Lithological and Petrographic Characteristics of Aleuropelitic Ishimskian Deposits in the Western Part of Tobol-Ishim Interstream Area

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Abstract. The lithological and petrographic analysis of aleuropelitic rocks of Ishimskian suite of the Upper Miocene was conducted for outcrops "Bigila", "Pyatkovo" and "Masali" in the south of Tyumen Region. The data obtained complete the previously performed research of material composition, physical properties and identification of preliminary age of the upper part of Ishimskian suite. The results of these studies do not record significant differences in the lithology of the studied species, presented in different exposures: rocks are identical in their mineral composition and structural and textural features, confirming the community of their formation conditions.

The studied rocks are composed mainly of fine poorly rounded quartz; in small quantities contained feldspar and mica. Feldspars consist principally of plagioclase, less microcline, which is confirmed by the determination of rocks chemical composition by X-ray analysis. Micas are present in the form of thin flakes with a bright interference color. Very rarely there are small grains of round glauconite, yellow-green, the exact origin of which is not yet set. In the outcrop Masali aleuropelitic rocks are overlapped by clayey silt with a high content of dispersed organic matter and coalified plant detritus. High dispersion and predominantly quartz composition allows us to characterize the studied rocks as marshallits. In this respect, more detailed studies must be based on analytical and instrumental methods that could be applied for this type of rocks. Persistence of the thickness of deposits over a large area gives grounds to consider the formation of the Ishimskian suite along with other horizons of the Middle Cenozoic as objects for prospecting siliceous raw materials.

Keywords: aleuropelites, Ishimian suite, lithology, Tyumen region, marshallit, natural microsilica
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Introduction

Deposits of Ishimskian suite of Upper Miocene, distributed in the valleys of small rivers in the south of the Tyumen region, are highly informative for the reconstruction of paleogeographic conditions and history of the territory of the Tobol-Ishim interstream in the Neogene. These rocks are generally described as bleached aleuropelites or mealy silts (Astapov et al., 1964), in some studies their resemblance is noted with the Eocene diatomites and tripolis of Trans-Urals (Kuznetsov, 1963).

Despite the importance of stratification in the continental Neogene in Western Siberia and the great potential for paleogeographic reconstructions, deposits of Ishimskian suite in northern areas of its distribution remain poorly studied. Suite stratotype is considered section of Petropavlovsk (Martynov, 1967; 1964; Zykin, 2012). General information on the distribution of the suite within the Tobol-Ishim interstream is contained mainly in the works of A.P. Astapov, relating to the 70-s of the last century (Astapov et al., 1964; 1979; Astapov, 1977).

The results of earlier studies of Ishimskian aleuropelites revealed abnormally high dispersion of these sediments for rocks quartz composition, which allowed characterizing them as marshallites (Smirnov et al., 2016), as well as to confirm that they belong to the Late Miocene (Kuzmin et al., 2016). In this paper we present the results of lithological and petrographic analysis of the Ishimskian suite deposits from three outcrops in the western part of the Tobol-Ishim interstream and their interpretation.

Objects and methods of investigation

Field studies were carried out on the territory of Zavodoukovsky and Uporovsky districts of the Tyumen region within three key areas – "Bigila", "Masali" and "Pyatkovo" – confined to the eponymous human settlements (Fig. 1). According to the geomorphological zoning of the south of Western Siberia, the area of the field work is located on the Ishim denudation sloping plain (Varlamov, 1972) with altitudes of 50-150 m above sea level (Zemtsov et al., 1988). The area is distinguished by the degree of relief stratification sufficiently high for the south of the Tyumen region: a linear division of ravines, gullies and valleys of the small rivers is 0.6-1.2 (Atlas of the Tyumen Region, 1971). The river network of the studied area belongs to the Kara Sea basin; main river – Tobol. Valleys of small rivers – Bigila, Kizak and Kurchigay – are included into the valleys of the river network of the Neogene.

