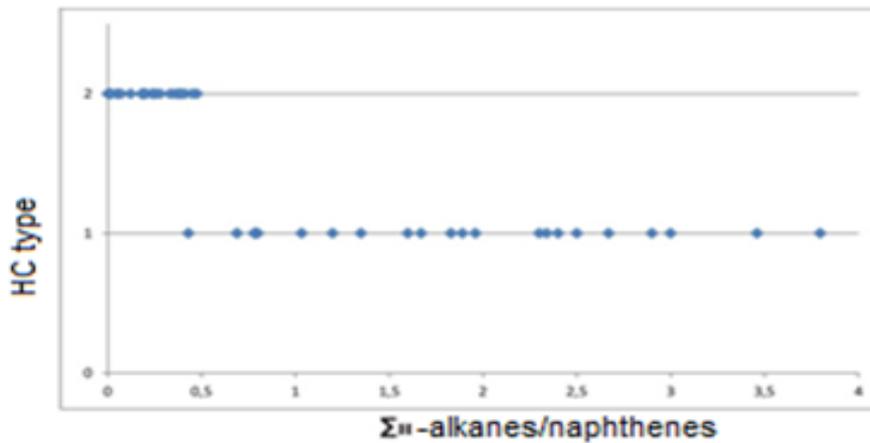

Fig. 4 Distribution diagram of the relationship between ∑n-alkanes and naphthenes by HC type (1 – oil, 2 – bitumoid).

The distribution of the relationship between n-alkanes and naphthenes by depth was built for wells Nos. 1 and 2 (Figs. 5, 6).
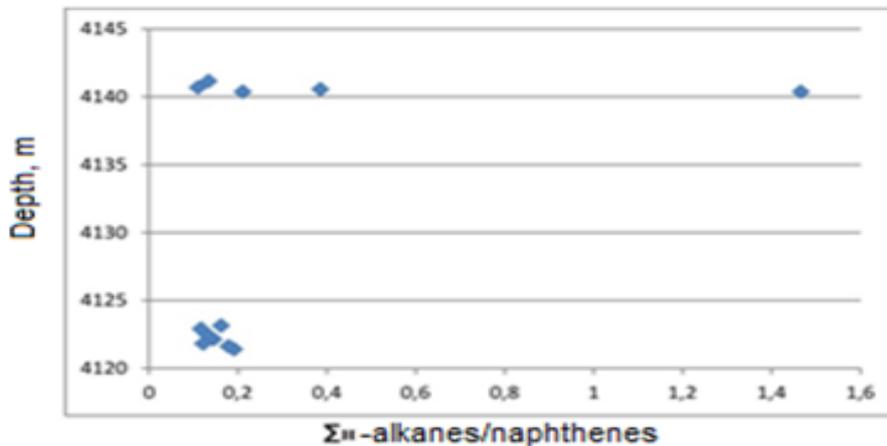

Fig. 5 Distribution of the relationship between n-alkanes and naphthenes by depth (well No. 1).
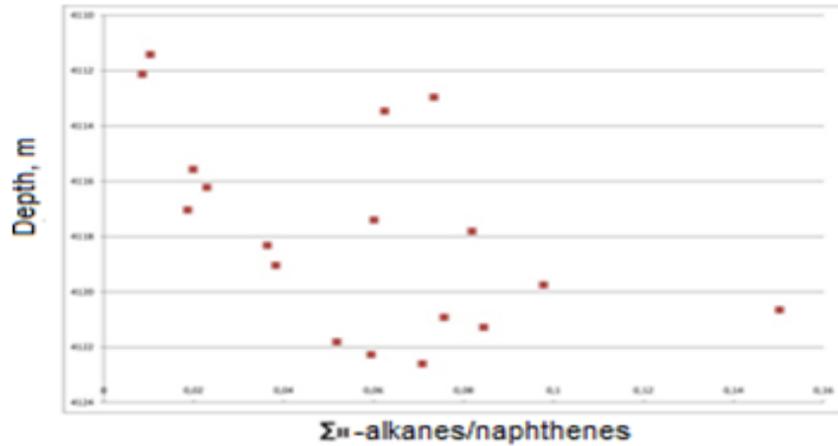
Fig. 6 Distribution of the relationship between n-alkanes and naphthenes by depth (well No. 2).

