

Transformation Of The Mineralogical Composition Of The Oozy Matter In The Soils Of Polesye And Opolye Exposed To Intensive Agrarian Activity

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ABSTRACT. The present article is the first study of the mineralogical composition of the oozy matter of the soils of the west of European Russia of natural and intensive agrarian ecosystems of Polesye and Opolye. The purpose of the research is to study the mineralogical composition of the oozy matter of the soils of Polesye and Opolye in the west of European Russia and to assess the regional features of transformation of the most active mineral part of soils. The objects of the research are soils of the key soil areas located in the western part of European Russia. The methods of the research included taking of soil samples from the walls of soil pits along all genetic horizons. The oozy fraction was extracted by the method of N.I. Gorbunov, the oriented oozy fraction preparations were examined by the X-ray diffractometric method. The study results showed that the most active fraction of the oozy matter of the tested soils consists of hydromicas, chlorite, mixed-layer mica-smectite and mica-vermiculite formations with feldspar and quartz as accompanying minerals. In the natural ecosystems of Polesye, the mineralogical composition of the oozy matter of soils is generic. In the intensive ecosystems of Polesye, the mineralogical composition of the oozy matter of soils has been changed. In the agrarian horizons of Polesye and Opolye soils, significant transformations of the mineralogical composition and the change in the type of particle arrangement has been established, as well as an increase in the smectite content as compared with the illuvial part of soil crossovers and matrix rocks. Conclusion: intensive agrarian activity significantly increase the smectite content and change the type of particle arrangement in the agrarian horizons of the studied soils, except for the grey forest soils with a second line of humus. At deeper soil levels the agrarian impact on the mineralogical composition of the oozy soil matter disappears.

Keywords: Umbric Albeluvisols Abruptic, Greyic Phaeozems Albic, mineralogical composition of the oozy fraction, natural and intensive agricultural ecosystems.

INTRODUCTION

In most cases, the dominant component of the oozy fraction in soils is crystallized agrillaceous minerals referred to the subclass of layered silicates, the crystalline lattices of which contain silicon-oxygen tetrahedron as an indispensable component. The most widespread among them are kaolinites, micas and hydromicas (micaceous clay), vermicullites, montmorillonites (smectites), and chlorites [22].

Because of their high dispersion, argillaceous minerals have enormous unit areas measured as tens and hundreds of square meters per g of mineral. These minerals also exhibit high chemical activity for their surface contains oxygen ions and/or hydroxyl groups that easily generate hydrogen bonds. In most argillaceous minerals, the crystalline lattice is charged negatively; however, this negative charge is neutralized by positively charged particles called cations. A strong electric field is formed around the cations on the argillaceous crystallite surface, which predetermines the manifestation of catalytic properties of argillaceous minerals.

The high chemical activity of argillaceous minerals is also conditioned by the occurrence of mixedvalent ions, especially iron ones, in their crystalline lattices. This is why, argillaceous minerals can be both oxidizing and deoxidizing for the environment.

The molecules of water on the argillaceous mineral surface, especially those captured within the electric field of the cations on this surface, have several distinct features, including a strong dissociation property. In this case, the hydroxyl group remains near the cation and the hydrogen ion can dissociate, which endows water with clearly acidic properties.

The exploration of the content and composition of argillaceous minerals in soils is essential. Usually, the content of these minerals ranges from several percent in light soils to 20-40% in loamy and clayey soils. The reactions continuously observed on the argillaceous mineral surface are sorption and desorption, fixation and exchange of cations and other particles, hydration and dehydration.

Kaolinites included in finely dispersed fractions have no favorable effect on soil fertility for their crystalline lattice contains no critical fertilizer elements for plants. If these elements are applied with mineral amendments in cationic form and incompletely absorbed by the plants, kaolinite absorbs a small part of the added compounds due to low cation exchange capacities (CEC), which is why these elements may be leached out from the soil and enter subterranean waters and thus pollute the environment. Soils with a high kaolinite content have a low buffering ability with respect to most of the fertilizer elements found in cationic form in the soil solution.

Micas and micaceous clays contained in the soil produce a positive effect on fertility and the interaction between the soil and certain pollutants. This is conditioned by the fact that their crystalline lattices contain potassium known as a critical fertilizer element; in addition, micas and micaceous clays are the main natural source of potassium compounds available to plants.

The efflorescence of potassium and its release from crystalline lattices of trioctahedral micas and micaceous clays occur much faster than their efflorescence and re-lease from dioctahedral structures, which is due, first of all, to the differences in the orientation of the OH-groups contained in the octahedral vertices inside the tri-layer package [30].

The occurrence of wedgy exchange positions, highly selective to big low-hydrated cations, in lateral shears of micaceous clay particles determines the capacity of such minerals for the reliable, nonexchangeable fixation of K⁺ and NH4⁺ ions, which also heavily affects the conditions of the ammonium and potassium nutrition for plants.

