

Geochemical peculiarities of bottom sediments in polytypic lakes of Ukrainian Polissya

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Abstract: The basic chemical components of bottom sediments in polytypic lakes are analyzed in this article. In the study of bottom sediments much attention is paid to the chemical composition of their ashes (Fe_2O_3 , CaO , P_2O_5 , S_{total} , N_{total}). The examination of sedimentation in the lakes of Ukrainian Polissya is important for sorting the base of geochemical information about the types of the lake sediments, the conditions of their creation, geochemistry of definite elements as indexes of the process, and environment of sedimentogenesis and early diagenesis.

Despite the resemblance of some natural conditions, different types of lake sedimentation are determined in the range of the landscape - limnological area. Different landscape conditions meet their own rows of chemical elements. Lake sediments are typical geochemical environments of fresh water accumulation of sediments. Combinations of microelements create a definite individuality of every type of sediment. Indexes of components content gives the opportunity to follow horizontal and vertical changes in the structure of lake sediments, to work out the conditions and process of forming sediment and lake development in detail to apprise sapropel and other minerals, and to determine the ways of their economic use.

Key words: lake, polytypic lakes, bottom, sediments, sedimentation, Ukrainian Polissya

Nowadays, lake bottom sediments attract great attention. The branches of their application are highly diverse in agriculture, medicine, building, and chemical industry. The necessity of studying a lakes bottom sediments from the point of view of their substantial composition and reserves is stipulated by that on the territory of Polissya where soil with low fertility is widely distributed. In fact this soil is poor on nitrogen, phosphorus and potassium. The constant extension of manufacture and application of organic fertilizers is important to increase its fertility. Significant reserve of local organic fertiliser together with peat forms lake sediments - sapropels, of which 63882,8 thousand tons is deposited in the region (Ilyin, 2001).

Lake reservoirs in the range of its basin is a fundament of accumulation. From the time of appearing, a lake is the place of accumulation and

creation of heterogeneous mineral and organic substances. Their content, the speed of accumulation, capacity links with natural peculiarities of water-shed and totality of phenomena all take place in the lake.

Mineral and organic substances in the lake are spread on different depths of the basin, not only depending on the place of their accumulation and creation, but merely under the influence of the size of parts and the dynamics of the water mass. The bottom sediments, their chemical and biological content, character of spreading, and capacity expose common direction of balance of substance and energy of a lake and is its final product (Jakushko, 1971).

The main indication of every type of lake sediment (terrigenous, chemical, biogenic) is the correlation of mineral and organic parts in it, and also

the content of chemical components in each of them. Material, accumulated in reservoirs is represented by three-components-sediments with different content of organic substance, productive-destructive processes, clastogenic material - a product of mechanic allotment of cover rocks of water-shed, mainly aluminosilicates, and chemical component, mainly calcium carbonate of biochemical and physical-chemical nature (Methods..., 1987).

Lake sediments relates to the very complicated objects of examination, their composition and features depend on different qualitative combination of substances. In this connection, it is no

coincidence that in the chemistry of bottom sediments there are many unsolved problems, launching firstly methodological recommendation, which would regulate the condition of carrying out the definite stages of examinations and would allow to replenish results, got in different scientific institutions.

In the study of bottom sediments in heterogeneous lakes of Ukrainian Polissya we have paid main attention to chemical content of their ash content ($F62(1)3$, CaO, PaOs, S_{total} , N_{total} and others), the combination of them creates definite individuality of every type of sediments (Tab. 1).

Table 1. Chemical content of the lake bottom sediments, % on dry substance (average indexes) (according to the materials of the Kiev prospecting expedition).

