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Research Article

ALLOCATION OF FACIES ZONES IN DEPOSITS OF THE YUS11 BENK OF FAINSKI DEPOSIT

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ABSTRACT

The object of the study are productive container rocks of horizon YUS1, confined to the upper Vasyugan suite (J3 c – o) of Fainski oilfield. Vasyugan suite is transgressive-regressive sediments' complex and conditionally divided into two sub-suites: lower Vasyugan (with much clay) and upper Vasyugan which includes sandstones of productive formation YUS11. All special geological studies were carried out by the method of multi-paleoreconstructions' integration, "electrical" method, method of facies modeling, techniques of facial-cyclical studies (lithological and facies analysis). Highlighting of specific facies areas was conducted on the basis of the detailed correlation of sections of wells with the use of GSW data, materials for interpretation of seismic works, visual description and laboratory studies of the drill sample, the results of geological objects' tests. A detailed paleotectonic and facies zoning of productive deposits of YUS11 layer within the Fainsk license area was conducted for the first time.

INTRODUCTION

A lithologic and sedimentary model of sedimentary deposits of Fainski oilfield's YUS_1^1 benk was built in the course of geological-field and paleogeographic studies. Also, a detailed lithological study of the productive container rocks in order to clarify their facies and study area zoning based on the identification of isolated facies zones was conducted.

Geological heterogeneity of clastic sediments and their facies zonality formation is primarily determined by the conditions of sedimentation. The problem of studying facies and conditions of their formation was studied by a wide range of experts (Akramkhodzhayev, 1986; Denisov, 1988; Nesterov, 1976; Izotova, 1993; Conybear, 1979; Grossheim, 1984; Reding, 1981; Reding, 1990; Pettyjohn, 1976; Reinecke, 1981; Rukhin, 1961; Hellem, 1983; Shilov, 2001). Studies have shown that the conditions of sedimentation define different morphological characteristics of the sediments, the knowledge of which allows to predict the distribution of container rocks' zones, prospective for hydrocarbons' search. Paleogeographic method has the essential role in this search for successful traps in the whole complex of geological research.

The object of this research work are productive container rocks of horizon $YUS_{1,}$ confined to the upper Vasyugan suite (J_3 *c – o*) of Fainski oilfield. Vasyugan suite is transgressive-regressive sediments' complex and conditionally divided into two sub-suite: lower Vasyugan (with much clay) and upper Vasyugan which includes sandstones of productive formation YUS_1^1.

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MATERIALS AND METHODS

To clarify the geological structure of the upper Jurassic sediments and the establishment of the genesis of YUS_1^1 benk's container rocks, paleotectonic constructions were made and facies analysis performed.

For the subdivision and correlation of productive deposits based on geophysical studies of wells (GSW) and seismic data, we have identified the following regional plugs – layers corresponding to a major regional interruption in lithogenesis:

- Pack of oolitic siderite rocks occurring at the bottom of Vasyugan suite (reflecting seismic horizon "T");

- Rock mass of Georgiev and Bazhenov formations' mudstones (reflecting seismic horizon "B").

Selection of these key horizons is due to their good areal and deposit's quarry correlability, which is confirmed by seismic data and GSW materials.

Advanced GSW complex including radioactive methods, lateral sounding, caliper logs and other types of logging were used for identification of the local plugs' aqueous section.

All special geological studies were carried out by the method of multi-paleoreconstructions' integration by N. Markowski (Markovski, 1973), "electrical" method by R.H. Nanz (Nanz, 1954) and V. Muromtsev (Muromtsev, 1984). Method of facies modeling by L. Chernova, techniques of facial-cyclical studies (lithological and facies analysis) by L. Botvinkina, Yu. Zhemchuzhnikova, P. Timofeeva (Botvinkina, 1956; Zhemchuzhnikov, 1959; Timofeyev, 1969).

Highlighting of specific facies areas was conducted on the basis of the detailed correlation of sections of wells with the use of GSW data, materials for interpretation of seismic works, visual description and laboratory studies of the drill sample, the results of geological objects' tests.