The side wedgy exchange positions of micaceous clays are highly selective to the absorption of hazardous radiocesium. It has been established that an increase in the content of the specified minerals in the soil heavily curtails the absorption of radiocesium from polluted soils by plants [38].

Montmorillonites contained in the oozy fraction have a major effect on soil features. Other things equal, soils with a high montmorillonite content are characterized by high CEC, large unit area, high swelling power and water-retaining capacity; in addition, montmorillonite can affect several agrochemical characteristics of soils and the supply of plants with nutrition elements. Montmorillonites contain many macroand micronutrients in exchange form. These elements are released with the destruction of crystalline lattices and can be used by plants.

The result of a high CEC and a large unit area is that, when the fertilizer is added in cationic form to the soil rich in montmorillonites, some part of the elements is exchangeably absorbed by these minerals. While living organisms consume the fertilizer elements from the soil solution, their reserves in it are replenished with exchangeable forms. This is why, montmorillonites endow the soil with a high buffering capacity relative to cations [23].

The high CEC of montmorillonites allows them to increase the buffer value of soils on exposure to acid precipitation, especially for buffer reactions within a pH range of 4.2 to 5, whereas highly charged montmorillonites (0.4 to 0.6 units per basic cell) nonexchangeably fix the potassium and ammonium ions needed for plant nutrition.

Vermiculites absorb from the soil solution the potassium and ammonium ions added with fertilizers, fix these ions in the crystalline lattice and, therefore, prevent them from being washed out from the soil into drain waters, and produce a major effect on plant nutrition. On the one hand, fertilizer doses are increased for soils with a high potassium- and ammonium-fixing capacity to maintain optimal concentrations of these ions, which increases the product cost. On the other hand, the nonexchangeable reserve of these fertilizer elements replenishes the content of their exchangeable and water-soluble forms in the course of absorption by plants [19]. In case of the interaction with acid precipitation the high CEC of vermiculites predetermines the soil's buffer capacity against hydrogen ions.

Chlorites are a source of magnesium and some micronutrients for the nutrition of plant roots. If their additional octahedral layer is partially dissolved, the chemical activity intensifies and they can be used to absorb anionic and cationic radionuclides [34].

The occurrence of chlorites in the oozy fraction increases the buffering capacity of soils on exposure to acid agents for dissolution and other transformations of these minerals take place with the absorption of hydrogen cations, especially, when the neutralization of these cations occurs at pH < 4.2 [35, 37, 39].

Thus, the exploration of the mineralogical composition of the oozy fraction as the most active soil fraction is relevant for the understanding of peculiarities of agrotech-nogenic soil formation. The influence of soil ooze minerals on the behaviour of various substances in the soil, including inbound ones, and on their mobilization, fixation, and transformation is hard to overestimate. The mineralogical analysis of fine soil fractions is mandatory in validating the genetic specificity of a soil.

According to the basic studies conducted by B.P. Gradusov [4–12], the oozy fractions of boreal soils in plain agricultural regions have the following polymineral composition: hydromicas, mixed-layer mica smectites, a certain amount of kaolinite and chlorites. The high levels of soddy podzols and grey forest soils are depleted with an expanding smectite component. In this context, minerals play a critical role in the genesis of soils, manifestation of their ecological functions, and creation of efficient fertility, for example, in the ability to mobilize and fix fertilizer potassium and ammomium as well as various radionuclides, especially, cesium and strontium that enter the soil with the precipitates after atmospheric nuclear tests and technogenic accidents.

In anabiotic medium argillaceous minerals participate as catalysts in various geo-chemical processes [14]. It is assumed that these minerals were involved in the origin of life on the Earth by participating in the generation of polymers from L, D, and LD forms of amino acids [17, 32, 33, and 36]. Kaolinite clays catalyzed mainly the polymerization from L-isomers of amino acids [2, 16, and 33].

The mineral matrix formed in the soil by mineral surfaces organizes around itself various substances and thus determines a lot of properties, such as moisture cantilevering, interaction with water, content and composition of exchange cations, shape and strength of structural aggregates, and others. The soil matrix has areas, where pollutants can be concentrated in amounts several times higher than their concentrations calculated per gram of soil. This is why, the MAC and other parameters of pollution assessment, that are expressed per unit soil weight, downplay the hazard of pollution by understating actual concentration levels [15].

The problems of soil mineralogy in agrotechnogenesis are formulated and exposed to an in-depth analysis in fundamental studies of N.P. Chiizhikova [25–29]. However, these works ignore the west of European Russia, where diverse Polesye and Opolye landscapes are located in close neighbourhood. These landscapes have long been used for intensive agricultural activities and have the highest content of Chernobyl radionuclide pollutants in Russia.

At the same time, it is necessary to solve the problems of modern agricultural production, monitor and forecast the changes in the natural environment using information about distinct regional characteristics of the transformation of the most active mineral part of the soils.

