Specification of the geological structure of the Bobrikov horizon on the basis of lithological and facies analysis

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At the moment most of the oil fields on the territory of the Republic of Tatarstan are at the last stage of reservoir development. In the assets of each field office are productive formations that are generally unprofitable because it has a complex geological structure and insignificant petroleum resources. The most crucial task for geologists is to solve the problem of pretreatment of the probable resources and involving them into the exploitation. The problem may be solved by searching for new methodological approaches in the territory study.

At the present time the lithofacies analysis of formations is widely used in the petroleum geology, both at the beginning of the territory research, and at the stage of industrial development of deposits, and the entire oil field. The genetic approach, including the restoration of ancient environmentsof sedimentation, is necessary to identify the nature of the relationship of individual parts of the geosystem to each other [1]. There is a possibility to formalize the properties of the geological space and to reveal the sequence of changes in the geological body. Currently there are various points of view regarding the conditions for the Bobrikovsky sediments formations. Some geologists adhere to the alluvial and alluvial-deltoid model of their sedimentation [3], others believe that their formation occurred in marine environment conditions [2].

Reconstruction of the facial conditions of sedimentation was conducted according to the electrometric models of the Muromtsev facies [4]. Developed system of diagnostic features makes it possible to establish the facies nature of the sediment -not only as a result of the study of rocks, but also in their electrometric characteristics. For each sedimentary facies, there is a special form of the anomalies of the PS curve,- an electrometric facies model. The shape of the PS curve contains an important information on a range of grounds. These models are able to evaluate the structure and thickness of the sediments under study [4]. The study of the constituent elements of the PS curve (roofing, lateral, plantar lines, width of anomalies, etc.) makes it possible to determine the nature of the process of sediment accumulation.

Fig. 1 Subcurve: 1-the head zone, 2-the middle zone, 3-the lower zone
In this regard, V.S. Muromtsev has developed a sedimentological model of facies based on the unique principle. The idea is that the formations of each facies were formed under the conditions of changing paleohydrodynamic regimes. This statement makes it possible for each facies to determine its own sedimentological model, which reflects the consistent sequence of paleohydrodynamic levels inherent only in a given facies.

The first key horizon is marine clay which is characterized by a minimum deflection of the PS curve. The line of minimum deflection is limited by the zero or clay line. The second key horizon is sandstones, without clay particles. They are reflected in the PS curve by the maximum deflection. The sand line is drawn from the maximum deviation of the PS curve. The distance between the sand line and the clay line is set to one.

There is a common procedure of description the different types of anomalies and comparing them with each other (from top to bottom as penetration of the well increases). V.S. Muromtsev has developed a special terminology that allows to compare individual parts of anomalies using electrometric characteristics, and the values of aPS in particular. It is possible to construct an electrometric model of facies, in accordance with certain paleohydrodynamic regimes of sedimentation.

In the course of work based on V.S. Muromtsev’s method electrofacies for 35 wells of the Bobrikovsky horizon of the field were made. The roof and the base of the PS curve were cut off throughout the entire distribution of the formation. After precipitation of electrofacies, the PS curves were located on the map of the top of the reservoir collector of the Bobrikovsky horizon (Fig. 2). Applying electrometric models of Muromtsev V.S and, analyzing the forms and constituent elements of the PS anomaly, 8 zones of deposition environment were identified. The colors are compared with the conditions for the formation of productive strata in the marine basin, as shown on figure 3.

For a visual demonstration of comparisons of electrometric models of Muromtsev with oilfield geophysics of the filed, an example of a well log data of one of the wells is shown on figure 4.
Fig. 2 Spatial localization of electrofacies on the map of the top of the reservoir rock of the Bobrikovsky horizon

Fig. 3 Spatial localization of zone of sedimentation
1-Behind-bank lagoon and alongshore channel, 2-internal surface, clay part of the fluvial plain, 3-river mouth bar, 4-coastal regressive bar, 5-head current, 6-astatic part of the offshore bar, 7-offshore bar, 8-storm sandstones
The depositional model of the facies of the offshore bar is characterized by the gradual increase of the sedimentation environment activity, and then by its stabilization after the bar reaches the sea surface and turns into an island [5]. The electrometric model of the offshore bar is a complex anomaly consisting of two geometric figures: two triangles and a quadrilateral above it (stage I). Anomaly is in the zone of negative deviations of the PS. The uppermost line is horizontal and oblique; lateral vertical is smooth and wavy; bottom line is oblique. This similarity of all the distinctive characteristics of the PS curve with the electrometric model of Muromtsev allows to classify the section of the well column, as the marginal-marine facies, namely, the facies of the offshore bar.

The compilation of core-sample in combination with a detailed study of well logs data revealed that the deposition of Bobrikovsky horizon formed in the coastal part of the sea basin.

According to the fieled analysis, the deposition of sandy deposit in Bobrikovsky time, was formed by demolition of detrital particles coming from the shore and their input from the deeper sections of the seabed. Ablation of the material occurred from the northeast of the field. The greatest deposition of sand material on the territory of the field in bobrikovsky time, occurred at the river mouth (river mouth bar), along the sea coasts in the region of the wave output in shallow water, in the zone of their destruction (coastal bank, bars) and In the zone of wave exit to the coast (shore front).

Deposits have a complex inhomogeneous structure, both in surface and in section. The productive strata was developed in the northeast and in the southeastern part of the deposit, as a
separate sand-siltstone bodies with a meridional strike. Lithologically, rocks are represented by uneven interbedding of medium-grained sandstones and calcareous siltstones.