Within the boundaries of the areas under consideration Ishimskian suite combines layers of assorted sand and bleached tripoli aleuropelitic rocks, considered geologically coherent and unified suite up to 20 m (Fig. 2) (Astapov et al., 1979). The transition from the sandy alluvium to aleuropelites is gradual; bottom contact is usually clear, even with signs of minor areal erosion. In the studied outcrops the presence of basal horizon is recorded, which is composed of coarse-grained, sometimes gravelly sands, with mafic minerals and quartz pebbles, with a scythe, belt, diagonal stratification, with thickness of 5-10 cm.

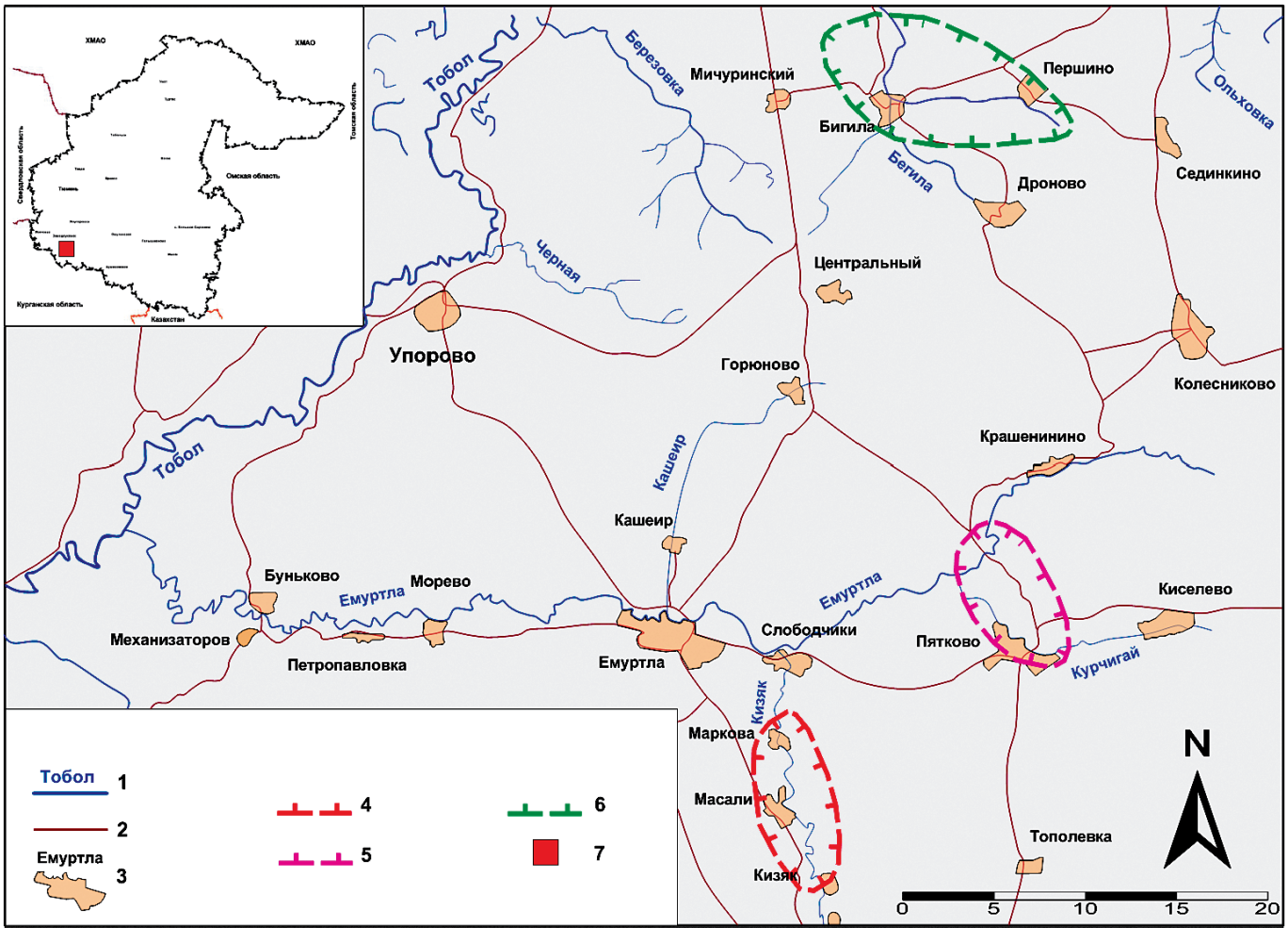

Fig. 1. Map of the actual material: 1 – river network; 2 – roads; 3 – settlements; 4 – border of key area "Masali", 5 – border of key area "Pyatkovo", 6 – border of key area "Bigila", 7 – location of the research areas within the south of the Tyumen region.

In outcrops aleuropelitic strata is conventionally divided into two parts: the largely ferruginous lower and upper bleached. Rarely in the lower pack of aleuropelites there are small clusters of black manganese nodules, rod-shaped, nodular, with tuberculate surface.

