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THE LITHOLOGICAL CHARACTERISTICS OF NOVOPETRIVSKA SUITE SAND STRATA OF KRASNOKUTSK TITANIUM-ZIRCONIUM DEPOSIT

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ЛІТОЛОГІЧНІ ХАРАКТЕРИСТИКИ ПІЩАНОЇ ТОВЩІ НОВОПЕТРІВСЬКОЇ СВІТИ КРАСНОКУТСЬКОГО ТИТАНО-ЦИРКОНІЄВОГО РОДОВИЩА

On the basis of lithological characteristics of Miocene sand series of Krasnokutsk placer deposit the comparison with stratigraphyc interval of Novopetrivska suit (Lower, Middle and Upper subsuite) was realized. Basing upon obtained lithological data (structural, textural) considering results of presiding studies (interpretation), the generalization of lithofacial composition and conditions of singled out subsuites was executed.
Keywords: lithostratigraphy, lithology, Miocene, titanium-zirconium placer, Novopetrivska suite

На основі літологічних характеристик піщаної товщі міоцену Краснокутського родовища проведено літостратиграфічне розчленування новопетрівської світи (верхня, середня та нижня підсвіти). На базі отриманих літологічних характеристик (речовинних, структурних, текстурних) виконано узагальнення по літофаціальному складу та умовам утворення порід виділених підсвіт.
Ключові слова: літостратиграфія, літологія, Міоцен, титано-цирконієве родовище, новопетрівська підсвіта

INTRODUCTION

The «actuality of the problems is associated with the need for multylateral study of titanium-zirconium ores promising placer deposits to expand titanium-zirconium base in Ukraine.

The purpose of this work – the reflection of lithological characteristics of titanium-zirconium ores of Novopetrivska suite sand strata of Krasnokutsk deposit.

In connection with the intended purpose the following tasks were set:

- the development of a general lithostratigraphic scheme for Novopetrivska suite of the deposit area;
- characterization of size distribution of rock;
- the study of mineral grains roundness for light and heavy fractions of sands;
- study of the lamination character and genetic types revealing;
- the identification of facies types and the formation of a general genetic concept.

The studies were conducted using the data of 1957 – 1961-th geological surveys and based upon own field works. The lithostratigraphic scheme of Novopetrivska suite (compiled on the basis of the Project of modernized stratigraphic schemes) with authors participation (Khrushev et al., 2013) has also been used for lithostratigraphical studies.

The work has been performed in the frames of the state budget theme IGN NASU «Structural-lithological modeling for advanced geological sites of salt and titanium-zirconium placer gold and formations» (supervisor prof. D.P. Khrushchov) with financial assistance of Ukrainian Foundation for Basic Research funds project «Digital structural-lithological geological-dynamic modeling of heavy minerals placer deposits» (2012 – 2013), and Development of information-prognostic digital retrospective-static models of heavy mineral placers in East European platform (the Russian Federation and Ukraine)" (2014 – 2015).

RESEARCH METHODS

The general principles of lithostratigraphic studies, granulometric analysis techniques, the structure of minerals and sands, lamination studies as well as the principles of facies analysis have been used.

GENERAL GEOLOGICAL CHARACTERISTICS OF THE DEPOSITS

Review of geological knowledge. Krasnokutsk deposit is located in Krasnokutsk district of Kharkov region. The deposit was discovered by geologists of Kiev exploration trust in 1956. Since 1957, the deposit has been systematically studied, in 1959 – 1961 the preliminary exploration has been perfomed.

In Krasnokutsk deposit four ore fields (Southern, Central, Stepanovski and Kozievski) were explored. The first three fields were subjected to preliminary exploration, the fourth – to search exploration. As a result of the preliminary exploration the reserves of category C_1 and search exploration of - C_2 category have been estimated.

The geological characteristics of the deposit. From the tectonic point of view Krasnokutsk deposit is located in the north-eastern marginal zone of the Dnieper-Donets depression. Features of the

geological structure and Krasnokutk deposit ore are reflected in the works of I.S. Romanov (Романов, 1976, Романов, Злочевская, 1958), S.N. Tsymbal (Цымбал, Полканов, 1975). All ore bodies are located in Middle Novopetrivska subsuite.