RESULTS AND DISCUSSION

Substantiation of the Geological Model of the YUS_1^1 Horizon on the Basis of the Method of Paleoreconstruction

Sediments of producing benk YUS_1^1 of Vasyugan suite, containing the main hydrocarbon reserves of Fainski field were studied using the above-mentioned complex of methods.

The first phase of this work was the establishment of hypsometric position of the land, sea and demolition debris sources in the considered in geological time. This is a necessary condition for regional scale research. Also, was conducted the palaeotopography reconstruction of the sedimentation basin's bottom within the study area. It should be noted that the sedimentation processes are determined by a number of reasons, with palaeotopography bottom having a major influence.

Restoring palaeotopography was conducted using the method of reconstruction "plug above" with respect to the bottom of a particular formation, while analyzing thickness of deposits overlying paleoplan of plug formation. Thus, palaeotopography surface is mapped at the beginning of the studied reservoir's formation.

The roof of the Bazhenov formation (adopted in calculations as the conventional "zero") was chosen as the base plug surface. At the same time its regional distribution, stratigraphical justification, stability of lithological characteristics and the location in vertical direction by not more than 60 – 80 m from the studied surface (by N. Markov) – all was taken into account.

Yet the depth of the bottom of the sedimentation paleobasin at the end of Bazhenov's time within the drilled portion of Fainski deposit can be defined by the following expression

$$\Delta H = H_{п}^{Ю} - H_{Б} \qquad (1)$$

where $H_{п}^{Ю}$ – absolute mark of the bottom of the container rocks lower interlayer of investigated formation; $H_{Б}$ – stratigraphical roof of Bazhenov formation.

It is believed that smoothing of irregularities of palaeotopography's bottom occurs during the formation of a powerful clay rock mass, and the surface of unhardened micronite is parallel to the water's edge in the sedimentation basin.

The card on the reflected seismic horizon "B" was used as a priori information for the establishment of the palaeotopography's bottom surface (base) of the formation within poorly studied part of the study area. Additionally, we take into account the regional patterns of the geological structure of the studied upper Jurassic sedimentary sequence. Involving geological and geophysical data on the neighboring areas. Thus, reconstruction of paleoplan of the YUS_1^1 reservoir sedimentation basin's bottom at the end of Bazhenov time (Fig. 1) was carried out.

Conducted paleotectonic analysis showed that the accumulation of sediments occured in shallow-marine conditions at the stationary level of sea paleobasin. Relief of paleobottom is represented by low-amplitude increasing and sometimes smeared out elevations, shafts, slopes, valleys and troughs.

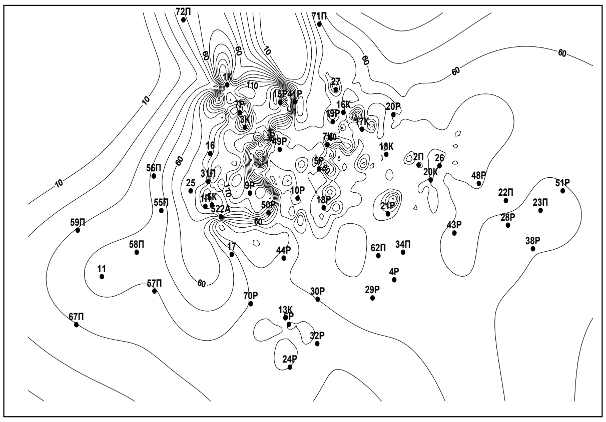

Fig. 1 Paleorelief of the basin's bottom of YUS11 reservoir sedimentation map, at the end of Bazhenov time.

Poorly differentiated relief of sedimentation basin's bottom was leveled by previous transgression due to the accumulation of clay deposits of lower Vasyugan subsuite.

Construction of Facies Model of Sediments of YUS1¹ Productive Formation of Vasyugan Suite

In the next stage of research the YUS_1^1 paleoplan formation was analyzed in conjunction with the SP and GR curves according to the procedure of (Muromtsev, 1984) with the involvement of core data. This allowed to diagnose genetic models "electro facies" on the deposit area, diagnose facies zones on level of the benk and to identify their confinement to individual structural elements in the entire studied area.