Previous studies have established (Smirnov et al., 2016) that, in general, the thickness is not uniform in mineral composition laterally and vertically.

The top of the aleuropelitic column is characterized by the largest values of silicone dioxide and the smallest of lithophile element oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.), and accordingly, the higher content of silica and lower content of clay minerals. Aleuropelitic rock has the following mineralogical composition: quartz (61.1-85.6 %), potassium feldspar and microcline (up 6.9 %), acid plagioclase or albite (to 14.2 %) (Smirnov et al., 2016).

The study was carried out in thin sections prepared by the standard method (Shvetsov, 1958).

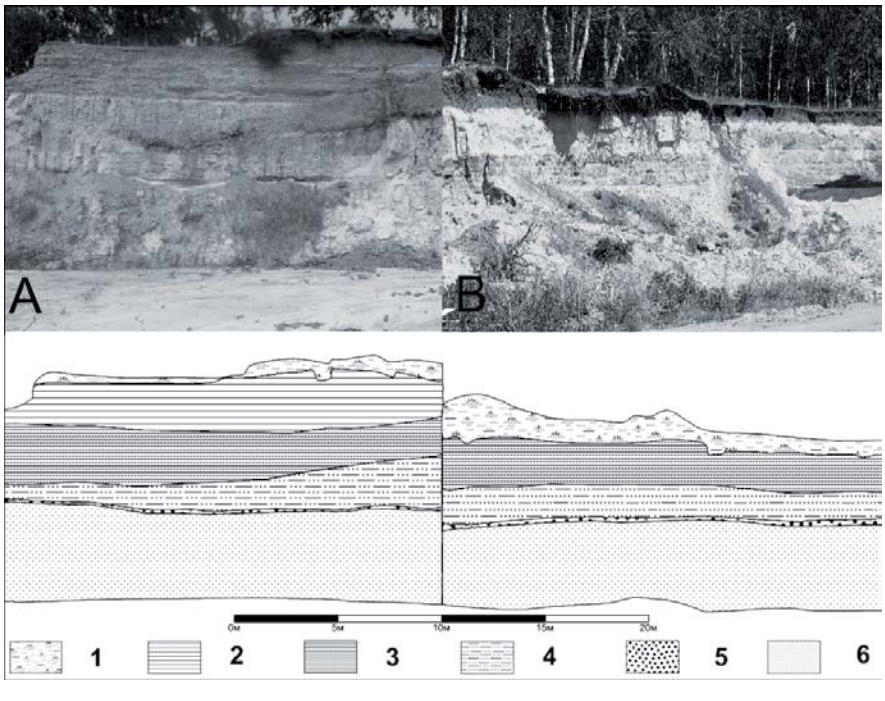

Fig. 2. Outcrops scheme (sections: A – "Masali", B – "Bigila"); 1 – soil-vegetation layer; 2 – clay and silty rocks overlying aleuropelites of Ishimskian suite; 3 – upper (light) pack of aleuropelitic column; 4 – lower (ferruginous) pack of aleuropelitic column; 5 – basal horizon; b – sands of Ishimskian suite