THE LITHOLOGICAL CHARACTERISTICS OF NOVOPETROVSKA SUITE

As a result of correlation with Miocene regional stratigraphic scheme (Project of modernized stratigraphic schemes of Ukraine) the lithostratigraphic scheme for Krasnokutsk deposit area has been developed. According to this scheme the Novopetrivska suite consists of three subsuites: Lower, Middle and Upper. The lithological description of these subsuites is presented below.

Lower Novopetrivska subsuite lies on a sandy rocks of Sivash substage (Bereka regional stage). The thickness of sands ranges from 2 – 3 to 7 – 8 m. The subsuite is presented with greenish-gray thin laminated carbonaceous sands, greenish-gray, dark gray, sometimes black clays containing bands of sand, sometimes with inclusion of wood and brown coal (SLE. 532 , 606, 607, 610, etc.). Within the area clay layers form marking horizon. Their thickness varies from 0.5 to 2.3 m. The average thickness is 1.0 m. The maximum thickness of clays is registered in the southwestern part of the deposit area.

Clays are composed mainly by monthmorillonite. The clays contain admixtures of iron oxides and despersed pyrite. These mechanical analysis show that claysre are sandy, the content of particles <0.05 mm, in average is only about 44%. A significant part (54.15%) forms a fraction of 0.25 - 0.05 mm. The contact of clays with host rocks are sharp, the relief of bottom and top of clays is uneven.

The subsuite sands are characterized with wavy and horizontal lamination, expressed with presence of coal, ore or clay material.

Sediments facial identification- alluvial and lacustrine-swamp sedimentation. All placers, without exception, are related only to the same stratigraphic level, namely – the Middle Novopetrivska subsuite.

Middle Novopetrivska subsuite is considered as productive horizon. The relief of it's bed is uneven, the absolute level of fluctuating between 102 - 134 m. The thickness of the deposits varies from 7 - 10 m to 23 - 26 m, the maximal thickness is observed in the depressions sites of the relief.

Characteristic features of sand are as follow: essentially quartz composition of small and fine-grained material with dimegranulometric composition, clearly expressed thin laminated texture, sands good sorting washed from the clay material, good rounding of quartz grains, the presence of associations of ore minerals in the scattered and concentrated contents.

Sands lamination of Middle subsuite horizon is one of the criteria for genetic identification of placers. In the sands of the middle subsuite one can observe a linear, linear-cross (Fig. 1), wavy, wavy-cross and other forms of lamination.

Sand lamination is well expressed, caused mainly by the difference of granulometric and mineralogical composition and color.

The lamination is most clearly manifested in mineralized sands; on the light-colored (white, yellowish-white, yellow) background one can see he dark gray, gray, pale gray and pale orange thin laminas. Dark gray(ore containing) laminas have a thickness from a few millimeters to 30 - 50 mm. Lamiae especially enriched with ore minerals, have a thickness not more than one centimeter. Middle subsuite ore sands of the deposit are characterized by two textural features:

1) within the boundaries of the individual series one can see the rytmicity of subordinate order, expressed with alteration of layers of different types of lamination (prevailingly linear, wave-like, cross wave-like etc); each of these type is stipulated with alternation of ore enriched and ore-free layers. The maximum concentration of ore minerals is confined to the wavy-cross and syncline-like lamination. This layering occur again in the vertical section from 2 - 3 to 5 times.

2) the relief of cross-wave lamination roof is usually smooth, the bottom is always wavy (the reflection of washing out), roofing wavy-smooth cross-bedding, the sole is always wavy. The roof lamination is expressed clearly.

These forms of lamination and a pattern of heavy and light mineral fractions differentiation are characteristic for coastal marine zone.

Certain genetic characteristics provides the determining of roundness of ore and nonmetalliterous mineral grains. Here is the diagram of grains roundness in Middle Novopetrivska subsuite sands (Fig. 2).

The mark system of grain roundness estimation by I.S. Romanow (Романов, 1958) with detailed description by F.J. Pettijohn (Петтиджон, 1981).

Mark rounding 4 - angular grains - very slight traces of sharp edges and corners working up, the secondary corners (minor projections of grains surface) are numerous and sharp.

