Litho-facies factors of Late Jurassic productive sediments in Myldzhino gas-condensate field (Tomsk Oblast)

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Abstract. Research results of the lithological composition for Upper Jurassic productive sediments in Myldzhino gas condensate field (Tomsk Oblast) have been described. System lithological studies have been based on the layer-by-layer profile description. Recently electrometrical research methods for facies analysis and litho-facial interpretation have been applied. Both lithological and field geophysics data provided problem-solving related to stripping conditions, structure and lithological trap locations.

1. Introduction

Myldzhino gas condensate field is located in Kargasok region (Tomsk Oblast) about 450 km northwest from Tomsk. Geological field profile is comprised of Paleozoic basement sediments, Mesozoic-Cenozoic mantle sediments. The sedimentation composition involved Jurassic, Cretaceous, Paleogene, Neogene and Quaternary sediments. Commercial oil-gas–bearing capacity has been identified in Jurassic and Lower Cretaceous sediments.

2. Geological setting

Upper Vasyugan subsuite J 1 horizon is traditionally divided into undercoal, intercoal and overcoal sequences embracing productive arenaceous layers [1, 2]. The research target involved undercoal sediment thickness which was comprised of two sections. The lower section with variable thickness and lithological composition, indexed as J 1 4, is characterized by two sequence types – aleurite-arenaceous and clay-aleurites. The upper section included mainly thick arenaceous member overlayersed (in most studied profiles) by a 1m thick coaly layer and indexed as Lower J 1 3 N.

The horizon sediments formed in various facies coastal–marine environments of the sedimentary basin that resulted in the lithological composition variation. Numerous studies have defined that the undercoal sequence rock formation occurred under conditions of prevailing marine regression and areal rugged topography [3].

3. Results and discussion

To identify the specific distribution features of various lithological rock compositions within the field, pinching out nature and facies variation analysis of sediments, a series of thematic maps were plotted, including lithological composition maps, lithologic-facies maps, etc. The lithological composition of
Cyclite J is shown on the map characterizing the distribution of diverse rock composition, whereas the sediments comprise arenaceous, aleurolitic and clayey rocks (figure 1).

Figure 1. Cyclite J lithological composition map

According to well logging and core data two J sequence types were identified. The first sequence is predominately characterized by arenaceous sediments, which developed in the NE (wells № 38, 22, 42, 8, 4, 36, 12, 62), SE (wells № 1, 3, 27, 7, 30) and SW (well №14) areas. The second J sequence type is well-developed and characterized by clayey-aleurite interbedding. The gross sand ratio of J within the distribution zone varies from 5.9 to 78.9.

The facies map of investigated stratigraphic units was plotted on the basis of facies analysis data reflecting the distribution of stratigraphic time-sediment span types and the genetic interpretation of their accumulation environment.

Although the formation of cyclite J is correlated to the beginning of the sedimentation cycle regression, the inherited morphology features of Nizhnevasyugan sedimentation basin bottom could be observed.

In this case, the bottom relief is more uplifted towards the east which is governed by arenaceous, aleurite-arenaceous accumulations and aleurite sediments which are mostly typical for uplifting-sloping facies. Arenaceous-aleurite-clayey and clayey-aleurite facies sediments are widely distributed throughout the studied area.

The integrated analysis of both textural-structural features and electrometric cross-section characteristics of studied sediments made it possible to identify different hydrodynamic regime zones in the sedimentation basin and corresponding facies. The distribution zones of arenaceous sediments are confined to areas of highly intensive and intensive (I and II levels) hydrodynamic activity (figure 2). These zones are located in the outermost SW (well №14), SE (wells №7, 3) and NE (wells №38, 22, 8, 4, 36, 62) areas. Maximal SP curve deviation is typical for anomaly apex, reflecting the dynamic activity of water environment in the final sedimentation stage of this zone.

Arenaceous-aleurite rock distribution zones which formed during the medium (III) hydrodynamic sedimentation level are confined to sloping uplift areas and are localized (wells № 42, 1, 27, 13).
Environment dynamic regime for these zones is less intensive than in the areas of II regime that resulted in a smaller DP curve amplitude deviation in case of formal shape resemblance.

