Litho-facies and paleotectonic background of hydrocarbon reservoirs in North Kalinov gas-condensate field (Tomsk Oblast)

T G Ten[1,2], E V Panova[1,3] and R N Abramova[1]

[1] Institute of Natural Resources, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk, 634050, Russia

E-mail: [2] ten@tpu.ru , [3] elenapanova@tpu.ru

Abstract. Based on micro-macroscopic core analysis, geophysical field data, contour mapping and referencing detailed litho-facies and paleotectonic investigation of Upper Jurassic pay thickness in North Kalinov gas condensate field was conducted. Paleotectonic analysis reflected the structure development history and determined the formation and distribution of oil fields.

1. Introduction

In the process of oil and gas exploration geologists and geophysicists often focus their attention only on the present-day prospect areas. However, in complicated developed areas reflecting continuous tectonic restructuring activity, it is essential to find up-dated effective development exploration methods and analyze the following results. Exploration experience indicate the fact that even in established petroleum-bearing areas there are crestal locations deprived of oil-gas deposits, although present-day location structures and other factors determining possible oil accumulation (reservoirs, cap rocks, migration behavior, hydrogeological conditions etc.) do not differ from these productive structures [1].

The research target involves the integrated litho-facies and paleotectonic analysis of the productive sediments in Upper Jurassic formation of North Kalinov field.

2. Geological setting

North Kalinov elevation is located approximately 7 km. S-E of Gerasimovsk structure. Top of Jurassic sediments in North Kalinov elevation is divided into two areas by the deep downfold zone: rather small N-W area and major complex-structure S-E area. N-W area in the vicinity of wells № 30 and 24 to structure contour-2920km. is isolated within a separate sloping local structure of 2.1×1.0 km. and amplitude of 25m.; while the S-E area embraces 12×6 km. A series of divergent tectonic faults penetrate the structure geometry and frequently breaking it into separate blocks. Excluding unaltered strike orientation, the structure geometry in the Bazhenov suite bottom is rather simply. Both areas are bonded by a contour structure of 2475 m., forming north-west trending fold of 3×11 km. (figure 1).

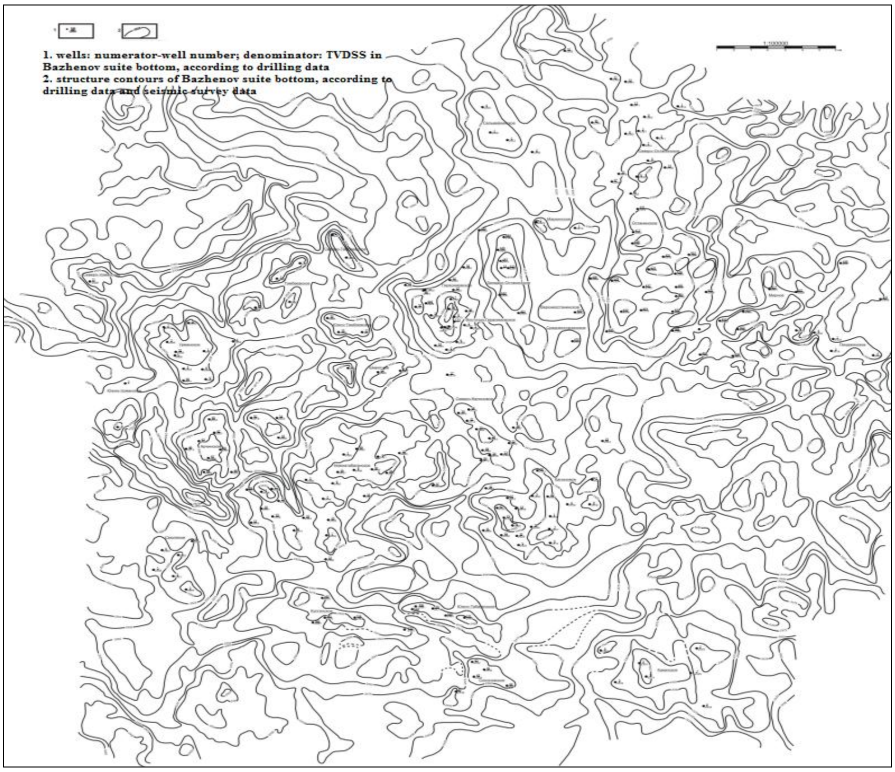

Figure 1. Structural map of junction zones in Nurolsk depression and Pudinbsk mega lithic bank within Bazhenov suite bottom (according to R.V. Belov, 1987).