Research results

According to the results of previous studies (Smirnov et al., 2016) loose aleuropelitic rock, presented in a natural outcrop "Bigila" has aleuropilitic structure with particle size of less than 0.01-0.001 mm, individually up to 0.03 mm. Fragments are mainly represented by quartz and the finest scales of hydromica (Fig. 3). There are rounded isolations of up to 0.03 mm, yellowish in parallel Nicols, belonging to mixed layers of formations that are supported by the analysis of chemical composition made by means of X-ray diffraction (Smirnov et al., 2016). Ore minerals are more or less evenly scattered with pyrite impregnation, which is not more than 1 to 2 %, and ore minerals, undetermined due to full leucoxenization (about 5 %). The accessory minerals are presented by titanium with a crystal size of 0.01 mm and constituting 4-5 %.

In outcrop "Masali" apparent thickness of exposed rocks is 4.5 m. At the bottom of outcrops aleuropelites occur light, almost white; aleuropelitic stratum overlaps clay-silty rocks with a high content of sand material and organic matter (Kuzmin et al., 2016). Aleuropelitic rock is light-gray, homogeneous, weakly cemented, flabby, mica, light, when crushed dusty, sticks to the tongue, when interacting with HC1, the reaction is not observed. Rock structure is aleuropelitic, pelitomorphic; texture of rocks is homogeneous (Fig. 4).

The rock consists of 90 % angular quartz grains, the maximum size of which is 0.12 mm, an average particle diameter greater than 0.05 mm, make up 3-5 % of the rock volume, the predominant grain size is 0.005-0.012 mm. In a small number feldspar and mica are contained (mostly highly water sensitive). Feldspars are presented by acidic plagioclase. Hydromica is present in the form of thin flakes with a bright interference color. Small, round, yellow-green glauconite grains are very rare.

In the sample there are round-shaped formations consisting of quartz grains of the same size, of which the rock is composed, cemented by a rather amorphous material, apparently opal/ halcedony. Clay minerals are presented by chlorite scales.

Across the sample there are rather small black grains (size <0.005 mm) scattered, the mineral composition of which cannot be reliably determined in view of their very small size (presumably ore minerals).

Since the rock is weakly cemented, flabby, with a little amount of binder, within 3-5 %, has a point (contact) and pore distribution type, consists of authigenic silica, chlorite and hydromica. Rock sample has a relatively high microporosity (sample rapidly turned into blue), formed by intergranular pores with size of less than 0.005 mm. Moves of burrowing organisms are also met, filled with the larger material. Moves are intensely impregnated with limonite (Fig. 5).

Clay-siltstone rocks overlying aleuropelites, from light gray to dark brown, almost black, are sometimes ferruginized, with a high content of organic material and sand. The rocks are composed of clay minerals, mainly hydromica, with an admixture of debris of sand fraction. Fragments of quartz in fine sand fraction are of size 0.05-0.16 mm; silty impurity is less than 5%. Throughout the presence of dispersed organic matter and coalified plant detritus is recorded.

In "Pyatkovo" section similar in appearance to the first two objects of rock are exposed; the only significant difference is a

