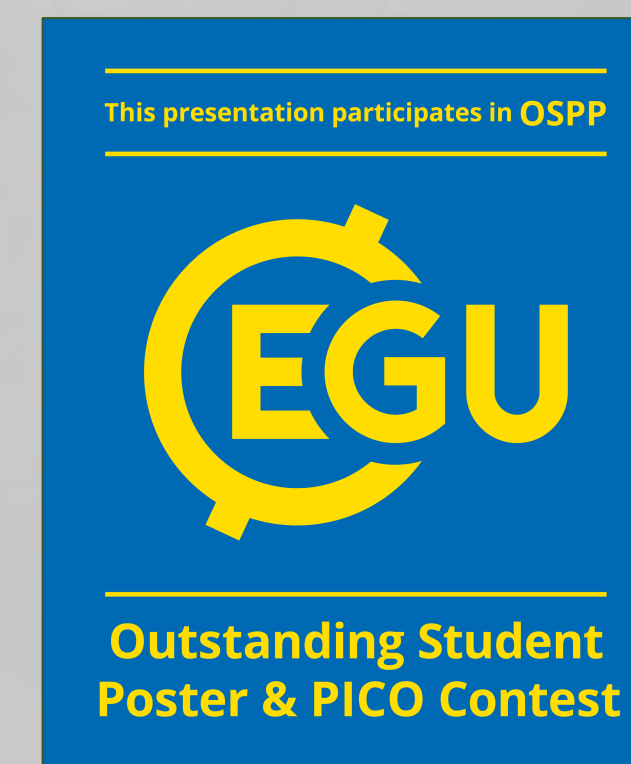


# Trends in mineralogical composition changes in upper horizons of postagrogenic soils.

Nikita Churilin<sup>1</sup> (nikitachur@ya.ru), Evgeny Varlamov<sup>1</sup>, Alexandra Churilina<sup>1</sup>  
<sup>1</sup>V.V. Dokuchaev Soil Science Institute, Moscow, Russia



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## Introduction

Due to large areas of abandoned land in Russia, it is necessary to identify indicators that allow to establish the direction of the evolution of the properties and composition of the post-agrogenic soil. This is necessary for the rational use of abandoned areas. One of these indicators is the mineralogical composition of finely-dispersed fractions (<1, 1-5, 5-10  $\mu\text{m}$ ), which determine the stocks of plant nutrients and a number of physical properties and soil fertility.

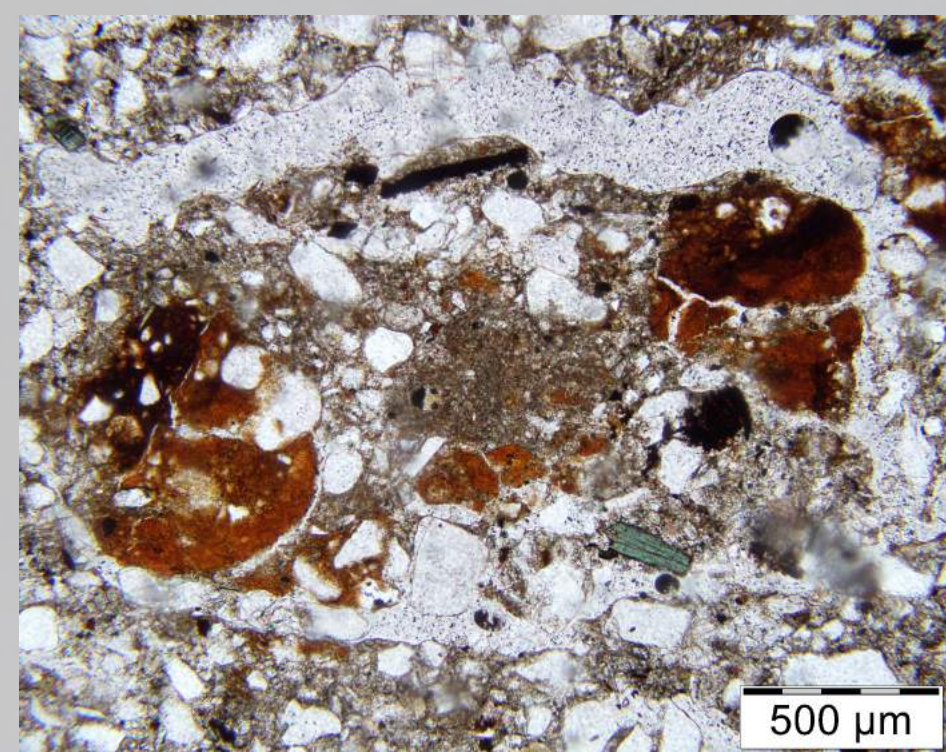
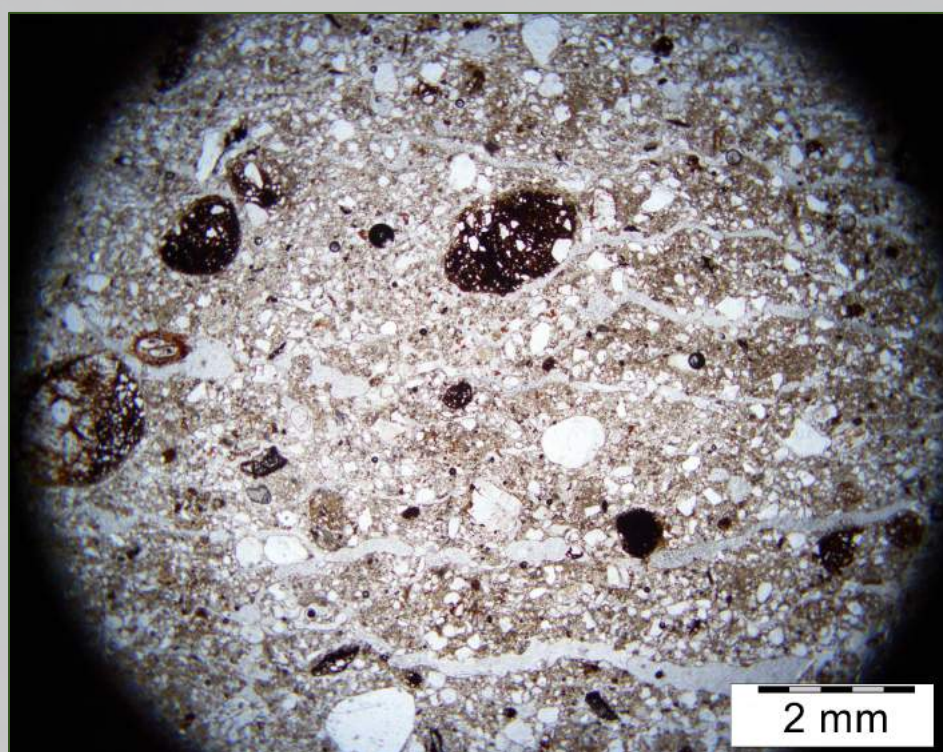
Plant communities play the leading role in transformation of soil. The need of studying former arable lands increases due to large number of abandoned lands in Russia. It is necessary to study mineralogical composition of soils involved into natural processes to understand the trends of their development after agricultural activities in the past.