A detailed analysis of the reconstructed paleoplan of the bottom of sedimentation basin has allowed to establish the existence of several sedimentation areas located submeridionally to each other. They are divided by a central allotment, which tends to lower parts of paleorelief, delineated by 70 m (or more) isopachyte. Thus, an original boundary of facies zones' change in the area of the given isopachyte has been allocated.

Planation of the inherited forms of paleorelief's bottom of the sedimentation basin has led to the accumulation of relatively sustained (vertically and laterally) terrigenous sediments. There has been a mechanical differentiation of sediments and accumulation of, mainly, silty-argillo-arenaceous sediments of YUS_1^1 formation on the positive forms of bottom relief in a stable mode of sedimentation and low hydrodynamic activity of water at low-amplitude underwater elevations and structural headlands (5-15 m). Favorable conditions of sedimatation have existed for the silty-argillo-arenaceous sediments at the upstructure portion of the underwater sedimentations. Blurring the elevations and slopes of growing structures in the course of underwater currents' and waves' activity, led to redeposition in a submerged part of sandy deposits. Part of the debris coming from the regional and local provenances was deposited within the lower forms of paleorelief or softly undulated areas.

As a result of YUS_1^1 facies analysis the authors have allocated several distinct lithofacies zones, characterized by their poroperm properties and geological and statistical sections: 1) zone of sediments' development of alongshore and discontinuous currents; 2) zone of the beach sediments' development; 3) zone of behind-bank paleolagoon and stagnant zones deposits' development; 4) zone of sediments' alongshore sand bars development; 5) zone of sublittoral zone deposits' development (Table 1 and Fig. 2).

Scheme of distribution of data of facies zones within the deposit is shown in (Fig. 3). The largest area is occupied by sediments of the sublittoral zone, uncovered by 322 wells.

Deposits of various facies zones also differ in technological development indices. The oil flow rates vary from 9.1 (for bar structures) to 32.7 tons per day (for sedimentation of alongshore and discontinuous currents). And liquid rates vary from 35.5 (for lagoon sediments) to 79.9 tons per day (for sediments of alongshore and discontinuous currents). The injectivity of key wells varies from 96.3 (for sediments of the sub-littoral zone) to 197.0 m^3 per day (for sediments of alongshore and discontinuous currents).

The sediments of alongshore and discontinuous currents and sediments of the beach type are being developed at an accelerating rate. For which a uniform type of cut and improved filtration and capacitance properties are typical. For these deposits, the current oil recovery factor (ORF) exceeds 0.2. Deposits of the sub-littoral zone are produced much more slowly – the current ORF does not exceed 0.089 (for the developing zone – 0.162). Intermediate position is occupied by paleolagoon deposits, for which the current ORF value is 0.104. Sand bar deposits are also characterized by high values of the current ORF, which is explained by the more favorable geological-geophysical and filtration-capacitive characteristics of this gacies zone.

Comparison of geological and physical parameters and features of the YUS_1^1 object development allows us to combine the facies zones under consideration into three enlarged geological facies groups:

Table 1. Characteristics of poroperm properties and initial hydrocarbon charge of ettle withing the selected facies zones (according to GIS data)