Lakes	Ash content	Fe ₂ O ₃	CaO	P ₂ O ₅	Stotal	Ntotal
Bolotne	42.2	0.91	37.40	0.09	0.48	0.51
Burkiv	26.0	2.85	2.80	-	-	-
Gryvenske	44.0	4.64	17.20	1.13	1.57	2.48
Kovpyne	21.9	1.25	7.60	0.22	1.41	3.21
Luky	31.0	1.90	7.30	-	-	-
Lyubyaz	67.0	12.00	5.00	-	-	-
Lyutsymyr	44.7	5.60	3.80	-	-	-
Nabolotske	34.0	6.54	2.00	-	-	-
Neretva	30.3	5.69	22.30	0.93	1.52	2.10
Orikhove	38.2	7.66	2.70	0.73	1.82	3.28
Okhnych	27.0	1.72	1.35	0.17	1.02	3.35
Okhotnytske	28.5	1.07	5.87	0.15	1.14	3.08
Pishchanske the Great	32.8	2.67	2.61	0.27	1.42	2.86
Prybych	18.0	1.42	2.08	0.14	1.38	3.16
Pulemetske	81.6	2.28	1.64	0.30	0.26	-
Svityaz	65.3	1.98	16.40	0.26	0.56	-
Synove	35.2	2.30	8.50	0.43	1.70	2.40
Skomorje	27.0	3.90	5.10	-	-	-
Trosne	39.5	0.24	2.22	0.15	1.41	2.64
Tur	53.0	13.80	9.90	0.44	4.16	1.97
Turychanske	33.3	1.60	25.90	0.26	0.87	2.00
Ukho	43.0	1.93	22.70	0.30	1.21	1.85
Chorne Velyke	41.0	1.17	17.60	0.20	0.92	1.93
Jagodynske	58.0	2.12	27.70	0.20	0.10	0.71

(-) no data

The data of the total content of components gives the opportunity to follow the changes in the structure according to the square and section of bottom sediments, to appraise the sapropel and other minerals, and to determine the ways of their practical usage. Sedimental-diagenetic processes of forming sediments, their structure and spreading show the general character of natural processes in the range of the investigative region with physical-geographical features peculiar to it. The role of physical-geographical parts in the lake sedimentogenesis of the humidity zone are frequently examined in the works of N. Strakhov (1954), N. Semenovych (1966), L. Rossolimo (1971) and others. The most important factors that control the lake sediments are geographical position of the lake, the depth of dismemberment of the relief, littological base of cover rocks of water-shed, and intensification of modern geomorphological processes of tectonic regime. G. Gorctskiy (1977) indicates that geological, geomorphological, paleopotamological, wide paleogeographical heredity in anthropogenic and neogenic ages are always accompanied by deep geochemical heredity.

The most important geochemical indication for lakes (especially in the southern part of the temperate zone) is the process of carbon accumulation and the character of distributing carbon sediments. Their content in the types of sediments differs markedly and at the same time reflects specific features of watershed and inner peculiarities of reservoirs.

The analysis of the factual materials allows the determination of the spreading of the carbonated sediments, accounting for the bedding in the contemporary stratum of the lakes. It allows for the possibility to determine the links between the lake sedimentation and the character of watershed relief and the hydrogeographical network in order to concretize the role of the source of substance as a factor of carbonated accumulation.

The capacity of the stratum of carbon accumulation serves as an index of comparative stability of reservoir regimes and the landscape-geological surroundings of its watershed. Reducing carbonated accumulation sometimes links with the changing of water regime, strengthening eutrophication (accumulation of the organic substances in sediments) and reducing the carbonated substance as a result of the reduction of the receipt of carbonated material and acidifying of the environ-

ment due to swamping, influx of allochthon-humus-substance, and other courses.

The content of carbonates is not more than 10% in the bottom sediments, although sediments with a heightened content of carbonates up to 35% (CaO) is observed. This marked increase of carbonates in the sediments is an important typical index, and also a definite indicator of the littology of the watershed.

Thus in many investigated reservoirs there are sediments with a heightened (more than 20%) content of CaO according to definite conditions (lakes Gryvynske, Neretva, Ukho). Some reservoirs have carbonated background of sedimentation in definite parts of a basin and they can be referred to as lake-carbonate accumulators. Lakes: Ukho, Neretva, Turychanske, Bolotne, and Yagodynske are classical in this way (Tab. 1, Figs 1, 2).