The distribution depicted in the figure of Jurassic formations (YU_2^1) in both wells corresponds to bitumoid (micro-oil).

The work has revealed genetic bonds of micro-oil by the relationships between n-alkanes and isoprenoids (Fig. 7). The stellar diagram shows a cross-well correlation of formations.
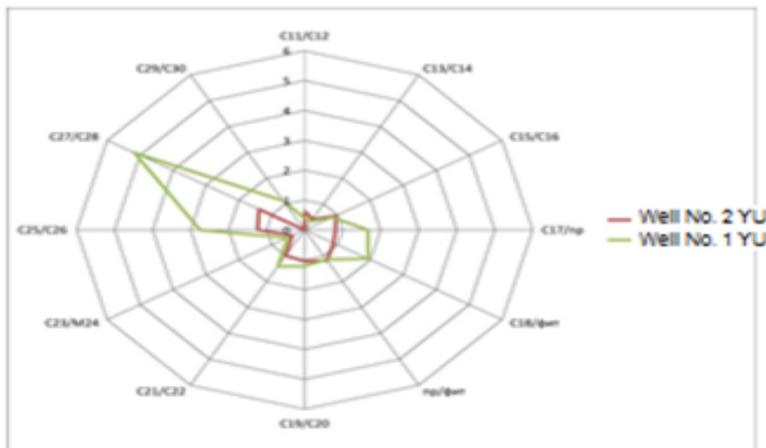

Fig. 7 Diagram of relationships between n-alkanes and isoprenoids by results of standard chromatography of micro-oil of wellsNo. 1 and 2.

Based on the diagram, one can make a conclusion that micro-oil of wellsNo. 1 and 2 is not idiogenous, since the difference between relationships of n-alkanes and isoprenoids exceeds 10-15%. This indicates no hydrodynamic bond between the studied wells, which can be caused by a screen or immobility of the researched fluid.

Most ratios of phytane/n-C18 and pristane/n-C17 lie within the area of the shallow sea algal type that corresponds to the initial sapropelic organic substance, which corresponds to modern concepts of sediment genesis conditions of Jurassic sediments in the north of the Western-Siberian sediment basin [7, 8].

To restore naphtha and determine the phase condition of the hydrocarbonic system, deeply sorbed gases were analyzed in reservoirs and normal alkanes, iso-, cycloalkanes and aromatic hydrocarbons were determined. Based on the works of Chakhmakhchev (1983) [3] who distinguished geochemical criteria for defining types of hydrocarbon fluids, the study results of deep sorbed gases were analyzed and charts were built to determine HC types in reservoirs based on benzene/n-hexane and toluene/n-heptane relationships (Figs. 10 and 11).
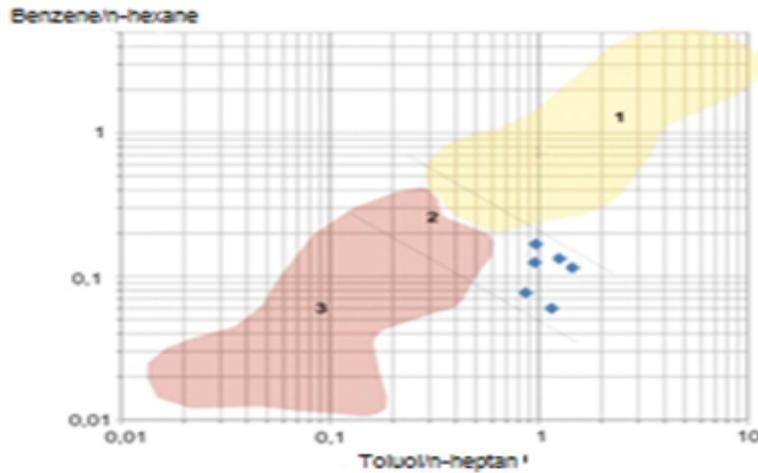
Fig. 10 Chart to determine HC reservoir types for well No. 1.
(1 – gas condensate reservoirs; 2 – transition area; 3 – gas condensate oil and oil reservoirs).