3. Research data

Well-known geologist-researchers, such as A.A. Bulinnikova, F.G.Gurari, T.I. Gurova, V.P. Kazarinov, A.E. Kontorovich, Yu. K. Mironov, L.G. Markova, I.I. Nesterov, M.Ja. Rudkevich, L.V. Rovnina, S.I. Filina and others have devoted their publications to the issues of paleogeography and sedimentation conditions within Western-Siberian platform.

During a relatively short geological period (Callovian-Oxfordian) S-E Western Siberian platform, as well as Western Siberia, in general, was under the influence of very intensive tectonic activity: Late Callovian -Early Oxfordian regression altered to typical continental conditions of Early Oxfordian and then, at the beginning of Mid- Oxfordian- marine transgression. This fact greatly influenced the composition of investigated formation where one can observe all types of terrigenous rocks-from interstratified conglomerates in the formation bottom to clay and carbonaceous-argillaceous rocks in the formation top [1]. Vertically, rock types have an irregular distribution pattern. The major North Kalinov oil-gas condensate field is associated with sand formations, so-called percarbonate thicknesses. This is the target study discussed in the following paper.

At the end of Mid Oxfordian as a result of transgression the investigated territory gradually became an expanding basin with numerous islands, formerly covered by the sea. Sediments of J_1^2 layer within the North Kalinov area (wells № 25, 31, 34, 35) were formed under rapid current conditions within the boundaries of crest offshore bars (figure 2). The cross-sections showed medium-coarse-grained sandstones, well-sorted clastics. Interbedding is characterized as diverse cross bedding, horizontally interrupted which, in its turn, is conditioned by carbonaceous-micaceous matter -wash. These sediments involve abundant coal lenses and interbeds of conglomerate structure.

