MINERAL COMPOSITION OF SAPROPELS OF LAKES OF THE LEFT AND RIGHT BANKS OF THE OB RIVER

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Abstract: The objective of this work is to study the mineral composition of botám sediments of ten small lakes situated on the right bank of the Ob River in the Surgut District of the Khanty-Mansiysk Autonomous Okrug – Yugra and ten small lakes situated on the left bank of the Ob River in the Kondinsky District of the Khanty-Mansiysk Autonomous Okrug – Yugra. The research was carried out using wave dispersive X-ray fluorescence (WDFR) spectroscopy. We determined the content of bitumen, organic substances, ash in the studied samples, also the chemical composition of the ash. Based on these data, the studied bottom sediments were classified, and the bottom sediments of the lakes of the right and left banks were compared.

Keywords: Sapropel, Trace Elements, Organic Matter, Wave Dispersive X-Ray Fluorescence Spectroscopy.

1 Introduction

Sapropels are modern or subfossil, fine-structured, colloidal deposits of continental water reservoirs. Sapropel composition includes the remains of microscopic aquatic organisms, a considerable amount of organic matter, a certain amount of inorganic components of biogenic origin, as well as mineral impurities of a salutary nature. Peat is genetically close to sapropels. The main difference between sapropels and peat is their finer structure. In addition, the primary sources of organic matter are different. Peat is biogenic humic formation, the primary sources of organic matter of which are carbohydrates of peat-forming plants. In sapropels, the primary sources of organic matter are fats and protein substances of sapropel-forming organisms - plankton and algae, which determines the difference in the chemical composition of peat and sapropels. According to the content of the organic and inorganic components, sapropels belong to the organic-mineral and organic groups of bottom sediments. Sapropels are contrasted to high-ash lake deposits, such as clays, sands, marls, taking 15% organic content as a conventional border for this distinction [Korde, N. V.: 1960].

Sapropel deposits draw the attention of researchers due to the possibilities of their practical use. Sapropel is used in medicine as applications, diluted baths for mud therapy, in agriculture as fertilizer, in animal husbandry as a mineral supplement [Shtin, S. M.: 2005]. The theoretical interest in sapropels is connected with the opinion of a number of scientists that a long time ago sapropels were the material that carbon sedimentary rocks were formed of [Zanin, Yu. N., Zamirailova, A. G., Livshits, V. R., & Eder, V. G.: 2008].

The objective of this reserch was to study the mineral composition of sapropels of ten lakes of the right bank and ten lakes of the left bank of the Ob River (Western Siberia). These results are generalizing from previous and new studies [Sartakov, M.P., Osnitsky, E.M., Kudrin, K.Iu., Larina, N.S.: 2019;Sartakov, M.P., Osnitsky, E.M., Larina, N.S., Komissarov, I.D., Litvinenko, N.V.: 2019;Sartakov, M.P., Osnitsky, E.M., Kudrin, K.Yu., Larina, N.S., Komissarov, I.D.: 2019].

2 Research Objects and Methods

Sapropel was sampled from ten small lakes situated on the right bank of the Ob River in the Surgut District of the Khanty-Mansiysk Autonomous Okrug – Yugra and ten small lakes situated on the left bank of the Ob River in the Kondinsky District of the Khanty-Mansiysk Autonomous Okrug – Yugra. Geomorphologically, the lakes of the right bank of the Ob River are situated on the second supra-floodplain terrace. The surface area of the lakes ranges from 2.2 to 154.7 ha; the water depth reaches 4.8 meters. The lakes of the left bank of the Ob River are situated on the second supra-floodplain terrace. The surface area of the lakes ranges from 3.9 to 120.3 ha; the water depth reaches 6.1 meters.

Most of the lakes are supplied by spring floods and precipitation. The lakes are situated among cedar, pine, birch forests, and vast swamps. The type of overgrowing of water reservoirs is mixed - a combination of rafts and vast thickets. The bottom of the lakes is covered with a layer of macrophytes.

The sampling of sapropels and lake waters was carried out according to the “Guidelines for methods of hydrobiological analysis of surface waters and bottom sediments” [Sartakov, M.P., Osnitsky, E.M., Kudrin, K.Iu., Larina, N.S.: 2019;]. The sampling of lake water for general chemical analysis was performed at a depth of 1m into a 1L plastic container. The determination of macro- and microelements was carried out in dry sapropel samples using wave dispersive X-ray fluorescence (WDFR) spectroscopy in the engineering center of composite materials based on compounds of tungsten and rare-earth elements of the State Agrarian University of Northern Trans-Urals. Samples were analyzed on an ARL Optim’X spectrometer equipped with the OXSAS IT complex for instrument control and result processing [Sartakov, M.P., Osnitsky, E.M., Larina, N.S., Komissarov, I.D., Litvinenko, N.V.: 2019;]. The sample preparation and analysis were performed in accordance with GOST 33850-2016 “Soils. Determination of chemical composition by X-ray fluorescence spectrometry”. The concentrations were calculated using the method of fundamental parameters with correction coefficients of the interelement influence of the UniQuant module [Sartakov, M.P., Osnitsky, E.M., Kudrin, K.Yu., Larina, N.S., Komissarov, I.D.: 2019].