MATERIALS AND METHODS

The research objects were soils of the key land sections (KLS) situated in the Bryansk oblast' in the west of European Russia. The Novozybkov and Klintsy KLS are situated in the east of Polesye [18], whereas Starodub KLS 1 and 2 are situated in the central southwest of Russian Opolye [1, 20, and 24]. After the precipitation of 137Cs, the soils of the Novozybkov and Klintsy KLS were polluted by its concentrations of 555 to 1480 kBq/m² whereas the pollutant concentration in both Starodub KLS was 37-185 kBq/m².

Each KLS consisted of base soil sites with an area of 25 to 30 sq. m. These were adjacent sites, differing in the agrogenic impact on the soil and were called 1) a natural ecosystem and 2) an intensive agroecosystem. Sixty-to-seventy-year long fallow sites in the afforestation belts of the Novozybkov, Klintsy, and Starodub state strain-testing stations (SSST) in the Bryansk oblast' were used as the ecosystem models. The intensive agroecosystems were situated on the SSST fields and were characterized by ecological succession, powerful argarian impact on the soil, and inclusion in the biocycle of large amounts of substances not registered in those landscapes earlier.

Three years after the precipitation of the radionuclides from Chernobyl, a full-profile soil section and several bypits were arranged in each KLS. The bypits were used to conduct a detailed macro- and mesomorphological study of the crossovers using modern methodological approaches [13, 20, and 21] and select the soil monoliths that are now available at the geology and soil museum of the Bryansk state agrarian university and can be provided for further study.

The mixed samples were taken from the soil section walls along the upper and in the middle of the other genetic horizons. The oozy fraction was extracted by the method elaborated by N.I. Gorbunov [3]. In V.V.Dokuchaev Soil Institute, the oriented oozy fraction preparations were examined by the X-ray diffractometric method using the equipment produced by Carl Zeiss Jena (Germany). The operational settings of an XZG–4A general-purpose diffractometer are specified below: the tube voltage is 30 kV, the anode current is 30 mA, the goniometer rotation speed is 2^o/min, the irradiation is copper and let pass through nickel as a filter. The X-ray diffractograms were recorded for air-dry samples saturated with glycol alcohol and annealed for 2 h at 550°C. The semi-quantity content of main mineral phases in the oozy fraction was determined by the method elaborated by P.E. Biscaye [31]. The relative areas of diffraction maxima were measured in ranges of 7.0, 10, and 17–18 Å on the X-ray patterns of the preparations saturated with glycol alcohol, which corresponded to the intensities of the primary basal reflections of kaolinite and chlorite, hy-dromica and mixed-layer formations with a smectite package. Then, the areas of diffraction peaks were cal-

culated to their sum, with allowance for structural factors. The recalculation coefficient used for hydromica, 7.0 Å reflection of kaolinite and chlorite and mixed-layer formation was 4, 2, and 1, respectively.

RESULTS AND DISCUSSION

According to the resulting X-ray diffraction patterns and the data about the distribution of diffraction peak intensities, the oozy matter of the examined soils of the Polesye and Opolye ecosystems has the following mineralogical composition: hydromica, chlorite, mixed-layer mica smectite and mica vermiculite formations, generated from chlorite-vermiculite packages and kaolinite. The companion minerals are feldspar and quartz (Table 1).

Table 1. Argillaceous minerals of the oozy fraction of the soils in the Polesye and Opolye ecosystems according to the Biscaye method

Sam-	Soil genetic horizon and its		Argillaceous mineral content, % from total				
ple	Jon, genetic		kaolinite + chlorite	hydromica	smectite component		
No.	de	ptn, cm	7 Å	10 Å	Å		
Low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial coh							
sive sand underlaid with sabulous moraine							
24	A1	2-15	18.68	39.22	49.09		
25	A2A1	15-23	35.96	38.20	25.84		
26	В	23-57	28.57	38.96	32.47		
27	Cg	57-91	25.53	42.55	31.91		
28	Dg	91-145	13.04	43.48	43.48		
Low-differentiated deep tilled cultivated contact deeply gleyey sabulous medium-soddy low-podzolic soil							
on fluvial glacial cohesive sand underlaid with sabulous moraine							
29	Aa	0-34	20.59	35.30	44.12		
30	В	34-56	13.91	62.60	23.48		
31	Cg	56-115	16.28	51.16	32.56		
32	Dg	115-200	18.18	54.55	27.27		
	N	/ledium-soddy de	eply podzolic sabulous	soil on fluvial gra	cial clay sand		
33	A1	2-15	20.00	40.00	40.00		
34	A2A1	15-34	32.14	35.70	32.14		
35	A2	34-65	19.44	50.00	30.55		
36	B1	65-85	11.70	56.70	31.67		
37	B2	85-115	16.94	54.24	28.81		
38	С	115-162	20.45	45.45	34.09		

