Identification of electrofacies on the basis of well logging to determine sedimentation environment of horizon JK_2 in Em-Egovskoe field (Western Siberia)

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Abstract. Well logging results are one of the ways to study the buried terrigenous rocks genesis. To ensure the most objective characterization of the rock and identification of electrofacies it is necessary to use a complex geological and geophysical survey. The comprehensive investigations of environmental conditions based on well logging have been performed for the horizon JK_2 of Tumenskoe formation in Em-Egovskoe area, Krasnoleninskoe field (Western Siberia). The defined electrofacies were compared with the results of earlier conducted granulometric and mineralogical analyses. The totality of research provided for a conclusion that the investigated sediments of horizon JK_2 had been formed within the destructive tidal delta. Thus, objective facies prediction can only be ensured by analyzing core and well logging data comprehensively.

1. Introduction

Nowadays, lack of core on the one hand but well-developed well logging on the other hand lead to great popularity of genetic interpretation of well logging. Well logging became the main factor in study of the terrigenous rocks genesis. The measurement of deposit geophysical characteristics with the help of well-logging equipment permits obtaining the value of many physical parameters (rocks resistivity, radioactivity, velocity of sound propagation, density, etc.). Moreover, well logging is used to correlate and determine the lithological composition, to define porosity and calculate oil, gas, and water content in reservoirs, as well as to reconstruct depositional environment.

Under the condition of simple structural traps reduction, the particular attention was focused on the composite structured oil and gas traps. Development of these traps is based on knowledge of facies features of terrigenous reservoirs, which, in its turn, makes it possible to predict their location, pinchouts and the change of filtration-capacitive properties of reservoirs [1].

A number of researchers have developed electrometric models of facies based on geometry of spontaneous polarization (PS) curve that reflects definite sequence of graduation change in the process of forming certain facies conditions [1, 2, 3].

As a rule, spontaneous polarization curves are enough to determine sedimentary model of sand formation relying on the core data. However, the more quantity of well logs is used, the more reliable lithological and petrophysical features of rocks are obtained. This decreases the ambiguity and the number of mistakes in facies interpretation [4].

Due to limited amount of core material in deep prospecting, exploratory and producing wells, the most part of parameters determining facies or lithofacies are directly given by well logging data. The term "electrofacies" was introduced by O. Serra in 1970. This term was defined as "the set of log responses, which characterizes a bed and distinguishes it from others" [4].

2. Identification of electrofacies of horizon JK_2 in Em-Egovskoe field

The results of earlier conducted granulometric and mineralogical analyses [5] of horizons JK_{2-5} in Em-Egovskoe field (Western Siberia) and core description show that the reservoirs are represented by sand and silt varieties of thickness-dependent clay bands. There are fine-grained sandstones, silty with a predominant sand (0.12-0.30 mm) and silt (0.05-0.10 mm) [6].

Granulometric interpretation [6] helped to determine transitional depositional environment of the studied sediments in which the association of tidal plains and deltaic systems are singled out. This association within tidal plains forms tidal channels and estuaries sedimentation environment similar to those in river channel conditions [7].

The detailed analysis was performed only for the horizon JK_2 as Tyumen horizons JK_{2-5} are characterized by complex geology and maximum set of statistical data that permits making more accurate facies reconstruction.

The top of Abalack formation (horizon JK_1) was used as the marker bed for Jurassic sediments correlation. Low-resistivity cavernous clays of Abalack formation are perfectly recognized and correlated in wells according to the well logging. The horizon JK_1 is represented by marine argillites with calciferous layers and glauconite impurities. Thickness of horizon JK_1 ranges from 23.5 m (well № 1141) to 46.1 m (well № 1841), with average value of 29.4 m.

A special geological feature of Tyumen formation in Em-Egovskoe area lies in the fact that direct qualitative characteristics are not relevant. This does not make possible to identify the reservoirs by traditional way. For example, hole caliper data are usually less informative and poorly correlated with other well logging techniques; microprobe curves often have the increment through the whole well section or do not have the mud cake; the differentiation of spontaneous polarization curve is almost absent. The reasons for the absence of spontaneous polarization curve anomaly are the following: proximity of mud filtrate and formation water mineralization values; high shaliness of the cross-section; ultra-deep flushed zone in reservoir; very high oil saturation of reservoir with hydro-fobization of pore channels surface, etc. Therefore, the facies diagnostics was carried out using the set of well logging techniques, i.e. spontaneous polarization curves (PS), induction logging (IL) and gamma ray logging (GR). These methods were chosen on the basis of well log configuration comparison for the completed wells.

Moreover, it should be noted that the use of well logging technique set permits not only defining more accurately the sedimentation environment but also identifying the bed boundaries in the course of correlation.