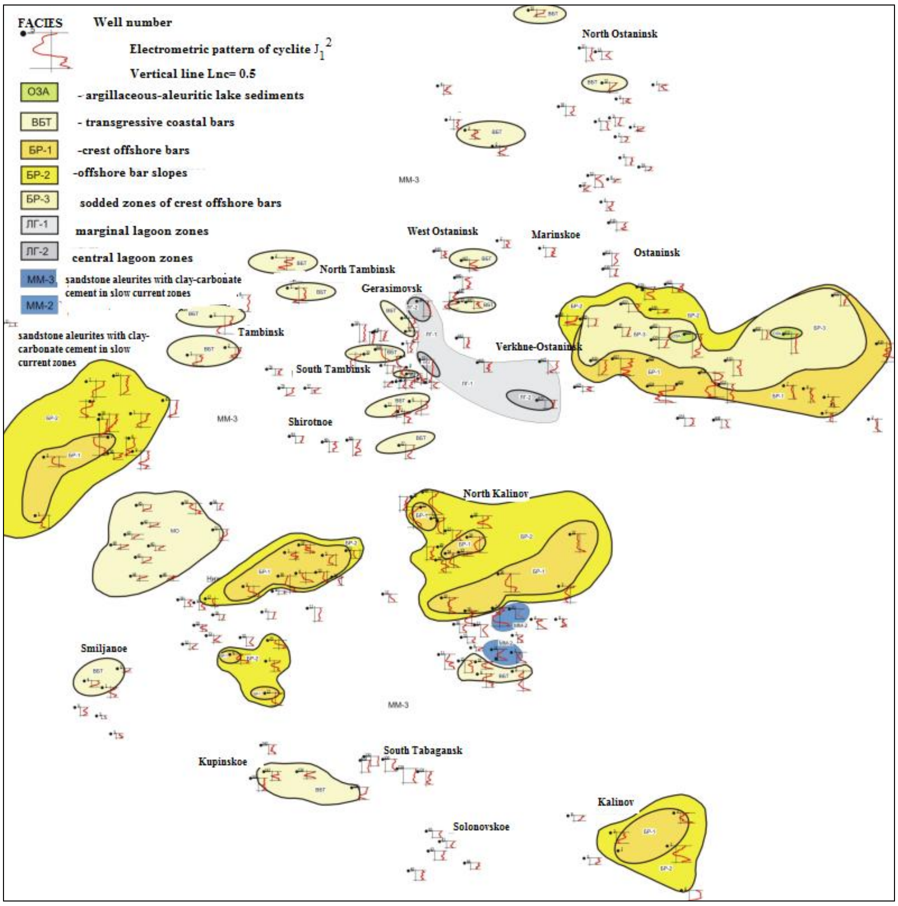

Figure 2. Litho-facies map of J_1^2 layer.

Offshore bar slope facies were determined within the vicinity of wells № 28, 24, 26, 21, 29. The cross-section embraces diverse- grained sandstones with interlayered clay, pebble aleurolite and clay. Interbedding is characterized as diverse cross-bedding and swaley cross bedding. There are also coal, chlorite and glauconite inclusions. Clay interlayers include ichnofossils. Sediments within well № 27 formed under conditions typical for transgressive coastal bars [5].

Layer J_1^2 formed in shallow marine environment at the time of continuous slow transgression. Thefactors -transgression, abundant terrigenous material ingress under conditions of advancing waves resulted in the formation of different accumulative bodies (figure 3).

Facies of offshore bar slopes formed on the crest location limbs. The cross-section is divided into zones with different sequences: bottom zone – alternating fine-grained sandstones and aleurolites; middle zone- predominately, fine-medium grained sandstones; top zone- developed interbedded aleurolite and clay rocks. Interbedding is characterized as diverse cross bedding, one-directional swaley cross bedding, lenticular. Pelecypoda shells could be observed in the core samples (North Kalinov, well № 25). Fauna remains are rare, but could be as detritus.

Sodded zones of crest offshore bars, according to structure geometry, formed within uplifted crest locations (North Kalinov № 21, 35). These facies sediments formed upon the outcropping of crest offshore bars and include aleurolite-clay rocks [2]. The rock structure is lumpy, typical for abundant fauna and root remains.