Medium-tilled soddy podzolic sabulous soil on fluvial glacial clay sand							
39	Aa	0-30	25.64	46.15	28.21		
40	A2	30-54	18.18	58.18	23.64		
41	B1	54-74	19.80	55.44	24.73		
42	B2	74-95	9.61	61.54	28.84		
43	С	95-170	10.64	63.83	25.53		
	Med	ium grey forest li	ght loamy deep efferve	scent soil on carb	onate loess loam		
1	A1	1-16	16.95	61.01	22.03		
2	A1A2	16-29	16.70	48.15	35.18		
3	Bt	29-49	19.14	44.02	36.84		
4	В	49-75	13.63	54.55	31.82		
5	BC	75-106	22.39	44.78	32.84		
6	Сса	106-123	12.50	50.00	37.50		
	Cultivated grey forest light loamy deep effervescent soil on carbonate loess loam						
20	Aa	0-30	13.16	52.63	34.21		
21	Bt	30-51	16.70	33.30	50.00		
22	В	51-73	19.51	43.90	36.60		
23	BC	73-95	15.97	52.78	31.25		
	Light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand						
7	A1	2-13	13.79	55.17	31.03		
8	A1	13-27	21.05	52.63	26.31		
9	A1A2	27-39	6.06	51.52	42.42		
10	A2Bh	39-70	-	-	-		
11	Bh	70-103	19.35	64.51	16.13		
12	BC	103-160	18.52	44.44	37.03		
13	С	160-200	12.66	58.23	29.11		
Ligl	ht loamy cult	ivated grey fores	t soil with a second hur	nic horizon on ca	rbonate-free loess clay sand		
14	A1a	0-26	13.21	52.80	33.96		
15	A1A2	26-47	13.33	53.33	33.30		
16	BhA2	47-67	20.00	35.00	45.00		
17	Bh	67-88	13.30	53.30	33.30		
18	CBh	88-107	16.47	61.18	22.33		
19	СВ	107-150	26.70	53.30	20.00		

The intensities of the reflections of argillaceous and other minerals of the soil ooze were exposed to a detailed analysis for identifying the major trends for changes in both its mineralogical composition and the structural features of the main minerals and mixed-layer formations. The resulting data include: 1) the intensity values measured as areas of the main basal reflections of argillaceous minerals with allowances for structural factors according to Biscaye; 2) intensities of the main reflections of argillaceous and companion minerals as well as the general reflections at d/n 4,4 Å, measured as diffraction peak heights and recalculated by 100% (Table 2).

Sam-	- Soil, genetic hori-		% from total							
ple No.	zon, and its depth, cm		4.2Å	4.4Å	4.7Å	5Å	7Å	10Å	12.5Å	14Å
Low-o	different	iated conta	ct deeply	gleyey sab	ulous med	ium-soddy	l / low-podz	olic soil or	l 1 fluvial gla	cial cohe-
sive sand underlaid with sabulous moraine										
24	A1	2-15	11.95	10.62	6.64	6.19	19.47	12.83	13.72	18.58
25	A2A1	15-23	19.02	10.55	4.77	4.52	17.59	9.04	11.56	22.87
26	В	23-57	17.18	12.40	5.63	8.17	18.02	3.39	10.14	16.06
27	Cg	57-91	8.05	3.81	5.51	6.36	22.46	17.37	15.25	21.19
28	Dg	91-145	8.47	5.65	6.21	7.91	10.73	17.51	20.90	22.60
Low-	different	iated deep	tilled cult	ivated con	tact deepl	y gleyey sa	ibulous me	edium-sod	dy low-poo	zolic soil
		on f	luvial glac	ial cohesiv	e sand und	derlaid wit	h sabulous	moraine		
29	Aa	0-34	11.31	9.19	2.83	4.95	16.16	18.02	15.55	21.55
30	В	34-56	10.06	4.14	4.73	8.28	17.75	26.63	14.20	14.20
31	Cg	56-115	12.50	6.77	4.17	8.85	10.94	31.77	17.71	7.29
32	Dg	115-200	5.14	4.67	7.94	8.41	15.89	24.47	17.29	15.89
		Mediun	n-soddy de	eeply podz	olic sabulo	ous soil on	fluvial grad	cial clay sa	nd	
33	A1	2-15	24.15	15.48	6.19	6.81	15.79	7.18	6.67	15.80
34	A2A1	15-34	10.59	7.06	7.06	8.82	17.65	8.82	13.53	26.47
35	A2	34-65	11.77	6.47	5.88	7.06	20.00	14.12	12.35	22.35
36	B1	65-85	9.22	6.45	5.53	8.29	17.03	23.96	15.67	13.82
37	B2	85-115	9.72	4.86	6.25	9.03	13.89	20.83	17.36	18.06
38	С	115-162	14.07	7.41	5.18	7.41	17.78	20.00	14.07	14.07
		Mediu	m-tilled so	oddy podzo	olic sabulo	us soil on f	luvial glaci	ial clay san	id	
39	Aa	0-30	8.79	6.04	5.49	6.04	20.88	12.09	14.83	25.82
40	A2	30-54	14.41	11.71	8.11	9.91	18.02	13.51	9.01	15.32