About 100 wells of Em-Egovskoe field were interpreted to identify facies environment of the studied territory. Figure 1 presents the correlation of horizon JK_2 in Em-Egovskoe field.

3. Definition of facies sedimentation environment of horizon JK_2 formation

The comparison of granulometric analysis results and identified types of well logging curves resulting from differentiation and correlation shows that the sediments of horizon JK_2 were formed within the estuary (figure 2).

Deltaic sediments refer to the transition facies group. They are formed at the interface of continental and marine sedimentation environments. Both marine and continental deltaic sediments are genetically a single whole. A number of researchers distinguish the set of paleographic zones in the well-studied deltas. These zones are characterized by certain depositional environment [1, 8].

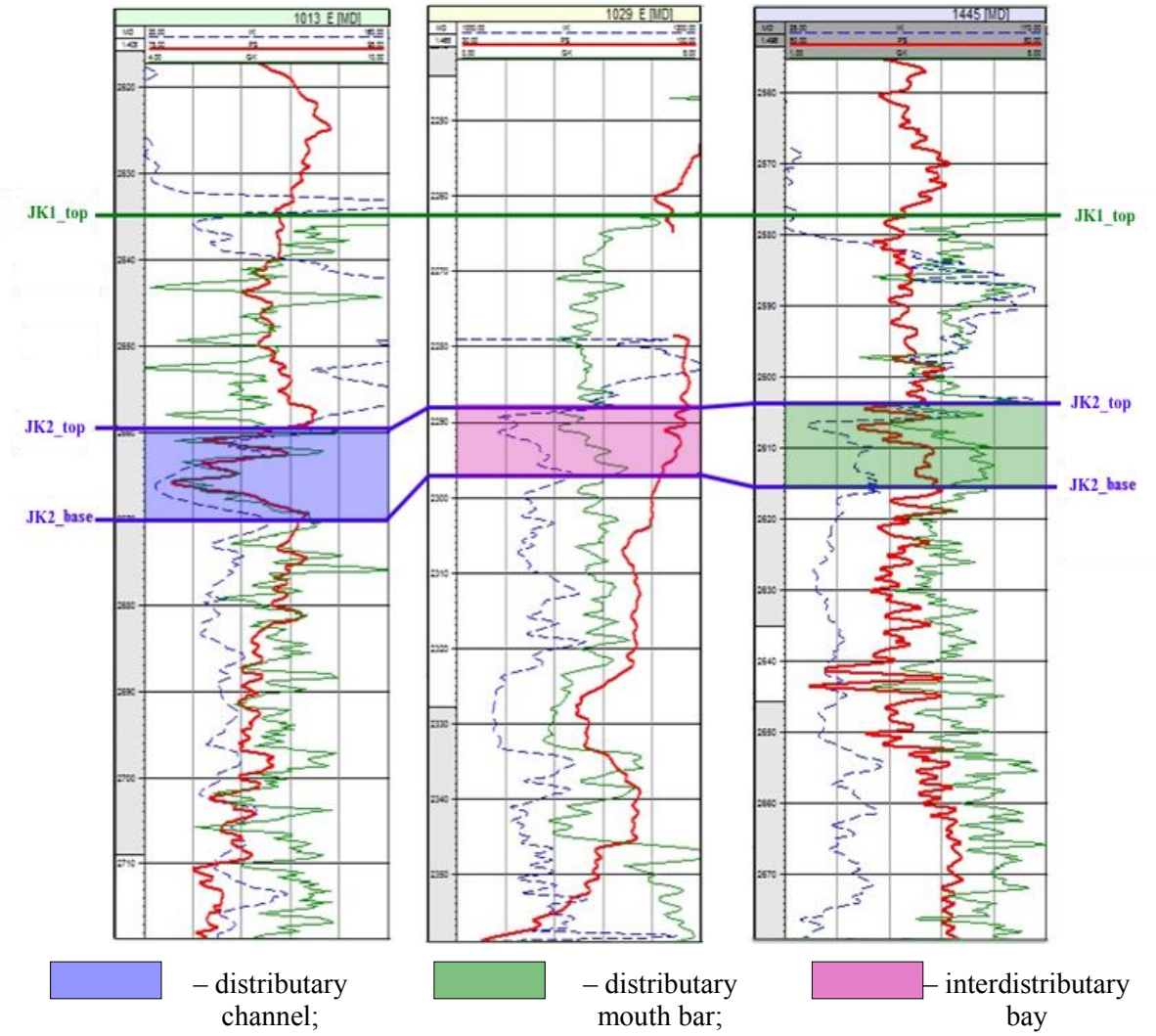

Figure 1. Correlation diagram of horizon JK_2 in Em-Egovskoe field through wells № 1013-1029-1445.

The studied deltaic sedimentation environment may be divided in clearly distinguished subenvironments (figure 2) [9].