The obtained patterns for well No. 1 indicate that the studied interval is not productive for oil, gas, and gas condensate. Most probably, the high content of micro-oil indicates traces of HC migration.
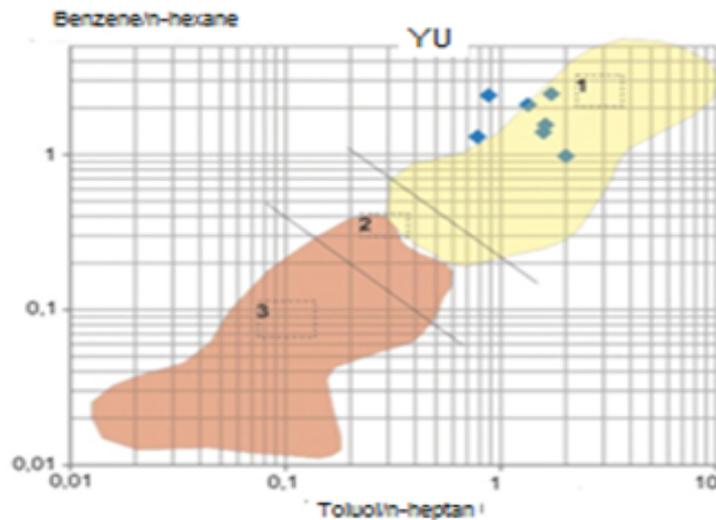

Fig. 11 Chart to determine HC reservoir types for well No. 2.
(1 – gas condensate reservoirs; 2 – transition area; 3 – gas condensate oil and oil reservoirs).

The relationships reflected in Fig. 11, as well as diagnostic indicators, indicate that the saturation nature of the studied interval in well No. 2 belongs to the gas condensate system.

The novelty of the paper consists in developing criteria based on studying deeply sorbed gases of the rock.

A specific feature of studying deeply sorbed gases is preliminary thermal desorbtion of the rock substance, with heating to 300 degrees and further application on the chromatographic column. The slide shows the obtained chromatographic in the upper part of the well No. 1 sample with predominating diesel fraction, and in the lower part of the well No. 2

sample with predominating naphtha. It can be suggested that the content of any fraction will depend on the amount of clay material in the rock, but the authors contested this fact by building relationships of the dependency between the percentage of clayiness from naphtha and kerosene fraction. The clayiness was determined with the SkyScan chromatograph. The clay material has specific X-ray density and is well distinguished on tomographic sections, with the contents calculated relative to the sample volume[4-6].

The percentage of each fraction was calculated using the internal normalization method. Finally, dependencies of naphtha and kerosene fractions

to percentage of clayiness were built, with no correlation found.

The interpretation of analysis data for deeply sorbed gases is done by a qualitative method (instead of quantitative), i.e.one compares the chromatogram consistency with the reference rather than concentration of specific components. A mathematic device was developed for that purpose. Data for each chromatogram are normalized relative to the maximum peak, then a productive and non-productive reference is selected depending on the area and sediments and the percentage deviation is calculated.

CONCLUSIONS

Based on the studies of the qualitative and quantitative characteristics of micro-oil and studying deeply sorbed gases, it has been defined that the saturation nature of the interval under study belongs to the gas condensate system. The obtained results are proved by YU_2^1 formation tests within 4111-4136 m where the natural flow of the gas condensate mixture with the rate of Q_{gcs}=27.96 thousand m^3/day was obtained.

The tested interval of well No. 1 is not productive, and micro-oil indicates HC migration traces. The water inflow of Q=12.3 m^3/day was obtained upon the test results.

Upon the results of the completed studies, it can be said that an integrated geochemical approach will allow objectively assessing the productivity of perspective intervals.

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