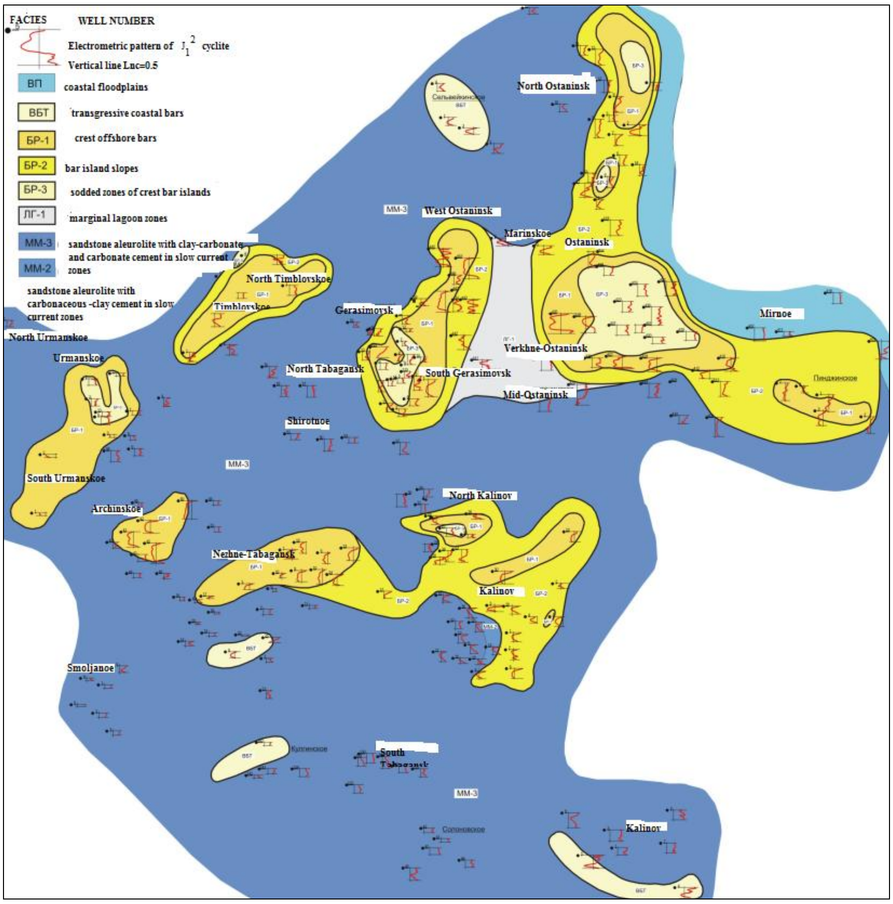

Figure 3. Litho-facies map of layer J_1^1.

Thus, it was determined that sediments in the coal thickness (layers J_1^2 and J_1^1) were formed in shallow marine environment with rapid current [4]. The inmost thickness and maximum sand content is associated with sediments of bar-genesis. The most favorable location in generating traps is the near-crestal zone (wells № 28, 25, 26, 34).

4. Research results and discussion

The target of backstripping is to determine the spatial location of underlying layers to overlying layers. It is necessary to define whether these layers were tilted and contorted in the folds forming oil -gas traps in this or that geological time, i.e. define the relative time of trap formation [3]. Paleotectonic analysis results of individual crest locations are represented (K.A. Mashkovich, 1976) as an isopach triangle, proposed by E.N. Permjakov and Yu. A. Karavashkin. Such a graphical representation provides the possibility to correlate the development history of selected stratigraphical sequences to definite geological periods (figure 4). The paleotectonic analysis markers for investigated territory was Bazhenov suite and coal layers U_1, U_2, U_3 и U_4, the quality and reliability is out of the question. The available graphical results of paleotectonic analysis is the fact that even one sketch visually depicts the different development stages of crest location for various stratigraphical sequences [3].

Examining the development history of above-described structure it was proved that at the end of Mid Callonian sediment thickness increased and crest location began forming in the vicinity of well № 21 (figure 4; III). Tracing the further development of Mid Jurassic sediments to the end of Mid Oxfordian indicated dome displacement north-westward (well № 25) and a distinctive contoured anticline structure (figure 4; IV). At the end of Oxfordian, North Kalinov crest location involved 2 domes within the vicinity of wells № 25 and 24 (figure 4; V).