3 Results and Discussion

Figures 1 and 2 show charts of the content of organic matter (OM) in the studied sapropels and silicon oxide in the ash for bottom sediments of the lakes on the right and left banks of the Ob River.

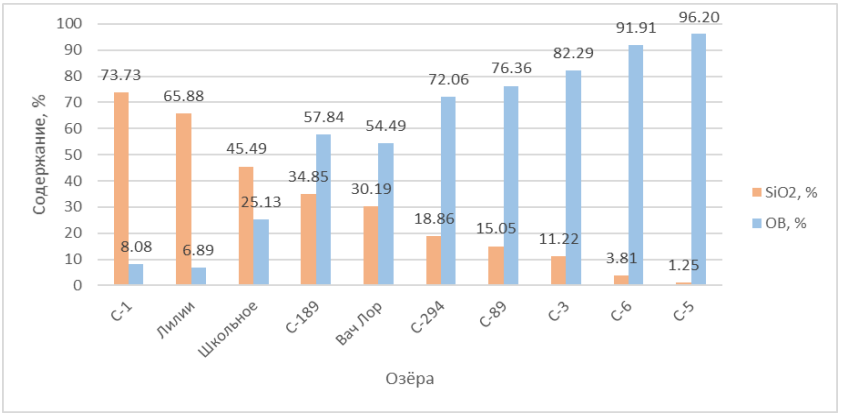

Fig 1. OM content in sapropels and SiO_2 in ash of bottom sediments in lakes of the right bank of the Ob River.

Bottom sediments can be grouped in accordance with their OM composition. Less than 10% organic content is characteristic of siltstone sands and clay silt; 10-30% organic content - weakly sapropel siltstone and clay silt; 30-50% organic content - clay sapropelic silt, 50-70% organic content - sapropelic clay silt; more than 70% organic content - sapropels [Shtin, S. M.: 2005]. According to this classification, bottom sediments of such lakes on the right bank of the Ob River as Lake S-1, Lilii are siltstone sands, Lake Shkolnoe - weakly sapropel siltstone and clay silt, lakes S-189, Vach Lor - sapropelic-clay silt, lakes S-294, S-89, S-3, S-6, S-5 - sapropels. Bottom sediments of such lakes on the left bank of the Ob River as 7, Baybalak 2 are siltstone sands; Lake 6, Dorozhnoe, Baybalak 1, Lesnoe - weakly sapropel siltstone and clay silt; lakes 4, 1 - clay sapropelic silt; Lake 8 - sapropelic-clay silt; Lake 9 - sapropels.

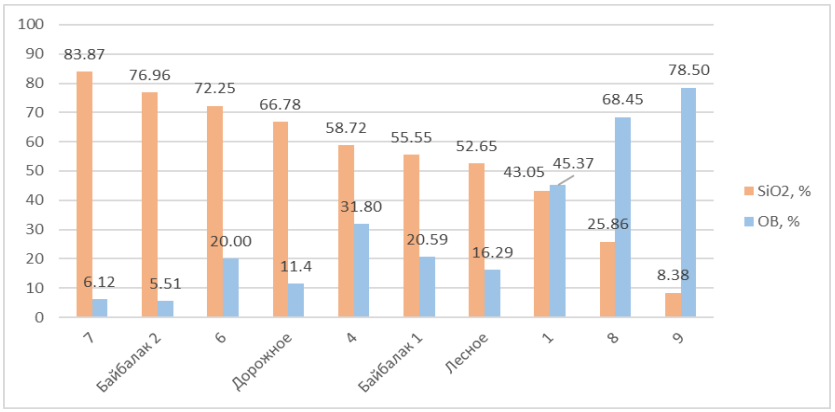

Fig 2. OM content in sapropels and SiO_2 in ash of bottom sediments in lakes of the left bank of the Ob River.

According to another classification, sapropels can be divided into type, class, and kind according to the content of ash, calcium and iron oxides, biological and mineralogical composition [Shtin, S. M.: 2005]. Table 1 presents this classification for bottom sediments in lakes of the right bank of the Ob River. Table 2 presents this classification for bottom sediments in lakes of the left bank of the Ob River.

Table 1: Classification of studied sapropels of the right bank of the Ob River.