Type of sediments	Name	Openness, *10^{-3} micrometer^2	Porosity, %	Initial hydrocarbon charge, %
Sediments of alongshore and discontinuous currents	Number of clefts	155	155	108
	Number of definitions	2011	2011	1407
	Average number	**41.2**	**16.4**	**58.2**
	Variability index	1.38	0.11	0.24
	Variation interval	0.76 – 182.9	12.7 – 19.2	21.0 – 84.2
Alongshore sand bars	Number of clefts	34	34	24
	Number of definitions	349	349	244
	Average number	**42.8**	**16.2**	**56.3**
	Variability index	1.46	0.12	0.35
	Variation interval	0.79 – 182.9	12.7 – 19.2	19.9 – 71.2
Beaches formation	Number of clefts	130	130	91
	Number of definitions	1269	1269	871
	Average number	**38.4**	**16.1**	**51.8**
	Variability index	1.58	0.1	0.37
	Variation interval	0.76 – 182.9	12.7 – 19.2	16.4 – 80.1
Sublittoral zone	Number of clefts	322	322	228
	Number of definitions	3320	3320	2300
	Average number	**38.5**	**15.9**	**49.4**
	Variability index	1.59	0.13	0.3
	Variation interval	0.76 – 182.9	12.7 – 19.2	14.0 – 77.7
Paleolagoon and stagnant zones formation	Number of clefts	38	38	26
	Number of definitions	243	243	167
	Average number	**12.4**	**14.6**	**45.2**
	Variability index	2.87	0.11	0.38
	Variation interval	0.76 – 182.9	12.7 – 19.2	12.3 – 60.0

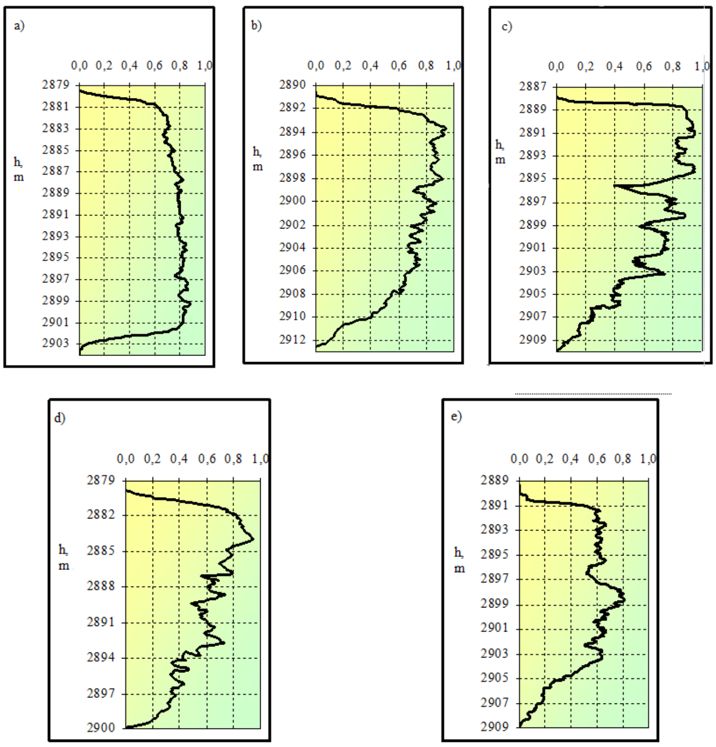

Fig 2 Geological and statistical psephicity quarry for various aqueous subfacies sediments of Horizon YUS11 of Fainsk deposit:
a) alongshore and discontinuous currents' sediments; b) alongshore sand bars; c) beach deposits; d) sublittoral sediments; e) paleolagoon and stagnant zones deposits'.

