Paragenesis of the Upper Jurassic-Lower Cretaceous Sediments in the Priverhoyansky and Indigiro-Zyryansky Basins

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Abstract. The results of comparison geological-geochemical study of the Upper Jurassic-Lower Cretaceous sediments of the Preverkhoyansky and Indigiro-Zyryansky basins are considered from the positions of uniform sedimentary basin evolution. Based on lithologic-petrographic data the differences were established in the catagenetic transformations degree of the organic matter (OM) of the Upper Jurassic-Lower Cretaceous deposits from MC3 within the Preverkhoyansky basin and up to MC5 - in the Indigiro-Zyryansky. The distinctions are due, mainly, by a post-collision stage of development of the territory of the Indigiro-Zyryansky basin. The geochemical characteristic of organic matter is given. The identity of composition and distribution of hydrocarbons-biomarkers indicates a common source of the initial OM formed in the conditions of continental facies in the Preverkhoyansky basin. Contrary, OM accumulation of the Upper Jurassic deposits of the western part of the Indigiro-Zyryansky basin occurred in sea and lagoon facies. OM enriched by sapropel material that indicated more oil generation potential of rocks. Based on analysis of the received results the map of prospects of oil-and-gas bearing with allocation of sites for conducting prime exploration works on oil and gas is constructed for the Upper Jurassic-Lower Cretaceous deposits of the Preverkhoyansky and Indigiro-Zyryansky basins.

1. Introduction
On an extensive northeast part of the Russian Federation there are territories with low degree geologic and geophysical study. First of all, the Preverkhoyansk (PVB) and the Indigiro-Zyryansky Basins (IZB) belong to such territories within the Sakha (Yakutia) Republic. From common geologic positions, such as big thickness sedimentary cover, existence of the permeable horizons and relatively quiet tectonic position demonstrate certain prospects of oil-and-gas bearing of the Upper Jurassic-Lower Cretaceous deposits of PVB and IZB. A degree of geologic and geophysical study of these deflections and the main geological results presented in number of papers [1-3]. The established commercial gas-bearing capacity of PVB and adjacent part of the Vilyuysk syncline relate with the Upper Paleozoic and Lower Mesozoic section. The gas-bearing capicity of this section is due to the gas-generate potential the Upper Paleozoic continental carboniferous complex. It is known a large number of oil seepages in various coal basins of the world including the Russian coal provinces [4-8]. That confirms generation by carboniferous deposits of both gaseous and liquid hydrocarbons capable to emigrate and originate hydrocarbon pools [9-10]. The last researches IPNG of Siberian Branch of the Russian Academy of Science have established oil rings around some gas-condensate deposits of the Vilyuysk syncline [11-13].

2. Data and Methods
Mobilistic insights into oil and gas geology are due a great interest on zones of a joint of platform and folded areas. Zones of a joint of ancient platforms and folded areas represent relicts of the ancient sediment rock basins which are structural and material reflection of the proceeded during one
geotectonic cycle - from disclosure to closing of oceans as result of a divergence and a convergence of continents. Following A.F. Safronov we allocate four stages of development of suburb systems–riff, passive-suburb, collision and post-collision [14-16]. Formation of a suburb deflection connects with a collision stage as the imposed hollow – with post-collision. The goal of paper is to clear up the main mechanisms of formation of PVB and IZP revealing their most perspective regions on the base of geologic and geochemical data.

3. Results and Discussion

On the base of the literatary data, own collection of samples and the existing points of view on geological development of the region the comparison analysis is made using geological and geochemical characteristics of PVB and IZB (table1).

We believe that the Kolyma block in the Upper Precambrian – the Lower Paleozoic was a part of the Siberian craton. In the process of the Later Devonian-Earle Carboniferous riftogenesis (regeneration of a Riphein riftogenesis) the Oymyakonsky and Southern Anyuysky oceans were formed. V.E. Hain with coauthors assume that these oceans connected by strait. The considered deflections from the Later Paleozoic (Vise) to the Upper Jurassic time passed a suburb stage of development with formation of the Verkhoyansk and Zyrian complexes of deposits [17].

The collision stage of development of the region begins from the Upper Jurassic time. At a collision stage there was a formation folded-overlapping structure and the Preverkhoyansk regional deflection. On this stage the area became into the region accumulation of continental carboniferous deposits. In the territory of PVB, we have allocated the Upper Jurassic-Lower Cretaceous oil-and-gas complex of deposits of continental genesis [1]. On a northwest part of IZP collision deposits are detected in a section by the data of the Indigirka well N. 272-02, where the Bastakhsky suite is presented by an non-uniform layering of argillites, sandstones, more rare aleurolites with thin layers of black coals. Magmatic belts around the Kolyma block flowed out. An age of the main batholithic belt is within the narrow interval of 143-138 million years by data of the method of $^{40}$Ar/$^{39}$Ar it was an end the Jurassic-beginning of the Cretaceous [18, 19].