Lakes	Content, %			Biological and mineralogical composition	Type	Class	Kind
	Ash	CaO	Fe_2O_3				
S-5	3,80	0,434	0,383	Organic residues > 45%	Biogenic	Organic	-
S-6	8,09	0,625	0,536				
S-3	17,71	1,190	0,746				
S-89	23,64	2,550	0,898				
S-294	27,94	1,120	0,876				
Vach Lor	45,51	1,480	2,160	Organic residues - 45%, SiO2 > 30%	Clastogenic	Organic-silicate	Organic-sandy
S-189	42,16	0,995	2,450				
Shkolnoe	74,87	1,300	4,830	Organic residues < 45% SiO2 > 30%		Silicate	Sandy
Lilii	93,11	1,300	3,200				
S-1	91,92	1,100	1,200				

Sapropels of lakes S-5, S-6, S-3, S-89, S-294 belong to a biogenic type and organic class. They can be used as fertilizers, feed supplements, therapeutic mud, for the production of building materials, adhesives, and drilling fluids. The sapropels of lakes Vach Lor, S-189, Shkolnoe, Lilii, S-1 are classified as clastogenic, but differ in class and type. They can be used as fertilizers, therapeutic mud.

Table 2: Classification of studied sapropels of the left bank of the Ob River.

Lakes	Content, %			Biological and mineralogical composition	Type	Class	Kind
	Ash	CaO	Fe_2O_3				
9	21,50	3,070	3,940	Organic residues > 45%	Biogenic	Organic	-
8	31,55	0,631	0,564				
1	54,63	0,527	3,260	Organic residues > 45%, SiO2 > 30%	Clastogenic	Organic-silicate	Organic-sandy
4	68,20	1,050	2,540	Organic residues < 45%, SiO2 > 30%		Silicate	Sandy
Baybalak 1	79,41	1,780	3,180				
6	80,00	0,221	0,924				
Lesnoe	83,71	1,980	5,150				
Dorozhnoe	88,60	1,380	2,680				
7	93,88	0,158	1,070				
Baybalak 2	94,49	0,752	2,170				

Sapropels of lakes 9, 8 belong to a biogenic type and organic class. They can be used as fertilizers, feed supplements, therapeutic mud, for the production of building materials, adhesives, and drilling fluids. Sapropels of lakes 1, 4, Baybalak 1, 6, Lesnoe, Dorozhnoe, 7, Baybalak 2 are clastogenic but differ in class and type. They can be used as fertilizers, therapeutic mud.

The bitumen content in sapropels of the right bank is shown in Table 3, in sapropels of the left bank - in Table 4.

Table 3: Bitumen content in bottom sediments of the right bank

Bottom sediments	Lakes	Bitumen, %
Siltstone sands	S-1	0,64
	Lilii	0,70
Weakly sapropelic siltstone silt	Shkolnoe	0,20
Sapropelic clay silt	S-189	2,70
	Vach-Lor	4,97
Sapropel	S-3	3,75
	S-5	10,00
	S-6	11,13
	S-294	11,60
	S-89	12,88

The bitumen content is the highest in sapropels with high organic content; the sample taken from Lake S-3 is the exception. It contains bitumen at the level of sapropelic clay silt.

The bitumen content is the lowest in siltstone sands and weakly sapropelic siltstone silt.

Table 4: Bitumen content in bottom sediments of the right bank

Bottom sediments	Lakes	Bitumen, %
Siltstone sands	7	0,85
	Baybalak 2	0,90
Weakly sapropelic siltstone silt	6	1,11
	Dorozhnoe	2,00
	Baybalak 1	0,75
	Lesnoe	0,81
Clay sapropelic silt	4	0,50
	1	1,59
Sapropelic clay silt	8	0,50
Sapropel	9	5,68

Table 5 presents the main elements included in the ash of the studied sapropels of the lakes on the right bank of the Ob River.

Table 6 shows the main elements included in the ash of the studied sapropels of the lakes on the left bank of the Ob River.

Table 5: Elemental composition of sapropel ash of the right bank of the Ob River

Elements	Lakes									
	S-1	Shkolnoe	Lilii	S-189	Vach Lor	S-294	S-89	S-3	S-6	S-5
Si, %	34,470	30,800	21,270	16,290	14,110	8,820	7,040	5,240	1,780	0,583
Al, %	5,390	6,750	6,800	1,050	3,780	1,840	1,120	0,955	0,565	0,361
Fe, %	0,840	2,240	3,370	1,710	1,510	0,613	0,628	0,522	0,375	0,268
K, %	1,980	1,800	1,560	0,192	0,994	0,590	0,259	0,204	0,154	0,038
Na, %	0,825	1,100	0,589	0,063	0,287	0,116	0,057	0,067	0,096	0,016
Ca, %	0,787	0,931	0,930	0,712	1,060	0,804	1,820	0,850	0,447	0,310
Mg, %	0,348	0,983	1,260	0,164	0,390	0,141	0,132	0,126	0,066	0,054

Among the elements presented there can be distinguished two groups. The first group of elements (Al, K, Na) constitute the terrigenous (clastic) part of the bottom sediment. The second group of elements (Ca, Mg) make up carbonates. Sr, also included in this group, was not found. The third group of elements (Zn, Cu, Hg), associated with anthropogenic effect, was not identified.