The fourth sedimentation environment regime is characterized by low hydrodynamic activity showing extensive distribution. SP curve, having explicit regressive character, indicates even smaller amplitude deviation. Clayey-aleurite sediments accumulated within this zone, apparently in the near-crestal uplift section. In the setting of overall marine basin regression this is characteristic for uplifted overgrowth areas and the decrease of the hydrodynamic environment activity.

The localized distribution involves alternating hydrodynamic regime zones from low to very low (IV-V) and these accumulation zones are basically argillaceous sediments (wells № 33, 53, 44, 23, 15, 35).

\( J_1^4 \) sandstones, confined to the upper top of the horizon, are mainly light-grey, grey, sometimes brownish and yellowish, homogeneous, cross-bedded or lenticular-stratified due to the granulometric composition contrast and deposition of coaly-micaceous material and siderite microconcretions with coal lenses [4]. These sandstones have the following specific features: crude oil and condensate odour and gas bubbling. The marine worm burrows and traces (well №14) and glauconite inclusions in the sandstones (wells №22, 8, 62) are indicators of shallow-marine sedimentation. Arenaceous, aleurolite and argillaceous rocks have been identified in Lower \( J_1^3 \) cross section (figure 3).
Throughout the major territory (wells № 38, 42, 17, 16, 21, 3, 11, 44, 37, 15, 7, 13, 14, 28, 31, 2) the horizon includes fine-grained sandstones (values $\alpha_{dp}$ from 0.8 to 0.6), fringing coarse-medium grained sandstone proveniance within the remaining territory.

Composite arenaceous-aleurite development sections (values $\alpha_{dp}$ from 0.6 to 0.4) are localized and can be found within the fine-grained sandstone development zones in the west (area near well № 33), in the center (wells № 5, 35, 29, 12) and in the east (wells № 55, 20).

Sandstones in Lower $J_1^3$ layer are light-grey, grey, brownish-grey, medium-loose cemented and rarely coherent. Structure is homogenous or stratified. Bedding is horizontal, cross, wave-like and lenticular due to granulometric composition contrast, clayey-siltstone material and coal interlayers and lenses, deposition of coaly-micaceous material and siderite microconcretions. Bioturbation structures are observed (figure 4).
Four facies zones with different hydrodynamic regimes within sedimentation basin and facies types were identified on the basis of integrated investigation results (figure 5).

The first (I) sedimentation regime exhibited highly intensive hydrodynamic activity typical for active wave zones, where the sandstones are of medium/ fine-grained texture, well- sorted and showing a homogenous structure. The rocks formed under conditions of uplift-sloping facies conditions could be related to some extent to submarine seafloor uplifting. These sediments are characterized by highly and high intensive hydrodynamic level during the whole formation period of Lower J$_1^3$.

Intensive hydrodynamic activity (II) zones are widely distributed throughout the studied area. The cross-sections showed increased sand content in the upper Lower J$_1^3$ horizon.

Medium hydrodynamic activity (III) zones in sedimentation environment are found in the western and eastern Myldzhino areas (wells № 17, 54, 55, 33, 37, 29). SP curves showed marked regressive orientation of granularity alteration. These zone formations are confined to the lower relief areas; most likely, these are lagoons being filled up with argillaceous-aleurite material.

Low hydrodynamic activity (IV) zone has a limited distribution (well № 23). The cross-sections include clayey-aleurite material, moreover, SP curves showed marked regressive orientation of granularity alteration.

Identification of zones with similar hydrodynamic regimes, their spatial distribution and relationships proved the fact of the formation conditions of Lower J$_1^3$. It was determined that Lower J$_1^3$ sediments accumulated under conditions of continuous Oxfordian marine regression, resulting in sea basin shallowing under severe topography of the shallow sea basin itself during intensive tectonic activity.

![Figure 5. Lower J$_1^3$ lithologo-facial map](image-url)
At the same time corrosion processes intensified within the clastic source areas, which, in its turn, resulted in the increased amount of transported clastics to the sedimentation basin. Non-uniform uplifting resulted in intensive hydrodynamic activity within submarine arches and bars. Such sedimentation conditions furthered the accumulation of arenaceous, aleurite-arenaceous material, its improved sorting and immense thickness increase.

4. Conclusion
Thus, integrated processing of geologic and geophysical data, structural-textural and biofacies analyses provided high accuracy identification of productive sediment formation conditions, their variability in time and space, which, in its turn, could improve geological exploration efficiency.

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