Mark rounding 3 – semiangular grains– certain traces of working up, the edges and corners are

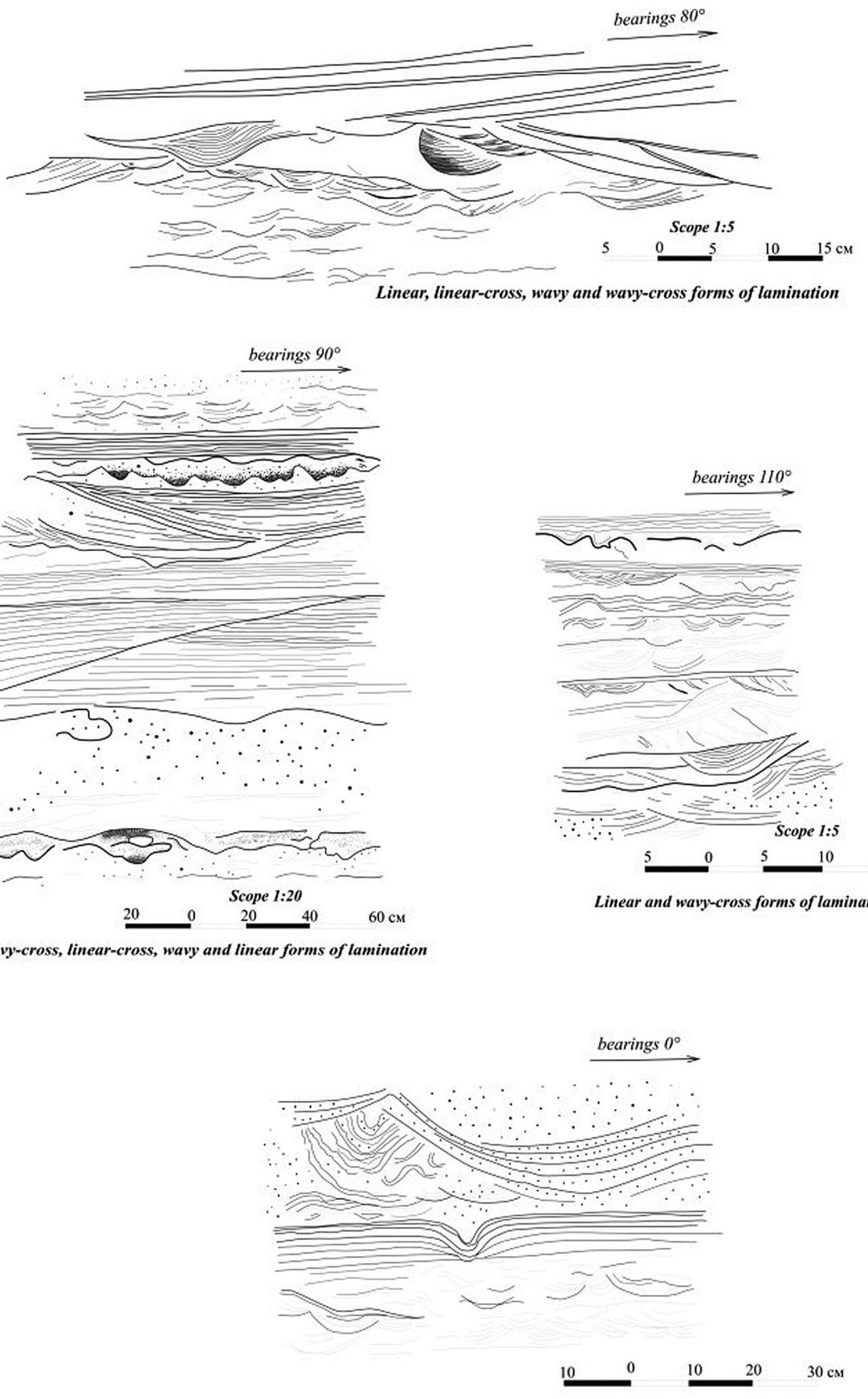

Fig. 1. Types of ore sand lamination of Krasnokutsk deposit (Романов, Злочевская, 1958).

rounded, to some extent, minor angles are not so numerous and not so sharp.