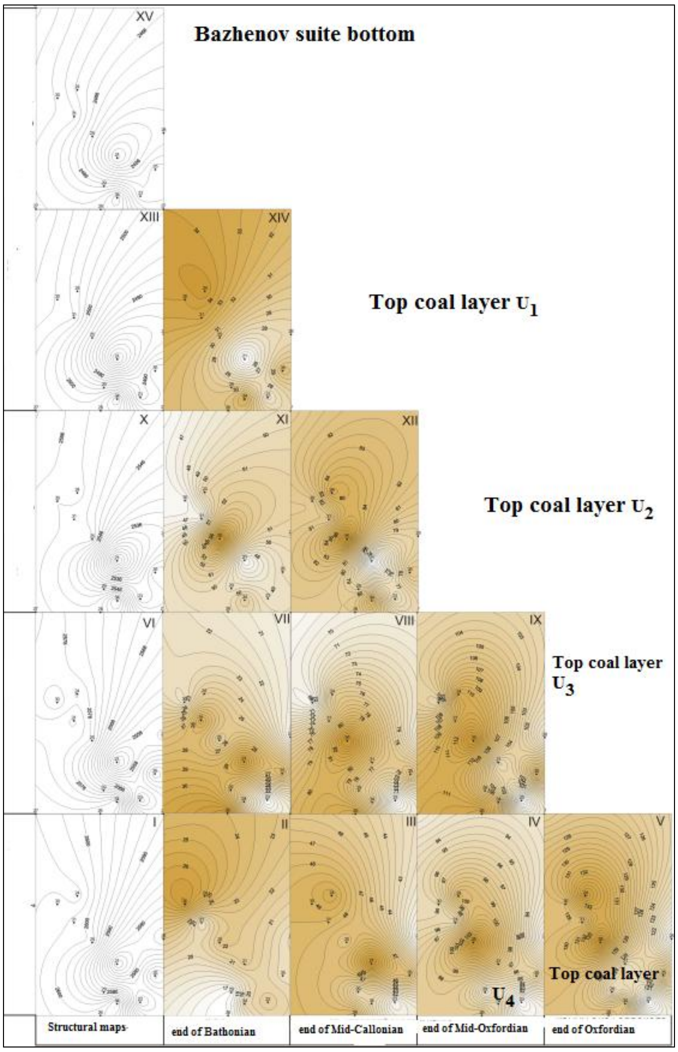

Figure 4. Structural and paleostructural maps of North Kalinov field.

Based on the analysis of maps showing total Mid Jurassic sediment thicknesses at the end of Oxfordian (V) and structural maps plotted according to horizon markers (I, VI, X, XIII, XV) indicates the fact that the reconstruction of the structure geometry itself occurred only after the formation of investigated thickness (based on comparable structural maps to horizon markers).As a consequence of this reconstruction, the hypsometric location of well № 21 is higher, while the location of wells № 24 and 25 are confined to the anticline structure flank.

Geological cross-section of Mid Jurassic sediments in North Kalinov field to line drilling of wells № 30-31-25-21-23 reflects present-day location of anticline structure within the vicinity of well № 21 (figure 5). Hydrocarbon potential of North Kalinov field is associated with the sand layers in Vasugan suite coal thickness (map XIV in isopach triangle). According to well testing, the remaining layers in investigated cross-section are aquiferous. Gas condensate deposit is confined to the W-N crest location flank. The dome within the vicinity of well № 25 has an earlier location, which, in its turn, is conditioned the trap filling. The dome within the vicinity of well № 21 formed a bit later.

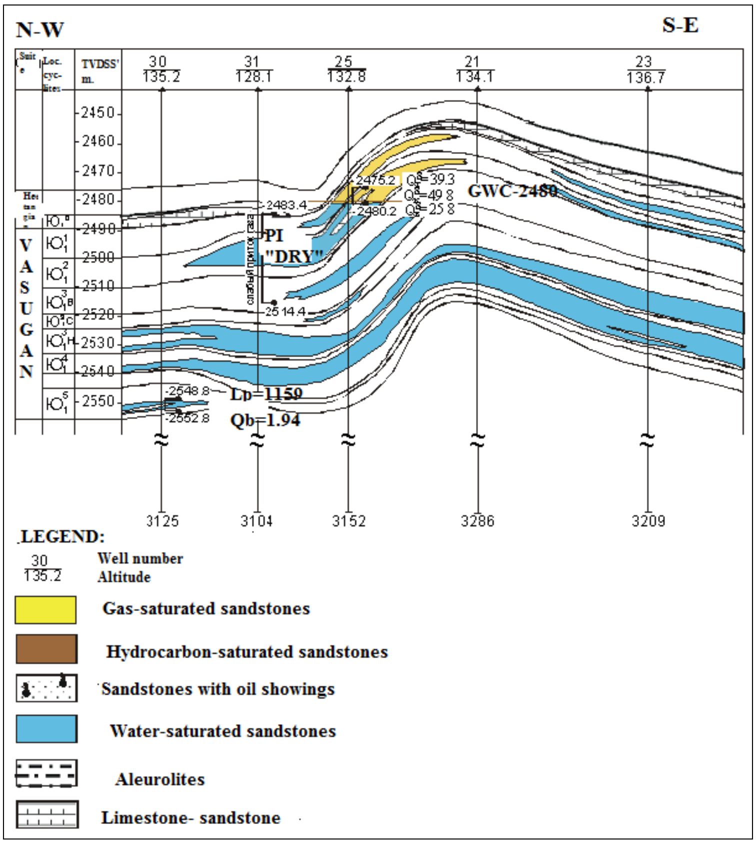

Figure 5. Geological cross-section of Upper Jurassic sediments in North Kalinov field to line drilling 30-31-25-21-23.

5.Conclusion

In exploration a versatile approach in investigating geological features is essential relevant to the changing existing conditions and their development in geological time. Applying an integrated analysis furthers the solving of possible productive structures long before deep prospecting.

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