Litho-mineralogical characteristics and facies formation conditions of oil-reservoir rocks $J_1^1$ and $J_1^2$ in Kazan oilfield (Tomsk Oblast)

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Abstract The detailed investigation results of textural rock characteristics indicated the predominate lithological facies in formation layers $J_1^1$ and $J_1^2$ (Kazan oil/gas-condensate field), their sedimentation sequence and further alteration of environmental formation conditions. The stage processes and secondary alterations in rocks significantly influencing the reservoir properties were determined.

1. Introduction
Kazan oil/gas-condensate field is located in the south of Tomsk Oblast. Structure-tectonically this field is confined to the Kazan dome-shaped uplifted Nurolsk depression. The geological profile embraces metamorphosed rocks of Paleozoic folded basement and argillo-arenaceous sediments of Mesozoic-Cenozoic sedimentary mantle. In terms of field development, the Upper Jurassic layers $-J_1^1$ and $J_1^2$ (Vasugan suite) extending horizontally and vertically and tapped in all drilled wells are of principal interest.

2. Research methods
The mineralogical and structure-texture description of core samples and thin sections (core sampling depth 2481.3-2511.2m.) was based on the investigated strata data from one Kazan field appraisal well. The lithological rock classification involved sample splitting according to well logging. Determining structure types and lamination of cored layers was performed with respect to the suggested Botvinkina (1962; 1965) and Alekseev (2007) methods, whereas mineralogic-petrographic analysis techniques are described in the works of Logvinenko and Sergeeva (1986).

3. Results and discussion
Net pay formation is composed of medium/fine-grained light-grey sandstones interlayered by silty-clay material. According to a detailed lithological core description the constant texture diversity of layer rocks was identified (table 1).
Type | Description
--- | ---
Non-stratified (a) | Homogeneous (massive)
Indistinctly laminated (b, c) | Graded
Disrupted (d) (burrows) | Partially disturbed  
Completely disturbed
Bedding (bedded texture) |  
Cross-bedded (e) | Slightly sheared
Lenticular (swaley bedding) (f) | Slightly / severely disrupted
Wavy cross-bedding (g,h) | Parallel  
Non-parallel slightly / severely disturbed
Horizontal bedding (i) | Non-uniform (heterogeneous)

Table 1. Classification of J₁¹¹ and J₁²² layer texture (Kazan oil field)

The rock structure-texture analysis results of lengthwise coring from the appraisal well indicated the rock formation conditions within the sedimentary sequence of studied layer (table 2).

| Facies | Sub-facies | Macrofacies |
|---|---|---|
| Continental | Alluvial | Floodplain deposits in river valleys |
| | Lacustrine | Deposits in stagnant and marshy lakes |
| | | Deposits in open lacustrine waters |
| Transition (Coastal-continental) | Shallow basin | Deposits in bay-lagoon coasts |
| Basin | | Deposits in open moving basin shoals |

Table 2. Facies dismembering pattern for J₁¹¹ and J₁²² layers (Kazan oil field)

Besides the above-mentioned textural core sample description of rock sections, the following characteristic features were investigated: lithological varieties and further identification of the mineral-petrographic composition of sandstone and siltstone layers, cementing material composition and content, grain-cement relationship and secondary alteration of investigated samples.

Terrigenous constituent of rock included quartz grains (60-75%) and feldspar (including potassium feldspar and plagioclase – up to 15-35%), rarely, fragments of quarzites, micro-quarzites, meta-andesites, meta-basalts, meta-granites and pegmatites, argillic/argillic-hydromica sericite and sericite shales (up to 10-15%). According to Shvanov classification (1987), rock alteration is classified as mesomictic, to a lesser extent, oligomictic (figure 1).
The bulk of the fragment material included fine-grained sand fraction (0.1-0.25mm). Cement content in sandstones ranges from 3-5% to 20%, while in the layer roof – up to 35%. Cementation type- filmy, porous and sometimes basal.

The thin sections exposed angular, subangular, as well as subrounded and rounded fragments. Degree of grain roundness ranges from 0.2-0.5. The sandstones are well-sorted.

Competent fragments are mica - muscovite dominated (up to 3-5%), often alternating to hydromuscovite with decreased interference color and cracking on grain tips (figure 2). Chlorite replacement is found in separate muscovite horse.

