

# Textural and structural features, composition and formation conditions of arenaceous rocks in PK<sub>1</sub> horizon, Pokursk suite in south-eastern Pur-Tazovsk area (Yamalo-Nenets Autonomous Territory)

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**Abstract.** Terrigenous deposits of the productive PK<sub>1</sub> horizon in Pokursk suite of Pur-Tazovsk area (Yamalo-Nenets Autonomous Territory) were studied to specify the structure and identify the formation features. Complex horizon structure of sequential silt, mudrock interbedding and alternation has been identified. Littoral-marine type of sedimentation (occurring during the total marine transgression increase) by the help of genetic rock features identified during the core sampling and by the granulometry and X-ray-phase results analysis has been determined.

## Introduction

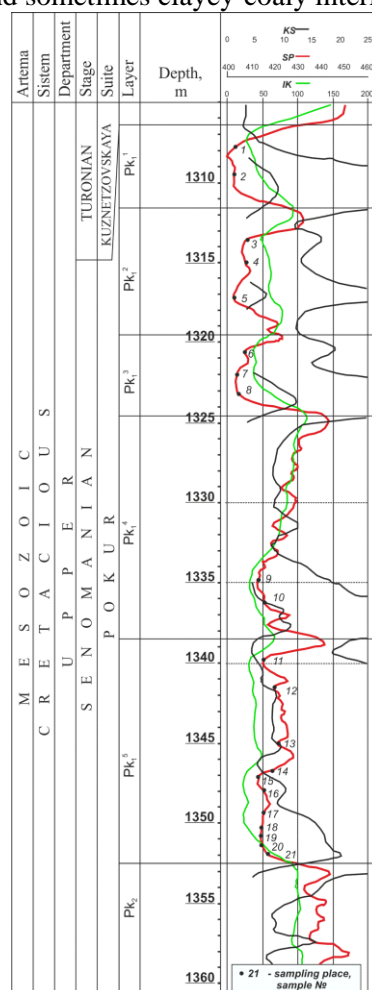
Identification of arenaceous reservoir rock genesis and mode of occurrence is one of the major Petroleum Geology targets, particularly when the non-structural traps should be explored. The target of this research is to specify productive PK<sub>1</sub> (Upper Cretaceous, Cenomanian) horizon structure of Pokursk suite in south-eastern Pur-Tazovsk area (Yamalo-Nenets Autonomous Territory) and identify formation features on the basis of rock genetic features determined by the core microscopic analysis, granulometry and X-ray-phase analysis. Relevance of the research is explained by the Cenomanian complex structure characterized by the polyfacial sedimentation and the absence of data about its formation. Thus, the Cenomanian deposits have been characterized as continental ones in the performance reports on some oilfields. In fact, the performance reports and published data consider the genesis of the Cenomanian deposits of Western Siberia to be related to transition zones of sedimentation (deltaic facies) [1, 4, 5] or desalinated sea basins [11, 7, 8]. According to our research data, PK<sub>1</sub> horizon deposits of Pur-Tazovsk area were formed along the coast of the shallow sea basin against the sea floor down warping and marine transgression increase.

## Structure, lithology characteristic features, genetic features and formation conditions of PK<sub>1</sub> horizon by the microscopy data

Studied PK<sub>1</sub> horizon deposits encompassing gas deposit, occur at the depth intervals of 1307.5–1353.0 m in the upper layers of the productive Cenomanian formation, overlapped by the Upper Cretaceous marine clayey rocks of Kuznetsov suite (Turonian Stage). According to the lithology characteristic features and formation conditions (profile description and genetic features identification were made by