Mark rounding 2 - semirounded grain – significant traces of working up, the edges and corners are rounded, minor corners are considerably smoothed, their number is not significant. The area of the primary facets is restricted, the original angles between them are smoothed, but still noticeable.

Mark rounding 1 - rounded - the original faces are almost completely disappeared, some relatively flat surfaces are preserved yet. The angles between preserved facets are obtuse, all of the primary edges and corners are smoothed to smooth curves, the secondary angles are rare.

Mark rounding 0 - well rounded grains – the original faces, edges or corners are not preserved, the surface consists entirely of large bulges, there are no flat areas, no minor angles. The original form of a fragment can be assumed only by the general form of grain.

The results of individual grain roundness determined under the microscope (Fig. 3) suggest that the average ratio of heavy minerals grain rounding exceed the same ratio for light mineral. The greatest roundness have grains over 0.25 mm. In general subrounded, rounded and well-rounded forms dominate, which correspound to the criteria of the coastal marine conditions diagnostic of the deposit forming.

As to the granulometric composition the sands of Middle Novopetrivska subsuite are rather heterogeneous (Table 1).

As a result of field work carried out in the territory of Krasnokutsk deposit (2013 – 2014), samples were taken, after sieve analysis. The results of particle size analysis on the samples of field trips are given in Table 1.

These data are comparable with the results of grain size analysis by I.S. Romanov (1956 – 61). As a result of grain size analysis with reflection on

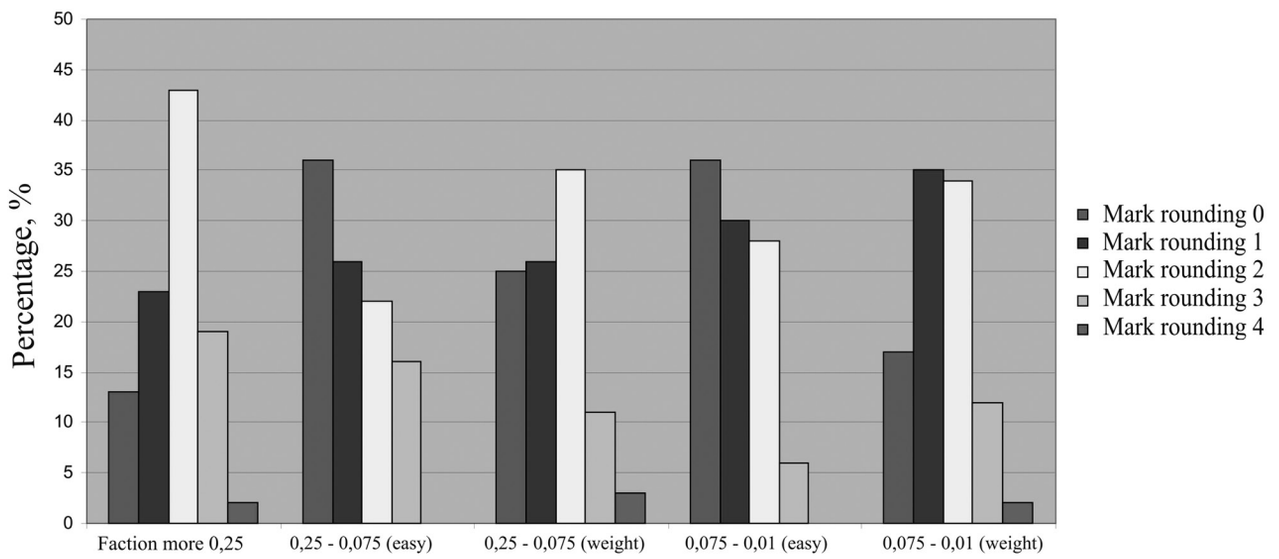

Fig. 2. The results of grain roundness in Middle Novopetrivska subsuite sands depending on the specific gravity and particle size distribution.