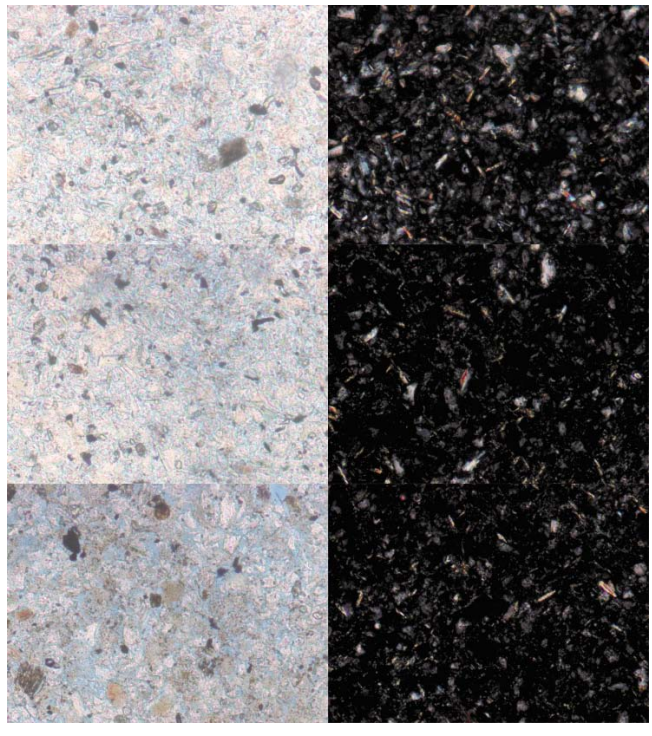

Fig. 3. General view of the aleuropelitic rock outcrop "Bigila" (left – parallel Nicols, right – crossed Nicols).

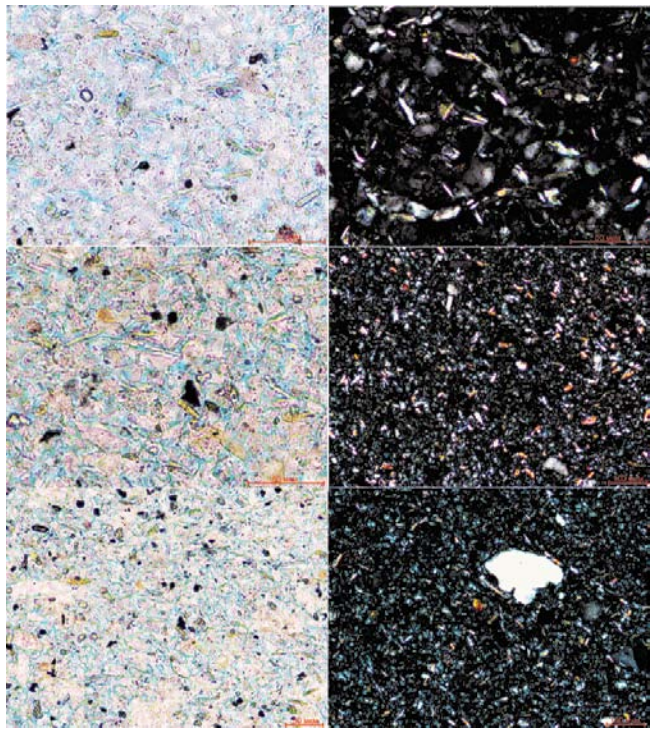

Fig. 4. General view of the aleuropelitic rock outcrop "Masali" (left – parallel Nicols, right – crossed Nicols).

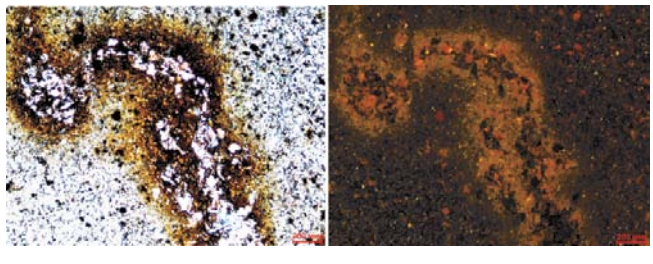

Fig. 5. Moves of burrowing organisms (left – in direct light, right – in the reflected light).