**The aim of the study is to identify changes in mineralogical composition of the upper horizons of postagrogenic soils.**

### Spruce forest (70 years old) A15-01



Albic Dystric Retisol  
(Cutanic Abruptic Loamic)



Inside the aggregates there are few clay substance. It's represented by clay nodules, which are destroyed by cracking or dissolving.

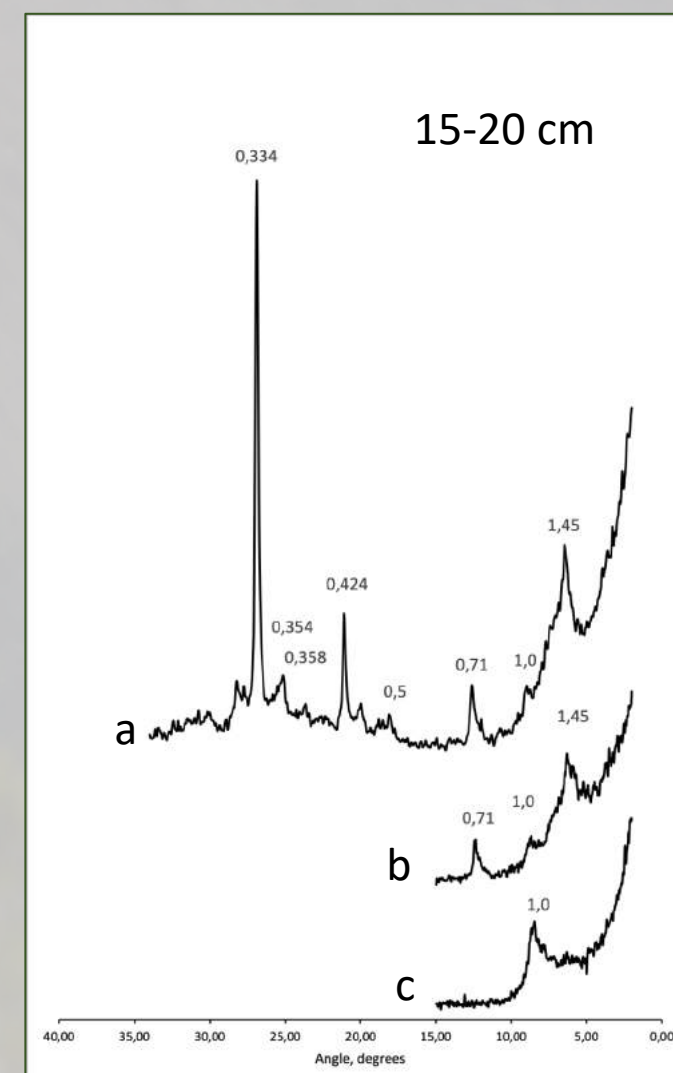
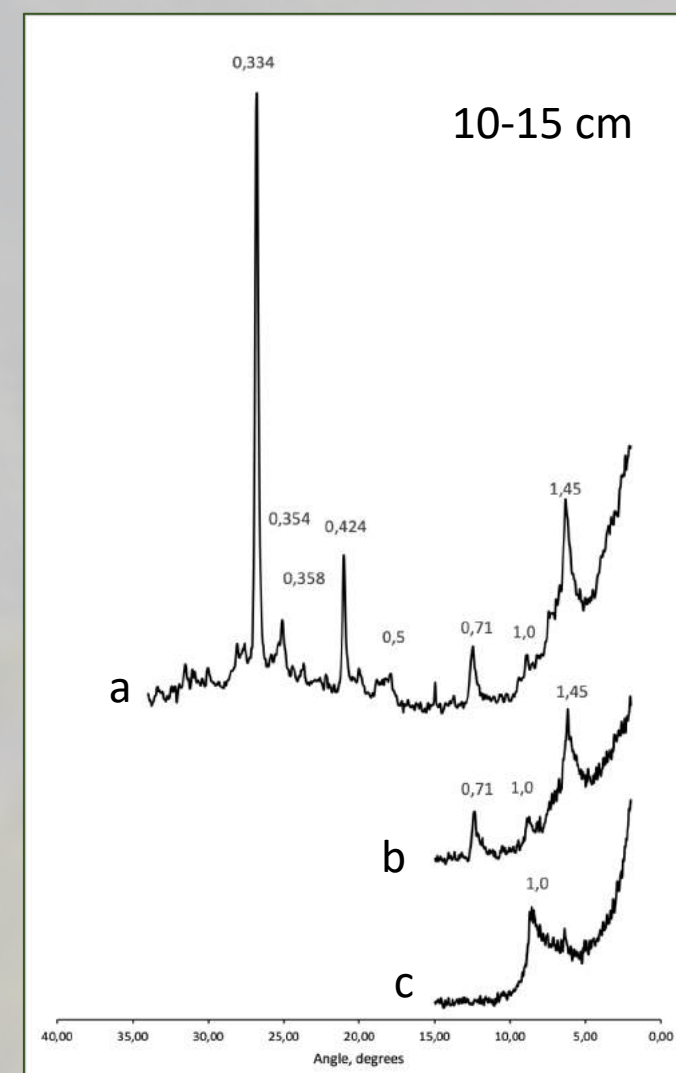
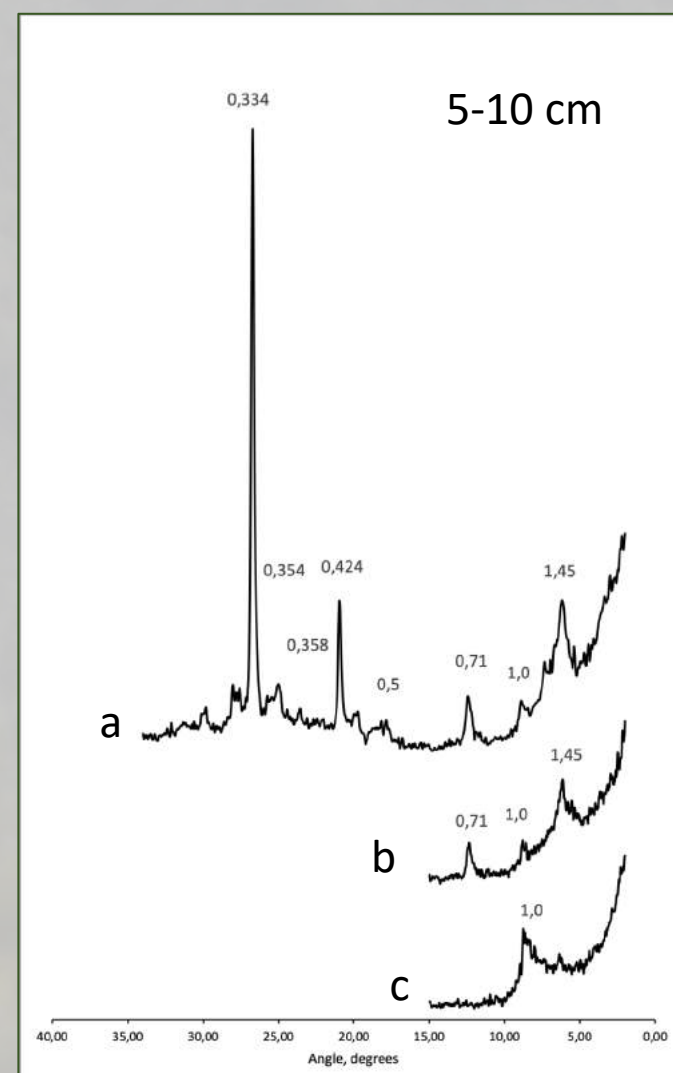
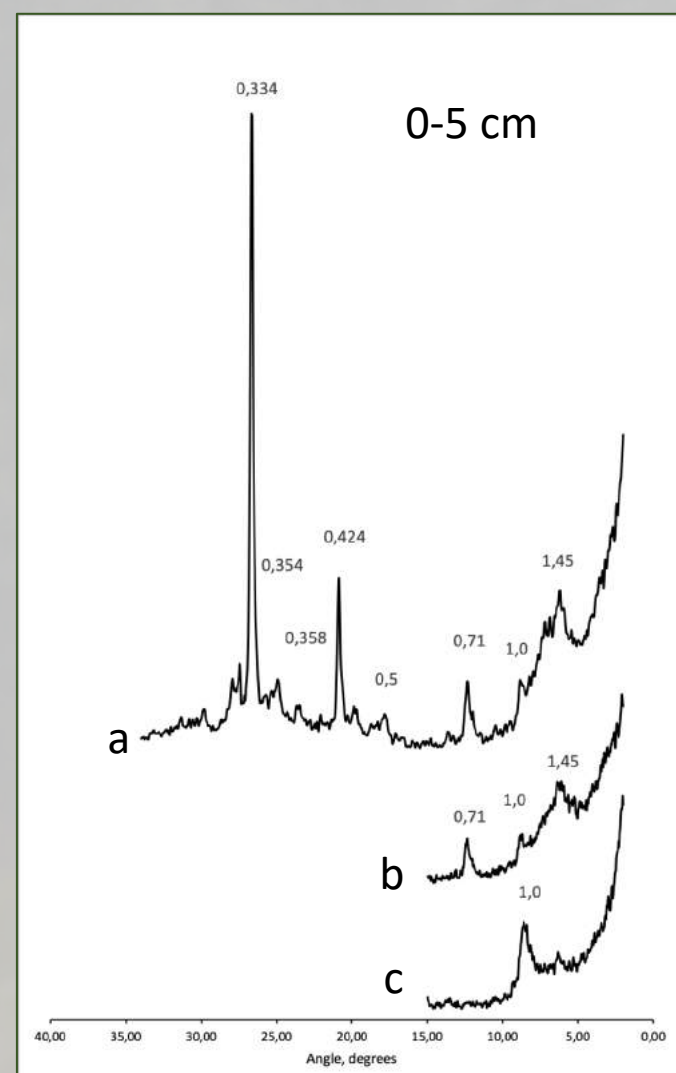
Such nodules are in the intra-pedal mass and apparently were brought from the underlying horizons as a result of plowing or activity of the mesofauna.