Table 2. Ooze minerals reflection intensities measured as diffraction peak heights

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41	B1	54-74	8.19	3.88	6.47	7.76	17.67	25.86	16.81	13.36
42	B2	74-95	10.45	5.97	6.72	8.21	14.18	21.64	16.42	16.42
43	С	95-170	9.79	6.29	4.89	7.69	13.98	27.27	16.08	13.99
	Medium grey forest light loamy deep effervescent soil on carbonate loess loam									
1	A1	1-16	12.76	11.22	5.36	7.91	13.77	21.17	15.56	12.24
2	A1A2	16-29	5.36	3.57	5.80	7.14	16.52	19.64	19.64	22.32
3	Bt	29-49	9.24	4.89	5.98	7.61	15.76	17.40	17.40	21.73
4	В	49-75	2.72	1.51	6.04	7.55	13.90	22.05	23.26	22.96
5	BC	75-106	5.08	3.55	5.08	7.11	19.29	19.29	19.29	21.31
6	Сса	106-123	8.49	3.77	4.24	7.07	15.57	23.11	18.87	18.87
	С	ultivated gr	ey forest l	ight loamy	deep effe	rvescent s	oil on carb	onate loe	ss loam	
20	Aa	0-30	16.67	12.92	5.83	8.75	14.17	17.50	14.17	10.00
21	Bt	30-51	9.52	5.44	4.76	6.12	16.33	19.05	19.73	19.05
22	В	51-73	7.81	4.17	6.25	7.29	16.67	17.71	18.75	21.33
23	BC	73-95	6.77	4.17	8.33	10.42	15.10	14.58	17.71	22.92
Light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand										
	Light l	oamy grey	forest soil	with a sec	ond humio	: horizon o	n carbona	te-free loe	ess clay sar	nd
7	Light l	oamy grey 2-13	forest soil 15.89	with a sec 15.23	ond humio 3.31	horizon o 5.63	n carbona 14.57	te-free loe 18.21	ess clay sar 14.57	nd 12.58
7	Light I A1 A1	oamy grey 2-13 13-27	forest soil 15.89 24.06	with a sec 15.23 20.68	ond humio 3.31 3.76	5.63 4.89	n carbona 14.57 13.16	te-free loe 18.21 10.90	ess clay sar 14.57 10.90	nd 12.58 11.65
7 8 9	Light I A1 A1 A1 A1A2	oamy grey 2-13 13-27 27-39	forest soil 15.89 24.06 14.55	with a sec 15.23 20.68 14.55	ond humio 3.31 3.76 4.09	5.63 4.89 6.36	n carbona 14.57 13.16 10.45	te-free loe 18.21 10.90 20.00	ess clay sar 14.57 10.90 16.36	nd 12.58 11.65 13.64
7 8 9 10	Light I A1 A1 A1A2 A2Bh	oamy grey 2-13 13-27 27-39 39-70	forest soil 15.89 24.06 14.55 21.54	with a sec 15.23 20.68 14.55 26.70	ond humio 3.31 3.76 4.09 5.13	5.63 4.89 6.36 6.15	n carbona 14.57 13.16 10.45 11.28	te-free loe 18.21 10.90 20.00 13.84	ess clay sar 14.57 10.90 16.36 9.23	nd 12.58 11.65 13.64 6.15
7 8 9 10 11	Light l A1 A1 A1A2 A2Bh Bh	oamy grey 2-13 13-27 27-39 39-70 70-103	forest soil 15.89 24.06 14.55 21.54 11.96	with a sec 15.23 20.68 14.55 26.70 12.21	ond humio 3.31 3.76 4.09 5.13 3.56	5.63 4.89 6.36 6.15 7.63	n carbona 14.57 13.16 10.45 11.28 17.56	te-free loe 18.21 10.90 20.00 13.84 21.37	ess clay sar 14.57 10.90 16.36 9.23 13.49	nd 12.58 11.65 13.64 6.15 12.21
7 8 9 10 11 12	Light l A1 A1 A1A2 A2Bh Bh BC	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160	forest soil 15.89 24.06 14.55 21.54 11.96 11.19	with a sec 15.23 20.68 14.55 26.70 12.21 8.20	ond humio 3.31 3.76 4.09 5.13 3.56 6.72	5.63 4.89 6.36 6.15 7.63 8.21	n carbona 14.57 13.16 10.45 11.28 17.56 14.92	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93	nd 12.58 11.65 13.64 6.15 12.21 -
7 8 9 10 11 12 13	Light l A1 A1 A1A2 A2Bh Bh BC C	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45	5.63 4.89 6.36 6.15 7.63 8.21 9.22	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05	nd 12.58 11.65 13.64 6.15 12.21 - 20.74
7 8 9 10 11 12 13 Ligi	Light I A1 A1 A1A2 A2Bh Bh BC C t loamy	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 r cultivated	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second b	5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla	nd 12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand
7 8 9 10 11 12 13 Ligi 14	Light l A1 A1A2 A2Bh Bh BC C ht loamy A1a	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 / cultivated 0-26	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores 13.83	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with 11.25	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second f 5.14	5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori 5.14	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car 12.54	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre 19.94	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla 14.79	nd 12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand 17.36
7 8 9 10 11 12 13 Ligi 14 15	Light I A1 A1A2 A2Bh Bh BC C ht Ioamy A1a A1A2	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 cultivated 0-26 26-47	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores 13.83 14.88	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with 11.25 13.27	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second f 5.14 5.50	c horizon o 5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori 5.14 7.44	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car 12.54 15.53	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre 19.94 14.24	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla 14.79 15.86	nd 12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand 17.36 13.27
7 8 9 10 11 12 13 Ligi 14 15 16	Light l A1 A1 A1A2 A2Bh Bh BC C ht loamy A1a A1A2 BhA2	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 cultivated 0-26 26-47 47-67	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores 13.83 14.88 18.99	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with 11.25 13.27 21.86	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second H 5.14 5.50 3.94	c horizon o 5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori 5.14 7.44 6.45	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car 12.54 15.53 14.34	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre 19.94 14.24 12.54	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla 14.79 15.86 11.11	nd 12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand 17.36 13.27 10.75
7 8 9 10 11 12 13 Ligi 14 15 16 17	Light l A1 A1 A1A2 A2Bh Bh BC C C ht loamy A1a A1A2 BhA2 Bh	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 r cultivated 0-26 26-47 47-67 67-88	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores 13.83 14.88 18.99 14.63	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with 11.25 13.27 21.86 15.24	ond humid 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second H 5.14 5.50 3.94 4.88	c horizon o 5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori 5.14 7.44 6.45 5.49	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car 12.54 15.53 14.34 22.56	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre 19.94 14.24 12.54 9.15	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla 14.79 15.86 11.11 18.90	nd 12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand 17.36 13.27 10.75 9.15
7 8 9 10 11 12 13 Lig 14 15 16 17 18	Light l A1 A1 A1A2 A2Bh Bh BC C C ht loamy A1a A1A2 BhA2 Bh CBh	oamy grey 2-13 13-27 27-39 39-70 70-103 103-160 160-200 r cultivated 0-26 26-47 47-67 67-88 88-107	forest soil 15.89 24.06 14.55 21.54 11.96 11.19 6.45 grey fores 13.83 14.88 18.99 14.63 10.84	with a sec 15.23 20.68 14.55 26.70 12.21 8.20 4.15 t soil with 11.25 13.27 21.86 15.24 9.64	ond humio 3.31 3.76 4.09 5.13 3.56 6.72 6.45 a second H 5.14 5.50 3.94 4.88 7.23	horizon o 5.63 4.89 6.36 6.15 7.63 8.21 9.22 numic hori 5.14 7.44 6.45 5.49 7.83	n carbona 14.57 13.16 10.45 11.28 17.56 14.92 17.51 zon on car 12.54 15.53 14.34 22.56 17.47	te-free loe 18.21 10.90 20.00 13.84 21.37 17.91 18.43 bonate-fre 19.94 14.24 12.54 9.15 22.29	ess clay sar 14.57 10.90 16.36 9.23 13.49 14.93 17.05 ee loess cla 14.79 15.86 11.11 18.90 13.85	12.58 11.65 13.64 6.15 12.21 - 20.74 ay sand 17.36 13.27 10.75 9.15 10.30