The distributary channel is a channel with natural stream which transports the part of sediments and river water to the sea.

The distributary mouth bar is a sand bank formed at the interface of the distributary channel and the shoreline. The shallow is formed as a direct consequence of the decrease in flow rate and transport capacity when the flow is outside the channel. The sediments are continuously affected both by the flow itself and the sea waves. The deposits consist of sand and aleurite, there are often thin bands of detritus.

The interdistributary bay is mainly represented by the deposition area of aleurite and clay that are characterized by high rates of deposition [9].

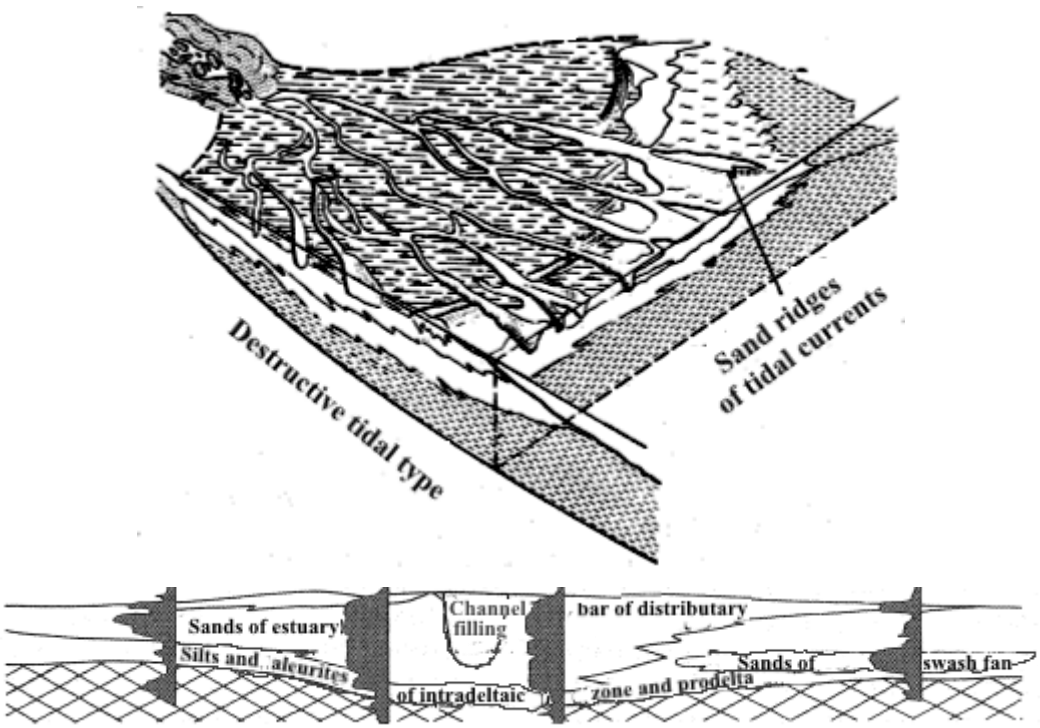

Figure 2. Destructive delta (according to Fisher and Braun) and electric logging profile of deltaic sand bodies [10].

The sand ridge of tidal streams is a continuation of the river channel expanded to the sea.

The channel deposits are represented by coarse-grained and poorly sorted material.

The well logging curves which have been singled out may be compared with the following facies of horizon JK_2 according to the chosen sedimentation model (tidal delta) (figure 3):

- distributary channel;
- distributary mouth bar;
- interdistributary bay.

Facies of distributary channel. PS shows that facies of distributary channel are characterized by "barrel-shaped" and "bell-shaped" forms. These facies are characterized by high amplitudes of PS and low values of GR. Sediments in well № 2548 are represented by light-gray with brownish color, fine-grained, silty, tight sandstone consolidated by clay matter.

Facies of distributary mouth bar. PS shows "funnel-shaped" form. Amplitude of PS is less than one for previous facies. Gamma ray logging curves are characterized by gradual increase in value. Sediments in well № 15r are represented by interlayering of gray, polymistic, fine-grained, dense, tight sandstone and dark-gray, micaceous, tight argillite.

Facies of interdistributary bay are lithologically represented by the sediments that are close to argillaceous sediments. Sediments in well № 505r are represented by thin lamination of light-gray, tight, quartz and clayey siltstone and dark-gray, tight and silty argillites. Thin interlayers of carbonaceous matter and detritus are identified.