The type of lake relies on the character of carbon systems. At the same time the carbon balance can be shifted to this or that side of the same lake, depending on the seasonal changes of temperature and the regime of carbon dioxide in the water environment. Fluctuation of content of carbon dioxide in different seasons reflects the intensification of life development in lakes, processes of photosynthesis, accumulation, and decay of organic substances. Morphological peculiarities of the lake basin, conditions of saturation of water mass with oxygen, and volume arid stability of hypolimnion have great importance in this case.

Zones of carbonate formation, dissolubility and accumulation of calcium are formed in the lakes under the influence of counted factors. The zone of carbon formation is the most stable in the top layers of clean reservoirs, where stability of hydrochemical conditions and comparatively weak development of organic substance provide stability of carbonate calcium systems during the year. In these lakes the stability of CaCO_3 is possible in the bottom sediments in the case when there is a sufficient receipt of carbonate material.

Sedimental layers of lakes Ukho and Chorne Velyke are characterized by intensive carbonate-forming, lakes Prybych and Gryvenske are characterized by early holocen accumulation of carbon sediments, while lakes Neretva and Okhnych are characterized by broken accumulation of carbonate sediments.

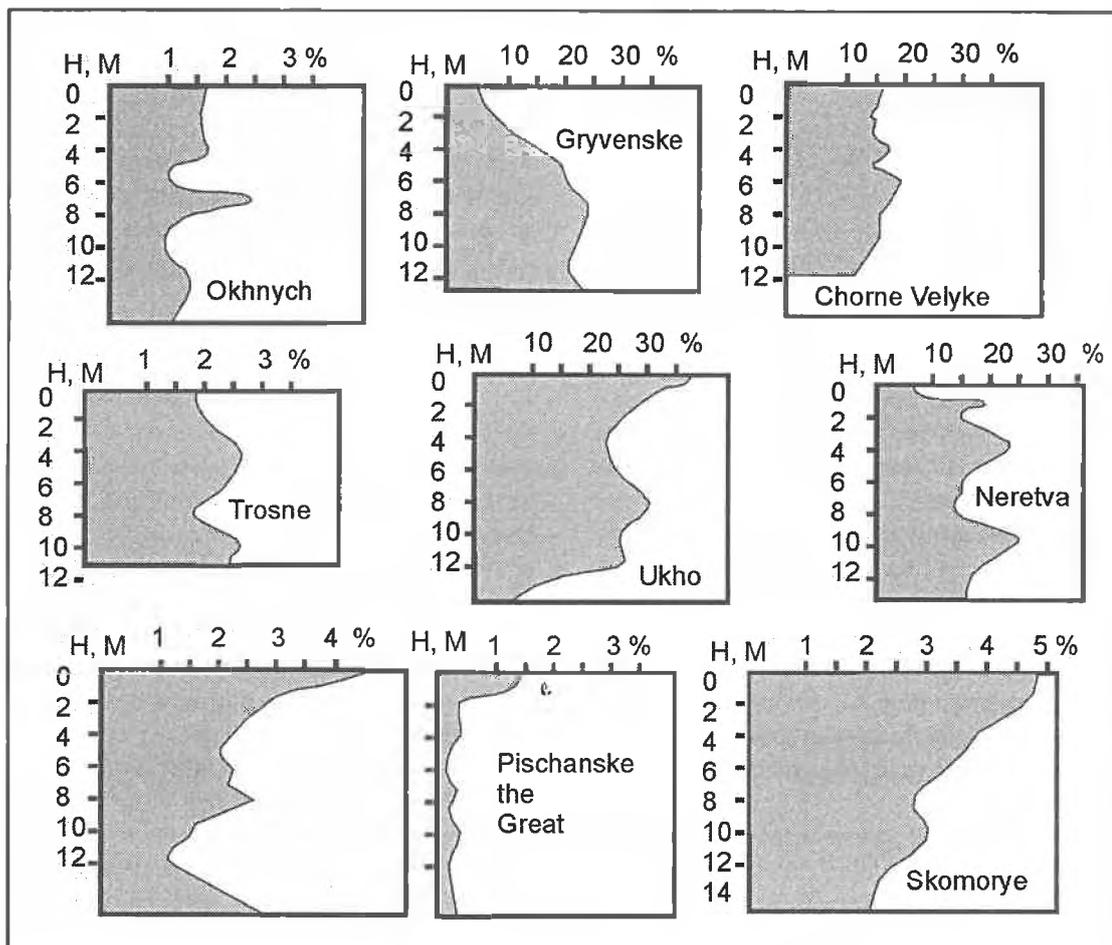


Fig. 1. Content of CaO in sedimental layers of lakes (% average parameters).

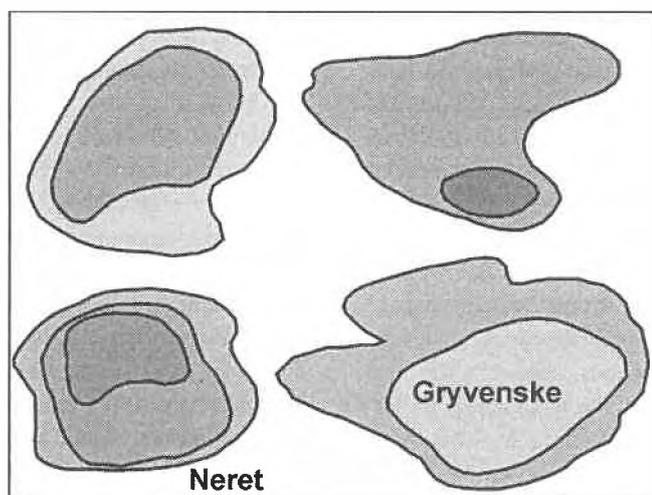


Fig. 2. Map-scheme of distribution CaO in the top layer of bottom sediments of lakes.

Investigation of spreading carbonate sediments testifies that in the range of the study territory two types of lakes are found. The reservoirs in which modern carbon accumulation takes place refer to the first type. The second type unites smaller parts of reservoirs. There is no modern biochemical forming of carbons in them and carbon substances from the watershed become unstable. These lakes are characterized with high bioproductivity, sharp seasonal fluctuation of carbon dioxide and calcium hydrocarbonate in the water mass.