As shown by considering the data obtained in succession, the points in the scope of the main components technique (MCT, Fig. 1), that correspond to the values of intensity derived as peak heights, form a broad area without any visible signs of ordering.

V1 100-1 * 4 95-1 90-1 * 2*23*32 1.1. 85- I * 5*13 80-1 *22* 6*28*41*37 75-1 *27* 3*21*42 70-1 *39,34*12*36*30*43 65-1 *35*31 60-1 *18*19 55-1 *24,29*38* 1 50~ I *40*14*11 45-,1 *17,15*20* 9 40-1 *25 35-1 *26* 7 30-1 25-1 20-1 *33 15-1 ***1**6 10-1 5-1 * 8 0-1 *10 ٧2

Fig. 1. Characteristic of the mineralogical composition of the oozy fraction of the genetic horizons of the soils of the Polesye and Opolye ecosystems in the west of European Russia, studied with the help of intensities measured as diffraction peak heights:

- 1.1) is for all of the studied soils;
- 1.2) is for the soils of the Novozybkov KLS
- 1.3) is for the soils of the Klintsy KLS
- 1.4) is for the soils of Starodub KLS 1
- 1.5) is for the soils of Starodub KLS 2



Since the respective dispersion of the data about the first and the second main component is 42 and 22% (Table 3), it made sense to analyze the distribution of the points more thoroughly. Therefore, auxiliary curves (Fig. 2; 2.2–2.5) were drawn using the data from the MCT plot (Fig. 2; 2.1) for the following pairs of sections: soil of a natural ecosystem versus the soil of an intensive ecosystem.