Table 6: Elemental composition of sapropel ash of the left bank of the Ob River

Elements	Lakes									
	Baybalak 2	7	6	Dorozhnoe	4	Baybalak 1	Lesnoe	1	8	9
Si, %	35,980	39,210	33,770	31,220	27,450	25,970	24,610	20,130	12,090	3,920

Al, %	4,380	2,940	2,110	4,590	1,560	5,050	7,270	2,170	0,958	1,440
Fe, %	1,520	0,748	0,646	1,880	1,780	2,220	3,600	2,280	0,395	2,760
K, %	1,140	1,120	0,808	1,400	0,265	1,570	1,530	1,140	0,187	0,296
Na, %	0,476	0,152	0,208	0,595	0,079	0,757	0,702	0,210	0,076	0,153
Ca, %	0,538	0,113	0,158	0,988	0,752	0,757	1,410	0,377	0,451	2,200
Mg, %	0,627	0,159	0,144	0,718	0,192	0,755	1,010	0,138	0,118	0,207

4 Conclusion

The bottom sediments of the right bank of the Ob River classified as siltstone sands are in S-1, Lilii. Siltstone sands of the left bottom of the Ob River are 7, Baybalak 2. All these samples are of clastogenic type, silicate class and sandy kind. Their bitumen content is less than 1.00%. They are characterized by a high ash content, more than 90%. The ash of the right bank samples is characterized by a higher content of elements constituting the terrigenous part (Al, K, Na) compared with that of the left bank samples. No traces of anthropogenic effects have been identified. The main field of application is fertilizers and therapeutic mud.

Weakly sapropelic siltstone silt of the right bank lakes is Shkolnoe. Weakly sapropelic siltstone silts of the left bank lakes are 6, Dorozhnoe, Baybalak 1, Lesnoe. All these samples are of clastogenic type, silicate class and sandy kind. Lake Shkolnoe has the lowest bitumen content among all samples studied – 0.20%. The bitumen content in bottom sediments of the left bank lakes ranges from 0.75% to 2.00%; the ash content – from 74.87% to 88.60%. Lakes Shkolnoe and Baybalak 1 have the highest content of elements constituting the terrigenous part. No traces of anthropogenic effects have been identified. The main field of application is fertilizers and therapeutic mud.

Clay sapropelic silts are not found in bottom sediments of the right bank lakes. Clay sapropelic silts of the lakes on the left bank are 4, 1. The bottom sediments of Lake 4 are of clastogenic type, silicate class and sandy kind. The bottom sediments of Lake 1 are of clastogenic type, organic-silicate class and organic-sandy kind. The bitumen content is 0.50% and 1.59% respectively; the ash content – 54.63% and 68.20%. They are characterized by a high content of elements constituting the terrigenous part. No traces of anthropogenic effects have been identified. The main field of application is fertilizers and therapeutic mud.

Sapropelic clay silts of the right bank lakes are S-189, Vach Lor. Sapropelic clay silt of the left bank lakes is Lake 8. The bottom sediments of lakes Vach Lor, S-189 are of clastogenic type, organic-silicate class and organic-sandy kind. The bottom sediments of Lake 8 are of biogenic type, organic class. The bitumen content of the right bank lakes is 2.70% and 4.97% respectively; that of the left bank lakes is 0.50%. The ash content in the right bank samples is 45.51% and 42.16% respectively; that of the left bank samples is 31.55%. The ash of the right bank bottom sediments has an average content of elements constituting the terrigenous part in comparison with other studied samples. The content of these elements in the left bank samples is minimal. No traces of anthropogenic effects have been identified. The main field of application of the right bank sapropels is fertilizers and therapeutic mud; the left bank sapropels are mainly used as fertilizers, feed supplements, therapeutic mud, for the production of building materials, adhesives, and drilling fluids.

Sapropels of the right bank lakes are S-3, S-5, S-6, S-294, S-89. Sapropel of the left bank lakes is Lake 9. All these samples are of biogenic type and organic class. The bitumen content in bottom sediments of the right bank lakes is more than 10%, except S-3 sample with the bitumen content of 3.75%. The bitumen content of the left bank sample is 5.68%. The ash content of the right bank samples ranges from 3.80% to 27.94%; that of the left bank sample is 21.50%. No traces of anthropogenic effects have been identified. The main field of application is fertilizers, feed supplements, therapeutic mud, for the production of building materials, adhesives, and drilling fluids.

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