Studying the distribution of various facies and prediction of projected growth of the sand package in the field, the most consistent results of sedimentation were obtained sharing the combined use of logs (data on SP curve) with the seismic data of the nearby field. The low cored intervals and the lack of 3-D seismic survey in the field, does not allow to make reliable conclusions about the nature of the sedimentation of bobrikovsky formations. In this article information from database of the nearby field was used.

The Sbr and the Sbr partial barrier are the productive strata in the formations of the bobrikovsky horizon. Within the field there are zones of lithologic-facies replacement of the productive formation on siltstones with clay intrusions. The strata of the Sbr is limited in area and marked in the partial barrier of the well log. The thickness of the Bobrikov deposits varies from 3 to 69 m. The increase of terrigenous deposits occurs due to the "erosion" cut, lithologically represented by the interlayering of clayey and siltstone-sandy rocks, with calcareous cement and occasionally with the inclusion of coal shales. Analyzing the thickness map, based on the seismic data, riverbed of furcation type was traced, characterized by low hydrodynamics of the water. Sand material, from the continental accumulative plain of the nearby field, superposed to the delta of the river located in the north-west part of the field (fig. 5).

Based on the analysis of the facies in the south-west part of the nearby field, the most expressed groups of facies were identified: 1-internal surface, clay part of the fluvial plain; 2-riverbed of furcation type; 3- external (sandy) surface, part of the fluvial plain; 4-riverbed of the flood-plain lobe, that smoothly leads down to the delta.

As can be seen on figure 5 below, the facies map shows the partial barrier of the furcation type on the territory of the nearby field. According to the 3-D seismic data survey and drilling, it smoothly leads down to the delta of the river in the south-west direction. According to the data of the oilfield geophysics, the facies characteristic of the deltaic strata refers to the destructive estuarine delta controlled by the incoming tides and hydrodynamics of the river system. The analysis reconfirms that the sedimentation of sand-siltstone bodies of the bobrikovsky horizon occurred in shallow-marine conditions by the influence of the flow of the river and churning of the water.

For the purpose of identifying the peculiarities of the sedimentation of Bobrikovsky formations on the territory of the field, macro-description of the core-sample from four wells were used (Fig. 6).
Fig. 5. The map of facies on the territory of the nearby field. 1- internal surface, clay part of the fluvial plain, 2- bed of river of the furcation type; 3- external surface, (sandy) part of the river fluvial plain; 4- bed of river of the flood-plain lobe, that smoothly leads down to the delta.

Fig. 6 Association of zones of sedimentation with an macro-description of the core-sample of the Bobrikovsky horizon
It should be noted that the macro-description of the core-sample is only present in the northern part of the field. The research has shown that macro-description of rocks coincides with the deposition zone. Penetration of the well No.1485 showed formations of the offshore bar. This facies is characterized by a small grain size in the uppermost line and the presence of the carbonaceous material [6]. Penetration of three wells located in the north-western part of the field showed formations of the mouth-bar. The facies of the mouth-bars are formed by the confluence of the river waters into the sea basin. The fresh water stream from the river mouth-bar flows over the surface of the salty sea water. As the salty sea water has a high density, the fresh water stream loses its speed and deposits the terrigene material in the littoral sea, which modifies the composition of the formations. The gray sands, characterized by a significant admixture of carbonaceous deposit, were accumulated under condition of fresh and sea water "blending". Coals and carbonaceous shales are an allochthonous deposit. The gray color of rocks indicates the deposit formation in humid climate.

To assess the cohesion of the reservoir rocks of the Bobrikovsky horizon in area, with the aim of supporting of the workovers program and further borehole drilling, the dynamic of the reserve development and reservoir properties of the field are analyzed (Fig. 7).

Fig. 7 The map of remaining (mobile) oil reserves with spatial localization of the sand package on the territory of the field
It is a well-known that high values of effective porosity rang among to the facies of the offshore bar, since these formations consist of well-sorted grains and in the sand package is almost completely absent the clay and aleurolitic matter. All this shows a low degree of cementation of rocks. The facies of the coastal bank are characterized by lower values of effective porosity as compared to the facies of the offshore bar, since these formations of the bay mouth bar consist mainly of very fine grained sandstones. The content of grains in the coastal bar is 60-80%, characterized by a gentle incline of oblique layers that aim to the coast [8]. Considering all reservoirs of the field, the reservoir properties of rocks in the oil leg are different. Zones with low effective porosity (19 %) in the oil leg is confined to the facies of a coastal regressive bar (deposit No. 1). The high value of the effective porosity (24 %) is associated with the facies of the offshore bar (deposit No. 2). Consequently, this heterogeneity is associated with the reservoir facies of each reservoir. On the map of remaining (mobile) oil reserves shows the irregularity reservoir production in area (Fig. 7). The zone of maximum reservoir production is distributed in the second reservoir, because this reservoir is localized in the facies of the offshore bar. Favorable conditions for the formation of the offshore bar in the area of the field, owing to the well-sorted grains and the high value of the reservoir quality. It points to a high rate of the petroleum reservoir engineering of the second reservoir.

Therefore, workovers program and borehole drilling are recommended in the central part of the offshore bar, characterized by a highly porous and high permeability oil reservoir rock.

Therefore, a local study of the fields using the electrometric data from the core-sample material of the formation of the Bobrikovsky horizon and the field development made it possible to identify and produce the map development of facies. Also was defined the features of lithological changes, thickness and reservoir properties of the constituent rocks. In addition, the analysis of the field development using the electrometric models of Muromtsev helped to identify advantageous zones involving them into development of field.

On top of that the presented method of operational local forecasting can be used on a group of fields of the Republic of Tatarstan to identify lithological and lithologically screened traps of oil. It also allows to solve the issue of placing of wells at the exploration stage, which contributes to a reduction of borehole drilling or application of other exploration methods to search of oil and gas fields.
References