Horizon	Depth, cm	Fraction, %			
		<1 $\mu\text{m}$	1-5 $\mu\text{m}$	5-10 $\mu\text{m}$	>10 $\mu\text{m}$
EL1	0-5	4,0	5,3	6,4	84,1
EL2	5-10	4,0	4,7	5,8	85,5
EL3	10-15	3,9	5,0	5,9	85,1
EL4	15-20	4,0	5,1	5,9	85,1

Particle-size composition of the former arable horizon in the spruce forest (70 years old).

Horizon	Depth, cm	Fraction content <1 $\mu\text{m}$ %	Fraction <1 $\mu\text{m}$ , %				Soil, %			
			ML	I	CH	K	ML	I	CH	K
EL1	0-5	4,0	49	24	12	15	2,0	1,0	0,5	0,6
EL2	5-10	4,0	54	20	12	14	2,2	0,8	0,5	0,5
EL3	10-15	3,9	59	18	13	10	2,3	0,7	0,5	0,4
EL4	15-20	4,0	56	20	12	11	2,3	0,8	0,5	0,5

The ratio of the main minerals in fraction <1  $\mu\text{m}$  from the soil under the spruce forest (70 years old). ML - mixed-layer minerals; I - illite; CH - chlorite; K - kaolinite.



On the present diffractograms of clay fraction in sub-horizons we can see the following components: mixed-layer minerals (presumably chlorite-vermiculite), illite of trioctahedral type, chlorite and kaolinite. There is a high amount of fine quartz, as well as a small admixture of potassium feldspar and plagioclase. Mixed-layer minerals is diagnosed by the presence of a series reflexes in the region of 1.3 - 1.5  $\mu\text{m}$ . After 550 degree heating, the swelling clays are destroyed and only the reflex of 1.0  $\mu\text{m}$  remains.

X-ray diffractograms of the fraction <1  $\mu\text{m}$  (a - air-dry; b - saturated with ethylene glycol; c - heating 550°)

Illite is diagnosed by the 1.0  $\mu\text{m}$  reflex, which does not change when it saturated with ethylene glycol and heating. In terms of the d001/d002 reflex ratio, we can say that this mineral belongs to trioctahedral illites.

Chlorite is diagnosed by the presence of a series of reflexes: 1.42  $\mu\text{m}$  (d001), 7.1  $\mu\text{m}$  (d002), 4.74  $\mu\text{m}$  (d003), and 3.54  $\mu\text{m}$  (d004), on the intensity they can be referred to the magnesian-iron type. Kaolinite was diagnosed by reflexes 7.1 (d001) and 3.58 (d002). When saturated with ethylene glycol, the position of the reflex does not change, and when it exposed to high temperature, the crystal lattice is destroyed.

## Conclusion

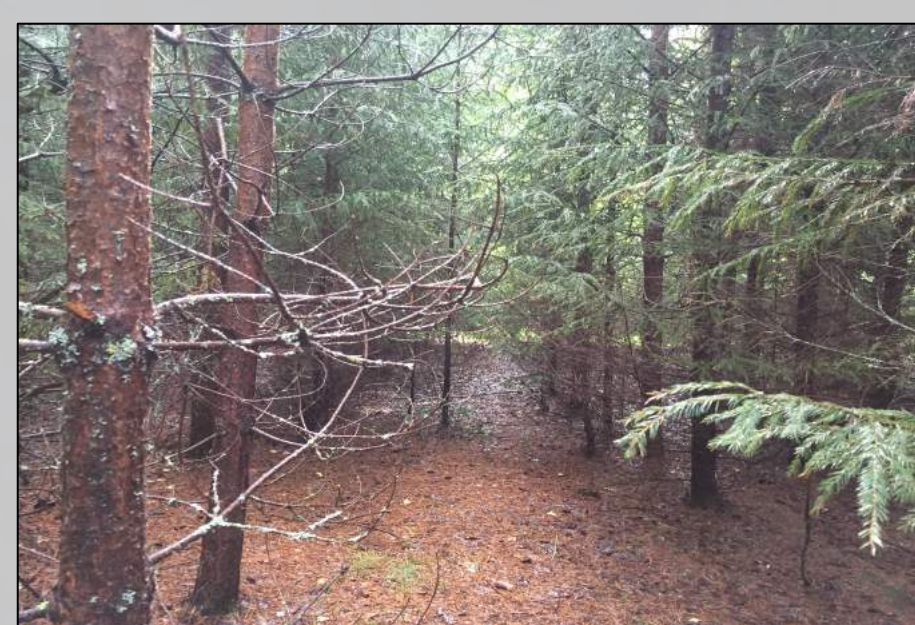
- Under the 70-year-old spruce forest the former plowed horizon (ELp) acquired morphological features similar to the native EL horizon with no apparent division into sub-horizons. There is only morphological feature of the former plowing like flat border with the horizon BEL.
- For 70 years the processes of podzol formation in the old spruce grove led to the clarification of the upper horizon and to the decrease of the content of the clay fraction.
- Under the 17-year-old spruce grove it is also impossible to divide sub-horizons at the macro level in the Pe horizon. The traces of the formerly plowing of the BT horizon are appear in a higher content of silt and brown coloration.
- The processes of podzolization in the course of 17 years of postagrogenic development are at the initial stage. An increase in the crystallization of mixed-layer minerals to the lower part of the former arable horizon was noted, which suggests the initial stages of podzol formation in its upper 5 cm.