Materials mentioned above show the variety of natural conditions of carbonate formation. This gives the opportunity to determine the paleoconditions of accumulation of sediments in holocen, to appraise the links between the process of sedimentation and geochemistry of landscape, and to foresee the deposit and practical usage of lake carbonate sediments.

In this territory there are either lakes with a heightened content of iron in modern sediments or lakes with carbon accumulation. As a component of the lake environment, iron characterizes all stages and states of reservoirs, including the peculiarities of substance content, alkaline-acid and oxidizing-reducing features, as well as spatial and temporary changes of processes of sedimentation and diagenesis.

Analyses of documents (Blazhchushyn, 1984; Krotov, 1950; Lopotko et al., 1978; Rossolimo, 1937; Shterenberg, 1979; Strakhov et al., 1954; Zhukhovitska, Generalova, 1991) testifies that in the lakes different in landscape-geochemical and morphological relations, a wide range of conditions is formed for sedimentation and diagenetic transformation of iron material with the appearing of new mineral phases and associations.

Antropogenic eutrophication of reservoirs includes all components of the environment of the lake into cyclical transformations. Sharing of iron in the cycle of phosphorous and sulphur is an actual problem in the studying of the state of lakes and their water as well as their protection and usage.

Formation of sediments with a heightened content of iron is the most typical for mesotrophic lakes with a high content of oxygen during the year. In most cases iron sediments are concentrated in littoral and sublittoral zones or sometimes in the profundal of the lakes. In stratificative reservoirs the changes of environmental conditions helps to change trivalent iron into bivalent iron.