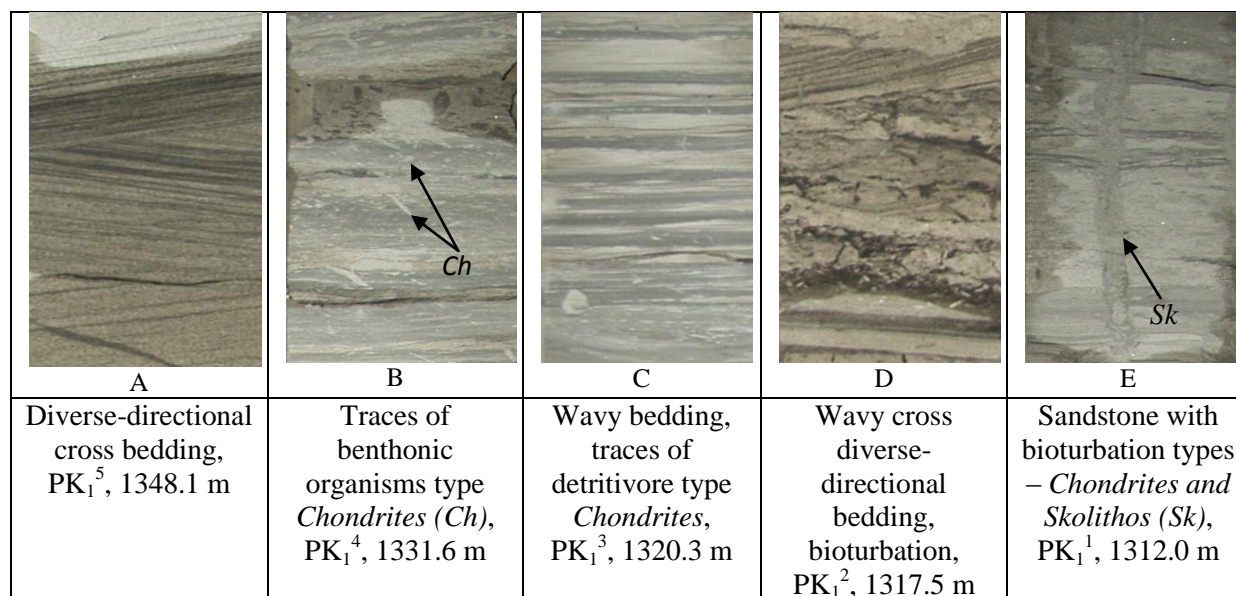
[3, 6], they are divided into five arenaceous interlayers, indexed as  $PK_1^5$ – $PK_1^1$  from the bottom to the top and separated by thin clayey and sometimes clayey-coaly interlayers (figure 1).



**Figure 1.** Dissection chart,  $PK_1$  horizon geophysical characteristics, sample numbers and sampling areas.

$PK_1^5$  lower layer (1353.0–1339.0 m) is discordant to the washout and lies on the lumpy mudrock pierced by plant roots. It is characterized mostly by fine- and medium-grained sandstones with horizontal, oblique-low-angle and diverse-directional cross bedding oriented angularly 30–35° to the core axis (figure 2, A). The bedding is specified by the inwash of clayey material and plant detritus on the bedding planes. Rare clay bands with benthonic detritovore ichnofossils (*Chondrites*) as the holes and short channels occur. Intraclast layers (clasts of water-worn and re-deposited sedimentary rocks) of argillaceous siderite and clayey composition are identified. The crowned layers of the deposit are of clayey, dark grey, unclear-wavy-stratified rocks comprising small impurities of plant detritus and pyrite concretions.

$PK_1^4$  layer situated above (1339.0–1325.3 m) overlies  $PK_1^5$ , which can be observed in the water-worn bedding, uneven contact and rounded intraclasts of the argillaceous siderite and clayey composition. The layer is characterized by fine-grained aleurite sandstones with carbonaceous plant detritus inwash, that shows the cross (the angle of gradient is 35–40° the core axis) unidirectional and diverse-directional lamination, which are deformed by turbidity, washout and channels of small benthonic animals (for example, *Chondrites*) (figure 2, B). Upwards in the profile, the sandstone layers are replaced by mudrock gradually transferring into coal.