Table 3. Eigen values (λ) and vectors of the correlation matrix of intensities measured as heights of the diffraction peaks of the oozy fraction of the soils from the Opolye and Polesye ecosystems in the west of European Russia

		λ		
Feature/mineral	Intensities	3.38	1.72	
		42%	22%	
Quartz	4.2 Å	-0.53	-0.02	
Aggregate reflection of argillaceous minerals	4.4 Å	-0.52	0.07	
Chlorite	4.7 Å	0.23	-0.08	
Mica-hydromica	5 Å	0.20	0.28	
Chlorite + kaolinite	7 Å	0.10	-0.58	
Mica-hydromica	10 Å	0.28	0.56	
Mixed-layer mica smectites				
(vermiculites)	12.5 Å	0.42	0.14	
Chlorites	14 Å	0.32	-0.50	

V	1	
100-1	* 8	2.1
95- I	*24*20*29	
90 - I	*34	
85- I		
80-1	*33,26*25	
75-1		
70-1	*28, 9*27	
65-1	*16* 3* 5	
60- I	*38*39	
55- I	* 2	
50- <i>i</i>	* 6,35	
45- I	*13*31	
40-1	* 7*18*21*19*10*12	
35-1	* 4*11*37*32*23	
30-1	*36,41	
25-1	*17	
20-1	*40	
15-1	*42,22* 1	
10-1	*30	
5-1	*43	
0-1	*15	
•••		
	V2	

Fig. 2. Characteristic of the soils of the Polesye and Opolye ecosystems in the west of European Russia by the mineralogical composition of the oozy fraction, derived by the main components technique:

2.1) is for all of the studied soils;

2.2) is for the soils of the Novozybkov KLS

2.3) is for the soils of the Klintsy KLS

2.4) is for the soils of Starodub KLS 1

2.5) is for the soils of Starodub KLS 2





The changes in the mineralogical composition and structural state of the minerals along the direction of the first main component are determined mainly by the cor-relation of an intensity of 17 Å of the smectite component reflection and a reflection of 12.5 Å of mixed-layer formations (positive values), and also with a quartz reflection of 4.2 Å and a reflection of 4.4 Å common to layered minerals. The differences in the mineralogical composition of the oozy soil matter for the second main component are determined mainly by the oppositely directed changes in the indicator for hydromica and chlorite.

The materials from Table 1 and Figure 1 allow studying with greater attention the peculiarities of correlations in only the layered minerals of the oozy soil matter. The MCT plots are characterized by the following parameters: the respective dispersion for the first and the second main component are 61 and 39% (Table. 4). The points, corresponding to the features of the mineralogical composition of ooze by the content levels of smectite, hydromicas, and kaolinite with chlorite, form a broad area without any visible splitoffs in communities.

Table 4. Eigen values (λ t) and vectors of the correlation matrix of intensities of the content of the main mineral phases of the oozy fraction in the soils from the Opolye and Polesye ecosystems in the west of European Russia

Feature	$\lambda_t - 1.84$	$\lambda_t - 1.16$
	61%	39%
Kaolinite + chlorite, 7Å	0.37	0.80
Hydromica, 10 Å	-0.74	0.05
Smectite component, 17 Å	0.57	0.59

In the natural low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine the main differences in mineralogical composition in the section are expressed in the changes along the direction of the second component, that is, connected to a factor of 7 Å of the kaolinite and chlorite in the mineralogical composition of ooze. The oozy matter of the medium-soddy deeply podzolic loamy soil on fluvial glacial clay sand is similar by the ratio of layered forms. The oozy fraction of the upper horizon has an elevated content of smectite.

The light loamy grey forest deep effervescent cultivated soil on carbonate loess loam of the intensive agroecosystem differs from its natural counterpart by a higher content of smectite. The cultivated light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand changes in the direction of the first component. In this case, however, the smectite content in the agrohorizon is higher than in the illuvial part of the soil crossover and in the deep subsoil.

The data on the changes in intensities as diffraction peak areas (integral intensities) were used for deriving from the MCT plot the patterns of distribution by the main genetic soil horizons (Fig. 2).

The differences among the soils by the mineralogical composition of oozy matter are insignificant. Only two trends can be highlighted: the first is an increase in the 17 Å factor of smectite in the illuvial horizons and the growing differences in the content of all of the components in the oozy matter of the upper humic horizons as compared with the deep subsoil; the other one is that, at the same time, the oozy matter of the tillage horizons forms a highly narrow range of values of the content of argillaceous minerals with a moderate amount of smectite, hydromica and 7 Å minerals.