In the capacity of the component, iron is included into the content of all lakes without exception. Therefore the content, forms, and the possibility of its accumulation differs greatly in different lakes. To the lakes with iron sediments we refer to reservoirs in which the content of Fe_2O_3 is above 7%, so it heightens the clarks amount. Only three of the lakes studies in detail refers to the last type. They are Tur (13.8%), Lyubyaz (12%), Orikhove (7.6%). From all sources of iron accumulation in the sediments the greatest importance must be given to the arrival of bivalent ionic solutions and colloids with soil water.

Geochemical features of phosphorous, an important biogenic element, are determined by its ability to control the establishment during the sedimentation of the deposits dynamic balance between the water phase and deposits, the state of the ecosystem, and processes of eutrophication of reservoirs. With an increase in productivity of the lake the accumulation of organic substance takes place in it, a renewed environment develops, the quantity of moving phosphorus forms in sediments rises, and the opportunity of its migration from the bottom into the water mass increases. Thus, sediments of the lake become the course of secondary pollution of reservoirs.

The phosphorus content in the sediments of the studied reservoirs fluctuates in a wide range from one hundredth to some hundredths. The concentration of phosphorus rises from the sands of the littoral zone (0.05%) to deep pelagic deposits, where its quantity is 0.50%. The layers with low and high concentration of phosphorus are determined (Fig. 3).

Geochemistry of phosphorus in lake sediment is characterized by the dynamic balance of forms of elements, depending on physical-chemical conditions and morphogenetic features of the lake basin. Abyssal parts with comparatively slow hydrodynamic regimes of natural layers are the most suitable for accumulation of phosphorus. This peculiarity is fixed, comparing its forms in pelogen of shallow-water sublittoral and abyssal pelagic deposits.

The processes of sedimentation and diagenesis of sulphur is one of the stages of the geochemical cycle of sulphur, which leads to a disappearing of dissoluble sulphates and burring sulphur in the deposits. The importance of this investigation grows in connection with the problems of ecology and human influence on the global biogeochemical processes (Global..., 1983).

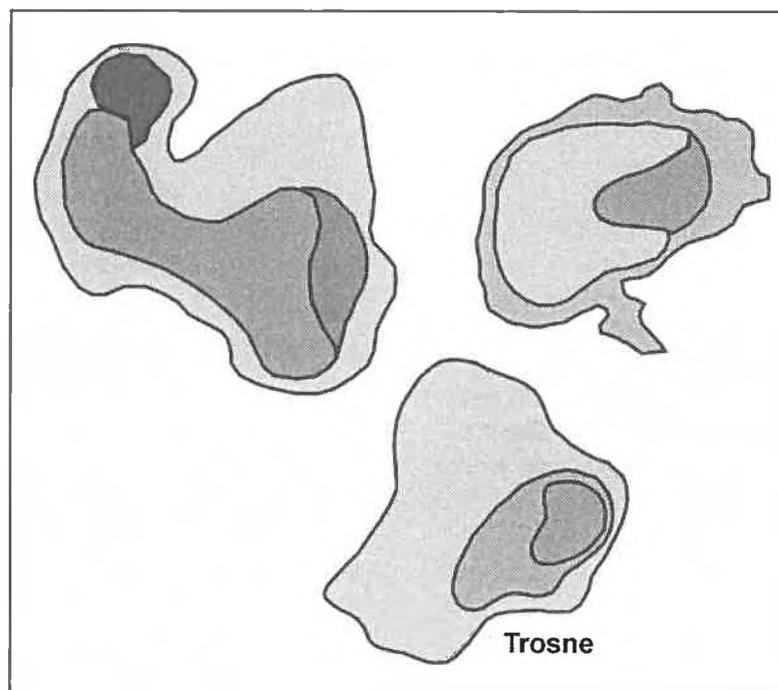


Fig. 3. Map-scheme of division of P_2O_5 in the top layer of bottom sediments of lakes.

