Environmental formation conditions of Kimmeridgian-Oxfordian Upper Jurassic sediments in Aleksandrov megaswell

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Environmental formation conditions of Kimmeridgian-Oxfordian Upper Jurassic sediments in Aleksandrov mega-swell

G Il'ina[1], Ye Schmidt[2] and R Abramova[3]

[1 2 3]Institute of Natural Resources, Tomsk Polytechnic University, Tomsk, Russia
E-mail: ilgf@sibmail.com[1], lena_shmidt@bk.ru[2]

Abstract The research target is Upper Jurassic sediments within Vasugan horizon. Identification of Vasugan and Naunak suites based on the differentiation and well log correlation and detailed lithological core analysis of Vakhsk, Ob and Protochni fields revealed the existing paleo-environments. It was established that continental facies significantly influenced sedimentation within the investigated territory.

1. Introduction

Detailed paleogeographic differentiation describing the formation conditions of thicknesses and isolated reservoirs (1980-1990) revealed and defined the transition zone of Vasugan and Naunak suites as v-interpenetrating coastal-marine and continental sedimentary units (according to the Law of Facies- Walther's). Ranging formation age of separate petrographic horizons, i.e. facies types and their boundaries, is governed by coastline movements. The overlying sediments within the sedimentary thickness profile extend on the lithosphere surface and/or sedimentation basin bottom. In the case of sea level transgression and / or regression the horizontal sediment zones (facies) merge into sedimentary thickness vertically. As a result sediments in one and the same facies are of different ages towards land-sea direction [1].

2. Geological setting

The investigation target is Aleksandrov mega-swell embracing the formation conditions of Upper Jurassic suite. Aleksandrov mega-swell sheath (mantle) formed during Triassic age with the formation of rift structures intersecting geosyncline structural-formational zones [2, 3], and the formation of basement blocks uplifting during the Mesozoic and Cenozoic periods dominating as regional oil and gas accumulation zones. Jurassic sediments compose up to 1/7 of the terrigenous mantle functioning both as caprocks (Upper Jurassic Bazhenov suite rocks) and as reservoir rocks of petroleum deposits (Vasugan, Naunak and Tumen suite sediments).Vasugan and Naunak suite sediments were exposed to the entire Aleksandrov mega-swell and includes interbedded sandstones, siltstones and claystones. The sandstones are characterized as gray or light-gray, polymistic texture, aleuro-psammo and psammo-aleuro structures, random, massive; total amount of clastic particles ranges from 88 to 92 % and cement content -8-12%. Clastic matter includes quartz (32-65 %), feldspar (20-50 %), rock fragments (10-47 %), mica (1-3 %). Although the sediment composition in Vasugan and Naunak suites is identical, the rocks have different assortment of particles (sandstone in Vasugan suite- 2.44 and in Naunak- 1.72) and different content of pellite fraction (in Vasugan suite- 21.15% and in Naunak- 13.26%). Siltstones are predominately fine-grained, from dark gray to black, subconchoidal fracture, finely horizontal bedding of clays with isolated glauconite grains. Total amount of clastic material- 60 %. Claystones are dark gray to black, coarsely tabulated, horizontally bedded. Major clay matter is composed of strongly montmorillonite hydromica aggregates with undirectional clay particle orientation.

According to well logging data

a) high apparent resistivity (AR) values of enclosing rocks (4.0-28.0 Ohm*)* were determined, especially for carbonized argillaceous-silt interlayers;

b) self-potential (SP) curve revealed values of up to 80mV in sand interlayer intervals;

c) spontaneous potential reduction value ($a_{пс}$) is directly proportional to rock porosity (permeability) value.

The cumulative thickness of Vasugan and Naunak suites within the mega-swell is uniformly distributed. Thickness ranges from 33m in Saimovsk area to 89m in Traigorodsk area. This thickness is more contrastively revealed within the wells: from 0 m (well № 217 in Chebachya area) to 94m (well № 1 in Pankovskaya area). The thickness decreases westward to eastward in Aleksandrov mega-swell. Maximum values were revealed in the central and north-east areas of this structure. Sand content(net-to-gross system) is coherent with corresponding total suite thickness data, i.e. the maximum net-to-gross system in N-E megaswell (Vakhskaya, Traigorodsk and Migitinsaya areas) and central area (Obskaya) is relevant to the zone of maximum developed thickness suite zone (north-eastern area) and reduced thickness zone (central area of the structure).