The secondary rock alterations showed mechanical and plastic deformation characteristics of clastic grains as cracking and formation of random-oriented cracks or as formation of composition plane in the folds of feldspars. The cracks are localized in the central grain sections or peripherally in grains, as well as persistent throughout the fragments, partially forming hydromica (figure 3).

Coupled with pressure solution and generation of orthomorphic and incorporated grain contact textures, the regeneration of grains by quartz cement was observed (figure 4). The grain fringe shape is governed by the volume of free pore space and its dimension varies from a thousandth mm to 0.1mm. Inclusions of numerous dispersed clay flakes are predominately observed in the central section of the fringes, embracing the possible contours of earlier regenerated growths.

Figure 1: Classification diagram of sandy rocks (Shvanov, 1987)

Figure 2. Formation of hydromica from muscovite (detected by analyzer)

Figure 3. Cataclasis cracks in terrigenous sandstone material (detected by analyzer)
Leaching zones with further formation of intragranular porosity were partially revealed in feldspars where sericite, calcite and/or saussurite aggregates (in some cases) also formed parallel (figure 5).

**Figure 4.** Regenerated and orthomorphic - incorporated texture in quartz (detected by analyzer)  
**Figure 5.** Formation of leached pores in clastic material- feldspar (detected by analyzer)

Well-decrystallized kaolinite as vermicular growths (figure 6) was identified in closed intergranular pore spaces. Segregation of reddish-brown and/or brownish-black paleo-organic material is frequently restricted to kaolinite pores (figure 7).

**Figure 6.** Decrystallization of kaolinite aggregates in pore spaces (detected by analyzer)  
**Figure 7.** Segregation of bitumen in sandstone pore spaces (detected without analyzer)

Carbonate cement corrodes terrigenous material and expands into grains as spots and/or into the pore space, forming pore-filling, porous-basalt or basalt cement (figure 8).

Carbonaceous, argillous and sideritic lamina were observed in the rocks. Paleo-organic growths of red-brown to black, sometimes as detrital inclusions, were commonly found in the thin sections, indicating the micro-lamination of rocks (figure 9). Paleo-organic material occurs in different alteration stages – from gelification to fusainisation.
Process development of recessive and superimposed lithogenesis in rock-samples from the appraisal well is depicted in table 3.

| Sample No. | depth, m. | Stage processes | Superimposed (epigenetic) processes |
|------------|-----------|-----------------|-----------------------------------|
|             |           | Orthomorphic    | Deformation                        | Carbonization          |
|             |           | Incompaction    | Plastic deformation                | Calcite                |
|             |           | Plastic        | Shattered cracks                   | Siderite               |
|             |           | fragments       |                                   | Pore leaching          |
|             |           | Pyritization    |                                   | Kaolinitization        |
|             |           | Hydromarcation  | Regeneration                       | Bleemen formation      |
|             |           |                 |                                   | Pyritizing oxidizing   |
|             |           |                 |                                   | dolomite               |

**Table 3** Characteristic features of lithogenetic processes in sandstones of \( J_1^1 \) and \( J_1^2 \) layers (Kazan field)

*Note: Thick vertical lines reflect the qualitative occurrence frequency of mineral and texture regeneration*

4. Conclusion

Textural feature rock classification of sandstone reservoir layers promoted the identification of corresponding reservoir facies. The transition sedimentation environment characterizing the shift of continental facies to basin facies was identified in the cross-sections. Thus, in the studied well the continental sediments included lacustrine aleurites and fine-grained sandstones of surface lacustrine...
macrofacies sediments. Medium-fine-grained sandstones, with well-sorted material and high carbonate content accumulated in the basins (i.e. extensive fresh-water intracontinental basin with levelled floor and depth up to the first ten meters). This subgroup includes macrofacies sediments outermost from basin coastline.

The predominate stage processes – compaction (orthomorphism, incorporation) and deformation (cataclasis) were determined. It should be noted that mechanical rock deformation expands more potential hydrocarbon migration paths. Superimposed (epigenetic) alterations involve those processes that both positively and negatively influence the reservoir properties. Both pore leaching and kaolinitization improve the reservoir properties of sandstones, consequently, carbonization, cementing rock pore space and “healing” cracks decrease the reservoir pore space and permeability.

References
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