The changes in the mineralogical composition of the oozy matter occured in three pairs of soils different in agrogenic exposure, including the soddy podzols of the Novozybkov KLS and the grey forest soils of the Starodub KLS. These agroecosystems are classified as intensive; in addition to an increase in the hydromica content in the soil ooze, they also exhibit the trend for the displacement of the point corresponding to the selected indicators, along the direction of the first main component towards an increase in the quartz content (by the diffraction peak height at 4.2 Å), and for the disordering of layered silicates, which shows in the increasing in-tensity of reflection from (hkl) at 4.4 Å.

In the soddy podzols of the Klintsy KLS the differences in mineralogical composition, structural features of the minerals, and the degree of their aggregation show along the direction of the first main com-

ponent and are fraught with a minor increase in the smectite and chlorite content in tilled soils, which intensifies the reflections of 14 and 12.5 Å.

See Figure 1 for the points corresponding to the intensity levels measured as the heights of deep subsoil peaks. These points form a comparatively small field. The differences among the samples along the first main component are minimal and have to do with the change in the correlation of component 14, tex-tural randomness levels (reflection of 4.4 Å), and quartz content (reflection of 4.2 Å). The actual differences among the samples are insignificant, shown on the MCT plot mainly along the second main component, and determined mainly by the correlation of the mica-hydromica content and the sum of chlorite and kaolinite.

On the whole, the considered parameters of the transitional genetic horizons of the soil crossovers are similar to the ones of the deep subsoils. A slight trend for the in-creasing significance of the quartz content and textural randomness is registered.

Significant changes in mineralogical composition and particle arrangement have been registered in horizons A. The range of the points corresponding to these horizons is heavily shifted to the MCT plot region with medium and maximal quartz content and textural randomness levels.

The selection from horizons A1, A2, A1A2, and Aa is of major interest. This selection shows a sharp expansion in the area of the points corresponding to the values of the parameters for these horizons as compared with all of the other horizons and deep subsoils. The differences in values of parameters 14 Å, that is, the content of smectite and vermiculite, are especially significant. The amplitude of the difference in the properties of hydromicas and chlorites along the second main component is significantly elevated as well.

The considered indicators have allowed identifying distinct ranges in all of the three test sites. The points of the soddy podzolic samples from Polesye have minimal medium indicators of phases 14 Å and 12.5 Å. The upper horizon samples of the grey forest soils from Opolye are characterized by medium and maximal quartz contents, textural randomness, and medium hydromica and chlorite contents. To understand the peculiarity of the tilled soils, let us focus on the arrangement of the points corresponding to the agrohorizons. They have no big differences by the first main component V1 and are characterized by medium indicator levels of 14 Å; 12.5 Å; 4.2 and 4,4 Å. The differences in the samples along the direction of second main component V2 have to do with the changes in the hydromica parameters and the chlorite/kaolinite combination.

CONCLUSION

The oozy matter of the soddy podzols of Polesye and the grey forest soils of Opolye in the natural and agrarian systems in the west of European Russia have the following mineralogical composition: hydromica,

chlorite, mixed-layer mica smectite and mica vermiculite formations, generated from chlorite-vermiculite packages and kaolinite. The companion minerals are feldspar and quartz.

In the natural ecosystems of Polesye, the mineralogical composition of the oozy matter of soils is generic. In low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine, the main differences in mineralogical composition or crossover have to do with kaolinite and chlorite. The oozy matter of sabulous medium-soddy deeply podzolic soil on fluvial glacial clay sand is similar in terms of the layered form ratio. The oozy fraction of the upper horizon has an elevated content of smectite.

In the grey forest soils of Opolye, the oozy matter of the upper genetic horizons has maximal and average quartz content levels and textural randomness of particles, together with average hydromica and chlorite contents. The two trends registered are: 1) an increase in the smectite content in the illuvial horizons and 2) the growing differences in the content of all of the components of the oozy matter in the upper humic horizons as compared with the deep subsoils.

In the intensive ecosystems of Polesye, the mineralogical composition of the oozy matter of soils has been changed. In addition to an increase of the hydromica content in the oozy fraction, the lowdifferentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine and the grey forest soils of Opolye are also characterized by the trend for an increase in the quartz content factors and the disordering of layered silicates. Compared with the similar soil from the natural ecosystem, the grey forest soil has an elevated smectite content, whereas an opposite situation is true for the grey forest soils with a second humic horizon.

Significant changes in the mineralogical composition and the nature of particle arrangement have been registered in the agrohorizons of the soils from Opolye and Polesye. In these soils, the smectite content is higher than in the illuvial part of the soil crossovers and matrix rocks. The considered parameters are similar in the transitional genetic horizons of the soil sections and the matrix rocks. A slight trend for the increasing significance of the quarz content and textural randomness is registered.

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