The role of sulphite forming is determined by its concrete link with accumulations of organic substances as well as its connection with an open system in relation with atmospheric oxygen and dissoluble sulphate. All this gives an opportunity to use sulphate as an indicator of littogenesis.

The cycle of sulphate in reservoirs is not studied a great deal, and facts connected with fresh-water lakes of the humid zone are rare. In recent years the investigation of bacterial sulphat-reduction on the microbiological base was strengthened greatly, and widened the notion about the scale and quantitative appraisal of this process in fresh-water environments (Iorgensen, 1986).

For investigative lakes, the quality to accumulate sediments that stipulates an intensive biochemical sulphur cycle in them is typical. A requisite of studying sulphur geochemistry is the composition of organic mass of lake sedimentation with the participation of albuminous-proteinous sulphate compounds, isolation of lake systems, and limited contact with oxygen with constant supplies of sulphurs in the environment of sedimental accumulation.

The average content of sulphur in the sediments of different origin is approximately 1.25% (for dry

substance). The range of fluctuation is from 0.10% (Lake Yagodynske) to 4.18% (Lake Tur), which testifies to the variety of conditions of its accumulations (Tab. 1). The dominant content of sulphur is 1.0-1.5 %, and the abnormal (more than 2%) is met rarely (Ilyin, 1996).

The division of sulphur in the sediments is rather stable (Fig. 4) and is connected with the content of organic substance within them. Its biggest content is typical for organic sapropels.

Chemical composition and the connection of basic components create definite individuality of every type of deposit. This has great importance for studying sediments in spatial-temporal aspects, allowing the renewal not only of changes of natural conditions but explanations of the ways of coming and transmitting of the substance.

The range of fluctuation of basic chemical components in the sediments of contemporary lakes is given in the Tab. 2.

Thus in spite of the similarity of natural conditions in the range of one landscape-limnological region, different types of lake sedimentation are observed. Different landscape conditions correspond to definite rows of chemical elements.