## Objects & Methods

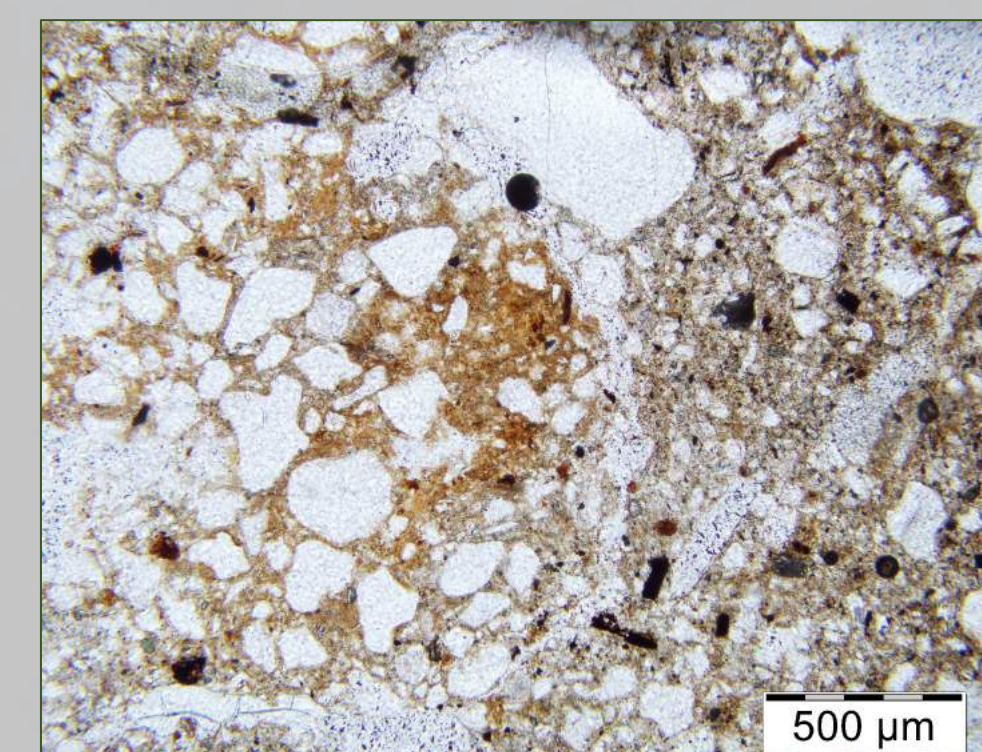
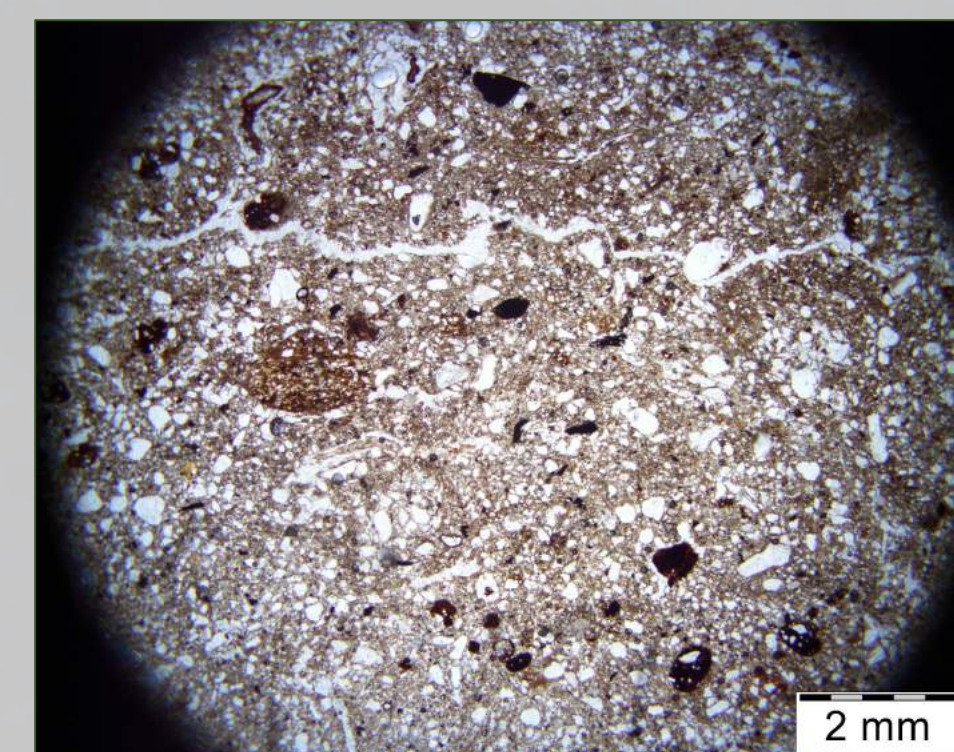
Soils were sampled in the south of Arkhangelsk region. Soils are formed on clay moraine of Moscow glaciation. Soil profiles were dug on interfluve. We selected 2 plant communities on different stages of succession: 16-year-old spruce forest with no herbaceous vegetation and 70-year-old bilberry spruce forest with domination of *Vaccinium myrtillus* and *Vaccinium vitis-idaea*.