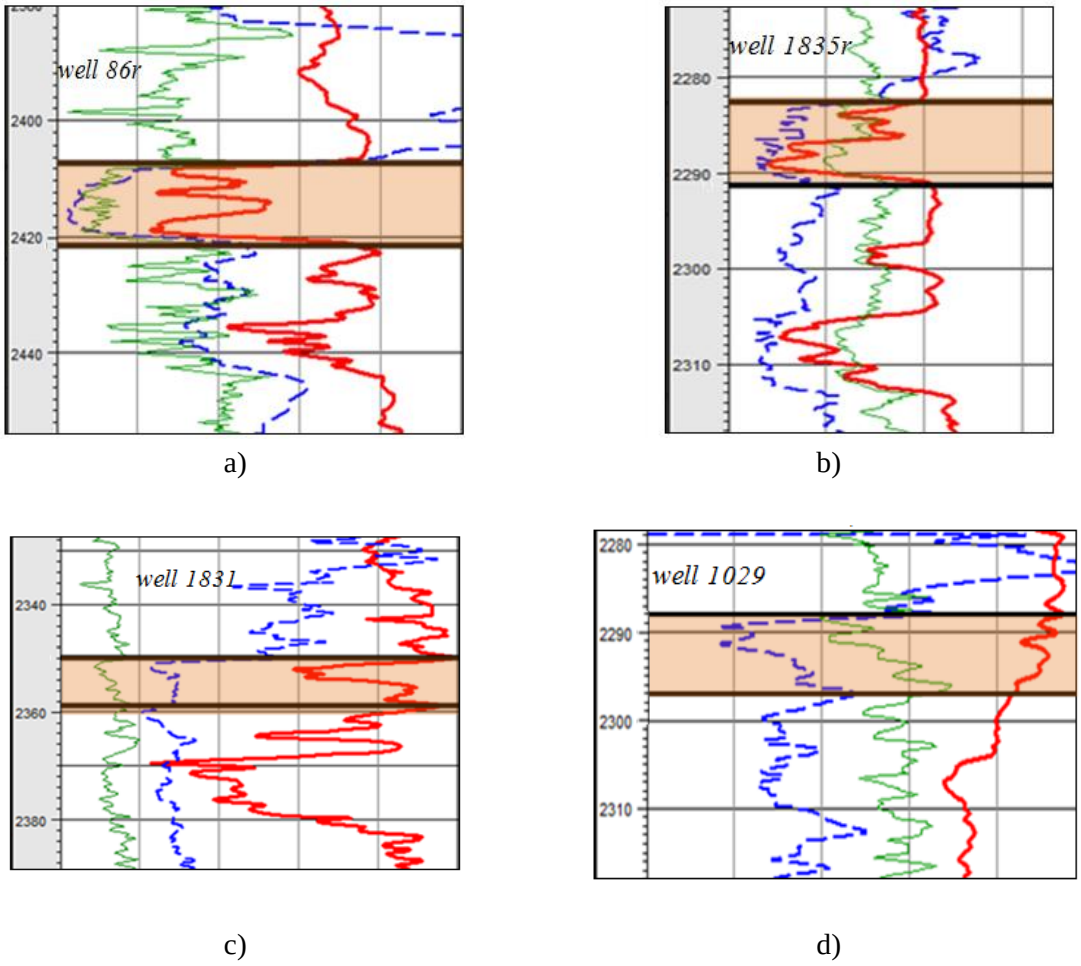

Figure 3. Identified types of electrofacies: a and b) distributary channel, c) distributary mouth bar, d) interdistributary bay.

It should be noted that the determined deltaic depositional environment does not contradict to the accepted lithologic and paleogeographic maps [11].

The horizon JK_2 was formed during Jurassic period – Bathonian stage. At that moment, the studied territory was confined to lowland plain and characterized by the development of the zone containing sand and silt rocks ranging from 30 to 10%. The damp and warm climate is proved by high coal-bearing rock capacity, gray color of rocks, and high content of siderite and significant fraction of kaolinite in horizon sediments [12].

The existing lithofacies schemes of the studied territory predetermine the extensive development of sandstones within the lowland depositional plain, precisely in coastal areas of large water basins during the Early Bathonian. At the second stage of the Bathonian, the transitional facies of these water basins were replaced by marine ones. This contributed to the development of the deltaic depositional environments [12]. The presence of the plain located to the East from Krasnoleninskoe fold which had been covered by the sea also indicates the transitional depositional environments [11].

4. Conclusion

Comparing the results obtained by granulometric, mineralogical and paleogeographic research with the results of facies analysis based on the well logging, the authors draw a conclusion that the sediments of horizon JK_2 were formed by destructive tidal delta. Based on the proposed set of well logging techniques, it is possible to identify electrofacies and compare them with the main facies types

of the sedimentation environment: distributary channel, distributary mouth bar and interdistributary bay.

Only comprehensive use of the well logging techniques and the data obtained by core analysis allow identifying the reservoirs even in hard-to-identify sediments which are represented by thin interlayers of sandstone, siltstone, and argillite.

5. References

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