**Figure 2.** PK<sub>1</sub><sup>5</sup>–PK<sub>1</sub><sup>1</sup> layer rock features.

PK<sub>1</sub><sup>3</sup> layer (1325.3–1320.0 m) underlies unevenly coal seam. It is characterized by the fine-grained aleurite sandstones, poorly cemented by clayey cement with primarily wave-like (cross-wave, undulating, wave, lenticular-wave), rarely, horizontal lamination. The bedding is fine and thin, formed as the result of carbonaceous plant detritus inwash and clayey material. At the top of the bed, the lamination is deformed by the root systems. The crowned layers of the profile are of thin lenticular wave-like alternation of light-grey aleurites and grey clayey rocks where benthonic detritivore ichnofossils (*Chondrites*) (figure 2, C) are found.

PK<sub>1</sub><sup>2</sup> layer (1320.0–1312.5 m) has unstable lithological composition. Continuous alteration of fine-grained light-grey aleurite sandstones (from light-grey coarse-grained arenaceous to grey fine-grained and clayey) and dark grey clayey rocks with the changing through the profile: from cross wave (unidirectional and diverse-directional) (figure 2, D) to wavy, lenticular wave and rarely horizontal. Layers often have multiple washouts, turbidity and intensive bioturbation traces (*Chondrites*). Bioturbation traces and root systems remains are often found in the rocks.

PK<sub>1</sub><sup>1</sup> layer (1312.5–1307.5 m) occurs on the underlying deposits with sharp contact. It is characterized by the light-grey aleurites and sandstones, arenaceous aleurites with wave-like bands of clayey material, benthonic “sand eaters” (*Skolithos*) and detritivore ichnofossils (*Chondrites*) (figure 2, E). Upwards in the profile, the layers are replaced by clayey with unclear bedding rocks characterized by turbidity traces of precipitation, holes and channels of small benthonic organisms (*Chondrites*).

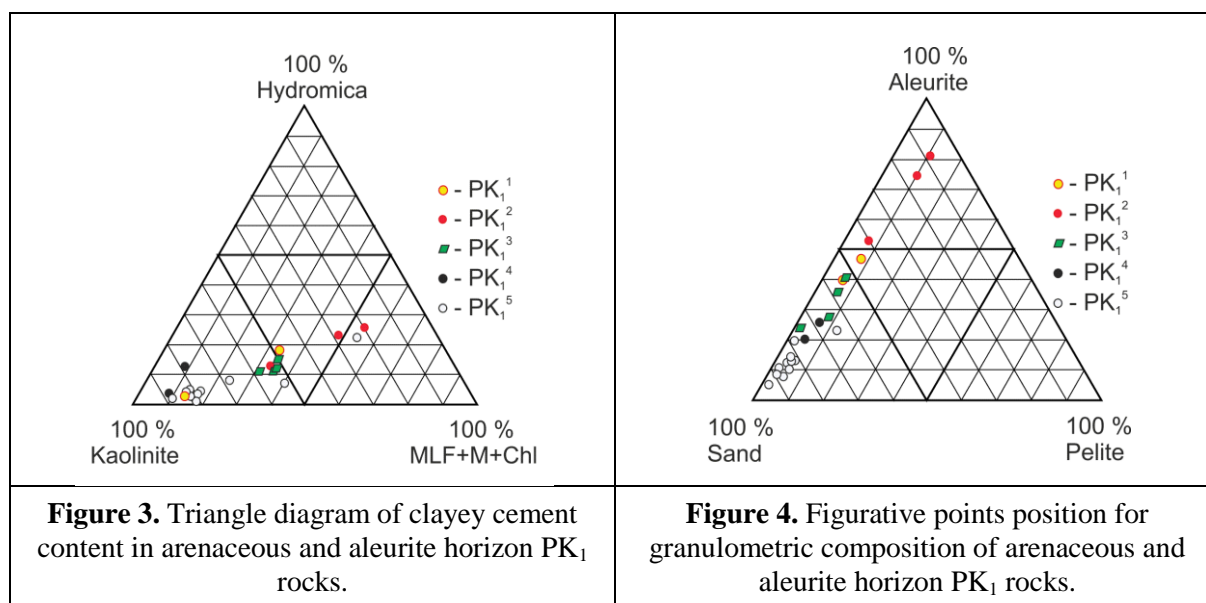
The lower part of the profile (layers PK<sub>1</sub><sup>5</sup> and PK<sub>1</sub><sup>6</sup>) are composed of more coarse-grained rocks with cross, diverse-directional and wavy lamination, coal bands, root remains and benthonic ichnofossils was formed under conditions of alternating wave motion of water with relatively high dynamics; the upper part (layers PK<sub>1</sub><sup>3</sup>, PK<sub>1</sub><sup>2</sup> and PK<sub>1</sub><sup>1</sup>) with coarse-grained arenaceous aleurite rocks, mainly wavy lamination and intensive bioturbation was formed under conditions of lower dynamics and alternating wave motion of water. Features of marine (wavy lamination and multidirectional cross-bedding characterize wave character of the aquatic sedimentary environment, ichnofossils type *Skolithos* and *Chondrites* are formed in sublittoral [2]) and continental origin (coal bands, root remains) show the alteration of marine/continental conditions and coastal-marine regime of sedimentation. In general, the sediment accumulation in PK<sub>1</sub> horizon occurs in the setting of the sea floor downwarping of the sedimentation basin and is related to Cenomanian-Turonian marine transgression.