To separate soil fractions <1 micron, 1-5 micron and 5-10 micron samples were rubbed into a thick paste and sedimented. Oriented preparations of fractions were examined by XRD method. The content of the main mineral phases in the fraction less than 1  $\mu\text{m}$  is determined by the method of Biscaye. Micromorphological studies have been performed on the classical methods using mineralogical microscope Olympus BH51 with a digital camera Olympus DP26.

### Spruce forest (18 years old) A15-02



Dystric Retisol (Cutanic Loamic Anthraquic)



Microzonality is observed in enrichment of the intra-pedal mass with a clay substance.

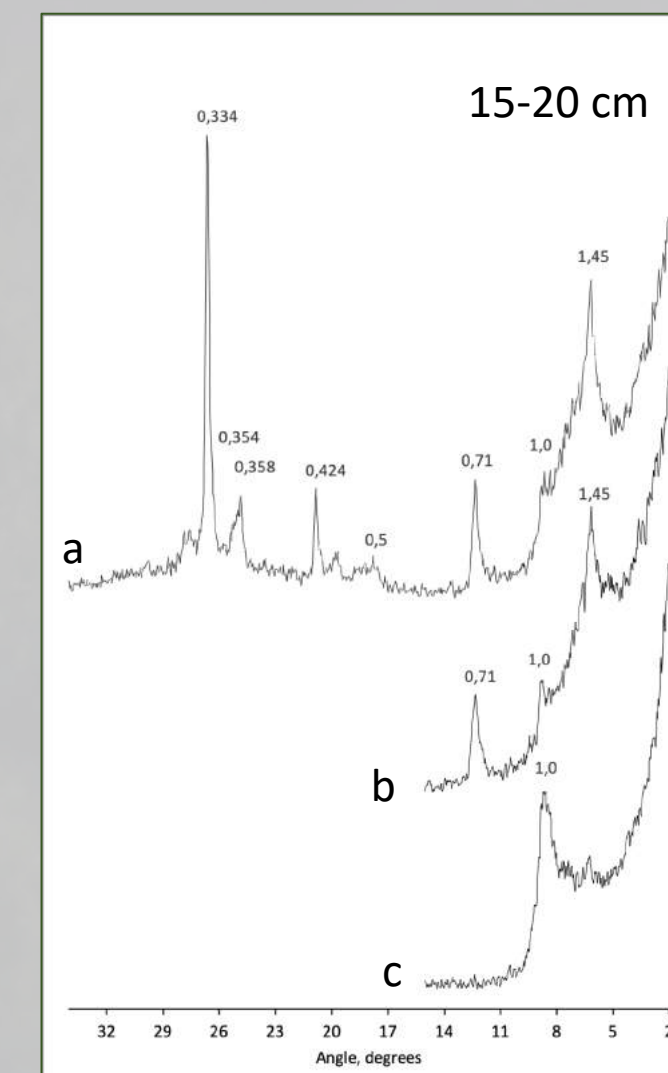
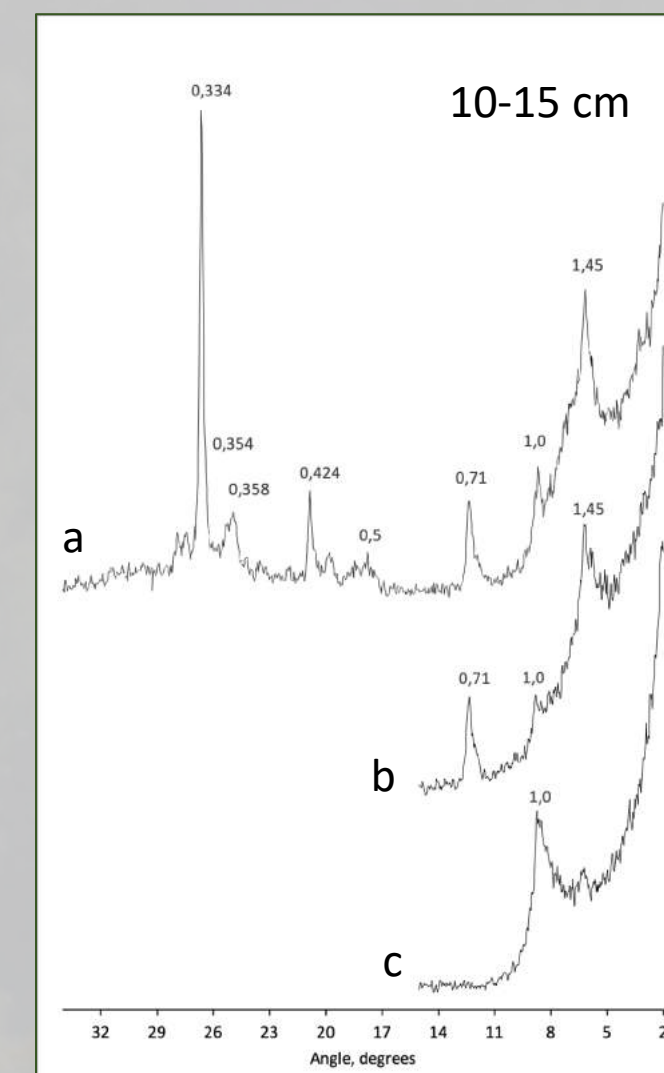
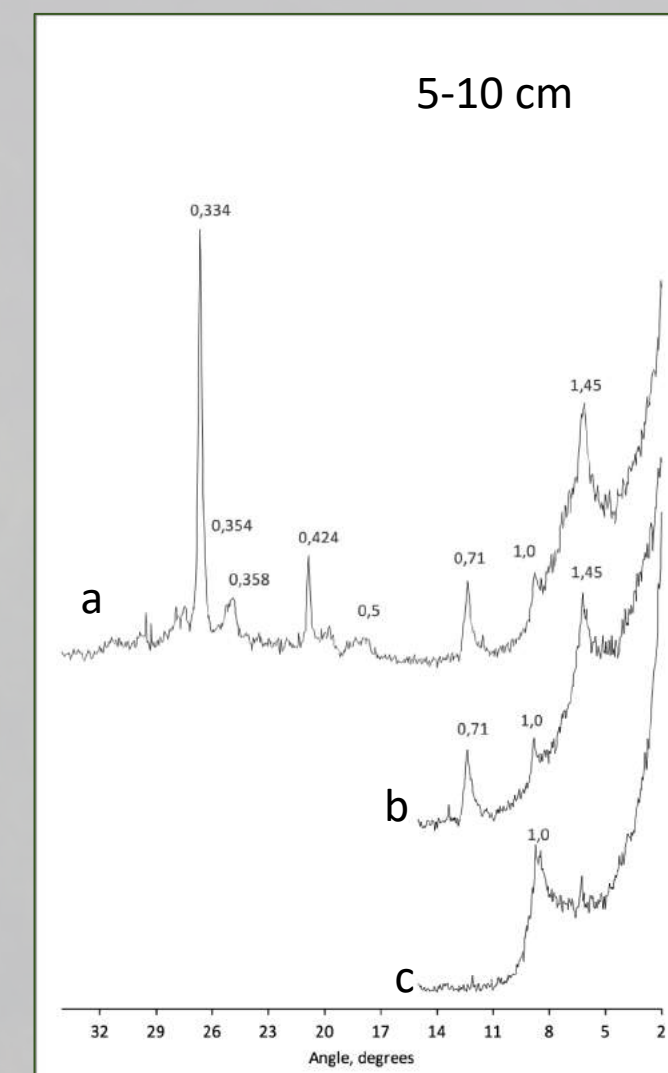
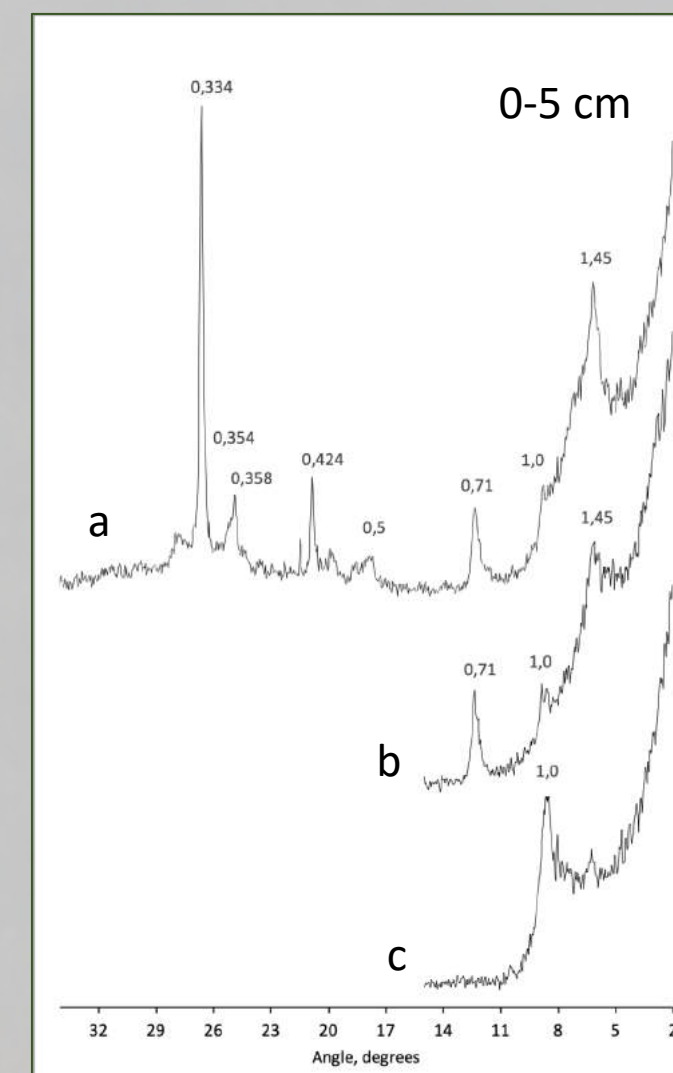
Clay substance can be removed from the following fragments: in priopore parts of moraine aggregates deposited, the amount of clay is less than in its parts.