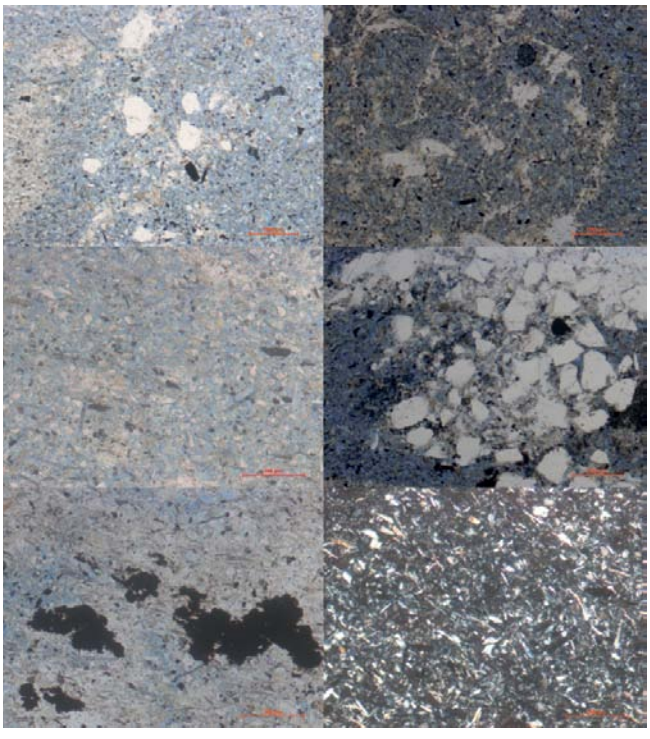

Fig. 6. General view of the aleuropelitic rock outcrop "Pyatkovo" (left – parallel Nicols, right – crossed Nicols).

slightly higher content of sand fraction. Aleuropelites are light gray, heterogeneous, weakly lithified, mica, with an admixture of sand fraction (2-4 %). The main rock mass consists of small quartz, with a predominant size of 0.01 to 0.03 mm, with a small admixture of feldspars (orthoclase, less plagioclase) of the same size (Fig. 6).

Sand bodies are arranged in the form of irregularly shaped lenses and consist mainly of poorly rounded quartz grains with individual grains of feldspar (plagioclase, slightly leached). The lenses also compose of siltstone admixture and grains with a good roundness. The grains of quartz are with no apparent trace of postsedimentary changes. Grain size ranges from 0.01 to 0.12 mm (0.25 mm predominant grain size).

The rock has irregular alternation of layers rich in kaolinite, which, as a result, is denser than layers of fine rock. In the volume of rocks we can see an abundance of fine elongated grains of mica minerals, mainly weakly altered biotite. Grains of quartz are often isometric, although elongated grains are frequent. From authigenic minerals: chlorite, kaolinite, hydromica minerals, pyrite concretions unit, up to 0.05 mm. There are rare grains of epidote.

The layered rocks are disturbed. As in the rocks exposed in other outcrops, there are signs of burrowing organisms. On one level with lens of sandy material (along conventional bedding, weakly guess) coalified organic residues are common (small carbonaceous detritus).

Discussion and conclusions

The studied rocks are loose, almost entirely composed of angular grains of quartz, predominantly pelitic and silt dimension with a small admixture of large fragments and small number of clay cement. This description in lithological science is applied to marshallites that further argues earlier suggested statement that these rocks should be seen as the marshallites (Molchanov, Yusupov, 1981).

This fact, combined with the consistency of rocks in large parts gives grounds to consider the Ishimskian deposits as a source of natural microsilica in the south of the Tyumen region and exploration object for siliceous raw material (Smirnov, Konstantinov, 2016).

The results of these studies do not record significant differences in the lithology of the studied rocks. The rocks are identical in their mineral composition and structural-textural features, confirming the generality of the formation conditions. The totality of the available data indicates that the Ishimskain suite is an integral sedimentary rhythm.

Formation of Ishimskian sediments probably happened in a lake shallow water at constant fluctuation of water level, resulting in a constant flow-through and high oxygen potential of surface water, determined the intensive washing, elutriation and bleaching of clay material that took place under conditions of low-amplitude movements of the basement (Astapov, 1977; Panova, 1971).

Outcrop Masali the only studied area that has two-part structure, where aleuropelites-marshallites are blocked by clayey silt, heterogeneous in composition, origin and genetic relationship of which with the underlying rocks is not yet clear.

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