### Deposits genesis identification for horizon PK<sub>1</sub> according to analytical results

Marine origin of sediments is indicated by the cementing mixed-layer minerals like hydromica-montmorillonite, montmorillonite, chlorite (according to the X-ray-phase analysis) (figure 3). The components content increases through the profile from bottom to top, but kaolinite content substantially decreases in the same direction.

Granulometric spectrum of arenaceous aleurite rocks is dominated by arenaceous and aleurite fractions; pelitic fractions the content of which is not higher than 10 % (figure 4), are dramatically subjected to good deposit elutriation. The rocks are poorly cemented by the clayey cement; these can be easily deformed and, as a result, provides informative granulometric characteristics.

According to the granulometric analysis data (table 1) and calculations made by Falk's equation [3], granulometric spectra of rocks have the following characteristics: positive values of asymmetry – prevalence of coarse-grained fractions and high dynamic activity of the sedimentation environment; positive values of excess reflect the sediment resorting stability [9, 10]; sorting coefficient increase ( $S_o$ ) through the profile from the bottom to the top – sediment resorting improvement from the medium – to well-sorted grains.



Notes: MLF – mixed layered minerals type of hydromica-montmorillonite, M – montmorillonite, Chl – chlorite.

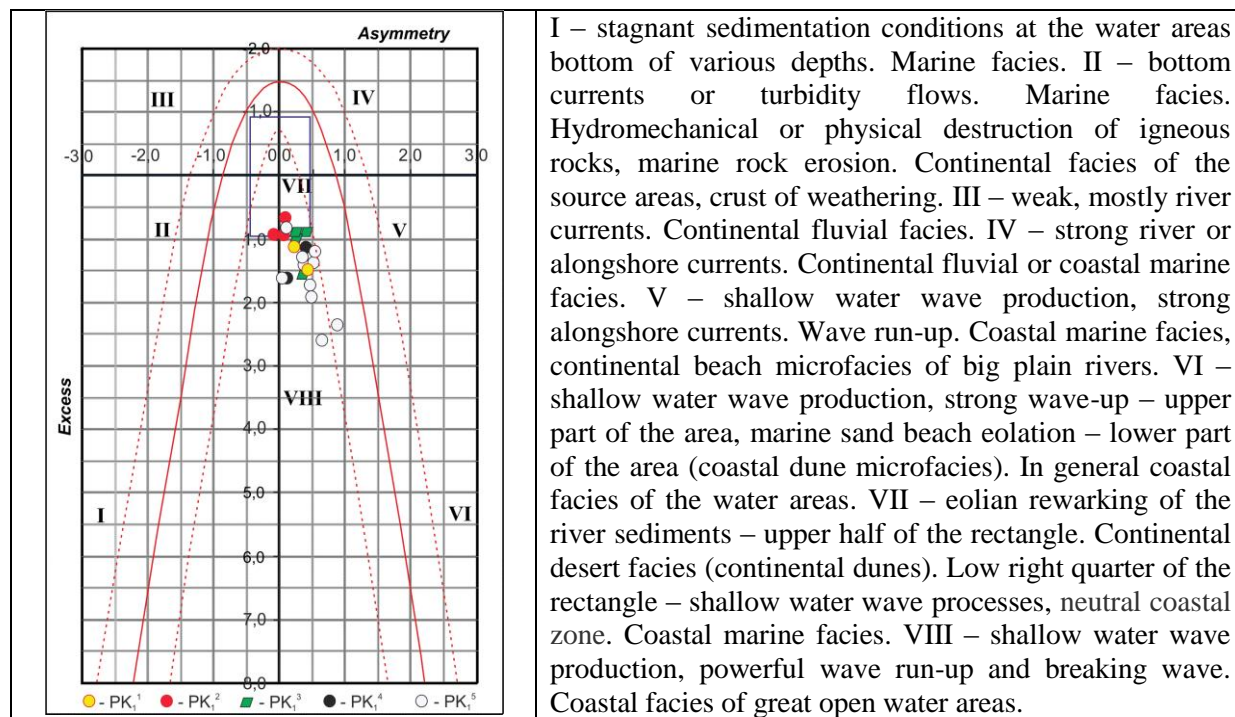
**Table 1.** Granulometric parameters of arenaceous rocks in horizon PK<sub>1</sub>