The post-collision stage of development begins with the Palaeocene. In PVB, separated from younger oceanic basin by the Verkhoyano-Kolymsky broad folded region, the scale of post-collision lowering is small (the Nizhnealdansky hollow). The Cenozoic deposits have the depth of 800-900 m. The Nizhnnealdansky hollow formed as a result of isostatic reaction of continental crust to loading of the tectonic plates overlapped on deflection [12, 13, 16]. In IZP located on other end of the Verkhojano-Kolymsky folded area a post-collision bend is more considerable. The Cenozoic deposits have the total depth of 2500 m. On base of the considered history of geological development of the region and data on to day on geologic and geochemical study differentiated estimate of prospects of oil-and-gas bearing of PVB and IZB (figure 1) is made:

The Upper Jurassic-Lower Cretaceous carboniferous complex of deposits of PVB lies at depths of the main zone of oil generation, in IZP deposits have reached the main zone of gas generation;

- the main zones of oil accumulation of PVB are predicted mainly to a prifolding wing. In the Tomporuksky shaft ("front anticlinal structure") from a section structural map wells from depth of 300-400 m from the Jurassic and Lower Cretaceous deposits the core with liquid oil has been taken;
- the main zones of gas-accumulation are predicted in complicated structures 1 and 2 orders which were formed in Lower Cretaceous time and also in a priplatform wing outside PVB;
- the main prospects of gas bearing capicity of IZB are connected with the Prialazeysky wing of a deflection;
- the Oligocene-Pliocene structures are presented a certain interest in a prifolded wing of IZB. Here, at an available depth, the "front" anticlines were formed due to overlapping

The analysis of geochemical data on the studied section has shown evidence two groups of samples in each suite one of which closes towards the singenetic bitumoids, another to – mixed with traces of supurposition epibitumoids. In bitumoids of argillites and clay limestones features of element composition, chemical structure bitumoids and their fractions, distribution of relic hydrocarbons are
The Upper Jurassic-Lower Cretaceous deposits are continental formations. Organic matter belongs to sapropelite-humus, catagenic stage is from PC₃ to MC₅. The deposits were at main stage of oil generation.

Corg=0.1-27.0%. The yield of chloroform bitumoid – 0.01-0.80%. Aromatic structures dominate in composition of bitumoids. The features of distribution of molecules-biomarkers are typical for terrigenous organic matter that propose generation mainly gaseous hydrocarbons [7, 26].

A broad spreading of oil rings are around gas-condensate pools [7, 10].
due to nature of terrigenous organic matter. The same character of IR spectra of bitumoids across section, features of distribution of saturated hydrocarbons with prevalence of high-molecular homologs with maximum on $nC_{21,23,25}$ and the low content of isoprenoids, presence of bicyclic seskiviterpane of a row of a drimane and gomodrimane which genesis is closely connected with terpenes of the highest plants [24]. With lowering of rocks the content of bitumoids exit (twice), bituminoid coefficient and the content of hydrocarbons increase, there are changes in chemical structure that confirms processes of catagenic maturation of organic matter from PC$_3$ to MC$_3$. It indicates ability of terrigenous organic matter to generate liquid hydrocarbons.

In aleurolites and sandstones increase of bitumoids content, features of chemical structure and distribution of saturated hydrocarbons with a maximum of $n$-alkanes in area $nC_{15-19}$ and presence of vanadil-porphyrines indicate considerable participation of algal material. It confirms the sufficient oil generative potential of the studied deposits.

Figure 1. The map of prospective of oil-and-gas bearing regions of the Preverkhoyansk and Indigiro-Zyryansky deflection: (1) zone of primary gas-accumulation; (2) zone of primary oil accumulation; (3a) limits of suborder structures, (3b) limits of structures of the I-II order: (B) Bulunsky deflection; (Ky) Kyutyundinsky graben; (J) Jardzhansky deflection; (Sh) Sobopolsky deflection; (Ld) Lindensky deflection; (Kl) Kelinsky deflection; (Tl) Tukulansky ledge; (Tm) Tomponsky deflection; Tmp (Tomporuksky mountain shaft); (4) explosive breaks; (5) Hapchagaysky megashaft and gas-condensate fields; (6) administrative border of the Sakha (Yakutia) Republic.
4. Conclusions
Sedimentation of deposits in the Upper Jurassic-Lower Cretaceous time in both basins proceeded predominantly at continental conditions. They represent a section of collision stage of development of the East of the Siberian platform. The steady mode of a deflection, the reducing conditions of the water basin, promoted fast burial and accumulation of organic material it had found reflection in rather high content of organic matter in the Upper Jurassic-Lower Cretaceous rocks. According geochemical data a mixed character of fossil organic matter in IZB was defined. Considerably participation of aquagenic material together with terrigenous humus organic matter allows proposing a sufficient oil generating potential of rocks more for the Upper Jurassic deposits and in smaller – for the Lower Cretaceous deposits.

The Upper Jurassic-Lower Cretaceous continental carboniferous formations of PVB are characterized by more favorable conditions for formation of oil and gas. At an optimum combination of structural and lithologic conditions it is high the probability finding commercial deposits of gas and considerable accumulations of oil in a subgas zone, both in traditional collectors and in nontraditional reservoirs.

On shelf of the East Siberian Sea, proceeding from the submitted concept of geological development of the considered territories, it is possible to assume existence of a similar the Upper Jurassic-Lower Cretaceous deflection of northwest spreading with which prospects of oil-and-gas bearing in the Upper Mesozoic-Cenozoic deposits can be connected.

5. References
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