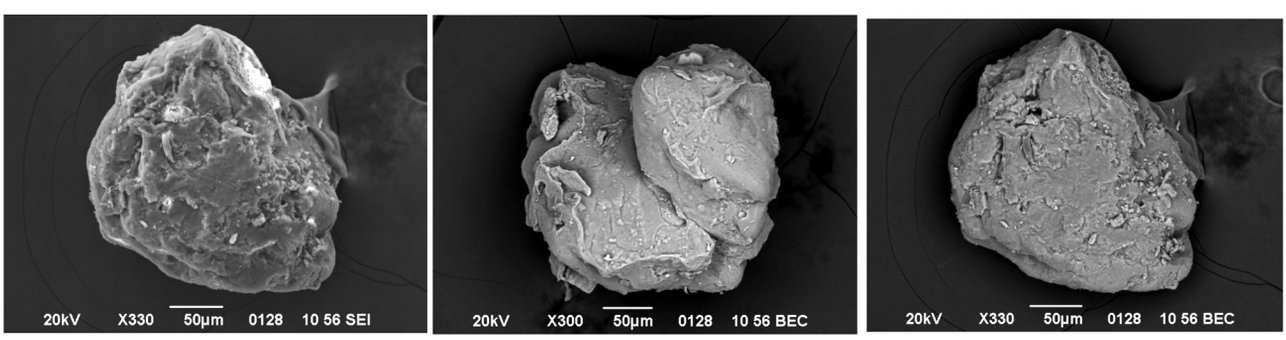

Fig. 3. Semirounded form of grains, Middle Novopetrivska subsuite. Photos have been made at Laboratory geology of ore deposit of Institute of Geology of ore deposits, petrography, mineralogy and geochemistry of RAS, 2014.

3-component diagrams (Рухин, 1969) according to classification of L.V. Pustovalov (Пустовалов, 1940) the major part of sand is determined as a sandy-clay silt (aleurite). The results of grain size analysis are illustrated by laboratory tests conducted on sedimentograph Mastersizer 2000 (Fig. 4).

Particle size distribution is shown in a graph with reflection of size volume, respectively to the surface area of the particles. The Mastersizer 2000 measurement (Стадніченко, Подоба, 2008) is based on particles volume, the subsequent parameters are obtained by mathematical re-computerution. The data based upon the volume, provide the most adequate reflection of particles fractions. The use of other parameters is advisable in other cases.

The graph shows practically the one model of distribution of particles in the sample squeaking. The maximum number of particles of a given sample falls on a range of dimensions (fraction) of 0.07 - 0.5 mm. Thus, this mode corresponds to aleurite (or more exactly – coarse aleurite) of Middle Novopetrivska subsuite.

The studies of the lithological characteristics of sands show that it formation occurred in a coastal shallow facies and ore placers are confined to small-scale fine-grained sand and aleurites.

Upper Novopetrivska subsuite in the study area is represented by continental facies type and temporary flows. The deposits of subsuite have a limited occurence, and are developed only in the northeastern part of the area. Hypsometry of the subsuite roof about 145 - 175 m.

These sediments lie throughout of the coastal marine sands of the Middle Novopetrivska subsuite. Their thickness varies from 1.0 to 9.0 m. The average thickness is 4.2 m.

Table 1. The grain size analysis of sands, Middle Novopetrivska subsuite

№ sample	Fraction, mm					
	>1	1 – 0,63	0,63 – 0,315	0,315 – 0,2	0,2 – 0,16	<0,16
1.2.	-	-	52,42	32,54	11,92	3,12
1.3.	1,03	8,99	62,52	24,31	2,56	0,59
1.4.	-	0,10	0,19	0,97	12,75	85,99
1.5.	-	0,25	0,50	1,14	14,13	83,98
1.6.	-	0,30	11,74	15,14	14,39	58,43
1.6 (1)	-	0,29	13,79	14,97	14,57	56,38
1.6 (2)	-	0,49	14,61	16,91	15,05	52,94
2.1.	-	-	0,05	4,91	28,70	66,34
2.2.	-	-	0,05	0,39	0,39	99,17
4.2.	-	0,84	10,02	24,43	7,26	57,45