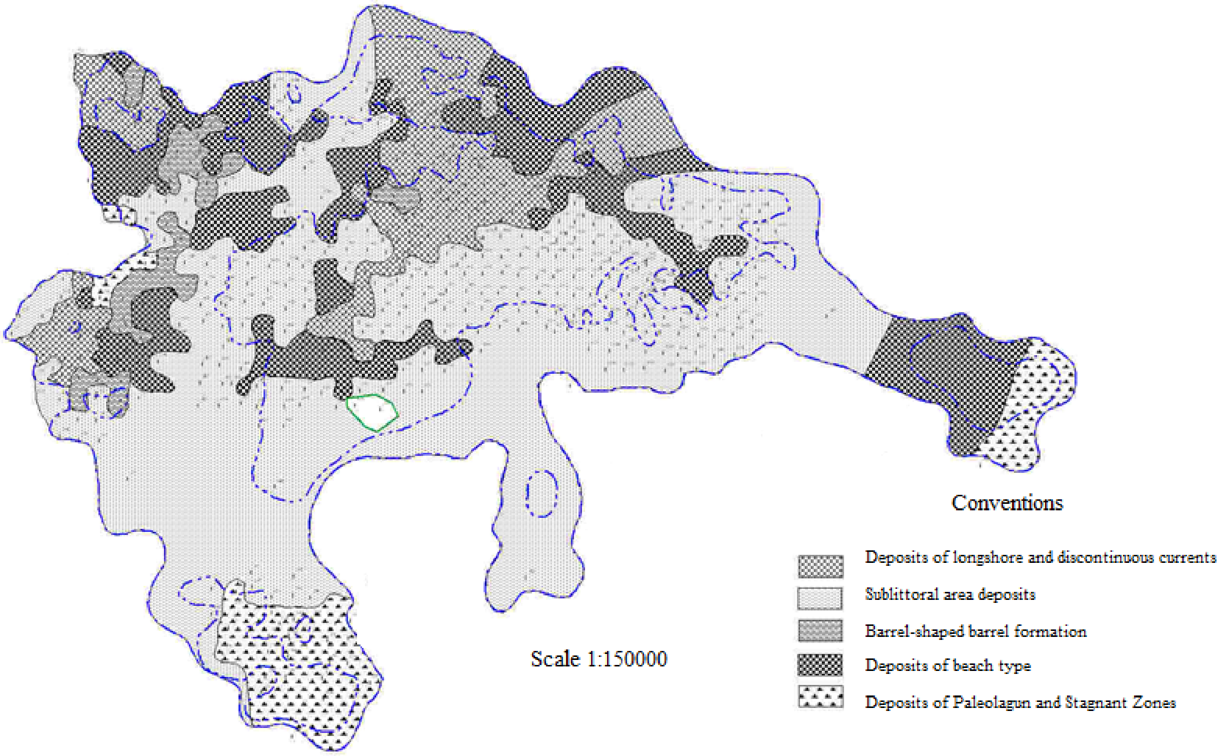

Fig. 3 Map of expansion of aqueous subfacies sediments within the territory of Fainsk licensed site (Western Fainsk part is not presented on the map).

1) zone of development of alongshore and discontinuous currents' sediments, characterized by good reservoir properties vertically, but by a weak hydrodynamic connection laterally. They have maximum ORF values for a given geo-object (0.241-0.243). This zone is developed within the entire northern and northwestern part of the main reservoir (Asomkinsk area) and contains 20.8% of the initial geological reserves of the deposit;

2) sediments of the sub-littoral zone, characterized by low reservoir properties vertically, but by a good hydrodynamic connection between the wells laterally. This region occupies the eastern part of the main deposit (Middle-Asomkinsk area) and contains 45.0% of the initial geological reserves of the deposit;

3) sediments of the subfacies of behind-bank paleolagoons and stagnant zones, characterized by the lowest reservoir properties and a weak connection between sandstone interlayers laterally. This region is sporadically developed in the central and southern parts (the South Asomkinsk area) of the main reservoir. These deposits generally contain no more than 2.3% of the initial geological reserves of the deposit. Presumably this type of sedimentary formations is also developed within the Western Fainsk area.

CONCLUSIONS

1. A detailed paleotectonic and facies zoning of productive deposits of $YUS1^1$ layer within the Fainsk license area was conducted for the first time.

2. The geological heterogeneity of the studied terrigenous deposits and the formation of their facies zonality are primarily determined by the conditions of sedimentation.

3. It is established that the Upper Jurassic deposits formed in coastal-marine conditions and are characterized by considerable heterogeneity both vertically and laterally.

4. The filtration-capacitive properties of container rocks within the Upper Jurassic sedimentary complex are extremely unevenly distributed, which is caused by the mosaic development of facies zones over the area of the deposit

5. The nature and degree of production of oil reserves of various facies zones are determined by their lithological and texture-structural features.

6. Based on the facies modeling of productive deposits of the $YUS1^1$ layer, the main recommendations for the further development of the Fainsk deposit have been formulated.

7. It is recommended to conduct an analysis of

geological and technical measures taking into account the facial affiliation of the test site.

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