This could be conditioned by the facial differences in sand material deposition. This can be explained by the fact of traceable changing distribution of organic remains in vertically Oxfordian – Kimmeridgian sediments. Marine fauna remains (belemnite layers, pelecypoda shells, foraminifer *Globulina*) were found in the sediments of the upper suite section, i.e. layer U_1^1 located within the central and south-western areas of Aleksandrov mega-swell (Obskaya area-wells №1,2; Kondakovskaya area- wells № 32, 33; Chebachya area- well № 220 and Protochaya area- well № 1). According to the organic remains in Obskaya area – well № 1 (core sampling interval 2271,1-2276,1 m) the sediments were defined as Oxfordian –lower Kimmeridgian (J_3o-km); according to *Globulina obskaensis Dain* remains in Obskaya area – well № 2 (core sampling interval 2312,8-2314,9m) the sediments were defined as Late Oxfordian (J_3o_3); pelecypoda shells *Entolium sp. indet., Meleagrinella sp. Indet* found in Kondakovskaya area- well № 32 (core sampling interval 2045,9-2052,8m) are typical of Oxfordian sediments (J_3o); pelecypoda shells *Buchia cf. Concentrica* found in Kondakovskaya area- well № 33 (core sampling interval 2138,9-2140,9m) are typical of Early Kimmeridgian sediments (J_3 km_1). Downwardly, fauna has not been found in the layers (U_1^2, U_1^3, U_1^4). However, plant remains (*Coniopteris sp*.), pollen and vegetal spores, characteristic of Upper Jurassic sediments (J_3) in Naunak suite, are pervasive in these layers. Fauna remains identical to those found in layers U_1^{2-4} (J_3o-km_3) can be found in the north-eastern area of the mega-swell in the upper suite section[7].

3. Research methods

It is rather difficult to identify correlating Vasugan and Naunak suite analogues as they are genetically different: Vasugan suite- coastal-marine while Naunak suite- coastal plain continental sediments. Based on the traces of marine sediments, the composition of which is related to pollen-spore spectrum, I. Nesterov (1966) defined a sovereign stratigraphic unit- Milidzhinskaya suite. Later (in 1967) this suite was renamed Naunak [I.Nesterov, et al., 1975].

Passega C-M diagram (1981) was applied in dividing Naunak and Vasugan suites and identifying the sedimentation genesis (fig. 1) which involved the sand and silt cross-sections of upper Vasugan sediments.

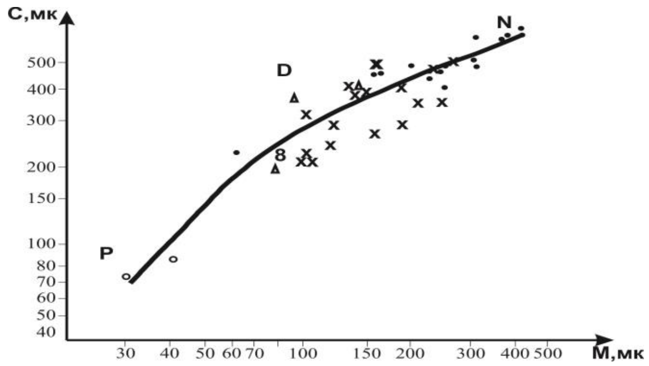

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Figure 1. Passega C-M diagram for sand and silt cross-sections of Upper Jurassic sediments in Aleksandrov mega-swell. Suite sandstones: 1- Naunak, 2- Vasugan; suite silts: 3- Naunak, 4- Vasugan

It is noted that the application of genetic diagrams, including Passega C-M diagram, accurately indicate only the features of this or that deposition environment. The diagrams could show either identical and / or approximately close features in different facies, as the movement of water and material transport are similar. Re-deposited rocks could inherit the properties of the breakdown rocks which could be noted on the diagrams [4,5]. Above-mentioned facts indicate that it is necessary to apply a multi-discipline study, involving several methods (fig.2).

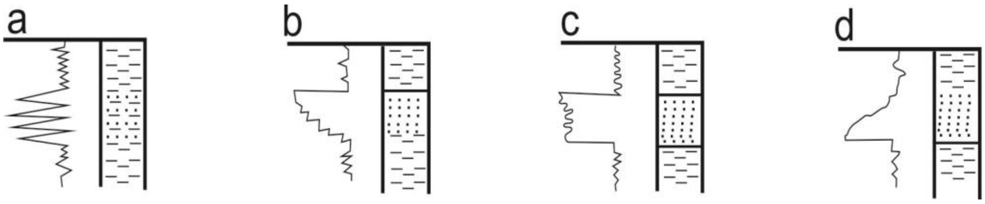
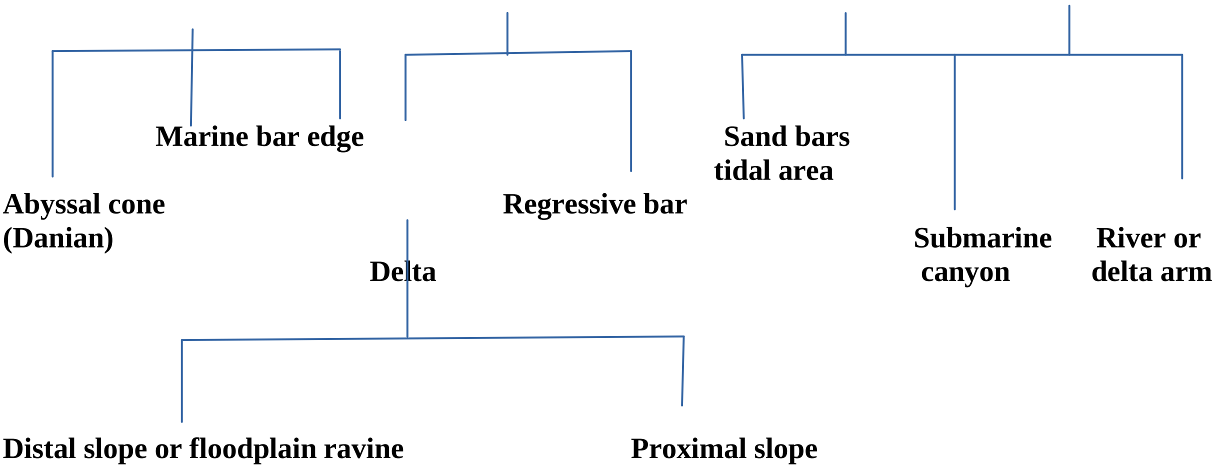