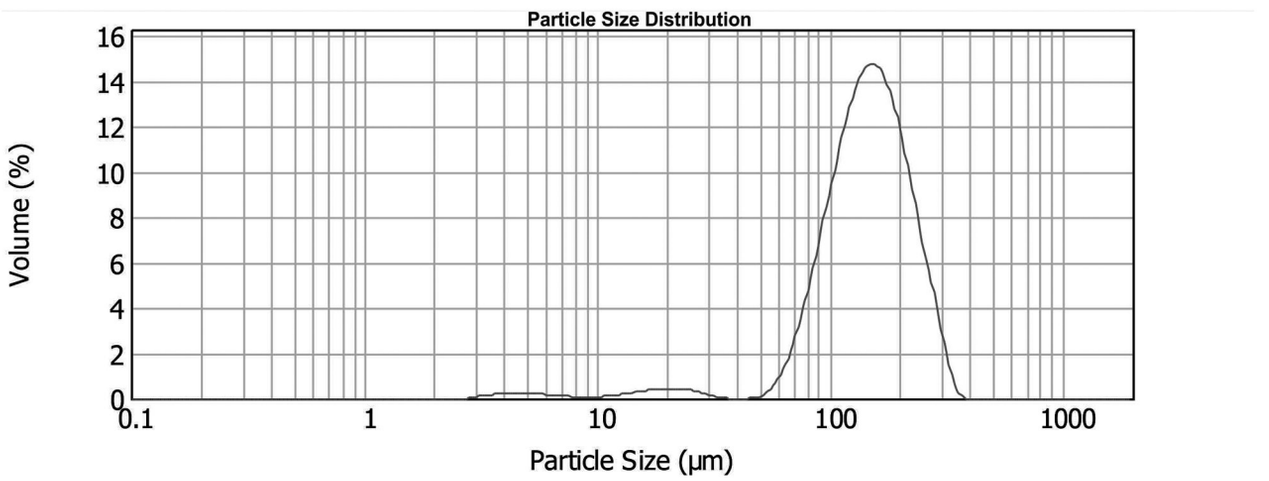

Fig. 4. The results of sand sample analysis carried out on the Mastersizer 2000.

Table 2. Size distribution of Upper Novopetrivska subsuite sands, by I.S. Romanov (Romanov, 1976)

Fraction, mm	from	to	mean
>2	0,0	1,26	0,44
2,0 – 1,0	0,0	1,35	1,40
1,0 – 0,5	0,11	13,80	4,15
0,5 – 0,25	3,70	43,02	17,68
0,25 – 0,10	27,97	67,24	49,22
0,10 – 0,05	2,13	17,18	6,85
0,05 – 0,01	1,82	5,46	3,00
0,01 – 0,005	1,73	22,54	7,40
0,005 – 0,001	0,62	4,23	2,09
<0,001	5,97	9,72	7,77

The sediments of the subsuite of 80 - 90% are represented by silty sand (80 – 90%) and a small part of the section - by fine-grained sands and coarse-grained sandstones. The concentration of heavy minerals in industrial conditions are not met here.

Sands are characterized by high homogenous texture. According to granulometric analyzes they are identified as silty and clay sand. The clay fraction content is ranging from 13.1 to 36.7%, silty from 5 to 22% (table 2).

The mineralogical composition of sand is rather homogenous. The quartz is prevailing (95 - 98%), heavy and dark colored minerals are present in minor quantity. The separation of minerals by specific gravity did not occur. Heavy minerals are scattered in the whole mass of sand and do not form concentrations. The content of the bulk concentrate ranges from 0.2 to 10.6 kg/t. The bulk concentrate includes: rutile (up to 2.7 kg/t); ilmenite (up to 3.6 kg/t); zircon (up to 3.0 kg/t), tourmaline, kyanite and sillimanite, hematite and others.

The prevailing structure of sands is cross-bedded. The lamination is caused by alternation of thin layers of different colors and grain size. In most cases the alternation of rusty yellow color different tints is spread.

CONCLUSIONS

On the basis of lithological characteristics for Miocene sand series of Krasnokutsk placer deposits its comparison with stratigraphyc interval of Novopetrivska suit (by the Project of Modernized stratigraphic schemes) has been realized. By means of section correlation three subsuites were singled out: Lower, Middle and Upper Novopetrivska. Basing upon obtained lithological data (structural, textural), considering results of presiding studies (interpretation), the generalization of lithofacial composition and conditions of singled out subsuites was made. The defining of lithofacial and facies complexes represented a basement for the deposit rock massif structurization being necessary for digital structural-lithological modeling of the object and middle scale paleogeographic reconstruction.

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