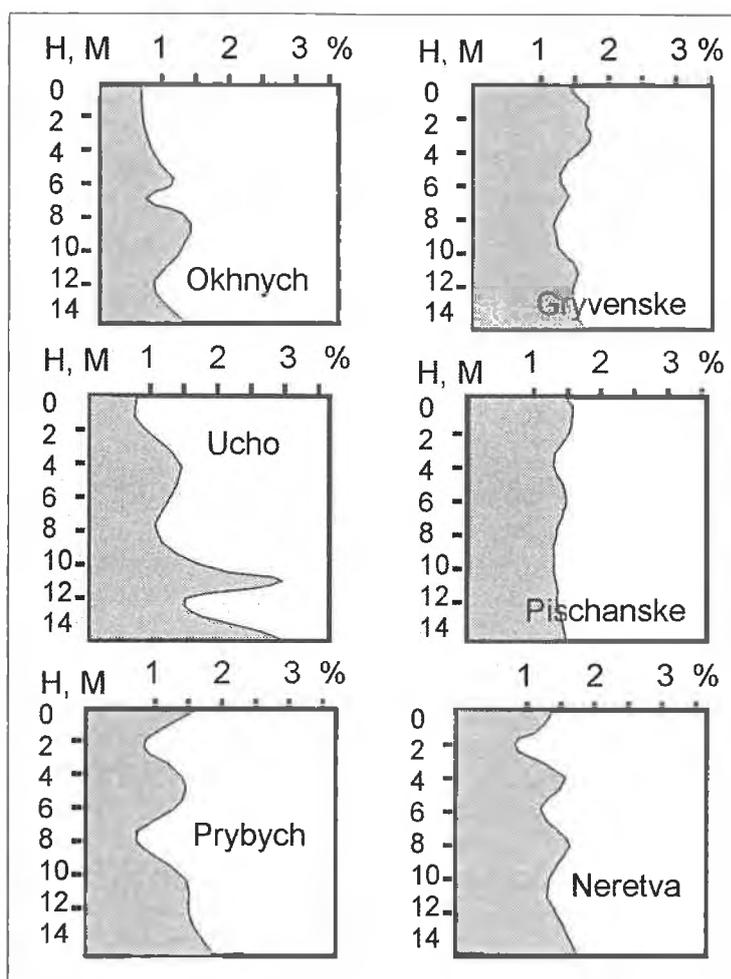


Fig. 4. The content of sulphur in sedimental layer of lakes (% on absolutely dry substance).

Table 2. Range of fluctuation of content of chemical components in the sediments of lakes, % on dry substance (according to the fund materials of the Kiev prospecting expedition).

Lakes	Ash content	CaO	Fe ₂ O ₃	P ₂ O ₅	K ₂ O	^total	Ntotal	Bottom sediments type
Gryvynske	31.0-66.0	2.75-31.5	2.04-7.53	0.31-2.81	0.01-0.25	0.91-4.65	0.98-3.67	carbonate sapropel
Neretva	24.0-52.0	3.44-35.2	0.55-15.4	0.25-5.52	0.05-0.16	0.33-2.41	0.98-2.77	carbonate sapropel
Okhnych	15.0-53.0	1.05-2.96	1.09-3.14	0.05-0.27	0.10-0.89	1.08-1.39	1.85-4.57	organic sapropel
Pishchanske the Great	27.0-51.0	1.40-23.6	0.97-9.77	0.18-0.83	0.05-1.08	1.13-2.41	1.10-5.89	organic-silicate sapropel
Prybych	7.00-46.0	1.27-5.03	0.23-2.72	0.07-1.27	0.02-0.68	0.33-1.98	1.36-4.52	organic sapropel
Skomoroye	19.0-38.0	2.36-3.94	1.64-3.93	0.12-0.22	0.07-0.49	1.63-3.10	1.81-4.57	organic sapropel
Trosne	28.0-55.0	1.77-3.78	1.72-3.21	0.10-0.38	0.17-0.56	0.78-2.09	1.66-3.10	organic-silicate sapropel
Ukho	32.0-57.0	15.7-34.4	0.31-3.91	0.09-0.57	0.05-0.90	0.67-2.94	0.04-2.70	carbonate sapropel
Chorne Velyke	31.0-70.0	9.27-23.6	0.39-2.66	0.12-0.30	0.06-0.43	0.61-1.81	1.02-3.95	carbonate sapropel

Investigations of sedimentation in the lakes of Ukrainian Polyssya will give reliable basic geochemical information about the types of lake deposits, the conditions of their formation, geochemistry of definite elements, and will be an indicator of processes and environments of sedimentogenesis and early diagenesis. Deposits of lakes are typical geochemical environments of fresh-water accumulation of sediments.

The examples given above point to a wide specter and perspective of usage of bottom lake sediments in different branches of industry and their high economic effectiveness and ecological reliability.

Establishing of sapropel industry primarily provides agriculture, chemical, microbiological, building, mixed fodder industries, balneological and resort centers with this appraisal substance.

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Streszczenie

W artykule przedstawiono analizę podstawowych substancji chemicznych tworzących osady denne jezior Polesia Ukraińskiego. Szczególną

uwagę poświęcono określenie składu chemicznego (Fe_2O_3 , CaO , P_2O_5 , S_{total} , N_{total}) spopielenych osadów dennych. Układy tych mikroelementów tworzą określony, indywidualny charakter każdego typu osadu. Badania osadów są niezbędne w tworzeniu informacji geochemicznej o: ich typach,

warunkach gromadzenia, środowisku sedymentogennym i pierwotnej diagenety. Natomiast poziome i pionowe zmiany struktury osadów

jeziornych świadczą o dynamice zewnętrznych warunków i procesów zachodzących w całej zlewni jeziora.