Layer	Average content (%) and fraction size (mm)					Granulometric coefficients			
	1–0.5	0.5–0.2	0.2–0.1	0.1–0.01	<0.01	Md, mm	Sorting ( $S_o$ )	Asymmetry (from-to)	Excess (from-to)
PK <sub>1</sub> <sup>1</sup>	0.08	2.28	47.71	43.83	6.10	0.08–0.09	0.39–0.48	0.22–0.34	1.07–1.15
PK <sub>1</sub> <sup>2</sup>	0.05	2.45	19.43	69.04	9.03	0.05–0.08	0.36–0.43	0–0.08	0.7–1.04
PK <sub>1</sub> <sup>3</sup>	0.04	6.69	55.63	31.50	6.15	0.09–0.12	0.40–0.53	0.19–0.37	0.89–1.6
PK <sub>1</sub> <sup>4</sup>	0.08	5.06	67.19	22.11	5.55	0.10–0.11	0.49–0.53	0.06–0.32	1.14–1.61
PK <sub>1</sub> <sup>5</sup>	0.17	40.14	42.74	12.14	4.81	0.12–0.21	0.48–0.77	0–0.68	0.74–2.62

Imaging points of granulometric spectra of arenaceous and aleurite rocks in the range of VIII and VII fields (figure 5) on Rozhkov dynamogenetic diagram (asymmetry – excess) is relevant to the shallow water wave production, powerful wave run-up and breaking wave of the coastal facies in great open water areas (layers PK<sub>1</sub><sup>5</sup>, PK<sub>1</sub><sup>4</sup> and PK<sub>1</sub><sup>3</sup>) and shallow water wave processes, neutral coastal zone of the coastal marine facies (layers PK<sub>1</sub><sup>3</sup>, PK<sub>1</sub><sup>2</sup>, PK<sub>1</sub><sup>1</sup>). Sandstones were formed in stable high dynamic

environment where active reworking of the material dominated over its supply [9, 10]. Formation conditions together with the core data taken into consideration may be related to the shore bars, as the sand material accumulated, they emerged and were covered by vegetation.

Coastal layers  $PK_1^5$  and  $PK_1^4$  have been identified in the sediment formation and coastal marine formation conditions ( $PK_1^3$ ,  $PK_1^2$  and  $PK_1^1$ ).



**Figure 5.** Rozhkov dynamogenetic diagram (asymmetry – excess) [9].

## Conclusions

Core and granulometric analysis data have identified the complex structure of the productive layer  $PK_1$ , 5 reservoirs are separated by coaly-clayey (in the lower part) and clayey bands have been determined.

Lithological composition has been described, genetic features have been identified and coastal (layers  $PK_1^5$  and  $PK_1^4$ ) and coastal marine (layers  $PK_1^3$ ,  $PK_1^2$  and  $PK_1^1$ ) conditions for deposits formation have been determined.

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