Horizon	Depth, cm	Fraction, %			
		<1 $\mu\text{m}$	1-5 $\mu\text{m}$	5-10 $\mu\text{m}$	>10 $\mu\text{m}$
ELp1	0-5	7,2	8,0	7,0	77,8
ELp2	5-10	6,3	8,1	6,9	78,7
ELp3	10-15	6,7	8,6	5,5	79,1
ELp4	15-20	6,7	8,4	6,0	78,9

Particle-size composition of the former arable horizon in the spruce forest (18 years old).

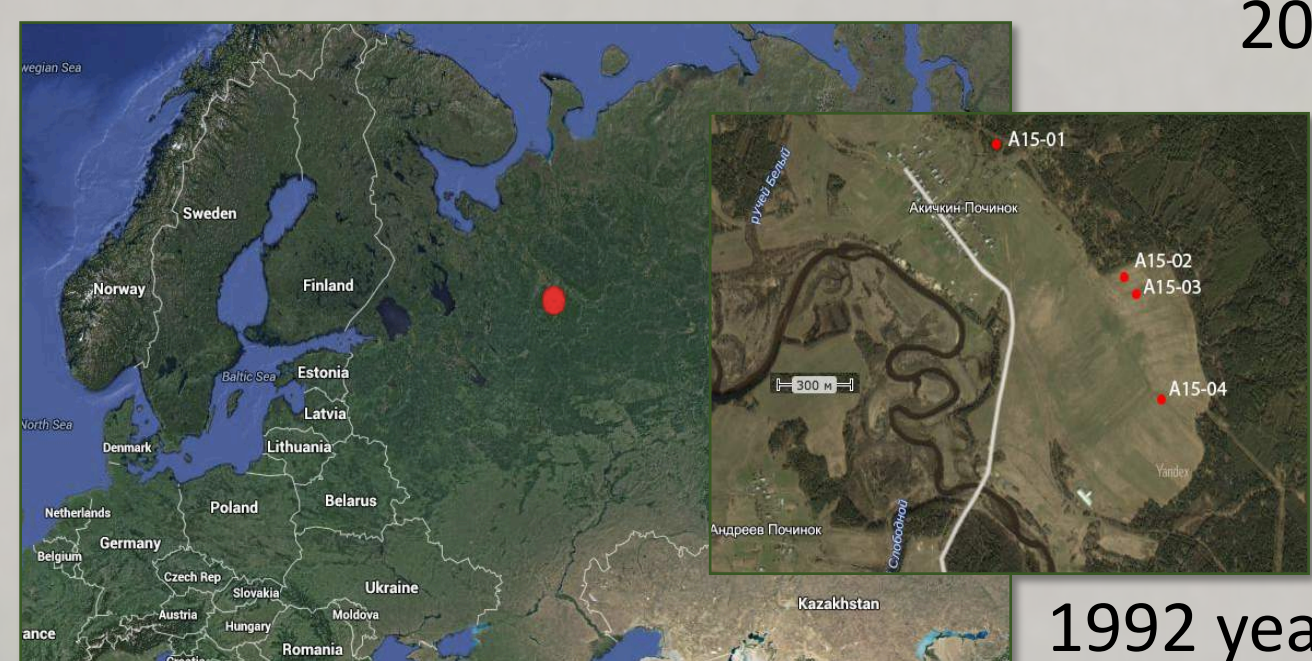
Horizon	Depth, cm	Fraction content <1 $\mu\text{m}$ %	Fraction <1 $\mu\text{m}$ , %				Soil, %			
			ML	I	CH	K	ML	I	CH	K
EL1	0-5	7,2	57	22	8	13	4,1	1,6	0,6	1,0
EL2	5-10	6,3	57	21	7	15	3,6	1,3	0,4	1,0
EL3	10-15	6,7	50	29	6	15	3,4	1,9	0,4	1,0
EL4	15-20	6,7	54	21	7	18	3,6	1,4	0,5	1,2

The ratio of the main minerals in fraction <1  $\mu\text{m}$  from the soil under the spruce forest (18 years old). ML - mixed-layer minerals; I - illite; CH - chlorite; K - kaolinite.



The content of fine quartz is higher in the soil under the old spruce forest (the reflex intensity 0,334 is stronger). Perhaps, in the young spruce forest, kaolinite has more perfect form (reflex 0,358). Chlorite in the young spruce forest (individual) is better crystallized - based on the shape of peaks 0,142. In general, the mixed-layer phase is better expressed in the young spruce forest (perhaps, this is indicated by a more "flat" area toward small angles in saturation with ethylene glycol).

X-ray diffractograms of the fraction <1  $\mu\text{m}$  (a - air-dry; b - saturated with ethylene glycol; c - heating 550°)



2018 year



1992 year

The maximum intensity of the process of destruction of clay minerals in eluvial horizons is typical for podzolic soils. The swelling minerals of the montmorillonite group are mostly destroyed, less - illite, and even less - kaolinite. As a result, the mineralogical composition of the clay fraction in the horizons is differentiated: in the upper horizons there is a loss of swelling minerals and accumulation of kaolinite, and sometimes illite minerals in <1  $\mu\text{m}$  fraction (Sokolova, 1982). In a sample from a depth of 0-5 cm, a relative accumulation of illite and kaolinite is observed under the old spruce forest, while the maximum content of these minerals in the micro profile under the young spruce is noted in the lower horizons.