Figure 2. Four types of gamma logging curves: a- thin interbedded sandstones and slates; b- cross-section, revealing upward coarse material, sharp sandstone-slate contrast; c – homogeneous sandstone with distinct upper and lower contacts; d- thickness with gradual upward fine-grained material, i.e. from sandstone to slate, including abrupt bottom formation.



Viewing the deposition conditions, it is important to consider the rock component particle size-deposition system alteration dependence. This fact plays an important role in the case of limited core recovery [6]. The configuration and type of well logs indirectly reflect the changes of sediment particle sizes, which, in its turn, stipulates the possibility of applying different well logging methods to develop the models showing the changes of vertical grain sizes. In this case, it is viable to use both SP curves reflecting reservoir properties and radioactivity logging (RL) identifying clay content. For example, V. Murotsev method (1984) is lab-referenced to rock material excluding overall genetic description of the rocks obtained from low core recovery or without any core recovery.

If applying gamma log and SP curve regularity patterns in accordance with Selley method (1989), then this problem could be solved (fig. 2). It should be noted that none of the above-mentioned features could be a major one for identifying this or that deposition environment. However, these features in combination with content values of glauconite (typical for deep-water facies) or carbon-bearing detritus (typical for coastal and continental facies) could be auxiliary identification criteria for physic-geographical formation conditions of sand bodies.

4. Results and discussion

Based on the analysis results of deposition conditions, reservoir properties and petrographic composition of Upper Jurassic rocks in Vasugan and Naunak suites, the most potential areas with lithologically screened accumulations could be in the transition zone (fig.3).

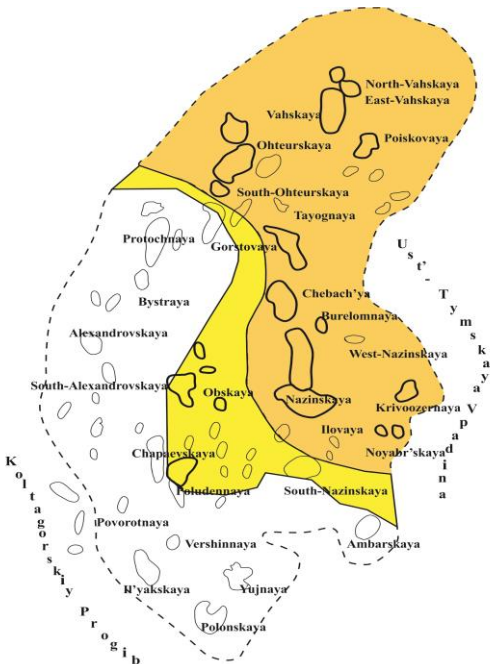


Figure 3. Diagram of paleogeographic formation conditions of Vasugan and Naunak suite sediments in Aleksandrov mega-swell

Formation zone of Vasugan suite sediments (marine sediments of littoral slope)

Formation zone of Naunak suite sediments (continental sediments of coastal plain)

Formation zone of transition sediments (sediments of beach sands)

5. Conclusion

The division of Vasugan and Naunak suites (Aleksandrov mega-swell) based on Selley method, Passega C-M diagram and analysis of organic remains in core samples, provides a rather detailed and complete genesis characteristic description of the sand layers in Upper Jurassic sediments [7, 8]. However, there still remains one relevant question- what is the influence of rock genesis on HC saturation and filtration properties of the rock itself? Core sampling and logging data indicated the fact that there is an insignificant difference between Vasugan and Naunak suites regarding their reservoir

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properties. Increasing clay mineral content in Vasugan suite sand-silt rocks is conditioned by the slow transport rate of the clastic material, which, in its turn, influenced the suite aggregate thickness [9, 10].
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